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Part I

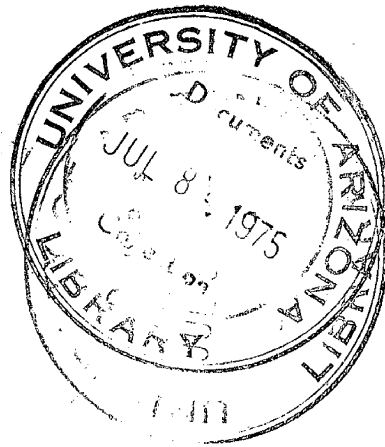
U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

**Tables of  
Spectral-Line Intensities**

**Arranged by Elements**



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*W. F. Meggers prepares to measure one of the spectrograms on which these tables of spectral-line intensities are based.*



# Tables of Spectral-Line Intensities Part I - Arranged by Elements

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**Second Edition**

William F. Meggers, Charles H. Corliss and  
Bourdon F. Scribner

Institute for Basic Standards  
National Bureau of Standards  
Washington, D.C. 20234

The intensity, character, wavelength, spectrum, and energy levels of 39 000 lines between 2000 Å and 9000 Å observed in copper arcs containing 0.1 atomic percent of each of 70 elements.

(Supersedes NBS Monograph 32, Parts I and II and its Supplement)



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## Preface

A second edition of the NBS Tables of Spectral-Line Intensities (Part I. Arranged by Elements and Part II. Arranged by Wavelengths) has been prepared. New classifications have been provided for 8500 previously unclassified lines, improved wavelengths are given for about 9000 lines and some revision of the intensity scale has been made. (Supersedes NBS Monograph 32, Parts I and II and its Supplement.)

Key words: Classification of spectral lines; intensities of spectral lines; spectral-line intensities; tables of spectral-line intensities; wavelengths of spectral lines.

This new edition of the NBS Tables of Spectral-Line Intensities incorporates three improvements on the original edition of 1961. In the original edition only about 25 000 of the 39 000 lines in the tables had been classified. In the ensuing thirteen years, about 8500 more lines (chiefly rare-earths) have been classified and the new classifications are here incorporated.

Furthermore in the course of spectroscopic research during that period, many spectra have been remeasured. About 9000 improved wavelength values have been adopted here. Many of the new values are accurate to somewhat better than two decimal places but in most cases there remains some uncertainty in the third place. We have therefore printed only two decimal places in this edition.

The third improvement to be found in this edition is in the intensity scale. Three changes have been made. The calibration of the region below 2450 Å, which was published by Corliss [1967], has been incorporated in the new edition. Secondly, a slight error in the original reduction of the intensity data from the overlapping regions of the plates has been corrected. In the original reduction the duplicate observations in the overlapping regions were simply averaged. This was a theoretically correct procedure since the observations had already been normalized to the intensity scale of the copper matrix. However, it was observed that this normalization did not produce identical scales on each plate. A more practical procedure would have been to have adjusted each plate to a common scale determined by the mean intensity level of all the plates. This was pointed out by J. L. Tech [1971] who has now applied this correction to all of the complex spectra in the tables. The elements with less than 100 lines (simple spectra) remain uncorrected for this relatively minor error because there are not enough lines in the overlapping regions to determine correction factors.

Finally, the whole scale of relative intensity numbers has been multiplied by ten to eliminate numbers less than unity. The intensity numbers now range from 1 to 90 000.

For the convenience of the user, the tables are presented in two separate parts, in the same way as the original edition. Part I is arranged by element in alphabetic order of chemical name. In Part II all observed lines are consolidated in a single table arranged in order of increasing wavelength and in a supplementary table of selected strong lines.

The values of ionization potentials for many of the elements are taken from the compilations of C. E. Moore but those for the lanthanides, actinides and Hf are taken from the compilation of W. C. Martin, Lucy Hagan, Joseph Reader and Jack Sugar (J. Phys. Chem. Ref. Data, Vol. **3**, No. 3, 1974). The values of atomic weights are taken from the 1969 Report of the International Commission on Atomic Weights.

## References

- Corliss, C. H. (1967), Revision of the NBS Tables of Spectral-Line Intensities below 2450 Å. NBS Monograph 32 Supplement.
- Tech, J. L. (1971), A High-Dispersion Spectral Analysis of the Ba II Star HD 204075 ( $\zeta$  Capricorni). NBS Monograph 119.

Charles H. Corliss

Washington, D.C., April 25, 1974

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			K	K					K	K	
Aluminum .....	Al	13	933.2	2793.	3	Neodymium .....	Nd	60	1289.	3335.	159
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Barium .....	Ba	56	1002.	1900.	6	Osmium .....	Os	76	3323.	4500.	188
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Iridium .....	Ir	77	2727.	4662.	115	Thulium .....	Tm	69	1818.	2220.	311
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Manganese .....	Mn	25	1517.	2335.	140	Yttrium .....	Y	39	1799.	3611.	372
Mercury .....	Hg	80	234.3	629.7	144	Zinc .....	Zn	30	692.6	1184.	377
Molybdenum .....	Mo	42	2890.	4880.	145	Zirconium .....	Zr	40	2125.	4682.	378

\*Melting and boiling points are quoted from American Institute of Physics Handbook, 3rd ed., New York, 1969.



# Tables of Spectral-Line Intensities—Part I

## Arranged by Elements

The relative intensities, or radiant powers, of 39 000 spectral lines with wavelengths between 2000 and 9000 Ångstroms have been determined on a uniform energy scale for seventy chemical elements. This was done by mixing 0.1 atomic percent of each element in powdered copper, pressing the powder-mixture to form solid electrodes which were burned in a 10 ampere, 220 volt direct-current arc, and photographing the spectra with a stigmatic concave grating while a step sector was rotating in front of the slit. The sectored spectrograms facilitated the estimation of intensities of all element lines relative to copper lines which were then calibrated on an energy scale provided by standardized lamps, and all estimated line intensities were finally adjusted to fit this calibration. Comparisons with other intensity measurements in individual spectra indicate that the National Bureau of Standards spectral-line intensities may have average errors of 20 percent, but first of all they provide uniform quantitative values for the seventy chemical elements commonly determined by spectrochemists. These data are presented by element in part I, and all 39 000 observed lines are given in order of wavelength in part II.

Key words: Classification of spectral lines; intensities of spectral lines; spectral-line intensities; tables of spectral-line intensities; wavelengths of spectral lines.

### 1. Introduction

Spectrochemistry was born a century ago when Kirchhoff and Bunsen [1]<sup>1</sup> definitely demonstrated that chemical elements were uniquely identified by spectral radiations, or lines as seen in a spectroscope provided with a slit. This led immediately to the identification of many chemical elements in the sun and to the discovery of several new elements, but no quantitative chemical analyses were made until much later.

In 1874, Lockyer [2] stated that “while the qualitative spectrum analysis depends upon the *positions* of the lines, the quantitative analysis depends not upon their position but upon their *length, brightness, thickness, and number* as compared with the number visible in the spectrum of a pure vapor”. Thus, position (or wavelength) and brightness (or intensity) are recognized as being the two most important properties of spectral lines; wavelengths identify chemical elements and intensities indicate the concentrations of identified elements in mixtures or chemical compounds.

During the past century there has been spectacular improvement in the accuracy of spectral wavelength determinations; the early ones were limited to 3 or 4 figures, the later use of diffraction gratings and wavelength standards permitted the specification of 5 or 6 figures. Since 1900 the application of interferometers and better gratings has refined many wavelengths to 7 figures, and recently some 8-figure values of wavelength standards have been provided.

Unfortunately during this past century very little progress has been made in assigning uniform quantitative intensity values to spectral radiations. The great bulk of spectral observations have been made photographically because photographic emulsions provide detailed, permanent records of spectra not only in the visible but also in the invisible ultraviolet and infrared regions. But even if the light source is reproducible and standardized it is not easy to evaluate the spectral efficiencies of spectrographs and photographic emulsions so the usual procedure has been to make subjective visual estimates of relative intensities of spectral lines on an arbitrary scale based on the relative blackness and/or width of spectral-line images appearing on a developed photographic plate. Consequently, in thousands of individual papers and in numerous comprehensive compilations of spectral data we find only qualitative data on intensities which may have some meaning for adjacent lines in a given spectrum but none at all when comparing widely spaced lines, or lines of different spectra of the same element or of different chemical elements.

In the beginning, most intensity data were reported on an arbitrary scale of 10 steps, weak lines being assigned an intensity of 1, and the strongest line intensity 10. Even as late as 1945 extensive new spectral tables prepared by Gatterer and Junkes [3] displayed estimated intensities on this limited 1 to 10 scale. Since 1910 some spectroscopists have arbitrarily expanded this arbitrarily compressed

<sup>1</sup> Figures in brackets indicate the literature references on page xiv.

scale. For example, in the very extensive spectral tables published by Exner and Haschek [4] the estimated intensities range from 1 to 1000. In wavelength tables compiled by Twyman and Smith [5] the maximum intensity is 20, in the compilation of Kayser and Ritschl [6] estimated intensities rise to 4000, and in the well-known M.I.T. Wavelength Tables [7] they soar to 9000. The most recent compilation of Tables of Spectrum Lines by Zaidel, Prokof'ev, and Raikiif [8] quotes data from the M.I.T. Tables and more modern sources but adds nothing new on spectral line intensities.

In or about the year 1925, microdensitometers were developed for the purpose of quantitative measurement of relative intensities among related lines in multiplets to test the sum rules derived from the quantum theory of spectral structure, but no general applications were made. Since then thousands of spectrochemists have applied microdensitometers to quantitative chemical analyses by calibrating intensity ratios of analysis- and internal-standard lines but such measurements have contributed nothing to the basic data on spectral line intensities. Likewise, with few exceptions, the modern substitution of electronic photodetectors for photographic emulsions has added nothing to our knowledge of true line intensities over long ranges of different spectra of many chemical elements.

How may one hope to obtain, with a reasonable amount of labor, quantitative intensity data on the same scale for thousands of spectral lines representing practically all of the metallic elements? A hint was given in 1874 by Lockyer [2] who observed that "the lines of any constituent of a mechanical mixture disappeared from the spectrum as its percentage was reduced." Acting on this suggestion, Hartley [9], in 1884, began to study the spark spectra of metals in solutions with concentrations of 1 percent, 0.1 percent, 0.01 percent, and 0.001 percent, and proposed a method of quantitative spectrochemical analysis based on the lines that could be detected at each dilution. Similar studies were later made by Pollok and Leonard [10], by de Gramont [11], and by Löwe [12], all showing that with progressive dilution of an element its spectral lines weakened and vanished until only the most sensitive line remained to reveal its presence. In all these works the principle of quantitative spectrochemistry appeared to rest on the *number of lines* detectable rather than on their individual *intensities*. Casual observation must have shown lines of equal strength in spectra of solutions differing 1000 fold in concentration but no one mentioned it. It is difficult to understand why these early studies of residual spectra in quantitatively prepared mixtures or solutions did not suggest a method for obtaining physical intensities, but it is a fact that before our work had begun no one had attempted to express spectral line intensities as directly proportional to the number of radiating atoms or concentration of the element. The present monograph reports such an attempt [13].

Our method of deriving line intensities from arc spectra of elements diluted in copper was recently adopted by Allen [14, 15] to obtain oscillator strengths of some radiations from 3200 to 5400 Å representing nine elements.

At various times since 1932 we have photographed the arc spectra of 70 chemical elements diluted in silver or in copper, and determined the line intensities of the diluted elements relative to selected lines of the matrix. An energy calibration of the latter finally led to physical intensities of 39,000 spectral lines representing 70 elements, all on the same energy scale. These experiments and results are based on the following propositions, regarded as fundamental for the quantitative description of residual spectra of diluted elements excited in ordinary d-c arcs.

1. *The limiting detectability of any line is defined as the atomic concentration that ensures positive detection of the line.* This limit is determined mainly by unavoidable background on a fully exposed spectrogram. The spectrum of an arc burning in air consists of discrete lines due to atoms, and of more or less extensive band systems from transient compounds (usually monoxides), all superposed on a continuous background arising from thermal radiation of incandescent oxides, from transitions in the continuum, and possibly from scattered light. This background sets a limit to the exposure for faint lines that may be given by any actual spectrograph. If this were not true, the exposure could be increased indefinitely to compensate for unlimited reduction in concentration, and detectability would always be infinite. Faint lines are not recorded by underexposure, and they cannot be recognized on a very dense background produced by overexposure. In order to guarantee positive recognition and unambiguous chemical identification a spectral line should be sufficiently well defined to permit accurate wavelength measurement. Experience shows that the minimum photographic density that meets this requirement is of the order of 0.05 above that of the background.

2. *The limiting detectability of any element in an arc depends on the matrix in which the element finds itself.* There is no doubt that in the conventional arc relative volatilities of the chemical elements as well as relative ionization potentials affect the relative strengths of their mixed spectra. In general, the elements with high-vapor pressure and/or low-ionization potential will be favored in spectral excitation, but elements with either high or low volatility may be underestimated if not uniformly present during the exposure, and easily ionized elements may appear less sensitive because of more complete ionization. In this connection it must be noted that large differences in apparent detectability are possible if concentrations are expressed in relative weights instead of numbers of atoms. Thus,

0.01 atomic percent of boron in uranium is equal to  $< 0.0005$  weight percent since the uranium atom is 22 times heavier than the boron atom.

3. *The primary substance (matrix) has no important effect on the relative intensities of lines due to a secondary substance.* It is conceded that the relative intensities of analogous spectra of different elements, and of successive spectra of the same element, may vary with the composition of the samples and/or with the type, or portion, of light source from which radiation is taken, but there is no evidence that the relative intensities of lines in any particular spectrum of a given element are thereby greatly changed. It may be expected, therefore, that the relative intensities of lines observed in one metal arc will remain valid in any other metal arc, provided the arcs are at approximately the same temperature. The absolute intensities and the relative strengths of successive spectra may be altered by excitation conditions. For example, silicon may be more sensitive in carbon than in calcium, and it is well known that when easily ionized alkalis are present in sufficient quantity to influence discharge conditions they reduce the intensity of other spectra, especially those characteristic of ionized atoms.

4. *The order of lines arranged according to decreasing detectability in progressive dilution is the same as the order of decreasing intensity in the spectrum of the pure element.* In other words, emission line intensities in residual arc spectra (barring self-absorption) are proportional to the number of radiating atoms; and relative intensities may therefore be derived from concentrations at which different lines show the same intensity or limiting detectability.

Arc spectra usually exhibit a variety of lines, sharp or narrow ones, diffuse or wide ones (including band heads), strong ones accompanied by photographic spreading of developed images, others wide on account of hyperfine structure, and some partially reversed. All of these types, except the last, appear in residual arc spectra at low concentrations, and it may be questioned if it is possible to place them on a uniform intensity scale. It may be assumed that if total blackening integrated over the width of the line when recorded at a moderate level of density be con-

sidered in estimating relative intensities these will be on a uniform scale within the limits of precision in making such estimates on lines of different types.

5. *The order of spectral lines arranged according to decreasing intensity is the same when the intensities are decreased by rotating stepped sectors as when the intensity reduction is produced by successive dilution of the element in a matrix.* This was recognized by Löwe [12] who published an atlas of spark spectra of 44 elements diluted from 1 percent to 0.001 percent and later obtained practically the same results by observing spectra with stepped exposure times [16]. In our experiments the labor of preparing samples of 70 elements in four or more dilutions was greatly reduced by adopting only one dilution (0.1 atomic percent) and then producing further reductions of spectral-line intensities by means of rotating step sectors.

6. *Limiting detectability (as defined in 1.) may be adopted as a physical scale of intensities.* Such intensities may be fixed as follows: In a fully exposed spectrogram of copper containing 0.1 atomic percent of another element any faint but unmistakable line at a given wavelength is assigned unit intensity. Any similar line appearing with unit intensity in a spectrogram when the energy, or concentration, is reduced to  $1/5$  is said to be 5 times as strong. Thus, all lines can be assigned relative intensities proportional to their limiting detectabilities by determining either the energy reduction or the concentration reduction at which the stronger lines finally show unit intensity. The atomic percent concentration at which any line will show unit intensity then results from dividing 0.1 by its required energy or concentration reduction. For example, a line of intensity 10 should show plainly at 0.01 atomic percent, while one of intensity 1000 should be easily seen at 0.0001 atomic percent (one in a million). Assuming the ratio concentration/intensity to be constant, the maximum intensity at 100 percent is easily obtained. Thus, a line of intensity 1000 at 0.1 atomic percent will have an intensity value of  $1000 \times 100/0.1 = 1,000,000$  at 100 percent. This indicates a much larger range of spectral intensities than mentioned heretofore, but it is not unrealistic.

## 2. Experiments

Whereas all earlier experiments on residual spectra of diluted elements involved spark excitation of solutions or fused salts, we decided to employ d-c arc excitation for the following reasons. It has been shown [17] that the first ionization potentials of some seventy metallic elements range from 4 to 11 V and the strongest spectral lines of most of these elements have wavelengths between 2000 and

9000 Å, which is the spectral region covered by the present investigations. Furthermore, it is known [18] that the second ionization potential of these elements ranges from 10 to 75 V and that the strongest lines of singly ionized atoms generally have shorter wavelengths than those of neutral atoms, nearly half of them being shorter than 2000 Å so that they can be detected only in vacuum spectrographs.

Because low-voltage arcs have less ionizing action than high-voltage sparks more atoms will remain in the neutral state and, in general, therefore, arc spectra will exhibit stronger lines and higher sensitivity than spark spectra.

The use of arc spectra in these experiments threatened to introduce errors on account of self-absorption of radiated energy in the arc aura or envelope which consists largely of unexcited neutral vapor atoms. In all spectra of arcs between metal electrodes this is the cause of conspicuous self-reversal of all lines involving the atom's ground state. However, this is a function of vapor density surrounding the arc and if this is reduced to 0.001, self-reversal is usually negligible (see fig. 2). This is our reason for making these experiments with individual elements diluted in copper in the ratio 1 to 1000. When ground-state lines of extraordinary intensity were suspected of some self-absorption, intensity ratios were checked or corrected by examining our earlier spectrograms made with this element diluted to 0.0002 atomic percent in silver.

### 2.1. Dilution in Silver

Our preliminary experiments, begun in 1932, can be described briefly as follows: solutions of known strength of the elements under investigation were prepared and proper amounts added to pure silver oxide, which was then reduced to metal by heating to make samples containing 8 definite atomic ratios extending from 0.05 to 0.0002 atomic percent of the element added to silver, with a factor of about 2 between 7 successive dilutions. In order to save time and labor, each series of silver samples incorporated 3 to 6 chemical elements, in addition to zinc which supplied internal standards. These samples were burned on pure copper electrodes of a 220 volt d-c arc with 10 amperes. An image of the arc was projected onto the slit of a stigmatic concave grating spectrograph by means of a fused-quartz lens. Each series of excited samples was exposed on successive segments of the slit, and was photographed in four spectral regions ranging from 2000 to 9000 Å (see fig. 1). A comparator was employed to measure wavelengths (relative to silver and copper lines) for the identification of the added elements, and relative inten-

sities of all lines belonging to residual spectra of diluted substances were estimated and related to concentration. These results were not satisfactory for the following reasons: The use of silver as a matrix and of copper for arc electrodes precluded the possibility of getting any data for these two elements or for any lines masked by silver and copper lines. Also the inclusion of 3 or more elements in each series of samples resulted in the blending of many lines, especially in complex spectra, so that it was not possible to assign proper intensities in these cases. Furthermore, the method of sample preparation and observing appeared to be unsuited to very volatile elements, or compounds, because no residual spectra could be recorded for them even at concentrations of 0.1 atomic percent.

### 2.2. Dilution in Copper

In 1941 these preliminary experiments were abandoned in favor of a modified procedure which led to satisfactory results. The chief changes in procedure came with the availability and use of pure metal powders, and a hydraulic press to form solid electrodes of mixed powders. Instead of reducing spectral line intensities to the limit of detectability by successive dilutions of the element in different samples only one dilution (0.1 atomic percent) was prepared and line intensities were reduced by observing through rotating step sectors. The successful procedure may be outlined as follows: An element under investigation was mixed with pure copper powder in the atomic ratio of 1 to 1000. These mixtures were pressed into solid electrodes, and burned in a 220-V, 10-A d-c arc which was imaged entirely on the collimator of a stigmatic grating spectrograph by a lens at the slit. A rotating step sector in front of the slit reduced the spectral intensities to one-fifth in each of four steps (see fig. 2). Spectral intensities of the element added to copper were estimated relative to those of selected copper lines, and this was done separately for each of 70 elements throughout the range of spectrum from 2000 to 9000 Å. The true intensities of the selected copper lines above 3300 Å that served as internal standards were then measured, by photographic photometry, relative to the known energy distribution in the spectrum of an incandescent tungsten-strip filament at a certain

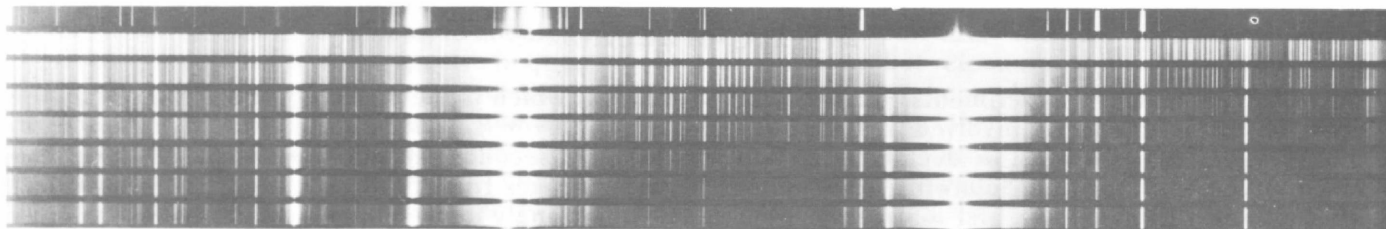


FIGURE 1. Arc spectra of elements (*V, Nb, Ta*) diluted progressively in silver, and burned on copper electrodes. Spectral range 3880 to 4320 Å.



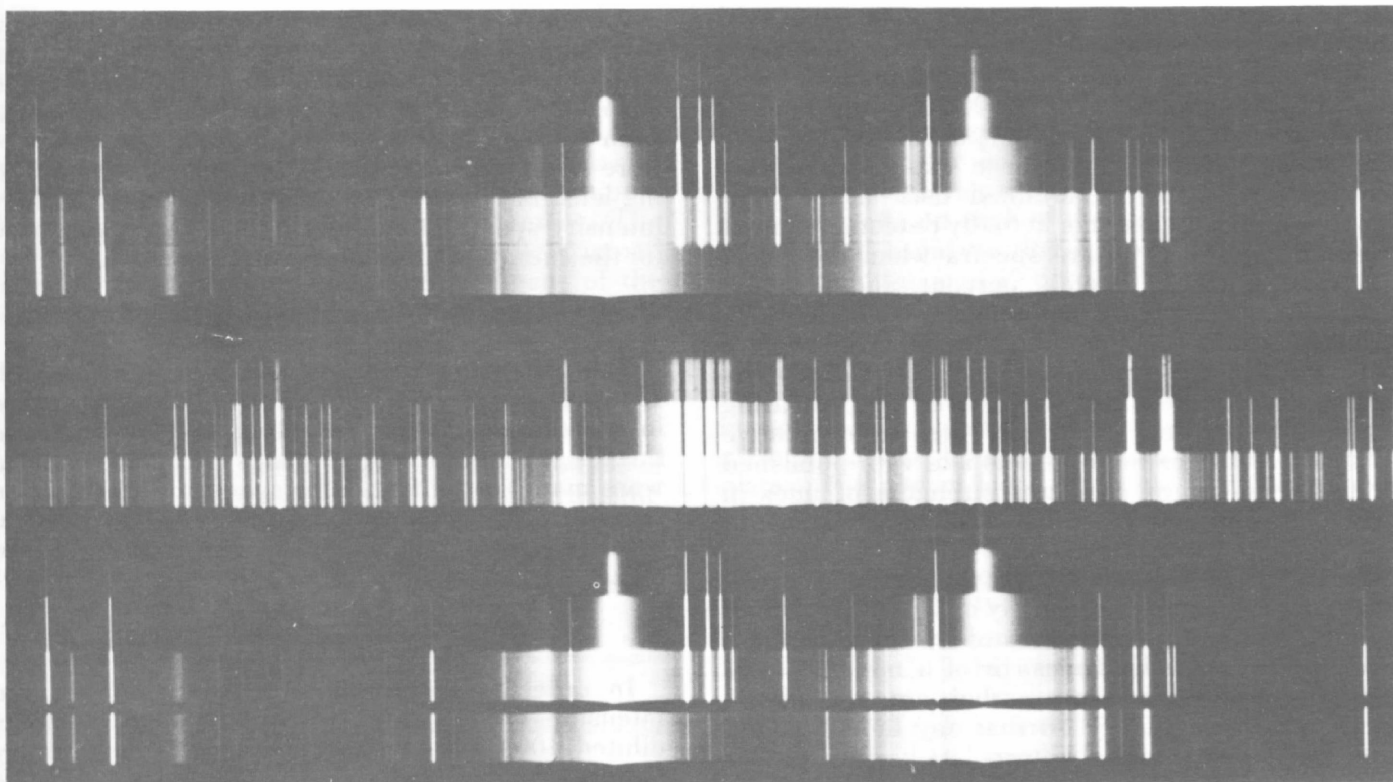


FIGURE 2. Arc spectra of pure manganese (center), and of copper containing 0.1 percent Mn (above and below), all through a rotating step sector.  
Spectral range 3960 to 4105 Å.

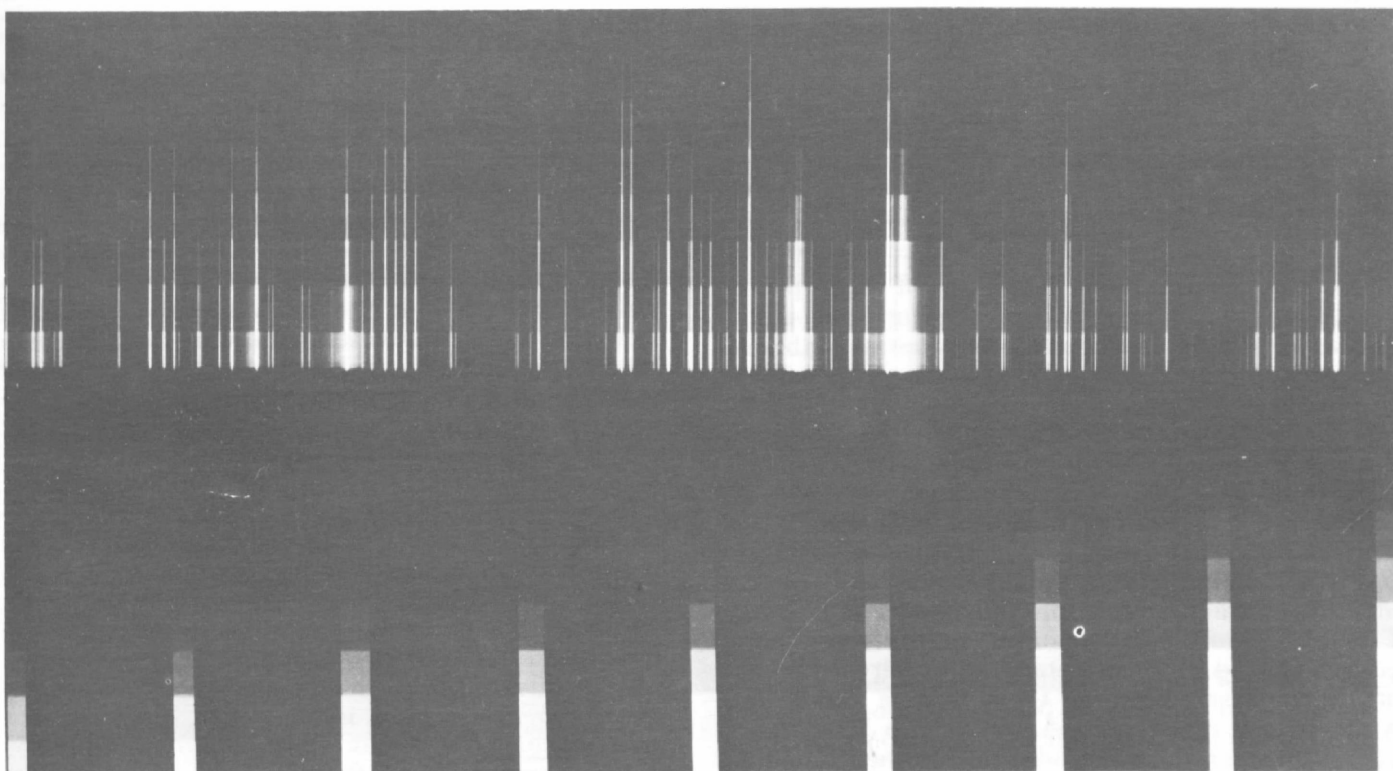


FIGURE 3. Energy calibration of copper lines.  
Above, arc spectrum of copper through rotating step sector. Spectral range 3400 to 3850 Å. Below, standard-lamp spectrum at 50 Å intervals through same step sector.

temperature (see fig. 3). Between 2000 and 3300 Å a calibrated hydrogen lamp was used to determine the relative intensities of copper lines. Finally the apparent intensities of 39 000 spectral lines of 70 elements, relative to copper, were adjusted to fit the copper calibrations. These experiments thus provide empirically determined lists of the principal lines of all elements actually detectable under average conditions in arc spectra when their concentrations are 0.1 atomic percent, and the individual lines bear intensity numbers approximately proportional to their detectability or their relative energy. That these intensity numbers really represent physical intensities was proved by comparing them with earlier, accurately measured relative intensities of lines in multiplets and with published relative *f*-values or oscillator strengths of lines in different multiplets extending over a wide range of spectrum.

In order to provide intensity data for spectral lines that are partially or wholly obscured by copper lines a sectored spectrogram of the pure element excited with self-electrodes, or of a metallic compound or salt excited in a carbon arc, was photographed on every plate so that any lines blended with copper could be interpolated with proper estimates of their relative intensities. Comparison of relative intensities in copper and in carbon matrices also supplied new information on successive spectra, I and II, especially of rare-earth spectra. Similar data for copper itself were obtained by using pressed electrodes of pure silver powder to which 0.1 atomic percent of copper was added, plus the same quantities of gold and zinc to serve as internal standards.

Further details of experimental materials, apparatus, and procedure are given in the following paragraphs.

### 2.3. Arc Electrodes

For this investigation materials of high purity were acquired, preferably in the form of metal powders, although some elements, not available in pure powdered metal form, were obtained as oxides. In every case the proper amount was added to powdered copper to produce a mixture in which there was one atom of the added element to each 1000 atoms of copper. These mixtures were homogenized by mechanical shaking and then compressed into solid cylindrical pellets in a hydraulic press at 5000 psi. The pellets were ¼ in in diameter, ¼ in in length, and weighed about 1.5 g. Two of a kind were mounted in massive water-cooled clamps in an arc stand and a direct current of 10 A passed between them from a 220-V line with ballast resistance. A 3-mm gap was maintained between the electrodes during the exposures which varied in duration from 1 s to 5 min depending on spectrographic efficiency and sensitivity of photographic plates in different spectral regions.

The arc was imaged on the collimator of a concave grating spectrograph by means of a quartz lens immediately in front of the slit to obtain uniform illumination along its length and collect light from all parts of the arc. Rotating step sectors were operated immediately in front of the collecting lens, one with 5 to 1 ratio was used for all line-intensity spectrograms, but a 2 to 1 step was used for the energy calibration of copper lines.

### 2.4. Spectrograph

The dispersing apparatus was a 6-in grating with 15 000 lines per inch, and 22 ft radius of curvature in a Wadsworth-type mounting to give stigmatic images on photographic plates. All observations were made in the first-order spectrum in which the reciprocal dispersion was 5Å/mm, and the practical resolving power about 50,000 with a slit width of 30 μ.

### 2.5. Photographic Plates

In order to determine, relative to copper, the intensities of all lines of 70 chemical elements diluted 1000 fold it was necessary to make many hundreds of spectrograms, and to employ 4 varieties of photographic plates to cover the wavelength range 2000 to 9000 Å. The spectral range 2000 to 3000 Å was recorded on Eastman<sup>2</sup> 103-0 Ultra-violet Sensitive plates, 2600 to 4900 Å on Eastman 33 plates, 4600 to 6900 Å on Eastman II-F plates, and 6600 to 9000 Å on Eastman I-N plates. Each plate was developed for 4 min in a rocking tray containing D-19 developer at 70 °F.

The exposure times in each spectral range were chosen by trial to obtain a suitable continuous background in the first step of the rotating step sector. Because of variations in spectral sensitivity of photographic materials and in spectrographic efficiency two exposures of the contaminated-copper arcs were usually made on each plate, with exposure durations in the ratio 2 to 1, and the sectored comparison spectrum of the contaminant was placed between them. Measurements were usually confined to the exposures which showed the optimum background in the first step of the rotating sector.

### 2.6. Energy Calibration of Copper Lines

In order to determine the factors necessary to convert the estimates of apparent intensities of the lines of 70 elements relative to copper into true relative intensities, it was necessary to determine the true relative intensities of selected reference lines in the spectrum of copper. The energy calibration of copper lines was performed as follows:

<sup>2</sup> Certain commercial products and instruments are identified in this paper in order to specify adequately the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the products or equipment identified are necessarily the best available for the purpose.

A G.E. tungsten ribbon filament lamp (type F339-85, 30 A, 6V) equipped with a fused quartz window served as the reference standard of spectral energy distribution in the wavelength range 3300 to 9000 Å. The brightness temperature of the filament at 6500 Å was measured at two values of filament current by Henry Shenker in the National Bureau of Standards Pyrometry Laboratory. The true temperature  $T$  of the filament was determined from the brightness temperature by means of the following equation obtained from Wien's law

$$\frac{1}{T} = \frac{1}{T_B} + \frac{\lambda}{C_2} \ln A$$

where  $C_2 = 1.438$  cm-deg and  $A$  is the product of the emissivity of tungsten (0.427) and the transmittance of the quartz window (0.916) at 6500 Å.

TABLE I. *Temperature of tungsten lamp*

Current	Brightness temperature	True temperature
<i>A</i>	<i>K</i>	<i>K</i>
38.00	2492	2787
40.00	2567	2881

The energy distribution from blackbodies operated at these temperatures was taken from tables prepared by Stair and Smith [19] in the 2300 to 3500 Å range, by Skogland [20] in the 3200 to 7600 Å range and by Lowan and Blanch [21] in the 7200 to 10 000 Å range. The data from these tables were adjusted to a common basis and multiplied by the emissivity of tungsten and the transmittance of fused quartz at intervals increasing from 50 Å in the ultraviolet to 200 Å in the infrared. The emissivity of tungsten was taken from a weighted mean curve of published values to which reference is made by Stair and Smith [19]. The transmittance of fused quartz was calculated from data on its index of refraction published by Sosman [22]. The final product, representing the relative energy distribution of the radiation emerging from the quartz window of the lamp, was plotted on a convenient scale to permit interpolation to any wavelength in the range 2300 to 10 000 Å.

Spectrograms of the pure copper arc and of the tungsten lamp were made under conditions identical with those described above except that for these a 2 to 1 step sector with 8 steps was used for closer calibration (fig. 3). Microphotometer measurements of transmittance were made in each step of the standard-lamp spectrum at intervals of 50 Å and a family of calibration curves of transmittance versus log exposure (hereafter referred to as log  $J$ ) was drawn up for each plate. The exposure of the standard-lamp  $J_s$  was read from the calibration curve

for each wavelength at a transmittance of 40 percent (where the curve is linear) and then divided by the calculated intensity  $I_s$  at that wavelength.  $I_s$  is the calculated intensity emitted by the standard-lamp. A standardization curve of  $\log J_s/I_s$  versus  $\lambda$  was plotted for each plate. Calibration curves of transmittance versus  $\log J$  were then drawn from measurements on each of the selected copper lines and the log exposure ( $\log J_{Cu}$ ) of each copper line at a transmittance of 40 percent was read from each curve.  $\log J_s/I_s$  was then subtracted from the average of numerous values of  $\log J_{Cu}$  to give  $\log I_{Cu}$  which is the log of the true relative intensity of the copper line. The values of  $\log I_{Cu}$  from plates in adjacent wavelength regions were adjusted to a common basis by means of lines common to both plates. The plot of  $\log J_s/I_s$  versus  $\lambda$  is the relative response function of the plate-spectrograph combination and as such was itself useful in the infrared where the copper spectrum lacks lines suitable for use as an intensity reference.

From 2 to 24 determinations were made on each of 202 lines of Cu I between 2800 and 8100 Å with an average of about 9 determinations per line. The values of  $I_{Cu}$  obtained by this procedure below 3300 Å were systematically low because of the rapid decline in intensity from the standard lamp in the direction of short wavelengths. The intensity from the lamp at 5500 Å is about 40 times the intensity at 3300 Å and about 300 times the intensity at 2800 Å. This fact introduces possible errors from scattered light of the intense visible radiation which tends to raise  $J_s$  and consequently depress  $I_{Cu}$ .

The spectrum of copper is composed of sharp lines and diffuse lines. Since the microphotometer measurements were made at the peaks of the lines rather than integrated over their widths, the measured intensities of the two groups of lines are on different relative scales, the scale of the diffuse lines being smaller than that of the sharp lines. The reference lines selected for calibration of the estimates of apparent intensity are all sharp lines.

The random error of the photometric procedure, including microphotometer error and irregularities of response of the "N" plates was determined from 92 measurements of apparent relative intensities in spectra of the standard lamp on two plates. The standard deviation of individual measurements from the mean was found to be about 1.5 percent. It is probable, therefore, that the uncertainties in these intensity measurements of the copper lines lie entirely in the systematic errors discussed above and in the random fluctuations of the arc under study.

Since the ribbon filament lamp was too faint in the region from 2000 to 3300 Å to serve as a standard, recourse was taken to a Hanovia hydrogen arc lamp. Output from this lamp was compared by R. Stair in the Radiometry Section of the Bureau with a standard tungsten-in-quartz lamp and a

standard mercury arc in the region from 2500 to 3800 Å; this provided an independent overlapping calibration which carried us down to 2500 Å.

The intensity numbers below 2500 Å become less accurate as the short wavelength limit is approached. Lacking any reliable energy calibration

for shorter waves, the intensity estimates from 2500 to 2000 Å were necessarily adjusted by judicious extrapolation, guided by the declining densities of background in the spectrograms, caused by the increasing absorption in the apparatus and in the air at shorter wavelengths.

### 3. Results

Because these relative intensities of 39,000 lines of 70 elements are based on empirical detectability they will be generally applicable to spectrochemical analysis provided that proper corrections are made on account of different excitation in different matrices. Chemical elements differ in volatility, electron emission, spectral excitation, and spectral background, and consequently their spectral detectability in different mixtures or matrices depends on certain controlling factors. One of the important factors is the atomic ionization potential which ranges from 3.9 *V* for Cs to 11.3 *V* for C, and for the investigated 70 elements has an average value of 7.3 *V*. By mixing these 70 elements with copper, which has an ionization potential of 7.7 *V*, we obtained excitation conditions very near the average for all. To convert our intensity numbers from copper to any other matrix would require the empirical determination of the proper conversion factor for each element.

It should be pointed out that sensitivity of detection in spectrochemical analysis is commonly given in percent by weight. In order to find the weight percent from the atomic percent given in the tables the following simple relation applies,

$$C_w = \frac{C_a A_x}{A_{Cu}}$$

where  $C_w$  is the concentration in percent by weight,  $C_a$  is the atomic percent (0.1 in this case),  $A_{Cu}$  is the atomic weight of copper, and  $A_x$  is the atomic weight of the element  $X$ .

Although our original intention was to determine the relative strengths of many spectral lines from different chemical elements for purposes of quantitative spectrochemical analysis we believe that the results may also interest theoretical spectroscopists and astrophysicists. For instance, if our intensity numbers, based on concentration detectability and relative energy calibration, actually express relative energies then all may be converted to oscillator strengths, or to relative *gf*-values, or even to absolute *f*-values, if the proper conversion factors can be found.

Because of the low concentration of each element in the copper arc from which the spectra were observed, the lines were extraordinarily free from

self absorption. This fact suggests that these emission intensities could be converted into relative *gf*-values, provided that a valid excitation temperature can be assigned to the copper arc.

The temperature of the copper arc can be determined by comparing the observed relative intensities of the lines of an element with the relative *gf*-values of those lines [23], provided that the arc can be shown to be in local thermodynamic equilibrium for the energy states under consideration. A preliminary investigation of this sort has been carried out by using relative *gf*-values determined by R. B. King and his coworkers for Ti I [24], Ti II [25], V I [26], Cr I [27], Fe I [28], [29] and Ni I [30] in the region above 3000 Å. Figure 4 is a typical example of the correlation of intensities and *gf*-values indicating the temperature of the copper arc. The comparison shows that our copper arc is sufficiently in equilibrium to yield a temperature which may be useful in calculating approximate *gf*-values of some utility from our intensity numbers. A preliminary value of 5000 K ± 300 K has been obtained as the average temperature of the 10 A, 220 V, copper arc.

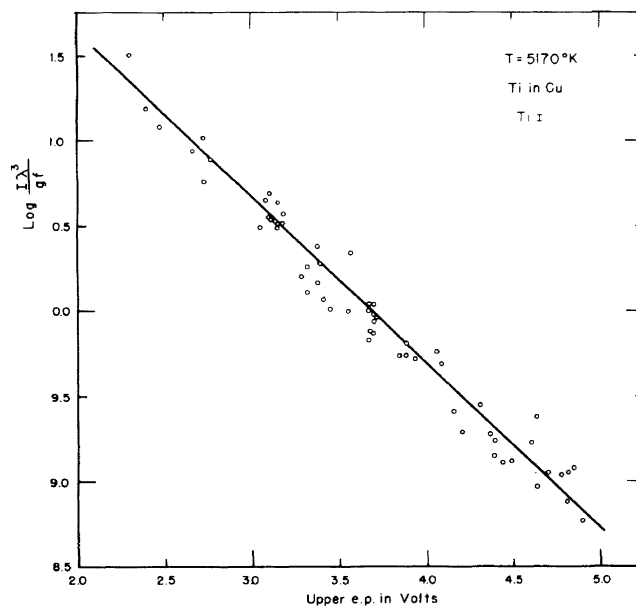


FIGURE 4. Plot of  $\log I\lambda^3$  over *gf* versus upper excitation potential of Ti I lines.

The temperature of the arc is derived from the slope of the line which best fits the points.



Because our intensity data represent single (some times two) personal subjective estimates of photographic densities in sectored spectrograms there is no possibility of deriving statistically any probable errors or standard deviations for individual values. However, an estimate of the accuracy or reliability of our data may be obtained by comparing them with quantitative results published by other investigators. For example, figure 4 shows the ratios of our intensities to the relative  $f$ -values (or intensities) reported by King and King [24] who measured the total absorptions of Ti I lines in furnace absorption spectra; they stated [28] that "The average deviations of the individual intensity measures from the mean values vary from 4 to 15 percent for different lines" measured between 4 and 16 times on different plates. Each little circle plotted in figure 4 represents a Ti I multiplet of 1 to 12 lines. The average of 59 deviations from the mean of all is 25 percent.

A second indication of the reliability of our intensities is obtained by comparing our values with the relative intensities of lines in multiplets of five elements (Cr, Fe, Mn, Ti, V) measured with photographic densitometry by Frerichs [31] to test the sum rules. Such a comparison in 21 different multiplets indicates deviations ranging from 5 to 22 percent, with an overall average of 14 percent.

A third estimate of the errors in our data results from their comparison with photoelectric intensity measurements in the iron arc by Crosswhite [32], who claims an accuracy of the order of 1 percent. The average difference between intensities of 330 iron lines (3175 to 5658 Å) common to these two sets of observations is  $\pm 27$  percent, but some of this difference may be due to temperature if this is not the same in both arcs.

Other comparisons could be made but the above three are different and typical; they suggest that the average error of our spectral-line intensities within a spectrum of each element is probably between 15 and 25 percent. The uniformity of the intensity scale between the spectra of the various elements is more difficult to assess. Considerable care was taken to obtain spectrograms under comparable conditions for all of the elements; however, differences in volatilities of the elements or their oxides, and differences in ease of excitation may possibly result in shifts of intensity scales between elements. An inspection of the intensities of the strongest lines of the elements indicates that the values are generally in the same order as sensitivity of detection of the elements where these are known. Although no high precision was expected in our mass-production of intensities it is emphasized that reasonably uniform, quantitative values are now available for 39 000 lines emitted by 70 chemical elements.

The tables of spectral-line intensities resulting from this investigation are presented in two parts.

In part I the data are arranged by element in alphabetical order of chemical name. The heading of each table by element states the atomic symbol, atomic number, atomic weight, ratio of atomic weight to that of copper, the electron configuration and term symbol of the normal state of each spectrum and the corresponding ionization potential expressed in  $\text{cm}^{-1}$ . Following the heading is a selected list of references. Under *Wavelengths* are listed all of the sources from which the wavelengths used in the table were compiled. Under *Classification* or *Spectrum Assignments* are listed the sources from which the assignment of spectrum and energy levels were obtained. A few spectra showed bands of metallic oxides. References to data about these bands are given under *Molecular Spectra*.

Following the references there is abstracted from the main table a list of the strong lines arranged in order of decreasing intensity. These lists of the strong lines generally contain 2 percent or more of the lines in the main table.

Electron configurations and spectral term designations of quantum numbers are of unusual interest in the production of the strongest spectral lines, or *raies ultimes*. According to well-known rules governing the relative intensities of lines in multiplets, the strongest line arises from transitions between levels having the largest  $J$  and  $L$  values when  $\Delta J = \Delta L = 1$ . A rule relating to *raies ultimes* was expressed [33] a quarter of a century ago as follows: "A *raie ultime* in any spectrum originates with a simple interchange of a single electron between  $s$  and  $p$  states, usually preferring configurations in which only one electron occurs in such states." The above simple rules for the strongest lines appear to be valid for all spectra.

Then comes the main table, listing in order of wavelength, for every line of an element which appears on our plates, the intensity, character, wavelength, spectrum, and energy levels. The calibrated intensity numbers in the first column represent the relative radiant power emitted by our arc at each wavelength. Lines which differ in profile from a normal sharp symmetrical shape are described in the second column, with the notation suggested in the Transactions of the Joint Commission for Spectroscopy [34] as follows:

- b – band head,
- c – complex,
- d – unresolved double line,
- h – hazy,
- l – shaded longward,
- s – shaded shortward,
- w – wide.

The wavelengths in column 3 are taken from the places noted in the list of references and are given

to the nearest 0.01 Å. They are all normal air wavelengths, even those below 2000 Å. Column 4 gives the spectrum, I, II, or III (respectively from neutral, singly ionized and doubly ionized atoms) in which the line occurs or the molecule from which a band head originates and column 5 the numerical values, rounded off to the nearest wavenumber, of the levels between which the transition occurs. These data are taken from the *Classification* reference.

The wavelength of a doubly classified line appears before the first pair of energy levels and the second pair follows immediately. In these tables all energy levels are given in vacuum wavenumber units,  $\text{cm}^{-1}$ , for which the name kayser ( $K$ ) has been proposed [35]. For all spectral lines explained as transitions between energy levels this serves as a mutual check since the wavelengths in normal air, when converted to vacuum wavenumbers by a conversion table [36], will coincide within one unit with the difference between the two energy levels. Furthermore these numbers serve as an index to the term designation in "Atomic Energy Levels" [37] where electron configurations, quantum numbers, and magnetic splitting factors are given.

A comparison of the excitation energies of any two classified lines may be made by directly comparing their energy levels in  $\text{cm}^{-1}$ . This direct and simple procedure avoids the labor of converting all energy levels from  $\text{cm}^{-1}$  to electron volts by means of the relation  $1 \text{ eV} = 8065 \text{ cm}^{-1}$ .

In part II the intensity data are arranged in two tables in order of increasing wavelengths. In table I the strong lines of each element which were ab-

stracted from the main tables in part I are here arranged in order of wavelength. Following this is table 2 in which the individual main tables of part I have been consolidated into a single table arranged by wavelength. This table contains about 39 000 lines of 70 elements. The intensities in the table are on a scale of relative radiant power and the scale is the same from element to element. Following the intensity numbers are given the wavelength, the element symbol, and the spectrum. The intensity of a double line appears before the first wavelength and the second wavelength follows immediately.

This investigation has extended over a period of 28 years, and represents a very considerable amount of intermittent labor contributed mainly by a relatively small number of individuals. The program was initiated by Meggers and Scribner; the latter prepared diluted-element mixtures, electrodes and spectrograms, while the former identified wavelengths, supplied many line classifications, and estimated relative intensities of some fifty thousand lines. In the production of the mixtures and the copper electrodes and spectrograms valuable assistance was given by Harriet E. Brown. Corliss contributed the copper calibration, the conversion of apparent intensities to relative radiant powers, and prepared the final tables. Mrs. Ruth Peterson carefully prepared and checked all the data on IBM cards so that it could be printed automatically. Valuable advice and assistance on the IBM machine operations was given by William Bozman. To all our able and reliable assistants the authors extend their sincere appreciation and thanks for cheerful and conscientious cooperation.

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WASHINGTON, D.C., January 1, 1961.





**Tables of Spectral-Line Intensities—Part I**  
**Arranged by Elements**



# Aluminum

Al,  $Z=13$ ,  $M=26.9815$ , Ratio  $\frac{\text{Al}}{\text{Cu}}=0.4246$

Al I Normal state of valence electrons  $3s^2 3p^2 P_{1/2}^{\circ}=0$ . I.P. = 48279  $\text{cm}^{-1}$ .

Al II Normal state of valence electrons  $3s^2 1S_0=0$ . I.P. = 151860  $\text{cm}^{-1}$ .

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K. B. S. Eriksson and H. B. S. Isberg, Arkiv for Fysik **23**, 527 (1962).

### Classification:

Al I, F. Paschen, Ann. Physik **12**, 516 (1932).

*Aluminum – all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
500 d	2269.10	I	112 - 44169	40	2575.40	I	112 - 38929
	2269.22	I	112 - 44166	150	2652.48	I	0 - 37689
460	2367.05	I	0 - 42234	200	2660.39	I	112 - 37689
850	2373.12	I	112 - 42238	3200	3082.15	I	0 - 32435
170	2373.35	I	112 - 42234	6500 d	3092.71	I	112 - 32437
40	2378.40	I	112 - 42144		3092.84	I	112 - 32435
240	2567.98	I	0 - 38929	4500	3944.01	I	0 - 25348
480	2575.10	I	112 - 38934	9000	3961.52	I	112 - 25348

# Antimony

$$\text{Sb, } Z = 51, M = 121.7, \text{ Ratio } \frac{\text{Sb}}{\text{Cu}} = 1.916$$

Sb I Normal state of valence electrons  $5s^25p^34S_{1/2}^0$ . I.P. = 69700  $\text{cm}^{-1}$ .

Sb II Normal state of valence electrons  $5s^25p^2\ ^3P_0$ . I.P. = 133328  $\text{cm}^{-1}$ .

## References

Wavelengths and classification:

Sb I, W. F. Meggers and C. J. Humphreys, J. Research NBS **28**, 463 (1942) RP 1464.

### *Antimony—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
3000	2029.49	I	16396 - 65653	18	2474.57	I	18464 - 58863
5000	2039.77	I	9854 - 58863	180	2478.32	I	16396 - 56733
13000	2049.57	I	8512 - 57287	35	2480.44	I	16396 - 56699
42000	2068.33	I	0 - 48332	30	2510.54	I	8512 - 48332
5000	2098.41	I	8512 - 56152	3200	2528.52	I	9854 - 49391
1000	2118.48	I	18464 - 65653	12	2554.64	I	18464 - 57597
1900	2127.39	I	0 - 46991	80	2574.06	I	16396 - 55233
3200	2139.69	I	8512 - 55233	6000	2598.05	I	8512 - 46991
1600	2141.83	I			2598.09	I	9854 - 48332
3200	2144.86	I	8512 - 55121	340	2612.31	I	18464 - 56733
8500	2175.81	I	0 - 45945	320	2652.60	I	18464 - 56152
1500	2179.19	I	9854 - 55728	380	2670.64	I	8512 - 45945
400	2201.32	I	16396 - 61809	140	2682.76	I	18464 - 55728
1000	2208.45	I	9854 - 55121	50	2692.25	I	16396 - 53528
650	2220.73	I	8512 - 53528	170	2718.90	I	18464 - 55233
320	2224.93	I	8512 - 53443	50	2727.23	I	18464 - 55121
550	2262.51	I	16396 - 60581	900	2769.95	I	9854 - 45945
120	2288.98	I	9854 - 53528	70	2851.11	I	18464 - 53528
380	2293.44	I	9854 - 53443	1400	2877.92	I	8512 - 43249
200	2306.46	I	16396 - 59738	500	3029.83	I	16396 - 49391
2200	2311.47	I	0 - 43249	1000	3232.52	I	18464 - 49391
50	2360.50	I	16396 - 58747	850	3267.51	I	16396 - 46991
100	2373.67	I	18464 - 60581	100	3383.15	I	16396 - 45945
80	2383.64	I	18464 - 60404	100	3637.83	I	18464 - 45945
60	2422.13	I	18464 - 59738	50	3722.79	I	16396 - 43249
80	2426.35	I	16396 - 57597	40	4033.55	I	18464 - 43249
190	2445.51	I	8512 - 49391				

## Arsenic

$$\text{As, } Z = 33, M = 74.9216, \text{ Ratio } \frac{\text{As}}{\text{Cu}} = 1.179$$

As I Normal state of valence electrons  $4s^2 4p^3 {}^4S_{1/2}^{\circ} = 0$ . I.P. = 79165  $\text{cm}^{-1}$ .

As II Normal state of valence electrons  $4s^2 4p^2 {}^3P_0 = 0$ . I.P. = 163000  $\text{cm}^{-1}$ .

### References

#### Wavelengths and Classification:

As I, W. F. Meggers, A. G. Shenstone, and C. E. Moore, J. Research NBS **45**, 346 (1950) RP 2144.

*Arsenic – all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
55000	1936.96	I	0 - 51610	400	2370.77	I	18648 - 60815
65000	1971.97	I	0 - 50694	400	2381.18	I	10915 - 52898
36000	1989.70	I	10592 - 60835	110	2437.23	I	10592 - 51610
11000	1990.48	I	10592 - 60815	360	2456.53	I	10915 - 51610
5000	1994.78	I	18186 - 68301	440	2492.91	I	10592 - 50694
44000	2003.34	I	10915 - 60815	440	2745.00	I	18186 - 54605
5500	2009.19	I	18648 - 68403	1400	2780.22	I	18648 - 54605
4200	2013.32	I	18648 - 68301	900	2860.44	I	18186 - 53136
480	2165.52	I	18648 - 64812	200	2898.71	I	18648 - 53136
2600	2288.12	I	10915 - 54605	30	2990.99	I	18186 - 51610
160	2344.03	I	18186 - 60835	80	3032.85	I	18648 - 51610
2600	2349.84	I	10592 - 53136	40	3119.60	I	18648 - 50694
500	2369.67	I	18648 - 60835				



## Barium

Ba,  $Z = 56$ ,  $M = 137.3$ , Ratio  $\frac{\text{Ba}}{\text{Cu}} = 2.161$

Ba I Normal state of valence electrons  $5p^6 6s^2 \ ^1S_0 = 0$ . I.P. =  $42035 \text{ cm}^{-1}$ .  
Ba II Normal state of valence electrons  $5p^6 6s \ ^2S_{1/2} = 0$ . I.P. =  $80687 \text{ cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

F. Sullivan and K. Burns, Sci. Studies St. Bonaventure Coll. **9**, 7 (1941).

H. N. Russell and C. E. Moore, J. Research NBS **55**, 299 (1955) RP 2633.

#### Classification:

Ba I. H. N. Russell and C. E. Moore, J. Research NBS **55**, 299 (1955) RP 2633.

Ba II. A. Fowler, Report on Series in Line Spectra (Fleetway Press, London, 1922).

Barium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1400	2304.24	II	4874 - 48259	6500	5535.48	I	0 - 18060
2000	2335.27	II	5675 - 48484	20	5680.18	I	9216 - 26816
190	2347.58	II	5675 - 48259	500	5777.62	I	13515 - 30818
60	2528.51	II	20262 - 59799	90	5800.23	I	13515 - 30751
100	2634.78	II	21952 - 59895	70	5805.68	I	9597 - 26816
30	2702.63	I	0 - 36990	300	5826.28	I	11395 - 28554
18	2771.36	II	21952 - 58025	2800	5853.68	II	4874 - 21952
180	3071.58	I	0 - 32547	50	5907.64	I	9034 - 25957
500	3501.11	I	0 - 28554	500	5971.70	I	9216 - 25957
70	3889.33	I	0 - 25704	500	5997.09	I	9034 - 25704
1400	3891.78	II	20262 - 45949	500	6019.47	I	9034 - 25642
30	3892.66	I	11395 - 37077	1100	6063.12	I	9216 - 25704
100	3909.91	I	9034 - 34603	1700	6110.78	I	9597 - 25957
140	3935.72	I	9216 - 34617	20000	6141.72	II	5675 - 21952
35	3937.87	I	9216 - 34603	500	6341.68	I	9216 - 24980
180	3993.40	I	9597 - 34631	360	6450.85	I	9034 - 24532
30	3995.66	I	9597 - 34617	600	6482.91	I	11395 - 26816
1500	4130.66	II	21952 - 46155	12000	6496.90	II	4874 - 20262
60	4132.43	I	0 - 24192	1600	6498.76	I	9597 - 24980
200	4166.00	II	21952 - 45949	700	6527.31	I	9216 - 24532
200	4283.10	I	11395 - 34736	650	6595.32	I	9034 - 24192
70	4350.33	I	12637 - 35617	320	6675.27	I	9216 - 24192
100	4402.54	I	12637 - 35344	320	6693.84	I	9597 - 24532
150	4431.89	I	12266 - 34823	16	6771.85	I	23074 - 37837
30	4488.97	I	13515 - 35785	60	6865.69	I	11395 - 25957
35	4493.64	I	13515 - 35762	12	6867.85	I	22947 - 37504
130	4505.92	I	12637 - 34823	1400	7059.94	I	9597 - 23757
50	4523.24	I	13515 - 35617	190	7120.33	I	9034 - 23074
130	4524.93	II	20262 - 42355	6	7153.58	I	23757 - 37732
65000	4554.03	II	0 - 21952	60	7195.24	I	12266 - 26160
80	4573.85	I	12637 - 34494	20	7228.84	I	22065 - 35894
140	4579.64	I	13515 - 35344	950	7280.30	I	9216 - 22947
40	4599.75	I	12637 - 34371	110	7392.41	I	12637 - 26160
20	4619.98	I	12266 - 33905	20	7417.53	I	9597 - 23074
30	4673.62	I	9597 - 30987	30	7459.78	hl	22947 - 36349
130	4691.62	I	13515 - 34823	170	7488.08	I	9597 - 22947
30	4700.43	I	12637 - 33905	20	7610.48	I	23062 - 36200
80	4726.45	I	11395 - 32547	10	7636.90	hl	23074 - 36165
100	4899.97	II	21952 - 42355	40	7642.91	hl	23757 - 36837
18	4902.90	I	13515 - 33905	500	7672.09	I	9034 - 22065
20000	4934.09	II	0 - 20262	300	7780.48	I	9216 - 22065
30	4947.33	I	18060 - 38267	8	7839.57	h	24980 - 37732
20	5054.98	I	18060 - 37837	170	7905.75	I	13515 - 26160
60	5159.92	I	18060 - 37435	80	7911.34	I	0 - 12637
20	5267.03	I	18060 - 37041	60	8210.24	h	18060 - 30237
220	5424.55	I	12266 - 30696	400	8559.95	h	11395 - 23074
14	5473.69	I		30	8860.98	I	12637 - 23919
320	5519.05	I	12637 - 30751	35	8914.99	I	12266 - 23480

# Beryllium

$$\text{Be, } Z = 4, M = 9.01218, \text{ Ratio } \frac{\text{Be}}{\text{Cu}} = 0.1418$$

Be I Normal state of valence electrons  $2s^2^1S_0 = 0$ . I.P. = 75192  $\text{cm}^{-1}$ .

Be II Normal state of valence electrons  $2s^2S_{1/2} = 0$ . I.P. = 146882  $\text{cm}^{-1}$ .

## References

Wavelengths and Classification:

Be I, L. Johansson, Arkiv for Fysik **23**, 119 (1962).

Be II, F. Paschen and P. G. Kruger, Ann. Physik **8**, 1005 (1931).

Molecular Spectra:

BeO, A. Lagerqvist and R. Westoo, Arkiv Mat. Astron. Fysik **32A**, No. 10 (1945).

*Beryllium – all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
1100 h	2174.99	I	21979 – 67942	4800	3130.42	II	0 – 31935
	2175.10	I	21981 – 67942	3200	3131.07	II	0 – 31929
9500	2348.61	I	0 – 42565	600	3321.01	I	21978 – 52081
700	2494.54	I	21978 – 62054	1000	3321.08	I	21979 – 52081
	2494.58	I	21979 – 62054	1000	3321.34	I	21981 – 52081
1000	2494.73	I	21981 – 62054	120	4572.66	I	42565 – 64428
	2650.45	I	21979 – 59697	70 bl	4708.60	Be O	42565 – 54677
1400 c	2650.55	I	21978 – 59695	40 h	8254.10	I	42565 – 54677
	2650.61	I	21979 – 59695				
	2650.62	I	21981 – 59697				
	2650.69	I	21979 – 59694				
	2650.76	I	21981 – 59695				

# Bismuth

$$\text{Bi, } Z = 83, M = 208.9806, \text{ Ratio } \frac{\text{Bi}}{\text{Cu}} = 3.289$$

Bi I Normal state of valence electrons  $6s^2 6p^3 \ ^4S_{1/2}^{\circ} = 0$ . I.P. = 58790  $\text{cm}^{-1}$ .

Bi II Normal state of valence electrons  $6s^2 6p^2 \ ^3P_0 = 0$ . I.P. = 134600  $\text{cm}^{-1}$ .

## References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939), above 2000 Å.

G. R. Toshniwal, Phil. Mag. **4**, 774 (1927), below 2000 Å.

Classification:

Bi I, S. Mrozowski, Phys. Rev. **62**, 526 (1942).

*Bismuth—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
48000	1953.89	I	0 - 51158	4000	2897.98	I	11418 - 45915
9000	1959.48	I	0 - 51019	3200	2938.30	I	15437 - 49461
10000	2021.21	I	0 - 49461	2800	2989.03	I	11418 - 44865
44000	2061.70	I	0 - 48489	700	2993.34	I	11418 - 44817
4600	2110.26	I	0 - 47371	2400	3024.64	I	15437 - 48489
2500	2133.63	I	11418 - 58272	60	3034.87	I	
360	2228.25	I	0 - 44865	36000 c	3067.72	I	0 - 32588
1700	2230.61	I	0 - 44817	140	3076.66	I	11418 - 43912
340	2276.58	I	0 - 43912	550 c	3397.21	I	15437 - 44865
190	2400.88	I	15437 - 57075	500 c	3510.85	I	15437 - 43912
25	2515.69	I	11418 - 51158	380 c	3596.11	I	21660 - 49461
70	2524.49	I	11418 - 51019	140	4121.53	I	21660 - 45915
700	2627.91	I	11418 - 49461	140	4121.86	I	
280 c	2696.76	I	11418 - 48489	600 c	4722.19	I	11418 - 32588
140 d	2730.50	I	21660 - 58272		4722.55	I	
360	2780.52	I	11418 - 47371		4722.83	I	
140 c	2809.62	I	15437 - 51019	10 c	5552.35	I	

## Boron

$$B, Z = 5, M = 10.81, \text{Ratio } \frac{B}{Cu} = 0.1701$$

B I Normal state of valence electrons  $2s^2 2p^2 P_{1/2}^o = 0$ . I.P. = 66928  $\text{cm}^{-1}$ .

B II Normal state of valence electrons  $2s^2 \ ^1S_0 = 0$ . I.P. = 202895  $\text{cm}^{-1}$ .

### References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Classification:

B I, H. E. Clearman, J. Opt. Soc. Am. **42**, 373 (1952).

*Boron—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
4200	2088.93	I	0 - 47857	2400	2496.78	I	0 - 40040
6500	2089.59	I	16 - 47857	4800	2497.73	I	16 - 40040

# Cadmium

$$\text{Cd, } Z = 48, M = 112.40, \text{ Ratio } \frac{\text{Cd}}{\text{Cu}} = 1.769$$

Cd I Normal state of valence electrons  $4d^{10}5s^2^1S_0 = 0$ . I.P. = 72539  $\text{cm}^{-1}$ .

Cd II Normal state of valence electrons  $4d^{10}5s^2^1S_{1/2} = 0$ . I.P. = 136375  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology, Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

Cd I, A. Fowler, Report on Series in Line Spectra (Fleetway Press, London, 1922).

Cd II, A. G. Shenstone and J. T. Pittenger, J. Opt. Soc. Am. **39**, 219 (1949).

*Cadmium – all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character.	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
19000	2144.38	II	0 - 46619	50	3133.17	I	30656 - 62563
9000	2265.02	II	0 - 44136	320	3261.06	I	0 - 30656
150	2267.47	I	30656 - 74745	800	3403.65	I	30114 - 59486
15000	2288.02	I	0 - 43692	2500	3466.20	I	30656 - 59498
400	2306.61	I	30656 - 73996	800	3467.66	I	30656 - 59486
190	2312.84	II	46619 - 89844	3600	3610.51	I	31827 - 59516
300 h	2329.28	I	31827 - 74745	700	3612.88	I	31827 - 59498
50	2572.93	II	44136 - 82991	70	3614.45	I	31827 - 59486
50 h	2836.91	I	30114 - 65354	800	4678.16	I	30114 - 51484
80 h	2880.77	I	30656 - 65359	1400	4799.92	I	30656 - 51484
20	2881.23	I	30656 - 65354	2800	5085.82	I	31827 - 51484
160 h	2980.63	I	31827 - 65367	260 h	6438.47	I	43692 - 59220



# Calcium

Ca,  $Z = 20$ ,  $M = 40.08$ , Ratio  $\frac{Ca}{Cu} = 0.6307$

Ca I Normal state of valence electrons  $4s^2\ ^1S_0 = 0$ . I.P. = 49305  $\text{cm}^{-1}$ .

Ca II Normal state of valence electrons  $4s\ ^2S_{1/2} = 0$ . I.P. = 95752  $\text{cm}^{-1}$ .

## References

Wavelengths and Classification:

Ca I, G. Risberg, Arkiv for Fysik **37**, 231 (1967).

Ca II, B. Edlen and P. Risberg, Arkiv for Fysik **10**, 553 (1956).

*Calcium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	
70	2398.56	I	0 - 41679	60	h	5041.62	I	21850 - 41679
30	2721.64	I	0 - 36732	100	h	5188.85	I	23652 - 42919
35	2994.96	I	15158 - 48538	110		5261.71	I	20335 - 39335
20	2997.31	I	15210 - 48564	130		5262.24	I	20335 - 39333
20	2999.64	I	15210 - 48538	110		5264.24	I	20349 - 39340
				280		5265.56	I	20349 - 39335
20	3000.86	I	15210 - 48524					
70	3006.86	I	15316 - 48564	480		5270.27	I	20371 - 39340
30	3009.20	I	15316 - 48538	160		5349.47	I	21850 - 40538
200	3158.87	II	25192 - 56839	25	h	5512.98	I	23652 - 41786
500	3179.33	II	25414 - 56858	120		5581.97	I	20349 - 38259
				700		5588.76	I	20371 - 38259
90	3181.28	II	25414 - 56839					
50	3624.11	I	15158 - 42743	100		5590.12	I	20335 - 38219
100	3630.75	I	15210 - 42745	360		5594.47	I	20349 - 38219
100	3644.41	I	15316 - 42747	240		5598.49	I	20335 - 38192
120	3706.03	II	25192 - 52167	120		5601.28	I	20371 - 38219
				120		5602.85	I	20349 - 38192
150	3736.90	II	25414 - 52167					
42000	3933.66	II	0 - 25414	220		5857.45	I	23652 - 40720
12	3948.90	I	15158 - 40474	340		6102.72	I	15158 - 31540
35	3957.05	I	15210 - 40474	950		6122.22	I	15210 - 31540
22000	3968.47	II	0 - 25192	30		6161.29	I	20349 - 36575
				1400		6162.17	I	15316 - 31540
140	3973.71	I	15316 - 40474					
11000	4226.73	I	0 - 23652	30	h	6163.76	I	20335 - 36555
240	4283.01	I	15210 - 38552	60	h	6166.44	I	20335 - 36548
220	4289.36	I	15158 - 38465	70		6169.05	I	20349 - 36555
200	4298.99	I	15210 - 38465	140	h	6169.56	I	20371 - 36575
				700		6439.07	I	20371 - 35897
1100	4302.53	I	15316 - 38552					
260	4307.74	I	15210 - 38418	180		6449.81	I	20335 - 35835
400	4318.65	I	15316 - 38465	35		6455.60	I	20349 - 35835
300	4425.44	I	15158 - 37748	700		6462.57	I	20349 - 35819
650	4434.96	I	15210 - 37752	80		6471.66	I	20371 - 35819
				320		6493.78	I	20335 - 35730
180	4435.69	I	15210 - 37748					
1400	4454.78	I	15316 - 37757	80		6499.65	I	20349 - 35730
180	4455.89	I	15316 - 37752	20		6572.78	I	0 - 15210
10	4456.61	I	15316 - 37748	40	h	6717.68	I	21850 - 36732
16	h	I	21850 - 43933	190		7148.15	I	21850 - 35835
				90		7202.19	I	21850 - 35730
25	4578.55	I	20335 - 42170					
50	4581.40	I	20349 - 42171	60	h	7326.15	I	23652 - 37298
80	4585.86	I	20371 - 42171	120		8498.02	II	13650 - 25414
50	h	I	21850 - 42344	1000		8542.09	II	13711 - 25414
				550		8662.14	II	13650 - 25192

## Carbon

$$C, Z = 6, M = 12.011, \text{Ratio } \frac{C}{C_u} = 0.1890$$

C I Normal state of valence electrons  $2s^2 2p^2 \ ^3P_0 = 0$ . I.P. = 90820  $\text{cm}^{-1}$ .  
C II Normal state of valence electrons  $2s^2 2p^2 \ ^1P_{1/2}^o = 0$ . I.P. = 196659  $\text{cm}^{-1}$ .

### References

#### Wavelength:

L. Johansson, Arkiv for Fysik **31**, 201 (1966).

#### Classification:

C I, A. Fowler and E. H. Selwyn, Proc. Roy. Soc. (London) [A] **118**, 34 (1928).

#### *Observed line of carbon*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
100	2478.56	I	21648 - 61982

## Cerium

$$\text{Ce, } Z = 58, M = 140.12, \text{ Ratio } \frac{\text{Ce}}{\text{Cu}} = 2.205$$

Ce I Normal state of valence electrons  $4f5d6s^2 \ ^1G_4^o = 0$ . I.P. = 44100  $\text{cm}^{-1}$ .  
 Ce II Normal state of valence electrons  $4f5d^2 \ ^4H_{3/2}^o = 0$ . I.P. = 87500  $\text{cm}^{-1}$ .

### References

**Wavelengths:**

W. C. Martin and C. H. Corliss, unpublished material (1969).

**Classification:**

Ce I, W. C. Martin, unpublished material (1969).

Ce II, C. H. Corliss, J. Res. Nat. Bur. Stand. (U.S.), **77A**, (Phys. and Chem.), No. 4, 419–546 (July–Aug. 1973).

**Molecular Spectra:**

CeO, W. W. Watson, Phys. Rev. **53**, 639 (1938).

### *Strong lines of cerium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
3500	4186.60	II	6968 - 30847	1100	4248.68	II	5514 - 29044
3100	3952.54	II	2642 - 27935	1100	4572.28	II	5514 - 27379
2800	3999.24	II	2382 - 27380	1000	3577.45	II	3794 - 31738
2700	3942.75	II	6913 - 32269	1000	3709.29	II	4204 - 31156
2700	4012.39	II	4523 - 29439	1000	3709.93	II	988 - 27935
2700	4133.80	II	6968 - 31152	1000	3808.11	II	2382 - 28634
2500	3801.52	II	7234 - 33531	1000	3889.98	II	5456 - 31156
2400	4460.21	II	3854 - 26268	990	3201.71	II	6913 - 38138
2100	4040.76	II	3594 - 28335	990	3272.25	II	5651 - 36202
2100	4562.36	II	3854 - 25766	980	3912.44	II	2382 - 27935
2000	3942.15	II	0 - 25360	980	3956.28	II	4911 - 30180
2000	4137.65	II	4166 - 28327	980	4123.87	II	6913 - 31156
2000	4289.94	II	2642 - 25945	980	4127.37	II	5514 - 29735
1800	3655.85	II	2563 - 29909	980	4149.94	II	5819 - 29909
1800	4073.48	II	3854 - 28396	980	4239.92	II	3854 - 27433
1700	4391.66	II	2596 - 25360	980	4337.77	II	2635 - 25682
1700	4628.16	II	4166 - 25766	980	4418.78	II	6968 - 29592
1500	3882.45	II	2596 - 28345	910	3993.82	II	7341 - 32373
1500	4075.71	II	5651 - 30180	910	4003.77	II	7523 - 32492
1500	4075.85	II	4911 - 29439	910	4014.90	II	4266 - 29167
1500	4222.60	II	988 - 24663	910	4042.58	II	3996 - 28725
1500	4296.67	II	4166 - 27433	910	4083.23	II	5651 - 30135
1400	3716.37	II	0 - 26900	910	4202.94	II	3594 - 27380
1400	4151.97	II	5514 - 29592	910	4364.66	II	3996 - 26900
1400	4471.24	II	5617 - 27976	910	4382.17	II	5514 - 28327
1300	4165.61	II	7341 - 31340	880	3221.17	II	4523 - 35559
1200	3560.80	II	5456 - 33531	880	3660.64	II	988 - 28298
1200	3854.18	II	1874 - 27812	880	3667.98	II	2880 - 30135
1200	3854.31	II	1874 - 27811	860	3786.63	II	1410 - 27811
1100	3838.54	II	2642 - 28686	860	3848.59	II	4204 - 30180
1100	3878.36	II	1410 - 27187	860	3853.15	II	0 - 25945
1100	4071.81	II	2635 - 27187				

Cerium — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	2461.48	II		35	2810.18	II	2563 - 38138
130	2462.97	II	9779 - 50368	30	2811.87	II	2581 - 38134
55	2464.36	II		85	2814.81	II	4323 - 39839
45	2473.39	II	7011 - 47430	60	2814.96	II	7059 - 42573
45	2486.37	II	7259 - 47466	60	2817.50	II	5716 - 41198
55	2498.98	II		270	2830.90	II	7259 - 42573
85	2513.30	II	7713 - 47489	100	2833.31	II	
110	2518.51	II		45	2835.60	II	5943 - 41198
45	2519.02	II	988 - 40674	17	2837.89	II	6521 - 41748
85	2543.09	II	9778 - 49089	12	2837.99	II	0 - 35226
200	2548.68	II	11341 - 50564	35	2839.36	II	2596 - 37804
28	2551.77	II	11387 - 50564	22	2841.72	II	8281 - 43461
35	2562.42	II	9316 - 48330	30	2842.52	II	2635 - 37804
55	2569.17	II	12260 - 51171	22	2842.83	II	
35	2569.88	II		35	2845.45	II	11455 - 46588
70	2573.14	II	9779 - 48630	45	2849.03	II	3363 - 38453
28	2592.34	II	2635 - 41198	85	2854.67	II	1874 - 36894
70	2609.50	II	8278 - 46588	85	2854.88	II	2635 - 37652
28	2609.90	II	12260 - 50564	45	2855.32	II	16159 - 51171
70	2613.90	II	9779 - 48025	45	2855.45	II	2642 - 37652
85	2635.15	II	7011 - 44949	45	2855.72	II	2581 - 37588
35	2647.11	II	9723 - 47489	75	2858.01	II	16192 - 51171
28	2648.30	II	11340 - 49089	35	2859.52	II	9634 - 44595
35	2649.33	II	9725 - 47459	22	2861.35	II	988 - 35926
340	2651.01	II	9779 - 47489	45	2861.62	II	2596 - 37531
35	2656.84	II	10703 - 48330	50	2862.79	II	0 - 34921
75	2666.50	II	3594 - 41085	35	2866.81	II	4523 - 39395
50	2673.07	II	1410 - 38810	45	2871.08	II	988 - 35808
60	2682.73	II	3594 - 40858	25	2871.63	II	0 - 34813
30	2687.99	II	10274 - 47466	250	2874.14	II	
30	2691.69	II	11949 - 49089	75	2880.64	II	5969 - 40674
60	2695.96	II	4911 - 41992	35	2881.13	II	7294 - 41992
120	2696.07	II	1874 - 38954	75	2882.61	II	6518 - 41198
120	2706.88	II	4266 - 41198	50	2885.29	II	6550 - 41198
35	2708.13	II	5119 - 42034	45	2888.70	II	14481 - 49089
35	2709.41	II	5676 - 42573	35	2890.17	II	9491 - 44081
75	2715.17	II	2581 - 39400	17	2892.03	II	6518 - 41085
35	2715.24	II		17	2892.15	II	4266 - 38833
35	2717.28	II	11760 - 48550	50	2894.09	II	4266 - 38810
35	2719.98	II	5819 - 42573	60	2894.22	II	2382 - 36924
120	2723.38	II	11949 - 48657	85	2896.73	II	2382 - 36894
35	2724.95	II	2635 - 39322	110	2908.42	II	4460 - 38833
30	2729.16	II	5943 - 42573	30	2912.91	II	10275 - 44595
10	2730.70	II	10820 - 47430	30	2915.56	II	3363 - 37652
15	2730.80	II	5965 - 42573	45	2916.68	II	4266 - 38542
30	2732.04	II	4266 - 40858	100	2918.67	II	2642 - 36894
50	2732.17	II	13028 - 49618	25	2918.78	II	4202 - 38453
60	2732.83	II	7062 - 43643	35	2922.37	II	16159 - 50368
35	2736.33	II	5924 - 42459	25	2922.58	II	4323 - 38529
110	2741.96	II		75	2925.19	II	16192 - 50368
75	2745.72	II	11742 - 48151	30	2929.11	II	4323 - 38453
100	2750.89	II	5651 - 41992	25	2934.35	II	4460 - 38529
35	2756.80	II	7818 - 44081	35	2939.54	II	9634 - 43643
150	2761.42	II	0 - 36202	45	2940.79	II	3594 - 37588
85	2762.22	II	8403 - 44595	60	2944.35	II	10642 - 44595
35	2762.90	II	6390 - 42573	50	2950.30	II	3704 - 37589
35	2767.01	II	2141 - 38270	45	2955.60	II	7259 - 41083
50	2780.01	II	2581 - 38542	120	2955.94	II	2382 - 36202
35	2781.89	II	988 - 36924	30	2956.71	II	0 - 33812
35	2781.99	II	6638 - 42573	50	2959.11	II	13675 - 47459
120	2784.27	II	8176 - 44081	110	2964.80	II	5676 - 39395
100	2785.35	II	12260 - 48151	85	2965.27	II	5119 - 38833
100	2790.53	II	7818 - 43643	45	2970.32	II	3996 - 37652
140	2791.42	II	9316 - 45130	100	2972.58	II	4911 - 38542
45	2803.04	II	5924 - 41589	50	2974.48	II	5283 - 38893

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	2974.61	II	4845 - 38453	60	3091.29	II	2581 - 34921
400	2976.91	II	4266 - 37849	45	3095.59	II	5675 - 37971
150	2977.46	II	5819 - 39395	170	3096.50	II	4911 - 37196
120	2980.41	II	14482 - 48025	60	3096.88	II	1874 - 34155
85	2981.91	II	4323 - 37849	35	3097.08	II	2642 - 34921
50	2984.56	II	2642 - 36138	45	3102.56	II	3704 - 35926
60	2985.82	II	4323 - 37804	370	3103.38	II	3594 - 35808
35	2985.91	II	3363 - 36844	85	3104.01	II	3996 - 36202
25	2986.67	II	1874 - 35346	200	3107.47	II	6638 - 38810
250	2990.87	II	2382 - 35808	100	3108.96	II	8928 - 41083
35	2991.72	II	15134 - 48550	320	3110.28	II	3996 - 36138
25	2991.90	II	4202 - 37616	300	3111.17	II	2635 - 34768
110	2994.42	II	4266 - 37652	45	3114.05	II	1874 - 33977
320	2995.64	II	5437 - 38810	45	3123.57	II	4511 - 36517
50	2998.77	II	4511 - 37849	220	3127.53	II	3594 - 35559
22	2999.43	II	3594 - 36924	200	3130.33	II	4266 - 36202
22	2999.48	II	4323 - 37652	240	3130.87	II	0 - 31931
75	3000.07	II	2880 - 36202	140	3132.59	II	2382 - 34295
160	3002.14	II	3594 - 36894	160	3133.33	II	5943 - 37849
190	3002.75	II	4511 - 37804	160	3136.72	II	4266 - 36138
120	3003.56	II	2642 - 35926	100	3137.60	II	3363 - 35226
85	3008.13	II	6638 - 39872	45	3138.30	II	3704 - 35559
400	3008.79	II	2581 - 35808	100	3142.31	II	988 - 32802
50	3011.88	II	4460 - 37652	200	3144.60	II	2635 - 34426
370	3017.20	II	5676 - 38810	290	3145.28	II	2642 - 34426
75	3020.88	II	5716 - 38810	45	3146.23	II	5119 - 36894
50	3021.04	II	5437 - 38529	290	3146.41	II	2382 - 34155
30	3022.79	II	16545 - 49617	100	3148.46	II	3594 - 35346
25	3023.43	II	4523 - 37588	65	3148.65	II	7059 - 38810
35	3023.49	II	8928 - 41992	45	3149.43	II	4460 - 36202
35	3024.57	II	10115 - 43168	75	3151.13	II	5119 - 36844
35	3026.62	II	4202 - 37232	130	3154.51	II	2642 - 34333
25	3027.63	II	4323 - 37342	160	3155.69	II	4523 - 36202
60	3028.96	II	6390 - 39395	160	3155.79	II	1874 - 33553
170	3030.31	II	5819 - 38810	290	3164.15	II	2382 - 33977
35	3032.73	II	2382 - 35346	140	3166.24	II	2581 - 34155
75	3033.12	II	4845 - 37804	100	3166.61	II	2596 - 34166
210	3037.73	II	4323 - 37232	45	3167.23	II	9634 - 41198
45	3039.51	II	5651 - 38542	45	3167.32	II	3996 - 35559
45	3044.40	II	5011 - 37849	290	3169.18	II	5651 - 37196
60	3046.71	II	5716 - 38529	290	3171.61	II	2635 - 34155
35	3050.59	II	4845 - 37616	45	3172.30	II	2642 - 34155
200	3051.98	II	4323 - 37079	130	3176.80	II	8403 - 39872
350	3055.24	II	4511 - 37232	45	3177.14	II	4460 - 35926
320	3056.78	II	2642 - 35346	45	3178.75	II	3363 - 34813
45	3058.55	II	5119 - 37804	45	3180.82	II	2382 - 33812
25	3059.74	II	4523 - 37196	480	3183.52	II	4523 - 35926
680	3063.01	II	7234 - 39872	75	3184.21	II	2581 - 33977
60	3068.68	II	4266 - 36844	240	3186.13	II	5819 - 37196
85	3069.64	II	4511 - 37079	180	3188.79	II	3996 - 35346
75	3071.11	II	1874 - 34426	100	3189.64	II	2635 - 33977
85	3071.62	II	2382 - 34929	200	3190.34	II	2642 - 33977
50	3072.39	II	2382 - 34921	45	3193.33	II	9779 - 41085
100	3072.89	II	5119 - 37652	710	3194.83	II	4911 - 36202
45	3076.25	II	4845 - 37342	45	3195.94	II	2596 - 33876
60	3077.33	II	5651 - 38138	200	3199.28	II	5676 - 36924
50	3077.64	II	5651 - 38134	45	d 3200.52	II	4323 - 35559
100	3079.64	II	5676 - 38138	990	3201.71	II	6913 - 38138
85	3079.91	II	1874 - 34333	100	3205.96	II	7012 - 38195
75	3080.64	II	15593 - 48045	100	3210.95	II	6518 - 37652
100	3082.30	II	3704 - 36138	200	3218.38	II	3363 - 34426
320	3083.67	II	6390 - 38810	710	3218.94	II	6913 - 37971
250	3084.44	II	5437 - 37849	100	3220.87	II	6550 - 37589
200	3090.37	II	7523 - 39872	880	3221.17	II	4523 - 35559
75	3090.52	II	2581 - 34929	45	3222.41	II	4202 - 35226

Cerium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	3223.37	II	7818 - 38833	45	3325.06	II	3594 - 33660
330	3225.67	II	8403 - 39395	180	3325.34	II	8131 - 38195
710	3227.11	II	2596 - 33574	45	3327.66	II	2596 - 32638
100	3229.12	II	4266 - 35226	65	3327.91	II	5676 - 35716
240	3229.36	II	2596 - 33553	140	3329.01	II	4737 - 34768
45	3230.08	II	988 - 31938	75	3330.49	II	7062 - 37079
480	3231.24	II	3996 - 34934	45	3331.23	II	4323 - 34333
140	3233.44	II	2635 - 33553	100	3333.04	II	0 - 29994
710	3234.16	II	2642 - 33553	100	3333.66	II	5819 - 35808
330	3234.89	II	7234 - 38138	200	3334.46	II	10058 - 40040
45	3235.01	II	4323 - 35226	100	3339.51	II	2382 - 32318
75	3235.67	II	4911 - 35808	75	h 3340.89	II	5011 - 34934
390	3236.74	II	4460 - 35346	240	3341.87	II	4511 - 34426
390	3243.37	II	4523 - 35346	330	3343.86	II	5819 - 35716
100	3245.17	II	4460 - 35266	440	3344.76	II	4266 - 34155
200	3246.67	II	3363 - 34155	100	3346.52	II	4460 - 34333
100	3249.19	II	2642 - 33410	100	3349.96	II	5716 - 35559
45	3249.43	II	4460 - 35226	45	3349.98	II	7746 - 37589
140	3252.48	II	7234 - 37971	100	3352.28	II	4511 - 34333
140	3254.01	II	3704 - 34426	100	3352.94	II	3594 - 33410
100	3258.87	II	7294 - 37971	65	3352.99	II	5119 - 34934
200	3260.98	II	8176 - 38833	75	3353.33	II	6390 - 36202
140	3263.45	II	8176 - 38810	200	3355.02	II	1410 - 31208
200	3263.88	II	3704 - 34333	180	3356.41	II	3363 - 33149
45	3265.42	II	7523 - 38138	240	3357.22	II	4266 - 34044
100	3271.15	II	3594 - 34155	200	3360.54	II	11310 - 41059
100	3271.55	II	6638 - 37196	180	3361.77	II	3794 - 33531
16	3271.96	II	7062 - 37616	100	3364.35	II	988 - 30703
27	3272.06	II	2596 - 33149	240	3366.55	II	4460 - 34155
990	3272.25	II	5651 - 36202	55	3368.70	II	2642 - 32318
330	3274.86	II	5676 - 36202	45	3368.80	II	13785 - 43461
140	3276.25	II	2635 - 33149	200	3371.18	II	4511 - 34166
140	3279.01	II	5437 - 35926	200	3373.46	II	2563 - 32198
200	3279.84	II	2382 - 32863	200	3373.73	II	4523 - 34155
75	3280.49	II	4460 - 34934	75	3375.78	II	8928 - 38542
45	3281.10	II	7062 - 37531	480	3377.13	II	4911 - 34514
100	3283.35	II	7523 - 37971	140	3379.17	II	4460 - 34044
65	3283.68	II	2635 - 33080	100	3381.49	II	6638 - 36202
45	3284.22	II	5119 - 35559	200	3383.68	II	4266 - 33811
330	3285.22	II	3996 - 34426	75	3387.78	II	5716 - 35226
100	3286.03	II	4511 - 34934	100	3390.52	II	3594 - 33080
100	3290.33	II	3594 - 33977	100	3393.92	II	4204 - 33660
45	3290.58	II	4845 - 35226	65	3394.14	II	4523 - 33977
45	3293.59	II	4460 - 34813	40	3396.72	II	3746 - 33177
240	3295.28	II	3996 - 34333	45	3400.25	II	7523 - 36924
140	3296.18	II	7259 - 37588	75	3403.60	II	4202 - 33574
200	3296.88	II	6521 - 36844	40	3404.13	II	2563 - 31931
100	3299.99	II	6550 - 36844	200	3404.91	II	1874 - 31235
220	3300.15	II	5819 - 36112	240	3405.98	II	4460 - 33812
240	3304.84	II	5676 - 35926	45	3407.25	II	
140	3306.63	II	5969 - 36202	90	3416.57	II	5965 - 35226
140	3307.23	II	2635 - 32863	140	3416.86	II	988 - 30246
55	3307.99	II	2642 - 32863	290	3417.45	II	5676 - 34929
150	3308.02	II	2581 - 32802	75	3417.90	II	8403 - 37652
45	3308.08	II	988 - 31208	100	3418.93	II	12751 - 41992
100	3309.27	II	5716 - 35926	140	3420.18	II	4323 - 33553
140	3311.50	II	3363 - 33553	45	3422.49	II	8928 - 38138
200	3312.22	II	8897 - 39079	45	3422.53	II	2642 - 31851
65	3313.30	II	5965 - 36138	600	3422.71	II	3594 - 32802
100	3314.03	II	0 - 30166	110	3423.85	II	9634 - 38833
240	3314.72	II	3996 - 34155	75	3425.35	II	2382 - 31568
200	3317.80	II	5676 - 35808	65	3425.95	II	7713 - 36894
75	3318.96	II	5437 - 35559	390	3426.21	II	988 - 30166
55	3318.98	II	2596 - 32717	75	3426.59	II	2563 - 31738
45	3320.42	II	3704 - 33812	130	3430.32	II	7059 - 36202

Cerium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	3431.50	II	4911 - 34044	45	3520.98	II	5651 - 34044
180	3433.09	II	10275 - 39395	330	3521.88	II	4911 - 33297
35	3435.20	I		90	3524.07	II	5965 - 34333
27	3435.21	II	8702 - 37804	210	3526.68	II	8170 - 36517
22	3435.25	II	5819 - 34921	120	3527.85	II	0 - 28338
45	3437.81	II		65	3528.05	II	5819 - 34155
35	3437.82	I	0 - 29079	45	3528.64	II	12751 - 41083
140	3439.84	II	4511 - 33574	45	3529.01	II	5716 - 34044
290	3441.21	II	2880 - 31931	160	3530.02	II	2382 - 30703
140	3442.39	II	4511 - 33553	90	3530.95	II	4737 - 33050
65	3442.96	II	5119 - 34155	65	3531.59	II	4737 - 33045
90	3446.73	II	2563 - 31568	27	3531.62	I	2378 - 30686
75	3451.57	II	5965 - 34929	90	3532.61	II	7259 - 35559
45	3454.80	I		90	3532.88	II	0 - 28298
45	3456.67	II	988 - 29909	600	3534.05	II	4204 - 32492
100	3456.77	II	6638 - 35559	150	3534.44	II	7523 - 35808
75	3459.84	II	9634 - 38529	90	3535.57	II	2880 - 31156
45	3460.17	II	2140 - 31033	110	3536.70	II	10275 - 38542
100	3461.35	II	4266 - 33149	65	3537.15	II	6550 - 34813
45	3461.79	II	7259 - 36138	110	3537.43	II	5716 - 33977
100	3463.22	II	7059 - 35926	35	3538.76	II	9723 - 37974
100	3463.76	II	5651 - 34514	27	3538.81	II	6518 - 34768
100	3464.16	II	2880 - 31738	770	3539.08	II	2581 - 30829
75	3464.21	II	5119 - 33977	45	3541.66	II	3704 - 31931
45	3467.78	II	1874 - 30703	90	3543.29	II	9634 - 37849
100	3468.11	II	4323 - 33149	45	3543.52	II	5943 - 34155
55	3468.89	II	988 - 29807	210	3545.60	II	2880 - 31076
22	3469.00	II	9634 - 38453	45	3545.75	II	9778 - 37973
45	3470.40	II	988 - 29794	65	3545.79	II	2635 - 30829
75	3474.22	II	3363 - 32139	55	3545.91	II	7523 - 35716
100	3475.67	II	1874 - 30637	290	3546.19	II	1874 - 30065
480	3476.84	II	10642 - 39395	150	3547.01	II	4323 - 32508
35	3477.39	II	4911 - 33660	65	3548.83	II	9634 - 37804
45	3477.45	II	7059 - 35808	90	3551.43	II	2596 - 30745
100	3479.60	II	0 - 28731	110	3551.66	II	3704 - 31851
65	3480.28	II	0 - 28725	22	3551.77	II	4266 - 32413
35	3480.34	II	1410 - 30135	55	3552.07	II	3594 - 31738
45	3480.38	II	3594 - 32318	240	3552.73	II	2563 - 30703
75	3480.98	II	12366 - 41085	110	3554.64	II	9492 - 37616
75	3481.16	II	5437 - 34155	420	3555.00	II	2581 - 30703
140	3482.14	II	3704 - 32413	65	3556.90	II	12751 - 40858
240	3482.35	II	4845 - 33553	40	3558.71	II	5716 - 33808
55	3484.70	II	4460 - 33149	1200	3560.80	II	5456 - 33531
75	3484.74	II	2880 - 31568	45	3561.54	II	4166 - 32235
710	3485.05	II	0 - 28686	90	3562.10	II	4204 - 32269
180	3488.55	II	7059 - 35716	110	3563.82	II	4266 - 32318
140	3490.13	II	5651 - 34295	120	3568.13	II	9634 - 37652
90	3493.11	II	4460 - 33080	90	3569.32	II	5651 - 33660
100	3493.73	II	3704 - 32318	45	3570.98	II	2581 - 30577
75	3495.01	II	3594 - 32198	120	3572.43	II	5676 - 33660
100	3495.94	II	4266 - 32863	90	3573.71	II	3594 - 31568
75	3496.33	II	2642 - 31235	45	3575.30	II	8176 - 36138
55	3500.68	II	10275 - 38833	210	3576.23	II	1410 - 29365
160	3501.46	II	1874 - 30425	1000	3577.45	II	3794 - 31738
45	3506.25	II	2563 - 31076	90	3580.57	II	1874 - 29794
210	3507.94	II	1410 - 29909	90	3583.66	II	9634 - 37531
90	3508.47	II	2581 - 31076	110	3584.34	II	4911 - 32802
65	3508.71	II	12366 - 40858	90	3586.77	II	4266 - 32139
55	3510.69	II	5819 - 34295	45	3587.22	II	5943 - 33812
45	3513.79	II	988 - 29439	160	3587.64	II	5943 - 33808
65	3513.85	II	11388 - 39839	35	3587.69	II	9723 - 37589
600	3517.38	II	7294 - 35716	90	3588.13	II	7059 - 34921
55	3518.37	II	10115 - 38529	160	3588.43	II	5437 - 33297
150	3519.08	II	2635 - 31043	55	3588.49	II	10114 - 37973
210	3520.52	II	1410 - 29807	330	3590.60	II	5969 - 33812



Cerium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
22	3594.58	II	6521 - 34333	45	3666.01	I	0 - 27269
22	3594.62	II	0 - 27812	45	3666.04	I	0 - 27269
22	3594.64	II	10641 - 38452	90	3667.28	II	5819 - 33080
110	3596.11	II	8403 - 36202	880	3667.98	II	2880 - 30135
45	3596.73	II	4523 - 32318	150	3668.72	II	0 - 27250
150	3598.20	II	2382 - 30166	90	3670.52	II	7059 - 34295
90	3599.97	II	4737 - 32508	130	3671.94	II	2581 - 29807
160	3600.58	II	6390 - 34155	220	3672.18	I	
65	3603.36	II	5119 - 32863	350	3672.79	II	7294 - 34514
150	3604.20	II	988 - 28725	180	3673.64	II	2581 - 29794
390	3607.63	II	5437 - 33149	45	3674.06	II	9634 - 36844
550	3609.69	II	7234 - 34929	45	3674.14	II	10925 - 38134
120	3610.91	II	7341 - 35027	90	3676.16	II	2596 - 29790
45	3611.31	II	2382 - 30065	90	3679.16	II	2635 - 29807
75	3611.34	II	2563 - 30246	220	3679.42	II	8176 - 35346
16	3611.64	II	7878 - 35559	180	3680.08	II	2642 - 29807
27	3611.73	II	3363 - 31043	45	3680.85	II	2635 - 29794
90	3612.34	II	4523 - 32198	180	3681.38	II	8403 - 35559
420	3613.70	II	4266 - 31931	180	3682.08	II	5651 - 32802
55	3615.64	II	2141 - 29790	45	3686.04	I	2208 - 29330
120	3616.20	II	5651 - 33297	180	3687.80	II	3594 - 30703
160	3618.58	II	5011 - 32638	65	3688.66	II	5943 - 33045
65	3619.95	II	2563 - 30180	45	3689.16	II	4460 - 31559
45	3621.15	II	5437 - 33045	100	3693.42	II	10275 - 37342
440	3622.15	II	6913 - 34513	50	3693.71	II	8281 - 35346
65	3622.41	II	3363 - 30962	300	3694.91	II	2382 - 29439
380	3623.74	II	5964 - 33552	75	3695.96	II	10925 - 37974
440	3623.84	II	6390 - 33977	60	3696.12	II	3996 - 31043
130	3624.15	II	2581 - 30166	120	3697.66	II	7259 - 34295
90	3628.25	II	2581 - 30135	60	3698.13	II	4202 - 31235
45	3628.61	I	2208 - 29759	110	3698.36	II	6521 - 33553
55	3630.42	II	10115 - 37652	140	3698.66	II	2880 - 29909
200	3631.19	II	3704 - 31235	150	3699.92	II	4911 - 31931
150	3632.11	II	2642 - 30166	120	3702.79	II	3704 - 30703
45	3633.40	II	0 - 27515	220	3704.98	II	5819 - 32802
90	3637.75	II	3594 - 31076	110	3706.94	II	4202 - 31171
130	3638.28	II	5819 - 33297	85	3707.39	II	4166 - 31131
45	3640.69	II	6518 - 33977	1000	3709.29	II	4204 - 31156
55	3642.83	II	4323 - 31766	1000	3709.93	II	988 - 27935
45	3644.30	II	5716 - 33149	50	3713.99	II	988 - 27905
130	3645.23	II	5437 - 32863	110	3714.77	II	8804 - 35716
130	3645.45	II	2642 - 30065	35	3715.14	II	4460 - 31369
150	3646.65	II	4523 - 31938	120	3715.47	II	6390 - 33297
350	3646.97	II	2382 - 29794	1400	3716.37	II	0 - 26900
260	3647.75	II	7523 - 34929	110	3716.93	II	7259 - 34155
260	3647.95	II	8403 - 35808	75	3717.48	II	6518 - 33410
45	3649.73	II	4460 - 31851	420	3718.19	II	1410 - 28298
90	3650.12	II	2596 - 29984	420	3718.38	II	4204 - 31090
180	3650.88	II	8176 - 35559	210	3719.80	II	2563 - 29439
130	3652.11	II	3995 - 31369	60	3722.10	II	5514 - 32373
65	3652.26	II	11949 - 39322	150	3722.29	II	2581 - 29439
420	3653.11	II	2880 - 30246	110	3722.76	II	2596 - 29450
660	3653.67	II	3794 - 31156	45	3723.66	II	4323 - 31171
310	3654.97	II	2642 - 29994	150	3724.64	II	5011 - 31851
1800	3655.85	II	2563 - 29909	420	3725.68	II	5969 - 32802
45	3658.26	II	2581 - 29909	170	3726.96	II	988 - 27812
440	3659.23	II	1410 - 28731	490	3728.02	II	5676 - 32492
350	3659.97	II	1410 - 28725	110	3728.18	II	2635 - 29450
180	3660.16	II	10275 - 37588	800	3728.42	II	5456 - 32269
880	3660.64	II	988 - 28298	50	3729.00	II	4266 - 31076
130	3661.73	II	4266 - 31568	75	3729.92	II	3363 - 30166
100	3662.99	II	4266 - 31559	140	3730.33	II	11742 - 38542
90	3663.70	II	4911 - 32198	17	3731.19	I	3312 - 30105
55	3664.73	II	5437 - 32717	20	3731.25	I	1279 - 28072
75	3665.05	II	3854 - 31131	110	3731.88	II	8928 - 35716

*Cerium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	3732.46	II	2382 - 29167	25	3793.83	I	0 - 26351
30	3732.56	I	3976 - 30759	18	3793.85	II	7059 - 33410
30	3732.58	II	2581 - 29365	100	3794.68	II	6518 - 32863
150	3733.52	II	4266 - 31043	170	3795.25	II	3794 - 30135
110	3737.52	II	4460 - 31208	50	3796.67	II	7713 - 34044
160	3737.74	II	6913 - 33660	75	3799.04	II	3594 - 29909
75	3740.13	II	10115 - 36844	35	3799.09	I	1279 - 27594
75	3741.01	II	2642 - 29365	2500	3801.52	II	7234 - 33531
75	3741.73	II	7259 - 33977	800	3803.09	II	2880 - 29167
22	3742.21	I	228 - 26943	15	3803.83	I	228 - 26510
15	3742.25	I	0 - 26714	35	3803.84	II	12260 - 38542
50	3743.97	I	0 - 26702	50	3804.16	II	5651 - 31931
50	3744.05	II	5437 - 32139	120	3807.69	II	5676 - 31931
60	3746.26	II	2595 - 29281	1000	3808.11	II	2382 - 28634
170	3746.38	II	4523 - 31208	490	3809.21	II	4911 - 31156
320	3748.06	II	5819 - 32492	75	3809.50	II	4460 - 30703
170	3750.08	II	6638 - 33297	35	3810.10	II	3746 - 29984
150	3751.00	II	3594 - 30246	100	3810.90	II	5965 - 32198
250	3751.45	II	10275 - 36924	60	3811.60	II	11743 - 37971
35	3751.76	II	2635 - 29281	250	3812.20	II	4737 - 30962
140	3752.34	II	5676 - 32318	35	3814.94	II	3704 - 29909
75	3753.77	II	12763 - 39395	85	3815.01	II	2140 - 28345
200	3755.43	II	3363 - 29984	490	3815.85	II	6518 - 32717
170	3755.72	II	5617 - 32235	50	3816.31	II	5943 - 32139
160	3757.22	II	7818 - 34426	470	3817.46	II	4845 - 31033
160	3757.86	II	2563 - 29167	100	3818.69	II	4523 - 30703
50	3760.40	II	2581 - 29167	300	3819.02	II	4460 - 30637
75	3760.69	II	4460 - 31043	170	3821.26	II	2563 - 28725
300	3762.98	II	7341 - 33908	190	3821.69	II	4266 - 30425
85	3763.61	II	4266 - 30829	150	3823.70	II	8281 - 34426
680	3764.12	II	2880 - 29439	470	3823.90	II	2581 - 28725
200	3765.04	II	4523 - 31076	100	3827.22	II	5437 - 31559
85	3765.89	II	5651 - 32198	120	3827.37	II	14963 - 41083
160	3766.51	II	3704 - 30246	160	3829.69	II	1410 - 27515
50	3768.00	II	4511 - 31043	170	3830.02	II	6390 - 32492
300	3768.76	II	8403 - 34929	470	3830.55	II	7713 - 33812
100	3769.04	II	1410 - 27935	490	3831.08	II	3854 - 29949
160	3769.94	II	8403 - 34921	110	3832.22	II	5651 - 31738
210	3770.76	II	7062 - 33574	100	3832.74	II	2642 - 28725
300	3771.60	II	4323 - 30829	490	3834.55	II	2563 - 28634
60	3772.65	II	5819 - 32318	85	3834.78	II	3996 - 30065
85	3773.20	II	6550 - 33045	50	3835.75	II	7234 - 33297
75	3773.44	II	5437 - 31931	50	3835.89	II	7746 - 33808
75	3776.15	II	15517 - 41992	270	3836.10	II	1874 - 27935
250	3776.61	II	3594 - 30065	110	3837.20	II	2581 - 28634
140	3777.66	II	1874 - 28338	1100	3838.54	II	2642 - 28686
45	3779.61	II	4511 - 30962	120	3839.49	II	7259 - 33297
25	3781.10	II	5119 - 31559	120	3841.71	II	10115 - 36138
620	3781.62	II	4266 - 30703	50	3842.04	II	7059 - 33080
440	3782.52	II	3996 - 30425	200	3843.76	II	7523 - 33531
100	3783.03	II	7234 - 33660	60	3845.28	II	3996 - 29994
200	3783.58	II	5716 - 32139	100	3845.48	II	10115 - 36112
860	3786.63	II	1410 - 27812	220	3846.52	II	8176 - 34166
35	3787.46	II	11742 - 38138	250	3848.10	II	4266 - 30246
100	3787.57	II	2635 - 29029	860	3848.59	II	4204 - 30180
120	3787.91	II	988 - 27380	35	3849.48	II	3703 - 29673
45	3788.20	II	4845 - 31235	75	3849.56	II	1410 - 27380
520	3788.75	II	3794 - 30180	50	3849.66	II	10925 - 36894
25	3790.34	II	5943 - 32318	120	3850.10	II	5965 - 31931
12	3790.83	II		100	3852.10	II	2382 - 28335
50	3790.88	II	7202 - 33574	860	3853.15	II	0 - 25945
85	3791.68	II	7294 - 33660	1200	3854.18	II	1874 - 27812
300	3792.32	II	3704 - 30065	1200	3854.31	II	1874 - 27811
50	3793.42	II	7522 - 33876	620	3855.29	II	4204 - 30135
75	3793.51	II	5965 - 32318	390	3857.02	II	5819 - 31738

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
170	3857.23	II	3363 - 29281	130	3909.75	II	4166 - 29736
370	3857.64	II	2382 - 28298	130	3909.93	II	7234 - 32802
75	3857.81	II	4511 - 30425	140	3910.70	II	9634 - 35198
50	3857.93	II	3996 - 29909	140	3911.30	II	6638 - 32198
200	3862.46	II	5676 - 31559	230	3912.19	II	4511 - 30065
85	3865.40	I		980	3912.44	II	2382 - 27935
160	3866.81	II	988 - 26841	110	3913.99	II	4523 - 30065
200	3868.13	II	3594 - 29439	100	3914.95	II	3746 - 29281
60	3868.47	II	5119 - 30962	390	3915.52	II	5676 - 31208
100	3868.51	II	5716 - 31559	390	3916.14	II	4266 - 29794
60	3869.56	II	9723 - 35559	140	3916.90	II	2382 - 27905
160	3870.87	II	5514 - 31340	70	3917.25	II	3508 - 29029
35	3871.80	II	7259 - 33079	230	3917.64	II	5119 - 30637
60	3873.04	I	1279 - 27091	770	3918.28	II	5617 - 31131
60	3873.25	II	10115 - 35926	480	3919.81	II	5651 - 31156
270	3874.68	II	8176 - 33977	590	3921.73	II	5716 - 31208
140	3875.01	II	3996 - 29794	560	3923.11	II	4511 - 29994
140	3875.06	II	4266 - 30065	450	3924.64	II	4511 - 29984
170	3876.13	II	4911 - 30703	70	3924.80	II	4323 - 29794
620	3876.97	II	4460 - 30246	35	3927.00	II	7259 - 32717
1100	3878.36	II	1410 - 27187	110	3927.39	II	2880 - 28335
120	3879.06	II	15517 - 41289	70	3927.57	II	11742 - 37196
60	3879.31	II	5437 - 31208	150	3928.32	II	4460 - 29909
60	3879.60	II	12366 - 38134	70	3929.96	II	5651 - 31090
60	3880.40	II	14276 - 40040	110	3930.81	II	7059 - 32492
170	3881.87	II	2581 - 28335	770	3931.09	II	1410 - 26841
1500	3882.45	II	2596 - 28345	310	3931.37	II	2382 - 27812
60	3883.54	II	4323 - 30065	230	3931.83	II	5943 - 31369
75	3883.58	II	2596 - 28338	150	3932.15	II	5651 - 31076
100	3884.21	II	12457 - 38195	310	3933.73	II	5676 - 31090
100	3886.50	II	4523 - 30246	70	3934.07	I	228 - 25640
100	3888.36	II	14963 - 40674	35	3934.75	II	4266 - 29673
120	3888.39	II	5119 - 30829	50	3935.93	II	5676 - 31076
120	3889.00	II	4460 - 30166	55	3937.15	II	12260 - 37652
75	3889.30	II	3746 - 29450	50	3937.63	II	5819 - 31208
75	3889.48	II	2635 - 28338	50	3937.81	II	2563 - 27950
1000	3889.98	II	5456 - 31156	560	3938.09	II	4523 - 29909
210	3890.75	II	2140 - 27835	55	3939.52	II	8532 - 33908
210	3890.98	II	2642 - 28335	55	3939.66	II	1874 - 27250
50	3891.77	II	4737 - 30425	770	3940.34	II	2563 - 27935
170	3893.23	II	5283 - 30962	100	3940.64	II	3996 - 29365
75	3893.85	II	7878 - 33553	310	3940.97	II	3363 - 28731
75	3894.30	II	4323 - 29994	2000	3942.15	II	0 - 25360
620	3895.11	II	3363 - 29029	2700	3942.75	II	6913 - 32269
590	3896.80	II	4511 - 30166	150	3943.14	II	2581 - 27935
50	3897.43	II	10275 - 35926	55	3943.50	II	8804 - 34155
490	3898.27	II	3794 - 29439	770	3943.89	II	6390 - 31738
270	3898.94	II	1874 - 27515	70	3944.84	II	10115 - 35457
50	3899.39	II	5514 - 31152	85	3944.92	II	2563 - 27905
75	3900.20	II	8176 - 33808	110	3946.68	II	7818 - 33149
120	3901.30	II	5943 - 31568	310	3947.97	II	3363 - 28686
60	3901.68	II	9723 - 35346	180	3949.39	II	1874 - 27187
200	3903.34	II	4523 - 30135	35	3949.78	II	5924 - 31234
85	3903.93	II	12366 - 37974	65	3949.82	I	4455 - 29766
250	3904.34	II	4460 - 30065	180	3950.42	II	5119 - 30425
50	3904.58	II	7259 - 32863	70	3950.80	II	7746 - 33050
200	3906.92	II	4202 - 29790	110	3951.62	II	7746 - 33045
770	3907.29	II	8928 - 34514	100	3952.11	II	4511 - 29807
150	3907.45	II	4166 - 29750	3100	3952.54	II	2642 - 27935
100	3908.09	II	4845 - 30425	340	3953.66	II	3996 - 29281
560	3908.41	II	6913 - 32492	150	3953.95	II	4523 - 29807
390	3908.54	II	3704 - 29281	310	3955.36	II	7341 - 32616
110	3908.77	II	7062 - 32638	150	3955.92	II	4523 - 29794
35	3909.05	II	8403 - 33977	230	3956.06	II	5819 - 31090
270	3909.31	II	3594 - 29167	980	3956.28	II	4911 - 30180

*Cerium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	3956.74	I	1663 - 26929	910	4003.77	II	7523 - 32492
28	3956.78	I	1279 - 26545	55	4004.08	II	1873 - 26841
140	3956.90	II	5437 - 30703	100	4004.58	II	7234 - 32198
35	3957.15	II	2642 - 27905	370	4005.64	II	988 - 25945
35	3957.20	I	228 - 25492	70	4007.45	II	5119 - 30065
150	3957.97	II	7234 - 32492	210	4007.59	II	4845 - 29790
230	3958.27	II	5819 - 31076	40	4008.66	II	7259 - 32198
230	3958.87	II	7062 - 32314	55	4009.06	II	7202 - 32139
180	3959.62	II	4202 - 29450	140	4010.14	II	6638 - 31568
150	3959.80	II	4737 - 29984	100	4011.56	II	5716 - 30637
100	3960.38	II	5965 - 31208	2700	4012.39	II	4523 - 29439
770	3960.91	II	2596 - 27835	910	4014.90	II	4266 - 29167
150	3962.09	II	7818 - 33050	250	4015.88	II	8403 - 33297
100	3963.37	II	4911 - 30135	140	4017.60	II	5819 - 30703
150	3964.18	II	12751 - 37970	200	4019.04	II	8176 - 33050
390	3964.50	II	2596 - 27812	140	4019.90	II	8176 - 33045
770	3967.05	II	2635 - 27835	240	4022.27	II	9054 - 33908
150	3967.18	II	5437 - 30637	35	4023.37	II	6521 - 31369
110	3967.53	II	9723 - 34921	140	4024.35	II	4523 - 29365
150	3970.04	II	11742 - 36924	840	4024.49	II	3794 - 28634
55	3970.42	II	9634 - 34813	240	4025.15	II	3508 - 28345
170	3970.64	II	2635 - 27812	70	4027.05	II	6913 - 31738
450	3971.68	II	3996 - 29167	170	4027.69	II	5924 - 30745
110	3971.88	II	2642 - 27812	840	4028.41	II	2563 - 27380
270	3972.07	II	6390 - 31559	55	4030.16	II	10115 - 34921
70	3973.03	II	4511 - 29673	250	4030.34	II	2382 - 27187
85	3974.00	I	1388 - 26545	840	4031.34	II	2581 - 27380
70	3974.19	II	5011 - 30166	55	4037.39	II	8774 - 33536
270	3975.07	II	7713 - 32863	340	4037.67	II	5943 - 30703
70	3976.78	II	7059 - 32198	170	4038.25	II	10870 - 35626
35	3977.53	II	8774 - 33908	85	4039.89	II	8789 - 33536
150	3977.77	II	5943 - 31076	2100	4040.76	II	3594 - 28335
770	3978.65	II	4323 - 29450	110	4041.27	II	5965 - 30703
560	3980.88	II	5716 - 30829	55	4042.14	II	8928 - 33660
40	3981.90	II	5969 - 31076	910	4042.58	II	3996 - 28725
110	3982.16	I	2208 - 27313	230	4045.21	II	6521 - 31235
560	3982.89	II	6638 - 31738	85	4045.32	II	10314 - 35027
310	3983.29	II	4166 - 29263	620	4046.34	II	4460 - 29167
770	3984.68	II	7713 - 32802	130	4047.28	II	5283 - 29984
55	3986.40	II	5965 - 31043	110	4049.03	II	3996 - 28686
370	3989.44	II	7259 - 32318	85	4050.81	II	7059 - 31738
35	3989.76	II	4737 - 29795	210	4051.43	II	5119 - 29794
180	3990.11	II	2880 - 27935	210	4051.99	II	5965 - 30637
70	3990.69	II	5651 - 30703	700	4053.51	II	0 - 24663
22	3991.22	II	13785 - 38833	450	4054.99	II	2596 - 27250
55	3991.33	II	5119 - 30166	85	4055.16	II	6518 - 31171
70	3992.13	II	7818 - 32860	110	4055.84	I	1279 - 25928
700	3992.39	II	3594 - 28635	85	4056.90	II	8403 - 33045
370	3992.91	II	5924 - 30962	85	4058.24	II	3704 - 28338
910	3993.82	II	7341 - 32373	50	4058.78	II	3704 - 28335
110	3994.57	II	5676 - 30703	110	4060.47	II	6550 - 31171
35	3995.42	II	3704 - 28725	50	4060.71	I	0 - 24619
14	3996.36	II		28	4061.80	I	4199 - 28812
70	3996.49	II	4266 - 29281	280	4062.22	II	11016 - 35626
50	3997.48	II	6550 - 31559	230	4062.94	II	2581 - 27187
140	3997.72	II	8804 - 33812	110	4063.92	II	3746 - 28345
2800	3999.24	II	2382 - 27380	85	4064.91	II	3704 - 28298
17	4000.68	II	9779 - 34768	85	4065.16	II	7259 - 31851
17	4000.80	II	5437 - 30425	85	4066.50	II	12260 - 36844
110	4001.06	II	5716 - 30703	55	4066.91	I	3976 - 28557
230	4001.56	II	5011 - 29994	280	4067.28	II	8532 - 33111
140	4001.73	II	3704 - 28686	85	4068.44	II	7278 - 31851
180	4002.81	II	7294 - 32269	420	4068.84	II	5676 - 30246
110	4002.97	II	3363 - 28338	55	4070.09	II	20881 - 45443
110	4003.17	II	5011 - 29984	70	4070.84	II	12366 - 36924

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	4071.08	II	5437 - 29994	510	4124.79	II	5514 - 29751
1100	4071.81	II	2635 - 27187	50	4125.78	II	3704 - 27935
270	4072.92	II	2642 - 27187	55	4126.66	II	4460 - 28686
1800	4073.48	II	3854 - 28396	980	4127.37	II	5514 - 29735
210	4073.74	II	8449 - 32989	250	4127.74	II	4511 - 28731
28	4074.65	II	1410 - 25945	200	4128.07	II	3594 - 27812
1500	4075.71	II	5651 - 30180	180	4128.36	II	7523 - 31738
1500	4075.85	II	4911 - 29439	85	4129.18	II	5969 - 30180
210	4076.24	II	6518 - 31043	530	4130.71	II	4523 - 28725
420	4077.47	II	2382 - 26900	480	4131.10	II	2642 - 26841
530	4078.32	II	7722 - 32235	28	4131.86	II	6550 - 30745
270	4078.52	II	7455 - 31967	100	4132.31	II	5716 - 29909
85	4079.02	II	7059 - 31568	55	4132.64	II	6638 - 30829
140	4079.67	II	7234 - 31738	2700	4133.80	II	6968 - 31152
270	4080.44	II	2880 - 27380	270	4135.44	II	4511 - 28686
670	4081.22	II	3854 - 28350	55	4135.89	II	10642 - 34813
910	4083.23	II	5651 - 30135	55	4136.77	II	5283 - 29450
110	4083.48	II	9054 - 33536	85	4136.90	II	5969 - 30135
110	4083.64	II	16192 - 40673	270	4137.47	II	5119 - 29281
450	4085.23	II	5437 - 29909	2000	4137.65	II	4166 - 28327
85	4086.42	II	4266 - 28731	270	4138.10	II	7454 - 31613
250	4087.36	II	4266 - 28725	210	4138.35	II	10870 - 35027
70	4087.57	II	8532 - 32989	55	4139.43	II	3363 - 27515
40	4088.58	II	6638 - 31090	55	4140.75	II	4202 - 28345
230	4088.85	II	5716 - 30166	770	4142.40	II	5617 - 29751
70	4089.74	II	7294 - 31738	150	4142.83	II	5676 - 29807
70	4089.86	II	6518 - 30962	390	4144.49	II	3854 - 27976
130	4090.47	II	6521 - 30962	670	4145.00	II	5617 - 29735
130	4090.95	II	6638 - 31076	480	4146.23	II	4523 - 28634
50	4092.09	II	4204 - 28634	85	4148.16	II	5965 - 30065
100	4092.72	II	5819 - 30246	280	4148.90	II	8789 - 32885
50	4093.29	I	2208 - 26632	420	4149.79	II	5716 - 29807
150	4093.96	II	4266 - 28686	980	4149.94	II	5819 - 29909
35	4098.14	I	4417 - 28812	420	4150.91	II	8531 - 32616
85	4098.98	II	5676 - 30065	1400	4151.97	II	5514 - 29592
40	4099.75	II	8695 - 33080	55	4152.93	II	13515 - 37588
450	4101.77	II	6968 - 31340	230	4153.13	II	1874 - 25945
70	4102.36	II	8928 - 33297	50	4153.93	II	3746 - 27812
50	4104.43	II	5437 - 29794	85	4155.28	II	
250	4105.00	II	8532 - 32885	180	4155.53	II	9054 - 33111
70	4106.13	II	5819 - 30166	450	4159.03	II	8281 - 32318
70	4106.85	II	8702 - 33045	70	4160.11	II	4266 - 28296
55	4106.92	II	3996 - 28338	70	4160.18	II	7059 - 31090
510	4107.42	II	3996 - 28335	110	4161.18	II	7722 - 31747
50	4107.80	II	8774 - 33111	150	4162.63	II	7059 - 31076
25	4108.26	II	7234 - 31568	310	4163.52	II	11016 - 35027
40	4109.56	II	3508 - 27835	1300	4165.61	II	7341 - 31340
200	4110.38	II	8789 - 33111	55	4166.20	II	10925 - 34921
70	4110.84	II	2581 - 26900	150	4166.65	II	4737 - 28731
250	4111.39	II	5819 - 30135	620	4166.88	II	10869 - 34861
35	4111.93	II	6390 - 30703	250	4167.80	II	9054 - 33040
100	4113.73	II	3996 - 28298	320	4169.77	II	5819 - 29795
50	4114.15	II	7259 - 31559	320	4169.88	II	4323 - 28298
420	4115.37	II	7455 - 31747	55	4171.39	II	5943 - 29909
250	4117.01	II	11015 - 35298	110	4172.16	II	2880 - 26841
200	4117.29	II	5965 - 30246	110	4174.48	II	4737 - 28686
200	4117.59	II	10642 - 34921	70	4175.24	II	5965 - 29909
770	4118.14	II	5617 - 29893	130	4176.08	II	3996 - 27935
250	4119.02	II	4460 - 28731	340	4176.70	II	9054 - 32989
310	4119.79	II	8774 - 33040	70	4179.29	II	3594 - 27515
310	4119.88	II	2635 - 26900	340	4181.08	II	5119 - 29029
450	4120.83	II	2581 - 26841	340	4185.33	II	3363 - 27250
510	4123.24	II	5819 - 30065	3500	4186.60	II	6968 - 30847
510	4123.49	II	7722 - 31967	530	4187.32	II	4460 - 28335
980	4123.87	II	6913 - 31156	50	4189.18	II	5943 - 29807

Cerium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	4189.64	II	7294 - 31156	200	4263.43	II	8403 - 31851
170	4190.63	II	7234 - 31090	70	4263.95	II	8789 - 32235
55	4191.03	II	20783 - 44637	170	4264.37	II	7259 - 30703
560	4193.09	II	7234 - 31075	100	4267.23	II	4523 - 27950
370	4193.28	II	8532 - 32373	55	4268.30	II	5943 - 29365
370	4193.87	II	4460 - 28298	140	4269.25	II	7818 - 31235
180	4194.91	II	9054 - 32885	620	4270.19	II	4523 - 27935
70	4195.82	II	4511 - 28338	390	4270.72	II	7722 - 31131
630	4196.34	II	3363 - 27187	130	4273.44	II	8804 - 32198
140	4197.51	II	3996 - 27812	70	4275.46	II	8176 - 31559
180	4197.67	II	3996 - 27811	140	4275.57	II	4523 - 27905
280	4198.00	II	4911 - 28725	40	4278.25	II	10799 - 34166
180	4198.43	II	4523 - 28335	200	4278.86	II	2581 - 25945
280	4198.67	II	7341 - 31152	140	4280.14	II	5924 - 29281
840	4198.72	II	4166 - 27976	110	4281.00	II	4460 - 27812
240	4201.24	II	7294 - 31090	85	4281.16	II	4460 - 27811
100	4201.32	II	8403 - 32198	280	4285.37	II	7341 - 30670
910	4202.94	II	3594 - 27380	200	4288.66	II	2635 - 25945
55	4203.51	II	0 - 23783	200	4289.44	II	3594 - 26900
70	4204.74	II	6390 - 30166	2000	4289.94	II	2642 - 25945
55	4205.16	II	9779 - 33553	110	4292.58	II	6518 - 29807
35	4205.79	II	7059 - 30829	110	4292.76	II	4523 - 27812
35	4205.89	II	10275 - 34044	70	4294.75	II	8281 - 31559
270	4209.41	II	5514 - 29263	200	4296.07	II	8928 - 32198
70	4210.00	II	5283 - 29029	40	4296.37	II	6521 - 29790
100	4213.04	II	5437 - 29167	1500	4296.67	II	4166 - 27433
370	4214.04	II	4911 - 28634	420	4296.78	II	6913 - 30180
310	4217.59	II	8532 - 32235	70	4299.09	II	3996 - 27250
55	4221.17	II	7062 - 30745	590	4299.36	II	1410 - 24663
1500	4222.60	II	988 - 24663	770	4300.33	II	3594 - 26841
110	4223.88	II	4266 - 27935	40	4300.86	II	6550 - 29795
40	4224.56	II	9198 - 32863	85	4302.65	II	10642 - 33876
100	4227.42	II	5716 - 29365	110	4304.28	II	9634 - 32860
770	4227.75	II	5617 - 29263	150	4304.72	II	5943 - 29167
85	4228.30	II	7059 - 30703	420	4305.14	II	6913 - 30135
85	h 4230.13	II	4202 - 27835	770	4306.72	II	4166 - 27379
390	4231.74	II	10035 - 33659	110	4309.58	II	5969 - 29167
100	4232.06	II	7722 - 31345	390	4309.74	II	3704 - 26900
140	4232.56	II	5819 - 29439	150	4310.70	II	3996 - 27187
85	4233.20	II	6550 - 30166	110	4311.59	II	7059 - 30246
240	4234.21	II	4202 - 27812	35	4313.10	II	5119 - 28298
85	4234.73	II	6638 - 30246	55	4314.93	II	6638 - 29807
200	4236.02	II	4737 - 28338	100	4315.41	II	7259 - 30425
85	4236.36	II	8774 - 32373	140	4317.33	II	8403 - 31559
980	4239.92	II	3854 - 27433	55	4317.99	II	6521 - 29673
85	4242.01	II	7523 - 31090	560	4320.72	II	3704 - 26841
390	4242.72	II	2382 - 25945	70	4324.60	I	0 - 23117
85	4243.74	II	13785 - 37342	150	4324.79	II	7713 - 30829
310	4245.89	II	5819 - 29365	70	4326.82	II	5924 - 29029
310	4245.98	II	4266 - 27812	310	4330.45	II	2596 - 25682
85	4246.40	II	7203 - 30745	150	4331.75	II	9723 - 32802
390	4246.72	II	2141 - 25682	310	4332.71	II	5651 - 28725
70	4247.46	II	3363 - 26900	70	4334.87	II	8278 - 31340
70	4248.10	II	10275 - 33808	55	4335.49	II	8176 - 31235
1100	4248.68	II	5514 - 29044	240	4336.23	II	5676 - 28731
35	4250.66	II	3996 - 27515	150	4336.28	II	4460 - 27515
55	4251.60	II	8804 - 32318	980	4337.77	II	2635 - 25682
55	4251.86	II	4323 - 27835	340	4339.31	II	10870 - 33908
390	4253.37	II	3746 - 27250	70	4340.56	II	8176 - 31208
70	4254.74	II	6638 - 30135	55	4342.14	II	4911 - 27935
620	4255.79	II	5676 - 29167	70	4342.48	II	10275 - 33297
170	4256.16	II	4323 - 27812	55	4343.56	I	228 - 23244
110	4257.12	II	3704 - 27187	70	4345.85	II	9634 - 32638
130	4259.75	II	7234 - 30703	150	4345.96	II	4511 - 27515
110	4261.17	II	8774 - 32235	70	4346.43	II	8170 - 31171



Cerium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28	4347.60	II	8176 - 31171	85	4439.24	II	11016 - 33536
40	4347.70	II	4911 - 27905	130	4440.88	II	6518 - 29029
700	4349.79	II	4266 - 27250	150	4443.75	II	5437 - 27935
560	4352.71	II	4845 - 27812	480	4444.39	II	7455 - 29949
170	4353.37	II	12751 - 35716	450	4444.70	II	8532 - 31024
35	4356.75	II	7234 - 30180	55	4446.15	II	10925 - 33410
55	4357.91	II	9198 - 32139	28	4447.67	I	0 - 22477
100	4359.07	II	8804 - 31738	770	4449.34	II	4911 - 27380
100	4360.18	II	6521 - 29450	100	4449.64	II	8170 - 30637
28	4360.41	II	7818 - 30745	620	4450.73	II	5514 - 27976
40	4360.44	II	8281 - 31208	55	4452.55	II	15517 - 37970
35	4361.36	II	7062 - 29984	55	4453.16	II	4737 - 27187
130	4361.66	II	4266 - 27187	85	4454.99	II	4460 - 26900
35	4363.39	II	5819 - 28731	85	4455.66	II	2382 - 24819
22	4363.47	II	10642 - 33553	40	4457.78	II	8403 - 30829
910	4364.66	II	3996 - 26900	2400	4460.21	II	3854 - 26268
100	4367.00	II	11016 - 33908	450	4461.14	II	7341 - 29751
70	4367.56	II	8281 - 31171	420	4463.41	II	7722 - 30120
85	4368.23	II	7294 - 30180	55	4464.17	II	7341 - 29735
70	4369.24	II	7012 - 29893	140	4464.69	II	8278 - 30670
100	4372.40	II	4323 - 27187	40	4465.44	II	7062 - 29450
50	4373.24	II	5437 - 28298	280	4467.54	II	4523 - 26900
350	4373.82	II	4523 - 27380	1400	4471.24	II	5617 - 27976
50	4375.17	II	7059 - 29909	450	4472.72	II	3594 - 25945
530	4375.92	II	3996 - 26841	40	4474.69	II	8789 - 31131
110	4380.06	II	5011 - 27835	700	4479.36	II	4523 - 26841
110	4381.78	II	5819 - 28634	700	4483.90	II	6968 - 29263
910	4382.17	II	5514 - 28327	170	4484.82	II	9054 - 31345
70	4386.35	II	7202 - 29994	85	4485.52	II	7878 - 30166
170	4386.70	II	4460 - 27250	840	4486.91	II	2382 - 24663
700	4386.84	II	1874 - 24663	40	4488.81	II	8804 - 31076
310	4388.01	II	6968 - 29751	40	4492.95	II	7341 - 29592
170	4390.28	II	11742 - 34514	140	4494.22	II	6390 - 28634
1700	4391.66	II	2596 - 25360	130	4495.39	II	5011 - 27250
150	4393.19	II	5969 - 28725	140	4496.23	II	8403 - 30637
85	4394.78	II	7059 - 29807	250	4497.85	II	7722 - 29949
70	4396.58	II	7012 - 29751	85	4500.34	II	9723 - 31938
200	4398.79	II	4460 - 27187	25	4501.10	I	0 - 22210
510	4399.20	II	2635 - 25360	100	4506.41	I	0 - 22184
70	4400.54	II	2642 - 25360	70	4508.08	II	5011 - 27187
70	4400.87	II	5119 - 27835	35	4509.12	II	7092 - 29263
55	4403.30	II	11341 - 34044	28	4509.17	II	10869 - 33040
70	4405.47	II	5119 - 27812	22	4509.25	II	7722 - 29892
170	4407.28	II	5651 - 28335	55	4510.17	II	7818 - 29984
65	4408.85	II	7234 - 29909	50	4510.92	II	8928 - 31090
35	4408.90	II	10314 - 32989	85	4511.64	II	9779 - 31938
350	4410.64	II	10870 - 33536	110	4515.86	II	8532 - 30670
350	4410.76	II	7455 - 30120	35	4518.02	I	0 - 22127
130	4412.02	II	5676 - 28335	100	4519.59	II	10870 - 32989
110	4413.19	II	987 - 23640	40	4521.96	I	3100 - 25208
70	4413.80	II	7259 - 29909	22	4522.08	II	7059 - 29167
310	4416.90	II	4266 - 26900	770	4523.08	II	4166 - 26268
980	4418.78	II	6968 - 29592	840	4527.35	II	2581 - 24663
70	4419.30	II	5676 - 28298	840	4528.47	II	6968 - 29044
50	4423.44	I	0 - 22600	40	4531.28	I	1663 - 23725
200	4423.68	II	8532 - 31131	50	4531.33	I	228 - 22291
310	4427.07	II	3363 - 25945	40	4532.01	I	1663 - 23722
480	4427.92	II	4323 - 26900	110	4532.49	II	13659 - 35716
310	4428.44	II	4266 - 26841	28	4534.22	II	7746 - 29795
650	4429.27	II	8774 - 31345	85	4536.89	II	12260 - 34295
70	4430.00	II	16268 - 38835	70	4537.88	II	7878 - 29909
55	4432.72	II	11742 - 34295	110	4539.07	II	11016 - 33040
70	4432.92	II	5283 - 27835	840	4539.75	II	2642 - 24663
50	4433.73	II	7259 - 29807	210	4544.96	II	3363 - 25360
110	4437.61	II	6638 - 29167	35	4545.87	II	5943 - 27935

Cerium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	4546.06	I	228 - 22219	150	4580.13	II	8532 - 29893
55	4548.89	I	3100 - 25077	28	4680.99	II	11016 - 32373
70	4549.64	II	11016 - 32989	270	4684.61	II	7294 - 28634
70	4550.30	II	9054 - 31024	55	4685.23	II	7012 - 28350
250	4551.30	II	5909 - 27935	65	4686.77	II	8804 - 30134
22	4552.06	I	228 - 22190	80	4688.89	I	1279 - 22600
22	4553.06	I	1663 - 23620	18	4689.50	II	8928 - 30246
28	4554.56	II	3996 - 25945	22	4690.17	II	7012 - 28327
70	4555.43	II	20783 - 42729	28	4690.50	II	8278 - 29592
25	4556.22	II	16192 - 38134	45	4690.71	I	4417 - 25730
70	4558.60	II	4911 - 26841	45	4692.06	II	5943 - 27250
650	4560.28	II	7341 - 29263	65	4694.88	II	6518 - 27812
310	4560.96	II	5514 - 27433	65	4696.50	I	1663 - 22949
2100	4562.36	II	3854 - 25766	65	4701.45	II	9779 - 31043
28	4563.38	II	6390 - 28298	65	4702.01	II	6550 - 27812
55	4565.23	I	228 - 22127	45	4707.00	I	4199 - 25438
420	4565.84	II	8774 - 30670	55	4707.24	I	0 - 21237
40	4569.66	II	10924 - 32802	45	4707.94	I	7092 - 28327
1100	4572.28	II	5514 - 27379	22	4710.00	II	3593 - 24819
85	4572.79	II	11949 - 33812	200	4714.00	II	8928 - 30135
55	4576.48	II	9723 - 31568	100	4714.81	II	8532 - 29735
70	4578.78	II	13027 - 34861	90	4717.88	II	5651 - 26841
85	4579.28	II	20881 - 42712	35	4722.30	II	4511 - 25682
35	4581.10	I	3312 - 25134	35	4723.31	II	5676 - 26841
420	4582.50	II	5617 - 27433	16	4724.31	I	0 - 21161
22	4583.09	I	0 - 21813	40	4724.83	I	0 - 21158
130	4591.12	II	8928 - 30703	110	4725.09	II	4202 - 25360
840	4593.93	II	5617 - 27379	16	4727.56	I	228 - 21375
55	4597.17	II	10869 - 32616	80	4730.13	II	7202 - 28338
22	4599.02	II	5969 - 27706	100	4733.52	II	10115 - 31235
35	4601.37	II	10646 - 32373	35	4733.96	I	1663 - 22781
22	4604.21	II	8281 - 29994	40	4734.69	I	1388 - 22503
35	4605.48	II	9317 - 31024	22	4735.35	II	7523 - 28634
420	4606.40	II	7341 - 29044	310	4737.28	II	8789 - 29893
70	4608.49	I	2378 - 24071	40	4739.12	II	7202 - 28298
55	4608.75	II	11387 - 33079	100	4739.53	II	10058 - 31152
55	4610.46	I	0 - 21683	45	4741.64	II	8281 - 29365
85	4611.56	II	12366 - 34044	45	4744.80	I	7780 - 28850
70	4613.02	II	7059 - 28731	45	4744.94	II	3593 - 24663
70	4615.18	I	0 - 21661	160	4747.17	II	2581 - 23640
420	4624.90	II	9054 - 30670	16	4749.50	II	12763 - 33812
1700	4628.16	II	4166 - 25766	22	4750.83	I	2208 - 23251
40	4630.79	I	1663 - 23251	22	4751.53	I	10035 - 31075
170	4632.32	I	0 - 21581	28	4752.24	II	12260 - 33297
35	4633.60	II	7059 - 28634	22	4752.58	I	3100 - 24135
40	h 4636.74	II	5819 - 27380	55	4755.54	II	5819 - 26841
70	4640.86	I	3312 - 24853	110	4757.84	II	7713 - 28725
70	4641.06	I	2437 - 23978	16	4759.92	II	8804 - 29807
85	4643.17	I		65	4763.90	II	8278 - 29263
70	4644.20	II	8281 - 29807	22	4764.72	I	2208 - 23190
40	4647.28	II	2641 - 24153	100	4768.77	II	7012 - 27976
40	4647.38	II	5676 - 27187	230	4773.94	II	7455 - 28396
70	4649.88	I	0 - 21499	22	4775.08	I	1388 - 22325
110	4650.51	I	228 - 21725	16	4775.10	I	3312 - 24248
130	4654.29	II	4202 - 25682	28	4780.23	II	11949 - 32863
55	4659.40	II	3363 - 24819	40	4783.94	II	12763 - 33660
35	4659.94	II	7713 - 29167	28	4784.78	I	4199 - 25093
40	4663.24	II	12097 - 33535	28	4784.78	I	8904 - 29798
35	4665.28	II	9779 - 31208	35	4786.57	I	1663 - 22549
35	4666.71	II	4523 - 25945	45	4787.14	II	7092 - 27975
110	4669.50	II	11454 - 32864	55	4788.43	I	3976 - 24853
85	4670.74	II	5437 - 26841	35	4789.69	II	5969 - 26841
50	4670.89	I	3312 - 24715	45	4793.12	II	11340 - 32198
22	4670.91	I		65	4800.90	II	7293 - 28117
85	4674.49	I	1663 - 23049	45	4805.93	I	1388 - 22190

Cerium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28	4807.66	I	228 - 21023	19	4955.96	I	3976 - 24148
28	4807.66	I	6475 - 27269	28	4960.85	II	13659 - 33811
35	4808.50	I	4417 - 25208	19	4961.50	II	5617 - 25766
45	4820.03	I	2208 - 22949	19	4965.16	I	
28	4820.61	I	1388 - 22127	28	4966.37	I	7780 - 27910
110	4822.55	I	0 - 20730	28	4968.40	II	8176 - 28297
40	4834.05	I	2369 - 23049	28	4970.66	I	2208 - 22321
45	4835.63	II	7722 - 28396	130	4971.50	II	14404 - 34513
65	4836.71	I	1279 - 21948	28	4971.92	I	4746 - 24853
28	4837.48	I	3312 - 23978	45	4972.23	I	11517 - 31623
45	4843.06	I	2208 - 22851	28	4974.09	I	2378 - 22477
28	4844.29	II	6550 - 27187	45	4977.20	II	7294 - 27380
90	4845.53	I	0 - 20631	35	4984.42	II	8281 - 28338
55	4846.59	II	7722 - 28350	15	4984.57	II	7878 - 27935
140	4847.77	I	4762 - 25384	45	4986.37	II	8278 - 28327
55	4849.91	I	0 - 20613	45	4986.44	I	6238 - 26287
20	4850.20	II	11325 - 31937	65	4987.54	I	3196 - 23240
45	4852.62	I	6234 - 26836	35	4988.69	I	2437 - 22477
45	4852.62	I	3100 - 23701	55	4991.00	II	11310 - 31340
40	4853.59	I	3312 - 23909	45	4992.39	I	4173 - 24198
40	4858.72	II	9317 - 29893	130	4994.63	I	7780 - 27796
65	4859.50	I	2208 - 22781	45	4998.13	I	2208 - 22210
28	4861.74	I	228 - 20791	45	5002.78	II	8702 - 28686
22	4863.13	I		23	5004.81	I	4160 - 24135
65	4863.25	I	1663 - 22219	23	5006.42	I	6663 - 26632
35	4868.65	I	1279 - 21813	23	5006.42	I	4746 - 24715
65	4874.00	II	8928 - 29439	210	5009.10	I	3196 - 23154
35	4874.35	I	0 - 20509	100	5011.77	II	8449 - 28396
28	4881.54	I	228 - 20708	35	5012.52	I	5315 - 25260
180	4882.46	II	12326 - 32802	35	5013.74	I	
20	4886.18	I	9379 - 29839	23	5013.78	I	3312 - 23251
45	4889.59	I	1279 - 21725	19	5014.29	I	8603 - 28540
28	4891.88	I	3976 - 24412	19	5014.29	I	5409 - 25346
22	4892.85	I	228 - 20661	19	5016.48	I	7890 - 27819
90	4893.95	II	10704 - 31131	19	5016.48	I	3312 - 23240
35	4897.09	I	5315 - 25730	23	5016.55	I	0 - 19928
35	4898.20	I	3312 - 23722	65	5021.44	I	3976 - 23885
80	4899.90	I		120	5022.87	II	8424 - 28327
28	4901.67	I	228 - 20624	23	5025.15	I	4766 - 24660
28	d 4904.89	I	1279 - 21661	19	5027.34	II	11455 - 31340
20	4908.14	I	4766 - 25134	65	5028.33	I	1279 - 21161
45	4914.94	II	7092 - 27433	23	h 5030.64	I	3210 - 23083
55	4915.32	I	0 - 20338	35	5031.77	I	4173 - 24041
55	4915.32	I	7890 - 28229	35	5031.99	II	11341 - 31208
45	4915.66	I	6238 - 26576	23	5033.81	I	
28	4919.88	I	0 - 20320	19	5033.85	I	8603 - 28463
45	4920.80	I	4762 - 25078	45	h 5036.64	I	1388 - 21237
22	4921.92	I	4746 - 25058	120	5037.78	II	8131 - 27976
45	4924.25	I	1279 - 21581	23	5039.73	I	1663 - 21499
22	4924.90	I	6238 - 26538	35	5039.80	II	13027 - 32864
22	4928.09	II	7092 - 27379	23	5039.94	I	
13	4930.54	I	0 - 20276	120	5040.85	I	3764 - 23596
16	4930.70	I	2437 - 22713	35	5042.08	I	3312 - 23139
55	4939.12	I	1279 - 21520	15	5042.24	I	5519 - 25346
28	4939.65	I		23	5043.20	I	9379 - 29202
19	4940.39	I	4455 - 24691	180	5044.02	II	9772 - 29592
110	4943.44	I	9726 - 29949	65	5048.83	I	2369 - 22170
28	4943.83	II	7713 - 27935	35	5050.98	I	4455 - 24248
95	4944.61	II	8131 - 28350	23	5053.26	I	2378 - 22162
19	4948.68	I	3100 - 23301	35	5053.54	I	3100 - 22882
11	4948.72	I	4417 - 24619	55	5054.18	I	1279 - 21059
35	4949.53	II	15517 - 35716	35	5055.79	I	3976 - 23749
9	4951.90	I	2378 - 22567	45	5063.96	I	5802 - 25543
11	4951.94	I	5802 - 25990	95	5065.93	I	6809 - 26543
19	4954.02	I	2369 - 22549	35	5067.16	II	12762 - 32492

Cerium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
14	5071.50	I		45	5181.93	I	2369 - 21661
23	5071.55	I	1663 - 21375	35	5183.20	I	2437 - 21725
120	5071.78	I	7780 - 27491	35	5183.20	I	5572 - 24859
75	5074.72	I	4160 - 23860	370	5187.46	II	9772 - 29044
240	5075.35	II	8278 - 27976	19	5188.53	II	
65	5076.48	II	11458 - 31152	75	5188.66	I	
75	5077.85	II	11388 - 31076	35	5189.26	I	9379 - 28644
470	5079.68	II	11166 - 30847	210	5191.66	II	7012 - 26268
65	5080.47	I	1663 - 21340	65	5191.71	I	5802 - 25058
23	5083.55	I	4746 - 24412	19	5194.76	I	0 - 19244
23	5084.17	I	4762 - 24426	35	5200.11	I	3100 - 22325
19	5084.46	I	7174 - 26836	40	5200.40	I	2437 - 21661
35	5089.62	I	6856 - 26498	13	5200.46	I	7890 - 27114
35	5090.88	II	13659 - 33296	55	5201.36	I	0 - 19220
45	5091.73	I	1388 - 21023	45	5202.46	I	8055 - 27271
45	5091.73	I	6663 - 26297	45	5202.58	I	4746 - 23962
35	5093.37	I	3764 - 23391	55	5203.27	I	2369 - 21582
23	h 5097.26	I	3100 - 22713	55	5204.27	I	4417 - 23627
23	5099.38	I	1663 - 21267	35	5204.72	I	3976 - 23184
45	5111.61	I	4762 - 24320	35	5205.13	I	3312 - 22518
130	5112.70	I	4455 - 24009	35	5205.51	II	10058 - 29263
95	5115.24	I	4746 - 24290	35	5208.70	I	8400 - 27594
95	5115.24	I	7169 - 26713	28	5208.91	I	4199 - 23391
65	5115.65	I	5802 - 25344	28	5210.34	II	7713 - 26900
160	5117.17	II	11310 - 30847	35	5211.04	I	4762 - 23947
19	5117.95	II	10058 - 29592	190	5211.92	I	6809 - 25990
45	5118.88	I	3210 - 22740	35	5216.38	I	6475 - 25640
23	5119.46	I	7174 - 26702	45	5221.90	I	2437 - 21582
23	5119.46	I	6856 - 26384	45	5222.94	I	3976 - 23117
23	5119.51	I	5904 - 25431	260	5223.46	I	4762 - 23901
65	5120.78	I	4199 - 23722	19	5226.24	I	4766 - 23895
45	5121.36	I	9206 - 28726	19	5226.38	II	7713 - 26841
65	5122.39	I	2208 - 21725	180	5229.75	I	2208 - 21324
28	5122.68	I		45	5230.16	I	3210 - 22325
65	5125.01	I	4455 - 23962	55	5230.84	I	5315 - 24427
7	5127.93	I	8055 - 27551	140	5232.92	II	10646 - 29751
15	5128.02	I	7348 - 26843	19	5233.77	I	228 - 19330
170	5129.57	I		55	5234.02	II	8278 - 27379
55	5134.45	I	9379 - 28850	23	5235.77	II	11949 - 31043
35	d 5135.32	I	4417 - 23885	45	5237.07	II	10646 - 29735
45	5137.12	I	8235 - 27696	13	5238.47	I	3100 - 22184
23	5137.78	I	5802 - 25260	40	5238.50	I	1663 - 20747
23	5138.00	I	0 - 19457	19	5238.90	I	2437 - 21520
19	5139.77	I	1279 - 20730	17	5239.83	II	9317 - 28396
45	5140.50	I	2437 - 21885	19	5240.12	I	4173 - 23251
110	5147.57	II	10314 - 29735	65	5243.07	I	4173 - 23240
65	5149.66	I	1663 - 21076	95	5244.50	I	2437 - 21499
100	5149.99	I		19	5245.28	I	1279 - 20338
65	5150.39	I	2208 - 21619	260	5245.92	I	4762 - 23819
28	5153.91	I	6337 - 25734	19	5249.16	I	1663 - 20708
35	5153.99	I	4199 - 23596	35	5249.61	I	3312 - 22355
19	5154.39	II	6550 - 25945	35	5251.06	I	7933 - 26972
280	5159.69	I	5315 - 24691	55	5251.99	I	11850 - 30885
280	5159.69	I	2437 - 21813	19	5252.02	I	5006 - 24041
280	5159.69	I	7169 - 26545	75	5252.67	II	9317 - 28350
280	5161.48	I	7780 - 27149	19	5253.41	I	2369 - 21399
55	5163.27	II	11341 - 30703	55	5254.82	I	5802 - 24826
75	5164.38	I	8235 - 27593	28	5255.98	I	9333 - 28353
19	5169.23	I	4173 - 23513	28	5258.40	II	5651 - 24663
35	5169.72	I	228 - 19566	28	5259.92	I	2369 - 21375
190	5174.55	I		85	5261.70	I	3210 - 22210
19	5177.73	I	3210 - 22518	85	5264.18	I	4199 - 23190
28	5178.68	I	4417 - 23722	130	5265.71	II	10058 - 29044
75	5180.88	I	0 - 19296	35	5269.51	I	2369 - 21340
23	5181.75	I	3210 - 22503	15	5269.54	I	5006 - 23978

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	5271.04	I	4173 - 23139	28	5359.97	I	4199 - 22851
35	5271.81	I	3100 - 22063	6	5362.64	I	5572 - 24214
45	5271.86	I	4746 - 23709	9	5362.73	I	1388 - 20030
35	5271.92	I	8587 - 27551	75	5363.33	I	5519 - 24159
340	5274.23	II	8424 - 27379	75	5363.33	I	7467 - 26107
35	5275.79	II	10314 - 29263	15	5366.92	I	4455 - 23083
28	5276.24	I	8603 - 27551	23	5367.54	I	6809 - 25434
17	5277.52	I	0 - 18943	15	5368.05	I	4746 - 23370
15	5278.43	I	10673 - 29613	23	5369.07	I	2378 - 20998
17	5281.35	I	228 - 19158	15	5369.17	I	0 - 18619
35	5286.81	I	4173 - 23083	23	5370.31	I	5519 - 24135
45	5290.92	I	1279 - 20174	19	5371.56	I	0 - 18611
17	5291.29	I	3100 - 21993	23	5378.32	II	14276 - 32864
17	5291.29	I	7696 - 26589	28	5379.92	I	3976 - 22558
17	5292.45	I	4160 - 23049	11	5380.11	I	4199 - 22781
65	5294.05	I	4199 - 23083	35	5382.58	I	3312 - 21885
17	5294.95	I	4746 - 23627	15	5384.12	I	4173 - 22741
130	5296.56	I	3976 - 22851	75	5386.32	I	2437 - 20998
35	5298.26	I	2369 - 21237	55	5386.78	II	9779 - 28338
17	5299.16	I	5409 - 24274	19	5391.82	I	5904 - 24445
15	5302.11	I	5802 - 24658	23	5391.88	I	4199 - 22740
15	5303.08	I		300	5393.40	II	8897 - 27433
23	5303.32	I	2208 - 21059	55	5394.87	I	9462 - 27993
11	5303.33	I	1663 - 20513	35	5395.24	I	228 - 18758
23	5308.30	I	9135 - 27968	28	5395.70	I	4020 - 22549
23	5308.30	I	8101 - 26934	150	5397.64	I	2208 - 20730
65	5308.53	I	5315 - 24148	15	5397.99	I	7467 - 25987
13	5309.89	I	8055 - 26883	23	5399.06	I	5210 - 23727
13	5309.89	I	5904 - 24731	14	5399.56	I	7348 - 25863
35	5313.93	I	7174 - 25987	23	5399.60	I	3210 - 21725
35	5314.38	I	7890 - 26702	28	5401.21	I	3710 - 22219
23	5314.84	I	4160 - 22970	28	5401.21	I	6856 - 25365
23	5315.05	I	6234 - 25044	15	5402.56	I	5519 - 24024
19	5317.59	I	2437 - 21237	35	5404.36	I	7169 - 25668
35	5323.28	I	7933 - 26713	15	5406.65	II	13256 - 31747
130	5328.08	I	3976 - 22739	19	5407.67	I	3196 - 21683
35	5329.56	I	7780 - 26538	15	5408.36	I	6475 - 24960
190	5330.54	II	7012 - 25766	280	5409.23	II	8897 - 27379
28	5332.34	I	1663 - 20411	15	5411.54	I	6238 - 24712
17	5334.02	I	8101 - 26843	19	5411.76	I	3210 - 21683
17	5334.71	I	7696 - 26436	28	5414.11	I	4417 - 22882
75	5335.76	I	3210 - 21946	15	5417.83	II	8928 - 27380
65	5336.22	I	4455 - 23190	35	5418.70	I	1663 - 20112
17	5337.79	I		110	5420.38	I	4746 - 23190
15	5340.66	I	5006 - 23725	11	5421.29	I	6856 - 25297
7	5340.77	I	6238 - 24957	7	5421.38	I	12297 - 30738
17	5345.12	I	7841 - 26545	6	5422.16	I	6621 - 25059
23	5346.55	I	7933 - 26632	6	5422.23	I	4746 - 23184
23	5346.55	I	2208 - 20907	11	5422.26	I	5572 - 24009
35	5347.84	II	5969 - 24663	23	5423.43	I	4417 - 22851
15	5349.27	I	3196 - 21885	15	5426.37	I	228 - 18652
35	5350.53	I	7169 - 25854	15	5426.60	I	3196 - 21619
23	5350.65	I		23	5427.26	I	3764 - 22184
14	5350.72	I	8587 - 27271	13	5428.26	I	9379 - 27796
19	5351.37	I	3312 - 21993	11	5429.42	I	2378 - 20791
13	5352.22	I	5519 - 24198	8	5429.52	I	
23	5352.28	I	11030 - 29708	35	5430.25	I	6856 - 25266
450	5353.53	II	7092 - 25766	19	5430.53	I	5210 - 23620
55	5355.18	I	8603 - 27271	28	5431.41	I	5572 - 23978
23	5355.59	I	3210 - 21877	23	5433.34	I	3100 - 21499
15	5355.96	I	4417 - 23083	6	5436.04	I	5904 - 24294
45	5357.20	I	0 - 18661	9	5436.11	I	5572 - 23962
45	5357.20	I	4455 - 23117	28	5437.86	I	6234 - 24619
19	5359.26	I	2369 - 21023	19	5438.44	I	228 - 18611
23	5359.50	II	14387 - 33040	23	5445.43	I	228 - 18587

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
23	5446.18	I	3100 - 21456	35	5564.24	I	5315 - 23282
28	5446.45	I	7890 - 26245	170	5564.97	I	3196 - 21161
140	5449.24	I	5802 - 24148	28	5565.28	I	5006 - 22970
23	5450.03	I	4160 - 22503	130	5565.97	I	3764 - 21725
35	5451.74	I	5572 - 23909	19	5566.48	I	9830 - 27790
35	5453.96	I	4173 - 22503	45	5567.82	I	8587 - 26543
45	5456.39	I	1388 - 19711	13	5569.29	I	3210 - 21161
35	5457.20	I	4199 - 22518	19	5572.19	I	1388 - 19330
15	5457.86	I	4160 - 22477	6	5575.00	I	10879 - 28812
28	5458.83	I	0 - 18313	7	5575.11	I	8055 - 25987
55	5459.20	II	13028 - 31340	19	5577.28	I	6234 - 24159
45	5460.06	I	3210 - 21520	35	5578.28	I	8088 - 26010
9	5460.09	I	2437 - 20747	28	5578.90	I	3764 - 21683
55	5464.21	II	11455 - 29751	19	5582.69	I	4417 - 22325
95	5465.34	I	2369 - 20661	45	5582.73	I	1388 - 19296
140	5468.37	II	11310 - 29592	15	5584.61	I	3976 - 21877
140	5472.29	II	10058 - 28327	19	5584.66	I	2437 - 20338
28	5472.87	I	7174 - 25441	7	5586.62	I	6836 - 24731
28	5473.39	I	7841 - 26107	11	5586.74	I	
28	5473.53	I	1279 - 19544	13	5588.10	I	4173 - 22063
15	5477.41	I	6621 - 24873	28	5588.33	I	3210 - 21100
28	5478.62	I	1388 - 19636	9	5589.24	I	6663 - 24549
19	5481.15	I	5572 - 23811	9	5590.10	I	7890 - 25774
55	5481.97	I	6856 - 25093	13	5590.53	I	2437 - 20320
11	5483.39	I	5637 - 23869	15	5593.68	I	6663 - 24535
17	5483.50	I	5904 - 24135	13	5593.75	I	5519 - 23391
28	5491.15	I	5519 - 23725	65	5594.96	I	5315 - 23184
45	5498.16	I	3764 - 21946	100	5595.88	I	4455 - 22321
9	5506.10	I	4199 - 22355	35	5597.96	I	5572 - 23430
13	5506.46	I	5572 - 23727	23	5598.86	I	1388 - 19244
28	5510.68	I	4020 - 22162	240	5601.28	I	6809 - 24657
260	5512.08	II	8131 - 26268	19	5606.42	I	5409 - 23240
13	5513.12	II	11458 - 29592	19	5606.53	I	1388 - 19220
19	5514.21	I	6234 - 24364	11	5609.45	I	2378 - 20200
28	5516.08	II	13028 - 31152	75	5610.24	II	8449 - 26268
19	5517.39	I	8587 - 26707	45	5610.93	I	3764 - 21581
9	5517.84	I	6234 - 24352	35	5613.69	II	11455 - 29263
55	5518.47	II	9317 - 27433	75	5614.72	I	2369 - 20174
35	5522.46	I	4455 - 22558	17	5615.98	I	3196 - 20998
13	5526.08	I	5210 - 23301	9	5616.53	I	7467 - 25266
35	5526.85	II	4201 - 22290	17	5620.38	I	3210 - 20998
23	5527.18	I	3976 - 22063	9	5622.68	I	8270 - 26050
95	5535.23	I	3100 - 21161	13	5623.00	II	4511 - 22290
35	5537.54	I	3100 - 21153	11	5623.74	I	228 - 18005
28	5540.54	I	8307 - 26351	11	5625.25	I	4746 - 22518
15	5542.71	I	5637 - 23673	11	5628.21	I	6856 - 24619
13	5542.87	I	8509 - 26545	28	5632.49	I	6663 - 24412
19	5544.62	I	4160 - 22190	17	5633.04	I	4199 - 21946
19	5546.51	I	5572 - 23596	28	5633.10	I	3312 - 21059
13	5547.50	I	6303 - 24325	11	5634.44	I	1663 - 19406
65	5548.80	I	1279 - 19296	7	5634.52	I	6621 - 24364
35	5550.04	II	10314 - 28327	45	5637.35	II	11310 - 29044
19	5550.66	I	4173 - 22184	35	5638.20	I	0 - 17731
13	5551.41	I	0 - 18008	11	5638.42	I	5409 - 23139
9	5552.27	I	0 - 18005	11	5638.63	I	0 - 17729
110	5556.25	I	4746 - 22739	19	5640.10	I	4160 - 21885
55	5556.95	II	14625 - 32616	11	5640.79	I	5210 - 22933
13	5558.65	I	4199 - 22184	35	5646.58	I	4020 - 21725
55	5559.20	I	4455 - 22438	45	5650.59	I	4746 - 22438
6	5560.01	I	8991 - 26972	11	5652.98	I	
7	5560.10	I	9333 - 27313	190	5655.14	I	4199 - 21877
15	5561.45	II	11760 - 29735	11	5656.18	I	8055 - 25730
6	5562.13	I	2437 - 20411	11	5659.79	I	1279 - 18943
7	5562.20	I	1663 - 19636	11	5663.20	I	4160 - 21813
45	5563.02	I	7715 - 25686	13	5663.46	I	2378 - 20030

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	5663.98	I	5802 - 23452	23	5773.59	I	0 - 17315
19	5664.69	I	7696 - 25344	19	5774.99	I	3100 - 20411
9	5665.41	I	4417 - 22063	13	5775.80	II	15576 - 32885
95	5668.92	II	8131 - 25766	35	5782.42	I	8055 - 25344
240	5669.96	I	3210 - 20842	13	5782.78	I	3210 - 20498
11	5671.42	I	6663 - 24290	13	5783.99	II	11760 - 29044
35	5671.89	I	1388 - 19014	45	5784.86	I	6663 - 23944
23	5675.12	I	0 - 17615	11	5786.87	I	7169 - 24445
55	5676.87	I	7933 - 25544	13	5787.20	I	7933 - 25208
11	5677.22	I	4746 - 22355	120	5788.15	I	8587 - 25859
120	5677.75	I	4455 - 22063	11	5791.34	I	5097 - 22360
11	5679.03	II	13527 - 31131	17	5791.66	I	5519 - 22781
17	5680.26	II	2382 - 19982	9	5794.79	I	3710 - 20962
11	5682.76	I	1279 - 18871	35	5796.09	I	7467 - 24715
13	5683.11	II	15235 - 32826	19	5799.79	II	3703 - 20940
28	5683.76	II	11455 - 29044	95	5804.43	I	2437 - 19661
45	5685.84	II	15281 - 32864	55	5810.73	I	8055 - 25260
11	5687.82	I	6234 - 23811	11	5811.84	I	7348 - 24549
23	5688.49	I	4746 - 22321	120	5812.92	I	4455 - 21654
11	5691.47	II	5010 - 22576	11	5815.47	I	3974 - 21165
23	5692.12	I	5409 - 22972	28	5817.78	II	8176 - 25360
120	5692.94	I	3764 - 21324	45	5820.37	I	6337 - 23513
23	5695.66	I	4160 - 21712	55	5822.98	I	5572 - 22740
75	5695.84	II	13117 - 30669	11	5823.46	II	15822 - 32989
300	5696.99	I	5315 - 22864	13	5829.96	I	4020 - 21168
370	5699.23	I	6809 - 24350	19	5830.13	I	0 - 17147
55	5702.39	I	3100 - 20631	19	5831.38	I	7933 - 25077
35	5703.22	II	10820 - 28349	95	5831.91	I	3196 - 20338
17	5709.06	I	5572 - 23083	19	5834.24	I	3210 - 20346
9	5710.04	I	6856 - 24364	95	5835.84	I	7696 - 24826
45	5711.43	II	11760 - 29263	75	5838.15	I	3976 - 21100
17	5712.29	I	4160 - 21661	35	5839.36	I	0 - 17120
35	5715.25	II	12457 - 29949	11	5843.10	I	3210 - 20320
35	5716.46	I	6836 - 24325	35	5843.73	I	4160 - 21267
11	5718.36	I	1388 - 18871	6	5845.96	I	
11	5718.58	II	15134 - 32616	14	5846.08	I	7174 - 24274
240	5719.03	I	5802 - 23282	35	5848.32	I	7467 - 24561
9	5719.54	I	1279 - 18758	11	5848.84	II	14252 - 31345
35	5721.96	I	2208 - 19680	28	5851.02	I	1279 - 18365
95	5725.83	I	4417 - 21877	23	5851.10	I	8991 - 26077
17	5726.13	I	4160 - 21619	35	5853.06	I	5210 - 22291
19	5727.25	II	17571 - 35026	23	5853.34	I	3196 - 20276
9	5729.34	I	5210 - 22660	35	5853.67	I	2378 - 19457
7	5729.42	I	8509 - 25958	45	5857.11	I	4199 - 21267
17	5733.94	I	3196 - 20631	23	5858.14	I	3210 - 20276
19	5735.69	I	5519 - 22949	19	5858.56	II	10314 - 27379
95	5743.53	I	2437 - 19843	45	5859.37	I	5802 - 22864
19	5744.68	I	8587 - 25990	95	5862.49	I	4173 - 21226
11	5746.46	I	3764 - 21161	11	5870.85	I	6856 - 23885
9	5748.26	I	7174 - 24565	75	5871.59	I	2208 - 19235
17	5748.94	I	3764 - 21153	13	5873.90	I	2437 - 19457
11	5752.50	I	8055 - 25434	11	5878.03	I	3312 - 20320
35	5758.11	I	7696 - 25058	11	5878.14	II	14739 - 31747
35	5758.29	I	7174 - 24535	23	5878.90	I	5315 - 22321
9	5760.59	I	4020 - 21375	13	5879.03	II	15859 - 32864
11	5763.00	II	28096 - 45443	19	5888.52	I	9830 - 26808
23	5764.77	I	2369 - 19711	13	5892.47	I	3764 - 20730
23	5765.33	I	1279 - 18619	35	5893.19	I	6663 - 23627
75	5768.90	II	10646 - 27976	11	5897.75	I	5409 - 22360
23	5769.93	I	4173 - 21499	13	5898.08	II	7713 - 24663
35	5770.40	I	5519 - 22844	11	5899.71	I	7467 - 24412
13	5771.98	II	10058 - 27379	11	5900.68	I	0 - 16942
35	5772.22	I	3312 - 20631	23	5901.29	I	5904 - 22844
45	5772.88	I	1388 - 18706	13	5901.39	I	8603 - 25544
140	5773.12	I	4746 - 22063	23	5905.99	I	2369 - 19296

*Cerium — all observed lines — Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
11	5907.49	I	8270 - 25193	35	6035.49	II	13028 - 29592
55	5909.86	I	4160 - 21076	110	6043.39	II	9726 - 26268
55	5910.12	I	1279 - 18194	28	6045.42	I	7348 - 23885
45	5912.92	I	4746 - 21654	55	6047.40	I	3312 - 19843
11	5914.82	I	3210 - 20112	19	6051.80	II	1873 - 18393
45	5920.42	I	4173 - 21059	23	6057.50	I	1388 - 17892
23	5924.04	I	2369 - 19244	35	6058.00	I	2369 - 18871
19	5924.90	II	10641 - 27515	23	6066.75	I	1663 - 18141
55	5926.31	I	0 - 16869	9	6068.64	I	6809 - 23282
85	5928.35	I	2208 - 19072	19	6069.46	I	12960 - 29432
19	5929.50	I	4199 - 21059	35	6069.48	I	7696 - 24167
28	5929.82	I	4455 - 21314	35	6072.00	I	3196 - 19661
23	5932.16	I	3210 - 20063	35	6076.61	I	7696 - 24148
17	5933.58	II	2634 - 19483	17	6077.16	I	3210 - 19661
55	5934.32	I	8587 - 25434	17	6080.37	I	12114 - 28555
40	5934.45	I	7715 - 24561	17	6081.28	I	228 - 16668
95	5937.72	I	3976 - 20812	19	6088.86	I	
19	5938.44	I	4746 - 21581	19	6088.96	I	11810 - 28229
230	5940.86	I	3764 - 20591	35	6093.19	I	6475 - 22882
28	5941.54	II	8927 - 25753	45	6098.34	II	14276 - 30670
28	5942.67	I	228 - 17051	11	6099.80	I	2369 - 18758
28	5944.86	I	6475 - 23292	28	6108.74	II	13527 - 29893
23	5947.64	I	4417 - 21226	9	6111.82	I	5637 - 21994
23	5950.61	I	3312 - 20112	7	6111.92	I	8055 - 24412
11	5951.21	I	4199 - 20998	15	6118.56	I	7174 - 23513
9	5956.68	I	9462 - 26245	17	6118.90	I	5315 - 21654
14	5956.84	I	8991 - 25774	9	6119.81	I	1663 - 17998
35	5959.69	II	13118 - 29893	45	6123.67	I	7841 - 24167
9	5960.70	II	14252 - 31024	9	6124.25	I	7890 - 24214
13	5960.87	I	8055 - 24826	9	6130.15	I	13124 - 29432
11	5963.33	I	1663 - 18427	19	6132.00	II	14827 - 31130
8	5964.62	I	5409 - 22170	19	6132.18	I	
8	5964.64	I		11	6135.45	I	7715 - 24009
28	5966.18	I	5802 - 22558	7	6135.55	I	13939 - 30233
45	5966.33	I	5904 - 22660	9	6137.23	I	15131 - 31421
28	5972.09	I	15333 - 32073	23	6139.03	I	
11	5972.79	I	5210 - 21948	15	6142.92	I	4455 - 20730
75	5975.87	II	10704 - 27433	35	6143.36	II	13676 - 29949
35	5975.98	I	1279 - 18008	23	6146.43	I	6475 - 22740
19	5979.37	I	1279 - 17998	19	6147.84	I	5802 - 22063
11	5981.20	I	13572 - 30286	9	6149.56	I	4766 - 21023
45	5989.38	I	3100 - 19791	23	6151.72	I	4160 - 20411
45	5992.67	I	4417 - 21100	19	6159.82	I	7715 - 23944
35	5995.26	II	10704 - 27379	19	6162.14	I	2437 - 18661
35	5995.45	II	13218 - 29893	19	6165.45	I	12707 - 28922
19	5997.03	II	16192 - 32862	7	6172.84	I	14310 - 30505
11	6000.18	I	1663 - 18324	7	6172.86	I	13902 - 30098
55	6001.90	I	8603 - 25260	19	6175.28	I	12366 - 28555
4	6003.62	I		35	6186.17	I	8400 - 24561
7	6003.68	I	11061 - 27713	9	6186.93	I	11850 - 28008
55	6005.86	I	2369 - 19014	15	6187.97	I	228 - 16384
15	6006.20	I	228 - 16873	15	6195.23	I	3210 - 19347
55	6006.82	I	4199 - 20842	19	6195.53	I	4455 - 20591
19	6007.37	I	7169 - 23811	19	6198.05	I	13605 - 29734
75	6013.42	I	2437 - 19062	35	6208.98	I	9333 - 25434
23	6016.59	I	1279 - 17895	9	6209.56	I	3196 - 19296
4	6018.78	I	1388 - 17998	9	6211.05	I	4746 - 20842
6	6018.82	I		3	6212.29	I	8055 - 24148
9	6020.60	I	4160 - 20765	7	6212.49	I	
110	6024.20	I	3196 - 19791	11	6216.82	I	
15	6027.16	I	4160 - 20747	9	6223.25	I	1279 - 17343
11	6031.26	I	5006 - 21582	9	6228.23	I	0 - 16051
23	6033.58	II	17475 - 34044	35	6228.94	I	
35	6034.20	II	11760 - 28327	19	6229.13	I	
23	6034.41	I	5097 - 21664	23	6232.45	II	9726 - 25766



Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28	6237.45	I	3764 - 19791	6	6534.51	I	3312 - 18611
13	6238.71	I	3210 - 19235	7	6537.49	II	15859 - 31152
11	6241.87	I	0 - 16016	19	6551.70	I	3976 - 19235
3	6241.95	I	4766 - 20782	45	6555.65	I	6475 - 21725
13	6242.91	I		6	6560.79	I	3312 - 18550
15	6253.65	I	2208 - 18194	7	6563.46	I	
9	6256.36	I	12960 - 28940	7	6565.67	I	8400 - 23627
13	6257.99	I	13124 - 29099	9	6573.60	I	6475 - 21683
15	6264.27	I	13605 - 29564	5	6577.45	I	1388 - 16588
9	6270.28	I	7348 - 23292	23	6579.10	I	
45	6272.05	II	12457 - 28396	7	6599.63	I	4199 - 19347
15	6276.47	I	2437 - 18365	7	6605.35	I	2208 - 17343
7	6286.39	I	7467 - 23370	15	6606.35	I	2378 - 17511
7	6286.43	I	14609 - 30511	15	6606.86	II	13218 - 28350
35	6295.58	I	0 - 15879	22	6612.06	I	
28	6299.51	II	15282 - 31152	10	6623.00	I	3100 - 18194
23	6300.21	I	1279 - 17147	30	6628.93	I	2208 - 17289
13	6306.64	I	3210 - 19062	13	6650.89	I	15491 - 30523
35	6310.01	I	0 - 15843	4	6651.43	I	5315 - 20346
5	6317.95	I	15396 - 31219	3	6651.51	I	1663 - 16693
4	6317.99	I	6303 - 22127	22	6652.72	II	12326 - 27353
8	6331.97	I	228 - 16017	10	6661.41	I	7348 - 22355
9	6335.36	I	3764 - 19544	13	6665.59	I	3196 - 18194
15	6335.40	I		10	6675.54	II	12457 - 27433
11	6337.21	I	1663 - 17438	7	6679.80	I	3976 - 18942
13	6340.70	I	8400 - 24167	7	6679.88	I	4020 - 18987
35	6343.95	II	2634 - 18393	15	6686.60	I	12960 - 27912
6	6353.48	I	6475 - 22210	26	6700.66	I	12960 - 27880
6	6360.22	I		35	6704.27	I	2208 - 17120
35	6371.11	II	12705 - 28396	13	6704.52	II	19950 - 34861
6	6372.99	I	2208 - 17895	10	6706.04	II	14827 - 29735
4	6386.10	I	12467 - 28122	3	6710.09	I	3100 - 17998
5	6386.26	I	5572 - 21226	7	6713.47	I	4455 - 19347
28	6386.84	I	12114 - 27766	9	6720.28	II	14387 - 29263
7	6390.32	I	4199 - 19843	3	6726.54	I	7696 - 22558
23	6393.02	II	11742 - 27379	15	6728.71	I	2208 - 17066
11	6395.16	I		15	6729.57	I	3764 - 18619
7	6396.22	I	2369 - 17998	4	6733.21	II	15822 - 30669
4	6396.27	I	14027 - 29657	15	6744.70	II	13527 - 28350
6	6399.90	I	13124 - 28744	10	6746.90	I	13939 - 28757
3	6399.94	I	6856 - 22477	4	6749.38	I	9996 - 24808
11	6425.29	II	17976 - 33535	7	6749.49	I	3196 - 18008
35	6430.07	I		4	6755.08	II	13527 - 28327
19	6434.39	I	228 - 15766	6	6764.45	I	7348 - 22127
23	6436.40	I	3764 - 19296	6	6767.68	I	1279 - 16051
8	6439.97	I	2369 - 17892	4	6770.15	I	8603 - 23370
19	6446.12	I	14027 - 29536	30	6774.28	II	13218 - 27975
6	6451.99	I		35	6775.59	I	12114 - 26868
35	6458.03	I	1388 - 16869	10	6778.28	I	0 - 14748
8	6461.88	I	3764 - 19235	9	6780.21	II	
19	6466.88	II	14276 - 29735	9	6780.71	I	4199 - 18943
28	6467.39	I	2437 - 17895	6	6793.84	I	13194 - 27910
6	6468.97	II	7746 - 23200	5	6801.72	I	4173 - 18871
35	6473.72	I		5	6803.28	I	2208 - 16903
17	6490.97	I	6663 - 22064	18	6807.81	I	3210 - 17895
6	6494.94	I	7348 - 22740	10	6808.82	I	2437 - 17120
11	6503.27	II	17000 - 32372	6	6811.62	I	7841 - 22518
4	6503.98	I	3976 - 19347	9	6815.29	I	11061 - 25730
4	6504.12	I	4173 - 19544	15	6818.23	I	1388 - 16051
11	6507.16	II	14387 - 29751	7	6826.44	I	4417 - 19062
7	6509.01	I	228 - 15587	7	6829.38	II	4844 - 19483
23	6513.59	II	14387 - 29735	10	6829.73	II	14626 - 29263
19	6517.31	I	3210 - 18550	6	6834.24	II	12751 - 27379
6	6519.12	I	13605 - 28940	2	6839.92	I	6621 - 21237
6	6530.68	I	3764 - 19072	3	6839.97	I	10318 - 24934

Cerium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
4	6844.26	I	4455 - 19062	16	7235.71	II	
4	6844.48	II	16545 - 31151	22	7238.36	II	12457 - 26268
7	6846.78	II	15134 - 29735	12	7241.73	I	7715 - 21520
13	6847.25	I	1279 - 15879	25	7252.75	I	
9	6853.59	I	8603 - 23190	12	7262.64	I	5802 - 19567
12	6856.55	I	8603 - 23184	11	7277.90	I	2208 - 15945
3	6885.49	I	4173 - 18692	6	7279.94	I	3976 - 17708
2	6885.71	I	1279 - 15798	11	7296.17	I	2378 - 16080
10	6893.66	I	12366 - 26868	19	7301.42	II	14404 - 28096
7	6894.56	I	2369 - 16869	19	7313.45	II	15594 - 29263
10	6898.45	II	18393 - 32885	25	7329.91	I	13214 - 26853
9	6899.06	I	2208 - 16699	16	7334.68	II	19481 - 33111
6	6904.58	I	7841 - 22321	12	7343.44	I	2437 - 16051
4	6909.35	I	7715 - 22184	6	7345.62	I	4160 - 17770
9	6919.27	II	13527 - 27976	6	7361.89	I	3764 - 17343
30	6924.81	I	6663 - 21100	6	7362.40	I	2437 - 16016
10	6939.45	I	228 - 14635	4	7363.09	I	1663 - 15240
2	6970.40	I	7841 - 22184	2	7363.19	I	12720 - 26297
2	6970.53	I	3710 - 18052	6	7372.54	I	
19	6973.50	II	18704 - 33040	6	7383.74	I	9830 - 23370
10	6983.82	II	13118 - 27433	9	7390.46	II	0 - 13527
30	6986.02	I	228 - 14539	6	7393.40	I	4762 - 18284
9	6999.89	I	1663 - 15945	25	7397.77	I	0 - 13513
9	6999.93	I	1279 - 15561	11	7401.27	I	2437 - 15945
6	7013.35	I	6475 - 20730	12	7417.94	II	2382 - 15859
6	7014.81	I	5315 - 19567	6	7421.00	I	3196 - 16668
7	7017.24	I	3974 - 18221	11	7424.70	CeO	
4	7018.72	I	4417 - 18661	12	7433.08	I	4199 - 17649
4	7018.79	I	17147 - 31391	11	7438.56	I	4455 - 17895
6	7031.00	I		6	7440.49	I	2208 - 15644
6	7031.05	I		12	7444.44	I	2369 - 15798
6	7049.61	I	7696 - 21877	6	7458.42	II	15859 - 29263
6	7049.73	I	4020 - 18201	9	7462.32	I	2369 - 15766
12	7054.51	I	12366 - 26538	10	7472.41	I	14743 - 28122
11	7058.68	II	2382 - 16545	6	7478.71	I	3976 - 17343
11	7060.00	I	14743 - 28904	16	7486.57	II	20554 - 33908
35	7061.75	II	15594 - 29751	9	7500.70	I	2437 - 15766
11	7064.49	I	8587 - 22739	6	7508.13	I	8904 - 22219
35	7086.35	II	17232 - 31340	9	7509.49	I	7348 - 20661
11	7105.04	II	4322 - 18393	11	7527.46	I	11796 - 25077
7	7113.17	I	9830 - 23885	11	7527.68	I	
11	7115.08	II	14276 - 28327	10	7533.73	I	5802 - 19072
7	7120.86	II	5942 - 19982	4	7539.52	I	1279 - 14539
6	7123.44	I	6475 - 20509	4	7539.58	I	5572 - 18831
10	7124.73	I	4020 - 18052	10	7551.25	I	4199 - 17438
7	7132.07	II	5964 - 19982	12	7562.44	I	
7	7136.08	I	8055 - 22064	10	7562.86	I	2369 - 15587
16	7141.42	I	3976 - 17975	10	7563.60	I	7841 - 21059
7	7141.68	I	1279 - 15277	9	7586.01	I	5409 - 18587
19	7150.23	II	15282 - 29263	10	7603.10	I	4746 - 17895
10	7151.67	I	2369 - 16347	25	7616.11	II	12365 - 25492
16	7155.25	I	14531 - 28503	7	7632.55	I	8055 - 21153
16	7156.99	II	4511 - 18479	12	7646.08	I	4455 - 17530
7	7175.00	II	4459 - 18393	10	7647.88	I	6856 - 19928
7	7177.44	I	6663 - 20591	7	7663.39	II	15282 - 28327
7	7182.30	I	5315 - 19235	7	7670.76	II	
6	7186.20	II	18704 - 32616	7	7678.13	I	9830 - 22851
16	7189.40	II	13527 - 27433	12	7682.47	I	3210 - 16223
10	7191.72	I	2437 - 16338	25	7689.17	II	12751 - 25753
11	7201.56	II	4511 - 18393	9	7702.84	I	5315 - 18294
16	7201.89	I	0 - 13881	6	7717.68	II	1873 - 14827
10	7203.55	I	5802 - 19680	6	7724.61	II	14963 - 27905
12	7210.67	I	3210 - 17075	10	7732.33	I	3764 - 16693
6	7213.92	I	2208 - 16066	5	7741.43	II	19950 - 32864
19	7217.36	I	1388 - 15240	4	7743.77	I	9830 - 22740

Cerium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
4	7746.65	II	3363 - 16268	5	8079.37	I	4746 - 17120
16	7748.35	I	4746 - 17649	10	8094.43	I	3210 - 15561
4	7752.86	II	2634 - 15529	16	8120.36	I	2437 - 14748
5	7762.95	I	4173 - 17051	6	8171.39	I	1279 - 13513
6	7769.75	I	4199 - 17066	5	8175.59	II	3594 - 15822
5	7785.10	II	7713 - 20554	5	8199.29	I	6234 - 18427
10	7797.70	I	3196 - 16017	9	8220.70	I	3210 - 15371
4	7806.80	I	3210 - 16016	7	8223.61	I	4746 - 16903
7	7812.70	I	5802 - 18598	7	8224.29	II	3704 - 15859
9	7835.88	I	6809 - 19567	6	8239.48	I	6809 - 18942
4	7838.38	II	19481 - 32235	10	8241.55	II	988 - 13118
12	7842.59	I	1388 - 14136	7	8245.20	I	1388 - 13513
22	7844.94	II	14963 - 27706	5	8246.82	I	11061 - 23184
16	7850.02	II	5969 - 18704	6	8250.64	II	1410 - 13527
16	7851.18	II	15594 - 28327	12	8261.09	I	2437 - 14539
22	7857.54	II	7259 - 19982	2	8300.59	I	3196 - 15240
12	7864.49	I	5315 - 18027	2	8300.73	I	5572 - 17615
10	7866.04	I	1388 - 14098	9	8310.23	I	3210 - 15240
2	7874.13	I	10673 - 23370	7	8312.34	I	4173 - 16200
2	7874.22	I	7715 - 20411	5	h 8327.67	II	2382 - 14387
16	7898.96	II	7293 - 19950	6	8355.15	II	18704 - 30669
11	7913.52	I	6663 - 19296	9	8396.39	I	5802 - 17708
10	7927.30	CeO		6	d 8405.25	II	2382 - 14276
10	7927.72	I	4455 - 17066	16	8418.23	II	6517 - 18393
10	7934.50	II	15517 - 28117	11	8495.82	I	2369 - 14136
5	7953.61	I	7841 - 20411	6	h 8511.36	I	
9	7972.11	I	2208 - 14748	9	h 8523.34	I	2369 - 14098
7	7972.34	II	988 - 13527	12	8539.08	II	1410 - 13118
9	8002.56	I		9	h 8564.58	I	2208 - 13881
9	8002.70	I	7348 - 19840	7	h 8567.48	I	3976 - 15644
30	8025.56	II	0 - 12457	10	8612.64	I	3764 - 15371
5	8030.69	II	3704 - 16152	10	h 8647.66	I	4455 - 16016
5	8031.45	I	4455 - 16903	11	h 8702.38	II	3794 - 15282
6	8040.02	I	3210 - 15644	7	8716.66	II	988 - 12457
5	h 8066.91	I	5315 - 17708	25	8772.14	II	2880 - 14276
16	8070.71	I	4199 - 16586	9	8782.17	I	5315 - 16699
				12	8810.84	I	2437 - 13784
				30	8891.20	II	1874 - 13118

## Cesium

$$\text{Cs, } Z = 55, M = 132.9055, \text{ Ratio } \frac{\text{Cs}}{\text{Cu}} = 2.091$$

Cs I Normal state of valence electrons  $5p^6 6s^2 S_{1/2} = 0$ . I.P. = 31407  $\text{cm}^{-1}$ .

Cs II Normal state of valence electrons  $5p^6 ^1S_0 = 0$ . I.P. = 186600  $\text{cm}^{-1}$ .

### References

Wavelengths and Classification:

H. Kleiman, J. Opt. Soc. Am. **52**, 441 (1962).

*Cesium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
400	4555.31	I	0 - 21946	200	hs	6723.29	I 11178 - 26048
200	4593.20	I	0 - 21765	200	hs	6973.30	I 11732 - 26069
30	hs	I	11178 - 28829	35		6983.49	I 11732 - 26048
25	hs	I	11732 - 28836	40		7608.90	I 11178 - 24317
80	hs	I	11178 - 27811	60	hl	8015.72	I 14499 - 26971
14	h	I	11732 - 28300	80	hl	8079.03	I 14597 - 26971
120	hs	I	11732 - 27823	15000		8521.24	I 0 - 11732
8		I	11732 - 27811	550		8761.42	I 11178 - 22589
25	h	I	11178 - 26911	8000		8943.59	I 0 - 11178
30	h	I	11732 - 26911				

# Chromium

$$\text{Cr, } Z = 24, M = 51.996, \text{ Ratio } \frac{\text{Cr}}{\text{Cu}} = 0.8182$$

Cr I Normal state of valence electrons  $3d^5 4s^1 S_3 = 0$ . I.P. = 54570  $\text{cm}^{-1}$ .

Cr II Normal state of valence electrons  $3d^5 6S_{21/2} = 0$ . I.P. = 133060  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented by lines from Kiess (below).

### Classification:

Cr I, C. C. Kiess, J. Research NBS **51**, 247 (1953) RP 2457.

Cr II, C. C. Kiess, J. Research NBS **47**, 385 (1951) RP 2266.

### *Strong lines of chromium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
20000	4254.35	I	0 - 23499	2300	4351.77	I	8308 - 31280
19000	2055.52	II	0 - 48632	2100	2986.47	I	8308 - 41782
19000	3578.69	I	0 - 27935	1900	3919.16	I	8308 - 33816
17000	3593.49	I	0 - 27820	1900	3963.69	I	20520 - 45741
16000	4274.80	I	0 - 23386	1900	4344.51	I	8095 - 31106
14000	2061.49	II	0 - 48491	1800	2677.16	II	12304 - 49646
13000	3605.33	I	0 - 27729			II	12497 - 49838
11000	5208.44	I	7593 - 26788	1700	2843.25	II	12304 - 47465
10000	4289.72	I	0 - 23305	1600	3969.75	I	20524 - 45707
8900	2065.42	II	0 - 48399	1600	3976.66	I	20524 - 45663
8400	5206.04	I	7593 - 26796	1600	4646.17	I	8308 - 29825
5300	5204.52	I	7593 - 26802	1500	2986.00	I	8095 - 41575
2800	3017.57	I	8095 - 41225	1400	3014.92	I	7927 - 41086
2800	3021.56	I	8308 - 41393	1400	5409.79	I	8308 - 26787
2500	2835.63	II	12497 - 47752	1200	2849.84	II	12148 - 47228

## Chromium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
19000	2055.52	II	0 - 48632	35	2709.31	II	33418 - 70317
14000	2061.49	II	0 - 48491	140	2712.31	II	12148 - 49006
8900	2065.42	II	0 - 48399	45	2716.18	I	8308 - 45113
80	2364.71	I	0 - 42275	55	2717.51	II	31083 - 67871
130	2383.33	I	8308 - 50253	45	2718.43	II	31532 - 68306
140	2408.62	I	8308 - 49812	170	2722.75	II	12033 - 48750
170	2496.31	I	7927 - 47975	18	2724.04	II	31169 - 67868
110	2502.53	I	8095 - 48043	420	2726.51	I	7593 - 44259
190	2504.31	I	8095 - 48014	45	2727.26	II	31219 - 67876
50	2508.11	I	7927 - 47786	280	2731.91	I	7593 - 44187
60	2508.98	I	7927 - 47772	170	2736.47	I	7593 - 44126
40	2513.62	I	8095 - 47866	70	2739.38	I	23934 - 60428
110	2516.92	I	8095 - 47814	70	2740.10	II	12148 - 48632
80	2518.71	I	8095 - 47786	95	2741.07	I	24056 - 60528
390	2519.52	I	8308 - 47986	95	2742.03	II	12033 - 48491
190	2527.12	I	8308 - 47866	95	2742.17	I	24200 - 60657
40	2530.45	I	8308 - 47814	250	2743.64	II	11962 - 48399
70	2534.34	II	12497 - 51943	35	2746.21	II	29952 - 66355
50	2545.64	I	7751 - 47022			II	38315 - 74718
160	2549.54	I	7811 - 47022	110	2748.29	I	7751 - 44126
40	2553.06	I	7811 - 46968	330	2748.98	II	12033 - 48399
80	2557.15	I	7927 - 47022	390	2750.73	II	12148 - 48491
130	2560.69	I	7927 - 46968	45	2751.60	I	7927 - 44259
150	2571.74	I	8095 - 46968	280	2751.87	II	12304 - 48632
100	2577.65	I	8095 - 46878	110	2752.88	I	7811 - 44126
50	2588.20	I	8095 - 46720	35	2754.28	II	31083 - 67380
380	2591.85	I	8308 - 46878	22	2754.90	I	24834 - 61123
35	2603.57	I	8308 - 46705	22	2755.27	I	
35	2622.86	I	8308 - 46422	22	2756.75	I	24897 - 61161
22	2625.32	I	8095 - 46174	150	2757.10	I	7927 - 44187
18	2626.60	I	8308 - 46368	350	2757.72	II	12148 - 48399
18	2629.82	I	8095 - 46109	60	2758.98	II	38270 - 74505
35	2642.12	I	24200 - 62037	80	2759.39	II	31219 - 67449
250	2653.59	II	12033 - 49706	45	2759.73	II	31169 - 67394
250	2658.59	II	11962 - 49565	90	2761.76	I	7927 - 44126
70	2661.73	II	12148 - 49706	750	2762.59	II	12304 - 48491
320	2663.42	II	12304 - 49838	22	2763.06	I	27817 - 63998
70	2663.68	II	11962 - 49493	80	2764.35	I	8095 - 44259
440	2666.02	II	12148 - 49646	750	2766.54	II	12497 - 48632
280	2668.71	II	12033 - 49493	22	2767.54	I	25038 - 61161
350	2671.81	II	12148 - 49565	250	2769.92	I	8095 - 44187
280	2672.83	II	12304 - 49706	18	2771.45	I	23934 - 60005
1800	2677.16	II	12304 - 49646	45	2778.06	II	39825 - 75810
		II	12497 - 49838	22	2779.14	I	25106 - 61078
35	2678.16	I	7927 - 45255	80	2780.30	II	33521 - 69478
320	2678.79	II	12033 - 49352			II	38363 - 74319
18	2680.34	II	40415 - 77714	610	2780.70	I	8308 - 44259
230	2687.09	II	12148 - 49352	70	2785.70	II	33619 - 69506
60	2688.04	I	8095 - 45286	35	2787.63	II	30865 - 66727
55	2688.29	II	30157 - 67344	35	2787.84	I	
26	2690.26	I	8095 - 45255	90	2792.16	II	33694 - 69498
280	2691.04	II	12497 - 49646	55	2798.67	II	
35	2693.52	II	30219 - 67334	70	2800.77	II	33694 - 69388
35	2697.91	II	30299 - 67354	80	2812.01	II	33619 - 69171
		II	39825 - 76879			II	38563 - 74114
180	2698.41	II	12304 - 49352	60	2818.36	II	33521 - 68993
180	2698.69	II	11962 - 49006	45	2822.01	II	33418 - 68844
18	2700.60	I	8095 - 45113	180	2822.37	II	30392 - 65813
110	2701.99	I	8308 - 45306	22	2826.75	I	27817 - 63183
18	2702.53	I	24200 - 61191	180	2830.47	II	30299 - 65618
70	2703.48	I	8308 - 45286	70	2834.26	II	34631 - 69903
	2703.55	II	30392 - 67369	2500	2835.63	II	12497 - 47752
35	2703.86	II	12033 - 49006	45	2836.48	II	35608 - 70852
18	2705.43	I	24056 - 61008	55	2838.79	II	38270 - 73486
60	2708.79	II	33521 - 70427	110	2840.02	II	30219 - 65420

## Chromium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1700	2843.25	II	12304 - 47465	26	2932.70	II	31169 - 65257
22	2846.02	I	27704 - 62830	55	2933.97	II	31083 - 65157
45	2849.29	I	27817 - 62903	90	2935.14	II	30865 - 64924
		II	30299 - 65384	45	2940.22	II	42987 - 76988
1200	2849.84	II	12148 - 47228	60	2946.84	II	34813 - 68738
120	2851.36	II	30157 - 65218	55	2953.36	II	29952 - 63802
55	2853.22	II	30219 - 65257	45	2953.71	II	34631 - 68477
		II	42898 - 77935	55	2961.73	II	30308 - 64062
55	2855.07	II	32855 - 67871			II	33694 - 67449
		II	35569 - 70585	45	2966.05	II	31219 - 64924
880	2855.68	II	12033 - 47041	480	2967.64	I	8095 - 41782
90	2856.77	II	19631 - 54626	480	2971.11	I	7927 - 41575
70	2857.40	II	19798 - 54785	210	2971.91	II	30392 - 64031
610	2858.91	II	12497 - 47465	480	2975.48	I	7811 - 41409
440	2860.93	II	11962 - 46906	30	2976.72	II	30865 - 64449
790	2862.57	II	12304 - 47228	190	2979.74	II	30299 - 63849
750	2865.11	II	12148 - 47041	350	2980.79	I	7751 - 41289
55	2865.33	II	19528 - 54418	110	2985.32	II	30219 - 63707
610	2866.74	II	12033 - 46906	480	2985.85	I	7927 - 41409
90	2867.10	II	19631 - 54500	1500	2986.00	I	8095 - 41575
480	2867.65	II	11962 - 46824	2100	2986.47	I	8308 - 41782
210	2870.44	II	19798 - 54626	660	2988.65	I	7593 - 41043
110	2871.63	I	8095 - 42908	160	2989.19	II	30157 - 63601
160	2873.48	II	12033 - 46824	480	2991.89	I	7811 - 41225
90	2873.82	II	19631 - 54418	230	2994.07	I	7593 - 40983
320	2875.99	II	20024 - 54785	300	2995.10	I	7593 - 40971
230	2876.24	II	12148 - 46906	700	2996.58	I	7927 - 41289
180	2877.98	II	12304 - 47041	210	2998.79	I	7593 - 40930
70	2878.45	II	12497 - 47228	1100	3000.89	I	8095 - 41409
120	2879.27	I	7927 - 42648	750	3005.06	I	8308 - 41575
95	2880.87	II	19798 - 54500	140	3013.03	I	7751 - 40930
30	2881.14	I	24056 - 58754	710	3013.71	I	7811 - 40983
170	2887.00	I	7811 - 42439	710	3014.76	I	7811 - 40971
55	2888.74	II	36273 - 70880	1400	3014.92	I	7927 - 41086
700	2889.29	I		710	3015.19	I	7751 - 40906
55	2889.82	II	32854 - 67449	2800	3017.57	I	8095 - 41225
55	2891.42	I	24200 - 58775	430	3018.50	I	7811 - 40930
370	2893.25	I	8095 - 42648	240	3018.82	I	7927 - 41043
190	2894.17	I	7751 - 42293	430	3020.67	I	7811 - 40906
55	2896.46	II	32854 - 67369	2800	3021.56	I	8308 - 41393
		II	40228 - 74743	1100	3024.35	I	7927 - 40983
210	2896.75	I	7927 - 42439	85	3026.65	II	35708 - 68738
55	2897.67	II	35608 - 70108	170	3029.16	I	7927 - 40930
		II	32845 - 67344	710	3030.24	I	8095 - 41086
90	2898.54	II	31219 - 65710	140	3031.35	I	7927 - 40906
80	2899.21	I	7811 - 42293	28	3032.93	II	21823 - 54785
55	2899.48	II	32855 - 67334	390	3034.19	I	8095 - 41043
26	2903.97	II	31118 - 65543	550	3037.04	I	8308 - 41225
55	2904.68	I	24940 - 59358	80	3039.78	I	24200 - 57088
180	2905.49	I	7811 - 42218	550	3040.85	I	8095 - 40971
					3040.91	II	34631 - 67506
260	2909.05	I	7927 - 42293	55	3041.74	II	35611 - 68477
260	2910.90	I	8095 - 42439	110	3050.14	II	34813 - 67589
250	2911.14	I	8308 - 42648	710	3053.88	I	8308 - 41043
45	2911.68	II	35569 - 69903	24	3059.52	II	21825 - 54500
60	2913.73	I	25177 - 59488	85	3065.07	I	24940 - 57557
22	2915.23	II	35611 - 69903	28	3067.16	II	21824 - 54418
22	2915.46	II	39825 - 74114	85	3073.68	I	25177 - 57702
90	2921.24	II	40202 - 74424	55	3077.83	I	25106 - 57587
60	2921.82	II	31169 - 65384	28	3095.86	I	21841 - 54133
60	2927.08	II	38563 - 72717	28	3109.34	I	24834 - 56986
80	2928.15	II	30308 - 64449	28	3110.86	I	24897 - 57033
95	2928.30	II	31118 - 65257	240	3118.65	II	19528 - 51584
		II	38509 - 72649	45	3119.25	I	25038 - 57088
26	2929.44	II	36273 - 70399	40	3119.71	I	24940 - 56986
35	2930.85	II	29952 - 64063				

Chromium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
430	3120.37	II	19631 - 51670	360	3408.76	II	20024 - 49352
28	3122.60	II	33694 - 65710	210	3421.21	II	19528 - 48750
470	3124.94	II	19798 - 51789	270	3422.74	II	19798 - 49006
	3125.02	II	34659 - 66650	140	3433.31	II	19631 - 48750
120	3128.70	II	19631 - 51584	270	3433.60	I	20519 - 49635
590	3132.06	II	20024 - 51943	55	3434.11	I	20524 - 49635
140	3136.68	II	19798 - 51670	160	3436.19	I	20524 - 49618
140	3147.23	II	20024 - 51789	70	3441.12	I	20521 - 49573
		II	33619 - 65384	140	3441.44	I	20524 - 49573
85	3148.44	I	23934 - 55686	30	3443.79	I	23934 - 52963
100	3155.15	I	24056 - 55741	170	3445.62	I	20524 - 49538
100	3163.76	I	24200 - 55799	30	3447.02	I	20517 - 49520
240	3180.70	II	20513 - 51943	170	3447.43	I	20521 - 49520
30	3181.43	II	20520 - 51943	70	3447.76	I	20524 - 49520
65	h 3188.01	I	24092 - 55451	190	3453.33	I	20517 - 49467
220	3197.08	II	20520 - 51789	40	3453.74	I	20521 - 49467
24	3198.11	I	24092 - 55353	130	3455.60	I	20524 - 49454
30	3208.59	II	20513 - 51670	100	3460.43	I	24282 - 53172
170	3209.18	II	20518 - 51670	65	3465.25	I	20521 - 49371
140	3217.40	II	20513 - 51584	40	3467.02	I	24282 - 53117
30	3229.20	I	27817 - 58775	70	3467.72	I	24056 - 52885
28	3234.06	II	34631 - 65543	45	3469.59	I	24304 - 53117
65	3237.73	I	23934 - 54811	16	3472.76	I	21841 - 50628
120	3245.54	I	23934 - 54736	24	3472.91	I	23934 - 52720
130	3251.84	I	24056 - 54799	40	3473.61	I	21848 - 50628
130	3257.82	I	24200 - 54887	70	3481.30	I	21841 - 50557
95	3259.98	I	24200 - 54866	55	3481.54	I	24200 - 52915
30	3295.43	II	33694 - 64031	55	3494.97	I	24056 - 52660
24	3307.02	II	33619 - 63849	40	3495.38	II	19798 - 48399
55	3324.06	II	19631 - 49706	80	3510.54	I	24200 - 52678
		II	38509 - 68583	40	3511.84	II	20024 - 48491
28	3326.59	I	24940 - 54993	120	3550.64	I	25771 - 53927
30	3328.35	II	19528 - 49565	80	3558.52	I	25206 - 53299
30	3329.05	I	25177 - 55207	130	3566.16	I	25360 - 53394
95	3336.33	II	19528 - 49493	130	3573.64	I	21848 - 49823
130	3339.80	II	19631 - 49565	80	3574.04	I	21840 - 49812
110	3342.59	II	19798 - 49706	330	h 3574.80	I	21857 - 49823
30	3343.34	I	24897 - 54799		3574.94	I	21848 - 49812
95	3346.02	I	24200 - 54078	19000	3578.69	I	0 - 27935
95	3346.74	I	24056 - 53927	160	h 3584.33	I	25771 - 53663
95	3347.84	II	19631 - 49493	130	3585.30	II	21823 - 49706
65	3349.07	I	24282 - 54133	17000	3593.49	I	0 - 27820
55	3349.32	I	25038 - 54887	350	3601.67	I	21841 - 49598
30	3351.60	I	25038 - 54866	40	3602.57	I	21848 - 49598
55	3351.97	I	0 - 29825	85	3603.74	I	21848 - 49589
55	h 3353.03	I	31055 - 60871		3603.78	II	21824 - 49565
	3353.13	II	20024 - 49838	13000	3605.33	I	0 - 27729
170	3358.50	II	19798 - 49565	40	3608.40	I	31049 - 58754
160	3360.30	II	25034 - 54785	40	3609.48	I	20521 - 48218
65	3361.77	II	25047 - 54785	40	3610.05	I	20517 - 48210
55	3362.21	I	20519 - 50253	70	3612.61	I	31055 - 58728
430	3368.05	II	20024 - 49706	85	3615.64	I	0 - 27650
30	3376.40	I	31048 - 60657	130	3632.84	I	20524 - 48043
55	3378.34	II	25034 - 54626	350	3636.59	I	20524 - 48014
30	3379.17	I	20517 - 50102	630	3639.80	I	20519 - 47986
30	3379.37	II	25043 - 54626	85	3640.39	I	20523 - 47986
95	3379.83	II	25047 - 54626	70	3641.47	I	20521 - 47975
140	3382.68	II	19798 - 49352	220	3641.83	I	20524 - 47975
95	3391.43	II	19528 - 49006	45	3646.16	I	20524 - 47942
55	3392.99	II	25036 - 54500	85	3648.53	I	20517 - 47918
70	3393.84	II	25043 - 54500	220	3649.00	I	20521 - 47918
55	3394.30	II	25047 - 54500	170	3653.91	I	20517 - 47877
30	3402.40	II	25036 - 54418	220	3656.26	I	20524 - 47866
170	3403.32	II	19631 - 49006	45	3662.84	I	20521 - 47814
		II	25043 - 54418	130	3663.21	I	20524 - 47814



Chromium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	3665.98	I	20524 - 47794	40	3897.65	I	
95	3666.64	I	20521 - 47786	35	3902.11	I	
55	3668.03	I	20517 - 47772	360	3902.92	I	7927 - 33542
65	3676.32	I	24092 - 51287	60	3903.16	I	7811 - 33425
40	3677.68	II	21823 - 49006	960	3908.76	I	8095 - 33672
55	3677.89	II	21824 - 49006	120	hd	I	27729 - 53284
40	3679.82	I	20521 - 47689			I	27820 - 53375
19	3681.69	I	24092 - 51247	120		I	24282 - 49812
120	3685.55	I	20519 - 47645	190		I	7811 - 33338
130	3686.80	I	20524 - 47640	35		I	23163 - 48682
130	3687.25	I	20517 - 47629	1900		I	8308 - 33816
75	3687.54	I	20521 - 47631	600		I	7927 - 33424
19	3688.46	I	20517 - 47621	30		I	36578 - 62038
75	3712.95	II	21824 - 48750	600		I	8095 - 33542
40	3716.53	I	31393 - 58292	410		I	8308 - 33672
130	3730.81	I	0 - 26796	30		I	24286 - 49589
150	3732.03	I	0 - 26787	40		I	24304 - 49598
95	3742.97	I	20519 - 47229	35		I	24300 - 49589
480	3743.58	I	20524 - 47229	1900		I	20520 - 45741
570	3743.88	I	20519 - 47222	120		I	20519 - 45707
85	3744.49	I	20524 - 47222	1600		I	20524 - 45707
55	3748.61	I	20521 - 47190	85		I	21848 - 47022
340	3749.00	I	20524 - 47190	1600		I	20524 - 45663
50	3757.17	I	20517 - 47126	85		I	21841 - 46968
230	3757.66	I	20521 - 47126	40		I	21848 - 46968
60	3758.04	I	20524 - 47126	85		I	21857 - 46968
24	3767.43	I	20519 - 47055	960		I	20521 - 45615
260	3768.24	I	20517 - 47047	190		I	20524 - 45615
95	3768.73	I	20521 - 47047	160		I	31393 - 56449
95	3788.86	I	24277 - 50663	960		I	20517 - 45566
95	3790.45	I	24286 - 50661	160		I	20521 - 45566
130	3791.38	I	24286 - 50655	190		I	21841 - 46878
130	3792.14	I	24300 - 50663	40		I	21848 - 46878
120	3793.29	I	24300 - 50655	160		I	31378 - 56362
130	3793.88	I	24304 - 50655	120		II	45670 - 70585
85	3794.61	I	24282 - 50628	30		I	31378 - 56280
140	3797.13	I	24300 - 50628	85		I	31355 - 56210
200	3797.72	I	24304 - 50628	70		I	20521 - 45359
530	3804.80	I	24282 - 50558	120		I	20524 - 45354
110	3806.83	I	27817 - 54078	85		I	20524 - 45349
110	3807.93	I	24304 - 50557	85		I	31352 - 56155
180	3815.43	I	21841 - 48042	190		I	31048 - 55799
70	3818.48	I	20524 - 46705	160		I	31049 - 55741
180	3819.56	I	21841 - 48014	120		I	31055 - 55686
70	3823.52	I	7751 - 33897	40		I	20524 - 45113
130	3826.42	I	21848 - 47975			I	33113 - 57702
130	3830.03	I	27825 - 53927	85		I	21841 - 46422
380	3841.28	I	21841 - 47866			I	25039 - 49621
190	3848.98	I	21841 - 47814	35		I	35934 - 60468
140	3849.36	I	24282 - 50253	40		I	33060 - 57587
290	3850.04	I	21848 - 47814	40		I	21848 - 46368
140	3852.22	I	7811 - 33762	40		I	33040 - 57557
190	3854.22	I	21848 - 47786	40		I	20521 - 44875
110	3855.29	I	21857 - 47788			I	23934 - 48288
140	3855.57	I	24282 - 50211	40		I	21848 - 46174
260	3857.63	I	21857 - 47772	40		I	21848 - 46109
70	3874.53	I	24300 - 50102	40		I	24056 - 48310
		I	27825 - 53628	35		I	21857 - 46109
660	3883.29	I	31352 - 57097	40		I	24200 - 48446
50	3883.66	I	24277 - 50019	140		I	20519 - 44746
		I	31355 - 57097	35		I	33113 - 57335
570	3885.22	I	7811 - 33542	40		I	21857 - 46077
380	3886.79	I	8095 - 33816	40		I	31009 - 55207
60	3891.93	I	23934 - 49621	30		I	31028 - 55102
260	3894.04	I	7751 - 33424	120		I	20524 - 44591

Chromium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	4161.42	I	35934 - 59957	530	4384.98	I	8308 - 31106
140	4163.62	I	20524 - 44534	60	4387.50	I	24092 - 46878
70	4165.52	I	35884 - 59884			I	24200 - 46986
40	4169.84	I	33113 - 57088	70	4391.75	I	8095 - 30859
35	4170.20	I	33060 - 57033	60	4403.50	I	32097 - 54800
40	4172.77	I	37234 - 61192	24	4410.30	I	24300 - 46968
170	4174.80	I		60	4411.09	I	24304 - 46968
30	4175.94	I	24286 - 48226	35	4412.25	I	8308 - 30965
170	4179.26	I	25106 - 49028	50	4413.87	I	28637 - 51287
35	4184.90	I	24897 - 48786	60	4424.28	I	24282 - 46878
30	4186.36	I	31049 - 54929	24	4428.50	I	24304 - 46878
35	4190.13	I	23163 - 47022	50	4430.49	I	24282 - 46847
85	4191.27	I	20521 - 44373			I	28682 - 51247
35	4192.10	I	32097 - 55945	50	4432.18	I	23163 - 45719
85	4193.66	I	31048 - 54887	110	4458.54	I	24282 - 46705
70	4194.95	I	31055 - 54887			I	28637 - 51060
40	4197.23	I	31048 - 54866	30	4459.74	I	24304 - 46720
85	4198.52	I	31055 - 54866	30	4465.36	I	24300 - 46688
60	4203.59	I	20517 - 44300	30	4482.88	I	27176 - 49477
40	4204.47	I	32097 - 55875	40	4488.05	I	24092 - 46368
35	4208.36	I	31055 - 54811	50	4489.47	I	28682 - 50950
110	4209.37	I	31049 - 54799	60	4492.31	I	27223 - 49477
40	4209.76	I	25038 - 48786	660	4496.86	I	7593 - 29825
40	4211.35	I	24304 - 48043	50	4498.73	I	23512 - 45734
40	4216.36	I	24304 - 48014	70	4500.30	I	24834 - 47048
85	4217.63	I	24282 - 47986	50	4501.11	I	23512 - 45722
40	4221.57	I	24834 - 48515			I	28679 - 50890
		I	31055 - 54737	22	4501.79	I	23512 - 45719
40	4222.73	I	24300 - 47975	24	4506.85	I	33763 - 55945
40	4238.96	I	24282 - 47866	95	4511.90	I	24897 - 47055
60	4240.70	I	24056 - 47630	12	4514.37	I	33763 - 55908
		I	24940 - 48515	35	4514.53	I	23499 - 45643
20000	4254.35	I	0 - 23499	24	4521.14	I	33763 - 55875
70	4255.50	I	24200 - 47693	24	4526.11	I	24897 - 46986
60	4261.35	I	23499 - 46959	380	4526.47	I	20519 - 42606
110	4263.14	I	31048 - 54498	70	d 4527.34	I	20524 - 42606
30	4271.06	I	25038 - 48445			I	24092 - 46174
40	4272.91	I	23386 - 46783	24	4527.47	I	20519 - 42589
16000	4274.80	I	0 - 23386	380	4529.85	I	20524 - 42589
85	4280.40	I	31049 - 54405	50	4530.74	I	20521 - 42565
10000	4289.72	I	0 - 23305	240	4535.72	I	20524 - 42565
40	4291.96	I	27597 - 50890	40	4539.79	I	20517 - 42539
85	4295.76	I	21841 - 45113	240	4540.50	I	20521 - 42539
70	4297.74	I	31055 - 54317	240	4540.72	I	25038 - 47055
35	4300.51	I	27704 - 50950	35	4541.07	I	20524 - 42539
50	4301.18	I	27817 - 51060	19	4541.51	I	24834 - 46847
30	4305.45	I	23305 - 46525	24	4542.62	I	24897 - 46905
35	4319.64	I	23305 - 46449	140	4544.62	I	20517 - 42515
60	4325.08	I	23934 - 47048			I	24300 - 46298
780	4337.57	I	7811 - 30859	24	4545.34	I	20521 - 42515
1100	4339.45	I	7927 - 30965	600	4545.96	I	7593 - 29585
380	4339.72	I	7751 - 30787	50	4556.17	I	25106 - 47048
60	4340.13	I	21841 - 44875	22	4558.66	II	32854 - 54785
1900	4344.51	I	8095 - 31106	19	4564.17	I	38538 - 60441
70	4346.83	I	24056 - 47055	120	4565.51	I	7927 - 29825
380	4351.05	I	7811 - 30787	95	4569.64	I	25177 - 47055
2300	4351.77	I	8308 - 31280	120	4571.68	I	20519 - 42387
570	4359.63	I	7927 - 30859	22	4575.12	I	27176 - 49027
70	4363.13	I	23934 - 46847	360	4580.06	I	7593 - 29421
530	4371.28	I	8095 - 30965	24	4586.14	I	25106 - 46905
		I	35884 - 58755	360	4591.39	I	7811 - 29585
70	4373.25	I	7927 - 30787	70	4595.59	I	33763 - 55517
110	4374.16	I	24200 - 47055	50	4600.10	I	20519 - 42252
70	4375.33	I	24056 - 46905	480	4600.75	I	8095 - 29825
50	4381.11	I	21848 - 44667	50	4601.02	I	20524 - 42252

Chromium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	4613.37	I	7751 — 29421	130	4887.01	I	24897 — 45354
600	4616.14	I	7927 — 29585	19	4888.53	I	20521 — 40971
70	4619.55	I	24092 — 45734	35	4903.24	I	20517 — 40906
85	4621.96	I	20524 — 42154	260	4922.27	I	25038 — 45349
		I	31048 — 52678	110	4936.33	I	25106 — 45358
70	4622.49	I	28637 — 50264	70	4942.50	I	7593 — 27820
24	4622.76	I	24092 — 45719	110	4954.81	I	25177 — 45354
550	4626.19	I	7811 — 29421	35	4964.93	I	7593 — 27729
24	4632.18	I	28682 — 50264	60	5013.32	I	21841 — 41782
40	4637.18	I	20521 — 42080	17	5051.90	I	7593 — 27382
50	4637.77	I	20524 — 42080	17	5065.91	I	21841 — 41575
50	4639.52	I	25089 — 46637	40	5067.71	I	21848 — 41575
		I	28637 — 50184	40	5072.92	I	7593 — 27300
1600	4646.17	I	8308 — 29825	30	5110.75	I	21848 — 41409
24	4646.81	I	25011 — 46525	17	5113.13	I	21857 — 41409
24	4648.13	I	20517 — 42026	17	5123.46	I	8308 — 27820
24	4648.87	I	20521 — 42026	50	5139.65	I	27597 — 47048
		I	28679 — 50184	14	5144.67	I	21857 — 41289
35	4649.46	I	20524 — 42026	70	5166.23	I	27704 — 47055
		I	28682 — 50184	35	5177.43	I	27650 — 46959
570	4651.28	I	7927 — 29421	70	5184.59	I	27500 — 46783
840	4652.16	I	8095 — 29585	70	5192.00	I	27382 — 46637
35	4654.74	I	24971 — 46449	12	5193.49	I	27597 — 46847
19	4656.19	I	24897 — 46368	85	5196.44	I	21848 — 41086
40	4663.33	I	25011 — 46449	35	5200.19	I	27300 — 46525
70	4663.83	I	25089 — 46525	5300	5204.52	I	7593 — 26802
95	4664.80	I	25206 — 46637	8400	5206.04	I	7593 — 26796
35	4665.90	I	28679 — 50105	11000	5208.44	I	7593 — 26788
22	4666.22	I	23934 — 45358	19	5214.13	I	27176 — 46349
70	4666.51	I	25360 — 46783	30	5221.75	I	27223 — 46368
50	4669.34	I	25549 — 46959	85	5224.94	I	27825 — 46959
40	4680.54	I	25089 — 46449	12	5226.89	I	21857 — 40983
19	4680.87	I	24940 — 46298	19	5238.97	I	21848 — 40930
70	4689.37	I	25206 — 46525	30	5243.40	I	27382 — 46449
60	4693.95	I	24056 — 45354	290	5247.56	I	7751 — 26802
24	4695.15	I	24056 — 45349	60	5254.92	I	27500 — 46525
		I	35808 — 57101	60	5255.13	I	27935 — 46959
60	4697.06	I	21841 — 43125	19	5261.75	I	29825 — 48824
240	4698.46	I	25360 — 46637	530	5264.15	I	7811 — 26802
	4698.62	I	21848 — 43125	30	5265.16	I	27650 — 46637
35	4700.61	I	21857 — 43125	180	5265.72	I	7811 — 26796
190	4708.04	I	25549 — 46783	35	5272.01	I	27820 — 46783
240	4718.43	I	25772 — 46959	30	5273.44	I	27825 — 46783
50	4723.10	I	24834 — 46000	95	5275.17	I	23305 — 42256
50	4724.42	I	24897 — 46058			I	27223 — 46174
50	4727.15	I	24200 — 45349	35	5275.69	I	23305 — 42255
24	4729.72	I		70	5276.03	I	23305 — 42253
120	4730.71	I	24834 — 45966	19	5280.29	I	27176 — 46109
140	4737.35	I	24897 — 46000	10	5287.19	I	27729 — 46637
19	4745.31	I	21841 — 42908	340	5296.69	I	7927 — 26802
70	4752.08	I	33763 — 54800	70	5297.36	I	23386 — 42258
340	4756.11	I	25038 — 46058	660	5298.27	I	7927 — 26796
50	4764.29	I	28637 — 49621	85	5300.75	I	7927 — 26788
22	4766.63	I	28679 — 49653	17	5304.21	I	27935 — 46783
30	4767.86	I	28682 — 49650	24	5312.88	I	27820 — 46637
190	4789.32	I	20519 — 41393	24	5318.78	I	27729 — 46525
95	4792.51	I	25106 — 45966	340	5328.34	I	23499 — 42261
120	4801.03	I	25177 — 46000	70	5329.17	I	23499 — 42258
110	4829.38	I	20524 — 41225	17	5329.72	I	23499 — 42256
14	4836.86	I	25038 — 45707	14	5340.44	I	27729 — 46449
17	4861.20	I	20521 — 41086	10	5344.76	I	27820 — 46525
70	4861.84	I	20524 — 41086	780	5345.81	I	8095 — 26796
140	4870.80	I	24834 — 45358	380	5348.32	I	8095 — 26787
35	4885.78	I	20521 — 40983	30	5386.98	I	27176 — 45734
19	4885.96	I	24897 — 45358	22	5387.57	I	27163 — 45719

## Chromium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
10	5390.39	I	27176 - 45722	24 h	5785.00	I	26787 - 44069
40	5400.61	I	27223 - 45734	19 h	5785.82	I	26802 - 44081
22	5405.00	I	27223 - 45719	60 h	5787.99	I	26796 - 44069
1400	5409.79	I	8308 - 26787	180 h	5791.00	I	26787 - 44051
12	5442.41	I	27597 - 45966	35	6330.10	I	7593 - 23386
19	5463.97	I	27704 - 46000	22	6362.87	I	7593 - 23305
19	5480.50	I	27817 - 46058	19	6661.08	I	33816 - 48824
24	5628.64	I	27597 - 45358	11	6669.26	I	33672 - 48661
7	5642.36	I	31106 - 48824	5 h	6881.62	I	27729 - 42256
12 h	5649.37	I	30965 - 48661	10 h	6882.38	I	27729 - 42255
24	5664.04	I	27704 - 45354	21 h	6883.03	I	27729 - 42253
7 h	5681.20	I		27 h	6924.13	I	27820 - 42258
7 h	5682.48	I	30965 - 48559	17 h	6925.20	I	27820 - 42256
24	5694.73	I	31106 - 48661	30 h	6978.48	I	27935 - 42261
40	5698.33	I	31280 - 48824	11 h	6979.82	I	27935 - 42258
24	5702.31	I	27817 - 45349	7	7185.52	I	31393 - 45306
12	5712.64	I	36578 - 54078	6 h	7236.20	I	41393 - 55209
24	5712.78	I	24282 - 41782	85	7355.90	I	23305 - 36896
7	5719.82	I	24304 - 41782	130	7400.21	I	23386 - 36896
7	5746.43	I	28679 - 46077	150	7462.31	I	23499 - 36896
		I	31048 - 48445	11 h	7942.04	I	35398 - 47986
7	5753.69	I	36552 - 53927	5 h	8163.18	I	35398 - 47645
12 h	5781.20	I	24282 - 41575	9	8348.28	I	21841 - 33816
		I	26796 - 44089	6	8450.26	I	21841 - 33672
6 h	5781.81	I	23934 - 41225	3	8455.24	I	21848 - 33672
		I	26802 - 44093	6	8548.86	I	21848 - 33542
24 h	5783.11	I	28679 - 45966	40	8947.15	I	25039 - 36212
		I	26802 - 44089	19	8976.83	I	24898 - 36034
30 h	5783.93	I	26796 - 44081				

# Cobalt

$$\text{Co, } Z = 27, M = 58.9332, \text{ Ratio } \frac{\text{Co}}{\text{Cu}} = 0.9274$$

Co I Normal state of valence electrons  $3d^7 4s^2 \ ^4F_{4,1/2} = 0$ . I.P. = 63430  $\text{cm}^{-1}$ .

Co II Normal state of valence electrons  $3d^8 \ ^3F_4 = 0$ . I.P. = 137572  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented by references for Co I and Co II (below).

### Classification:

Co I, H. N. Russell, R. B. King, and C. E. Moore, Phys. Rev. **58**, 407 (1940).

Co II, J. H. Findlay, Phys. Rev. **36**, 5 (1930); N. E. Hager, Jr., unpublished material (1951).

R. Velasco and J. Adames, Publ. del Inst. de Optica de Madrid No. **26** (1966).

### *Strong lines of cobalt*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
21000	3453.50	I	3483 - 32431	5300	2407.25	I	0 - 41529
11000	3405.12	I	3483 - 32842	5300	2411.62	I	816 - 42269
9600	3502.28	I	3483 - 32028	5100	3462.80	I	5076 - 33946
8800	3443.64	I	4143 - 33173	5100	3465.80	I	0 - 28845
8800	3569.38	I	7442 - 35451	4800	2414.46	I	1407 - 42811
8000	3474.02	I	0 - 28777	4800	2415.30	I	1809 - 43200
		I	4690 - 33467	4800	3489.40	I	7442 - 36092
7900	3894.08	I	8461 - 34134	4800	3512.64	I	4690 - 33151
7300	3529.81	I	4143 - 32465	4800	3518.35	I	8461 - 36875
7000	3506.32	I	4143 - 32654	4500	3409.18	I	4143 - 33467
6900	3845.47	I	7442 - 33440	4500	3433.04	I	5076 - 34196
6700	3412.34	I	4143 - 33440	4400	4121.32	I	7442 - 31700
6700	3587.19	I	8461 - 36330	4300	2521.36	I	0 - 39649
6400	3526.85	I	0 - 28346	4100	2286.16	II	3350 - 47078
6000	3995.31	I	7442 - 32465	4100	2424.93	I	0 - 41226
5500	3873.12	I	3483 - 29295	4100	3449.17	I	4690 - 33674

## Cobalt—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1100	2174.60	I	0 - 45971	670	2389.54	II	4950 - 46786
720	2245.13	II	4029 - 48556	170	2391.37	I	
290	2268.17	I	4143 - 48217	240	2392.60	II	22009 - 63792
260	2274.49	I	0 - 43952	240	2393.90	II	4561 - 46321
810	2276.53	I		120	2397.03	I	
240	2283.52	II	4029 - 47807	620	2397.39	II	9813 - 51512
260	2284.85	I	816 - 44568	60	2400.84	I	4690 - 46330
4100	2286.16	II	3350 - 47078	1100	2402.06	I	816 - 42434
720	2287.81	I	4143 - 47839		2402.17	I	1809 - 43426
240	2291.46	I	4690 - 48317	410	2404.17	II	5204 - 46786
290	2292.00	II	17772 - 61388	120	2406.27	I	4143 - 45688
260	2293.39	II	4561 - 48151	5300	2407.25	I	0 - 41529
260	2295.23	I	0 - 43555	260	2407.67	II	10708 - 52230
220	2296.05	I	5076 - 48616	310	2408.75	II	4950 - 46453
450	2296.71	I	4690 - 48217	240	2410.51	I	14036 - 55509
190	2303.97	I	3483 - 46873	5300	2411.62	I	816 - 42269
290	2304.18	I	816 - 44202	1600	2412.76	I	1809 - 43243
360	2305.18	I	816 - 44183	95	2413.19	I	5076 - 46502
2900	2307.86	II	4029 - 47346	95	2413.58	I	14399 - 55819
2600	2309.02	I	0 - 43295	480	2414.06	II	4561 - 45972
1800	2311.60	II	4561 - 47807	4800	2414.46	I	1407 - 42811
1800	2314.05	II	4950 - 48151	4800	2415.30	I	1809 - 43200
1400	2314.98	II	5204 - 48388	140	2416.90	II	11322 - 52684
430	2316.16	I	1407 - 44568	140	2417.05	I	
530	2316.86	I	1407 - 44556	1000	2417.65	II	4029 - 45379
2400	2323.14	I	816 - 43848	670	2419.12	I	
810	2324.32	II	4029 - 47039	120	2420.73	II	
570	2325.55	I	1407 - 44394	190	2422.56	I	13796 - 55061
770	2326.14	II	4561 - 47537	120	2423.62	II	5204 - 46453
770	2326.48	II	3350 - 46321	4100	2424.93	I	0 - 41226
140	2329.10	II	18338 - 61260	60	2425.59	I	4690 - 45905
530	2330.35	II	4950 - 47848	140	2427.00	I	
1400	2335.99	I	1407 - 44202	120	2428.29	II	4029 - 45198
670	2337.94	II		410	2428.60	I	
1600	2338.67	I	1809 - 44556	120	2429.23	I	816 - 41969
480	2339.05	I	816 - 43555	3300	2432.21	I	816 - 41918
620	2344.26	II	5204 - 47848	770	2435.09	I	
620	2346.16	I	816 - 43426	720	2435.83	I	0 - 41041
910	2347.39	II	4950 - 47537	2900	2436.66	I	1407 - 42434
190	2350.28	I	4690 - 47225	70	2436.98	II	4950 - 45972
140	2351.39	I	1407 - 43922	2400	2439.05	I	1809 - 42797
1600	2352.85	I	3483 - 45971	530	2441.05	I	17234 - 58187
2000	2353.42	I	816 - 43295	60	2449.16	II	4561 - 45379
		II	4561 - 47039	95	2450.00	II	10708 - 51512
620	2355.48	I	1407 - 43848	240	2456.24	I	3483 - 44183
530	2358.18	I	1809 - 44202	29	2460.21	I	15184 - 55819
95	2361.53	II	5204 - 47537	480	2460.81	I	1809 - 42434
1900	2363.79	II	4029 - 46321	60	2462.12	I	13796 - 54399
960	2365.07	I	0 - 42269	85	2463.78	I	1407 - 41983
360	2369.68	I	4143 - 46330	85	2464.20	II	9813 - 50382
240	2370.51	I	816 - 42988	50	2464.62	I	1407 - 41969
170	2371.44	I	17234 - 59389	290	2467.69	I	1407 - 41918
340	2371.86	I	1407 - 43555	480	2470.28	I	3483 - 43952
95	2372.83	I	1407 - 43538	120	2473.90	I	816 - 41226
140	2373.38	I		480	2476.64	I	3483 - 43848
170	2375.18	II	4950 - 47039	430	2483.61	I	4143 - 44394
220	2377.22	I	5076 - 47129	29	2485.36	II	9813 - 50036
2000	2378.62	II	3350 - 45379	95	2486.44	II	10708 - 50914
1400	2380.48	I	816 - 42811	70	2493.93	I	8461 - 48546
170	2381.75	II		120	2494.73	I	3483 - 43555
1800	2383.46	II	4029 - 45972	380	2495.55	I	4143 - 44202
1400	2384.86	I	0 - 41918	380	2496.71	I	4143 - 44183
1000	2386.36	II	4561 - 46453	2200	2511.02	I	3483 - 43295
140	2387.46	I	4690 - 46563	29	2500.50	I	
3300	2388.92	II	3350 - 45198	29	2502.28	I	7442 - 47394

Cobalt—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
570	2504.52	I	3483 - 43399	120	2679.76	I	8461 - 45767
570	2506.46	II	9813 - 49698	170	2685.34	I	4690 - 41918
360	2506.88	I	4690 - 44568	55	2694.68	II	10708 - 47807
290	2507.68	I	4690 - 44556	190	2695.85	I	4143 - 41226
29	2512.40	II	24075 - 63865	55	2705.85	I	13796 - 50742
95	2512.90	I	7442 - 47225	190	2715.99	I	16468 - 53276
120	2513.12	I	4143 - 43922	130	2731.12	I	16471 - 53075
860	2517.87	I	4690 - 44394	65	2740.46	I	7442 - 43922
290	2519.82	II	10708 - 50382	190	2745.10	I	16778 - 53196
4300	2521.36	I	0 - 39649	95	2761.37	I	4143 - 40346
290	2524.96	II	11322 - 50914	190	2764.19	I	3483 - 39649
1100	2528.62	II	9813 - 49348	130	2766.22	I	17234 - 53374
2900	2528.97	I	816 - 40346	130	2778.82	I	15184 - 51160
720	2530.13	I	4690 - 44202	40	2796.23	I	5076 - 40828
860	2532.18	I	5076 - 44556	55	2797.08	I	8461 - 44202
60	2535.36	I	7442 - 46873	95	2803.77	I	4690 - 40346
2900	2535.96	I	1407 - 40828	150	2815.56	I	4143 - 39649
860	2536.49	I	4143 - 43555	23	2820.01	I	8461 - 43911
150	2541.94	II	10708 - 50036	75	2837.15	I	16778 - 52014
1700	2544.25	I	1809 - 41102	55	2850.04	I	8461 - 43538
190	2544.86	I	4143 - 43426	75	2862.61	I	1407 - 36330
23	2546.74	II	24412 - 63665	27	2872.50	I	8461 - 43264
340	2548.34	I	7442 - 46672	190	2886.44	I	816 - 35451
230	2549.30	I	1407 - 40622	55	2899.82	I	16471 - 50945
230	2553.00	I	4690 - 43848	27	2903.20	I	16468 - 50903
310	2553.37	I	4143 - 43295	95	2927.67	I	16778 - 50925
310	2555.07	I	5076 - 44202	30	2928.81	I	0 - 34134
190	2556.76	I	4143 - 43243	95	2929.51	I	16468 - 50593
230	2559.41	II	11322 - 50382	27	2957.68	I	16778 - 50579
960	2562.15	I	1809 - 40828	690	2987.16	I	0 - 33467
310	2564.04	II	10708 - 49698	690	2989.59	I	0 - 33440
1100	2567.35	I	1407 - 40346	30	2995.15	I	17234 - 50611
95	2572.24	I	4690 - 43555	120	3000.55	I	816 - 34134
65	2573.40	I	4690 - 43538	330	3013.60	I	0 - 33173
75	2573.54	I	4143 - 42988	690	3017.55	I	816 - 33946
960	2574.35	I	816 - 39649	120	3026.37	I	15184 - 48217
35	2574.86	II	13405 - 52230	55	3034.43	I	1407 - 34352
35	2575.73	I	1809 - 40622	210	3042.48	I	816 - 33674
770	2580.33	II	9813 - 48556	3100	3044.00	I	0 - 32842
120	2580.84	I	4690 - 43426	420	3048.89	I	1407 - 34196
310	2582.24	II	11322 - 50036	120	3060.05	I	15774 - 48444
120	2585.34	I	8461 - 47129	1700	3061.82	I	816 - 33467
310	2587.22	II	10708 - 49348	50	3062.20	I	816 - 33463
150	2590.59	I	7442 - 46032	65	3064.37	I	816 - 33440
120	2591.69	I	4690 - 43264	920	3072.34	I	1407 - 33946
75	2594.16	I	1809 - 40346	540	3082.62	I	0 - 32431
55	2600.98	I	3483 - 41918	670	3086.78	I	1809 - 34196
95	2606.12	I	5076 - 43436	270	3089.60	I	816 - 33173
40	2610.76	I	4143 - 42434	220	3098.20	I	1407 - 33674
95	2613.49	II	13261 - 51512	270	3121.42	I	0 - 32028
75	2614.13	I	1407 - 39649	95	3121.57	I	816 - 32842
150	2614.36	II	17772 - 56011	350	3137.33	I	1809 - 33674
120	2616.26	I	8461 - 46672	270	3139.94	I	816 - 32654
75	2617.86	I	5076 - 43264	410	3147.06	I	1407 - 33173
95	2622.06	I	4143 - 42269	95	3152.71	I	16196 - 47905
95	2622.43	I	4690 - 42811	410	d 3154.68	I	16471 - 48160
270	2627.64	I	3483 - 41529			I	15184 - 46873
130	2632.24	II	18032 - 56011	350	3158.78	I	816 - 32465
55	2644.78	I	8461 - 46260	130	3177.27	I	
310	2646.42	I	4143 - 41918	130	3188.37	I	15774 - 47129
770	2648.64	I	3483 - 41226	95	3219.15	I	816 - 31871
75	2649.94	I	8461 - 46186	130	3232.87	I	16471 - 47394
95	2650.27	I	5076 - 42797	220	3243.84	I	15184 - 46003
150	2663.53	II	9813 - 47346	260	3247.18	I	15184 - 45971
120	2675.98	I	5076 - 42434	380	3254.21	I	15184 - 45905

Cobalt—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
260	3260.82	I	16471 - 47129	1300	3520.08	I	816 - 29216
130	3271.78	I	15774 - 46330	2700	3521.57	I	3483 - 31871
510	3283.46	I	16778 - 47225	3800	3523.43	I	5076 - 33449
80	3287.19	I	15774 - 46186	6400	3526.85	I	0 - 28346
130	3307.15	I	15774 - 46003	2700	3529.03	I	1407 - 29735
190	3314.08	I	14036 - 44202	7300	3529.81	I	4143 - 32465
240	3319.48	I	23612 - 53728	1900	3533.36	I	1809 - 30103
240	3322.20	I	16471 - 46563	270	3543.26	I	15184 - 43399
190	3325.24	I	16196 - 46260	95	3548.44	I	13796 - 41969
350	3326.99	I	23612 - 53660	540	3550.60	I	1407 - 29563
700	3334.14	I	3483 - 33467	95	3552.99	I	15774 - 43911
190	3339.78	I	23856 - 53789	95	3558.78	I	4690 - 32782
160	3342.73	I	16778 - 46685	1100	3560.89	I	5076 - 33151
190	3346.94	I	23856 - 53725	880	3564.95	I	4690 - 32733
110	3348.11	I	16471 - 46330	8800	3569.38	I	7442 - 35451
610	3354.38	I	4143 - 33946	1600	3574.96	I	4690 - 32654
110	3361.56	I	24628 - 54367	2500	3575.36	I	816 - 28777
110	3362.80	I	24628 - 54356	50	3578.08	I	18390 - 46330
570	3367.11	I	3483 - 33173	50	d 3578.90	I	14036 - 41970
110	3370.33	I	4690 - 34352			I	14036 - 41969
110	3373.23	I	18390 - 48026	1000	3585.16	I	4143 - 32028
960	3385.22	I	4143 - 33674	6700	3587.19	I	8461 - 36330
1100	3388.17	I	4690 - 34196	1900	3594.87	I	1407 - 29216
2200	3395.38	I	4690 - 34134	1600	3602.08	I	1809 - 29563
11000	3405.12	I	3483 - 32842	940	3605.36	I	4143 - 31871
4500	3409.18	I	4143 - 33467	210	3611.70	I	18775 - 46455
6700	3412.34	I	4143 - 33440	75	3615.39	I	15774 - 43426
2200	3412.63	I	0 - 29295	45	3620.43	I	18390 - 46003
510	3414.74	I	5076 - 34352	40	3624.33	I	14399 - 41983
2700	3417.16	I	4690 - 33946	75	3624.96	I	5076 - 32654
220	3424.51	I	16778 - 45971	1000	3627.81	I	4143 - 31700
80	3428.23	I	24628 - 53789	150	3631.39	I	816 - 28346
2500	3431.58	I	816 - 29949	130	3632.84	I	23184 - 50703
4500	3433.04	I	5076 - 34196	150	3634.71	I	23208 - 50712
80	3438.91	I	26450 - 55521	75	3636.72	I	15774 - 43264
1600	3442.93	I	1407 - 30444	210	3639.44	I	15774 - 43243
8800	3443.64	I	4143 - 33173	130	3641.79	I	16471 - 43922
110	3446.09	I	25938 - 54948	150	3643.18	I	16471 - 43911
4100	3449.17	I	4690 - 33674	110	3647.66	I	1809 - 29216
2100	3449.44	I	3483 - 32465	190	3649.35	I	23184 - 50579
21000	3453.50	I	3483 - 32431	680	3652.54	I	1407 - 28777
1000	3455.23	I	1809 - 30743	65	3654.45	I	15774 - 43130
110	3456.93	I	816 - 29735	55	3656.97	I	4690 - 32028
300	3461.18	I	25569 - 54452	280	3662.16	I	18390 - 45688
5100	3462.80	I	5076 - 33946	260	3676.55	I	23184 - 50376
5100	3465.80	I	0 - 28845	380	3683.05	I	16778 - 43922
95	3471.38	I	25569 - 54367	75	3684.48	I	16778 - 43911
8000	3474.02	I	0 - 28777	65	3690.72	I	16468 - 43555
		I	4690 - 33467	230	3693.11	I	16778 - 43848
65	3478.56	I	18390 - 47129	230	3693.48	I	16471 - 43538
1900	3483.41	I	4143 - 32842	280	3702.24	I	23208 - 50211
380	3485.37	I	25139 - 53822	680	3704.06	I	8461 - 35451
4800	3489.40	I	7442 - 36092	55	3707.47	I	16471 - 43436
95	3490.74	I	4143 - 32782	230	3708.82	I	16471 - 43426
480	3491.32	I	1809 - 30444	45	3712.18	I	16468 - 43399
2400	3495.69	I	5076 - 33674	23	3726.66	I	13796 - 40622
480	3496.68	I	4143 - 32733	280	3730.48	I	15184 - 41983
9600	3502.28	I	3483 - 32028	380	3732.40	I	15184 - 41969
570	3502.62	I	1407 - 29949	190	3733.49	I	16778 - 43555
7000	3506.32	I	4143 - 32654	95	3734.14	I	16471 - 43243
2900	3509.84	I	4690 - 33173	150	3735.93	I	16778 - 43538
1400	3510.43	I	816 - 29295	1100	3745.50	I	7442 - 34134
4800	3512.64	I	4690 - 33151	110	3749.94	I	16471 - 43130
3800	3513.48	I	816 - 29270	45	3751.63	I	16778 - 43426
4800	3518.35	I	8461 - 36875	40	3754.35	I	20501 - 47129



## Cobalt—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	3755.45	I	16778 - 43399	140	4068.54	I	15774 - 40346
26	3760.39	I	14036 - 40622	280	4086.31	I	15184 - 39649
55	3774.60	I	16778 - 43264	830	4092.39	I	7442 - 31871
35	3777.54	I	16778 - 43243	30	4104.75	I	18775 - 43130
70	3808.11	I	3483 - 29735	550	4110.54	I	8461 - 32782
70	3814.46	I	15774 - 41983	2800	4118.77	I	8461 - 32733
140	3816.33	I	15774 - 41970	4400	4121.32	I	7442 - 31700
120	3816.47	I	15774 - 41969	28	4158.42	I	23184 - 47225
60	3841.46	I	7442 - 33467	45	4162.17	I	28845 - 52864
1400	3842.05	I	7442 - 33463	28	4187.25	I	16471 - 40346
6900	3845.47	I	7442 - 33440	90	4190.71	I	0 - 23856
650	3861.16	I	8461 - 34352	23	4234.00	I	0 - 23612
5500	3873.12	I	3483 - 29295	60	4252.31	I	816 - 24326
2800	3873.96	I	4143 - 29949	23	4285.79	I	1407 - 24733
280	3876.84	I	3483 - 29270	23	4331.24	I	27497 - 50579
790	3881.87	I	4690 - 30444	45	4339.62	I	20501 - 43538
120	3884.62	I	8461 - 34196	23	4371.13	I	16778 - 39649
60	3885.29	I	7442 - 33173	23	4373.63	I	28346 - 51204
28	3892.12	I	20501 - 46186	18	4391.57	I	24326 - 47091
28	h 3893.07	I	18775 - 44455	23	4417.40	I	24733 - 47365
7900	3894.08	I	8461 - 34134	18	4421.34	I	23612 - 46223
550	3894.98	I	5076 - 30743	16	4431.62	I	23208 - 45767
28	3898.49	I	15184 - 40828	18	4445.72	I	25041 - 47528
28	h 3904.05	I	28845 - 54452	60	4466.89	I	24326 - 46707
140	3906.29	I	4143 - 29735	90	4469.56	I	23856 - 46223
160	3909.93	I	0 - 25569	35	4471.55	I	24733 - 47091
140	3917.11	I	18390 - 43911	21	4478.32	I	25041 - 47365
80	3922.75	I	8461 - 33946	18	4483.93	I	25233 - 47528
30	3925.16	I	21216 - 46685	16	4494.76	I	28471 - 50712
28	h 3929.25	I	28346 - 53789	35	4517.11	I	25233 - 47365
30	3933.91	I	4690 - 30103	690	4530.96	I	23612 - 45676
1500	3935.97	I	7442 - 32842	70	4533.99	I	25041 - 47091
160	3940.89	I	5076 - 30444	60	4543.81	I	21920 - 43922
250	3941.73	I	3483 - 28845	90	4549.66	I	24733 - 46707
210	3945.33	I	7442 - 32782	140	4565.59	I	24326 - 46223
45	3952.33	I	3483 - 28777	16	h 4570.02	I	29295 - 51170
370	3952.92	I	7442 - 32733	16	4580.14	I	7442 - 29270
210	3957.94	I	4690 - 29949	190	4581.60	I	23856 - 45676
45	3961.00	I	21216 - 46455	35	h 4594.63	I	29295 - 51053
100	3969.12	I	20501 - 45688	35	h 4596.90	I	29295 - 51042
80	3972.53	I	28346 - 53512	14	4623.04	I	25740 - 47365
90	3973.15	I	15184 - 40346	18	h 4625.78	I	29949 - 51561
90	3974.73	I	4143 - 29295	120	4629.38	I	24628 - 46223
28	3977.18	I	18775 - 43911	85	4663.41	I	25269 - 46707
140	3978.66	I	4143 - 29270	50	4682.38	I	25740 - 47091
120	3979.52	I	816 - 25938	45	4693.21	I	26063 - 47365
45	3987.12	I	4143 - 29216	11	4698.38	I	26250 - 47528
70	3990.30	I	15774 - 40828	9	4727.94	I	3483 - 24628
70	3991.54	I	29270 - 54316	7	4734.83	I	26250 - 47365
70	3991.69	I	4690 - 29735	50	4749.68	I	24628 - 45676
45	3994.54	I	5076 - 30103	9	4754.36	I	26063 - 47091
6000	3995.31	I	7442 - 32465	11	4768.08	I	25740 - 46707
970	3997.91	I	8461 - 33467	35	4771.11	I	25269 - 46223
70	4013.94	I	16196 - 41102	35	4776.32	I	26598 - 47528
23	4019.30	I	4690 - 29563	50	4780.01	I	26450 - 47365
350	4020.90	I	3483 - 28346	110	4792.86	I	26232 - 47091
23	4023.40	I	15774 - 40622	75	4813.48	I	25938 - 46707
70	4027.04	I	1407 - 26232	100	4840.27	I	25569 - 46223
90	h 4035.55	I	28845 - 53618	11	4843.46	I	26450 - 47091
370	4045.39	I	8461 - 33173	150	4867.88	I	25139 - 45676
60	4052.92	I	28845 - 53512	14	4882.72	I	26232 - 46707
28	4057.20	I	1809 - 26450	10	4899.52	I	16471 - 36875
80	4058.19	I	4143 - 28777	10	5108.89	I	31700 - 51268
80	4058.60	I	16196 - 40828	17	5122.77	I	29563 - 49078
350	4066.37	I	7442 - 32028	14	5125.69	I	31700 - 51204

## Cobalt— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	5126.20	I	29216 - 48719	4	5830.08	I	28777 - 45925
17	5133.45	I	31700 - 51174	12	5890.48	I	16468 - 33440
35	5146.74	I	28777 - 48202	12	5915.54	I	17234 - 34134
17	5154.05	I	31871 - 51268	6	5935.39	I	15184 - 32028
17	5156.34	I	32733 - 52121	5	5946.49	I	29563 - 46375
21	5176.08	I	16778 - 36092	7	5984.08	I	14036 - 30743
50	5212.71	I	28346 - 47524	17	5991.88	I	16778 - 33463
50	5230.22	I	14036 - 33151	9	6000.67	I	29216 - 45877
45	5235.21	I	17234 - 36330	6	6006.36	I	35451 - 52095
50	5247.93	I	14399 - 33449	6	6007.67	I	36330 - 52971
10	5250.00	I	33674 - 52717	6	6049.10	I	36330 - 52857
9	5254.65	I	32028 - 51053	17	6082.44	I	28346 - 44782
17	5257.62	I	32028 - 51042	7	6086.65	I	27497 - 43922
9	5265.82	I	29216 - 48202	12	6093.13	I	14036 - 30444
26	5266.30	I	29735 - 48719	9	6116.98	I	14399 - 30743
45	5266.49	I	16468 - 35451	9	6122.65	I	28777 - 45106
26	5268.52	I	30103 - 49078	12	6189.00	I	13796 - 29949
17	h 5276.19	I	33173 - 52121	7	6230.97	I	14399 - 30444
45	h 5280.65	I	29270 - 48202	9	6249.51	I	16468 - 32465
9	5283.49	I	33173 - 52095	6	h 6257.58	I	29949 - 45925
7	5287.57	I	29295 - 48202	5	6273.03	I	32782 - 48719
8	5287.81	I	32654 - 51561	17	6282.63	I	14036 - 29949
26	5301.06	I	13796 - 32654	6	6320.41	I	35451 - 51268
4	5310.20	I	33946 - 52772	6	h 6347.83	I	35451 - 51200
17	h 5312.66	I	33946 - 52764	5	6395.20	I	30743 - 46375
10	5316.78	I	32465 - 51268	9	6417.82	I	18775 - 34352
3	5321.72	I	33674 - 52460	5	6429.91	I	17234 - 32782
15	h 5325.28	I	32431 - 51204	45	6450.24	I	13796 - 29295
5	5325.95	I	33946 - 52717	21	6455.00	I	29295 - 44782
21	5331.47	I	14399 - 33151	8	h 6477.88	I	30444 - 45877
8	5332.67	I	28777 - 47524	6	h 6490.34	I	16468 - 31871
8	5333.65	I	32431 - 51174	3	6551.44	I	15184 - 30444
8	5334.84	I	32431 - 51170	15	6563.42	I	16468 - 31700
12	h 5341.33	I	33440 - 52156	7	6595.90	I	29949 - 45106
50	5342.71	I	32431 - 51143	15	6632.44	I	18390 - 33463
26	5343.39	I	32465 - 51174	3	6678.81	I	15774 - 30743
7	5347.49	I	33467 - 52162	11	6771.06	I	15184 - 29949
7	5349.09	I	33467 - 52156	14	6814.94	I	15774 - 30444
50	5352.05	I	28845 - 47524	14	6872.40	I	16196 - 30743
26	5353.48	I	33440 - 52114	3	6937.81	I	21920 - 36330
14	5359.18	I	33467 - 52121	11	7016.61	I	16196 - 30444
21	h 5362.77	I	34134 - 52775	4	7027.81	I	31700 - 45925
35	5369.58	I	14036 - 32654	21	7052.89	I	15774 - 29949
6	5381.10	I	15774 - 34352	5	7054.04	I	21920 - 36092
9	h 5381.75	I	34196 - 52772	45	7084.99	I	15184 - 29295
14	h 5407.51	I	33674 - 52162	4	7113.56	I	31871 - 45925
7	h 5436.99	I	33173 - 51561	3	7134.32	I	32733 - 46746
21	h 5444.57	I	32842 - 51204	4	7154.71	I	16471 - 30444
7	5452.30	I	30743 - 49078	4	7159.18	I	32782 - 46746
17	h 5454.56	I	32842 - 51170	2	7193.60	I	32028 - 45925
7	5469.30	I	15184 - 33463	3	7285.28	I	23153 - 36875
9	5470.46	I	30444 - 48719	3	7354.59	I	15184 - 28777
9	5477.08	I	29949 - 48202	5	7388.70	I	21920 - 35451
45	5483.34	I	13796 - 32028	8	7417.38	I	16471 - 29949
9	5483.96	I	29295 - 47524	5	7457.36	I	31700 - 45106
8	h 5489.65	I	32842 - 51053	2	7533.48	I	32654 - 45925
4	5495.67	I	27497 - 45688	4	7553.99	I	31871 - 45106
12	5523.29	I	18775 - 36875	1	7564.96	I	39649 - 52864
7	h 5524.98	I	33173 - 51268	2	7586.72	I	23153 - 36330
17	5530.77	I	13796 - 31871	2	h 7590.57	I	16778 - 29949
3	5558.82	I	28471 - 46455	3	h 7606.30	I	32782 - 45925
15	5590.73	I	16471 - 34352	3	h 7610.24	I	21216 - 34352
6	h 5636.12	I	33463 - 51201	8	7712.68	I	20501 - 33463
17	5647.22	I	18390 - 36092	2	7734.23	I	33449 - 46375
3	5659.11	I	16468 - 34134	2	7743.27	I	31871 - 44782

Cobalt—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
5	7838.17	I	32028 - 44782	9	8093.96	I	32431 - 44782
2	7840.05	I	33173 - 45925	2	8116.41	I	32465 - 44782
2	7855.85	I	33151 - 45877	1	8152.11	I	32842 - 45106
1	7869.90	I	33173 - 45877	4	8193.03	I	33674 - 45877
1	7871.39	I	33674 - 46375	3	8208.66	I	34196 - 46375
7	7908.71	I	32465 - 45106	9	8372.84	I	32842 - 44782
3	7926.55	I	34134 - 46746	3	8378.39	I	33173 - 45106
9	7987.38	I	16778 - 29295	2 h	8574.57	I	21780 - 33440
13	8007.27	I	33440 - 45925	4	8575.35	I	22475 - 34134
3	8022.13	I	33463 - 45925	1	8586.74	I	33463 - 45106
3	8029.26	I	32654 - 45106	3	8589.73	I	33467 - 45106
5	8043.33	I	33946 - 46375	2	8661.09	I	21920 - 33463
6	8056.06	I	33467 - 45877	3	8819.15	I	41529 - 52864
1	8066.49	I	34352 - 46746				

# Copper

$$\text{Cu, } Z = 29, M = 63.546, \text{ Ratio } \frac{\text{Cu}}{\text{Cu}} = 1.0000$$

Cu I Normal state of valence electrons  $3d^{10}4s^2S_{1/2} = 0$ . I.P. = 62317  $\text{cm}^{-1}$ .

Cu II Normal state of valence electrons  $3d^{10}^1S_0 = 0$ . I.P. = 163666  $\text{cm}^{-1}$ .

## References

### Wavelengths and Classification:

Cu I, A. G. Shenstone, Phil. Trans. Roy. Soc. (London) [A] **241**, 297 (1948).

Cu II, A. G. Shenstone, Phil. Trans. Roy. Soc. (London) [A] **235**, 195 (1936).

*Copper—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5500	1999.69	II	21929 - 71920	240	2961.16	I	11203 - 44963
2400	2024.34	I	0 - 49383	40	2997.36	I	13245 - 46598
1600	2035.84	II	23998 - 73102	70	3010.84	I	11203 - 44406
2200	2037.12	II	22847 - 71920	60	3036.10	I	13245 - 46173
3800	2043.79	II	21929 - 70842	40	3063.41	I	13245 - 45879
650	2112.09	II	26265 - 73596	25	3093.99	I	11203 - 43514
2000	2135.98	II	21929 - 68731	80	3194.10	I	13245 - 44544
700	2138.53	I	11203 - 57949	25	3208.23	I	13245 - 44406
1400	2165.09	I	0 - 46173	50000	3247.54	I	0 - 30784
1800	2178.94	I	0 - 45879	25000	3273.96	I	0 - 30535
1200	2181.72	I	0 - 45821	40	3279.82	I	13245 - 43726
360	2192.26	II	22847 - 68448	80	3307.95	I	40909 - 71131
1700	d 2199.58	I	11203 - 56651	70	3337.84	I	11203 - 41153
	2199.75	I	13245 - 58691	35	3599.13	I	43514 - 71291
550	2214.58	I	11203 - 56344	35	3602.03	I	43514 - 71268
460	2225.70	I	0 - 44916	20	h 4022.63	I	30535 - 55388
950	2227.78	I	13245 - 58119	40	4275.11	I	39019 - 62403
1200	2230.08	I	11203 - 56030	20	4530.78	I	30784 - 52849
400	2247.00	II	21929 - 66419	80	4651.12	I	40909 - 62403
280	2293.84	I	11203 - 54784	400	5105.54	I	11203 - 30784
50	2369.89	II	26265 - 68448	200	5153.24	I	30535 - 49935
70	2441.64	I	0 - 40944	240	5218.20	I	30784 - 49942
360	2492.15	I	0 - 40114	40	5220.07	I	30784 - 49935
400	2618.37	I	11203 - 49383	40	h 5292.52	I	43514 - 62403
50	2700.96	II	73353 - 110366	100	5700.24	I	13245 - 30784
80	2766.37	I	13245 - 49383	400	5782.13	I	13245 - 30535
500	2824.37	I	11203 - 46598	200	7933.13	I	30535 - 43137
50	2882.93	I	11203 - 45879	400	8092.63	I	30784 - 43137

# Dysprosium

Dy,  $Z = 66$ ,  $M = 162.5$ , Ratio  $\frac{\text{Dy}}{\text{Cu}} = 2.557$

Dy I Normal state of valence electrons  $4f^{10}6s^2 5I_8 = 0$ . I.P. = 47810  $\text{cm}^{-1}$

Dy II Normal state of valence electrons  $4f^{10}6s^2 6I_{81/2} = 0$ . I.P. = 94100  $\text{cm}^{-1}$ .

## References

### Wavelengths:

J. G. Conway and E. F. Worden, Univ. Cal. Rad. Lab., UCRL-19944 (1970).

### Spectrum Assignments:

A. S. King, *Astrophys. J.* **72**, 221 (1930).

A. S. King and C. E. Moore, *Astrophys. J.* **98**, 33 (1943).

A. S. King, unpublished material (1956).

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### Classification:

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J. F. Wyart, Thesis, Univ. Paris-Sud, Orsay (1973).

### Molecular Spectra:

DyO, A. Gatterer, J. Junkes and E. W. Salpeter, *Molecular Spectra of Metallic Oxides* (Specola Vaticana, Vatican, 1957).

### *Strong lines of dysprosium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
22000	3531.70	II	0 - 28306	4400	3523.98	II	4341 - 32709
16000	4211.72	I	0 - 23736	4400	3534.96	II	828 - 29109
14000	3968.39	II	0 - 25192	4400	3538.52	II	0 - 28252
12000	4045.97	I	0 - 24708	4400	3550.22	II	4755 - 32914
12000	4186.82	I	0 - 23877	4400	3576.24	II	4755 - 32709
11000	3645.40	II	828 - 28252	4400	4218.09	I	4134 - 27834
10000	3944.68	II	0 - 25343	4400	4221.11	I	4134 - 27817
8000	4000.45	II	828 - 25818	4000	3630.24	II	4341 - 31879
7400	4077.96	II	828 - 25343	3900	4103.30	II	828 - 25192
7000	3872.11	II	0 - 25818	3800	3393.57	II	828 - 30287
6800	4194.84	I	0 - 23832	3800	3445.57	II	0 - 29014
5800	3898.53	II	4755 - 30399	3700	4215.16	I	0 - 23717
5700	4167.97	I	0 - 23985	3300	3585.06	II	0 - 27885
5500	3536.02	II	4341 - 32613	3300	3786.18	II	828 - 27232
5300	3385.02	II	828 - 30361	2700	3454.32	II	828 - 29769
5300	3407.80	II	0 - 29336	2700	3978.57	II	7463 - 32591
4700	3694.81	II	828 - 27885	2700	4225.16	I	7050 - 30711
4700	3757.37	II	828 - 27435	2500	4073.12	II	4341 - 28885
4400	3460.97	II	0 - 28885	2300	3836.50	II	4341 - 30399
4400	3494.49	II	828 - 29436				

*Dysprosium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
260	2356.91	II		70	2848.93	I	
65	2381.95			85	2856.42	II	
130	2387.36	II		17	2857.01	II	15530 - 50521
150	2392.15			40	2857.11	II	
180	2402.29	II		50	2859.72	II	
240	2410.01	II		55	2860.17	II	4341 - 39293
150	2422.75	II		70	2860.67	II	
260	2439.84	II		140	2862.70	I	0 - 34921
90	2455.15	II	828 - 41546	85	2866.26	II	13610 - 48489
110	2459.99	II		70	2867.62	II	11394 - 46256
90	2471.40	II		28	2869.82	II	
110	2480.93	II		95	2876.39	II	12336 - 47091
170	2490.61	II		190	2877.88	II	828 - 35565
90	2510.31	II		85	2878.70	II	
170	2513.55	II		85	2881.06	II	15822 - 50521
170	2517.61	II	0 - 39708	110	2884.28	II	4755 - 39416
130	2543.81	II		70	2884.81	II	
90	2545.12	II	4763 - 44043	120	2885.53	I	4134 - 38779
150	2552.29	II		70	2890.44	II	15822 - 50408
180	2557.94	II	828 - 39910	120	2890.74	II	
90	2560.21	II		70	2891.02	II	
90	2566.25	II		120	2900.82	II	4341 - 38804
220	2585.30	I		110	2904.62	II	4341 - 38758
90	2591.56	II		190	2906.39	II	0 - 34396
75	2592.54	II		70	2909.37	II	
130	2600.16	II	12336 - 50783	35	2909.69	II	12336 - 46694
130	2600.76	II		35	2909.88	II	
75	2608.69	II		35	2913.74	II	13408 - 47718
370	2623.69	I	0 - 38102	390	2913.95	II	0 - 34307
440	2634.80	II	0 - 37942	70	2918.65	II	
110	2642.15	I	0 - 37836	70	2927.06	II	12336 - 46490
110	2645.35	II		70	2931.00	II	13610 - 47718
110	2667.94	I	0 - 37471	110	2934.31	II	
55	2676.84	II		250	2934.52	II	14421 - 48489
50	2677.34	II	12336 - 49675	110	2941.05	II	15822 - 49813
85	2689.31	II	13610 - 50783	140	2944.56	II	10594 - 44545
85	2692.83	II	10594 - 47718	85	2946.31	II	828 - 34759
55	2709.01	II	0 - 36902	95	2946.77	II	4341 - 38266
55	2727.17	II	11394 - 48052	150	2947.06	II	11394 - 45317
85	2729.50	II		150	2947.21	II	12336 - 46256
55	2735.79	I		250	2948.31	II	10594 - 44501
40	2739.30	II	12336 - 48831	170	2950.33	II	12336 - 46220
85	2740.70	II		110	2952.12	II	828 - 34692
220	2755.75	II		55	2953.03	II	7463 - 41317
55	2757.08	II	10594 - 46853	140	2953.70	II	
70	2766.50	II	13408 - 49544	85	2957.75	II	13408 - 47208
70	2772.42	II	0 - 36058	85	2962.36	II	13610 - 47357
110	2772.61	II	828 - 36884	220	2964.60	I	0 - 33721
40	2779.58	II	17036 - 53002	55	2964.74	II	
55	2791.44	II	11394 - 47208	40	2975.55	II	13610 - 47208
120	2800.33	II	12336 - 48035	85	2975.85	II	14895 - 48489
110	2800.53	II	11394 - 47091	110	2977.42	II	0 - 33576
110	2801.41	II	12336 - 48022	50	2979.65	II	19451 - 53002
85	2810.85	II	0 - 35565	110	2985.97	II	10594 - 44074
50	2811.09	II	14895 - 50457	35	2987.88	II	15530 - 48988
85	2811.42	II	828 - 36387	50	2988.71	II	16601 - 50051
55	2815.22	II		70	2989.77	II	12336 - 45773
300	2816.39	II	0 - 35495	85	2991.36	II	16260 - 49680
140	2825.42	II	4763 - 40146	70	2991.61	II	11394 - 44812
55	2828.37	II	828 - 36173	55	2992.41	II	12674 - 46082
50	d 2835.12	II	12336 - 47597	50	2995.43	II	4755 - 38130
	2835.29	II		85	3002.38	II	10594 - 43891
55	2837.00	II		110	3003.76	II	828 - 34110
55	2837.61	II	828 - 36058	55	3008.81	II	16875 - 50101
55	2842.04	II	828 - 36003	140	3015.07	II	14895 - 48052

*Dysprosium — all observed lines — Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
220	3015.68	II	11394 - 44545	120	3152.37	II	12336 - 44049
180	3016.95	II		100	3153.31	II	
170	3025.59	II	4341 - 37382	1200	3156.52	II	11394 - 43066
390	3026.16	II	0 - 33035	65	3157.55	II	14421 - 46082
85	3027.56	II	12336 - 45356	120	3160.50	II	4755 - 36387
210	3029.81	II		110	3161.03	II	
110	3030.40	II	828 - 33817	670	3162.83	II	11394 - 43002
85	3031.15	II	17036 - 50017	100	3164.04	II	
	3031.19	II	16875 - 49856		3164.13	II	
95	3033.19	II	15530 - 48489	120	3167.40	II	
120	3036.70	II		80	3167.76	II	18121 - 49680
610	3038.28	II	12336 - 45240	80	3168.15	II	12336 - 43891
50	3042.09	II		100	3168.95	I	0 - 31547
280	3043.13	II	17606 - 50457	1000	3169.99	II	0 - 31536
170	3043.43	II	13408 - 46256	180	3170.75	II	13610 - 45139
70	3044.54	II	20166 - 53002	80	3170.97	II	4755 - 36282
55	3046.38	II		65	3171.47	II	13610 - 45132
210	3047.56	II	12336 - 45139	130	3174.88	II	11394 - 42883
150	3049.12	II	12336 - 45123	400	3177.89	II	16260 - 47718
180	3051.45	II	4755 - 37517	220	3178.37	II	828 - 32281
180	3052.32	II	20985 - 53738	80	3181.94	II	4755 - 36173
95	3056.96	II	14895 - 47597	65	3183.19	II	
85	3059.47	II	14347 - 47023	80	3184.19	II	
110	3060.02	II	14421 - 47091	200	3184.79	II	828 - 32218
280	3060.64	II		330	3186.38	II	12674 - 44049
120	3061.36	II	9432 - 42087	240	3187.68	II	14895 - 46256
85	3061.49	II	11394 - 44049	65	3188.66	II	14421 - 45773
110	3062.18	II	15822 - 48469	65	3192.97	II	17036 - 48346
390	3062.62	II	12674 - 45317	330	3193.30	II	0 - 31306
220	3066.99	II	14347 - 46943	130	3205.46	II	14895 - 46082
85	3070.46	II		240	3206.40	II	16881 - 48059
330	3071.91	II	4341 - 36884	80	3206.64	II	16875 - 48052
280	3073.54	II		220	3207.12	II	14895 - 46066
55	3075.18	II		290	3208.85	II	4341 - 35495
110	3076.89	II	828 - 33319	130	3212.04	II	14421 - 45545
140	3078.33	II	12336 - 44812	80	3212.44	II	
220	3078.68	II	10594 - 43066	80	3212.68	II	15530 - 46647
150	3079.33	II	12674 - 45139	190	3214.63	II	
95	3080.92	II	12674 - 45123	470	3215.19	II	13408 - 44501
140	3082.51	II	4755 - 37187	830	3216.63	II	16881 - 47960
85	3084.68	II	10594 - 43002	80	3217.38	II	
120	3093.10	II	4755 - 37076	160	3220.46	II	13610 - 44653
95	3093.82	II	14895 - 47208	240	3221.49	II	17036 - 48069
120	3095.74	II	13408 - 45701	170	3221.64	II	7463 - 38495
280	3101.93	II	16260 - 48489	290	3223.28	II	12674 - 43689
220	3103.24	II	4755 - 36970	240	3225.08	II	828 - 31826
190	3103.83	II	12336 - 44545	330	3225.95	II	10594 - 41583
180	3104.99	II	14895 - 47091	80	3226.07	II	18549 - 49537
410	3109.76	II	10594 - 42741	140	3226.38	II	17036 - 48022
85	3110.75	II	12674 - 44812	170	3228.97	II	16015 - 46976
50	3117.50	II	15530 - 47597	170	3229.36	II	15822 - 46779
190	3120.18	II	9432 - 41472	110	3229.94	II	4755 - 35707
170	3126.20	II	12674 - 44653	140	3232.64	II	4341 - 35266
330	3128.41	II	10594 - 42550	490	3235.89	II	0 - 30894
830	3135.38	II	10594 - 42478	290	3236.69	II	828 - 31715
360	3140.64	II	13408 - 45240	140	3240.86	II	20793 - 51640
500	3141.14	II	0 - 31826	100	3243.72	II	14421 - 45241
140	3142.30	II	14347 - 46161		3243.78	II	
95	3143.18	II	18978 - 50783	490	3245.12	II	14895 - 45701
220	3143.83	II	14895 - 46694	200	3248.36	II	14347 - 45123
140	3145.22	II	828 - 32613	90	3250.99	II	7463 - 38214
250	3146.16	II	15822 - 47597	1200	3251.27	II	10953 - 41702
120	3147.53	II	16260 - 48022	170	3251.90	II	11394 - 42137
120	3151.89	II	4341 - 36058	200	3252.19	II	17606 - 48346
100	3152.22	II		80	3253.91	II	18121 - 48844

Dysprosium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	3254.48	II	14421 - 45139	160	3371.69	II	14895 - 44545
290	3256.26	II	14421 - 45123	160	3371.81	II	9432 - 39081
80	3257.37	II	15530 - 46220	130	3372.78	II	17007 - 46647
170	3260.02	II	13408 - 44074	90	3374.29	II	14421 - 44049
140	3260.70	II	9432 - 40091	180	3375.74	II	12674 - 42289
140	3261.21	II	20985 - 51640	90	3376.00	II	7463 - 37076
170	3266.00	II	19492 - 50101	180	3376.37	II	4341 - 33950
	3266.02	II	4755 - 35365	130	3376.62	II	14895 - 44501
200	3266.21	II		160	3377.10	II	7463 - 37066
240	3269.11	II	0 - 30580	90	3378.21	II	15530 - 45123
80	3272.09	II	15530 - 46082	180	3378.42	II	7485 - 37076
200	3272.73	II	12336 - 42883	100	3378.88	II	10953 - 40541
120	3275.93	II	10594 - 41111	90	3381.54	II	10594 - 40158
100	3279.45	II	18978 - 49462	100	3384.09	II	14126 - 43668
160	3279.70	II	16875 - 47357	5300	3385.02	II	828 - 30361
890	3280.09	II	828 - 31306	210	3386.57	II	18549 - 48069
80	3281.65	II	13610 - 44074	610	3388.85	II	4755 - 34256
490	3282.77	II		100	3389.44	II	15822 - 45317
100	3282.89	II	4755 - 35207	140	3391.16	II	
80	3284.36	II	13610 - 44049	210	3391.96	II	18549 - 48022
90	3286.57	II	4341 - 34759	90	3393.36	II	4755 - 34216
200	3287.94	II	12336 - 42741	3800	3393.57	II	828 - 30287
130	3288.62	II	0 - 30399	140	3393.98	II	13610 - 43066
100	3291.12	II		1300	3396.16	II	0 - 29436
200	3293.88	II	17007 - 47357	90	3398.32	II	
200	3296.30	II	12674 - 43002	90	3399.36	II	12674 - 42083
130	3297.60	II	20467 - 50783	110	3402.01	I	9990 - 39376
80	3300.92	II	19251 - 49537	140	3403.24	II	
200	3305.40	II	14895 - 45139	110	3403.43	II	18678 - 48052
200	3305.51	II	15530 - 45773	210	3404.99	II	9870 - 39231
240	3306.19	II	17596 - 47833	270	3405.65	II	4755 - 34110
440	3308.79	II	12336 - 42550	110	3406.76	II	16875 - 46220
1100	3308.88	II	10594 - 40807		3406.82	II	
100	3310.97	II		380	3407.16	II	7463 - 36805
510	3312.72	II	4341 - 34519	5300	3407.80	II	0 - 29336
120	3313.31	II	19956 - 50129	420	3408.14	II	13408 - 42741
780	3316.32	II	828 - 30973	100	3409.46	II	
240	3317.12	II	7485 - 37623	140	3410.71	II	10953 - 40264
100	3318.13	II	4755 - 34884	110	3411.22	II	
1000	3319.88	II	0 - 30112	110	3411.52	II	9870 - 39175
270	3326.19	II	4341 - 34396	1300	3413.78	II	828 - 30112
90	d 3326.42	II	20467 - 50521	530	3414.82	II	4341 - 33616
	3326.52	II		120	3415.71	II	14421 - 43689
130	3327.08	II		270	3417.13	II	10953 - 40209
80	3327.30	II	16601 - 46647	270	3418.10	II	12336 - 41583
90	3328.80	II	7485 - 37517	780	3419.63	II	7485 - 36719
100	3331.27	II	10594 - 40604	90	3420.79	I	4134 - 33358
130	3334.14	II	9432 - 39416	160	3421.31	II	17036 - 46256
65	3334.45	II	19251 - 49233	130	3422.60	II	11394 - 40604
190	3339.51	II	4755 - 34691	270	3422.86	II	16875 - 46082
780	3341.00	II	10594 - 40516	110	3423.23	II	9432 - 38635
130	3341.44	II	828 - 30747	90	h 3423.82	II	
270	3341.88	II	4341 - 34255		3423.91	II	
200	3347.83	II	10594 - 40455	530	3425.06	II	4341 - 33529
270	3352.69	II	16875 - 46694	90	3425.40	II	
510	3353.58	II	828 - 30638	110	h 3428.99	II	17007 - 46161
120	3355.06	II	18549 - 48346	420	3429.44	II	9870 - 39021
190	3356.21	II	15530 - 45317	270	3431.79	II	13610 - 42741
130	3358.30	II	4755 - 34524	220	3432.58	II	4341 - 33465
190	3358.60	II	0 - 29765	130	3432.86	II	11394 - 40516
240	3359.46	II	14895 - 44653	1900	3434.37	II	0 - 29109
90	3360.65	II		90	3435.26	II	9870 - 38972
130	3365.81	II	14347 - 44049	130	3435.60	II	
510	3368.11	II	0 - 29681	130	3436.09	II	19251 - 48346
160	3370.85	II	13408 - 43066	90	3436.92	II	17606 - 46694



Dysprosium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
330	3438.94	II	13408 - 42478	290	3512.56	II	14421 - 42883
130	3439.33	II		290	3512.70	II	17606 - 46066
90	3440.45	II	18978 - 48035	560	3517.26	II	10953 - 39377
560	3440.93	II	16881 - 45934	110	3519.76	II	
1300	3441.45	II	828 - 29877	190	3521.16	II	
55	3442.50	II	18678 - 47718	90	3522.28	II	10953 - 39336
55	3442.55	II		290	3522.86	II	7463 - 35841
90	3443.48	II	20985 - 50017	4400	3523.98	II	4341 - 32709
130	3444.25	II	9432 - 38457	170	3524.63	II	9432 - 37795
3800	3445.57	II	0 - 29014	90	3524.93	II	15530 - 43891
830	3446.99	II	7463 - 36466	270	3525.74	II	10953 - 39308
170	3447.26	II	14421 - 43422	130	3526.64	II	10953 - 39301
170	3447.73	II	14895 - 43891	190	3526.90	II	11801 - 40146
440	3449.89	II	4341 - 33319	55	3528.90	II	12674 - 41004
110	3450.22	II		200	3529.03	II	0 - 28328
2700	3454.32	II	828 - 29769	22000	3531.70	II	0 - 28306
440	3454.51	II	13610 - 42550	140	3534.45	II	16260 - 44545
1300	3456.56	II	4755 - 33677	4400	3534.96	II	828 - 29109
110	3458.98	II	7485 - 36387	5500	3536.02	II	4341 - 32613
220	3460.40	II	9432 - 38322	290	3536.58	II	12336 - 40604
110	3460.66	II	9870 - 38758	290	3537.66	II	9870 - 38130
4400	3460.97	II	0 - 28885	4400	3538.52	II	0 - 28252
90	3461.31	II	20793 - 49675	400	3539.37	II	4755 - 33001
190	3463.34	II	7485 - 36350	110	3539.64	II	7485 - 35728
200	3463.87	II	4755 - 33616	160	3540.69	II	11801 - 40036
90	3467.86	II		1700	3542.33	II	7463 - 35685
720	3468.43	II	9432 - 38255	90	3542.86	II	19183 - 47401
90	3468.78	II		400	3544.20	II	9870 - 38078
130	3470.19	II	22908 - 51716	400	3544.35	II	9432 - 37637
560	3471.14	II	7463 - 36264	1400	3546.83	II	828 - 29014
560	d 3471.53	II	7485 - 36282	110	3547.58	II	10953 - 39134
	3471.60	II	7463 - 36260	90	3547.91	II	17596 - 45773
380	3473.70	II	7485 - 36264	330	3548.19	II	13408 - 41583
220	3474.27	II	12336 - 41111	140	3548.72	II	14895 - 43066
1300	3477.07	II	4755 - 33507	130	3549.25	II	12674 - 40841
90	3477.93	II	20793 - 49537	4400	3550.22	II	4755 - 32914
90	3478.48	II	11801 - 40541	190	3551.15	II	
90	3480.42	II	9432 - 38156	2200	3551.62	II	4755 - 32903
220	3480.81	II		90	3553.21	II	16601 - 44737
110	3482.10	II	7463 - 36173	130	3555.97	II	18978 - 47091
220	3484.68	II	7485 - 36173	110	3557.62	II	18678 - 46779
190	3485.92	II	13610 - 42289	440	3558.23	II	9432 - 37527
130	3487.20	II	15979 - 44647	440	3559.30	II	9870 - 37958
170	3487.57	II	17036 - 45701	290	3560.14	II	7485 - 35565
	3487.60	II	20166 - 48831	2200	3563.15	II	828 - 28885
110	3488.99	II	10953 - 39607	560	3563.69	II	
130	3490.65	II	16601 - 45241	220	3564.24	II	
220	3494.13	II	22172 - 50783	90	3565.69	II	11801 - 39838
4400	3494.49	II	828 - 29436	200	3569.66	II	0 - 28005
560	3496.34	II	7463 - 36057	100	3571.44	I	4134 - 32126
90	3497.13	II	9870 - 38457	90	3571.67	II	11801 - 39791
400	3497.81	II	14421 - 43002	780	3573.83	II	13610 - 41583
830	3498.71	II	4341 - 32914	1400	3574.15	II	7463 - 35434
220	3498.93	II	7485 - 36057	110	3576.00	II	828 - 28784
140	d 3499.86	II	14347 - 42911	4400	3576.24	II	4755 - 32709
	3499.96	II	4755 - 33319	90	3576.58	II	20517 - 48469
400	3501.50	II	4755 - 33306	1700	3576.87	II	7485 - 35434
220	3501.86	II		830	3577.98	II	4341 - 32281
220	3502.14	II	10953 - 39499	160	3579.11	II	9432 - 37363
270	3503.17	II	7463 - 36001	90	3579.44	II	22854 - 50783
830	3504.53	II	9432 - 37958	440	3580.04	II	9870 - 37795
830	3505.45	II	7485 - 36003	190	3582.02	II	19492 - 47401
270	3505.84	II		400	3584.42	II	11801 - 39691
1300	3506.81	II	828 - 29336	3300	3585.06	II	0 - 27885
290	3511.68	II	21134 - 49603	1400	3585.78	II	7485 - 35365

*Dysprosium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
560	3586.11	II	4341 - 32218	1000	3648.78	II	13408 - 40807
360	3590.07	II	14895 - 42741	110	3654.18	II	9870 - 37229
290	3590.66	II	12674 - 40516	130	3654.88	II	15530 - 42883
1100	3591.41	II		110	3655.62	I	8519 - 35866
560	3591.81	II	10594 - 38427	160	3661.78	II	10953 - 38255
560	3592.11	II	7463 - 35294	700	3664.62	II	11801 - 39081
100	3593.16	II	4755 - 32578	190	3665.23	II	16881 - 44156
220	3594.56	I	7565 - 35377	400	3666.84	I	7565 - 34829
1800	3595.04	II	10594 - 38402	150	3668.90	II	7463 - 34712
160	3595.28	II	11801 - 39607	150	3671.69	II	7463 - 34691
400	3596.06	II	9870 - 37671	990	3672.30	II	10594 - 37817
100	3596.48	II	9432 - 37229	420	3672.70	II	
220	3597.28	I	12892 - 40683	400	3673.14	II	0 - 27216
110	3597.94	II	14126 - 41912	1400	3674.08	II	0 - 27209
110	3598.26	II	7485 - 35268	230	3674.45	I	4134 - 31341
110	3599.04	II	16875 - 44653	120	3676.02	II	9870 - 37066
100	3599.56	II	22083 - 49856	2200	3676.59	II	828 - 28019
180	3600.25	II	9432 - 37199	640	3678.51	I	7565 - 34742
560	3600.38	II	9870 - 37637	820	3684.85	I	
360	3602.82	II	11801 - 39549	1300	3685.78	I	7565 - 34689
140	3603.16	II	7485 - 35230	120	3688.36	II	18978 - 46082
90	3604.34	I		160	3693.87	I	11673 - 38737
1800	3606.12	II	7485 - 35207	140	3694.42	II	7463 - 34524
100	3606.38	II	17596 - 45317	4700	3694.81	II	828 - 27885
130	3606.90	II	21272 - 48988	140	3696.95	II	24967 - 52008
110	3609.25	II	11801 - 39499	370	3697.31	II	7485 - 34524
110	3611.23	I	7565 - 35249	990	3698.21	II	11394 - 38427
290	3612.78	II		230	3700.58	II	
220	3613.08	II	16875 - 44545	540	3701.63	II	11394 - 38402
290	3614.07	II	14421 - 42083	330	3707.40	II	4341 - 31306
100	3614.70	II	9870 - 37527	440	3707.57	II	828 - 27792
100	3614.95	II	14895 - 42550	440	3708.22	II	4755 - 31715
130	3616.08	II	9870 - 37517	120	3708.36	II	
110	3616.37	II	9432 - 37076	420	3710.07	II	4755 - 31701
130	3617.20	II	4341 - 31978	120	3710.74	II	10953 - 37895
110	3617.63	II	9432 - 37066	330	3711.66	II	9870 - 36805
100	3617.78	II	17606 - 45240	160	3713.84	II	9432 - 36350
290	3618.10	II	16260 - 43891	110	3715.31	II	9432 - 36340
440	3618.51	II	828 - 28456	95	3715.57	II	13610 - 40516
160	3619.45	II	14126 - 41747	160	3716.94	II	16016 - 42911
200	3619.98	II	17036 - 44653	95	3717.28	I	
560	3620.16	II	11801 - 39416	80	3718.14	II	
100	3620.58	II	7463 - 35075	1600	3724.45	II	4341 - 31183
470	3624.27	II	14895 - 42478	95	3725.94	I	9990 - 36822
1100	3629.42	II	11394 - 38939	300	3728.00	I	9990 - 36807
4000	3630.24	II	4341 - 31879	120	3730.67	I	
220	3630.48	II	7463 - 35000	930	3739.34	I	12892 - 39627
110	3630.60	II		110	3739.86	II	7485 - 34216
440	3632.78	II	12674 - 40194	1200	3747.82	II	828 - 27502
220	3633.02	II	18549 - 46066	130	3750.32	II	14347 - 41004
110	3633.76	II	9870 - 37382	160	3751.80	II	7463 - 34110
90	3634.18	II	17036 - 44545	1400	3753.51	II	0 - 26634
110	3634.32	II	11801 - 39308	1400	3753.75	II	4341 - 30973
400	3635.27	II	11801 - 39301	95	3754.81	II	9432 - 36057
180	3636.25	II	9870 - 37363	1200	3757.05	I	7565 - 34174
360	3637.28	II	4341 - 31826	4700	3757.37	II	828 - 27435
220	3639.90	II		95	3758.99	II	9870 - 36466
1100	3640.25	II	4755 - 32218	640	3767.63	I	8519 - 35053
90	3640.83	II	26279 - 53738	330	3771.11	I	13495 - 40005
400	3643.92	II	0 - 27435	95	3771.35	I	12007 - 38515
11000	3645.40	II	828 - 28252	160	3772.64	I	9990 - 36490
360	3645.86	II	7463 - 34884	640	3773.05	I	9990 - 36487
180	3646.61	II	11801 - 39215	230	3773.30	II	14347 - 40841
160	3646.89	I	4134 - 31547	70	3773.77	I	
180	3648.46	II	7463 - 34864	370	3774.71	I	8519 - 35003

*Dysprosium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
95	3776.92	II	9870 - 36340	110	3887.54	I	
220	3777.43	I	14367 - 40833	190	3888.43	II	15979 - 41689
95	3779.03	II	11801 - 38255	190	3889.01	II	
150	3779.23	II	13338 - 39791	280	3891.86	II	16601 - 42289
95	3780.31	I	12007 - 38452	280	3892.90	I	7565 - 33246
95	3780.94	I	12655 - 39096	80	3894.53	I	12007 - 37676
420	3781.47	I	12007 - 38444	160	3895.37	II	14126 - 39791
190	3782.87	II	4755 - 31183	5800	3898.53	II	4755 - 30399
150	3783.60	II	11394 - 37817	270	3899.17	I	
150	3783.94	I	10088 - 36508	100	3901.38	I	13495 - 39120
330	3785.41	II	9432 - 35841	85	3903.33	I	8519 - 34131
3300	3786.18	II	828 - 27232	160	3904.21	II	4755 - 30361
120	3786.83	I	13495 - 39895	110	3905.60	II	14347 - 39944
130	3787.26	II	13338 - 39735	110	3905.94	I	14153 - 39748
1600	3788.44	II	828 - 27216	120	3912.54	I	12892 - 38444
700	3791.87	II	828 - 27193	85	3912.86	II	14347 - 39896
120	3801.93	II	17596 - 43891	140	3913.62	I	7565 - 33110
510	3804.14	II	0 - 26279	160	3913.97	II	12336 - 37878
120	3804.35	I	12007 - 38285	540	3914.87	II	4341 - 29877
580	3806.27	II	12674 - 38939	540	3915.59	II	4755 - 30287
110	3807.90	II	9432 - 35685	540	3917.29	I	7565 - 33086
280	3809.02	II	10953 - 37199		3917.38	I	12007 - 37527
210	3809.82	I	7565 - 33806	110	3918.55	II	10953 - 36466
180	3809.97	II	4341 - 30580	140	3919.12	I	15862 - 41371
470	3812.27	I	8519 - 34742	320	3923.38	II	12336 - 37817
160	3813.10	II	4755 - 30973	110	3924.47	II	15530 - 41004
470	3813.67	II	7463 - 33677	420	3927.86	I	11673 - 37125
230	3816.21	I	13495 - 39692	140	3929.33	II	17036 - 42478
1400	3816.76	II	7485 - 33677	540	3930.14	I	12892 - 38329
190	3817.53	I	7565 - 33753	190	3931.28	II	7485 - 32914
120	3818.75	II	13338 - 39517	2100	3931.52	II	4341 - 29769
120	3819.44	I		110	3932.08	II	4341 - 29765
95	3821.47	I	8519 - 34679	320	3932.22	II	9870 - 35294
110	3821.88	I	8519 - 34676	370	3933.00	II	7485 - 32903
280	3822.58	II	7463 - 33616	320	3934.21	II	
95	3824.02	I	12892 - 39035	160	3936.05	II	11801 - 37199
700	3825.68	II	7485 - 33616	85	3936.30	II	9870 - 35268
190	3829.78	I		420	3936.70	I	9990 - 35385
95	3831.08	II	14421 - 40516	140	3937.16	I	8519 - 33911
210	3831.64	II	12336 - 38427	270	3938.04	II	10953 - 36340
150	3832.88	II	10953 - 37036	210	3938.20	I	11673 - 37058
2300	3836.50	II	4341 - 30399	540	3942.53	II	4755 - 30112
160	3838.66	II	7463 - 33507	10000	3944.68	II	0 - 25343
370	3840.89	I	14367 - 40396	420	3946.93	II	13610 - 38939
1400	3841.31	II	828 - 26853	540	3950.39	II	10953 - 36260
330	3842.00	II	4341 - 30361	85	3953.19	I	12007 - 37295
330	3844.36	I	10088 - 36093	420	3954.55	II	9432 - 34712
420	3846.34	II	4755 - 30747	85	3956.32	I	14620 - 25268
420	3847.02	I	7565 - 33552	800	3957.79	II	9432 - 34691
330	3849.39	II	9870 - 35841	85	3959.38	II	17007 - 42256
1200	3853.03	II	4341 - 30287	370	3962.59	I	9990 - 35219
420	3858.40	I	7565 - 33475	110	3963.16	I	14153 - 39378
210	3865.48	II	9432 - 35294	85	3963.81	II	13338 - 38559
370	3866.58	II	7463 - 33319	110	3966.36	I	12007 - 37212
95	3867.85	II	14347 - 40194	320	3967.51	I	7565 - 32763
560	3868.45	II	7463 - 33306	14000	3968.39	II	0 - 25192
1600	3868.81	I	7565 - 33406	160	3971.21	I	12298 - 37472
300	3869.42	II	9432 - 35268	85	3972.41	I	
820	3869.86	II	0 - 25833	160	3973.88	I	7565 - 32722
210	3871.63	II	7485 - 33306	2700	3978.57	II	7463 - 32591
7000	3872.11	II	0 - 25818	270	3979.47	II	4755 - 29877
1200	3873.99	II	828 - 26634	110	3981.37	I	7565 - 32675
80	3875.18	II	10953 - 36751	1400	3981.92	II	7485 - 32591
470	3879.11	II	4341 - 30112	1600	3983.65	II	4341 - 29436
300	3881.99	II	12674 - 38427	800	3984.21	II	9432 - 34524

Dysprosium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	3984.69	II	14126 - 39215	200	4105.04	II	4755 - 29109
85	3987.07	II	15530 - 40604	75	4106.38	II	9870 - 34216
60	3988.88	I	9990 - 35053	1500	4111.34	II	0 - 24316
60	3988.93	I		120	4113.05	I	10925 - 35231
75	3990.34	II	16418 - 41472	200	4119.31	II	9432 - 33701
540	3991.32	II	10953 - 36001	490	4124.63	II	7463 - 31701
170	3993.57	I	8519 - 33552	150	4126.08	I	12892 - 37121
85	3994.53	I	4134 - 29161	390	4128.24	II	7485 - 31701
85	3995.99	I		350	4129.12	I	10925 - 35136
1600	3996.69	II	4755 - 29769	990	4129.42	II	4341 - 28550
110	3998.06	II	828 - 25833	350	4130.35	I	0 - 24204
8000	4000.45	II	828 - 25818	120	4131.02	II	11801 - 36001
420	4005.84	I	8519 - 33475	75	4132.83	II	13338 - 37527
320	4006.07	I	8519 - 33474	170	4133.35	II	12336 - 36522
100	4007.76	II	828 - 25772	390	4133.85	I	9990 - 34174
120	4010.07	II	19571 - 44501	250	4134.15	I	10925 - 35107
540	4011.29	II	7463 - 32386	100	4134.71	I	7050 - 31229
540	4013.82	I	0 - 24906	150	4138.54	I	8519 - 32675
540	4014.70	II	7485 - 32386	120	4139.56	I	7050 - 31200
210	4015.17	II	11801 - 36699	470	4141.50	II	828 - 24967
160	4020.87	II		1200	4143.10	II	4755 - 28885
370	4023.71	I	7565 - 32411	990	4146.06	I	9211 - 33324
250	4024.43	II	9870 - 34712	75	4147.97	I	
250	4024.90	I	9990 - 34829	150	4152.48	II	9432 - 33507
420	4027.78	II	9870 - 34691	100	4153.12	I	
520	d 4028.32	II	20884 - 45701	75	4154.24	I	
	4028.41	I	7565 - 32382	120	4159.31	I	8519 - 32554
85	4031.08	I	12007 - 36807	75	4160.25	I	
520	4032.47	II	13610 - 38402	75	4162.25	I	
160	4032.84	I	13495 - 38285	5700	4167.97	I	4134 - 28119
420	4033.65	II	9432 - 34216	75	4169.25	II	828 - 24806
420	4036.32	II	4341 - 29109	75	4170.56	I	
250	4038.51	II	7463 - 32218	370	4171.93	I	
190	4038.83	I	10088 - 34841		4172.00	I	
320	4041.98	II	7485 - 32218	140	d 4176.60	I	
12000	4045.97	I	0 - 24708		4176.78	I	
85	4047.73	I	9990 - 34689	50	4181.27	I	8519 - 32428
85	4048.38	II		250	4183.60	I	7050 - 30946
250	4048.93	I	8519 - 33210	930	4183.72	I	4134 - 28029
140	4049.36	I	4134 - 28822	12000	4186.82	I	0 - 23877
1600	4050.56	II	4755 - 29436	320	4190.94	I	7050 - 30904
250	4053.83	I	4134 - 28795	2200	4191.64	I	4134 - 27984
520	4055.14	II	9870 - 34524	6800	4194.84	I	0 - 23832
120	4057.44	II	23707 - 48346	320	4195.19	II	9870 - 33701
85	4060.57	II	13338 - 37958	800	4198.02	I	9211 - 33025
100	4072.61	II	17036 - 41583	680	4201.30	I	10925 - 34720
2500	4073.12	II	4341 - 28885	680	4202.24	I	7050 - 30840
120	4073.98	II	11801 - 36340	230	4205.06	I	
7400	4077.96	II	828 - 25343	370	4206.54	II	0 - 23765
75	4079.26	I		140	4207.70	I	9211 - 32970
85	4083.10	I	10088 - 34573	440	4211.24	I	4134 - 27873
190	4085.13	I	7050 - 31522	16000	4211.72	I	0 - 23736
370	4085.34	I	7565 - 32036	1800	4213.18	I	7050 - 30778
190	4087.20	II	11801 - 36260	85	4214.41	I	7565 - 31287
85	4087.38	I	10088 - 34547	3700	4215.16	I	4134 - 27851
85	4089.50	I	11673 - 36119	4400	4218.09	I	4134 - 27834
190	4091.52	II	10953 - 35387	4400	4221.11	I	4134 - 27817
120	4091.76	II	14126 - 38559	75	4222.05	II	4341 - 28019
85	4093.64	I	8519 - 32940	540	4222.21	I	9211 - 32889
390	4096.10	I	12892 - 37299	75	4224.67	I	
100	4096.62	I	12655 - 37058	2700	4225.16	I	7050 - 30711
100	4099.88	I	4134 - 28518	680	4232.02	I	9211 - 32834
75	4101.93	II	15822 - 40194	75	4234.83	I	16288 - 39895
3900	4103.30	II	828 - 25192	680	4239.85	I	9211 - 32790
860	4103.87	I	7050 - 31410	75	4243.44	I	7565 - 31124

*Dysprosium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
440	4245.91	I	10925 - 34470	50	4689.75	II	14895 - 36212
140	4247.34	II	12674 - 36212	95	4698.68	II	16601 - 37878
75	4248.45	II	14347 - 37878	85	4721.22	I	
440	4256.33	II	828 - 24316	70	4727.13	II	24786 - 45934
85	4258.15	I	7050 - 30528	170	4731.84	II	4341 - 25468
75	4267.87	I		40	4745.73	II	7485 - 28550
75	4268.26	I	4134 - 27556	60	4754.99	II	19492 - 40516
250	4276.69	I	7050 - 30426	50	4760.04	II	4341 - 25343
85	4279.73	I		60	4771.94	I	17613 - 38563
120	4291.95	I	4134 - 27427	50	4774.80	I	
370	d 4294.93	II		120	h 4775.79	I	15972 - 36905
	4295.04	I		75	4786.92	II	0 - 20884
75	4298.91	I	9990 - 33246	95	4791.29	I	4134 - 24999
75	4302.71	II	4755 - 27990	29	4800.64	I	15567 - 36392
1000	4308.63	II	0 - 23202	50	4807.94	I	7565 - 28358
60	4313.93	I	7565 - 30739	40	4810.28	I	17514 - 38297
75	4322.53	II	13338 - 36466	50	4812.80	I	8519 - 29291
140	4325.11	II	13408 - 36522	75	4819.04	I	15972 - 36717
320	4325.86	I		85	4824.96	I	18462 - 39182
100	4326.38	I	15567 - 38674	75	4828.88	I	
120	4328.90	II	4341 - 27435	50	4829.68	II	20884 - 41583
160	4339.65	II	4755 - 27792	70	4832.38	I	17514 - 38202
60	d 4346.37	II	20793 - 43794	35	4833.75	II	15530 - 36212
160	4347.71	I	13495 - 36490	75	4841.75	I	18472 - 39120
200	4358.44	II	828 - 23765	40	4856.24	II	19571 - 40158
60	4361.34	II	14895 - 37817	40	4868.05	II	20467 - 41004
100	4364.20	II	19571 - 42478	40	4875.93	I	
160	4366.72	I	7565 - 30459	85	4880.16	I	0 - 20485
320	4374.24	II	0 - 22854	40	4884.55	I	
320	4374.76	II	4341 - 27193	95	4888.08	I	8519 - 28971
120	4375.31	II	17606 - 40455	40	4889.33	II	
60	4384.30	II	7485 - 30287	75	4890.10	II	828 - 21272
75	4389.77	I		50	4893.68	I	16288 - 36717
140	4394.98	II	828 - 23575	24	4899.24	I	
540	4409.38	II	0 - 22672	55	4916.41	I	18021 - 38356
60	4426.87	I		50	4922.22	II	
60	4430.99	II	18549 - 41111	65	4923.16	II	828 - 21134
150	4444.58	I	12892 - 35385	480	4957.34	II	0 - 20166
740	4449.70	II	0 - 22467	24	4959.59	I	19240 - 39398
110	4455.60	II	4755 - 27193	28	4973.57	I	18462 - 38563
250	4468.14	II	828 - 23202	40	4985.52	I	12502 - 32554
60	4484.36	I	10088 - 32382	50	5003.87	I	17727 - 37706
60	4503.23	II	7485 - 29685	55	5004.28	II	7485 - 27462
60	4516.95	I	11673 - 33806	24	5010.60	I	19797 - 39750
60	4518.51	II	22031 - 44156	24	5017.98	II	20884 - 40807
100	d 4527.58	I	19557 - 41638	70	5022.12	I	4134 - 24040
	4527.76	II	828 - 22908	30	5024.03	I	
100	4541.66	II	19571 - 41583	24	5024.54	I	7565 - 27462
60	4555.22	I	7565 - 29512	40	5027.87	I	18472 - 38356
140	4565.09	I	0 - 21899	50	5033.00	I	17687 - 37551
60	4567.04	I	13495 - 35385	160	5042.63	I	7565 - 27390
60	4573.85	II	20884 - 42741	24	5047.25	I	8519 - 28326
420	4577.78	I	0 - 21838	50	h 5050.21	I	7050 - 26846
75	4587.91	II	14421 - 36212	16	5053.19	I	
2100	4589.36	I	0 - 21783	30	5053.35	I	0 - 19783
60	4591.78	II	20517 - 42289	24	5055.46	I	19797 - 39573
990	4612.26	I	0 - 21675	95	5070.68	I	9990 - 29706
50	4613.83	I	17514 - 39182	120	5077.67	I	0 - 19688
50	4614.82	I	17513 - 39176	80	5090.38	II	828 - 20467
60	4617.26	II	4755 - 26407	80	5110.32	I	19557 - 39120
140	4620.03	II	828 - 22467	130	h 5120.04	I	17513 - 37039
50	4662.72	I	18462 - 39903	30	5135.02	I	8519 - 27987
110	4664.66	II	4341 - 25772	190	5139.60	II	0 - 19451
85	4673.60	II	17036 - 38427	40	5161.03	II	24786 - 44156
50	4682.03	II	19251 - 40604	40	5164.12	II	23707 - 43066

Dysprosium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	5165.34	I	18339 - 37694	24	5685.58	I	7050 - 24634
110	5169.69	II	828 - 20166	28 h	5693.67	Dy O	
20	5172.90	II		24 h	5694.10	Dy O	
80	5185.30	I	12007 - 31287	28 cw	5694.54	Dy O	
40	5188.45	II	18549 - 37817	28	5698.72	II	20884 - 38427
290	5192.86	II	0 - 19251	24	5702.91	I	7565 - 25095
95	5197.66	II	4341 - 23575	11	5705.95	Dy O	
15	5205.66	I	20193 - 39398	70 h	5718.46	I	18462 - 35945
15	5205.73	I		28 h	5725.84	Dy O	
50	5246.94	II		55 h	5728.64	Dy O	
16	5248.14	II		24 h	5738.73	Dy O	
16	5258.37	II	19927 - 38939	50	5740.20	I	22487 - 39903
70	5259.88	I	19240 - 38247	55	5745.53	I	9990 - 27390
130	5260.56	I		24	5750.48	I	
55 bl	5263.3	Dy O		24	5758.79	I	8519 - 25879
65	5267.11	I	9990 - 28971	80 h	5832.01	Dy O	
50	5272.25	II	4341 - 23303	55 h	5833.85	Dy O	
50	5275.29	II	19451 - 38402	40 h	5834.86	Dy O	
50	5279.70	II	19492 - 38427	28 h	5844.41	Dy O	
55	5282.07	I	8519 - 27445	24	5845.65	Dy O	
28	5284.99	II	17606 - 36522	40 h	5848.05	Dy O	
40	5297.82	II		40	5855.56	Dy O	
160	5301.58	I	0 - 18857	55 h	5868.11	II	0 - 17036
40	5309.02	II	19571 - 38402	40	5915.16	II	
50	5324.69	I	7050 - 25825	20	5924.56	II	14952 - 31826
24	5337.43	II	14845 - 33576	70	5945.80	I	12892 - 29706
65	5340.30	I		50 l	5964.46	I	9990 - 26752
30	5352.11	I	7565 - 26244	120	5974.49	I	0 - 16733
30	5368.20	II	828 - 19451	24	5984.86	I	19240 - 35945
16	5369.24	II	14845 - 33465	10	5985.99	I	9211 - 25912
20	5385.63	II	7485 - 26047	140	5988.56	I	0 - 16693
85	5389.58	II	0 - 18549	14	6000.84	I	20209 - 36868
40	5395.57	I	0 - 18528	14	6003.26	I	11673 - 28326
20	5398.26	Dy O		24 h	6005.75	Dy O	
24 h	5399.93	II	4341 - 22854	24 h	6006.54	Dy O	
50	5404.19	I	4134 - 22633	24 h	6006.97	Dy O	
80	5419.13	I	20884 - 39332	30	6008.94	I	7050 - 23687
16	5420.77	I	9990 - 28433	65	6010.82	I	4134 - 20766
70	5423.32	I	0 - 18433	24	6017.26	I	9211 - 25825
30	5424.27	I	17514 - 35945	24	6030.98	I	8519 - 25095
40	5426.70	II	20517 - 38939	24 bl	6042.49	Dy O	
30	5443.34	II	19451 - 37817	24	6058.18	I	7050 - 23552
95	5451.11	I	0 - 18339	30	6085.06	I	7050 - 23479
30	5455.47	II	19492 - 37817	140	6088.26	I	4134 - 20554
24	5469.10	II	16117 - 34396	24	6127.15	I	12655 - 28971
16	5471.91	II	17788 - 36058	24	6133.64	I	10088 - 26387
28	5496.83	I	18903 - 37090	24	6158.28	I	7565 - 23799
24	5502.79	I	9990 - 28158	100	6168.43	I	4134 - 20341
28	5506.52	I		20	6196.23	II	15691 - 31826
24	5515.41	II	4341 - 22467	270	6259.09	I	0 - 15972
30	5528.01	I	12655 - 30739	30	6260.36	I	13495 - 29465
13	5542.20	I	20209 - 38247	14	6343.32	I	22487 - 38247
65	5547.27	I	0 - 18021	40	6386.80	I	7565 - 23218
16	5562.48	I		24	6396.60	II	
40 d	5600.65	II	828 - 18678	50	6421.92	I	0 - 15567
24	5605.53	I	12007 - 29841	13 h	6436.55	I	22487 - 38019
30	5613.23	I	20209 - 38019	8	6460.83	I	7050 - 22524
20	5627.49	I	4134 - 21899	10	6468.58	II	33677 - 49132
100	5639.50	I	0 - 17727	11	6474.91	I	23736 - 39176
16	5641.50	II	828 - 18549	20	6483.59	II	16117 - 31536
55 h	5645.99	I	17514 - 35221	28	6486.59	I	15567 - 30979
80	5652.01	I	0 - 17687	8	6548.26	II	14845 - 30112
11	5666.43	I	20193 - 37836	20	6558.02	I	7050 - 22294
14	5671.25	I	19240 - 36868	160	6579.37	I	0 - 15194
14	5677.68	I	17613 - 35221	14	6594.14	II	14952 - 30112

Dysprosium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
6 h	6611.73	II	17589 - 32709	11	7120.81	II	14845 - 28885
7	6639.21	I	16717 - 31775	9	7121.23	I	4134 - 18172
15	6643.37	I	4134 - 19182	3	7141.52	II	18219 - 32218
7	6654.23	II	17589 - 32613	5	7149.30	II	18234 - 32218
22	6658.36	I	19907 - 34922	6 h	7156.48	I	23736 - 37706
29	6661.64	I	15972 - 30979	13	7175.11	II	14952 - 28885
75	6667.86	I	15567 - 30560	3 h	7198.65	I	4134 - 18021
9	6670.16	I	20789 - 35777	3 h	7206.77	I	12007 - 25879
10	6700.64	II	14845 - 29765	11	7213.27	I	12892 - 26752
7 h	6713.05	I	15567 - 30459	3	7222.52	I	17687 - 31529
6 h	6724.70	I	20554 - 35421	3	7222.90	I	7050 - 20891
6 h	6736.07	I	12007 - 26848	17 h	7230.04	I	16733 - 30560
7 h	6743.68	I		4 h	7234.68	II	20700 - 34519
29	6747.93	I	16693 - 31509	13	7250.01	I	9990 - 23780
7 h	6750.21	I	10088 - 24899	7	7261.74	I	7050 - 20817
10	6757.62	I	20341 - 35135	8	7273.57	II	15691 - 29436
45	6765.89	I	16733 - 31509	3	7279.90	I	12655 - 26387
6	6787.37	I	16693 - 31423	9	7288.24	II	17589 - 31306
7	6790.30	I	4134 - 18857	3 h	7300.28	I	12655 - 26349
8	6794.23	I	13952 - 28666	2 h	7314.71	II	35565 - 49233
8 h	6803.20			17	7345.13	II	0 - 13610
8	6805.54	I	16733 - 31423	3	7349.64	II	
9	6807.31	II		3 h	7354.39	II	828 - 14421
12	6818.20	I	13495 - 28158	5	7361.58	II	21627 - 35207
9	6827.07	I	23479 - 38123	11	7370.23	II	16117 - 29681
4	6828.35	II	18866 - 33507	20	7376.04	I	4134 - 17687
180	6835.42	I	0 - 14625	9	7381.57	I	9990 - 23534
4 h	6843.75	I	25912 - 40520	9 h	7403.10	I	7050 - 20554
7	6845.76	I	20817 - 35421	3	7404.02	I	10088 - 23591
4 h	6851.99	I	23479 - 38070	11	7407.59	I	0 - 13495
80	6852.96	I	15972 - 30560	24	7412.37	I	18021 - 31509
22	6856.46	I	20341 - 34922	55	7426.86	II	14845 - 28306
4 h	6886.40	I	23552 - 38070	5 h	7428.54	I	22487 - 35945
22	6888.83	I	8519 - 23031	9	7451.11	II	15691 - 29109
4	6894.51	I	23479 - 37980	20	7457.05	II	14845 - 28252
4	6895.51	I	12892 - 27390	3 h	7459.99	I	18021 - 31423
15	6897.97	II	17788 - 32281	7	7483.03	I	22061 - 35421
65	6899.32	II	14845 - 29336	3	7509.60	I	9211 - 22524
22	6906.53	II	18234 - 32709	17	7516.61	II	14952 - 28252
7	6912.20	II	16117 - 30580	7 h	7533.16	I	23736 - 37007
7 h	6925.49	I	23687 - 38123	55	7543.73	I	17727 - 30979
15	6929.55	I	4134 - 18561	17 h	7553.00	I	21899 - 35135
7	6932.45	II	15691 - 30112	5 h	7557.85	I	9990 - 23218
4	6939.65	I	23687 - 38093	27	7559.78	I	7565 - 20789
6	6942.11	I	13495 - 27896	40	7562.96	II	16117 - 29336
4 h	6945.26	I	4134 - 18528	20 h	7577.46	II	15691 - 28885
29	6950.28	II	14952 - 29336	3	7587.76	I	22045 - 35221
11	6951.42	I	22487 - 36868	27 h	7591.30	I	18339 - 31509
6	6952.93	II	18234 - 32613	5 h	7594.86	I	24906 - 38070
4	6957.63	I		4	7609.17	I	24931 - 38070
40	6958.08	I	0 - 14367	13 h	7611.55	I	22286 - 35421
6	6970.43	I	12007 - 26349	5 h	7616.21	I	22294 - 35421
13 h	6982.44	I	20817 - 35135	11 h	7617.70	I	24999 - 38123
13	6991.30	I	4134 - 18433	5 h	7635.32	I	20817 - 33911
45	6998.10	I	16693 - 30979	5 h	7639.30	I	23877 - 36964
3 h	7014.64	II	21806 - 36058	35 h	7641.09	I	21838 - 34922
20	7017.42	I	16733 - 30979	17	7645.86	I	18433 - 31509
3 h	7036.37	I	12298 - 26506	13	7646.64	I	22061 - 35135
7	7037.53	I	4134 - 18339	4	7648.11	II	18234 - 31306
35	7055.95	II	14845 - 29014	9	7661.48	I	7565 - 20614
9 h	7062.30	I	20766 - 34922	80	7662.36	I	17513 - 30560
24	7075.14	II		11	7666.78	II	14845 - 27885
3 h	7100.54	II	21627 - 35707	9 h	7676.69	I	21899 - 34922
5	7101.66	II	15691 - 29769	3	7693.86	I	
17	7109.26	II	14952 - 29014	5	7696.54	I	14970 - 27959

Dysprosium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
6	7711.91	II	18219 - 31183	6	8233.56	II	18219 - 30361
35	7715.33	I	18021 - 30979	4	8243.91	II	18234 - 30361
5	7721.01	II	27209 - 40158	20	8265.53	I	8519 - 20614
45	7729.76	II	14952 - 27885	4	8323.85	I	27190 - 39201
5	7739.38	II	21338 - 34255	35	8326.10	I	0 - 12007
4	7750.15	I	10925 - 23824	5	8388.53	I	11673 - 23591
20	7751.62	II	16117 - 29014	35	8392.01	II	20700 - 32613
5	7757.32	I	9211 - 22099	12	8405.85	II	18219 - 30112
4	7760.08	I	23877 - 36760	20	8416.64	II	18234 - 30112
4	7780.89	I	22286 - 35135	24	8438.58	II	17589 - 29436
8	7790.02	I	17727 - 30560	9	8444.46	II	21076 - 32914
35	7812.06	I	18711 - 31509	5	8472.58	II	23495 - 35294
4	7814.60	I	15194 - 27987	4	8480.66	II	14845 - 26634
7	7832.77	I	7050 - 19813	5	8490.15	I	12655 - 24430
7	7835.52	II	20748 - 33507	9	8510.79	II	17589 - 29336
8	7864.31	II	21806 - 34519	4	8517.68	II	21177 - 32914
8	7864.96	I	18711 - 31423	7	8525.73	II	21177 - 32903
27	7909.38	I	18339 - 30979	4	8528.32	II	21806 - 33529
5	7934.98	I	4134 - 16733	8	8548.93	II	21813 - 33507
3	7962.77	I	8519 - 21074	9	8557.79	II	14952 - 26634
11	7968.63	I	18433 - 30979	7	8567.97	I	24999 - 36667
9	7973.13	I	18021 - 30560	8	8575.58	II	18219 - 29877
12	7982.85	II	17589 - 30112	11	8630.12	I	12007 - 23591
4	8004.47	II	23976 - 36466	9	8635.78	II	21338 - 32914
8	8008.70	II	14952 - 27435	27	8655.94	II	18219 - 29769
9	8025.31	I	4134 - 16591	17	8657.68	II	17788 - 29336
6	8027.22	I	24708 - 37163	7	8667.37	II	18234 - 29769
6	8040.09	I	14625 - 27059	7	8672.62	I	12007 - 23534
4	8047.28	I	12007 - 24430	17	8678.49	II	17589 - 29109
4	8050.85	I	14367 - 26785	5	8685.26	I	7050 - 18561
8	8116.90	II	18866 - 31183	11	8696.83	II	18866 - 30361
3	8140.72	II	14952 - 27232	11	8715.95	II	20748 - 32218
4	8144.30	II		20	8750.40	II	17589 - 29014
13	8147.29	I	8519 - 20789	12	8780.83	I	
4	8169.06	II	21338 - 33576	45	8791.39	II	21338 - 32709
27	8198.77	II	15691 - 27885	7	8832.81	II	24685 - 36003
100	8201.57	II	16117 - 28306	13	8833.08	II	23976 - 35294
3	8208.34	II	18219 - 30399	24	8850.37	II	17589 - 28885
8	8217.04	II	20748 - 32914	45	8905.75	II	17788 - 29014
11	8218.62	II	18234 - 30399				



## Erbium

$$\text{Er, } Z = 68, M = 167.2, \text{ Ratio } \frac{\text{Er}}{\text{Cu}} = 2.632$$

- Er I Normal state of valence electrons  $4f^{12}6s^2 3H_6 = 0$ . I.P. = 49210  $\text{cm}^{-1}$ .  
 Er II Normal state of valence electrons  $4f^{12}6s 4H_{61/2} = 0$ . I.P. = 96200  $\text{cm}^{-1}$ .  
 Er III Normal state of valence electrons  $4f^{12} 3H_6 = 0$ . I.P. = 183400  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

Below 2670 Å;

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden*, (Specola Vaticana, 1945).

From 2670 to 6900 Å;

L. C. Marquet, Thesis, Univ. of Calif. at Berkeley (1963).

Above 6900 Å;

Th. A. M. van Kleef, unpublished (1973).

Spectrum assignments were made primarily from our plates and supplemented from S. Held, Report IA-813, Israel A.E.C. (1966).

#### Classification:

Er I, L. C. Marquet and S. P. Davis, unpublished (1967).

N. Spector, *J. Opt. Soc. Am.* **56**, 341 (1966); **57**, 308 (1967).

Er I and II, L. C. Marquet, Thesis, Univ. of Calif. (Berkeley, 1963).

K. L. Vander Sluis, unpublished (1969).

Th. A. M. van Kleef, unpublished (1973).

Er III, N. Spector, *J. Opt. Soc. Am.* **63**, 358 (1973).

### *Strong lines of erbium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
14000	4007.96	I	0 - 24943	3000	4020.51	I	6958 - 31824
11000	3906.31	II	0 - 25592	2700	3264.78	II	0 - 30621
7900	3692.65	II	440 - 27514	2700	3973.04	I	0 - 25162
7700	3372.71	II	0 - 29641	2300	3230.58	II	440 - 31386
7500	3862.85	I	0 - 25880	2300	3312.42	II	440 - 30621
6900	4151.11	I	0 - 24083	2300	3392.00	II	0 - 29472
6700	3499.10	II	440 - 29011	2100	3938.63	II	0 - 25382
5200	3896.23	II	440 - 26099	1800	3786.84	II	0 - 26400
4200	3892.68	I	0 - 25682	1700	3385.08	II	440 - 29973
3600	3830.48	II	0 - 26099	1600	3638.68	I	
3500	4087.63	I	0 - 24457	1600	3810.33	I	0 - 26237
3200	3937.01	I	0 - 25392	1500	2910.36	II	6824 - 41174
3200	3944.42	I	5035 - 30380	1500	2964.52	II	6824 - 40547
3200	3973.58	I	0 - 25159	1500	3558.02	I	7696 - 35794
3100	3616.56	II	0 - 27643	1500	3880.61	II	5132 - 30894

Erbium — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	2341.82	II		490	2670.26	II	6824 - 44263
110	2358.51	II	0 - 42387	330	2672.25	II	6824 - 44235
80	2377.83	II		100	2675.35	II	11309 - 48676
80	2383.28	II	440 - 42387	40	2688.40	II	13060 - 50246
100	2386.58	II		40	2689.93	II	
120	2387.17	II		60	2698.39	III	
110	2396.38	III	19316 - 61032	26	2700.67	II	5132 - 42149
90	2397.30	II	6824 - 48525	60	2701.69	II	
40	2400.30	II		60	2711.53	II	
35	2404.41	II		100	2712.12	II	5403 - 42264
40	2410.53	II		60	2713.25	II	
70	2420.28	II		30	2716.60	II	10667 - 47466
60	2425.23	II		60	2720.74	II	
90	2427.28	II		60	2721.59	II	13719 - 50451
40	2439.45	II		180	2726.22	II	440 - 37110
140	2446.39	II	0 - 40864	120	2730.10	II	12388 - 49005
40	2458.03	II		80	2731.56	II	440 - 37038
40	2459.75	II	6824 - 47466	270	2739.31	II	6824 - 43319
40	2460.71	II		310	2750.19	II	13027 - 49378
60	2464.63	III	20470 - 61032	60	2750.92	II	
35	2467.26	II		230	2755.01	II	
20	2477.59	II	6824 - 47174	610	2755.63	II	5403 - 41682
40	2478.32	II	6824 - 47162	110	2765.61	II	0 - 36148
35	2485.17	II	6824 - 47050	120	2766.38	II	12388 - 48525
40	2487.47	II		510	2770.02	II	10667 - 46757
60	2491.56	II		90	2774.62	II	13060 - 49091
40	2492.27	II	5403 - 45515	230	2778.97	II	12815 - 48788
60	2493.27	II		60	2779.61	II	14280 - 50246
90	2499.67	I		100	2781.19	II	13060 - 49005
80	2503.48	II	6824 - 46757	60	2781.54	II	13719 - 49660
60	2507.64	II		40	2782.00	II	5132 - 41067
50	2513.94	II		150	2784.95	II	5132 - 41029
26	2520.95	II		120	2786.11	II	440 - 36322
50	2534.99	II	6824 - 46260	60	2787.40	II	11309 - 47174
100	2537.02	II		180	2787.71	II	12815 - 48676
60	2544.90	II	6824 - 46106	30	2788.33	II	11309 - 47162
110	2547.28	II		50	2788.47	II	
40	2564.78	II		60	2792.52	III	20226 - 56025
50	2579.59	II		50	2793.84	II	
90	2581.56	II		80	2799.54	II	
290	2586.73	II		35	2799.72	II	440 - 36148
110	2587.04	II	0 - 38642	230	2802.53	II	0 - 35672
35	2587.34	II		100	2802.87	II	13338 - 49005
35	2591.91	II		80	2803.54	II	13719 - 49378
130	2592.57	II		310	2804.35	II	13027 - 48676
120	2595.03	II		150	2806.75	II	0 - 35618
80	2602.66	I		100	2818.86	II	13060 - 48525
80	2604.86	I		26	2819.34	II	440 - 35899
30	2606.69	II	11309 - 49660	40	2819.81	II	12388 - 47840
60	2612.37	II	13338 - 51606	410	2820.19	II	11309 - 46757
50	2614.54	II	13338 - 51574	40	2820.46	II	440 - 35885
60	2616.87	II	440 - 38642	50	2824.32	II	
80	2621.72	II		50	2824.90	II	
140	2624.18	II	6824 - 44920	30	2825.66	II	14280 - 49660
40	2627.77	II		60	2829.38	II	
35	2637.78	III	17647 - 55547	80	2830.42	II	5403 - 40723
40	2647.14	II	13338 - 51103	40	2831.21	II	
35	2651.35	II		270	2833.91	II	0 - 35277
70	2653.73	II	13338 - 51010	60	2837.11	II	7150 - 42386
40	2654.11	II		390	2838.71	II	13572 - 48788
70	2655.25	II		100	2840.63	II	
70	2656.10	II		50	2841.89	II	440 - 35618
60	2657.00	II		120	2845.86	II	
80	2665.04	II		60	2846.26	II	13027 - 48151
90	2666.30	II	5132 - 42626	40	2847.02	II	

Erbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	2848.06	II	16473 - 51574	40	2946.43	II	18463 - 52392
270	2848.37	II	14280 - 49378	230	2946.62	II	15732 - 49660
50	2848.92	II	13060 - 48151	150	2948.80	II	
150	2850.65	II	13719 - 48788	30	2949.26	II	
250	2855.41	II		80	2950.07	II	13027 - 46915
120	2858.56	II	0 - 34972	90	2951.26	II	5403 - 39277
310	2859.84	II	13719 - 48676	60	2955.37	II	
40	2860.26	II	11309 - 46260	50	2955.60	II	
40	2862.60	II		60	2956.45	II	16643 - 50457
30	2866.35	II		80	2956.95	II	16643 - 50451
30	2869.19	II	5132 - 39975	90	2958.89	II	
30	2870.52	II		60	2960.12	II	
90	2871.68	II	13338 - 48151	120	2962.49	II	
60	2872.83	II		150	2963.70	II	
150	2873.80	II	13060 - 47847	80	2963.90	II	13027 - 46757
110	2874.78	II	440 - 35215	60	2964.25	II	
80	2877.26	II		1500	2964.52	II	6824 - 40547
50	2878.54	II		60	2964.83	II	12388 - 46106
60	2878.90	II	14280 - 49005	60	2965.21	II	5133 - 38847
30	2879.22	II		80	2965.87	II	13719 - 47426
30	2882.60	II	7195 - 41876	60	2966.17	II	
80	2886.11	II		80	2967.94	II	
100	2887.09	II	16948 - 51574	60	2968.47	II	
100	2888.16	II		410	2968.76	II	0 - 33674
50	2893.49	II	17842 - 52392	150	2970.06	II	0 - 33660
150	2893.90	II	0 - 34545	60	2970.96	II	5404 - 39053
50	2895.92	II	5133 - 39654	50	2971.26	II	11309 - 44955
60	2896.57	II	15732 - 50246	80	2971.63	II	
310	2896.96	II	13338 - 47847	d	2971.73	II	
390	2897.52	II	13338 - 47840	150	2972.27	II	
80	2903.44	II	13719 - 48151	150	2973.74	II	5403 - 39021
1000	2904.47	II	6824 - 41244	210	2974.47	II	0 - 33610
120	2906.50	II	14280 - 48676	230	2975.68	II	10667 - 44263
100	2908.53	II		40	2979.95	II	440 - 33988
210	2909.58	II	12815 - 47174	110	2983.06	II	12388 - 45900
1500	2910.36	II	6824 - 41174	140	2983.22	II	11309 - 44820
70	2911.07	II	0 - 34342	270	2983.80	II	
30	2912.30	II		130	2985.52	I	0 - 33485
40	2912.82	II	5403 - 39724	40	2987.31	II	
100	2914.66	I		30	2988.20	II	
270	2915.62	II	10667 - 44955	140	2989.31	II	13719 - 47162
40	2918.83	II		80	2989.56	II	
100	2919.28	II	14280 - 48525	30	2994.09	II	19606 - 52996
80	2920.24	II	440 - 34674	110	2994.47	I	
80	2923.30	II		40	2995.47	II	
60	2927.36	II		90	2996.37	II	440 - 33804
150	2927.71	II	13027 - 47174	80	2997.87	II	
160	2928.28	II	14649 - 48788	70	2998.06	II	5133 - 38478
110	2928.45	II		1200	3002.41	II	6824 - 40121
350	2929.27	II	13338 - 47466	310	3002.65	II	
100	2929.73	II	440 - 34563	90	3003.83	II	440 - 33722
120	2930.64	II		60	3005.05	II	
80	2931.55	II	13060 - 47162	150	3008.19	II	13027 - 46260
60	2931.66	II	12815 - 46915	40	3009.44	II	440 - 33660
35	2932.36	II		50	3009.70	II	
30	2932.60	II	16948 - 51037	80	3010.31	II	440 - 33650
80	2934.51	II	13719 - 47786	90	3011.16	II	13060 - 46260
60	2934.64	II		230	3012.47	II	5132 - 38318
50	2939.32	II	7195 - 41206	60	3013.84	II	12587 - 45758
60	2939.47	II	5403 - 39413	30	3013.96	II	6824 - 39994
120	2941.17	II	13060 - 47050	30	3014.62	II	
90	2941.71	II		230	3016.84	II	14649 - 47786
140	2942.21	II		120	3017.74	II	6824 - 39952
100	2944.07	II	440 - 34397	100	3019.76	II	0 - 33106
270	2945.28	II	12815 - 46757	50	3020.33	II	

Erbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
60	3022.73	II	17378 - 50451	140	3152.37	II	
290	3025.95	II	13719 - 46757	410	3154.29	II	15732 - 47426
270	3028.27	II	0 - 33012	190	3160.35	II	440 - 32074
370	3031.31	II	6824 - 39804	60	3161.36	II	
310	3036.22	II	11309 - 44235	60	3164.52	II	
70	3048.39	II		190	3167.10	II	13719 - 45285
50	3049.21	II	19606 - 52392	80	3171.52	II	
90	3049.30	II		80	3172.62	II	5133 - 36643
70	3050.00	II	14649 - 47426	160	3175.52	II	0 - 31482
70	3050.85	II	13338 - 46106	80	3179.61	II	15732 - 47174
70	3053.78	II	17378 - 50115	160	3181.61	II	5404 - 36825
210	3054.42	II		160	3181.74	II	12815 - 44235
50	3061.29	II	12815 - 45471	870	3181.92	II	11042 - 42461
140	3061.68	II	10667 - 43319	410	3183.42	II	440 - 31844
60	3064.83	II	0 - 32619	250	3185.25	II	0 - 31386
70	3064.97	II		160	3187.79	II	440 - 31801
230	3066.22	II	5133 - 37737	120	3192.64	II	
120	3069.22	II	440 - 33012	310	3200.58	II	13027 - 44263
450	3070.74	II	10667 - 43223	120	3203.45	II	13027 - 44235
560	3072.53	II		80	3203.95	II	13060 - 44263
610	3073.34	II	0 - 32528	230	3205.15	II	14280 - 45471
70	3078.25	II	16529 - 49005	80	3208.05	II	12815 - 43977
210	3078.87	II	12815 - 45285	270	3214.44	II	13719 - 44820
70	3081.38	II	13027 - 45471	870	3220.73	II	
720	3082.08	II		610	3223.31	II	5133 - 36148
610	3084.02	II	0 - 32416	210	3227.16	II	12600 - 43578
60	3087.12	II		80	3229.93	II	5403 - 36355
70	3087.80	II	7150 - 39526	2300	3230.58	II	440 - 31386
70	3088.76	II		250	3232.03	II	12388 - 43319
150	3093.14	II	10667 - 42987	330	3237.98	II	5133 - 36007
120	3095.84	II		140	3240.48	II	
370	3099.19	II	13027 - 45285	180	3243.25	II	
70	3099.60	II		90	3243.47	II	14649 - 45471
150	3102.69	II	13338 - 45559	330	3249.34	II	5133 - 35899
70	3104.46	II		90	3256.35	II	
230	3106.78	II	440 - 32619	90	3258.48	II	
150	3110.88	II		560	3259.05	II	
310	d 3113.43	II			3259.11	II	14280 - 44955
			14649 - 46757	180	3262.80	II	14280 - 44920
80	3115.09	II	7149 - 39242	2700	3264.78	II	0 - 30621
130	3115.53	II	440 - 32528	90	3266.66	II	5404 - 36007
150	3116.95	II	0 - 32074	430	3267.10	II	12388 - 42987
150	3118.83	II	15732 - 47786		3267.18	II	12815 - 43413
80	3119.05	II		330	3269.41	II	13060 - 43638
150	3121.94	II	0 - 32023	90	3273.32	II	7195 - 37737
770	3122.72	II	5133 - 37147	90	3277.70	II	0 - 30500
80	3123.09	II	11309 - 43319	250	3278.22	II	5404 - 35899
150	3125.18	II		720	3279.33	II	5133 - 35618
150	3125.65	II		720	3280.22	II	440 - 30917
60	3127.38	II	5133 - 37099	180	3286.18	II	7195 - 37617
80	3131.07	II		470	3286.77	II	5404 - 35820
130	3132.03	II	0 - 31919	140	3287.99	II	
290	3132.52	II	11309 - 43223	90	3291.27	II	10893 - 41268
470	3132.77	II		90	3301.93	II	10893 - 41170
80	3135.62	II	16643 - 48525	330	d 3303.88	II	13060 - 43319
130	3137.85	II	13060 - 44920		3303.95	II	13719 - 43977
160	3138.50	II	16935 - 48788	90	3304.07	II	
410	3141.10	II	440 - 32267	370	3305.56	II	7195 - 37439
	3141.15	II	14280 - 46106	80	3307.46	II	11042 - 41268
70	3141.81	II		2300	3312.42	II	440 - 30621
80	3142.80	II		90	3313.49	II	14649 - 44820
80	3143.63	II	0 - 31801	180	3313.66	II	5133 - 35302
250	3144.33	II		180	3314.43	II	13060 - 43223
160	3144.51	II	13027 - 44820	80	3314.94	II	0 - 30158
130	3150.55	II	5133 - 36864	560	3316.39	II	

Erbium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	3317.47	II		140	3434.63	II	10893 - 40000
80	3318.23	II	11042 - 41170	100	3437.63	II	11042 - 40124
90	3318.77	II	0 - 30123	160	3438.31	II	
770	3323.19	II	5133 - 35215	80	3438.47	II	
290	3329.66	II		770	3441.13	II	440 - 29492
770	3332.70	II	7149 - 37146	390	3442.68	I	7696 - 36735
80	3336.74	II	7150 - 37110	100	3443.75	II	12587 - 41617
370	3337.25	II	5403 - 35359	270	3446.87	I	10557 - 39561
290	3337.79	II	7195 - 37146	100	3447.52	II	7150 - 36148
250	3340.03	II	5133 - 35064	160	3448.06	II	5404 - 34397
90	3340.48	II	12600 - 42527	160	3453.66	I	7176 - 36123
90	3341.60	II		180	3461.39	II	17378 - 46260
290	3341.84	II	7195 - 37110	250	3462.57	I	11557 - 40429
150	3343.68	II		270	3464.53	II	5133 - 33988
90	3344.37	II	0 - 29892	490	3469.51	I	7696 - 36511
1300	3346.04	II	440 - 30318	270	3469.72	II	11309 - 40121
150	3346.35	II		970	3471.71	II	
120	3347.64	II	11042 - 40905	100	3477.93	II	
160	3347.73	II	7195 - 37057	610	3479.41	II	7195 - 35927
180	3348.14	II	0 - 29859	290	3480.44	II	11042 - 39766
60	3348.76	II	10893 - 40747	100	3484.55	II	7195 - 35885
470	3350.06	II	13572 - 43413	190	3485.16	II	11309 - 39994
350	3350.26	II	5133 - 34972	970	3485.85	II	440 - 29120
180	3351.32	II		350	3486.82	II	5403 - 34074
90	3356.21	II		270	3489.35	I	8620 - 37271
180	3358.15	II	5133 - 34902	140	3492.50	II	7195 - 35820
150	3361.01	II	13558 - 43302	350	3496.86	II	5133 - 33722
90	3361.67	II	15732 - 45471	6700	3499.10	II	440 - 29011
1400	3364.08	II	440 - 30158	610	3502.78	I	7176 - 35717
190	3366.69	I	7696 - 37391	270	3505.07	II	7150 - 35672
1400	d 3368.02	II	440 - 30123	290	3505.68	I	9655 - 38172
	3368.13	I	7696 - 37378	390	3508.38	II	11309 - 39804
450	3370.55	II	5404 - 35063	110	3508.81	I	10557 - 39049
7700	3372.71	II	0 - 29641	80	3508.93	I	7176 - 35667
970	3374.17	II	0 - 29628	490	3514.89	II	
90	3376.10	II	7150 - 36761	390	3518.18	II	10667 - 39082
80	3376.99	II	13558 - 43161	210	3522.52	I	7176 - 35557
70	3379.01	II	14649 - 44235	610	3524.91	II	0 - 28361
130	3381.08	II	440 - 30008	270	3526.81	I	11401 - 39747
290	3381.32	II	7195 - 36761	100	3531.27		
230	3382.06	I	7176 - 36735	210	3539.47	II	15732 - 43977
1700	3385.08	II	440 - 29973	410	3539.59	I	11887 - 40131
150	3389.59	II	7150 - 36643	250	3543.02	II	13027 - 41244
450	3389.74	II	0 - 29492	270	3545.86	I	7176 - 35370
2300	3392.00	II	0 - 29472	270	3547.50	I	11557 - 39738
90	3394.09	II	10667 - 40121	310	3548.26	II	5132 - 33307
90	3394.39	II	440 - 29892	210	3549.55	I	7195 - 35359
190	3394.86	II	7195 - 36643	820	3549.84	II	5404 - 33566
350	3396.07	II		140	3551.79	II	13027 - 41174
290	3396.84	II	5133 - 34563	310	3553.20	II	5404 - 33539
190	3398.27	II	440 - 29859	210	3554.30	II	7150 - 35277
90	3401.20	II	11043 - 40436	100	3556.08	I	15185 - 43298
390	3401.83	II		160	3556.39	I	10557 - 38668
70	3406.95	II	440 - 29784	100	3556.84	II	7195 - 35302
180	3408.69	II	14649 - 43977	210	3557.07	I	11401 - 39506
150	3409.87	I	9350 - 38668	1500	3558.02	I	7696 - 35794
180	3417.28	II	10893 - 40148	510	3558.71	I	8620 - 36712
350	3417.63	II		1000	3559.90	II	0 - 28082
190	3420.18	II	10893 - 40123	210	3563.54	I	0 - 28053
190	3422.90	I	9350 - 38556	310	3565.17	I	9350 - 37391
270	3425.08	II	440 - 29628	210	3569.27	I	7176 - 35185
490	3428.39	II	7195 - 36355	210	3569.93	I	11557 - 39561
190	3429.88	II	11042 - 40189	160	3570.56	I	10557 - 38556
140	3431.06	I	9350 - 38487	920	3570.75	II	5132 - 33130
270	3433.13	II	0 - 29120	140	3573.86	II	5133 - 33106

Erbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
310	3578.24	I	11799 - 39738	35	3710.79	II	5133 - 32073
190	3579.44	I	10557 - 38487	100	3711.82	II	13060 - 39994
1000	3580.52	II	440 - 28361	520	3712.39	II	6824 - 33753
370	3586.60	I	8620 - 36494	120	3715.97	I	6958 - 33861
210	3587.79	II		100	3717.25	II	14280 - 41174
210	3588.32	I	7696 - 35557	320	3719.35	I	7176 - 34055
610	3590.76	I	8620 - 36461	100	3721.46	II	5404 - 32267
410	3595.84	I	11557 - 39360	65	3723.64	II	12600 - 39447
610	3599.50	II	11309 - 39082	170	3724.36	II	10894 - 37737
1000	3599.83	II	10667 - 38438	90	3724.49	II	
210	3604.71	II	12388 - 40121	230	3724.91	II	7150 - 33988
510	3604.90	II	12815 - 40547	1300	3729.52	II	0 - 26805
160	3605.69	I	6958 - 34684	450	3731.26	II	7195 - 33988
210	3607.20	I	15083 - 42797	55	3731.79	II	
410	3607.42	I	9350 - 37062	45	3732.22	I	9350 - 36136
3100	3616.56	II	0 - 27643	190	3734.45	II	5132 - 31902
510	3617.85	II	12815 - 40447	270	3734.58	II	0 - 26769
510	3618.92	II	5404 - 33028	65	3735.71	I	7696 - 34458
100	3625.28	II	17378 - 44955	540	3738.16	II	13060 - 39804
720	3628.04	I	5035 - 32590	180	3740.29	II	13719 - 40447
310	3629.37	I	11887 - 39432	340	3741.10	II	6824 - 33547
210	3630.06	II	19375 - 46915	900	3742.64	II	5133 - 31844
140	3630.30	II		200	3744.99	II	12388 - 39082
140	3631.78	I		140	3745.11	II	11043 - 37737
220	3632.09	II	7150 - 34674	55	3745.71	II	12587 - 39277
100	3632.78	II	13027 - 40547	900	3747.43	I	7176 - 33853
270	3633.26	I	8620 - 36136	55	3749.02	I	9655 - 36321
1000	3633.54	II	0 - 27514	190	3750.54	II	13338 - 39994
510	3634.67	I		35	3751.97	II	13188 - 39833
210	3636.41	I	11557 - 39049	540	3756.05	I	7696 - 34313
270	3637.16	II	5133 - 32619	35	3756.40	II	13338 - 39952
1600	3638.68	I		230	3761.99	I	7176 - 33750
270	3641.27	II	13719 - 41174	230	3766.16	II	10894 - 37439
65	3641.92	II		65	3767.73	II	
900	3645.94	II	13027 - 40447	160	3768.79	II	7195 - 33722
65	3646.78	II	7150 - 34563	270	3771.10	II	7150 - 33660
520	3650.41	II	5404 - 32790	110	3772.47	II	7150 - 33650
360	3652.58	II	5132 - 32502	90	3774.84	I	9350 - 35833
500	3652.87	II	7195 - 34563	110	3775.31	I	9655 - 36136
35	3656.38	II	5404 - 32745	230	3775.66	II	16935 - 43413
140	3659.58	I	7696 - 35014	160	3777.62	II	7195 - 33660
110	3660.78	II	19606 - 46915	110	3778.32	II	12388 - 38847
110	3662.04	II	16935 - 44235	140	3778.67	I	7696 - 34153
180	3662.86	I	7696 - 34990	410	3781.01	II	11043 - 37483
360	3664.45	I	7176 - 34458	65	3783.87	II	17842 - 44263
470	3669.02	II	7150 - 34397	1800	3786.84	II	0 - 26400
80	3675.18	II	7195 - 34397	65	3787.38	II	11043 - 37439
190	3676.51	II	7150 - 34342	560	3787.86	II	17842 - 44234
190	3678.95	I	8620 - 35794	110	3791.16	I	8620 - 34990
65	3680.10	II	13558 - 40723	90	3791.54	I	9350 - 35717
500	3682.70	II	7195 - 34342	560	3791.83	II	440 - 26805
320	3684.01	I	7176 - 34313	500	3792.79	I	7696 - 34055
380	3684.28	II	5133 - 32267	560	3797.06	II	440 - 26769
160	3689.12	II	5404 - 32503	80	3798.21	I	6958 - 33279
7900	3692.65	II	440 - 27514	180	3798.63	I	5035 - 31353
450	3696.25	II	7150 - 34196	65	3803.73	I	9350 - 35632
160	3696.92	II	16935 - 43977	45	3806.05	II	14280 - 40547
100	3697.27	I		80	3807.07	II	13188 - 39447
380	3697.68	I	7696 - 34733	1600	3810.33	I	0 - 26237
540	3700.72	II	440 - 27454	80	3817.75	II	5403 - 31589
190	3701.57	II	7195 - 34203	90	3818.71	II	5132 - 31312
35	3702.51	II	7195 - 34196	65	3827.31	I	5035 - 31155
100	3705.77	I	7176 - 34153	3600	3830.48	II	0 - 26099
160	3706.52	I	9350 - 36321	110	3832.31	II	5404 - 31490
520	3707.64	II	14280 - 41244	80	3832.53	I	15083 - 41168

## Erbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	3835.65	II	12587 - 38651	1400	3974.72	II	440 - 25592
200	3837.64	II	12388 - 38438	280	3976.73	I	10750 - 35890
110	3838.50	I	9350 - 35394	810	3977.02	I	5035 - 30172
90	3839.26	II	16948 - 42987	50	3979.13	II	12587 - 37711
40	3842.93	I		160	3980.14	II	7150 - 32267
80	3848.31	II	5404 - 31382	160	3980.60	I	12377 - 37492
90	3849.29	II	0 - 25971	1100	3982.33	I	6958 - 32062
540	3849.91	I	8620 - 34587	110	3983.14	II	12600 - 37698
320	3851.60	II	7150 - 33106	280	3987.53	I	13097 - 38168
680	3855.90	I	5035 - 30962	810	3987.66	I	5035 - 30105
540	3858.39	II	7195 - 33106	230	3991.15	I	15083 - 40131
7500	3862.85	I	0 - 25880	50	3994.85	II	5132 - 30157
250	3864.80	II	10894 - 36761	60	3995.26	II	13558 - 38580
50	3868.23	II	10893 - 36738	60	3999.07	I	8620 - 33619
50	3871.75	I	11557 - 37378	100	3999.16	II	5132 - 30130
150	3874.83	I	5035 - 30835	230	4004.05	I	6958 - 31926
100	3875.72			14000	4007.96	I	0 - 24943
1500	3880.61	II	5132 - 30894	230	4008.18	II	440 - 25382
1200	3882.89	II	7150 - 32896	280	4009.16	II	0 - 24936
100	3884.12	I	13097 - 38836	150	4009.78	I	9655 - 34587
50	3885.38	II	12587 - 38318	1100	4012.58	I	6958 - 31873
150	3887.15	II	11043 - 36761	50	4012.98	II	
250	3888.08	II		350	4015.57	II	5132 - 30028
150	3889.79	II	7195 - 32896	110	4016.36	I	13097 - 37989
400	3890.61	II	11042 - 36738	3000	4020.51	I	6958 - 31824
4200	3892.68	I	0 - 25682	450	4021.55	I	5035 - 29894
160	3895.80	II	7150 - 32811	110	4022.01	II	18463 - 43319
5200	3896.23	II	440 - 26099	190	4036.11	I	5035 - 29804
250	3899.03	I	9350 - 34990	180	4037.69	I	5035 - 29794
810	3902.76	II	7195 - 32811	75	4039.64	I	12377 - 37125
50	3903.84	II	17378 - 42987	230	4043.01	II	5403 - 30130
250	3903.98	I	5035 - 30642	1000	4046.96	I	10751 - 35454
250	3904.56	II	7150 - 32753	280	4048.34	II	7150 - 31844
1200	3905.40	I	0 - 25598	200	4049.49	II	0 - 24687
11000	3906.31	II	0 - 25592	940	4055.47	II	5132 - 29783
100	3908.44	II	13188 - 38766	550	4059.51	I	10751 - 35378
110	3910.50	I	5035 - 30600	690	4059.78	II	5404 - 30029
110	3911.54	II	7195 - 32753	140	4072.38	I	
50	3911.91	II	440 - 25996	140	4074.00	II	12587 - 37126
140	3912.42	II	11309 - 36861	420	4077.88	I	5035 - 29551
50	3915.69	II		550	4081.24	II	440 - 24936
85	3916.00	I	10751 - 36280	140	4083.05	I	6958 - 31443
280	3918.05	I	12377 - 37893	3500	4087.63	I	0 - 24457
210	3918.35	II	5404 - 30917	75	4091.78	I	10557 - 34990
280	3921.88	II	5403 - 30894	210	4092.90	I	5035 - 29460
810	3932.25	II	7195 - 32619	140	4094.64	II	0 - 24415
3200	3937.01	I	0 - 25392	1100	4098.10	I	6958 - 31353
2100	3938.63	II	0 - 25382	350	4100.56	II	5404 - 29784
85	3938.92	II	17842 - 43223	60	4103.98	II	5133 - 29492
50	3939.36	II	13060 - 38438	60	4106.58	II	12587 - 36932
150	3942.58	I	15083 - 40440	130	4109.33	I	6958 - 31286
150	3943.18	II	7150 - 32503	140	4112.62	II	16935 - 41244
3200	3944.42	I	5035 - 30380	320	4116.36	I	9655 - 33942
550	3948.06	I	8620 - 33942	320	4118.55	I	10750 - 35024
110	3950.98	I	13097 - 38400	140	4123.08	II	
250	3951.48	I	13097 - 38397	140	4124.76	I	5035 - 29272
320	3956.42	I	0 - 25268	600	4131.50	I	6958 - 31155
50	3959.90	II	12388 - 37634	550	4142.91	II	5132 - 29263
160	3961.21	I	9350 - 34587	6900	4151.11	I	0 - 24083
110	3963.36	II	6824 - 32048	60	4160.31	I	10557 - 34587
85	3964.51	I	5035 - 30252	190	4164.83	I	6958 - 30962
280	3966.35	I	10751 - 35955	130	4171.54	I	10750 - 34716
160	3969.44	II	5132 - 30317	140	4172.22	I	5035 - 28996
2700	3973.04	I	0 - 25162	140	4185.48	I	0 - 23885
3200	3973.58	I	0 - 25159	280	4189.98	II	5403 - 29263

## Erbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1000	4190.70	I	0 - 23855	130	4522.74	I	7696 - 29801
140	4194.72	I	13097 - 36930	35	4526.92	II	18463 - 40547
60	4197.43	I	11401 - 35218	35	4531.08	I	7696 - 29760
130	4205.32	I	13097 - 36870	35	4551.99	I	7176 - 29138
1400	4218.43	I		75	4552.14	II	17842 - 39804
200	4220.99	I	6958 - 30642	50	4555.70	I	10750 - 32695
60	4223.49	I		160	4563.26	II	11309 - 33217
60	4223.73	II		35	4563.93	I	
320	4230.20	II		50	4566.38	II	5403 - 27296
60	4232.46	I		35	4569.29	I	16464 - 38344
140	4234.78	II	5404 - 29011	75	4592.92	I	
75	4235.18	I	5035 - 28640	45	4596.74	I	7696 - 29445
60	4237.03	I	11799 - 35394	75	4598.12	I	7176 - 28918
200	4251.94	II	16935 - 40447	60	4602.07	I	17073 - 38797
60	4263.72	I	0 - 23447	1000	4606.61	I	0 - 21702
60	4264.87	I	12377 - 35818	75	4611.25	II	
60	4269.95	I	11887 - 35300	30	4624.78	II	
140	4276.48	II	12815 - 36192	160	4630.88	II	15732 - 37321
690	4286.56	I	5035 - 28357	110	4640.60	II	14649 - 36192
60	4288.51	I	0 - 23311	35	4656.69	II	17378 - 38847
320	4298.91	I		110	4665.44	II	
60	4301.26	I	12377 - 35620	30	4667.59	II	
320	4301.60	II	0 - 23241	45	4671.59	I	
140	4303.81	II	5132 - 28361	310	4673.16	I	0 - 21392
60	4306.36	I	11799 - 35014	570	4675.62	II	10667 - 32048
110	4319.94	II	13719 - 36861	150	4679.06	II	12388 - 33753
130	4328.81	I	10750 - 33845	35	4688.64	II	
50	4330.27	II	10667 - 33753	75	4697.17	II	
110	4331.36	I	0 - 23080	35	4702.18	II	
60	4335.03	I	10557 - 33619	30	4708.71	I	
50	4339.00	II	14280 - 37321	35	4718.69	I	17157 - 38343
140	4340.92	I	11557 - 34587	230	4722.69	I	0 - 21168
190	4348.34	I	5035 - 28026	85	4724.54	II	
50	4351.63	I	7176 - 30149	150	4729.05	I	8620 - 29760
110	4369.39	II	10667 - 33547	85	4731.59	II	15732 - 36861
60	4378.35	II	7195 - 30029	40	4736.96	II	16529 - 37634
60	4380.65	I	5035 - 27856	60	4745.27	I	6958 - 28026
160	4382.17	I	7176 - 29989	130	4751.52	II	
300	4384.70	II	440 - 23240	170	4759.65	II	0 - 21004
300	4386.40	I	7176 - 29967	60	4762.64	II	16643 - 37634
60	4388.38	II	18463 - 41244	95	4795.48	II	
75	4397.42	I	10751 - 33485	190	4820.35	II	11309 - 32048
100	4403.17	II	17842 - 40547	30	4828.67	I	
810	4409.34	I	0 - 22672	21	4829.52	I	7696 - 28397
75	4413.74	I	8620 - 31270	85	4831.15	II	13060 - 33753
60	4414.35	I	12377 - 35024	21	4834.74	II	16643 - 37321
180	4418.70	I	7176 - 29801	60	4842.03	I	5035 - 25682
570	4419.61	II	13572 - 36192	85	4848.83	I	9350 - 29967
110	4422.51	II	17842 - 40447	30	4851.64	II	17063 - 37669
320	4424.57	I	5035 - 27629	40	4853.12	II	
370	4426.77	I	0 - 22583	30	4854.41	II	
50	4432.23	I	6958 - 29514	140	4857.44	I	8620 - 29201
110	4437.66	I	10750 - 33279	50	4858.47	II	19375 - 39952
50	4448.62	II	13719 - 36192	35	4861.60	II	440 - 21004
100	4459.24	II	440 - 22859	150	4872.09	II	13027 - 33547
100	4473.50	II		30	4872.48	II	0 - 20517
85	4484.48	I	7696 - 29989	30	4878.33	II	7150 - 27643
30	4488.90	I	7696 - 29967	26	4879.89	II	13060 - 33547
50	4489.05	I		30	4886.29	II	5132 - 25592
130	4496.39	I	7696 - 29930	27	4888.84	I	7176 - 27625
200	4500.75	II	14649 - 36861	27	4896.95	II	13338 - 33753
45	4503.27	II		80	4898.15	I	15083 - 35493
35	4512.21	I		210	4900.08	II	12815 - 33217
35	4518.66	I	0 - 22124	55	4903.64	II	19606 - 39994
75	4519.44	II		27	4904.43	II	18463 - 38847



Erbium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	4917.08	I	19326 - 39658	35	5368.85	I	19723 - 38344
27	4925.06	I		35	5395.87	II	20319 - 38847
45	4925.43	II		60	5414.63	II	0 - 18463
18	4927.00	II	17378 - 37669	18	5422.81	II	
22	4927.33	II	23973 - 44263	18	5451.30	I	
70	4928.88	I	7176 - 27459	35	5454.27	II	13719 - 32048
210	4934.11	II	23973 - 44235	180	5456.62	I	9655 - 27977
130	4944.36	I	8620 - 28839	35	5462.43	II	21819 - 40121
180	4951.74	II	13027 - 33217	90	5468.32	I	10557 - 28839
45	4953.60	II		18	5477.47	II	
27	4954.68	II		80	5485.97	II	
35	4966.62	II	19992 - 40121	27	5497.44	II	
60	4966.97	I	5035 - 25163	27	5516.02	I	11557 - 29681
55	4969.88	I		80	5593.46	I	11887 - 29760
130	4976.42	I		45	5601.14	I	10557 - 28406
35	4990.31	I	15185 - 35218		5601.32	I	9350 - 27198
45	4992.36	II		45	5609.94	I	28053 - 45874
90	5000.38	II	0 - 19992	60	5611.82	I	7176 - 24991
250	5007.25	I	5035 - 25000	70	5622.01	I	7696 - 25479
90	5008.96	II		80	5626.53	II	14280 - 32048
45	5024.28	II		30	5636.20	I	11401 - 29138
140	5028.33	I	7696 - 27578	90	5640.36	I	9655 - 27380
120	5028.91	II	440 - 20319	22	5641.42	I	19362 - 37083
35	5029.77	II		22	5658.63	II	
200	5035.94	I	9350 - 29201	70	5664.95	I	8620 - 26268
210	5042.05	II	13719 - 33547	45	5665.44	II	
130	5043.86	I	15846 - 35667	55	5675.48	I	5035 - 22649
130	5044.89	I	7176 - 26993	14	5695.53	II	11042 - 28595
35	5045.98	II		27	5710.87	II	
55	5052.66	I	15846 - 35632	55	5717.48	I	10557 - 28043
70	5070.32	II		70	5719.55	I	8620 - 26099
130	5077.59	II		55	5726.97	I	0 - 17456
70	5080.52	I	5035 - 24712	22	5733.43	II	
60	5119.64	II		22	5736.56	I	17297 - 34724
120	5124.56	I	0 - 19508	22	5736.94	I	
130	5127.41	II	13719 - 33217	100	5739.19	I	10557 - 27977
120	5131.53	I	7696 - 27178	35	5740.61	I	5035 - 22450
130	5133.83	II	14280 - 33753	60	5748.65	I	6958 - 24348
60	5143.58	II		55	5752.53	I	10751 - 28130
35	5144.09	II		70	5757.63	II	
55	5163.80	II		290	5762.80	I	0 - 17347
170	5164.77	II		70	5769.92	I	5035 - 22361
130	5172.78	I	0 - 19326	45	5782.82	I	6958 - 24246
27	5179.49	II	26805 - 46106	70	5784.66	I	11557 - 28839
160	5188.90	II	14280 - 33547	22	5791.15	II	21819 - 39082
150	5206.52	I	0 - 19201	70	5800.79	I	5035 - 22269
60	5212.91	II		22	5806.10	I	15083 - 32301
30	5215.13	II		13	5814.23	I	
30	5218.26	II		13	5814.34	I	17796 - 34990
45	5229.34	II	21004 - 40121	430	5826.79	I	0 - 17157
140	5255.93	II	13027 - 32048	11	5833.88	II	
22	5256.47	II	17842 - 36861	45	5835.84	I	
27	5257.02	II		14	5839.95	I	11799 - 28918
35	5264.77	II		18	5841.16	I	11401 - 28516
80	5272.91	I		100	5850.07	I	5035 - 22124
55	5277.71	I	9655 - 28598	120	5855.31	I	0 - 17073
27	5279.34	II	14280 - 33217	12	5860.69	II	
45	5302.30	II	19992 - 38847	14	5871.63	I	10751 - 27777
55	5333.06	I	16472 - 35218	140	5872.35	I	7696 - 24721
27	5333.33	II		18	5873.53	I	10557 - 27578
27	5334.23	II		120	5881.14	I	8620 - 25619
22	5343.94	II		27	5886.30	II	
30	5344.50	II		27	5902.08	II	440 - 17378
90	5348.06	I	9350 - 28043	55	5906.06	I	6958 - 23885
45	5350.47	I	7176 - 25861	45	5909.24	I	9350 - 26268

Erbium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18	5916.46	I	6958 - 23856	27	6721.91	I	17073 - 31946
35	5933.50	I	11557 - 28406	13	6722.76	I	17347 - 32218
14	5937.16	II		70	6759.87	I	17157 - 31946
22	5946.37	I	11887 - 28699	12	6761.68	II	
55	5968.68	I	9350 - 26099	22	6762.92	I	23885 - 38667
27	5975.49	I	11557 - 28288	11	6764.55	I	17073 - 31852
35	6006.79	II	0 - 16643	11	6766.62	I	22124 - 36898
14	6007.90	I	10557 - 27198	9	6768.42	II	18889 - 33659
22	6008.75	II		18	6768.94	II	
55	6014.83	I	10557 - 27178	27	6773.37	I	22124 - 36883
35	6015.74	II	21819 - 38438	16	6776.14	II	
70	6022.56	I	8620 - 25220	14	6780.03	I	22269 - 37014
22	6032.12	II	23973 - 40547	18	6780.76	I	6958 - 21702
22	6045.63	II		8	6787.92	I	22269 - 36997
22	6048.14	II	0 - 16529	35	6790.92	I	17157 - 31878
45	6054.85	I	9350 - 25861	14	6796.96	II	6824 - 21533
70	6061.25	I		18	6803.85	II	
60	6076.45	II		22	6825.44	I	24246 - 38893
14	6105.18	II	17378 - 33753	22	6825.98	I	17073 - 31719
35	6116.01	I	11401 - 27747	12	6835.90	I	24246 - 38870
35	6125.32	I	0 - 16321	70	6848.10	I	17347 - 31946
12	6149.32	II		9	6857.24	I	11557 - 26136
30	6170.06	II	440 - 16643	55	6865.13	I	17157 - 31719
27	6183.21	II	17378 - 33547	11	6873.09	I	
360	6221.02	I	0 - 16070	18	6873.66	I	24348 - 38893
35	6230.90	I	11887 - 27932	16	6874.77	I	11557 - 26099
55	6262.56	I	9655 - 25619	27	6879.98	I	17347 - 31878
45	6267.93	I		11	6884.09	I	22361 - 36883
60	6268.87	I	11799 - 27747	7	6892.39	I	17347 - 31852
35	6274.94	I	7696 - 23628	14	6897.48	II	19903 - 34397
30	6286.86	I	11557 - 27459	9	6908.23	I	11799 - 26271
18	6288.59	I	16321 - 32218	12	6925.93	I	6958 - 21392
45	6299.42	I	9350 - 25220	6	6926.25	I	22450 - 36883
130	6308.77	I	0 - 15846	18	6938.36	I	17157 - 31565
55	6326.13	I	7176 - 22979	6	6944.94	II	18617 - 33012
22	6347.16	II		18	6951.88	I	11887 - 26268
11	6351.56	II		9	6973.01	I	11799 - 26136
45	6388.19	I	16070 - 31719	7	6989.30	I	11557 - 25861
14	6398.13	I	16321 - 31946	22	7001.40	I	9350 - 23628
11	6413.59	I		12	7058.55	I	10557 - 24721
9	6423.05	I	9655 - 25220	12	7065.04	I	17796 - 31946
9	6423.17	I	9655 - 25220	11	7070.99	II	21533 - 35671
22	6432.53	I	10557 - 26099	18	7101.27	I	11401 - 25479
16	6441.32	II	16552 - 32073	8	7109.67	I	11799 - 25861
7	6451.56	I	16070 - 31565	11	7155.40	II	
7	6454.02	II		5	7161.91	I	6958 - 20917
14	6481.74	I	23447 - 38870	14	7197.00	I	
27	6485.87	I		7	7264.82	II	
55	6492.35	I	16321 - 31719	7	7283.95	I	
12	6520.52	I	21551 - 36883	14	7329.73	II	18889 - 32528
22	6541.57	I	7696 - 22979	18	7355.37	I	11887 - 25479
11	6556.33	II	16552 - 31801	11	7356.34	I	11401 - 24991
18	6557.82	I	16321 - 31565	18	7428.67	I	25463 - 38921
60	6583.48	I	0 - 15185	55	7459.55	I	18816 - 32218
16	6593.51	I		9	7460.42	I	19125 - 32525
70	6601.11	I	17073 - 32218	120	7469.51	I	18335 - 31719
12	6616.74	II	23973 - 39082	22	7532.34	I	25598 - 38870
14	6637.65	I	10557 - 25619	6	7539.18	I	23885 - 37144
6	6648.97	I	23885 - 38921	27	7556.26	I	18335 - 31565
4	6649.06	I	16070 - 31105	6	7574.21	I	
11	6663.52	I	10751 - 25754	5	7590.51	I	19047 - 32218
13	6687.14	I	17073 - 32023	11	7597.33	I	23855 - 37014
7	6690.02	II	20728 - 35671	6	7607.23	I	23855 - 36997
7	6701.75	I	17029 - 31946	11	7613.52	I	29550 - 42681
11	6721.00	I	22269 - 37144	6	7623.48	I	23883 - 36997

*Erbium— all observed lines— Continued*

Intensity and Character		Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character		Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
16	h	7645.67	I	24068 - 37144	35		7921.85	I	19326 - 31946
8		7650.63	I		30		7937.84	I	19125 - 31719
22		7654.45	II	0 - 13060	8		7952.93	I	
12	h	7658.05	I		12		7964.51	I	19326 - 31878
22		7659.25	I	23831 - 36883	8		7979.03	II	
4		7665.64	I		8		7980.87	I	
35		7680.01	I	19201 - 32218	5		8023.03	I	19563 - 32023
9		7722.14	I	27822 - 40769	12		8035.91	I	19125 - 31565
8		7726.19	II	16552 - 29492	12		8181.85	I	7696 - 19915
11	h	7747.44	I	26017 - 38921	35		8312.82	I	7696 - 19723
22		7754.63	I	19326 - 32218	18		8328.57	II	18617 - 30621
4		7762.16	I	23831 - 36710	5		8367.58	II	440 - 12388
9		7796.69	I	19201 - 32023	55		8409.90	I	0 - 11887
35		7797.47	I	19125 - 31946	11		8466.18	II	16552 - 28361
9		7838.80	I	19125 - 31878	35		8472.42	I	0 - 11799
11		7844.00	I	19201 - 31946	14		8517.71	II	
16		7847.55	I	7176 - 19915	18		8521.37	II	18889 - 30621
5		7875.36	I	26198 - 38893	22		8768.64	I	0 - 11401
5		7879.36	I	16464 - 29152	11	h	8776.63	II	18617 - 30008
18		7899.55	I	19563 - 32218	9		8866.84	II	18617 - 29892
8		7913.08	I	26237 - 38870					

## Europium

$$\text{Eu}, Z = 63, M = 151.96, \text{Ratio } \frac{\text{Eu}}{\text{Cu}} = 2.391$$

Eu I Normal state of valence electrons  $4f^7 6s^2 {}^8S_{3/2}^{\circ} = 0$ . I.P. = 45700  $\text{cm}^{-1}$ .

Eu II Normal state of valence electrons  $4f^7 6s {}^9S_4^{\circ} = 0$ . I.P. = 90660  $\text{cm}^{-1}$ .

### References

**Wavelengths:**

A. S. King, *Astrophys. J.* **89**, 377 (1939).

**Classification:**

Eu I, H. N. Russell and A. S. King, *Astrophys. J.* **90**, 155 (1939).

Eu II, H. N. Russell, W. Albertson, and D. N. Davis, *Phys. Rev.* **60**, 641 (1941).

### *Strong lines of europium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
60000 cw	4205.05	II	0 - 23774	6400	3688.42	II	0 - 27104
39000 cw	3819.67	II	0 - 26173	4200	2727.78	II	0 - 36649
33000 cw	4129.70	II	0 - 24208	3400	2813.94	II	0 - 35527
32000 cw	3930.48	II	1669 - 27104	3200	2906.68	II	0 - 34394
30000 cw	3971.96	II	1669 - 26838				
28000 cw	3907.10	II	1669 - 27256	3000	4522.57	II	1669 - 23774
20000 cw	3724.94	II	0 - 26839	2000	2820.78	II	0 - 35441
14000 cw	4435.56	II	1669 - 24208	1900	2802.84	II	1669 - 37337
11000	4594.03	I	0 - 21761	1400	6645.11	II	11128 - 26173
9800	4627.22	I	0 - 21605	1000	2638.77	II	1669 - 39554
8300	4661.88	I	0 - 21445	1000	3212.81	I	0 - 31116

Europium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
21	2499.39	II	1669 - 41667	30	2958.91	I	0 - 33786
26	2554.78	II	16861 - 55991	35	2959.47	II	0 - 33780
26	2559.18	II	17004 - 56067	260	2960.21	II	1669 - 35441
160	2564.17	II	17004 - 55991	300	2991.33	II	0 - 33420
110	2568.17	II	17141 - 56067	35	2995.22	II	1669 - 35046
26	2574.76	II	17141 - 55968	40	3006.26	II	1669 - 34923
230	2577.14	II	16861 - 55652	35	3022.15	I	
26	2581.86	II	17248 - 55968	30	3040.77	II	1669 - 34546
26	2604.61	I		320	3054.94	II	1669 - 34394
30	2635.50	II	0 - 37932	120	3058.98	I	0 - 32681
1000	2638.77	II	1669 - 39554	35	3069.11	II	24208 - 56781
380	2641.27	II	0 - 37849	35	3076.07	II	
40	2653.61	II		220	3077.36	II	0 - 32486
640	2668.34	II	1669 - 39135	35	3089.35	II	
110	2673.42	II		120	3097.45	II	1669 - 33944
250	2678.29	II	1669 - 38996	320	3106.18	I	0 - 32185
250	2685.66	II	0 - 37224	950	3111.43	I	0 - 32130
550	2692.03	II	1669 - 38805	120	3130.73	II	
700	2701.14	II	0 - 37011	40	3132.16	I	
800	2701.90	II	0 - 37000	45	3149.88	II	
240	2705.28	II	0 - 36954	85	3173.61	II	0 - 31501
180	2709.99	I	0 - 36890	40	3185.54	I	0 - 31383
700	2716.98	II	1669 - 38464	420	3210.57	I	0 - 31138
70	2723.96	I	0 - 36700	1000	3212.81	I	0 - 31116
4200	2727.78	II	0 - 36649	420	3213.75	I	0 - 31107
190	2729.33	II	0 - 36628	45	3235.13	I	0 - 30902
380	2729.44	II	1669 - 38296	95	3241.40	I	0 - 30842
50	2731.37	I	0 - 36601	45	3246.03	I	0 - 30798
40	2732.61	I	0 - 36584	45	3247.32	II	
80	2735.25	I	0 - 36549	100	3247.55	I	0 - 30784
160	2740.62	II	1669 - 38146	100	3266.39	II	23774 - 54380
70	2743.28	I	0 - 36442	150	3272.77	II	23774 - 54321
120	2744.26	II	0 - 36429	210	3277.78	II	23774 - 54274
40	2745.61	I	0 - 36411	150	3301.95	II	24208 - 54484
70	2747.29	II	1669 - 38058	45	3304.50	II	
80	2747.83	I	0 - 36381	140	3308.02	II	24208 - 54429
90	2752.17	II	1669 - 37994	140	3313.33	II	24208 - 54380
480	2781.89	II	1669 - 37606	65	3319.89	II	24208 - 54321
1900	2802.84	II	1669 - 37337	95	3321.86	II	11128 - 41223
220	2811.75	II	1669 - 37224	85	3322.26	I	0 - 30091
30	2813.08	II		950	3334.33	I	0 - 29982
3400	2813.94	II	0 - 35527	45	3338.75	II	26838 - 56781
550	2816.18	II	1669 - 37168	110	3350.40	I	0 - 29839
2000	2820.78	II	0 - 35441	40	3351.56	II	
400	2828.72	II	1669 - 37011	40	3354.38	II	
120	2829.30	II	1669 - 37003	45	3367.64	II	10082 - 39768
140	2833.26	II	1669 - 36954	140	3369.06	II	10643 - 40317
80	2843.96	II	1669 - 36821	65	3380.25	II	24208 - 53783
60	2852.05	II		75	3390.78	II	
260	2859.67	II	1669 - 36628	190	3391.99	II	10082 - 39554
280	2862.57	II	0 - 34923	280	3396.58	II	26838 - 56271
25	2864.42	II	11128 - 46029	45	3419.84	II	
60	2876.06	II	1669 - 36429	65	3423.09	II	
100	2878.87	I	0 - 34726	150	3425.02	II	11128 - 40317
80	2887.85	II	0 - 34618	45	3426.44	II	9923 - 39099
200	2892.54	I	0 - 34562	45	3435.05	II	
140	2893.03	I	0 - 34556	65	3435.20	II	
360	2893.83	I		40	3435.72	II	
		II	0 - 34546	45	3440.82	II	27256 - 56311
3200	2906.68	II	0 - 34394	150	3441.00	II	10082 - 39135
160	2908.99	I	0 - 34366	45	3445.18	II	10082 - 39099
30	2917.44	II	1669 - 35936	85	3457.05	I	0 - 28918
850	2925.04	II	1669 - 35847	45	3457.56	II	10082 - 38996
60	2947.29	II	0 - 33920	130	3461.38	II	9923 - 38805
200	2952.68	II	1669 - 35527	85	3467.88	I	0 - 28828

Europium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	3477.07	I		30	h	3942.21	II 10082 - 35441
75	3505.30	II	1669 - 30189	60		3942.94	II
470	3521.09	II	26173 - 54565	120		3943.08	II 23774 - 49128
75	3531.15	II	26173 - 54484	30		3944.59	II
45	3532.23	II	27256 - 55559	30		3945.67	II
65	3538.08	II	26173 - 54429	30		3949.13	II
150	3542.15	II	9923 - 38146	60		3949.60	I 13049 - 38361
85	3543.85	II		45		3950.76	II
45	3549.71	II		55		3951.33	II
180	3552.52	II	10643 - 38784	60		3955.75	I 15582 - 40854
75	3589.27	I	0 - 27853	40		3957.92	II
45	3591.31	II		30		3963.61	I 15952 - 41175
150	3603.20	II	10313 - 38058	120		3964.90	II 10313 - 35527
75	3611.57	II	10313 - 37994	150		3966.59	II
45	3616.15	II	26838 - 54484	45		3967.18	I 14068 - 39268
95	3622.54	II	11128 - 38725	30000	cw	3971.96	II 1669 - 26838
95	3632.18	II	10082 - 37606	60		3978.42	I 13457 - 38586
45	3673.19	II	27104 - 54321	30		3979.63	II
45	3674.63	II	10643 - 37849	55	h	3986.60	I 13457 - 38534
45	3678.26	II	27256 - 54435	40		3988.24	II
6400	3688.42	II	0 - 27104	30		3993.93	II
60	3710.87	II	10643 - 37584	55		3995.98	II
95	3713.45	II	10082 - 37003	60		4003.71	II
95	3714.90	II	10313 - 37224	180		4011.69	II 24208 - 49128
35	3716.94	II		150		4017.58	II 10643 - 35527
35	3717.69	II		120		4039.19	I
40	3719.16	I	14564 - 41444	45	h	4078.24	I 13779 - 38292
20000	3724.94	II	0 - 26839	120		4085.38	II 9923 - 34394
45	3729.68	II		75		4096.80	II 10643 - 35046
45	3729.74	II	11128 - 37932	60		4106.88	I 12924 - 37266
21	3732.20	I	14068 - 40854	90	h	4112.04	II 10082 - 34394
45	3738.08	II		45		4119.30	II
350	3741.31	II	11128 - 37849	75		4127.28	I 16080 - 40302
100	3743.56	II	9923 - 36628	33000	cw	4129.70	II 0 - 24208
260	3761.12	II	10643 - 37224	30		4136.59	II
95	3765.93	II	10082 - 36628	40		4137.07	I 16080 - 40245
40	3774.10	I	16612 - 43101	30		4141.02	II
60	3781.40	II		60		4141.72	II
40	3788.76	II	27104 - 53490	30		4151.52	II 10313 - 34394
45	3791.50	II	10643 - 37011	45		4151.64	II
130	3799.01	II	10313 - 36628	30		4157.72	I 13049 - 37094
70	3801.36			110		4172.80	II
95	3807.54	II		30		4175.16	II
120	3811.33	I	14068 - 40298	110		4182.22	I 13222 - 37126
120	3815.50	II		40		4195.36	II
39000	3819.67	II	0 - 26173	40		4196.18	II
120	3826.68	II	26838 - 52963	60000	cw	4205.05	II 0 - 23774
140	3844.23	II	10643 - 36649	45		4221.08	II
190	3865.57	I	15582 - 41444	40		4223.88	II
45	3872.72	I	15582 - 41396	90	h	4227.40	II
70	3877.27	II		75		4229.33	II
150	3884.75	I	14564 - 40298	75		4232.45	II
23	3896.78	I		90		4237.51	II
23	3900.18	I		45		4238.69	II
70	3900.51	I	13222 - 38852	45		4244.74	I 13049 - 36601
28000	3907.10	II	1669 - 27256	45		4247.06	II
45	3915.24	II		45		4253.80	II
45	3916.00	I		30		4270.24	II
230	3917.29	I	13049 - 38569	150		4298.73	I 13779 - 37035
23	3917.70	II	9923 - 35441	90		4329.36	I 13457 - 36549
40	3918.52	I	13779 - 39291	75		4329.97	I 13779 - 36867
100	3919.09	II		60		4330.61	II
40	3928.87	II	10082 - 35527	40		4331.18	I 12924 - 36006
32000	3930.48	II	1669 - 27104	90		4337.68	I 13457 - 36504
55	3941.56	II		240		4355.09	II 26173 - 49128

Europium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	4361.57	II		90	5303.85	I	16612 - 35461
55	4369.47	II		30	5350.41	I	17945 - 36630
45	4372.20	II		75	5351.69	I	15421 - 34102
75	4383.17	II	26838 - 49647	40	5352.84	I	17945 - 36622
90	4387.88	I	13222 - 36006	90	5355.10	I	16612 - 35280
21	4405.27	II	16861 - 39554	540	5357.61	I	13457 - 32117
55	4407.07	II		60	5360.83	I	15138 - 33786
18	4419.66	II		120	5361.61	I	16080 - 34726
120	4434.81	II	27104 - 49647	110	5376.94	I	16612 - 35205
14000	4435.56	II	1669 - 24208	120	5392.94	I	15249 - 33786
75	4464.97	II	27256 - 49647	450	5402.77	I	13222 - 31726
24	4485.15	II	26838 - 49128	45	5405.33	I	16612 - 35107
3000	4522.57	II	1669 - 23774	45	5411.86	I	17341 - 35813
45	4535.59	I	15952 - 37994	55	5421.07	I	16612 - 35053
11000	4594.03	I	0 - 21761	90	5426.94	I	15680 - 34102
21	4602.63	I	16080 - 37800	40	5443.56	I	15421 - 33786
9800	4627.22	I	0 - 21605	380	5451.51	I	13779 - 32117
8300	4661.88	I	0 - 21445	260	5452.94	I	13049 - 31383
30	4713.59	I	15680 - 36890	40	5457.62	I	19273 - 37591
27	4740.50	I	13457 - 34546	90	5472.32	I	13457 - 31726
45	4792.59	I	13457 - 34317	120	5488.65	I	12924 - 31138
40	4829.30	I	15680 - 36381	45	5495.20	I	12924 - 31116
60	4830.33	I	17341 - 38037	15	5500.83	I	15952 - 34126
40	4840.47	I	17341 - 37994	120	5510.52	I	14068 - 32210
60	4849.64	I	15952 - 36567	30	5526.63	I	13049 - 31138
110	4867.62	I	13779 - 34317	30	5533.25	I	13049 - 31116
40	4884.05	I	16080 - 36549	30	5542.54	I	17341 - 35378
90	4894.68	I	16080 - 36504	200	5547.44	I	12924 - 30945
60	4900.86	I	14068 - 34467	150	5570.33	I	13779 - 31726
150	4907.18	I	14068 - 34440	200	5577.14	I	13457 - 31383
180	4911.40	I	14068 - 34423	75	5579.63	I	14564 - 32481
55	4953.52	I	15891 - 36073	120	5580.03	I	13222 - 31138
55	4960.21	I	15891 - 36045	90	5586.24	I	13049 - 30945
55	4962.55	I	15952 - 36098	75	5586.83	I	13222 - 31116
45	4975.76	I	17945 - 38037	18	5592.25	I	12924 - 30801
180	5013.17	I	14564 - 34506	18	5599.80	I	13049 - 30902
170	5022.91	I	14564 - 34467	18	5605.86	I	17341 - 35174
110	5029.54	I	14564 - 34440	40	5618.81	I	13222 - 31014
90	5033.55	I	15952 - 35813	60	5622.44	I	14068 - 31849
75	5067.95	I	13222 - 32948	75	5632.54	I	13049 - 30798
75	5092.69	I	16612 - 36242	210	5645.80	I	0 - 17707
90	5096.44	I	19447 - 39063	15	5651.11	I	17707 - 35398
170	5114.37	I	13049 - 32596	60	5673.85	I	13222 - 30842
90	5124.77	I	15891 - 35398	27	5681.10	I	13222 - 30819
170	5129.10	I	13457 - 32948	27	5684.24	I	19447 - 37035
90	5130.08	I	15891 - 35378	60	5730.87	I	13457 - 30902
210	5133.52	I	12924 - 32398	60	5739.00	I	19447 - 36867
270	5160.07	I	13222 - 32596	330	5765.20	I	0 - 17341
210	5166.70	I	13049 - 32398	180	5783.69	I	14564 - 31849
60	5193.74	I	17341 - 36589	15	5792.72	I	19631 - 36890
200	5199.85	I	17341 - 36567	60	5800.27	I	13779 - 31014
110	5200.96	I	15952 - 35174	170	5818.74	II	9923 - 27104
120	5206.44	I	16612 - 35813	600	5830.98	I	13779 - 30924
750	5215.10	I	13779 - 32948	27	5845.77	I	19447 - 36549
300	5223.49	I	13457 - 32596	27	5860.97	I	19447 - 36504
120	5239.24	I	13049 - 32130	15	5864.77	I	19364 - 36411
200	5266.40	I	13779 - 32762	90	5872.98	II	10082 - 27104
390	5271.96	I	15582 - 34545	15	5895.31	I	19544 - 36502
110	5272.48	I	13457 - 32418	27	5902.97	I	19764 - 36700
150	5282.82	I	15582 - 34506	12	5909.94	I	15680 - 32596
55	5287.25	I	13222 - 32130	75	5915.74	I	15582 - 32481
60	5289.25	I	17707 - 36608	12	5925.30	I	19712 - 36584
120	5291.26	I	19273 - 38167	27	5926.52	I	16080 - 32948
60	5293.68	I	15582 - 34467	45	5942.72	I	19462 - 36285
120	5294.64	I	17707 - 36589	27	5953.49	I	19794 - 36586

*Europium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	5953.84	II	10313 - 27104	8 h	6549.12	I	15952 - 31217
30	5954.28	I	19794 - 36584	75	6567.87	I	15680 - 30902
90	5963.76	I	15421 - 32185	45	6593.79	I	15680 - 30842
330	5966.07	II	10082 - 26838	18 h	6603.55	I	15680 - 30819
480 cw	5967.10	I	13457 - 30211	1400	6645.11	II	11128 - 26173
15 h	5968.43	I	19631 - 36381	26	6685.21	I	14564 - 29518
30	5971.69	I	19544 - 36285	95	6693.96	I	16080 - 31014
170	5972.75	I	15680 - 32418	7 h	6701.06	I	19447 - 34366
15	5980.47	I	19364 - 36081	12 h	6710.45	I	21761 - 36659
27	5983.14	I	15421 - 32130	30	6744.88	I	16080 - 30902
27	5983.78	I	19364 - 36072	30 h	6782.54	I	16080 - 30819
240	5992.83	I	16080 - 32762	14 h	6787.48	I	15891 - 30619
60	6004.36	I	15138 - 31788	140	6802.72	I	14068 - 28764
15 h	6005.61	I	15680 - 32327	35	6816.06	I	15952 - 30619
60 h	6012.20	I	15582 - 32210	11 h	6834.30	I	21445 - 36073
110	6012.56	I	15249 - 31876	17	6840.93	I	21605 - 36219
60	6015.58	I	19462 - 36081	17 h	6844.83	I	16612 - 31217
420	6018.15	I	0 - 16612	14 h	6847.04	I	21445 - 36045
60	6023.15	I	15138 - 31736	360	6864.54	I	0 - 14564
170	6029.00	I	15421 - 32003	21	6898.21	I	21605 - 36098
60	6044.66	I	15249 - 31788	60 h	6903.67	I	21761 - 36242
420	6049.51	II	10313 - 26838	14 h	6910.17	I	21605 - 36073
140	6057.36	I	15680 - 32185	30 h	6914.82	I	21761 - 36219
90	6075.58	I	15421 - 31876	120	7040.20	I	14564 - 28764
30	6077.38	I	15680 - 32130	12	7074.54	I	16080 - 30211
240	6083.84	I	13779 - 30211	330	7077.10	II	10082 - 24208
240	6099.35	I	13222 - 29613	100	7106.48	I	0 - 14068
60	6108.15	I	19364 - 35732	6	7164.66	I	21445 - 35398
120	6118.78	I	16080 - 32418	30	7175.55	I	15680 - 29613
60	6124.67	I	15680 - 32003	570	7194.81	II	10313 - 24208
330	6173.05	II	10643 - 26838	570	7217.55	II	9923 - 23774
110	6178.76	I	19273 - 35453	11 h	7224.68	I	21445 - 35282
260 cw	6188.13	I	13457 - 29613	15	7258.72	I	21605 - 35378
140	6195.07	I	13049 - 29186	30	7262.77	I	15421 - 29186
15 h	6207.60	I	16080 - 32185	11 h	7281.53	I	21445 - 35174
15	6230.51	I	15680 - 31726	6 h	7297.56	I	21761 - 35461
90 h	6233.73	I	16080 - 32117	540	7301.17	II	10082 - 23774
55	6250.47	I	12924 - 28918	11	7310.46	I	21605 - 35280
240	6262.25	I	13222 - 29186	12	7313.63	I	15249 - 28918
55	6266.95	I	0 - 15952	55 cw	7336.18	I	15891 - 29518
15 h	6285.95	I	12924 - 28828	4	7346.25	I	21445 - 35053
60	6291.34	I	0 - 15891	4	7356.65	I	21445 - 35034
170	6299.77	I	13049 - 28918	11	7362.25	I	15249 - 28828
230	6303.41	II	10313 - 26173	55 cw	7369.60	I	15952 - 29518
24 h	6313.78	I	13779 - 29613	720	7370.22	II	10643 - 24208
15	6318.58	I	19631 - 35453	4	7387.36	I	16080 - 29613
75	6335.82	I	13049 - 28828	12	7389.16	I	15138 - 28667
120 cw	6350.04	I	12924 - 28667	11 h	7404.41	I	21605 - 35107
60	6355.89	I	13457 - 29186	300	7426.57	II	10313 - 23774
60	6369.25	I	13222 - 28918	21 h	7436.59	I	21761 - 35205
55	6382.73	I	15138 - 30801	8	7470.53	I	15138 - 28520
75	6383.86	I	15138 - 30798	5 h	7491.00	I	21761 - 35107
120 cw	6400.93	I	13049 - 28667	50 cw	7528.70	I	17341 - 30619
40	6406.11	I	13222 - 28828	5 h	7533.02	I	15249 - 28520
180	6410.04	I	12924 - 28520	6	7547.32	I	15421 - 28667
140	6411.32	I	15249 - 30842	160	7583.91	I	15582 - 28764
55	6428.29	I	15249 - 30801	60 cw	7742.57	I	17707 - 30619
830	6437.64	II	10643 - 26173	70	7746.19	I	16612 - 29518
18	6439.93	I	15421 - 30945	8 h	7803.32	I	15952 - 28764
120	6457.96	I	15421 - 30902	8	7818.21	I	19631 - 32418
12	6470.70	I	14068 - 29518	35	7887.99	I	17945 - 30619
18	6483.02	I	15421 - 30842	7	8015.47	I	19712 - 32185
45	6501.55	I	15421 - 30798	24 cw	8209.80	I	17341 - 29518
60	6519.59	I	15680 - 31014	15 cw	8226.81	I	16612 - 28764
15	6522.72	I	15891 - 31217	6 h	8464.71	I	17707 - 29518



*Europium – all observed lines – Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
21 cw	8642.67	I	19447 - 31014				
7	8727.77	I	19447 - 30902				
6	8782.46	I	19631 - 31014				
12 cw	8790.88	I	19447 - 30819				
18	8870.30	I	19631 - 30902				

## Gadolinium

$$\text{Gd, } Z = 64, M = 157.2, \text{ Ratio } \frac{\text{Gd}}{\text{Cu}} = 2.475$$

Gd I Normal state of valence electrons  $4f^7 5d 6s^2 \text{ } ^9D_2^{\circ} = 0$ . I.P. = 49500  $\text{cm}^{-1}$ .

Gd II Normal state of valence electrons  $4f^7 5d 6s \text{ } ^{10}D_{21/2}^{\circ} = 0$ . I.P. = 97500  $\text{cm}^{-1}$ .

### References

Wavelengths:

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Classification:

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J. Blaise, J. Chevillard, J. Verges and J. F. Wyart *Spectrochimica Acta* **26B**, 1(1971).

Molecular Spectra:

GdO, A. Gatterer, J. Junkes and E. W. Salpeter, *Molecular Spectra of Metallic Oxides* (Specola Vaticana, 1957).

### *Strong lines of gadolinium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
8700	3768.39	II	633 - 27162	2900	3783.05	I	999 - 27425
6900	3422.47	II	1935 - 31146	2800	4078.70	I	533 - 25044
6100	3646.19	II	1935 - 29353	2700	3439.99	II	1935 - 30997
5400	3350.47	II	1159 - 30997	2700	3463.98	II	3444 - 32304
5400	3362.23	II	633 - 30367	2700	3664.60	II	7992 - 35272
5400	3584.96	II	1159 - 29045	2700	3712.70	II	3082 - 30009
5100	3796.37	II	262 - 26595	2600	4053.64	I	999 - 25661
5100	3850.97	II	0 - 25960	2600	4058.22	I	215 - 24850
4800	4225.85	I	1719 - 25376	2600	4098.61	II	6605 - 30997
4500	3743.47	II	1159 - 27865	2600	4325.57	II	11067 - 34179
4300	3358.62	II	262 - 30027	2600	4325.69	I	533 - 23644
4300	3545.80	II	1159 - 29353	2400	4175.54	I	1719 - 25661
4300	3852.45	II	262 - 26212	2400	4184.25	II	3972 - 27865
3900	3549.36	II	1935 - 30101	2200	3481.28	II	4841 - 33558
3900	3654.62	II	633 - 27988	2200	3916.51	II	4841 - 30367
3700	3813.97	II	0 - 26212	2200	4049.86	II	7992 - 32677
3500	3100.50	II	1935 - 34179	2200	4130.37	II	5897 - 30101
3300	3850.69	II	633 - 26595	2200	4190.78	I	999 - 24854
3100	3656.15	II	1159 - 28502	2200	4346.46	I	999 - 24000
3100	3687.74	II	2857 - 29966				

## Gadolinium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	2468.22	II	8551 - 49054	70	3003.58	II	3427 - 36711
55	2471.58	II	8885 - 49332	100	3005.09	II	3444 - 36711
35	2485.67	II	9329 - 49547	70	3009.37	II	3427 - 36647
70	2487.46	II	9143 - 49332	35	3009.65	II	4841 - 38058
110	2488.72	II	8885 - 49054	2100	3010.13	II	0 - 33212
55	2493.29	II	9452 - 49547	80	3010.90	II	3444 - 36647
35	2496.35	II	9452 - 49498	130	3012.19	II	4841 - 38030
45	2499.04	II	9329 - 49332	40	3022.10	II	10292 - 43372
28	2543.68	II	3444 - 42745	1900	3027.60	II	1159 - 34179
28	2586.13	II	3972 - 42628	120	3028.98	II	4841 - 37846
28	2661.50	II	11492 - 49054	45	3030.65	II	10292 - 43279
70	2720.50	II		2100	3032.84	II	633 - 33596
430	2750.22	II	3427 - 39777	1600	3034.05	II	262 - 33212
460	2764.08	II	2857 - 39025	60	3040.34	II	4852 - 37734
40	2768.51	II	3427 - 39537	130	3043.01	I	999 - 33852
320	2769.81	II	3444 - 39537	160	3046.48	I	533 - 33348
230	2770.17	II	3082 - 39170	280	3053.57	II	3972 - 36711
21	2770.98	II	2856 - 38934	100	3059.92	I	215 - 32886
45	2778.76	I	215 - 36192	1000	3068.64	II	633 - 33212
45	2779.14	II	2857 - 38828	70	3069.42	I	215 - 32785
440	2781.40	II	3082 - 39025	560	3072.56	II	10092 - 42628
70	2787.68	I	533 - 36395	640	3076.92	II	0 - 32491
390	2791.96	II	3444 - 39251	150	3077.08	II	3972 - 36461
100	2794.66	II	2857 - 38629	2100	3081.99	II	1159 - 33596
930	2796.93	II	3427 - 39170	95	3083.35	II	262 - 32685
60	2808.38	II	3427 - 39025	140	3084.01	II	9943 - 42359
750	2809.72	II	3444 - 39025	70	3085.06	II	9092 - 41497
160	2810.93	II	3972 - 39537	95	3087.05	I	0 - 32384
45	2814.01	II	7992 - 43518	280	3089.95	II	10392 - 42745
300	2833.75	II	3972 - 39251	140	3092.06	II	10633 - 42965
35	2836.69	II	9943 - 45185	460	3098.64	II	0 - 32263
70	2837.00	II	3082 - 38320	190	3098.90	II	0 - 32260
560	2840.23	II	3972 - 39170	3500	3100.50	II	1935 - 34179
140	2841.33	II	3444 - 38629	120	3101.18	II	10392 - 42628
40	2853.91	II		230	3101.91	II	262 - 32491
60	2856.52	II	4027 - 39025	580	3102.55	II	8551 - 40773
19	2859.78	II	4213 - 39170	130	3108.36	II	10803 - 42965
120	2862.48	II	4852 - 39777	170	3111.19	I	1719 - 33852
60	2865.06	II	3427 - 38320	160	3113.17	II	10633 - 42745
40	2866.33	II	10292 - 45170	120	3118.60	II	10908 - 42965
40	2871.75	II	4213 - 39025	120	3119.01	I	533 - 32585
460	2881.33	II	4841 - 39537	510	3119.94	II	262 - 32304
40	2882.13	II	4484 - 39170	100	3120.18	II	8885 - 40925
130	2885.60	II	7992 - 42636	60	3123.69	II	8884 - 40888
35	2907.44	II	9092 - 43476	370	3123.99	II	262 - 32263
170	2910.53	II	3972 - 38320	120	3124.25	II	262 - 32260
60	2913.08	II	4852 - 39170	95	3127.25	I	999 - 32967
45	2918.52	II	9943 - 44197	130	3128.56	II	9143 - 41097
95	2923.32	II	5340 - 39537	95	3129.96	II	9452 - 41392
35	2924.25	II	9092 - 43279	130	3130.81	II	9329 - 41260
35	2928.34	II	2857 - 36996	100	3133.09	II	0 - 31908
35	2947.80	II	3082 - 36996	460	3133.85	II	8885 - 40785
70	2948.01	II	5340 - 39251	210	3135.03	II	262 - 32150
35	2952.43	I	1719 - 35579	190	3136.93	I	0 - 31869
35	2955.60	II	9092 - 42916	190	3137.30	I	0 - 31865
70	2960.93	II	3082 - 36845	120	3138.71	I	533 - 32384
130	2963.60	II	9092 - 42825	95	3142.90	II	9452 - 41260
80	2965.43	II	4841 - 38553	230	3143.13	II	4841 - 36647
29	2972.74	II	3082 - 36711	930	3145.00	II	1159 - 32946
560	2980.15	II	633 - 34179	370	3145.52	II	9143 - 40925
35	2983.74	II	7992 - 41497	230	3146.88	II	9329 - 41097
40	2991.52	II	3427 - 36845	980	3156.53	II	633 - 32304
95	2993.04	II	3444 - 36845	200	3158.63	I	215 - 31865
1200	2999.04	II	262 - 33596	140	3160.69	II	633 - 32263
370	3002.86	II	7992 - 41284	980	3161.37	II	1935 - 33558

Gadolinium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	3167.20	I	999 - 32564	110	3401.07	II	633 - 30027
80	3169.47	II	11084 - 42626	540	3402.07	II	10392 - 39777
90	3171.09	II	1159 - 32685	110	3403.08	II	9452 - 38828
220	3190.28	I	533 - 31869	90	3405.04	II	10803 - 40162
90	3193.17	II	5340 - 36647	200	3406.92	I	533 - 29877
220	3199.30	I	1719 - 32967	1100	d 3407.56	II	10633 - 39971
160	3199.58	I	533 - 31778		3407.61	II	4841 - 34179
110	3203.41	I	999 - 32207	250	3409.30	II	3427 - 32750
70	3206.47	II	18369 - 49547	220	3411.02	I	999 - 30308
50	3215.26	I	999 - 32092	110	3412.02	II	9329 - 38629
690	3223.74	II	1935 - 32946	220	3413.27	II	10803 - 40092
	3223.78	I	1719 - 32730	1400	3416.95	II	3427 - 32685
110	3225.46	II	9092 - 40086	130	3417.33	II	10908 - 40162
160	3226.32	II	8551 - 39537	1400	3418.73	II	0 - 29242
220	3232.78	I	533 - 31457	6900	3422.47	II	1935 - 31146
90	3238.62	II	10392 - 41260	390	3422.75	II	1159 - 30367
100	3250.19	II	10633 - 41392	1100	3423.90	I	999 - 30197
110	3259.25	II	10803 - 41476		3423.92	II	0 - 29198
540	3266.73	I	533 - 31136	830	3424.59	II	2857 - 32049
250	3267.64	I	215 - 30809	390	3425.93	II	3082 - 32263
140	3268.34	II	262 - 30850	100	3426.34	II	9143 - 38320
110	3274.18	II	10392 - 40925	220	3428.47	II	10092 - 39251
110	3279.53	II	10908 - 41392	110	3430.24	II	10633 - 39777
100	3281.61	II	10633 - 41097	150	3430.98	II	9092 - 38230
250	3282.25	I	999 - 31457	690	3432.99	II	2857 - 31977
	3282.30	II	10803 - 41260	1700	3439.21	II	3082 - 32150
430	3291.48	I	1719 - 32092	830	3439.78	II	3427 - 32491
370	3292.21	II	8885 - 39251	2700	3439.99	II	1935 - 30997
430	3294.08	I	533 - 30882	110	3441.79	II	3444 - 32491
330	3313.73	II	3427 - 33596	390	3449.62	II	262 - 29242
200	3315.59	II	3444 - 33596	1400	3450.38	II	3972 - 32946
90	3316.56	II	9943 - 40086	1100	3451.23	II	3082 - 32049
190	3320.44	II	9143 - 39251	540	3454.14	II	1159 - 30101
130	3329.34	II	9143 - 39170	880	3454.90	II	262 - 29198
430	3330.34	II	7992 - 38010	200	3455.27	I	1719 - 30652
1400	3331.38	II	0 - 30009	200	3457.05	II	9092 - 38010
830	3332.13	II	8551 - 38553	220	3461.95	II	3427 - 32304
90	3334.06	II	9092 - 39077	220	3463.00	II	1159 - 30027
1100	3336.18	II	0 - 29966	2700	3463.98	II	3444 - 32304
90	3336.98	II	8551 - 38510	100	3466.50	II	5340 - 34179
590	3345.98	II	0 - 29878	330	3466.95	II	3427 - 32263
200	3350.10	II	9329 - 39170	1700	3467.27	II	3427 - 32260
5400	3350.47	II	1159 - 30997	150	3468.08	II	3082 - 31908
220	3357.61	I	533 - 30308	1700	3468.99	II	3444 - 32263
270	3358.43	II	3444 - 33212	80	3469.31	II	3444 - 32260
4300	3358.62	II	262 - 30027	1400	3473.22	II	262 - 29045
780	3360.71	II	262 - 30009	150	3476.31	II	10292 - 39050
5400	3362.23	II	633 - 30367	2200	3481.28	II	4841 - 33558
270	3364.24	II	0 - 29716	1700	3481.80	II	3972 - 32685
200	3365.59	II	262 - 29966	490	3482.60	II	3444 - 32150
150	3367.66	II	10092 - 39777	220	3486.20	I	533 - 29209
150	3369.62	II	8885 - 38553	110	3491.74	II	11084 - 39715
100	3373.84	I	0 - 29631	980	3491.95	II	0 - 28629
220	3374.69	II	3972 - 33596	1700	3494.40	II	633 - 29242
220	3379.76	II	10392 - 39971	90	3497.09	I	533 - 29120
100	3380.01	II	7992 - 37569	100	h 3501.58	II	9092 - 37643
220	3380.52	II	9452 - 39025	80	3503.21	II	10633 - 39170
90	3390.88	II	9452 - 38934	1400	3505.51	II	3972 - 32491
1100	3392.53	II	633 - 30101	780	3512.22	II	3444 - 31908
150	3393.63	II	10633 - 40092	1100	3512.50	II	10092 - 38553
540	d 3395.12	II	10092 - 39537	830	3513.65	I	999 - 29451
220	3397.22	I	1719 - 31147	90	3516.78	II	11670 - 40097
	3397.32	I	0 - 29426	100	3517.89	II	10092 - 38510
200	3399.41	II	3082 - 32491	90	3522.45	II	2857 - 31238
540	3399.99	II	2857 - 32260	980	3524.20	II	262 - 28629

Gadolinium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	3525.15	I	999 - 29359	310	3649.44	II	9452 - 36845
430	3528.54	II	3972 - 32304	450	3650.95	II	9329 - 36711
100	3534.24	II	9944 - 38230	160	3651.19	II	11670 - 39050
150	3537.15	II	10292 - 38556	620	3652.54	II	7992 - 35362
540	3542.77	II	5340 - 33558	3900	3654.62	II	633 - 27988
4300	3545.80	II	1159 - 29353	3100	3656.15	II	1159 - 28502
3900	3549.36	II	1935 - 30101	210	3658.19	I	533 - 27861
90	3553.72	II	10803 - 38934	100	3661.66	II	11084 - 38386
1400	3557.05	II	4841 - 32946	1400	3662.26	II	0 - 27298
540	3558.19	II	8551 - 36647	2700	3664.60	II	7992 - 35272
430	3558.47	II	4852 - 32946	80	3668.32	II	11670 - 38922
200	3564.05	II	4213 - 32263	2000	3671.20	II	633 - 27865
90	3564.64	II	11670 - 39715	1000	3674.05	I	215 - 27425
110	d 3567.12	II	10803 - 38828	350	3679.21	I	533 - 27705
110	3567.65	II	4027 - 32049	2000	3684.13	I	0 - 27136
100	3569.57	II	4484 - 32491	720	3686.33	II	7992 - 35111
90	3570.41	II	12309 - 40309	3100	3687.74	II	2857 - 29966
690	3571.93	II	0 - 27988	210	3694.03	II	3082 - 30144
330	3574.74	II	10092 - 38058	130	3696.76	II	11344 - 38386
100	3576.77	II	4027 - 31977	100	3696.93	I	0 - 27042
390	3578.36	II	4213 - 32150	2000	3697.73	II	262 - 27298
100	3579.55	II	10392 - 38320	1300	3699.73	II	2857 - 29878
150	3580.62	II	10908 - 38828	40	3703.51	II	13031 - 40024
980	3581.91	II	8551 - 36461	60	3709.13	II	6605 - 33558
100	3583.65	I	215 - 28112	2700	3712.70	II	3082 - 30009
5400	3584.96	II	1159 - 29045	2000	3713.57	I	215 - 27136
90	3586.58	II	11670 - 39544	40	3715.23	II	11084 - 37993
150	3587.19	II	633 - 28502	100	3715.92	I	215 - 27119
80	3588.21	I	0 - 27861	1400	3716.36	II	262 - 27162
540	3590.47	II	4841 - 32685	2000	3717.48	I	533 - 27425
90	3591.44	II	4213 - 32049	1800	d 3719.45	II	9944 - 36822
130	3591.91	II	4852 - 32685	3719.53	II	3972 - 30850	
1100	3592.71	II	8885 - 36711	250	3722.07	II	13926 - 40785
200	3593.44	II	4484 - 32304	60	3723.69	II	13926 - 40773
110	3596.84	I	999 - 28793	430	3725.47	II	9944 - 36778
540	3600.96	II	8885 - 36647	90	3726.57	I	215 - 27042
100	3602.00	II	10092 - 37846	1500	3730.84	II	3082 - 29878
1100	3604.87	I	1719 - 29451	270	3732.32	I	1719 - 28504
270	3605.26	II	9092 - 36821	230	3732.45	II	633 - 27418
250	3605.66	II	262 - 27988	230	3732.67	I	533 - 27316
130	3607.12	II	12309 - 40024	510	3733.08	II	9944 - 36724
830	3608.75	II	9143 - 36845	100	3736.44	I	1719 - 28475
830	3610.76	II	10633 - 38320	490	3739.76	I	999 - 27731
220	3610.91	II	9092 - 36778	330	3740.02	II	9092 - 35823
80	3612.88	II		90	3741.91	II	11670 - 38386
540	3613.39	II	9329 - 36996	4500	3743.47	II	1159 - 27865
270	d 3614.21	II	5897 - 33558	40	3744.14	II	3444 - 30145
	3614.42	I	0 - 27660	620	3744.83	I	1719 - 28415
430	3617.16	II	10392 - 38030	40	3746.44	II	13031 - 39715
390	3620.46	II	7992 - 35605	120	3748.88	II	11343 - 38010
190	3622.81	II	11084 - 38679	100	3751.10	I	215 - 26866
270	3624.89	II	10292 - 37872	80	3755.24	II	9944 - 36566
170	3625.26	II	8885 - 36461	80	3755.56	II	10092 - 36711
170	d 3626.32	II	9143 - 36711	230	3757.74	II	12318 - 38922
	3626.41	II	11670 - 39237	1000	3757.94	I	533 - 27136
250	3629.51	II	9452 - 36996	1400	3758.31	II	3427 - 30027
90	3630.25	II	10292 - 37831	820	3759.00	II	0 - 26595
130	3630.88	II	11344 - 38877	100	3759.98	I	0 - 26588
330	3634.76	II	9143 - 36647	100	3760.47	I	7562 - 34147
220	3639.05	II	12072 - 39544	620	3760.71	II	3444 - 30027
250	3640.18	II	4841 - 32304	290	3760.92	II	3427 - 30009
330	3641.39	II	10392 - 37846	870	3762.20	I	999 - 27572
870	3645.62	II	3427 - 30850	150	3763.00	II	1935 - 28502
6100	3646.19	II	1935 - 29353	210	3763.33	II	3444 - 30009
100	3648.48	I	1719 - 29120	370	3764.20	II	11084 - 37643

## Gadolinium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
160	3764.60	II	10092 - 36647	140	3867.26	II	4027 - 29878
870	3767.04	II	3427 - 29966	140	3871.54	II	633 - 26455
8700	3768.39	II	633 - 27162	140	3872.62	II	3427 - 29242
620	3769.45	II	3444 - 29966	250	3873.57	I	6976 - 32785
1400	3770.69	II	9092 - 35605	160	3874.46	I	533 - 26336
250	3771.26	I	533 - 27042	220	3875.46	II	4213 - 30009
210	3773.45	I	7654 - 34147	110	3881.84	II	3444 - 29198
160	3774.30	II	11343 - 37830	65	3884.66	II	11084 - 36819
210	3776.83	I	7235 - 33705	75	3887.16	II	633 - 26352
100	3779.83	II	9092 - 35541	75	3887.73	I	533 - 26248
1000	3782.34	II	10292 - 36723	150	3888.93	I	10947 - 36653
2900	3783.05	I	999 - 27425	85	3890.42	I	7234 - 32931
60	3783.73	II	13515 - 39936	55	3890.85	II	11084 - 36778
170	3787.15	I	0 - 26397	45	3892.72	I	7103 - 32785
1100	3787.56	II	3972 - 30367	1500	3894.70	II	0 - 25669
200	3790.63	I	215 - 26588	170	3895.23	II	4213 - 29878
770	3791.17	II	10092 - 36461	450	3895.79	I	9943 - 35605
80	3791.72	II	4484 - 30850	65	3897.32	I	7235 - 32886
490	3792.39	II	12318 - 38679	750	3902.40	II	3427 - 29045
80	3795.25	II	2857 - 29198	300	3902.71	I	999 - 26615
160	3795.75	I	999 - 27337	240	3904.29	I	215 - 25821
120	3795.93	II	13030 - 39367	450	3905.65	I	1719 - 27316
5100	3796.37	II	262 - 26595	65	3907.12	I	6976 - 32563
160	3798.39	II	10392 - 36711	45	3909.25	I	6976 - 32549
720	3801.29	II	11343 - 37642	65	3909.94	I	532 - 26100
150	3802.85	II	3427 - 29715	45	3911.62	I	7426 - 32984
210	3804.39	I	7427 - 33705	75	3912.75	I	7235 - 32785
210	3805.09	II	10292 - 36565	65	3913.78	II	4484 - 30027
560	3805.52	II	9092 - 35362	2200	3916.51	II	4841 - 30367
150	3807.65	II	10392 - 36647	120	3918.06	II	9092 - 34608
40	3810.25	II	12318 - 38555	120	3918.24	II	4852 - 30367
3700	3813.97	II	0 - 26212	450	3923.25	II	4484 - 29966
430	3814.74	II	13030 - 39237	110	3926.68	I	7427 - 32886
770	3816.64	II	262 - 26455	120	3932.98	II	9943 - 35362
430	3818.75	II	11343 - 37522	1200	3934.79	I	533 - 25940
60	3821.51	II	3082 - 29242		3934.82	II	262 - 25669
120	3822.17	II	4841 - 30997	220	3935.38	I	0 - 25403
120	3824.15	I	7562 - 33705	75	3938.11	II	12318 - 37703
350	3826.05	II	3972 - 30101	110	3938.97	II	11343 - 36723
230	3827.33	II	13515 - 39635	450	3941.80	I	1719 - 27081
230	3829.46	II	10292 - 36398	590	3942.63	I	215 - 25572
180	3830.98	II	13515 - 39610	270	3943.24	I	0 - 25353
370	3831.80	II	262 - 26352	220	3943.62	I	7235 - 32585
210	3832.97	I	533 - 26615	1400	3945.54	I	999 - 26337
330	3834.99	II	12318 - 38386			I	0 - 25338
970	3836.91	II	3972 - 30027	55	3949.25	II	11084 - 36398
40	3838.90	I	999 - 27041	300	3952.00	II	1159 - 26455
1000	3839.64	II	3972 - 30009	590	3953.37	I	533 - 25821
120	3840.26	I	215 - 26248	1200	3957.67	II	4841 - 30101
1200	3842.20	II	9092 - 35111	110	3958.68	I	0 - 25254
1400	3843.28	I	1719 - 27731	750	3959.44	II	4852 - 30101
80	3843.80	II	4841 - 30850		3959.52	II	5897 - 31146
1400	3844.58	II	1159 - 27162	180	3960.11	I	6976 - 32221
120	3845.47	II	4852 - 30850	55	3962.10	II	4483 - 29715
150	3846.49	I	6976 - 32967	220	3963.66	II	11343 - 36565
3300	3850.69	II	633 - 26595	75	3965.04	I	7235 - 32448
5100	3850.97	II	0 - 25960	590	3966.28	I	1719 - 26925
4300	3852.45	II	262 - 26212	590	3968.26	II	1159 - 26352
140	3854.18	II	4027 - 29966	750	3969.00	I	215 - 25403
470	3855.56	II	1935 - 27865	270	3969.29	II	4841 - 30027
140	3858.45	I	6976 - 32886	65	3970.18	I	6976 - 32157
160	3861.14	II	13030 - 38922	140	3971.06	II	4852 - 30027
250	3863.05	II	9943 - 35822	450	3971.75	II	4027 - 29198
130	3864.79	I	999 - 26866	85	3972.17	II	9943 - 35111
1600	3866.99	I	1719 - 27572	390	3972.71	I	0 - 25165

## Gadolinium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
590	3973.98	II	4852 - 30009	540	4063.59	II	4027 - 28629
300	3974.81	I	1719 - 26870	260	4066.04	I	7562 - 32150
120	3975.11	II	11669 - 36819	520	4068.35	I	7427 - 32000
750	3979.33	I	215 - 25338	260	4068.74	I	7562 - 32133
150	3983.01	II	5897 - 30997	750	4070.29	II	4484 - 29045
450	3987.21	II	3972 - 29045		4070.39	II	3427 - 27988
470	3987.84	I	0 - 25069	650	4073.20	II	3444 - 27988
95	3989.25	II	11084 - 36144	300	4073.76	II	6605 - 31146
320	3992.69	I	533 - 25572	1300	4078.44	II	4841 - 29353
220	3993.21	II	633 - 25669	2800	4078.70	I	533 - 25044
650	3994.16	II	4213 - 29242	190	4080.53	I	215 - 24715
700	3996.32	II	9092 - 34108	520	4083.70	I	6976 - 31457
320	3997.76	II	8551 - 33558	65	4084.68	II	11669 - 36144
65	4000.18	I	6786 - 31778	1500	4085.56	II	5897 - 30367
470	4001.26	II	4213 - 29198	260	4087.69	II	11084 - 35541
65	4001.96	II		650	4090.41	I	215 - 24656
65	4003.85	II	11492 - 36461	45	4091.75	I	7427 - 31859
260	4004.94	II	11669 - 36631	1100	4092.71	I	1719 - 26146
110	4006.96	I	215 - 25165	260	4093.72	I	7427 - 31848
320	4008.33	I	999 - 25940	260	4094.48	II	4213 - 28629
300	4008.91	II	9092 - 34029	2600	4098.61	II	6605 - 30997
110	4009.22	II	12071 - 37007	520	4098.90	II	4852 - 29242
150	4013.43	I	7427 - 32336	650	4100.26	I	999 - 25381
300	4013.80	II	11084 - 35991	95	4104.99	I	7103 - 31457
85	4013.95	II	3082 - 27989	75	4108.40	II	12662 - 36996
150	4015.22	I	7235 - 32133	45	4110.43	II	11669 - 35991
200	4015.58	I	1719 - 26615	150	4110.60	II	11084 - 35404
300	4017.25	I	7562 - 32448	390	4111.44	II	10292 - 34607
430	4017.71	I	6976 - 31859	130	4111.74	II	12318 - 36631
300	4019.73	I	533 - 25403	65	4112.94	I	7562 - 31869
300	4022.33	II	11084 - 35938	45	4113.77	II	12071 - 36373
1100	4023.14	I	1719 - 26568	75	4115.38	II	12704 - 36996
810	4023.35	I	533 - 25381	65	4119.21	I	11296 - 35566
220	4027.61	I	999 - 25821	65	4119.38	II	11669 - 35938
1100	4028.15	I	6976 - 31795	55	4125.78	I	8499 - 32730
860	4030.88	I	6976 - 31778	45	4127.72	II	12776 - 36996
700	4033.49	I	7235 - 32020	2200	4130.37	II	5897 - 30101
340	4035.40	I	215 - 24989	270	4131.48	II	11343 - 35541
260	4036.84	I	7235 - 32000	1100	4132.28	II	4852 - 29045
1400	4037.33	II	5340 - 30101	750	4134.16	I	533 - 24715
700	4037.90	II	4484 - 29242	410	4137.10	II	9943 - 34108
110	4039.49	II	12309 - 37058	45	4138.03	I	6976 - 31136
170	4039.67	II	12071 - 36819	120	4140.45	II	4484 - 28629
65	4042.76	II	11669 - 36398	45	4141.02	II	12704 - 36845
410	4043.71	I	7427 - 32150	45	4144.25	I	7426 - 31549
45	4044.02	I	533 - 25254	280	4148.86	I	1719 - 25815
1600	4045.01	I	0 - 24715	55	4149.48	I	7235 - 31328
130	4045.15	II	4484 - 29198	45	4150.61	II	9943 - 34029
270	4046.84	II	11669 - 36373	40	4151.63	II	12318 - 36398
270	4047.09	I	7654 - 32356	110	4153.51	II	12776 - 36845
160	4047.81	II	12309 - 37007	190	4154.86	II	8885 - 32946
110	4048.60	II	9092 - 33785	190	4157.78	I	999 - 25044
270	4049.20	I	7562 - 32252	40	4158.48	I	7562 - 31602
1300	4049.43	II	5340 - 30027	540	4162.73	II	3972 - 27988
2200	4049.86	II	7992 - 32677	280	4163.09	II	5340 - 29353
270	4050.37	I	7654 - 32336	280	4167.16	II	3427 - 27418
810	4053.29	II	9943 - 34608		4167.27	I	999 - 24989
2600	4053.64	I	999 - 25661	130	4170.11	II	3444 - 27418
810	4054.72	I	0 - 24656	120	4171.71	I	11830 - 35795
2600	4058.22	I	215 - 24850	120	4173.56	II	12892 - 36845
110	4059.37	II	13926 - 38553	2400	4175.54	I	1719 - 25661
650	4059.88	I	7235 - 31859	95	4182.77	I	7235 - 31136
270	4061.30	II	12071 - 36687	2400	4184.25	II	3972 - 27865
650	4062.59	II	10292 - 34900	85	4188.10	II	3427 - 27298
1900	4063.39	II	7992 - 32595	45	4188.82	I	12520 - 36386

Gadolinium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	4190.20	I	6976 - 30834	130	4322.20	II	3082 - 26212
2200	4190.78	I	999 - 24854	130	4324.06	II	9143 - 32263
750	4191.07	II	3444 - 27298	2600	d 4325.57	II	11067 - 34179
750	4191.63	I	999 - 24850		4325.69	I	533 - 23644
75	4193.15	II	9943 - 33785	45	4326.32	II	17817 - 40925
110	4197.07	II	12892 - 36711	1900	4327.12	I	0 - 23104
450	4197.68	II	10292 - 34108			II	2857 - 25960
85	4202.52	II	13030 - 36819	120	4328.94	I	7103 - 30197
590	4204.86	II	4213 - 27988	370	4329.58	I	6786 - 29877
55	4208.08	I	6550 - 30308	340	4330.61	II	4213 - 27298
1300	4212.00	II	3427 - 27162	240	4331.38	I	6550 - 29631
970	4215.02	II	3444 - 27162	75	4333.24	I	13506 - 36576
650	4217.20	II	5340 - 29045	40	4335.29	II	17725 - 40785
45	4223.02	II	12318 - 35991	40	d 4336.63	I	14669 - 37722
65	4224.27	I	7480 - 31147		4336.78	I	15121 - 38173
320	4225.03	I	1719 - 25381	140	4337.51	I	6378 - 29426
160	4225.15	II	4841 - 28502			II	17725 - 40773
4800	4225.85	I	1719 - 25376	40	4340.60	I	17600 - 40632
220	4227.14	II	4852 - 28502	450	4341.28	II	3427 - 26455
220	4229.80	II	13076 - 36711	910	4342.18	II	4841 - 27865
75	4232.47	II	12318 - 35938	1000	4344.30	II	4852 - 27865
65	4232.93	I	13506 - 37123	2200	4346.46	I	999 - 24000
55	4235.07	II	8885 - 32491	910	4346.62	I	215 - 23215
85	4235.88	II	13030 - 36631	220	4347.31	II	10600 - 33596
650	4238.78	II	9092 - 32677	75	4353.79	I	14253 - 37215
95	4241.28	II	13076 - 36647	30	4354.06	II	13030 - 35991
180	4243.84	II	11343 - 34900	55	4359.15	II	4484 - 27418
150	4245.34	I	7103 - 30652	30	4359.64	II	9329 - 32260
200	4246.57	II	9143 - 32685	160	4360.92	II	3427 - 26352
65	4250.28	I	6786 - 30308	160	4369.15	I	12057 - 34938
1700	4251.73	II	3082 - 26595	300	4369.77	II	3082 - 25960
860	4253.37	II	4484 - 27988	190	4370.18	I	6550 - 29426
650	4253.61	II	9092 - 32595	970	4373.83	I	533 - 23390
810	4260.12	I	533 - 24000	85	4376.07	I	6786 - 29631
1600	4262.09	I	6786 - 30242	190	4378.56	I	7562 - 30395
		II	5897 - 29353	140	4380.64	II	9329 - 32150
650	4266.60	I	999 - 24430	95	4382.06	II	4484 - 27298
470	4267.00	I	215 - 23644	140	4383.12	II	9452 - 32260
160	4268.73	II	8885 - 32304	45	4386.20	I	15121 - 37913
55	4270.28	I	6786 - 30197	30	4387.17	I	14253 - 37041
55	h 4273.29	I	7234 - 30629	180	4387.67	II	3427 - 26212
300	4274.17	I	0 - 23390	180	4389.88	I	7103 - 29877
55	h 4278.22	II	13030 - 36398	180	4390.00	I	11685 - 34458
910	4280.49	II	2857 - 26212	150	4390.95	II	3444 - 26212
45	4282.79	II	13030 - 36373	65	4391.44	II	9143 - 31908
430	4285.82	I	6550 - 29877	280	4392.06	I	7480 - 30242
300	4286.12	I	1719 - 25044	27	4394.72	II	6605 - 29353
55	4289.88	II	13515 - 36819	180	4397.51	II	9943 - 32677
540	4296.08	II	4027 - 27298	30	4400.18	II	9329 - 32049
140	4296.30	II	13378 - 36647	85	4400.76	I	7480 - 30197
220	4297.17	II	11343 - 34608	1400	4401.86	I	1719 - 24430
45	4298.43	II	13800 - 37058	520	4403.14	I	7947 - 30652
430	4299.29	I	6378 - 29631	260	4406.67	II	11492 - 34179
130	4304.90	II	12318 - 35541	260	4408.25	II	4484 - 27162
1100	4306.34	I	0 - 23215	220	4409.25	I	8498 - 31172
30	4307.87	II	13800 - 37007	520	4411.16	I	533 - 23196
260	4309.29	I	7947 - 31147	27	4413.44	I	6976 - 29628
85	4310.98	II	3972 - 27162	860	4414.16	I	8498 - 31147
1800	4313.84	I	215 - 23390	700	4414.73	I	999 - 23644
520	4314.40	I	7480 - 30652	340	4419.03	II	3972 - 26595
520	4316.05	II	5340 - 28502	140	4421.24	II	10600 - 33212
65	4316.27	II	9328 - 32490	1400	4422.41	I	215 - 22821
370	4320.52	I	7103 - 30242	45	4424.10	II	9452 - 32049
750	4321.11	II	4852 - 27988	120	4425.01	I	12345 - 34938
	4321.20	I	1719 - 24854	55	4426.15	II	3082 - 25669



## Gadolinium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	4427.61	II	9329 - 31908	130	4573.81	I	0 - 21858
1100	4430.63	I	0 - 22564	260	4575.91	I	7947 - 29795
85	4431.76	I	7947 - 30505	280	4579.59	I	12346 - 34175
45	4433.64	II	10633 - 33182	85	4581.09	II	5340 - 27162
240	d 4436.10	I	1719 - 24254	410	4581.29	I	999 - 22821
	4436.22	II	13926 - 36461	95	4582.38	II	10092 - 31908
160	4438.27	II	5340 - 27865	130	4582.53	II	8551 - 30367
30	4444.98	I	13506 - 35997	410	4583.07	I	7480 - 29294
75	4446.49	II	3972 - 26455	85	4584.26	I	7947 - 29754
27	4449.02	I	14777 - 37248	160	4586.99	I	12057 - 33851
27	4449.41	I	14777 - 37246	220	4596.98	II	4213 - 25960
40	4452.73	I	12487 - 34938	320	4597.91	II	4852 - 26595
40	4453.93	II	8551 - 30997	410	4598.90	I	7103 - 28842
22	d 4458.32	I	15852 - 38276	340	4601.05	II	4484 - 26212
	4458.41	I	15121 - 37544	240	4602.93	I	999 - 22718
30	4461.36	I	7427 - 29835	55	h 4606.06	I	15720 - 37425
110	4462.83	I	12057 - 34458	30	4608.03	II	19402 - 41097
55	4463.25	II	10092 - 32491	27	4608.58	I	533 - 22226
300	4464.74	I	12520 - 34911	55	h 4611.04	I	15720 - 37401
300	4466.55	II	4213 - 26595	520	4614.50	I	6786 - 28451
	4466.60	I	6976 - 29359	85	bl 4615.6	GdO	
520	4467.08	I		65	4619.14	I	10222 - 31865
75	4467.23	II	10803 - 33182	140	4624.42	I	6550 - 28169
110	4471.29	II	10392 - 32750	430	4636.64	I	6550 - 28112
65	4473.28	I	215 - 22564	110	4639.00	II	8551 - 30101
700	4474.13	I		170	4640.04	I	11685 - 33231
860	4476.12	I	0 - 22335	170	4646.00	I	11830 - 33348
220	4478.80	II	4841 - 27162	170	4647.64	I	1719 - 23229
280	4481.06	II	4852 - 27162	170	d 4648.59	I	12345 - 33851
220	4483.33	II	8551 - 30850		4648.70	I	10360 - 31865
220	4484.70	I	12520 - 34811	430	4653.54	I	6378 - 27861
27	4485.48	I	533 - 22821	85	4654.99	II	8551 - 30027
65	4486.35	II	18641 - 40925	45	4664.27	II	17817 - 39251
280	4486.90	I	1719 - 24000	55	4666.45	II	11067 - 32491
65	h 4488.40	II	10908 - 33182	140	h 4670.87	I	
500	4497.13	I	999 - 23229	55	4678.25	I	16534 - 37904
220	4497.32	I		170	4679.18	I	12487 - 33852
170	4498.28	II	3444 - 25669	260	4680.04	I	7480 - 28842
27	4503.79	I	999 - 23196	65	4683.07	I	7103 - 28451
430	4506.21	I	533 - 22718	430	4683.33	I	7947 - 29294
140	4506.33	II	4027 - 26212	65	h 4686.41	I	17016 - 38348
55	4506.93	II	3427 - 25609	140	4688.12	I	533 - 21858
55	4509.08	II	10092 - 32263	85	4691.16	I	6550 - 27861
140	4514.50	II	11067 - 33212	700	4694.33	I	8498 - 29795
85	4516.98	I	14253 - 36384	170	4695.49	I	12057 - 33348
1100	4519.66	I	215 - 22335	430	4697.42	I	6378 - 27660
65	4520.07	II	10633 - 32750	170	4703.13	I	8498 - 29754
55	4521.30	II	4484 - 26595	200	4709.78	I	999 - 22226
75	4521.94	II	18677 - 40785	55	4711.98	II	8885 - 30101
300	4522.82	II	11492 - 33596	30	4712.80	II	20047 - 41260
150	4524.12	I	13506 - 35603	110	4721.46	I	12057 - 33231
95	4536.97	I	12520 - 34555	150	4728.47	II	8885 - 30027
910	4537.81	I	533 - 22564	85	4728.64	I	533 - 21675
220	4540.02	II	18753 - 40773	220	4732.60	II	8885 - 30009
300	4542.03	I	215 - 22226	45	4734.43	II	5340 - 26455
65	4544.23	I	7427 - 29426	260	4735.75	I	6550 - 27660
240	4548.00	I	10947 - 32928	65	4738.11	I	11685 - 32785
65	4550.95	II	5897 - 27865	410	4743.65	I	6786 - 27861
45	4554.99	II	10803 - 32750	110	4745.82	I	7103 - 28169
120	4558.08	II	4027 - 25960	30	h 4749.15	I	16758 - 37809
27	4559.62	I	14253 - 36179	30	d 4755.35	II	19750 - 40773
45	d 4561.08	I	16775 - 38693		4755.50	II	20369 - 41391
27	4564.59	I	10884 - 32785	45	4758.26	I	533 - 21543
30	h 4570.98	II	10392 - 32263	320	4758.70	I	7103 - 28112
85	4572.20	I	6976 - 28842	110	4760.74	I	1719 - 22718

Gadolinium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
130	4763.82	I	10884 - 31869	75	4999.07	I	10884 - 30882
470	4767.24	I	7480 - 28451	65	5010.82	II	8551 - 28502
65	4780.99	I	11297 - 32207	55	5011.74	I	11830 - 31778
	4781.13	I	12057 - 32966	750	5015.04	I	8498 - 28433
180	4781.92	I	999 - 21905	30	5019.36	II	10092 - 30009
	4783.47	I	11685 - 32585	27	5020.37	I	7562 - 27476
	4783.56	I	11830 - 32730			II	9329 - 29242
300	4784.62	I	7947 - 28842	55	5023.13	II	9143 - 29045
110	4786.75	I	12345 - 33231	65	5031.29	II	13076 - 32946
45	4786.91	II	9143 - 30027	40	5031.56	II	9329 - 29198
	4791.15	II	9143 - 30009	75	5039.09	I	11297 - 31136
140	4801.05	II	9143 - 29966	19	5048.78	II	19223 - 39024
30	4802.58	II	4852 - 25669	65	5050.88	II	12892 - 32685
40	4803.54	II	11492 - 32304	27	5061.06	II	10391 - 30144
27	4805.82	II	8551 - 29353	27	5062.86	II	9452 - 29198
	4807.45	I	8498 - 29294	30	5067.06	II	20047 - 39777
45	4808.01	I	13926 - 34719	45	5070.19	I	
55	4816.83	I	11830 - 32585	45	5071.02	II	12776 - 32491
320	4821.69	I	1719 - 22452	30	5072.99	I	16534 - 36241
45	4829.94	I	11685 - 32384	55	5073.74	I	16296 - 36000
	4834.23	II	9328 - 30009	55	5082.80	I	16534 - 36203
130	4835.26	I	999 - 21675	95	5092.25	II	13926 - 33558
110	4848.10	I	12345 - 32966	65	5096.06	II	8885 - 28502
45	4856.17	I	11685 - 32273	130	5098.38	II	13076 - 32685
65	4856.72	I	16758 - 37343	55	5100.94	II	12892 - 32491
	4859.22	I	10884 - 31457	910	5103.45	I	7947 - 27536
75	4861.78	I	11297 - 31859	180	5108.91	II	13378 - 32946
110	4862.59	I	10576 - 31136	30	5123.68	II	10633 - 30144
170	4865.02	II	9329 - 29878	120	5125.56	II	11492 - 30997
85	4870.04	I	12057 - 32585	65	5130.28	II	12776 - 32263
	4871.50	I	10360 - 30882	65	5135.59	I	17015 - 36482
30	4873.34	II	9452 - 29966	75	5136.04	I	7103 - 26568
85	4881.08	I	11297 - 31778	85	5140.84	II	12704 - 32150
65	4881.36	I	12487 - 32967	75	5141.50	I	7480 - 26925
27	4881.92	II	18151 - 38629	75	5142.68	I	7427 - 26866
	4883.19	I	10222 - 30695	15	5149.38	II	13076 - 32491
27	4889.19	I	11685 - 32133	30	5149.84	II	12892 - 32304
65	4892.1	GdO		860	5155.84	I	7480 - 26870
85	4894.30	II	9452 - 29878	55	5156.76	II	12662 - 32049
75	4910.12	I	6976 - 27337	75	5158.48	I	7235 - 26615
	4915.83	I	7235 - 27572	45	5160.90	II	12892 - 32263
45	4916.60	I	10222 - 30556	75	5163.70	I	6976 - 26337
65	4923.58	II	17725 - 38030	55	5164.54	II	11492 - 30850
85	4929.84	I	15758 - 36037	45	5171.69	I	0 - 19331
65	4930.69	I	15519 - 35794	190	5176.28	II	8551 - 27865
	4934.12	I	11830 - 32092	40	5178.10	II	13378 - 32685
85	4936.01	I	15833 - 36087	45	5178.84	II	19947 - 39251
85	4936.33	I	10884 - 31136	40	5179.92	II	11067 - 30367
220	4938.61	I	12487 - 32730	45	5186.92	II	12704 - 31977
45	4948.56	I	15989 - 36191	55	5187.24	II	12776 - 32049
	4950.11	I	10360 - 30556	55	5187.88	I	6550 - 25821
30	4951.58	I	11830 - 32020	55	5191.08	II	12892 - 32150
110	4952.47	I	1719 - 21905	410	5197.77	I	7103 - 26337
65	4953.15	I	11685 - 31869	45	5199.21	II	13076 - 32304
40	4956.80	I	15173 - 35342	27	5200.55	II	19947 - 39170
	4957.29	I	15833 - 36000	55	5210.49	II	13076 - 32263
130	4958.79	I	11297 - 31457	85	5217.48	I	999 - 20160
		II	8885 - 29045	280	5219.40	I	6786 - 25940
40	4961.47	I	12057 - 32206	75	5220.30	II	10092 - 29242
27	4965.05	II	19402 - 39537	130	5233.93	I	7235 - 26336
	4968.58	II	17725 - 37846	22	5244.38	I	17318 - 36381
95	4969.16	I	10576 - 30695	65	5246.87	I	7562 - 26616
55	4972.61	I	6976 - 27081	320	5251.18	I	8498 - 27536
19	4985.30	II	10091 - 30144	120	5252.14	II	11067 - 30101
55	4998.37	II	18319 - 38320			I	6786 - 25821

Gadolinium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	5254.75	I	6378 - 25403	22	5475.72	I	6786 - 25044
140	5255.80	I	6550 - 25572	22	5480.23	I	10884 - 29126
22	5260.81	I	15833 - 34836	22	5482.01	I	10884 - 29120
30	5263.81	I	533 - 19525	22	5493.42	I	7947 - 26146
22	5268.01	I	7947 - 26925	27	5498.75	I	7480 - 25661
65	5268.78	I	533 - 19507	40	5499.97	I	11830 - 30007
22	5271.79	I	6976 - 25940	40	5500.43	II	11067 - 29242
30	5272.37	I	15989 - 34951	27	5505.11	I	16824 - 34984
55	5272.91	I	6378 - 25338	22	5515.61	I	16920 - 35046
55	5282.48	I	10576 - 29502	27	5521.75	I	6550 - 24656
280	5283.08	I	7947 - 26870	19	5524.60	II	19750 - 37846
30	5298.58	I	10222 - 29090	22	5533.37	I	6976 - 25044
280	5301.67	I	7480 - 26337	27	5538.32	II	10391 - 28442
220	5302.76	I	6550 - 25403	27	5539.81	II	
55	5306.70	I	6976 - 25815	22	5545.01	II	10600 - 28629
280	5307.30	I	7103 - 25940	27	5548.20	I	12487 - 30505
45	5311.84	I	16758 - 35579	19	5550.21	I	6976 - 24989
22	5315.79	II	19223 - 38029	22	5559.73	I	1719 - 19701
30	5316.80	II	19750 - 38553	30	5560.69	II	11067 - 29045
45	5321.25	I	6550 - 25338	27	5572.53	I	7103 - 25044
130	5321.50	I	6378 - 25165	40	5576.13	I	6786 - 24715
280	5321.78	I	6786 - 25572	55	5583.68	II	8551 - 26455
30	5322.37	I	10222 - 29006	13	5586.16	II	10092 - 27988
45	5322.69	I	10576 - 29359	22	5586.32	I	7480 - 25376
110	5327.32	I	10360 - 29126	55	5591.85	I	14669 - 32548
65	5328.30	I	10222 - 28985	40	5594.13	I	14036 - 31907
45	5331.92	I	10222 - 28971	19	5597.21	II	11492 - 29353
170	5333.30	I	10884 - 29628	22	5614.45	I	1719 - 19525
55	5337.53	I	10360 - 29090	27	5616.21	II	8551 - 26352
30	5341.17	I	7103 - 25821	190	5617.91	I	0 - 17795
30	5341.81	I	1719 - 20434	17	5621.43	II	18677 - 36461
300	5343.00	I	11297 - 30007	65	5629.55	I	215 - 17974
85	5345.13	I	6550 - 25254	110	5632.25	I	0 - 17750
75	5345.68	I	999 - 19701	30	5633.49	I	7103 - 24850
200	5348.67	I	6378 - 25069	260	5643.24	I	215 - 17931
300	5350.38	I	12487 - 31172	27	5644.84	II	8885 - 26595
240	5353.26	I	11830 - 30505	13	5653.33	I	7654 - 25338
45	5357.79	II	9329 - 27988	40	5664.42	GdO	
45	5359.18	I	16296 - 34951	30	5677.45	I	14298 - 31907
55	5361.66	I	10360 - 29006	55	5680.89	GdO	
95	5365.38	I	10576 - 29209	40	5683.33	I	
30	5367.70	I	10360 - 28985	27	5684.11	GdO	
30	5368.79	I	7947 - 26568	22	5686.66	I	215 - 17795
30	5369.61	I	10884 - 29502	40	5692.13	I	7480 - 25044
95	5369.92	I	6786 - 25403	390	5696.22	I	533 - 18084
150	5370.63	I	10222 - 28837	95	5701.35	I	215 - 17750
	5370.74	I	6550 - 25165	65	5709.42	I	999 - 18509
40	5372.22	II	11492 - 30101	40	5710.32	I	14669 - 32176
45	5384.15	I	10884 - 29451	22	5721.99	II	13378 - 30850
45	5385.39	I	17015 - 35579	45	5724.75	I	11830 - 29294
85	5389.50	I	10576 - 29126	120	5733.86	II	11067 - 28502
27	5411.20	I	10884 - 29359	45	5735.98	I	7947 - 25376
22	5412.64	II	10091 - 28561	45	5744.66	I	215 - 17618
85	5413.20	I	7103 - 25572	85	5746.36	I	533 - 17931
45	5413.39	I	6786 - 25254	40	5749.41	II	10600 - 27988
85	5415.69	I	7480 - 25940	40	5751.88	I	0 - 17381
27	5419.88	II	10600 - 29045	85	5754.17	I	7480 - 24854
45	5421.19	I	1719 - 20160	22	5771.20	GdO	
45	5436.30	I	7947 - 26337	17	5774.56	II	9143 - 26455
27	5441.58	I	8499 - 26870	75	5776.02	I	12487 - 29795
22	5447.74	II	10091 - 28442	240	5791.38	I	533 - 17795
65	5453.46	I	11297 - 29628	65	5796.80	I	15720 - 32966
30	5455.31	I	10884 - 29209	55	5802.92	I	0 - 17227
45	5469.72	I	7103 - 25381	27	5807.05	II	12662 - 29878
		II	8885 - 27162	55	5807.72	I	6786 - 24000

## Gadolinium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55 h	5809.22	I	15852 - 33061	40 h	6538.15	I	16886 - 32176
55	5815.85	II	12776 - 29966	22	6549.25	I	17931 - 33195
65 hs	5819.51	GdO		55	6564.78	I	17319 - 32548
45	5820.99	II	12704 - 29878	10	6568.00	II	17725 - 32946
45 h	5823.97	I	215 - 17381	10	6573.80	I	17750 - 32958
55	5840.47	II	12892 - 30009	30	6591.60	I	1719 - 16886
22	5845.71	II	12776 - 29878	15	6593.42	I	17795 - 32958
220	5851.63	I	999 - 18084	10	6610.04	II	13378 - 28502
55	5855.24	II	12892 - 29966	9	6628.43	I	16825 - 31907
280	5856.22	I	999 - 18070	50	6634.36	II	10600 - 25669
45	5856.96	II	9143 - 26212	35	6640.08	I	1719 - 16775
55	5860.73	II	8551 - 25609	10	6642.76	I	12487 - 27536
65	5877.26	II	11492 - 28502	30	6643.98	I	18014 - 33061
55	5886.46	I	15173 - 32157	10	6646.85	I	11297 - 26337
45	5897.62	II	13076 - 30027	10	6653.55	I	18509 - 33535
55	5904.07	II	13076 - 30009	10	6679.56	II	20574 - 35541
110	5904.56	I	999 - 17931	35	6681.23	II	11492 - 26455
170	5911.45	II		10	6692.86	I	10884 - 25821
65	5913.55	II	18366 - 35272	6	6694.92	II	21005 - 35938
55	5916.77	I	7103 - 24000	9	6702.12	II	18641 - 33558
85	5930.29	I	6786 - 23644	10	6704.18	II	13076 - 27988
85	5936.84	I	6550 - 23390	14	6718.14	II	18677 - 33558
65	5937.71	I	6378 - 23215	17	6727.83	II	11492 - 26352
55 h	5940.95	GdO		85	6730.73	I	999 - 15852
55 h	5942.78	GdO		50	6752.67	II	18753 - 33558
55	5951.60	II	11067 - 27865	14	6753.91	II	20098 - 34900
55	5956.48	II	8885 - 25669	9	6772.03	I	25676 - 40439
85	5977.25	I	6378 - 23104	14	6783.39	I	11830 - 26568
110 h	5988.02	I	15852 - 32548	26	6786.33	II	19376 - 34108
85	5999.08	I	6550 - 23215	10	6787.18	I	10947 - 25676
65	6000.96	GdO		12	6814.56	I	7235 - 21905
75 h	6001.87	GdO		26	6816.49	I	999 - 15665
55	6004.57	II	13378 - 30027	17	6820.90	I	17906 - 32563
55	6008.71	I	15519 - 32157	100	6828.25	I	533 - 15174
55	6021.13	I	6786 - 23390	35	6846.60	II	11067 - 25669
55	6080.65	II	13926 - 30367	9	6849.89	I	20160 - 34755
430	6114.07	I	1719 - 18070	30	6857.13	II	17725 - 32304
55	6180.42	II	13926 - 30101	15	6864.25	I	19479 - 34044
110 bl	6182.68	GdO		21	6887.63	II	20093 - 34607
110 bl	6200.86	GdO		14	6900.73	II	17817 - 32304
110 bl	6211.71	GdO		100	6916.57	I	215 - 14669
110 bl	6220.93	GdO		21	6920.62	II	17817 - 32263
55 bl	6231.62	GdO		15	6924.99	II	10091 - 24528
75 bl	6241.66	GdO		21	6926.49	I	10222 - 24656
55 b	6252.12	GdO		17	6945.98	II	17870 - 32263
55 bl	6262.64	GdO		15	6957.74	II	9328 - 23697
45 b	6273.00	GdO		15	6959.24	II	18319 - 32685
85	6289.73	II	17910 - 33804	14	6964.33	I	10360 - 24715
30	6292.87	I	999 - 16886	15	6971.66	II	18151 - 32491
75	6305.15	II	10600 - 26455	12	6976.35	II	9142 - 23473
30	6309.11	II	16061 - 31907	10	6978.27	II	20574 - 34900
27	6317.19	I	999 - 16825	26	6980.86	I	20434 - 34755
40	6331.35	I	18014 - 33804	8 h	6983.53	I	11830 - 26146
17	6333.75	I	6550 - 22335	50	6985.89	II	18366 - 32677
17	6336.34	I	6786 - 22564	10	6988.75	II	18641 - 32946
27	6346.65	II	10600 - 26352	75	6991.92	I	0 - 14298
27 h	6351.72	I	17795 - 33535	21	6993.18	I	10360 - 24656
17	6363.23	I	16196 - 31907	60	6996.76	II	18389 - 32677
40	6380.95	II	13378 - 29045	17	7000.75	II	17870 - 32150
17	6382.19	II	21157 - 36821	45	7006.16	II	18677 - 32946
22	6408.55	I	1719 - 17319	10	7016.60	I	7427 - 21675
22	6422.42	II	21157 - 36723	7	7017.73	II	9451 - 23697
17	6424.52	I	7654 - 23215	21	7037.26	II	18389 - 32595
19 h	6470.29	I	18084 - 33535	7	7045.02	II	22533 - 36723
15	6480.11	II	13926 - 29353	14	7051.00	II	17972 - 32150

## Gadolinium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
7	7052.79	I	999 - 15174	21	7650.32	I	10576 - 23644
13	7054.62	II	18319 - 32491	25	7672.56	I	10360 - 23390
10	7058.02	II	18096 - 32260	10	7676.06	I	11830 - 24854
10	7068.09	II	9328 - 23472	7	7677.16	I	19525 - 32548
7	7069.93	II	8884 - 23025	7	h 7683.36	I	19165 - 32176
18	7071.00	I	10576 - 24715	13	7694.45	I	10222 - 23215
18	7073.63	I	1719 - 15852	4	7717.66	I	7480 - 20434
5	7084.18	I	17795 - 31907	80	7733.50	I	999 - 13926
		II	18151 - 32263	6	7738.09	II	9142 - 22062
7	7085.52	II	18151 - 32260	3	h 7748.37	II	19402 - 32304
5	7093.90	I	18084 - 32176	35	7749.30	I	533 - 13434
14	7098.11	I	11297 - 25381	10	7755.97	I	12487 - 25376
14	7098.73	I	215 - 14298	10	7766.48	II	21157 - 34029
6	7099.44	I	12487 - 26568	7	h 7787.22	II	22062 - 34900
7	7100.71	I	10576 - 24656	8	7834.46	I	10884 - 23644
4	7101.73	II	17972 - 32049	7	7838.84	II	23970 - 36723
10	h 7116.77	II	18001 - 32049	11	h 7844.87	I	10360 - 23104
21	7118.86	II	18641 - 32685	10	7845.80	I	19165 - 31907
35	7122.57	I	0 - 14036	35	7846.35	II	22531 - 35272
8	7133.16	II	20093 - 34108	35	7856.93	I	6976 - 19701
13	7135.73	II	20098 - 34108	5	7867.73	I	17600 - 30307
6	h 7141.17	II	18151 - 32150	14	7869.72	I	11297 - 24000
6	7146.13	II	17988 - 31977	4	7884.39	I	7480 - 20160
18	7147.31	II	18690 - 32677	4	h 7908.06	II	17725 - 30367
6	7150.77	I	7562 - 21543	6	7910.08	I	10576 - 23215
13	7158.28	I	10884 - 24850	25	7930.25	II	8551 - 21157
6	7164.30	II	21157 - 35111	6	h 7963.25	II	19750 - 32304
170	7168.37	I	1719 - 15665	4	7966.66	I	6976 - 19525
21	7172.26	II	13926 - 27865	6	7978.15	I	6976 - 19507
4	7173.40	II	17972 - 31908	6	7993.82	I	10884 - 23390
28	7189.57	II	18690 - 32595	6	8006.26	I	7947 - 20434
6	7191.49	II	23970 - 37871	6	8010.53	II	8884 - 21364
13	7197.08	II	18369 - 32260	6	8019.82	I	7235 - 19701
6	h 7198.63	I	7562 - 21450	4	8037.40	I	19718 - 32157
13	7201.41	II	9142 - 23025	6	8048.08	I	7103 - 19525
10	7228.02	I	10884 - 24715	13	8077.59	I	7103 - 19480
25	7233.45	I	215 - 14036	3	8089.96	II	19947 - 32304
6	7242.24	II	9451 - 23255	4	h 8144.00	I	16228 - 28504
14	7252.70	II	13378 - 27162	18	8146.15	I	7235 - 19507
28	7262.66	I	533 - 14298	4	h 8185.90	I	7947 - 20160
14	7291.35	I	215 - 13926	5	8209.07	I	19978 - 32157
4	7301.22	II	20093 - 33785	11	8218.08	I	7235 - 19400
21	7313.28	I	999 - 14669	10	8275.42	I	7427 - 19507
18	7324.89	II	8884 - 22533	5	h 8315.02	II	8551 - 20574
8	7327.07	I	20160 - 33804	7	8316.38	II	20574 - 32595
14	7373.81	I	11297 - 24854	10	8349.73	I	7427 - 19400
14	7376.41	I	11297 - 24850	4	8374.76	I	10884 - 22821
13	7377.27	II	23270 - 36821	4	8377.79	I	11297 - 23229
6	7377.77	I	11830 - 25381	11	8398.30	I	7427 - 19331
13	7380.28	I	11830 - 25376	7	8442.58	II	23270 - 35111
8	7385.97	II	18955 - 32491	10	8445.47	I	7562 - 19400
13	7394.90	II	13076 - 26595	13	h 8527.88	I	7562 - 19285
13	7430.19	I	1719 - 15174	5	8559.11	I	10884 - 22564
4	7432.57	II	21157 - 34607	6	8561.72	I	7653 - 19331
5	7434.46	I	17362 - 30809	4	h 8579.77	II	25167 - 36819
35	7441.85	I	0 - 13434	4	8615.97	II	25404 - 37007
40	7464.36	I	533 - 13926	6	h 8659.66	I	17906 - 29451
6	7489.44	II	9328 - 22677	8	h 8661.48	II	8551 - 20093
6	7505.35	II	12892 - 26212	21	8668.63	I	6976 - 18509
55	7562.97	I	215 - 13434	5	8674.86	I	11297 - 22821
10	7563.19	II	19376 - 32595	6	8752.77	I	11297 - 22718
6	7566.10	I	11830 - 25044	11	8770.36	I	11830 - 23229
10	7588.20	I	12487 - 25661	13	8784.85	I	6550 - 17931
10	7611.78	I	11297 - 24430	10	8795.76	I	11830 - 23196
21	7621.96	I	10884 - 24000	21	h 8832.06	II	

*Gadolinium – all observed lines – Continued*

Intensity and Character		Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character		Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
14	h	8849.14	I	6786 - 18084					
18	h	8867.31	I	7235 - 18509					

# Gallium .

$$\text{Ga}, Z = 31, M = 69.72, \text{Ratio } \frac{\text{Ga}}{\text{Cu}} = 1.0972$$

Ga I Normal state of valence electrons  $4s^2 4p^2 P_{1/2}^{\circ} = 0$ . I.P. = 48388  $\text{cm}^{-1}$ .

Ga II Normal state of valence electrons  $4s^2 1S_0 = 0$ . I.P. = 165458  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

Ga I, W. F. Meggers and R. J. Murphy, J. Research NBS **48**, 334 (1952) RP 2320.

*Gallium - all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
35	2294.20	I	0 - 43574	340	2659.87	I	0 - 37585
70	2338.28	I	826 - 43578	800	2719.65	I	826 - 37585
40	2371.32	I	0 - 42158				
110	2418.70	I	826 - 42158	5000	2874.24	I	0 - 34782
750	2450.07	I	0 - 40803	9500	2943.64	I	826 - 34787
1300 h	2500.17	I	826 - 40811	1500	2944.18	I	826 - 34782
120	2500.70	I	826 - 40803	10000	4032.98	I	0 - 24788
25	2624.82	I	826 - 38913	20000	4172.06	I	826 - 24788

## Germanium

$$\text{Ge, } Z = 32, M = 72.6, \text{ Ratio } \frac{\text{Ge}}{\text{Cu}} = 1.142$$

Ge I Normal state of valence electrons  $4s^2 4p^2 \ ^3P_0 = 0$ . I.P. =  $63715 \text{ cm}^{-1}$ .

Ge II Normal state of valence electrons  $4s^2 4p^2 \ ^3P_{1/2}^o = 0$ . I.P. =  $128521 \text{ cm}^{-1}$ .

### References

Wavelengths and Classification:

K. L. Andrew and K. W. Meissner, J. Opt. Soc. Am. **49**, 146 (1959).

*Germanium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
30000	1954.47	I	557 - 51705	900	2497.96	I	0 - 40020
20000	1961.36	I	7125 - 58093	700	2533.23	I	557 - 40020
32000	1970.23	I	1410 - 52148	25	2556.30	I	16367 - 55474
14000	1987.62	I	1410 - 51705	280	2589.19	I	1410 - 40020
42000	1998.24	I	1410 - 51437	5000	2592.54	I	557 - 39118
17000	2019.07	I	557 - 50069	60	2644.19	I	16367 - 54175
24000	2041.71	I	0 - 48962	12000	2651.18	I	1410 - 39118
16000	2043.77	I	1410 - 50323	5500	2651.58	I	0 - 37702
4200	2054.46	I	1410 - 50069	5000	2691.34	I	557 - 37702
2200	2057.24	I	7125 - 55718	8500	2709.63	I	557 - 37452
7500	2065.21	I	557 - 48962	400	2740.43	I	16367 - 52847
26000	2068.66	I	557 - 48882	6500	2754.59	I	1410 - 37702
4200	2086.02	I	557 - 48480	70	2793.94	I	16367 - 52148
20000	2094.26	I	1410 - 49144	80	2829.01	I	16367 - 51705
2400	2105.82	I	1410 - 48882	7500	3039.06	I	7125 - 40020
950	2124.74	I	7125 - 54175	600	3067.01	I	16367 - 48962
3400	2198.71	I	7125 - 52592	200	3124.82	I	7125 - 39118
180	2256.00	I	7125 - 51437	1100	3269.49	I	7125 - 37702
180	2314.20	I	7125 - 50323	700	4226.57	I	16367 - 40020
240	2327.92	I	7125 - 50069	60	4685.84	I	16367 - 37702
200	2379.14	I	7125 - 49144	6	8789.87	I	37702 - 49076
1300	2417.37	I	7125 - 48480				



# Gold

$$\text{Au, } Z = 79, M = 196.9665, \text{ Ratio } \frac{\text{Au}}{\text{Cu}} = 3.100$$

Au I Normal state of valence electrons  $5d^{10}6s^2S_{1/2} = 0$ . I.P. = 74410  $\text{cm}^{-1}$ .

Au II Normal state of valence electrons  $5d^{10}1S_0 = 0$ . I.P. = 165000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

Au I and Au II, J. R. Platt and R. A. Sawyer, Phys. Rev. **60**, 866 (1941).

### *Gold—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
11000	2012.00	I	9161 - 58845	320	3029.20	I	9161 - 42164
2600	2021.38	I	9161 - 58616	1600	3122.78	I	9161 - 41174
180	2352.65	I	9161 - 51654	40	3897.89	I	42164 - 67812
120	2387.75	I	9161 - 51029	40	4040.94	I	21435 - 46174
2600	2427.95	I	0 - 41174	70	4065.08	I	37359 - 61952
16	2544.19	I	21435 - 60729	20	4315.09	I	45537 - 68705
30	2590.04	I	21435 - 60033	12	4437.27	I	46174 - 68705
260	2641.49	I	9161 - 47007	25	4488.25	I	45537 - 67812
3400	2675.95	I	0 - 37359	90	4607.34	I	47007 - 68705
30	2688.71	I	21435 - 58616	50	4792.60	I	41174 - 62034
80	2700.89	I	9161 - 46174	25	5837.40	I	37359 - 54485
1100	2748.26	I	9161 - 45537	60	6278.18	I	21435 - 37359
16	2883.45	I	21435 - 56106	60	7510.75	I	41174 - 54485
16	2932.19						

# Hafnium

$$\text{Hf}, Z = 72, M = 178.5, \text{Ratio } \frac{\text{Hf}}{\text{Cu}} = 2.809$$

Hf I Normal state of valence electrons  $5d^2 6s^2 {}^3F_2 = 0$ . I.P. = 53600  $\text{cm}^{-1}$ .

Hf II Normal state of valence electrons  $5d 6s^2 {}^2D_{1/2} = 0$ . I.P. = 120000  $\text{cm}^{-1}$ .

## References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

C. H. Corliss and W. F. Meggers, J. Research NBS **61**, 269 (1958) RP 2904.

Classification:

Hf I, W. F. Meggers, unpublished material (1966).

Hf II, W. F. Meggers and B. F. Scribner, J. Research NBS **13**, 625 (1934) RP 732.

Molecular Spectra:

HfO, W. F. Meggers, unpublished material (1958).

## Strong lines of hafnium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
8500	2028.18	II	13486 - 62775	1200	2820.22	II	3051 - 38499
6200	2012.78	II	3051 - 52717	1200	2904.41	I	4568 - 38988
2300	3399.80	II	0 - 29405	1200	2950.68	I	2357 - 36237
2200	3682.24	I	0 - 27150	1200	3020.53	I	2357 - 35454
2100	2866.37	I	0 - 34877	1200	3505.23	II	8362 - 36882
2100	3072.88	I	0 - 32533	1100	2638.71	II	0 - 37886
2000	2916.48	I	4568 - 38845	1100	2641.41	II	8362 - 46209
2000	2940.77	I	0 - 33995	1100	2954.20	I	4568 - 38408
1800	2898.26	I	2357 - 36850	1100	2980.81	I	0 - 33538
1400	2964.88	I	2357 - 36075	1100	3012.90	II	0 - 33181
1400	3777.64	I	0 - 26464	1100	3016.94	II	0 - 33136
1400	3785.46	I	4568 - 30977	1100	3057.02	I	4568 - 37270
1300	3561.66	II	0 - 28069	1100	3569.04	II	6344 - 34355
1300	3820.73	I	4568 - 30733	1100	4174.34	I	2357 - 26306
1200	2096.18	II	15084 - 62775	1000	3717.80	I	2357 - 29247

*Hafnium— all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
6200	2012.78	II	3051 - 52717	200	2537.33	II	3645 - 43044
8500	2028.18	II	13486 - 62775	110	2548.20	II	13486 - 52717
1200	2096.18	II	15084 - 62775	320	2551.40	II	17389 - 56572
540	2210.82	II	36883 - 82101	27	2551.85	II	12921 - 52097
320	2254.01	II	3645 - 47996	60	2559.02	I	2357 - 41422
160	2255.15	II	3645 - 47973	130	2559.19	II	12071 - 51134
250	2266.83	II	4905 - 49006	250	2563.61	II	4905 - 43901
620	2277.16	II	0 - 43901	55	2570.71	II	15084 - 53973
230	2321.14	II	4905 - 47973	890	2571.67	II	3645 - 42518
580	2322.47	II	0 - 43044	320	2573.90	II	12071 - 50910
300	2323.25	II	3645 - 46675	60	2574.89	I	5638 - 44463
120	2324.50	II	12071 - 55077	320	2576.82	II	8362 - 47158
300	2324.89	II	4905 - 47904	300	2578.14	II	4905 - 43681
200	2332.97	II	3645 - 46495	320	2582.54	II	3051 - 41761
200	2337.33	II	0 - 42771	130	2591.33	II	0 - 38579
230	2343.32	II	6344 - 49006	30	2594.12	I	4568 - 43105
320	2347.44	II	6344 - 48931	55	2599.22	II	15084 - 53546
540	2351.22	II	0 - 42518	55	2602.67	I	2357 - 40768
110	2353.02	I	0 - 42485	27	2602.87	I	0 - 38408
90	2365.98	II	4905 - 47158	390	2606.37	II	3051 - 41407
250	2380.30	II	3645 - 45643	450	2607.03	II	6344 - 44691
100	2381.00	II	14360 - 56346	55	2607.24	II	14360 - 52703
170	2393.18	II	12921 - 54693	120	2608.45	I	0 - 38325
450	2393.36	II	4905 - 46675	35	2609.96	I	4568 - 42871
670	2393.83	II	0 - 41761	22	2612.59	I	5522 - 43786
130	2400.78	II	3051 - 44691	230	2613.60	II	17389 - 55639
70	2404.56	II	13486 - 55060	70	2614.29	II	15254 - 53494
540	2405.42	II	6344 - 47904	90	2616.61	I	5639 - 43845
130	2406.44	II	11952 - 53494	450	2622.74	II	3645 - 41761
370	2410.14	II	8362 - 49841	35	2623.32	I	8984 - 47092
90	2413.33	II	12071 - 53494	70	2626.95	II	6344 - 44400
55	2415.96	II	11952 - 53331	27	2635.57	I	6573 - 44504
320	2417.69	II	3051 - 44400	60	2635.79	II	17711 - 55639
120	2425.98	II	13486 - 54693	160	2637.00	I	2357 - 40267
45	2428.75	I	2357 - 43518	1100	2638.71	II	0 - 37886
120	2428.99	II	12071 - 53227	1100	2641.41	II	8362 - 46209
130	2433.57	II	17369 - 58448	70	2642.08	I	2357 - 40194
45	2434.74	II	17389 - 58448	160	2642.75	I	4568 - 42396
35	2444.99	I	4568 - 45455	670	2647.29	II	8362 - 46125
390	2447.25	II	3051 - 43901	45	2649.15	II	14360 - 52097
140	2449.44	II	6344 - 47158	100	2651.16	II	17369 - 55077
35	2452.30	II	11952 - 52717	30	2652.86	II	41407 - 79090
110	2453.34	II	17369 - 58117	60	2657.50	II	15084 - 52703
450	2460.49	II	3051 - 43681	160	2657.84	II	4905 - 42518
70	2463.97	II	12921 - 53494	210	2661.88	II	6344 - 43901
430	2464.19	II	8362 - 48931	90	2665.97	II	12921 - 50420
90	2465.06	II	15084 - 55639	90	2668.28	I	5639 - 43105
35	2465.67	I	4568 - 45112	80	2669.00	I	3051 - 40507
140	2467.97	II	0 - 40507	45	2671.25	II	13486 - 50910
210	2469.18	II	13486 - 53973	22	2676.63	II	17711 - 55060
100	2473.92	II	12921 - 53331	18	2677.58	II	6344 - 43681
55	2481.44	II	17830 - 58117	18	2678.43	II	17369 - 54693
55	2482.65	I	0 - 40267	35	2682.19	I	6573 - 43845
55	2487.16	I	0 - 40194	290	2683.35	II	15084 - 52340
290	2496.99	II	3645 - 43681	55	2685.22	II	17830 - 55060
70	2500.74	II	15084 - 55060	18	2686.36	I	6572 - 43786
70	2502.66	I	2357 - 42302	18	2688.35	I	8984 - 46170
580	2512.69	II	4905 - 44691	70	2696.18	I	2357 - 39435
580	2513.03	II	6344 - 46125	60	2699.63	I	
130	2515.48	II	13486 - 53227	670	2705.61	I	0 - 36949
890	2516.88	II	3051 - 42771	110	2706.73	II	13486 - 50420
70	2517.86	I	0 - 39704	70	2711.83	I	8984 - 45848
70	2521.49	II	17830 - 57478	45	2711.99	I	17830 - 54693
340	2531.19	II	4905 - 44400	22	2712.14	II	12071 - 48931
80	2532.97	II	3051 - 42518	210	2712.42	II	4905 - 41761

Hafnium— all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
140	2713.84	I	2357 - 39194	55	2885.47	II	14360 - 49006
60	2718.51	II	14360 - 51134	210	2887.14	I	4568 - 39194
250	2718.59	I	0 - 36773	100	2887.54	I	6572 - 41194
80	2726.70	I	5639 - 42302	800	2889.62	I	0 - 34596
70	2729.10	I	2357 - 38988	60	2892.56	I	
90	2730.71	I	0 - 36610	18	2894.84	I	8984 - 43518
120	2730.85	I	4568 - 41175	1800	2898.26	I	2357 - 36850
35	2732.68	II	17389 - 53973	130	2898.71	II	13486 - 47973
70	2737.83	I	5522 - 42036	1200	2904.41	I	4568 - 38988
710	2738.76	II	4905 - 41407	890	2904.75	I	2357 - 36773
200	2743.64	I	5639 - 42076	140	2909.91	II	0 - 34355
35	2746.62	I	5639 - 42036	2000	2916.48	I	4568 - 38845
360	2751.81	II	8362 - 44691	30	2917.49	II	17830 - 52097
60	2756.91	II	17711 - 53973	580	2918.58	I	2357 - 36610
30	2758.31	I	10533 - 46776	320	2919.59	II	3645 - 37886
90	2758.78	I	0 - 36237	180	2924.62	I	5522 - 39704
450	2761.63	I	4568 - 40768	60	2929.01	I	6572 - 40704
60	2762.69	I	5639 - 41825	490	2929.63	II	0 - 34124
160	2766.96	I	5639 - 41769	450	2929.90	I	8984 - 43105
55	2770.46	II	12921 - 49006	710	2937.80	II	8362 - 42391
45	2772.32	II	14360 - 50420	2000	2940.77	I	0 - 33995
170	2773.02	I	2357 - 38408	160	2944.71	I	0 - 33949
980	2773.36	II	6344 - 42391	55	2947.13	II	15084 - 49006
180	2774.02	II	8362 - 44400	1200	2950.68	I	2357 - 36237
55	2775.27	II	11952 - 47973	27	2951.90	I	10509 - 44375
390	2779.37	I	2357 - 38325	1100	2954.20	I	4568 - 38408
70	2783.69	I	6572 - 42485	540	2958.02	I	5639 - 39435
45	2786.30	II	15254 - 51134	60	2960.82	II	17369 - 51134
100	2789.50	II	17389 - 53227	120	2961.80	II	12921 - 46675
140	2789.73	II	17711 - 53546	1400	2964.88	I	2357 - 36075
	2789.80	II	12071 - 47904	620	2966.93	I	6572 - 40267
230	2808.00	II	4905 - 40507	140	2967.23	II	11952 - 45643
27	2812.32	I	10509 - 46056	710	2968.81	II	4905 - 38579
230	2813.86	II	3051 - 38579	110	2973.37	I	6572 - 40194
170	2814.48	II	13486 - 49006	890	2975.88	II	4905 - 38499
90	2814.76	II	17711 - 53227	70	2977.60	II	12921 - 46495
45	2815.82	I	6573 - 42076	150	2979.28	I	5639 - 39194
45	2816.07	II	17830 - 53330	1100	2980.81	I	0 - 33538
230	2817.68	I	8984 - 44464	210	2982.72	I	10533 - 44049
140	2818.94	I	6572 - 42036	55	2984.05	I	8984 - 42485
200	2819.74	I	0 - 35454	170	3000.10	II	3051 - 36373
1200	2820.22	II	3051 - 38499	800	3005.56	I	10533 - 43795
55	2820.42	II	13486 - 48931	80	3011.24	II	17711 - 50910
490	2822.68	II	6344 - 41761	1100	3012.90	II	0 - 33181
80	2829.32	II	17369 - 52703	540	3016.78	I	0 - 33138
180	2833.28	I	0 - 35284	1100	3016.94	II	0 - 33136
110	2834.13	I	8984 - 44258	27	3017.37	I	6572 - 39704
70	2841.49	I	5522 - 40704	980	3018.31	I	0 - 33122
410	2845.83	I	5639 - 40768	1200	3020.53	I	2357 - 35454
270	2849.21	II	12071 - 47158	80	3024.60	I	8984 - 42036
70	2850.15	II	12921 - 47996	80	3024.76	II	17369 - 50420
270	2850.96	I	5639 - 40704	140	3025.29	II	8362 - 41407
180	2851.21	II	6344 - 41407	410	3031.16	II	4905 - 37886
55	2857.65	II	12921 - 47904	110	3046.08	II	15084 - 47904
55	2860.31	II	17389 - 52340	80	3049.29	I	8984 - 41769
180	2860.56	I	0 - 34948	710	3050.76	I	5639 - 38408
760	2861.01	II	0 - 34942	80	3054.52	II	3645 - 36373
760	2861.70	II	3645 - 38579	45	3055.44	II	15254 - 47973
2100	2866.37	I	0 - 34877	1100	3057.02	I	4568 - 37270
55	2867.70	I	8984 - 43845	130	3063.78	I	5522 - 38152
130	2869.82	II	3051 - 37886	130	3064.68	II	12071 - 44691
27	2873.65	I	10532 - 45321	850	3067.41	I	2357 - 34948
150	2876.33	II	15084 - 49841	90	3069.18	I	10532 - 43105
45	2877.16	I	10509 - 45255	2100	3072.88	I	0 - 32533
55	2879.11	II	11952 - 46675	170	3074.10	I	2357 - 34877

*Hafnium — all observed lines — Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
250	3074.79	I	5639 - 38152	210	3306.12	I	4568 - 34806
27	3075.30	I	10509 - 43016	120	3309.19	I	8984 - 39194
150	3080.66	II	17389 - 49841	340	3310.27	I	6573 - 36773
430	3080.84	I	2357 - 34806	45	3310.86	II	13486 - 43681
90	3092.24	II	12071 - 44400	670	3312.86	I	2357 - 32533
200	3096.76	I	4568 - 36850	70	3316.19	I	17901 - 48048
340	3101.40	II	6344 - 38579	180	3317.99	II	3051 - 33181
710	3109.12	II	6344 - 38499	45	3323.36	II	23146 - 53227
130	3110.87	II	14360 - 46495	130	3328.21	II	4905 - 34942
70	3116.95	II	15084 - 47158	45	3331.89	I	10509 - 40514
130	3119.98	I	4568 - 36610	890	3332.73	I	0 - 29997
45	3126.29	II	4905 - 36883	370	3352.06	II	8362 - 38186
90	3128.76	I	0 - 31952	90	3356.09	II	17369 - 47158
70	3129.58	I	0 - 31944	130	3356.78	I	15673 - 45455
710	3131.81	I	10533 - 42454	70	3358.30	II	17389 - 47158
45	3133.50	II	41761 - 73665	230	3358.91	I	14741 - 44504
850	3134.72	II	3051 - 34942	180	3360.06	I	0 - 29753
130	3137.51	I	10533 - 42396	140	3366.68	I	14092 - 43786
170	3139.65	II	6344 - 38186	35	3372.21	I	5639 - 35284
120	3140.76	II	12071 - 43901	180	3378.93	I	2357 - 31943
220	3145.32	II	0 - 31784	140	3384.14	II	14360 - 43901
220	3148.41	I	6572 - 38325	230	3384.70	II	3645 - 33181
120	3151.63	I	8984 - 40704	170	3386.21	I	16767 - 46290
35	3152.96	I	14092 - 45799	800	3389.83	II	3645 - 33136
450	3156.63	I	4568 - 36237	230	3392.81	I	15673 - 45139
270	3159.82	I	2357 - 33995	230	3394.59	II	4905 - 34355
710	3162.61	II	12071 - 43681	140	3394.98	II	17711 - 47158
45	3163.39	I	10509 - 42112	230	3397.26	I	4568 - 33995
90	3165.73	I	6573 - 38152	230	3397.60	I	8984 - 38408
450	3168.39	I	10509 - 42062	2300	3399.80	II	0 - 29405
890	3172.94	I	4568 - 36075	170	3400.21	I	0 - 29402
450	3176.86	II	4905 - 36373	180	3402.51	I	4568 - 33949
45	3178.43	I	14542 - 45995	90	3407.14	I	8984 - 38325
35	3179.61	I		140	3407.76	II	12071 - 41407
220	3181.01	I	5522 - 36949	230	3410.17	II	15084 - 44400
120	3181.15	I	4568 - 35994	60	3412.34	I	14542 - 43838
130	3189.62	I	0 - 31342	90	3413.74	II	13486 - 42771
360	3193.53	II	3051 - 34355	230	3417.34	I	2357 - 31611
670	3194.19	II	3645 - 34942	410	3419.18	I	5639 - 34877
60	3195.61	II	14360 - 45643	45	3421.42	II	4905 - 34124
200	3196.93	I		140	3427.44	I	8984 - 38152
130	3199.99	II	15254 - 46495	200	3428.37	II	0 - 29160
45	3203.67	II	13486 - 44691	250	3438.24	II	18898 - 47973
310	3206.11	I	2357 - 33538	140	3438.43	I	5522 - 34596
180	3210.98	I	5639 - 36773	100	3441.84	I	14741 - 43786
90	3213.72	I	14542 - 45649	45	3448.29	I	
180	3217.30	II	3051 - 34124	100	3452.31	I	5639 - 34596
180	3220.61	II	15084 - 46125	140	3462.64	II	4905 - 33776
130	3230.06	I		140	3467.60	I	15673 - 44504
130	3239.44	I		710	3472.40	I	0 - 28790
130	3243.35	I	16767 - 47590	200	3478.99	II	17389 - 46125
360	3247.66	I	2357 - 33139	480	3479.28	II	3051 - 31784
220	3249.53	I	2357 - 33121	45	3487.57	II	17830 - 46495
890	3253.70	II	3051 - 33776	250	3495.75	II	6344 - 34942
70	3254.86	I	14741 - 45455	80	3495.93	II	15084 - 43681
270	3255.28	II	3645 - 34355	250	3497.16	I	
45	3261.90	I	14435 - 45083	980	3497.49	I	0 - 28584
120	3262.47	I	10533 - 41175	100	3498.98	I	4568 - 33139
90	3265.29	I	15673 - 46290	1200	3505.23	II	8362 - 36882
70	3267.01	I		150	3513.28	I	10532 - 38988
70	3267.18	I	5639 - 36237	130	3518.75	II	14360 - 42771
180	3273.66	II	6344 - 36883	55	3521.56	I	17901 - 46290
270	3279.98	II	3645 - 34124	980	3523.02	I	2357 - 30733
45	3283.38	II	12071 - 42518	100	3530.87	I	19293 - 47606
160	3291.05	I	6572 - 36949	100	3531.23	I	5639 - 33949

*Hafnium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
980	3535.54	II	4905 - 33181	850	d	I	0 - 26306
760	3536.62	I	0 - 28267			I	5639 - 31944
180	3548.81	I	18011 - 46181	70		I	
540	3552.70	II	3645 - 31784	140		II	21638 - 47904
150	3554.00	I	14542 - 42671	320		I	2357 - 28584
1300	3561.66	II	0 - 28069	100		II	17711 - 43901
150	3564.31	I	0 - 28048	100		I	14092 - 40267
270	3567.36	I	6572 - 34596	1300		I	4568 - 30733
1100	3569.04	II	6344 - 34355	140		I	16767 - 42871
150	3579.90	I	14435 - 42361	280		I	14092 - 40194
110	3583.28	I	5639 - 33538	800		I	5639 - 31611
210	3597.42	II	15254 - 43044	140		II	17711 - 43681
	3597.51	I	8984 - 36773	600		I	2357 - 28267
540	3599.87	I	16767 - 44537	230		I	8984 - 34877
110	3615.04	I	0 - 27654	80		II	17830 - 43681
800	3616.89	I	2357 - 29997	200		II	12071 - 37886
110	3617.68	I	14542 - 42176	160		II	23146 - 48931
90	3620.04	I	5522 - 33138	380		II	3645 - 29405
110	3624.00	II	12921 - 40507	200		I	15673 - 41422
320	3630.87	II	28105 - 55639	150		II	13486 - 39226
100	3635.43	I	5639 - 33138	200		I	10532 - 36237
55	3637.59	I	5639 - 33122	200		I	5639 - 31342
800	3644.36	II	6344 - 33776	70		I	19791 - 45475
320	3649.10	I	2357 - 29753	620		I	0 - 25634
90	3650.53	I	19293 - 46678	35		II	30942 - 56572
200	3651.84	I	4568 - 31943	45		I	14542 - 40130
140	3661.05	II	15084 - 42391	80		I	19791 - 45365
80	3664.60	I	14018 - 41298	80		II	21638 - 47158
220	3665.35	II	11952 - 39226	620		II	3645 - 29160
100	3668.21	I	8984 - 36237	200		II	12921 - 38399
200	3672.27	I		120		I	10533 - 35994
480	3675.74	I	15673 - 42871	150		I	14741 - 40194
2200	3682.24	I	0 - 27150	110		II	28105 - 53546
280	3696.51	I	2357 - 29402	320		I	4568 - 29997
100	3698.40	II	17369 - 44400	120		II	17369 - 42771
240	3699.72	II	13486 - 40507	120		I	6572 - 31952
340	3701.15	II	17389 - 44400	80		I	24085 - 49389
100	3704.92	I	18381 - 45365	410		I	2357 - 27654
120	3705.40	II	17711 - 44691	80		II	17830 - 43044
1000	3717.80	I	2357 - 29247	160		I	0 - 25194
650	3719.28	II	4905 - 31784	150	bl	I	
140	3726.49	I	10509 - 37336	200		I	2356 - 27516
160	3729.10	I	20960 - 47769	80		II	28105 - 53227
460	3733.79	I	4568 - 31342	180		I	2357 - 27150
160	3737.88	II	18898 - 45643	90		I	16163 - 40882
120	3739.04	I	10533 - 37270	100		II	30942 - 55639
60	3743.99	I	18381 - 45083	70		II	17830 - 42518
100	3744.98	II	23146 - 49841	70		I	
400	3746.80	I	14741 - 41422	230		I	10509 - 35115
80	3747.49	II	15084 - 41761	140		I	14542 - 39128
140	3753.22	I	17901 - 44537	180		I	10509 - 34992
60	3762.51	II	31878 - 58448	35		I	16163 - 40619
100	3765.05	I	18225 - 44778	540		II	3645 - 28069
100	3765.56	I	6572 - 33122	110		I	5639 - 29997
170	3766.92	II	20135 - 46675	140		I	10532 - 34877
200	3768.25	I	10509 - 37039	110		II	12071 - 36373
60	3771.36	II	12070 - 38579	35		I	18381 - 42671
60	3773.12	I	14018 - 40514	110		I	10532 - 34806
1400	3777.64	I	0 - 26464	70		I	14018 - 38289
35	3782.43	I	5522 - 31952	150		II	14360 - 38579
70	3782.78	II	12070 - 38499	140		I	5639 - 29753
1400	3785.46	I	4568 - 30977	80		II	17369 - 41407
35	3787.37	I	18381 - 44778	150		II	17389 - 41407
650	3793.37	II	3051 - 29405	110		I	4568 - 28584
100	3798.66	I	10532 - 36850	1100		I	2357 - 26306

Hafnium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	4187.66	II	18898 - 42771	90	4766.51	I	14018 - 34992
120	4190.95	I	14435 - 38289	80	4773.72	I	5522 - 26464
160	4206.58	II	20135 - 43901	26	4774.89	I	22901 - 43838
190	4209.70	I	14542 - 38289	160	4782.74	I	18225 - 39128
170	4228.08	I	0 - 23645	40	4790.72	II	17711 - 38578
170	4232.44	II	18898 - 42518	310	4800.50	I	5638 - 26464
80	4245.16	I	8984 - 32533	35	4817.21	II	21638 - 42391
40	4245.84	II	20135 - 43681	65	4818.87	I	18381 - 39128
120	4252.08	Hf O		40	4834.19	I	14435 - 35115
170	4260.98	I	10533 - 33994	80	4837.23	I	5639 - 26306
200	4263.39	I	0 - 23449	21	4850.61	I	10509 - 31119
170	4272.85	II	13486 - 36883	40	4858.41	I	6572 - 27150
320	4294.79	I	2357 - 25634	130	4859.24	I	14542 - 35115
80	4296.41	I	5522 - 28790	80	4863.27	I	14435 - 34992
120	4318.14	I	5639 - 28790	21	4872.94	I	20960 - 41476
80	4320.67	II	17369 - 40507	80	4877.58	I	19293 - 39789
160	4330.27	I	4568 - 27654	22	4915.26	I	19791 - 40130
40	4334.64	II	23146 - 46209	25	4934.45	II	12921 - 33181
180	4336.66	II	21638 - 44691	55	4948.94	I	10533 - 30733
35	4349.74	I	24785 - 47769	25	4962.37	I	18143 - 38289
150	4350.51	II	23146 - 46125	120	4975.25	I	2357 - 22450
40	4351.15	I		15	4999.68	II	14360 - 34355
80	4352.57	I	8984 - 31952	95	5018.20	I	20960 - 40882
70	4353.34	I	16163 - 39128	15	5021.75	I	18381 - 38289
250	4356.33	I	4568 - 27516	55	5040.82	II	11952 - 31784
55	4356.99	I	5639 - 28584	95	5047.45	I	8984 - 28790
70	4365.37	I	14435 - 37336	55	5074.74	Hf O	
110	4367.90	II	13486 - 36373	30	5079.65	II	18898 - 38579
180	4370.97	II	12071 - 34942	55	5093.88	Hf O	
55	4408.81	Hf O		15	5112.13	I	5639 - 25194
120	4417.35	II	15254 - 37886	19	5128.53	II	17389 - 36883
160	4417.91	I	5639 - 28267	30	5157.96	I	22901 - 42283
35	4418.25	I	8984 - 31611	55	5167.42	I	24785 - 44132
35	4422.23	I	10532 - 33139	75	5170.18	I	19791 - 39128
200	4438.04	I	5522 - 28048	230	5181.86	I	0 - 19293
55	4443.07	I	18381 - 40882	30	5186.84	I	22901 - 42176
55	4453.00	I	0 - 22451	30	5187.75	II	15084 - 34355
140	4457.34	I	2357 - 24785	110	5243.99	I	8984 - 28048
140	4461.18	I	5639 - 28048	55	5247.10	II	28105 - 47158
45	4466.40	II	20135 - 42518	25	5260.44	II	17369 - 36373
55	4486.13	II	12071 - 34355	30	5264.95	II	18898 - 37886
55	4499.65	I	6572 - 28790	55	5275.04	I	16163 - 35115
45	4518.29	I	16163 - 38289	22	5286.09	I	23449 - 42361
140	4540.93	I	5639 - 27654	120	5294.87	I	4568 - 23449
80	4544.02	I	10532 - 32533	45	5298.06	II	15254 - 34124
250	4565.94	I	5639 - 27534	30	5307.82	I	23449 - 42283
23	4573.79	II	17369 - 39226	45	5309.68	I	16163 - 34992
45	4597.90	I	23644 - 45387	55	5311.60	II	14360 - 33181
500	4598.80	I	0 - 21739	12	5324.26	II	14360 - 33136
	4598.92	I	4568 - 26306	9	5346.30	II	28458 - 47158
23	4605.77	II	12071 - 33776	110	5354.73	I	25462 - 44132
90	4608.09	I	6573 - 28267	110	5373.86	I	2357 - 20960
230	4620.86	I	4568 - 26203	40	5389.34	I	8984 - 27534
70	4622.70	II	20135 - 41761	19	5391.36	II	17830 - 36373
45	4630.61	I	19293 - 40882	19	5404.47	I	19791 - 38289
210	4655.19	I	6572 - 28048	28	5424.02	I	22451 - 40882
80	4664.12	II	12921 - 34355	12	5435.78	I	21738 - 40130
26	4669.24	I	10532 - 31943	40	5438.74	I	0 - 18381
120	4699.01	I	18011 - 39286	14	5444.07	II	20135 - 38499
40	4699.72	II	20135 - 41407	75	5452.92	I	4568 - 22901
45	4708.84	I	22901 - 44132	30	5463.38	II	13486 - 31784
45	4719.10	II	11952 - 33136	15	5497.30	I	29753 - 47938
45	4731.37	II	17369 - 38499	15	5510.12	I	0 - 18143
40	4738.58	I	14018 - 35115	15	5510.45	I	18381 - 36524
40	4757.58	I	8984 - 29997	19	5524.35	II	15084 - 33181

Hafnium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	5538.02	I	21739 - 39791	10	6926.19	I	14092 - 28526
28	5538.26	I	10533 - 28584	19	6979.59	I	15673 - 29997
230	5550.60	I	0 - 18011	21	6980.91	II	15084 - 29405
230	5552.12	I	5639 - 23645	7	7019.25	I	29247 - 43489
55	5575.86	I	26203 - 44132	7	7030.33	II	20135 - 34355
14	5600.77	I	23449 - 41298	7	7035.13	I	16767 - 30977
95	5613.27	I	5639 - 23449	11	7061.90	I	25634 - 39791
25	5614.01	I	21739 - 39546	15	7062.87	I	25634 - 39789
8	5628.27	I	23449 - 41211	160	7063.83	I	5639 - 19791
19	5650.83	I	10509 - 28201	11	7094.40	I	25194 - 39286
40	bl	5698.03	Hf O	15	7100.54	I	15673 - 29753
25		5713.28	I	55	7119.52	I	17901 - 31943
160		5719.18	I	570	7131.81	I	0 - 14018
25	bl	5720.16	Hf O	650	7237.10	I	4568 - 18381
12		5748.72	I	410	7240.87	I	2357 - 16163
14		5767.18	II	6	7262.62	I	14435 - 28201
12		5809.50	II	75	7320.05	I	4568 - 18225
19		5817.47	I	16	7321.76	I	5639 - 19293
25		5842.23	II	6	7356.10	I	23449 - 37039
25		5845.87	I	6	7365.28	I	15673 - 29247
19		5847.77	I	20	7390.70	I	14741 - 28267
22		5883.66	I	6	7423.69	I	8984 - 22450
15		5926.47	I	25	7437.56	I	14092 - 27534
60		5933.69	I	13	7463.86	I	23645 - 37039
75		5974.28	I	7	7484.56	I	22880 - 36237
25		5974.72	I	15	7556.37	I	16766 - 29997
60		5978.66	I	75	7562.93	I	6572 - 19791
25		5992.96	I	15	7564.22	I	34806 - 48022
45	c	6016.79	I	11	7576.95	I	18381 - 31576
28	b	6021.12	Hf O	11	7592.96	I	23253 - 36419
25	b	6043.19	Hf O	13	7608.59	I	31943 - 45083
25		6054.17	I	360	7624.40	I	10533 - 23645
95		6098.67	I	20	7645.64	I	17901 - 30977
95		6185.13	I	110	7740.17	I	10532 - 23449
55		6210.70	I	8	7743.57	I	15673 - 28584
28		6216.82	I	5	7757.89	II	18898 - 31784
45		6238.58	I	40	7790.90	I	17901 - 30733
60		6248.95	II	7	7796.81	I	23253 - 36075
22	h	6299.54	I	35	7814.55	I	14741 - 27534
25	h	6311.85	I	310	7845.35	I	5639 - 18381
19		6318.33	I	7	7846.56	I	23253 - 35994
30		6338.10	I	130	7920.71	I	5522 - 18143
19	h	6380.19	I	29	7938.06	I	15673 - 28267
60		6386.23	I	250	7994.73	I	5639 - 18143
19	h	6409.52	I	7	8010.58	I	16766 - 29247
15	h	6556.50	I	25	8056.52	I	14741 - 27150
28		6587.23	I	25	8080.32	I	5639 - 18011
45		6644.60	II	16	8173.89	I	20908 - 33139
19		6647.06	II	130	8204.58	I	2357 - 14542
11		6659.40	I	7	8248.81	I	36237 - 48357
30		6713.48	I	55	8276.95	I	2357 - 14435
6		6716.00	I	13	8305.91	II	17369 - 29405
17		6754.61	II	25	8344.25	I	15673 - 27654
11		6769.95	I	5	8380.06	I	28584 - 40514
85		6789.27	I	5	8382.98	I	22880 - 34806
160		6818.94	I	35	8460.01	I	16767 - 28584
15		6826.56	I	150	8546.48	I	6572 - 18270
13		6850.07	I	160	8640.06	I	6572 - 18143
35		6858.70	I	40	8711.24	I	15673 - 27150
45		6911.40	I	65	9004.73	I	14092 - 25194



# Holmium

$$\text{Ho, } Z = 67, M = 164.9303, \text{ Ratio } \frac{\text{Ho}}{\text{Cu}} = 2.595$$

Ho I Normal state of valence electrons  $4f^{11}6s^2 4I_{71/2}^{\circ} = 0$ . I.P. = 48540  $\text{cm}^{-1}$ .

Ho II Normal state of valence electrons  $4f^{11} 6s 5I_8^{\circ} = 0$ . I.P. = 95200  $\text{cm}^{-1}$ .

## References

### Wavelengths:

Below 7000 Å;

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945).  
About 50 wavelengths were measured on our plates, including all lines above 7000 Å.

### Classification:

Ho I, J. Blaise, P. Camus, G. Guelachvili, J. Verges, and J. F. Wyart, *C. R. Acad. Sc. Paris, Ser. B*.275,81 (1972); 274,1302 (1972).

Ho II, J. Sugar, *J. Opt. Soc. Am.* **58**, 1519 (1968).

### Spectrum Assignments:

From 3837 Å to 4661 Å: A. S. King, *Astrophys. J.* **72**, 221 (1930).

The rest of the assignments are from our plates.

### Molecular Spectra:

HoO, A. Gatterer, *Ricerche Spettroscop.* **1**, 139 (1942).

### *Strong lines of holmium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
16000 c	3456.00	II		2900	4108.62	I	
13000 c	3891.02	II	637 - 26331	2700 c	3861.68	II	
8900 c	3796.75	II	0 - 26331	2700	4040.81	I	0 - 24740
8900 c	3810.73	II	0 - 26234	2500 c	3494.76	II	
8900	4103.84	I	0 - 24361	2500	4173.23	I	
8100 c	3398.98	II	0 - 29412	2000 c	3425.34	II	
8100	4053.93	I	0 - 24660	2000 c	3428.13	II	
8100	4163.03	I		2000	4227.04	I	
6300	3484.84	II		1800 c	3854.07	II	
5400	3416.46	II	637 - 29899	1700	4065.09	II	
5400 c	3474.26	II	637 - 29412	1600	3461.97	II	
5400 c	4045.44	II	0 - 24712	1600	3546.05	II	
4300	4127.16	I		1600 c	3662.29	I	
4100 c	3515.59	II		1500	4120.20	I	
3200	3453.14	II		1500	4136.22	I	
3200 cw	3748.17	II		1400 c	3414.90	II	0 - 29275
3000 c	3888.96	II		1400	3667.97	I	

*Holmium — all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
170	2502.91	II		100	2844.68	II	
80	2508.53	II		270	2849.10	II	
110	2513.55	II		45	2852.89	II	
95	2518.73	II		40	2860.87	II	
170	2533.80	I		100	2861.23	II	
130	2536.86	II		250	2861.49	II	
80	2556.84	I	0 - 39098	150	2862.72	II	
80	2567.73	II		90	2866.79	II	
80	2586.52	I		210	2871.99	II	
60	2591.05	II		90	2872.44	II	
95	2592.99	I		70	2873.88	II	
190	2605.86	II		230	2874.06	II	
110	2610.51	II		160	2874.43	II	
95	2613.99	II		360	2880.26	II	
60	2625.20	II		460	2880.98	II	
80	2640.09	I	0 - 37865	55	2882.04	II	
80	2640.30	II		35	2883.47	II	
60	2649.68	II		80	2884.64	II	
80	2666.24	II		70	2891.29	II	
70	2689.03	II		340	2894.99	II	
45	2704.18	II		160	2895.62	II	
45	2709.30	II		170	2900.84	II	
210	2713.65	II		55	2902.19	II	
45	2721.77	II		570	2909.41	II	
45	2728.32	II		55	2910.40	II	
230	2733.95	II		70	2914.09	II	
45	2738.79	I		45	2915.12	II	
270	2750.35	II		170	2915.82	II	
45	2757.77	II		300	2919.62	II	
110	2759.35	II		55	2921.85	II	
110	2766.85	II		70	2922.60	II	
270	2769.89	II		110	2925.35	II	
70	2772.60	II		160	2926.09	II	
110	2772.83	II		90	2926.99	II	
70	2773.84	II		300	2928.30	II	
140	2777.10	II		55	2936.24	II	
55	2778.87	II		90	2940.99	I	
55	2787.20	II		220	2942.05	II	
55	2791.08	II		55	2942.59	II	
55	2793.90	II		300	2944.49	II	
140	2794.41	II		35	2945.04	II	
100	2799.99	II		55	2945.83	II	
100	2806.72	II		70	2952.36	II	
70	2807.31	II		55	2952.73	II	
80	2809.09	II		250	2953.11	II	
160	2809.99	II		70	2954.28	II	
220	2811.36	II		70	2954.94	II	
180	2812.00	II		35	2955.27	II	
80	2814.44	II		70	2957.41	II	
190	2814.74	II		70	2964.40	II	
70	2814.91	II		55	2972.43	II	
45	2819.68	II		390	2973.00	II	
90	2819.80	II		55	2975.24	II	
80	2823.36	II		410	2979.63	II	
70	2823.73	II		55	2980.64	II	
300	2824.20	II		180	2981.46	II	
140	2826.64	II		80	2984.07	II	
55	2830.92	II		140	2985.48	II	
270	2831.69	II		410	2987.64	II	
55	2833.79	II		250	2990.27	II	
210	2834.99	II		90	2992.71	II	
110	2835.85	II		110	2995.86	II	
55	2836.70	II		90	2998.29	II	
70	2843.39	II		70	3000.69	II	
110	2844.18	II		45	3005.29	II	

Holmium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	3007.08	II		810	c	3181.50	II
320	3008.10	II		390		3183.84	II
160	3009.48	II		270	cw	3184.48	II
55	3012.07	II		200		3186.37	I
220	3014.60	II		140		3187.39	II
110	3016.21	II		160		3191.02	II
45	3017.73	II		70		3195.09	II
70	3018.16	II		140	c	3196.07	II
160	3023.14	II		65		3196.52	II
130	3024.38	II		390	c	3197.83	II
70	3026.13	II		110		3201.00	I
110	3028.18	II		390		3201.76	II
130	3033.44	II		160		3204.28	II
170	3035.65	II		100		3206.17	I
270	3038.69	II		200		3206.86	II
90	3044.40	II		270	c	3210.41	II
70	3046.44	II		120		3211.85	II
480	3049.38	II		80		3213.28	II
160	3050.73	II		140		3215.36	II
410	3054.00	II		200	c	3221.42	II
130	3054.87	II		80		3224.27	II
500	3057.45	II		65		3230.04	II
70	3060.24	II		80	c	3231.67	II
110	3062.53	II		320		3233.34	II
80	3063.14	II		80		3233.87	II
180	3064.19	II		200		3236.90	II
230	3074.30	II		200		3237.40	II
100	3075.53	II		65		3240.42	II
80	3078.41	II		80		3243.00	II
500	3082.34	II		80		3247.22	II
910	3084.36	II		80		3256.28	II
430	3086.54	II		200	c	3257.45	II
180	3102.69	II		120	c	3258.45	II
150	3105.18	II		80		3262.20	II
200	3108.31	II		70		3263.66	II
150	3108.65	II		80		3266.34	II
200	3109.91	II		90		3267.36	II
65	3111.85	II		80		3277.16	II
65	3114.36	II		390	c	3278.15	II
760	3118.50	II		270		3279.25	II
65	3129.21	II		120		3281.18	II
70	3130.77	II		980	c	3281.97	II
300	3130.99	II		140		3283.08	II
200	3134.39	II		390		3288.46	II
300	3144.36	II		270	c	3290.96	II
70	3146.13	II		120	c	3297.06	II
150	3148.85	II		90		3298.12	II
120	3149.94	II		130		3301.34	I
65	3153.04	II		200	c	3305.16	II
130	3153.82	I		130		3312.39	II
200	3156.18	II		140		3315.66	II
270	3156.97	II		200		3319.87	II
120	3157.35	I		230		3320.25	II
120	3158.40	II		80		3321.11	II
200	3159.67	II		110		3323.74	II
65	3160.47	II		120	c	3329.02	II
65	3164.06	II		200		3331.93	II
120	3165.69	II		160		3333.16	II
580	3166.62	II		630	c	3337.23	II
160	3167.89	II		390	c	3338.86	II
390	3171.72	II		160		3340.44	II
80	3172.37	II		80		3342.70	II
810	3173.78	II		980	c	3343.58	II
390	3174.84	II		200		3344.47	II
270	3176.97	II		65		3344.79	II

0 - 29899

Holmium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	3348.61	II		140	3469.40	II	
360	3350.49	II		130 c	3470.76	II	
320	3352.10	II		230 c	3472.31	II	
320 cw	3353.55	II		810 c	3473.91	II	
320	3354.58	II		5400 c	3474.26	II	637 - 29412
80	3356.98	II		200	3477.75	II	
320	3357.91	II		200 c	3478.06	II	
140	3360.87	II		80	3483.89	II	
120	3363.41	II		6300	3484.84	II	
320	3364.27	II		200 c	3485.87	II	
80 c	3368.36	II		160 c	3486.34	II	
100	3369.89	II		490	3489.58	II	
290	3370.87	II		290 c	3490.95	II	637 - 29275
100	3372.43	II		65	3492.11	I	
230	3374.16	II		580 c	3493.09	II	
70	3374.36	II		80	3493.60	I	
80	3380.49	II		2500 c	3494.76	II	
80	3386.41	I		80	3497.65	II	
160 c	3389.56	II		810 c	3498.88	II	
290 c	3390.75	II		70	3505.43	II	
160 c	3392.05	II		410 c	3506.95	II	
80	3392.47	II		130	3507.99	I	
320 c	3394.60	II		320	3509.37	II	
110	3397.33	II		810	3510.73	I	9147 - 37623
8100 c	3398.98	II	0 - 29412	160	3511.76	II	
110	3400.60	II		4100 c	3515.59	II	
200	3401.59	II		410 c	3519.94	II	
130	3402.18	II		220 c	3520.16	II	
120	3406.27	II		150	3532.76	I	
200	3408.21	II		220	3538.89	II	
200 c	3409.06	II		130 c	3539.35	II	
810 c	3410.26	II		630	3540.76	II	
390 c	3410.65	II		200	3541.41	I	
290	3411.55	II		1600	3546.05	II	
150	3412.87	II		160	3548.53	II	
200 c	3414.25	II		80 c	3550.60	II	
1400 c	3414.90	II	0 - 29275	1100 c	3556.78	II	
5400	3416.46	II	637 - 29899	80 c	3558.15	II	
80 c	3418.19	II		70	3559.03	II	
120	3418.47	I	8378 - 37623	410	3560.15	II	
1200	3421.63	II		160 c	3563.45	II	
290	3424.11	I	8427 - 37623	110	3567.32	II	
2000 c	3425.34	II		160	3568.79	II	
230	3426.76	II		290	3570.44	I	
2000 c	3428.13	II		410 c	3573.24	II	
630 c	3429.18	II		35	3574.20	II	
320 c	3432.10	II		630 c	3574.80	II	
140	3434.76	II		810	3579.12	I	
140	3435.61	II		410	3580.75	II	
160	3436.31	II		410	3581.83	II	
290	3437.04	I		80 c	3582.80	II	
130 c	3437.91	II		250 cw	3589.77	I	
65 c	3438.35	II		150	3591.23	II	
160	3445.66	II		630 c	3592.23	II	
130 c	3449.01	II		170 c	3593.07	II	
390	3449.35	I		1100 cw	3598.77	II	
140	3451.23	I		340	3599.48	I	
3200	3453.14	II		540 c	3600.95	II	
110 c	3453.85	II		130 c	3602.65	II	
810 c	3455.70	II		130	3605.77	I	
16000 c	3456.00	II		340	3613.31	II	
140	3461.36	II		110 c	3616.93	II	
1600	3461.97	II		70	3618.08	II	
360 c	3467.07	II		410	3618.43	I	
80	3468.13	I		200	3619.41	II	

*Holmium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
200	3623.59	I		3200 cw	3748.17	II	
170 c	3625.46	II		110 c	3748.78	II	
430 c	3626.69	II		90	3750.19	II	
490	3627.25	II		100 c	3752.07	II	
200	3630.91	I		130 c	3753.01	II	
430 c	3631.76	II		320 c	3753.73	II	
110	3632.95	II		160	3754.45	I	
130 c	3634.67	II		270 c	3757.26	II	
80 c	3635.35	II		90	3760.48	I	
430 c	3638.30	II		340	3769.09	I	
130 c	3640.17	II		250	3772.40	I	
220	3641.25	I		110	3773.83	I	
80 c	3642.36	II		220	3774.58	I	
90 c	3649.60	II		180	3774.90	I	
220	3654.45	II		130	3775.37	I	
200 c	3658.48	I		250	3776.15	I	
1600 c	3662.29	I		130 hc	3778.00	I	
430	3662.99	I		290	3780.37	II	
720	3666.65	I		110 c	3780.99	II	
130	3667.05	II		110	3782.65	II	
1400	3667.97	I		180	3785.23	II	
320	3669.05	II		320	3788.08	II	
450	3669.52	I		110	3788.44	II	
90	3670.28	II		270	3791.00	II	
70	3672.69	I		220	3791.55	I	
140 c	3674.36	II		110	3791.97	II	
450 c	3674.77	II		290	3792.95	I	
180 cw	3677.64	II		180	3794.69	I	
220	3678.59	II		8900 c	3796.75	II	0 - 26331
720	3679.19	I		200	3797.26	I	
670	3679.70	I		220	3798.25	II	
160 c	3680.00	II		290 c	3801.28	II	
720	3682.65	I		250	3804.15	I	
430	3685.16	II		110	3807.90	I	
140 c	3686.65	II		130	3809.49	II	
580	3690.65	I		110 c	3809.93	II	
230 c	3691.32	II		8900 c	3810.73	II	0 - 26234
340	3691.95	I		490	3811.86	I	
130	3694.66	I		900 c	3813.25	II	
110	3695.69	I		180	3818.69	II	
410	3700.04	I		300	3821.73	II	
130	3701.27	I		220	3825.64	I	
130	3701.78	II		390	3829.27	I	
490 c	3702.35	II		320 cw	3831.9	II	
80	3704.54	II		410 c	3835.35	II	
100	3706.90	II		1300 cw	3837.51	II	
250	3709.27	II		220	3838.36	II	
320	3709.76	I		410 c	3842.05	II	
160 c	3710.74	II		1100	3843.86	II	
160	3711.31	II		490 c	3846.73	II	
430	3712.88	I		300	3849.88	I	
270	3718.62	I		230 h	3851.54	II	
450	3720.72	I		320	3852.40	II	
180 c	3721.32	II		1800 c	3854.07	II	
160 c	3721.80	II		390 cw	3856.94	II	
270	3724.45	I		720	3857.72	II	
70	3725.05	I		250	3859.34	I	
180 c	3725.98	II		2700 c	3861.68	II	
1100	3731.40	I		540	3862.62	I	
360	3732.09	I		110	3864.91	II	
220	3732.59	I		360	3872.05	II	
180	3734.99	I		320 c	3874.09	II	
810	3736.35	I		630	3874.68	II	
180	3737.65	II		250	3879.59	II	
200	3742.40	I		540	3881.61	II	

Holmium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
3000 c	3888.96	II		8100	4053.93	I	0 - 24660
490	3890.42	I		540	4054.48	II	
13000 c	3891.02	II	637 - 26331	270	4057.55	I	
290 c	3893.08	II		220	4060.31	I	
100	3893.52	II		1700	4065.09	II	
540	3896.76	II		170	4067.57	I	8427 - 33005
270 c	3897.27	II		720	4068.05	I	
130	3899.64	II		270	4071.83	I	
130	3900.79	I		270	4073.13	I	
290	3902.23	II		290	4073.51	I	
320	3904.44	I		120 c	4080.23	II	
1300 cw	3905.68	II	637 - 26234	230	4083.67	I	
100	3909.56	I		140	4085.09	I	
120	3910.30	I		170	4087.35	I	
320	3911.80	I		200	4087.59	I	
110	3912.44	II		140	4091.64	I	
320	3919.45	I		120	4094.78	I	
100 c	3923.28	II		230	4100.22	I	
100	3924.55	II		90	4101.09	I	
100	3925.64	II		8900	4103.84	I	0 - 24361
130 ch	3929.93	II		120	4105.04	I	
320 c	3936.44	II		270	4106.50	I	
220	3938.85	I		100	4107.36	I	
320 cw	3940.53	II		2900	4108.62	I	
180	3942.54	I		300	4112.00	I	
100	3949.00	I		100	4112.72	I	
220	3950.56	I		270	4116.73	I	
90	3951.14	I		90	4118.94	I	
90 c	3955.05	II		1500	4120.20	I	
580	3955.73	I		1300	4125.65	I	
120	3957.39	I		4300	4127.16	I	
230 c	3959.51	II		300	4134.54	I	
490	3959.68	I		90	4135.08	I	
120	3963.29	II		1500	4136.22	I	
120	3967.33	I		130	4139.34	I	
100	3972.64	II		230	4142.19	I	
90	3973.83	II		290	4148.97	I	
110	3974.55	I		980 cw	4152.61	II	637 - 24712
220	3975.88	I		8100	4163.03	I	
390 c	3976.93	I		160	4172.23	I	
170	3976.97	II		2500	4173.23	I	
130	3982.04	II		540	4194.35	I	
220 cw	3985.71	II		100	4198.08	I	
160	3992.72	I		130	4203.21	I	
220	3993.73	II		65	4203.39	II	
80	3997.18	II		100	4211.30	II	
130	3998.29	I		90	4219.10	I	
380	3999.58	I		290	4222.29	I	
80 c	4001.32	II		290	4223.47	I	
160 cw	4002.59	II		2000	4227.04	I	
220	4003.39	I		390	4229.52	II	
110	4013.50	I		130 h	4231.24	I	
320	4014.20	II		290	4243.78	I	
160 c	4018.09	II		90	4245.40	II	
160 c	4022.76	II		1300 cw	4254.43	I	
160 c	4023.94	II		130 c	4258.61	II	
110	4025.39	I		490	4264.05	I	0 - 23445
320	4027.21	I		300	4266.04	I	
270	4028.86	I		100	4273.63	II	
180 c	4031.80	I		80	4284.58	II	
220	4037.62	I		90	4290.18	II	
220 c	4038.87	II		90 c	4298.47	II	
2700	4040.81	I	0 - 24740	90	4299.15	I	
5400 c	4045.44	II	0 - 24712	90	4301.09	II	
220 c	4047.52	I		200	4311.04	I	

Holmium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
90	4315.03	II		55	4683.08	I	
250	4330.64	II		55	4685.83	II	
80	4332.55	II		45	4688.19	II	
300	4337.13	II		70	4701.17	II	
100	4346.84	II		80	4701.69	II	
1300	4350.73	I		130	4709.84	II	
290	4356.73	II		65	4711.39	I	
140	4363.93	II		130	4717.52	I	9147 - 30338
70	4371.43	II		35	4728.72	II	
70	4373.33	I		35	4738.00	II	
80	4376.58	II		290	4742.04	II	
170	4379.14	II		35	4749.09	II	
90	4379.83	II		35	4751.40	I	
180	4384.83	II		100	4757.01	I	
70	4388.69	II		35	4762.39	II	
70	4394.98	I		35	4763.57	II	
150	4400.55	II		55	4777.48	II	
120	4401.24	II		30	4779.42	I	
180	4403.27	I		70	4781.19	I	
200	4420.56	II		65	4782.92	I	9147 - 30048
55	4426.20	II		55	4786.29	I	16735 - 37623
80	4429.81	II		35	4791.48	II	
70	4434.96	I	15081 - 37623	35	4795.92	II	
130	4444.63	I	15130 - 37623	45	4798.87	I	
70	4445.07	II		27	4812.92	II	
80	4447.23	II		55	4832.31	II	
65	4463.40	II		30	4833.32	I	
70	4467.28	I		30	4855.54	II	
70	4470.23	I		45	4860.39	I	
100	4473.59	II		27	4889.67	II	
300	4477.64	II		30	4892.35	I	18737 - 39171
120	4484.57	II		35	4896.44	II	
140	4510.82	I		55	4906.99	II	
90	4512.55	II		45	4922.73	I	
100	4526.14	II		55	4934.89	I	
170	4530.08	II		290	4939.01	I	0 - 20241
170	4531.28	I		27	4946.80	I	
130	4531.65	II		45	4948.18	II	
170	4534.58	I		65	4959.42	II	
65	4543.80	I		35	4961.03	II	
90	4548.94	II		55	4966.73	II	
45	4558.11	II		250	4967.21	II	
200	4562.52	I	8427 - 30338	220	4979.97	I	0 - 20074
65	4567.82	II		35	4988.96	I	8378 - 28417
55	4572.42	II		90	4995.05	I	
90	4578.07	I		35	5012.42	I	
70	4589.70	II		55	5013.28	II	
90	4608.00	I		65	5026.53	I	
45	4608.67	II		30	5028.17	I	
120	4609.32	II		55	5032.95	II	
	4609.52	II		65	5037.60	I	
130	4613.37	I	8378 - 30048	130	5042.37	I	
45	4613.99	II		35	5044.73	I	8427 - 28244
100	4618.84	I		30	5051.44	II	
100	4628.22	I		30	5054.92	II	
290	4629.10	II		35	5060.75	I	
55	4632.84	I		65	5074.34	I	
45	4638.19	II		80	5093.07	I	
	4638.29	II		140	5127.81	I	
70	4647.75	II		55	5129.27	II	
200	4649.77	II		130	5142.59	II	
45	4651.39	II		110	5143.22	II	
35	4652.71	II		160	5149.59	II	
130	4661.33	II		90	5167.88	I	
140	4674.62	II		130	5182.11	I	8378 - 27670

Holmium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	5187.85	I	9147 - 28417	27	b	5879.6	Ho O
90	5190.11	II		70	c	5882.99	I
18	5195.23	I		35	c	5892.56	I
45	5221.54	I		22		5904.29	I
35	5244.47	I		70		5921.76	I
							0 - 16882
65	5251.82	I		30	c	5933.71	I
55	5275.48	I		70	cw	5948.03	I
90	5301.25	I	0 - 18858	45		5955.98	I
35	5319.24	I		70		5972.76	I
35	5319.65	I		90		5973.52	I
							0 - 16735
80	5330.11	I	0 - 18756	22		5981.43	I
90	5359.99	I	0 - 18651	230	c	5982.90	I
55	5381.40	I		55		6002.04	I
30	5384.56	I		27		6005.33	I
30	5384.97	I		35		6021.43	I
18	5393.85	I		16		6038.97	I
70	5403.17	I		27		6050.71	I
100	5407.08	I		45		6060.31	I
14	5413.62	II		120		6081.79	I
16	5434.39	II		70	cw	6133.60	I
							0 - 16438
18	5435.87	I	8378 - 26770	35		6156.38	I
30	5445.39	I		27		6156.58	I
18	5449.8	II		55		6191.68	I
30	5451.90	I	0 - 18337	70		6208.65	I
14	5454.0	II		18		6234.17	I
30	5498.57	I		45	c	6255.75	I
30	5504.51	I		70	c	6305.36	I
27	5515.56	II		22		6306.68	I
18	5516.45	II		30		6321.94	I
30	5534.33	I		30	c	6354.35	I
27	5553.14	I		30	c	6372.59	I
35	5560.94	I		14	h	6373.86	I
35	5563.6	Ho O		22	h	6413.41	I
70	5566.52	I	21378 - 39338	27	c	6471.77	I
18	5573.96	II		13		6479.17	I
35	5584.7	Ho O		11		6515.30	I
55	5591.1	Ho O		11	h	6538.99	I
55	5592.3	Ho O		70		6550.97	I
30	5607.1	Ho O		15		6560.08	I
27	5613.64	I		35	d	6600.58	I
45	5626.4	Ho O		260		6604.94	I
65	5627.60	I	8378 - 26143	55		6607.47	I
30	5628.24	II		13		6628.35	I
55	5640.62	I	22024 - 39747	120		6628.99	I
70	5655.9	Ho O		15		6632.24	I
65	5658.9	Ho O		9	h	6652.98	I
140	5659.58	I		15		6662.52	I
70	5671.84	I		19	c	6680.46	I
65	5674.70	I		24	c	6681.62	I
140	5691.47	I		15	h	6682.02	I
70	5696.3	Ho O		55	cw	6694.32	I
140	5696.57	I		15	cw	6722.34	I
27	5734.02	I		40		6745.05	I
45	5736.4	Ho O		13		6766.74	I
55	5739.24	I		28	c	6774.68	I
							17059 - 31816
22	5749.58	I		55	c	6785.43	I
30	5766.64	I		13		6793.7	I
27	5803.8	Ho O		13	cw	6811.04	I
45	5819.2	Ho O		15	cw	6820.38	I
27	5821.90	I		24		6821.64	I
							5419 - 20074
22	5839.47	I		17	c	6825.72	I
45	5849.4	Ho O		8	h	6826.62	I
140	5860.28	I	0 - 17059	8	h	6852.97	I
27	5864.42	I		17	cw	6865.85	I
45	5870.85	I	9741 - 26770	9		6883.36	I
							16882 - 31443



*Holmium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
13	6888.50	I		16	7605.35	I	
15 c	6892.96	I		12	7617.05	I	8427 - 21552
17	6897.95	I	11530 - 26023	14	7627.98	I	8378 - 21485
15 h	6903.80	I	21682 - 36163	40 c	7628.42	I	
15 cw	6913.47	I		9 c	7641.14	I	
9	6916.70	I	11689 - 26143	4	7648.16	I	
40 cw	6939.49	I	16709 - 31115	14 c	7653.80	I	
45 cw	6950.39	I		12 c	7667.30	I	
13 hl	6955.3	I		20	7690.43	I	8378 - 21378
19	6976.7	II		50 c	7693.15	I	
10	6985.11			40 cw	7715.06	I	
9	6994.38			16	7719.05	I	8427 - 21378
14 h	7000.71			16 h	7738.98	I	
10	7079.07			8 c	7752.01	I	
12	7098.58			60 cw	7815.48	I	18651 - 31443
9	7242.08	I	12339 - 26143	40 cw	7823.63	I	
9	7250.60	I	12339 - 26127	8 h	7879.22	I	
14	7308.55			60	7894.64	I	
25	7341.43			10 h	8464.66	I	9741 - 21552
18	7389.40			10 h	8482.67	I	
5 h	7496.20	I	5419 - 18756	50	8512.94	I	9741 - 21485
10 h	7510.74	I		20	8545.61	II	
140	7555.09	I		18	8601.84	II	
18	7589.20	I	8378 - 21552	40	8670.19	I	0 - 11530
25	7591.87	I		8 h	8697.32	I	
9 h	7593.64	I		16 h	8805.48	II	
7 h	7594.35	I		20 c	8834.49	I	5419 - 16735
12	7602.31	II		90	8915.98	II	

# Indium

$$\text{In, } Z = 49, M = 114.82, \text{ Ratio } \frac{\text{In}}{\text{Cu}} = 1.807$$

In I Normal state of valence electrons  $5s^2 5p^2 P_{1/2}^o = 0$ . I.P. = 46670  $\text{cm}^{-1}$ .

In II Normal state of valence electrons  $5s^2 1S_0 = 0$ . I.P. = 152195  $\text{cm}^{-1}$ .

## References

Wavelengths and Classification:

In I, F. Paschen, Ann. der Physik **32**, 148 (1938).

In II, F. Paschen and J. S. Campbell, Ann. der Physik **31**, 29 (1938).

*Indium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
180	2306.06	II	0 - 43349	180	c	I	2213 - 37452
40	2389.54	I	0 - 41836	30	c	I	0 - 34978
60	2460.08	I	0 - 40637	1100		I	2213 - 36302
30	2468.02	I	2213 - 42718	20	c	I	2213 - 36020
100	2521.37	I	2213 - 41862	8000		I	0 - 32892
1100	2560.15	I	0 - 39048	13000		I	2213 - 32916
200	2601.76	I	2213 - 40637	3000		I	2213 - 32892
1600	2710.26	I	2213 - 39098	17000		I	0 - 24373
300	2713.94	I	2213 - 39048	18000		I	2213 - 24373
700	2753.88	I	0 - 36302	8	h	I	24373 - 38972
40	2775.37	I	0 - 36020	4	h	I	24373 - 38861

# Iridium

$$\text{Ir, } Z = 77. M = 192.2, \text{ Ratio } \frac{\text{Ir}}{\text{Cu}} = 3.025$$

Ir I Normal state of valence electrons  $5d^7 6s^2 \ ^4F_{4\ 1/2} = 0$ . I.P. = 73000  $\text{cm}^{-1}$ .

Ir II Normal state of valence electrons  $5d^7 6s \ ^5F_5 = 0$ .

## References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Classification:

Ir I, W. Albertson, Phys. Rev. **54**, 183 (1938); T. A. M. van Kleef, Physica **23**, 843 (1957).

Ir II, T. A. M. van Kleef, unpublished material (1969).

### *Strong lines of iridium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
17000	2088.82	I	0 - 47858	4500	2175.24	I	0 - 45957
15000	2033.57	I	0 - 49159	4400	2924.79	I	0 - 34180
14000	2092.63	I	2835 - 50606	4100	2502.98	I	0 - 39940
9900	2010.65	I	0 - 49719	3800	2849.72	I	0 - 35081
8700	2022.35	I	2835 - 52266	3700	2083.22	I	5785 - 53772
7900	2158.05	I	2835 - 49159	3700	2148.22	I	7107 - 53642
7900	2543.97	I	2835 - 42132	3500	2152.68	II	4788 - 51227
6200	2052.22	I	6324 - 55036	3500	2372.77	I	0 - 42132
5800	2169.42	II		3500	2639.71	I	0 - 37872
5100	3220.78	I	2835 - 33874	3400	3133.32	I	6324 - 38230
5000	2060.64	I	7107 - 55619	3300	2475.12	I	0 - 40390
4500	2126.81	II	0 - 47004	3200	3513.64	I	0 - 28452
4500	2127.94	I	0 - 46979				

*Iridium — all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
9900	2010.65	I	0 - 49719	230	2357.53	II	
8700	2022.35	I	2835 - 52266	410	2358.16	I	4079 - 46472
15000	2033.57	I	0 - 49159	500	2360.73	I	9878 - 52224
6200	2052.22	I	6324 - 55036	2500	2363.04	I	6324 - 48629
5000	2060.64	I	7107 - 55619	370	2368.04	II	4788 - 47004
3700	2083.22	I	5785 - 53772	3500	2372.77	I	0 - 42132
3100	2085.74	I	7107 - 55036	290	2375.09	II	
17000	2088.82	I	0 - 47858	250	2377.28	I	7107 - 49159
14000	2092.63	I	2835 - 50606	250	2377.98	I	7107 - 49146
2700	2112.68	I	6324 - 53642	500	2379.38	I	4079 - 46094
1800	2119.54	I	0 - 47165	540	2381.62	I	6324 - 48299
2000	2125.44	I	7107 - 54141	210	2383.17	I	13088 - 55036
4500	2126.81	II	0 - 47004	85	2383.79	I	9878 - 51815
2000	2127.52	I	2835 - 49824	120	2386.58	II	
4500	2127.94	I	0 - 46979	1300	2386.89	I	6324 - 48207
3700	2148.22	I	7107 - 53642	2500	2390.62	I	2835 - 44652
2500	2150.54	I	4079 - 50564	2700	2391.18	I	2835 - 44643
3500	2152.68	II	4788 - 51227	85	2401.77	I	13088 - 54711
2900	2155.81	I	0 - 46372	230	2407.59	I	7107 - 48629
7900	2158.05	I	2835 - 49159	290	2409.37	I	4079 - 45571
2100	2162.88	I	0 - 46220	290	2410.17	I	13088 - 54566
5800	2169.42	II		290	2410.73	I	12218 - 53687
4500	2175.24	I	0 - 45957	540	2413.31	I	4079 - 45503
2700	2178.17	I	0 - 45896	370	2415.86	I	5785 - 47165
1600	2187.43	II		620	2418.11	I	7107 - 48449
1100	2190.38	II		120	2424.32	I	10579 - 51815
740	2191.64	I	2835 - 48449	120	2424.66	I	9878 - 51108
910	2208.09	II		210	2424.89	I	5785 - 47011
1300	2220.37	I	2835 - 47858	370	2424.99	I	6324 - 47549
790	2221.07	II	8187 - 53196	290	2425.66	I	6324 - 47537
2500	2242.68	II	0 - 44576	170	2426.53	II	
620	2245.76	II	11719 - 56234	50	2426.78	I	5785 - 46979
2100	2253.38	I	7107 - 51471	540	2427.61	I	4079 - 45259
	2253.49	I	4079 - 48441	540	2431.24	I	0 - 41119
2100	2255.10	I	2835 - 47165	1300	2431.94	I	4079 - 45186
1400	2255.81	I	5785 - 50101	170	2432.36	I	7107 - 48207
350	2258.51	I	9878 - 54141	100	2432.58	I	13940 - 55036
1400	2258.86	I	6324 - 50580	270	2435.14	I	13088 - 54141
830	2264.61	I	2835 - 46979	85	2436.42	I	13088 - 54119
1100	2266.33	I	6324 - 50434	250	2445.34	I	6324 - 47206
1000	2268.90	I	10579 - 54639	40	2447.49	I	17779 - 58625
660	2280.00	I	6324 - 50170	250	2447.76	I	6324 - 47165
950	2281.02	II		190	2448.23	I	5785 - 46618
660	2281.91	I	9878 - 53687	40	2449.02	I	12952 - 53772
330	2284.60	I	13940 - 57698	910	2452.81	I	2835 - 43592
330	2295.08	I	5785 - 49342	85	2454.12	I	12952 - 53687
790	2298.05	I	11831 - 55333	1300	2455.61	I	0 - 40711
	2298.16	I	6324 - 49824	230	2455.87	I	4079 - 44785
460	2299.53	I	7107 - 50580	210	2457.03	I	5785 - 46472
910	2300.50	I	6324 - 49779	210	2457.23	I	13088 - 53772
2700	2304.22	I	2835 - 46220	85	2462.36	I	13088 - 53687
410	2305.47	I	5785 - 49146	85	2463.03	I	12218 - 52807
210	2307.27	I	7107 - 50434	85	2464.90	I	11831 - 52388
910	2308.93	I	6324 - 49621	120	2465.09	I	13088 - 53642
460	2315.38	I	0 - 43176	870	2467.30	I	4079 - 44597
410	2321.45	I	7107 - 50170	3300	2475.12	I	0 - 40390
410	2321.58	I	2835 - 45896	210	2478.11	I	2835 - 43176
210	2327.98	I	12218 - 55161	40	2479.16	I	13940 - 54264
540	2333.30	I	5785 - 48629	2100	2481.18	I	0 - 40291
740	2333.84	I	6324 - 49159	100	2485.38	I	9878 - 50101
580	2334.50	I	6324 - 49146	40	2486.37	I	18547 - 58754
1600	2343.18	I	5785 - 48449	40	2486.75	I	13940 - 54141
740	2343.61	I	5785 - 48441	40	2489.20	I	16103 - 56265
100	2352.62	I	12218 - 54711	620	2493.08	I	7107 - 47206
580	2355.00	I	9878 - 52327	210	2496.27	I	6324 - 46372

*Iridium—all observed lines—Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	2500.27	I	11831 - 51815	50	2628.20	I	16103 - 54141
250	2502.63	I	9878 - 49824	40	2629.41	I	13088 - 51108
4100	2502.98	I	0 - 39940	700	2634.17	I	12218 - 50170
170	2504.37	I	17779 - 57697	170	2635.27	I	4079 - 42014
120	2505.74	I	6324 - 46220	35	2638.97	I	12218 - 50101
85	2506.60	I	12506 - 52388	250	2639.42	I	2835 - 40711
120	2507.63	I	10579 - 50445	3500	2639.71	I	0 - 37872
85	2508.35	I	12952 - 52807	50	2640.38	I	10579 - 48441
170	2509.71	I	12218 - 52052	210	2644.19	I	5785 - 43592
170	2511.94	I	12506 - 52304	170	2653.76	I	9878 - 47549
170	2512.58	II	4788 - 44575	70	2653.95	I	16103 - 53772
210	2513.71	I	6324 - 46094	100	2656.81	I	10579 - 48207
120	2515.36	I	9878 - 49621	35	2657.71	I	11831 - 49446
40	2524.88	II		1800	2661.98	I	2835 - 40390
170	2525.05	I	10579 - 50170	350	2662.63	I	7107 - 44652
40	2526.77	I	19061 - 58625	80	2663.31	I	7107 - 44643
50	2532.20	I	18547 - 58027	2700	2664.79	I	0 - 37515
120	2532.52	I	5785 - 45259	140	2668.99	I	2835 - 40291
990	2533.13	I	9878 - 49342	55	2669.46	I	16103 - 53553
1100	2534.46	I	2835 - 42279	520	2669.91	I	4079 - 41522
580	2537.22	I	5785 - 45186	520	2671.84	I	5785 - 43201
170	2537.68	I	16103 - 55497	330	2673.61	I	5785 - 43176
40	2538.88	I	12952 - 52327	120	2676.83	I	13088 - 50434
40	2540.40	I	12952 - 52304	95	2679.06	I	11831 - 49146
100	2541.48	I	11831 - 51166	55	2681.10	I	5785 - 43072
580	2542.02	I	5785 - 45112	27	2682.46	I	6324 - 43592
40	2542.80	II		110	2684.04	I	10579 - 47825
7900	2543.97	I	2835 - 42132	55	2691.06	I	12952 - 50101
150	2545.54	I	12952 - 52224	270	2692.34	I	4079 - 41210
790	2546.03	I	7107 - 46372	27	2692.88	I	12218 - 49342
120	2547.20	I	6324 - 45571	27	2693.49	I	17779 - 54895
120	2547.69	I	13088 - 52327	3000	2694.23	I	2835 - 39940
210	2551.40	I	12952 - 52134	110	2704.03	I	2835 - 39806
190	2554.40	I	13088 - 52224	40	2704.93	I	10579 - 47537
210	2555.35	I	4079 - 43202	27	2706.88	I	17779 - 54711
170	2555.88	I	7107 - 46220	160	2712.74	I	6324 - 43176
150	2563.28	I	5785 - 44785	70	2720.45	I	6324 - 43072
910	2564.18	I	7107 - 46094	35	2723.76	I	16103 - 52807
210	2569.88	I	12952 - 51852	40	2729.56	I	10579 - 47204
100	2570.62	I	12218 - 51108	55	2730.71	I	11831 - 48441
70	2572.07	I	10579 - 49446	70	2732.67	I	12218 - 48802
70	2572.37	I	12952 - 51815	35	2739.32	I	13940 - 50434
230	2572.70	I	5785 - 44643	35	2740.00	I	7107 - 43592
740	2577.26	I	7107 - 45896	35	2740.18	I	5785 - 42268
100	2578.71	I	16565 - 55333	140	2744.00	I	10579 - 47011
70	2578.91	I	13088 - 51852	27	2747.51	I	19593 - 55979
35	2579.49	II	17478 - 56234	27	2749.32	I	17779 - 54141
35	2583.18	I	18547 - 57248	80	2758.23	I	5785 - 42029
740	2592.06	I	0 - 38568	70	2759.32	I	12218 - 48449
740	2599.04	I	7107 - 45571	55	2759.91	I	12218 - 48441
150	2602.04	I	16565 - 54985	27	2767.65	I	16103 - 52224
190	2604.55	I	13088 - 51471	80	2771.61	I	7107 - 43176
190	2607.52	I	13088 - 51427	330	2772.46	I	13088 - 49146
700	2608.25	I	6324 - 44652	27	2774.58	I	16103 - 52134
1800	2611.30	I	2835 - 41119	250	2775.55	I	9878 - 45896
70	2612.04	I	6324 - 44597	80	d 2777.43	I	11831 - 47825
210	2614.98	I	0 - 38230			I	17779 - 53772
70	d 2615.88	I	16103 - 54320	520	2781.29	I	6324 - 42268
	2616.00	I	12952 - 51166	330	2785.22	I	10579 - 46472
330	2617.78	I	4079 - 42268	80	2796.46	I	16103 - 51852
210	2619.88	I	0 - 38158	540	2797.35	I	5785 - 41522
70	2623.64	II		1600	2797.70	I	2835 - 38568
250	2625.32	I	7107 - 45186	380	2798.18	I	4079 - 39806
40	2625.67	I	16565 - 54639	40	2799.74	I	16681 - 52388
100	2626.76	I	12506 - 50564	410	2800.82	I	9878 - 45571

*Iridium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	2812.80	I	13088 - 48629	160	3011.69	I	9878 - 43072
680	2823.18	I	0 - 35411	120	3016.43	I	12952 - 46094
1200	2824.45	I	2835 - 38230	270	3017.31	I	13088 - 46221
70	2830.17	I	2835 - 38158	140	3019.23	I	26307 - 59419
55	2830.51	I	12218 - 47538	80	3020.01	I	26307 - 59410
40	2831.36	I	9878 - 45186	80	3022.41	I	26307 - 59384
110	2833.24	II	11719 - 47004	110	3025.82	I	13940 - 46979
110	2835.66	I	12952 - 48206	380	3029.36	I	6324 - 39324
820	2836.40	I	4079 - 39324	70	3032.41	I	12218 - 45186
160	2837.33	I	9878 - 45112	40	3033.62	I	11831 - 44786
1100	2839.16	I	13088 - 48299	95	3037.75	I	12506 - 45415
	2839.24	I	4079 - 39289	330	3039.26	I	12218 - 45112
820	2840.22	I	6324 - 41522	55	3040.47	I	18547 - 51427
160	2842.28	I	7107 - 42279	35	3042.65	II	11719 - 44576
3800	2849.72	I	0 - 35081	300	3047.16	I	13088 - 45896
40	d 2855.82	I	18547 - 53553	300	3049.44	I	5785 - 38568
	2855.93	I	16103 - 51108	40	3052.16	I	19061 - 51815
40	2860.66	I	12218 - 47165	80	3053.60	I	11831 - 44570
110	2863.84	I	9878 - 44786	300	3057.28	I	7107 - 39806
55	2866.69	I	12952 - 47825	70	3061.41	I	17779 - 50434
35	2867.63	I	16565 - 51427	40	3064.51	I	10579 - 43201
80	2869.70	I	10579 - 45415	1600	3068.89	I	2835 - 35411
380	2875.60	I	9878 - 44643	190	3069.09	I	5785 - 38358
380	2875.98	I	12218 - 46979	190	3069.71	I	12218 - 44785
270	2877.68	I	5785 - 40525	170	3076.69	I	10579 - 43072
140	2879.41	I	9878 - 44597	320	3083.22	I	12218 - 44643
55	2881.16	I	12506 - 47204	240	3086.44	I	9878 - 42268
820	2882.64	I	2835 - 37515	390	3088.04	I	5785 - 38158
650	2897.15	I	5785 - 40291	70	3094.01	I	4079 - 36390
80	2899.63	I	16103 - 50580	510	3100.29	I	2835 - 35081
35	2900.39	I	19593 - 54061	510	3100.45	I	6324 - 38568
260	2901.95	I	13088 - 47538	60	3114.05	I	16103 - 48206
260	2904.80	I	7107 - 41522	90	3114.55	I	13088 - 45186
40	2905.64	I	4079 - 38485	340	3120.76	I	6324 - 38358
200	2907.24	I	6324 - 40711	200	3121.78	I	13088 - 45112
70	2909.56	I	13940 - 48299	90	3122.38	I	13940 - 45957
440	2916.36	I	4079 - 38358	70	3128.39	I	13940 - 45896
230	2918.57	I	12218 - 46472	70	3133.09	I	5785 - 37693
4400	2924.79	I	0 - 34180	3400	3133.32	I	6324 - 38230
80	2930.63	I	12506 - 46618	70	3140.41	I	12952 - 44786
1200	2934.64	I	6324 - 40390	70	3145.07	I	28452 - 60239
880	2936.68	I	4079 - 38121	190	3150.61	I	5785 - 37515
250	2938.47	I	5785 - 39806	70	3154.55	I	12952 - 44643
190	2939.27	I	7107 - 41119	190	3154.74	I	10579 - 42268
140	2940.54	I	16103 - 50101	190	3159.15	I	12952 - 44597
40	2941.08	I	10579 - 44570	140	3168.18	I	13088 - 44643
2700	2943.15	I	6324 - 40291	490	3168.88	I	6324 - 37872
230	2946.97	I	13088 - 47011	370	3177.58	I	7107 - 38568
200	2949.76	I	13088 - 46979	170	3180.35	I	16103 - 47538
1200	2951.22	I	0 - 33874	370	3198.92	I	7107 - 38358
150	2962.99	I	11831 - 45571	610	3212.12	I	7107 - 38230
50	2965.20	I	9878 - 43592	70	3213.55	I	19061 - 50170
35	2968.49	I	12218 - 45896	70	3218.46	I	16103 - 47165
27	2974.10	I	4079 - 37693	370	3219.51	I	7107 - 38158
200	2974.95	I	16565 - 50170	5100	3220.78	I	2835 - 33874
440	2980.65	I	5785 - 39324	100	3221.28	I	28452 - 59487
150	2985.80	I	6324 - 39806	300	3229.28	I	12218 - 43176
190	2990.62	I	11831 - 45259	100	3230.76	I	10579 - 41522
300	2996.08	I	4079 - 37446	60	3232.00	I	28452 - 59384
70	2997.19	I	11831 - 45186	470	3241.52	I	4079 - 34920
180	2997.41	I	12218 - 45571	80	3254.40	I	19061 - 49779
220	3002.25	I	9878 - 43176	200	3262.01	I	9878 - 40525
600	3003.63	I	7107 - 40390	390	3266.44	I	5785 - 36390
80	3005.21	I	13940 - 47206	160	3277.28	I	13088 - 43592
40	3009.90	I	16565 - 49779	60	3287.06	I	9878 - 40291

*Iridium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	3287.59	I	7107 - 37515	23	4127.92	I	13940 - 38158
160	3310.52	I	11831 - 42029	27	4155.70	I	28452 - 52509
80	3312.13	I	11831 - 42014	15	4166.04	I	9878 - 33874
200	3322.60	I	13088 - 43176	90	4172.56	I	16565 - 40525
80	3322.87	I	19060 - 49147	35	4182.47	I	32513 - 56416
130	3334.16	I	13088 - 43072	15	4183.21	I	38230 - 62128
60	3338.37	I	10579 - 40525	18	4185.66	I	12506 - 36390
560	3368.48	I	2835 - 32513	23	4197.54	I	11831 - 35648
60	3419.42	I	13940 - 43176	27	4217.76	I	16103 - 39806
660	3437.02	I	6324 - 35411	13	4220.80	I	26365 - 50050
100	3437.50	I	16103 - 45186	75	4259.11	I	2835 - 26308
410	3448.97	I	4079 - 33065	27	4265.30	I	12952 - 36390
80	3476.46	I	6324 - 35081	260	4268.10	I	7107 - 30530
60	3477.77	I	10579 - 39325	23	4286.62	I	12218 - 35540
80	3484.48	I	9878 - 38568	75	4301.60	I	16565 - 39806
3200	3513.64	I	0 - 28452	55	4310.59	I	12218 - 35411
220	3515.95	I	7107 - 35540	220	4311.50	I	9878 - 33065
410	3522.03	I	4079 - 32464	18	4351.30	I	18547 - 41522
160	3557.17	I	16681 - 44785	18	4352.56	I	19061 - 42029
320	3558.99	I	5785 - 33874	18	4392.59	I	16565 - 39325
60	3568.00	I	12506 - 40525	160	4399.47	I	16565 - 39289
1200	3573.72	I	7107 - 35081	65	4403.78	I	12218 - 34920
320	3594.39	I	7107 - 34920	110	4426.27	I	9878 - 32464
220	3609.77	I	2835 - 30530	15	4450.18	I	16103 - 38568
190	3617.21	I	9878 - 37515	55	4478.48	I	13088 - 35411
80	3625.71	I	12952 - 40525	16	4495.35	I	33065 - 55304
160	3626.29	I	9878 - 37446	11	4496.03	I	34180 - 56416
660	3628.67	I	6324 - 33874	55	4545.68	I	13088 - 35081
220	3636.20	I	11831 - 39324	30	4548.48	I	30530 - 52509
300	3661.71	I	13088 - 40390	13	4550.78	I	12952 - 34920
300	3664.62	I	5785 - 33065	35	4568.09	I	10579 - 32464
320	3674.98	I	13088 - 40291	18	4570.02	I	23310 - 45186
200	3687.08	I	10579 - 37693	18	4604.48	I	35081 - 56793
80	3698.10	I	19060 - 46094	75	4616.39	I	12218 - 33874
140	3725.38	I	19060 - 45896	26	4656.18	I	13940 - 35411
200	3731.36	II		17	4668.99	I	16103 - 37515
130	3738.53	I	6324 - 33065	21	4708.88	I	19060 - 40291
530	3747.20	I	5785 - 32464	50	4728.86	I	13940 - 35081
40	3750.40	I	32831 - 59487	21	4731.86	I	16565 - 37693
40	3753.32	I	16565 - 43201	26	4756.46	I	33874 - 54893
65	3768.68	I	11831 - 38358	13	4757.96	I	16681 - 37693
50	3770.73	I	9878 - 36390	65	4778.16	I	12952 - 33874
120	3793.79	I	13940 - 40291	30	4795.67	I	12218 - 33065
35	3794.06	I	12218 - 38568	10	4807.14	I	19593 - 40390
3100	3800.12	I	0 - 26308	21	4809.47	I	13088 - 33874
230	3817.24	I	6324 - 32513	10	4840.77	I	9878 - 30530
170	3865.64	I	11831 - 37693	17	4845.38	I	11831 - 32464
480	3902.51	I	2835 - 28452	50	4938.09	I	12218 - 32464
95	3902.66	I	12952 - 38568	26	4970.48	I	12952 - 33065
480	3915.38	I	9878 - 35411	25	4999.74	I	32513 - 52509
400	3934.84	I	7107 - 32513	25	5002.74	I	6324 - 26308
120	3946.27	I	16681 - 42014	17	5009.17	I	12506 - 32464
65	3951.95	I	12218 - 37515	30	5014.98	I	13940 - 33874
30	3952.62	I	17779 - 43072	17	5046.06	I	35081 - 54893
30	3962.78	I	12218 - 37446	30	5123.66	I	12952 - 32464
35	3966.09	I	12952 - 38158	20	5177.95	I	16103 - 35411
590	3976.31	I	13088 - 38230	22	5238.92	I	16565 - 35648
460	3992.12	I	9878 - 34920	12	5340.74	I	23310 - 42029
180	4020.03	I	26307 - 51176	35	5364.32	I	19593 - 38230
350	4033.76	I	13088 - 37872	75	5449.50	I	32831 - 51176
130	4040.08	I	5785 - 30530	30	5454.50	I	34180 - 52509
370	4069.92	I	12952 - 37515	7	5469.40	I	19593 - 37872
150	4070.68	I	11831 - 36390	10	5620.04	I	37515 - 55304
100	4092.61	I	13088 - 37515	45	5625.55	I	16103 - 33874
140	4115.78	I	13940 - 38230	10	5828.55	I	38230 - 55382

*Iridium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
10	5882.30	I	34180 - 51176	7	6334.44	I	16681 - 32464
7	5887.36	I	23310 - 40291	5	6624.73	I	40291 - 55382
35	5894.06	I	16103 - 33065	10	6686.08	I	39940 - 54893
7	6026.10	I	13940 - 30530	5	6830.01	I	37872 - 52509
12	6067.83	I	39940 - 56416	5	6929.88	I	16103 - 30530
20	6110.67	I	16103 - 32464	4	7183.71	I	18547 - 32464
12	6288.28	I	16565 - 32464	6	7834.32	I	42132 - 54893



# Iron

$$\text{Fe, } Z = 26, M = 55.85, \text{ Ratio } \frac{\text{Fe}}{\text{Cu}} = 0.879$$

Fe I Normal state of valence electrons  $3d^6 4s^2 \ ^5D_4 = 0$ . I.P. =  $63700 \text{ cm}^{-1}$ .

Fe II Normal state of valence electrons  $3d^6 4s \ ^6D_{4.1/2} = 0$ . I.P. =  $130524 \text{ cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

Fe I, H. N. Russell, C. E. Moore, and D. W. Weeks, Trans. Am. Phil. Soc. **34**, 111 (1944).

Fe II, J. C. Dobbie, Ann. Solar Phys. Observatory, Cambridge, England, **5**, 1 (1938).

### Strong lines of iron

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
7000	3734.87	I	6928 - 33695	2800	2522.85	I	0 - 39626
6000	3581.20	I	6928 - 34844	2800	3020.64	I	0 - 33096
6000	3719.94	I	0 - 26875	2600	2488.15	I	416 - 40594
5000	3820.43	I	6928 - 33096	2600	2719.02	I	0 - 36767
4200	3859.91	I	0 - 25900	2400	3745.56	I	704 - 27395
4000	3440.61	I	0 - 29056	2000	2599.40	II	0 - 38459
4000	3570.10	I	7377 - 35379	2000	3608.86	I	8155 - 35856
4000	3749.49	I	7377 - 34040	2000	3618.77	I	7986 - 35612
3600	2166.77	I	0 - 46137	2000	3631.46	I	7728 - 35257
3400	3737.13	I	416 - 27167	1800	2489.75	I	978 - 41131
3200	3825.88	I	7377 - 33507	1800	2490.64	I	704 - 40842
3000	2084.12	I	0 - 47967	1800	3886.28	I	416 - 26140
3000	3758.24	I	7728 - 34329	1700	2966.90	I	0 - 33695
3000	4045.82	I	11976 - 36686	1700	3763.79	I	7986 - 34547
2800	2483.27	I	0 - 40257	1700	4383.55	I	11976 - 34782

Iron — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
3000	2084.12	I	0 - 47967	1400	2491.16	I	888 - 41018
3600	2166.77	I	0 - 46137	180	2493.18	II	21430 - 61528
1500	2178.09	I	416 - 46314		2493.26	II	21252 - 61347
630	2191.84	I	704 - 46314	140	2496.53	I	7377 - 47420
600	2196.04	I	888 - 46410	100	2498.89	I	416 - 40422
						II	21582 - 61587
220	2297.79	I	416 - 43923				
260	2332.80	II	385 - 43239	900	2501.13	I	0 - 39970
140	2338.00	II	863 - 43621	35	2501.70	I	6928 - 46889
360	2343.49	II	0 - 42658	100	2507.90	I	7728 - 47590
120	2348.10	II	1873 - 44447	900	2510.83	I	416 - 40231
120	2348.30	II	668 - 43239	70	2511.76	II	21712 - 61513
110	2359.10	II	863 - 43239	70	2512.36	I	416 - 40207
110	2360.00	II	1873 - 44233	90	2517.66	I	7986 - 47693
90	2360.29	II	2430 - 44785	700	2518.10	I	704 - 40405
200	2364.83	II	385 - 42658	60	2519.63	I	8155 - 47831
100	2368.60	II	2838 - 45044	2800	2522.85	I	0 - 39626
260	2373.73	II	0 - 42115	140	2523.66	I	
70	2375.19	II	3118 - 45207	500	2524.29	I	888 - 40491
150	2379.28	II	2430 - 44447	60	2525.02	I	
150	2380.76	II	668 - 42658	70	2525.39	II	21252 - 60838
1300	2382.04	II	0 - 41968	50	2526.30	II	20831 - 60402
80	2383.24	II	2838 - 44785	1400	2527.43	I	416 - 39970
60	2384.39	II	3118 - 45044	500	2529.13	I	704 - 40231
320	2388.63	II	385 - 42237	60	2529.55	II	22637 - 62158
1100	2395.62	II	385 - 42115	160	2529.83	I	888 - 40405
360	2399.24	II	668 - 42335	70	2530.69	I	704 - 40207
70	2404.43	II	863 - 42440	70	2533.63	II	21430 - 60888
1000	2404.88	II	668 - 42237	60	2533.80	I	
300	2406.66	II	863 - 42401	60	2534.42	II	21712 - 61157
300	2410.52	II	863 - 42335	700	2535.60	I	978 - 40405
220	2411.07	II	977 - 42440	120	2536.82	II	21582 - 60990
220	2413.31	II	977 - 42401	120	2537.17		
50	2424.14	II	22637 - 63876	70	2538.81	II	21430 - 60807
35	2430.07	II	22810 - 63949	70	2539.00	II	21252 - 60625
80	2439.74	I	19390 - 60366	800	2540.98	I	888 - 40231
60	2440.11	I	19788 - 60758	160	2542.10	I	21039 - 60365
110	2442.57	I	19621 - 60549	35	2543.38	II	21582 - 60888
50	2443.87	I	6928 - 47835	160	2543.92	I	20875 - 60172
40	2444.51	II	20831 - 61726	70	2544.71	I	20641 - 59927
30	2445.56	II	21812 - 62690	800	2545.98	I	704 - 39970
70	2447.71	I	0 - 40842	650	2549.61	I	416 - 39626
60	2453.47	I	7377 - 48123	25	2550.02	II	26353 - 65556
180	2457.60	I	6928 - 47606	60	2551.09	I	
70	2458.78	II	25805 - 66464	200	2562.53	II	7955 - 46967
110	2462.18	I	416 - 41018	130	2563.47	II	8392 - 47390
700	2462.64	I	0 - 40594	60	2566.91	II	8680 - 47626
35	2463.73	I	7728 - 48305	60	2570.52	II	
140	2465.15	I	7377 - 47930	40	2574.37	II	20831 - 59663
35	2467.73	I	7728 - 48239	60	2575.74	I	
140	2468.88	I	6928 - 47420	100	2576.69	I	6928 - 45726
140	2472.34	I	6928 - 47363	90	2577.92	II	8847 - 47626
900	2472.88	I	704 - 41131	50	2582.30	I	
	2472.91	I	416 - 40842	90	2582.58	II	8680 - 47390
220	2474.81	I	7728 - 48123	260	2584.54	I	6928 - 45608
70	2479.48	I	7986 - 48305	650	2585.88	II	0 - 38660
1000	2479.78	I	704 - 41018	90	2588.00	I	
2800	2483.27	I	0 - 40257	90	2591.54	II	8392 - 46967
900	2484.19	I	888 - 41131	30	2592.78	II	32875 - 71432
90	2486.37	I	0 - 40207	90	2593.73	II	8847 - 47390
70	2486.69	I	7728 - 47930	650	2598.37	II	385 - 38859
90	2487.06	I	8155 - 48351	2000	2599.40	II	0 - 38459
35	2487.37	I	704 - 40895	300	2599.57	I	7377 - 45833
2600	2488.15	I	416 - 40594	80	2605.65	I	6928 - 45295
1800	2489.75	I	978 - 41131	160	2606.82	I	7377 - 45726
1800	2490.64	I	704 - 40842	650	2607.09	II	668 - 39013

Iron—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
800	2611.87	II	385 - 38660	750	2755.74	II	7955 - 44233
320	2613.82	II	863 - 39109	240	2756.26	I	416 - 36686
320	2617.62	II	668 - 38859		2756.33	I	888 - 37158
120	2618.02	I	7728 - 45914	80	2757.32	I	8155 - 44411
90	2620.41	II	863 - 39013	20	2759.82	I	8155 - 44378
170	2621.67	II	977 - 39109	150	2761.78	I	7986 - 44184
150	2623.53	I	7728 - 45833		2761.81	II	8847 - 45044
440	2625.67	II	385 - 38459	160	2762.03	I	7728 - 43923
320	2628.29	II	977 - 39013	50	2763.11	I	7986 - 44166
40	2629.59	I	978 - 38996	20	2764.33	I	17727 - 53892
550	2631.05	II	863 - 38859	20	2766.91	I	8155 - 44285
550	2631.32	II	668 - 38660	180	2767.50	II	26170 - 62293
80	2632.24	I	7986 - 45965		2767.52	I	7377 - 43500
160	2635.81	I	7986 - 45914	180	2772.08	I	6928 - 42992
60	2641.65	I	7377 - 45221	30	2773.24	I	
120	2644.00	I	8155 - 45965	30	2774.73	I	8155 - 44184
30	2647.56	I	416 - 38175	150	2778.22	I	6928 - 42912
40	2656.15	I	19390 - 57028	30	2778.84	I	
30	2662.06	I	7728 - 45282	35	2781.84	I	7986 - 43923
70	2664.66	II	27315 - 64832	700	2788.10	I	6928 - 42784
50	2666.64	II	27620 - 65110	20	2789.80	I	21716 - 57550
100	2666.82	I	6928 - 44415	25	2791.79	I	19621 - 55430
180	2679.06	I	6928 - 44244	20	2795.01	I	0 - 35768
120	2689.21	I	7377 - 44551	80	2797.78	I	7377 - 43109
80	2699.11	I	7377 - 44415	150	2804.52	I	7377 - 43023
40	2703.99	II	27315 - 64286	160	2806.98	I	7377 - 42992
60	2706.02	I	19390 - 56334	420	2813.29	I	7377 - 42912
180	2706.58	I	7728 - 44664	20	2817.51	I	7728 - 43210
70	2708.57	I	20641 - 57550	500	2823.28	I	7728 - 43138
20	2710.55	I	12969 - 49851	150	2825.56	I	7728 - 43109
80	2711.65	I	7377 - 44244	30	2825.69	I	0 - 35379
190	2714.41	II	7955 - 44785	25	2828.81	I	7986 - 43326
100	2718.44	I	7986 - 44761	320	2832.44	I	7728 - 43023
2600	2719.02	I	0 - 36767	25	2835.46	I	0 - 35257
1200	2720.90	I	416 - 37158	100	2838.12	I	7986 - 43210
700	2723.58	I	704 - 37410	25	2840.42	I	416 - 35612
80	2724.96	I	7728 - 44415	90	2843.63	I	7377 - 42533
80	2726.05	I	8155 - 44827	260	2843.98	I	7986 - 43138
180	2727.54	II	8392 - 45044	70	2845.60	I	7728 - 42860
60	2728.02	I	7377 - 44023	16	2848.72	I	7986 - 43079
50	2728.82	I	19788 - 56423	380	2851.80	I	8155 - 43210
90	2730.74	II	8680 - 45290	50	2863.44	I	11976 - 46889
700	2733.58	I	6928 - 43500	40	2863.86	I	704 - 35612
30	2734.00	I	7986 - 44551	25	2866.63	I	7986 - 42860
30	2734.27	I	17550 - 54112	80	2869.31	I	416 - 35257
280	2735.48	I	7377 - 43923	50	2872.34	I	7728 - 42533
100	2736.97	II	8680 - 45207	100	2874.17	I	0 - 34782
700	2737.31	I	888 - 37410	25	2875.30	I	11976 - 46745
750	2739.55	II	7955 - 44447	50	2877.30	I	11976 - 46721
80	2742.26	I	7728 - 44184	10	2887.81	I	21716 - 56334
550	2742.41	I	704 - 37158	80	2894.50	I	18378 - 52916
280	2743.20	II	8847 - 45290	40	2895.04	I	12561 - 47093
50	2743.56	I	7728 - 44166	40	2899.42	I	18378 - 52858
300	2744.07	I	978 - 37410	20	2901.92	I	19350 - 53800
60	2744.53	I	7986 - 44411	25	2907.52	I	21999 - 56383
420	2746.48	II	8680 - 45080	200	2912.16	I	0 - 34329
380	2746.98	I	6928 - 43321	80	2918.03	I	26106 - 60366
		II	8392 - 44785	50	2920.69	I	12969 - 47197
120	2749.18	II	8680 - 45044	80	2923.29	I	26351 - 60549
600	2749.32	II	8392 - 44754	50	2923.85	I	21716 - 55907
700	2750.14	I	416 - 36767	60	2926.59	II	7955 - 42115
30	2750.88	I	17550 - 53892	200	2929.01	I	416 - 34547
80	2753.29	II	26353 - 62662	800	2936.90	I	0 - 34040
40	2753.69	I	8155 - 44459	130	2941.34	I	704 - 34692
40	2754.04	I	7986 - 44285	35	2944.40	II	13673 - 47626

Iron— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
800	2947.88	I	416 - 34329	110	3125.65	I	7986 - 39970
35	2948.43	I	21999 - 55906	70	3175.45	I	19351 - 50833
600	2953.94	I	704 - 34547	140	3180.23	I	19757 - 51192
320	2957.36	I	888 - 34692	60	3184.90	I	416 - 31805
80	2959.99	I	21716 - 55490	70	3191.66	I	0 - 31323
180	2965.26	I	978 - 34692	70	3192.80	I	20020 - 51331
1700	2966.90	I	0 - 33695	110	3193.23	I	0 - 31307
40	2969.36	I	888 - 34556	240	3196.93	I	19562 - 50833
80	2969.48	I	6928 - 40594	140	3199.52	I	19562 - 50808
340	2970.10	I	888 - 34547	150	3200.48	I	19913 - 51149
600	2973.13	I	704 - 34329	110	3205.40	I	20020 - 51208
1200	2973.24	I	416 - 34040	70	3210.83	I	19913 - 51048
10	2976.13	I	18378 - 51969	150	3211.99	I	19351 - 50475
10	2980.54	I	22249 - 55791	300	3214.04	I	19757 - 50862
280	2981.45	I	416 - 33947	60	3214.40	I	704 - 31805
12	2981.85	I	17550 - 51077	70	3215.94	I	19913 - 50999
1400	2983.57	I	0 - 33507	50	3217.38	I	19351 - 50423
120	2984.78	I	6928 - 40422	120	3219.58	I	19757 - 50808
	2984.83	II	13474 - 46967	70	3219.81	I	19562 - 50611
12	2986.46	I	888 - 34363	340	3222.07	I	19351 - 50378
120	2987.29	I	7377 - 40842	500	3225.79	I	19351 - 50342
50	2990.39	I	21999 - 55430	190	3227.75	II	13474 - 44447
1200	2994.43	I	416 - 33802		3227.80	I	19562 - 50534
10	2996.39	I	19552 - 52916	70	3230.97	I	19757 - 50699
360	2999.51	I	6928 - 40257	70	3233.97	I	19562 - 50475
50	3000.45	I	11976 - 45295	300	3239.44	I	19562 - 50423
1100	3000.95	I	704 - 34017	220	3244.19	I	19562 - 50378
100	3003.03	I	7728 - 41018	130	3265.62	I	17550 - 48163
35	3007.14	I	11976 - 45221	150	3271.00	I	17727 - 48290
100	3007.28	I	704 - 33947	280	3286.76	I	17550 - 47967
900	3008.14	I	888 - 34122	280	3305.97	I	17727 - 47967
280	3009.57	I	7377 - 40594	280	3306.35	I	17927 - 48163
50	3011.48	I	22249 - 55446	60	3355.23	I	26627 - 56423
80	3016.18	I	7986 - 41131	80	3369.55	I	21999 - 51668
200	3017.63	I	888 - 34017	120	3370.79	I	21716 - 51374
180	3018.98	I	7728 - 40842	80	3383.98	I	17550 - 47093
600	3020.49	I	704 - 33802	70	3392.31	I	17727 - 47197
2800	3020.64	I	0 - 33096	150	3392.66	I	17550 - 47017
1600	3021.07	I	416 - 33507	220	3399.34	I	17727 - 47136
260	3024.03	I	888 - 33947	150	3404.36	I	17727 - 47093
180	3025.64	I	19390 - 52431	300	3407.46	I	17550 - 46889
380	3025.84	I	978 - 34017	230	3413.14	I	17727 - 47017
180	3026.46	I	7986 - 41018	150	3417.84	I	17927 - 47177
190	3030.15	I	19621 - 52613	150	3418.51	I	17927 - 47172
190	3031.22	I	19788 - 52769	80	3422.66	I	17927 - 47136
190	3031.64	I	8155 - 41131	160	3424.29	I	17550 - 46745
950	3037.39	I	888 - 33802	70	3426.39	I	17550 - 46727
170	3040.43	I	7377 - 40257	70	3426.64	I	17727 - 46902
70	3041.64	I	12561 - 45428	320	3427.12	I	17550 - 46721
120	3041.74	I	7728 - 40594	80	3428.20	I	17727 - 46889
60	3042.02	I	8155 - 41018	4000	3440.61	I	0 - 29056
190	3042.66	I	7986 - 40842	800	3440.99	I	416 - 29469
1300	3047.60	I	704 - 33507	400	3443.88	I	704 - 29733
60	3055.26	I	12561 - 45282	160	3445.15	I	17727 - 46745
650	3057.45	I	6928 - 39626	50	3447.28	I	17727 - 46727
1000	3059.09	I	416 - 33096	80	3450.33	I	17927 - 46902
400	3067.24	I	7377 - 39970	80	3451.92	I	17927 - 46889
340	3075.72	I	7728 - 40231	80	3452.28	I	7728 - 36686
240	3083.74	I	7986 - 40405	600	3465.86	I	888 - 29733
200	3091.58	I	8155 - 40491	800	3475.45	I	704 - 29469
550	d 3099.90	I	8155 - 40405	320	3476.70	I	978 - 29733
	3099.97	I	7377 - 39626	60	3485.34	I	17727 - 46410
260	3100.30	I	7986 - 40231	800	3490.58	I	416 - 29056
260	3100.67	I	7728 - 39970	60	3495.29	I	20641 - 49243
60	3116.63	I	8155 - 40231	80	3497.11	I	17550 - 46137

*Iron— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	3497.84	I	888 - 29469	750	3727.62	I	7728 - 34547
60	3506.50	I	18378 - 46889	120	3732.40	I	17727 - 44512
400	3513.82	I	6928 - 35379	700	3733.32	I	888 - 27666
360	3521.26	I	7377 - 35768	7000	3734.87	I	6928 - 33695
180	3526.04	I	704 - 29056	3400	3737.13	I	416 - 27167
130	3526.17	I	7728 - 36079	70	3738.31	I	26351 - 53094
80	3533.20	I	23245 - 51540	600	3743.36	I	7986 - 34692
200	3536.56	I	23193 - 51461	2400	3745.56	I	704 - 27395
240	3541.09	I	22997 - 51229	600	3745.90	I	978 - 27666
220	3542.08	I	23111 - 51335	1400	3748.26	I	888 - 27560
60	3553.74	I	28820 - 56951	4000	3749.49	I	7377 - 34040
280	3554.93	I	22846 - 50968	70	3753.61	I	17550 - 44184
650	3558.52	I	7986 - 36079	3000	3758.24	I	7728 - 34329
1600	3565.38	I	7728 - 35768	60	3760.05	I	19390 - 45978
4000	3570.10	I	7377 - 35379	16	3760.53	I	17927 - 44512
6000	3581.20	I	6928 - 34844	1700	3763.79	I	7986 - 34547
130	3584.66	I	21716 - 49604	140	3765.54	I	26106 - 52655
360	3585.32	I	7728 - 35612	1200	3767.19	I	8155 - 34692
300	3585.71	I	7377 - 35257	10	3774.83	I	17927 - 44411
130	3586.11	I	26106 - 53983	10	3776.46	I	17550 - 44023
400	3586.99	I	7986 - 35856	30	3785.95	I	19621 - 46027
70	3589.11	I	6928 - 34782	30	3786.68	I	8155 - 34556
80	3594.64	I	22997 - 50808	460	3787.88	I	8155 - 34547
160	3603.21	I	21716 - 49461	60	3790.10	I	7986 - 34363
240	3605.46	I	21999 - 49727	30	3794.34	I	19788 - 46136
320	3606.68	I	21716 - 49434	650	3795.00	I	7986 - 34329
2000	3608.86	I	8155 - 35856	60	3797.52	I	26106 - 52431
200	3610.16	I	22650 - 50342	320	3798.51	I	7377 - 33695
130	3617.79	I	24336 - 51969	480	3799.55	I	7728 - 34040
2000	3618.77	I	7986 - 35612	120	3805.34	I	26628 - 52899
240	3621.46	I	21999 - 49604	60	3806.70	I	26351 - 52613
160	3622.00	I	22249 - 49851	30	3807.54	I	17927 - 44184
80	3623.19	I	19390 - 46982	320	3812.96	I	7728 - 33947
50	3625.15	I	22846 - 50423	1600	3815.84	I	11976 - 38175
2000	3631.46	I	7728 - 35257	5000	3820.43	I	6928 - 33096
80	3632.04	I	24772 - 52297	70	3821.18	I	26351 - 52514
130	3638.30	I	22249 - 49727	800	3824.44	I	0 - 26140
220	3640.39	I	21999 - 49461	3200	3825.88	I	7377 - 33507
60	3645.82	I	25091 - 52512	1300	3827.82	I	12561 - 38678
1600	3647.84	I	7377 - 34782	30	3833.31	I	20641 - 46721
160	3649.51	I	21716 - 49109	1300	3834.22	I	7728 - 33802
300	3651.47	I	22249 - 49628	35	3839.26	I	24575 - 50614
80	3659.52	I	19788 - 47107	800	3840.44	I	7986 - 34017
160	3669.52	I	21999 - 49243	800	3841.05	I	12969 - 38996
200	3677.63	I	22249 - 49433	60	3843.26	I	24575 - 50587
650	3679.92	I	0 - 27167	60	3846.80	I	26225 - 52213
160	3682.21	I	28605 - 55754	500	3849.97	I	8155 - 34122
110	3683.06	I	416 - 27560	70	3850.82	I	7986 - 33947
110	3684.11	I	21999 - 49135	20	3852.58	I	17550 - 43500
130	3686.00	I	23711 - 50833	850	3856.37	I	416 - 26340
800	3687.46	I	6928 - 34040	60	3859.22	I	19390 - 45295
130	3689.46	I	23711 - 50808	4200	3859.91	I	0 - 25900
240	3694.01	I	24507 - 51570	340	3865.53	I	8155 - 34017
80	3695.05	I	20875 - 47930	20	3867.22	I	24336 - 50187
300	3701.09	I	24181 - 51192	340	3872.50	I	7986 - 33802
80	3704.46	I	21716 - 48703	35	3873.76	I	19621 - 45428
800	3705.57	I	416 - 27395	500	3878.02	I	7728 - 33507
280	3707.82	I	704 - 27666	850	3878.58	I	704 - 26479
850	3707.92	I	17550 - 44512	25	3885.51	I	19552 - 45282
850	3709.25	I	7377 - 34329	1800	3886.28	I	416 - 26140
60	3716.45	I	23711 - 50611	350	3887.05	I	7377 - 33096
6000	3719.94	I	0 - 26875	350	3888.52	I	12969 - 38678
800	3722.56	I	704 - 27560	35	3893.39	I	23784 - 49461
80	3724.38	I	18378 - 45221	350	3895.66	I	888 - 26550
30	3726.92	I	24507 - 51331	35	3897.90	I	21716 - 47363

Iron — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	3898.01	I	8155 - 33802	110	4233.61	I	20020 - 43634
550	3899.71	I	704 - 26340	170	4235.94	I	19562 - 43163
550	3902.95	I	12561 - 38175	30	4238.82	I	27395 - 50980
18	3903.90	I	24119 - 49727	30	4247.43	I	27167 - 50704
140	3906.48	I	888 - 26479	120	4250.13	I	19913 - 43435
20	3916.73	I	26106 - 51630	240	4250.79	I	12561 - 36079
40	3917.18	I	7986 - 33507	360	4260.48	I	19351 - 42816
30	3918.65	I	24339 - 49851	120	4271.16	I	19757 - 43163
360	3920.26	I	978 - 26479	1000	4271.76	I	11976 - 35379
550	3922.91	I	416 - 25900	80	4282.41	I	17550 - 40895
700	3927.92	I	888 - 26340	140	4294.13	I	11976 - 35257
750	3930.30	I	704 - 26140	120	4299.24	I	19562 - 42816
20	3935.82	I	22838 - 48239	1000	4307.91	I	12561 - 35768
16	3940.88	I	7728 - 33096	60	4315.09	I	17727 - 40895
14	3942.44	I	22947 - 48305	950	4325.76	I	12969 - 36079
35	3948.78	I	26351 - 51668	40	4337.05	I	12561 - 35612
35	3949.96	I	17550 - 42860	40	4352.74	I	17927 - 40895
30	3951.17	I	26406 - 51708	14	4369.77	I	24575 - 47453
20	3952.61	I	21716 - 47008	60	4375.93	I	0 - 22846
35	3956.46	I	26106 - 51374	1700	4383.55	I	11976 - 34782
70	3956.68	I	21716 - 46982	850	4404.75	I	12561 - 35257
40	3966.07	I	12969 - 38175	480	4415.12	I	12969 - 35612
30	3966.63	I	25900 - 51103	60	4427.31	I	416 - 22997
30	3967.42	I	26628 - 51826	50	4442.34	I	17727 - 40231
550	3969.26	I	11976 - 37163	20	4443.20	I	23052 - 45552
25	3971.33	I	21716 - 46889	50	4447.72	I	17927 - 40405
60	3977.74	I	17727 - 42860	50	4459.12	I	17550 - 39970
20	3981.77	I	21999 - 47107	30	4461.65	I	704 - 23111
40	3983.96	I	21999 - 47093	60	4466.55	I	22838 - 45221
80	3997.40	I	21999 - 47008	60	4476.02	I	22947 - 45282
30	3998.06	I	21716 - 46721	30	d 4482.17	I	888 - 23193
400	4005.25	I	12561 - 37521		4482.26	I	17927 - 40231
35	4009.72	I	17927 - 42860	60	4494.57	I	17727 - 39970
40	4014.53	I	28820 - 53722	100	4528.62	I	17550 - 39626
40	4021.87	I	22249 - 47107	20	4531.15	I	11976 - 34040
3000	4045.82	I	11976 - 36686	25	4602.94	I	11976 - 33695
30	4062.44	I	22947 - 47556	16	4736.78	I	25900 - 47006
1200	4063.60	I	12561 - 37163	20	4859.75	I	23193 - 43764
1000	4071.74	I	12969 - 37521	60	4871.32	I	23111 - 43634
40	4107.49	I	22838 - 47177	35	4872.15	I	23245 - 43764
30	4109.81	I	22947 - 47272	12	4878.22	I	23270 - 43764
80	4118.55	I	28820 - 53094	35	4890.77	I	23193 - 43634
20	4127.61	I	23052 - 47272	80	4891.50	I	22997 - 43435
320	4132.06	I	12969 - 37163	10	4903.32	I	23245 - 43634
40	4134.68	I	22838 - 47017	50	4919.00	I	23111 - 43435
80	4143.42	I	24575 - 48703	120	4920.50	I	22846 - 43163
400	4143.87	I	12561 - 36686	40	4957.31	I	22997 - 43163
20	4147.67	I	11976 - 36079	130	4957.61	I	22650 - 42816
40	4154.50	I	22838 - 46902	12	5001.87	I	31307 - 51294
40	4156.80	I	22838 - 46889	10	5005.72	I	31323 - 51294
35	4175.64	I	22947 - 46889	25	5006.13	I	22846 - 42816
80	4181.76	I	22838 - 46745	12	5012.07	I	6928 - 26875
30	4184.90	I	22838 - 46727	10	5041.76	I	11976 - 31805
130	4187.04	I	19757 - 43634	20	5049.82	I	18378 - 38175
130	4187.80	I	19562 - 43435	10	5051.64	I	7377 - 27167
80	4191.44	I	19913 - 43764	10	5068.79	I	23711 - 43435
110	4198.31	I	19351 - 43163	8	5083.34	I	7728 - 27395
130	4199.10	I	24575 - 48383	10	5098.71	I	17550 - 37158
340	4202.03	I	11976 - 35768	20	5110.41	I	0 - 19562
14	4203.99	I	22947 - 46727	25	5133.68	I	33695 - 53169
40	4210.35	I	20020 - 43764	25	5139.26	I	24181 - 43634
16	4216.19	I	0 - 23711	35	5139.48	I	23711 - 43163
70	4219.36	I	28820 - 52514	130	5167.49	I	11976 - 31323
40	4222.22	I	19757 - 43435	60	5171.60	I	11976 - 31307
130	4227.43	I	26875 - 50523	40	5191.47	I	24507 - 43764

Iron— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
60	5192.36	I	24181 - 43435	6	6301.52	I	29469 - 45334
30	5194.95	I	12561 - 31805	5	6318.02	I	19788 - 35612
25	5202.34	I	17550 - 36767	10	6393.60	I	19621 - 35257
25	5216.28	I	12969 - 32134	16	6400.02	I	29056 - 44677
30	5226.88	I	24507 - 43634	10	6411.66	I	29469 - 45061
120	5227.19	I	12561 - 31686	8	6421.36	I	18378 - 33947
110	5232.94	I	23711 - 42816	10	6430.85	I	17550 - 33096
50	5266.58	I	24181 - 43163	30	6494.98	I	19390 - 34782
220	5269.54	I	6928 - 25900	6	6546.24	I	22249 - 37521
80	5270.36	I	12969 - 31937	9	6592.92	I	21999 - 37163
20	5281.80	I	24507 - 43435	18	6677.99	I	21716 - 36686
40	5283.63	I	26140 - 45061	4	6945.21	I	19552 - 33947
25	5302.31	I	26479 - 45334	3	6978.86	I	20038 - 34363
70	5324.18	I	25900 - 44677	6	7130.94	I	34017 - 48037
180	5328.05	I	7377 - 26140	8	7164.47	I	33802 - 47756
25	5328.53	I	12561 - 31323	20	7187.34	I	33096 - 47006
14	5339.94	I	26340 - 45061	12	7207.41	I	33507 - 47378
18	5341.03	I	12969 - 31686	6	7389.42	I	34692 - 48221
12	5364.88	I	35856 - 54491	7	7411.18	I	34547 - 48037
14	h 5367.46	I	35612 - 54237	14	7445.78	I	34329 - 47756
20	5369.96	I	35257 - 53874	18	7495.09	I	34040 - 47378
120	5371.49	I	7728 - 26340	30	7511.04	I	33695 - 47006
30	5383.37	I	34782 - 53353	5	7531.17	I	35257 - 48532
20	5393.18	I	26140 - 44677	3	7568.92	I	34547 - 47756
70	5397.13	I	7377 - 25900	4	7583.80	I	24339 - 37521
35	h 5404.15	I	35768 - 54267	10	7586.04	I	34782 - 47961
70	5405.78	I	7986 - 26479	3	7620.54	I	38175 - 51294
18	5410.91	I	36079 - 54555	2	7661.22	I	34329 - 47378
30	h 5415.21	I	35379 - 53841	6	7664.30	I	24119 - 37163
35	h 5424.08	I	34844 - 53275	10	7748.28	I	23784 - 36686
80	5429.70	I	7728 - 26140	10	7780.59	I	36079 - 48928
50	5434.53	I	8155 - 26550	14	7832.22	I	35768 - 48532
10	h 5445.04	I	35379 - 53739	14	7937.17	I	34782 - 47378
60	5446.92	I	7986 - 26340	14	7945.88	I	35379 - 47961
40	5455.61	I	8155 - 26479	14	7998.97	I	35257 - 47756
16	5497.52	I	8155 - 26340	3	8028.34	I	36079 - 48532
10	5501.47	I	7728 - 25900	12	8046.07	I	35612 - 48037
20	5506.78	I	7986 - 26140	10	8085.20	I	35856 - 48221
20	5569.62	I	27560 - 45509	3	8198.95	I	35768 - 47961
30	5572.85	I	27395 - 45334	30	8220.41	I	34844 - 47006
7	5576.11	I	27666 - 45595	3	8232.35	I	35612 - 47756
40	5586.76	I	27167 - 45061	40	8327.06	I	17727 - 29733
8	5602.96	I	27666 - 45509	9	8331.94	I	35379 - 47378
50	5615.65	I	26875 - 44677	4	8339.43	I	35768 - 47756
10	5624.55	I	27560 - 45334	35	8387.78	I	17550 - 29469
12	5658.83	I	27395 - 45061	12	8468.41	I	17927 - 29733
7	5763.01	I	33947 - 51294	9	8514.08	I	17727 - 29469
8	6024.06	I	36686 - 53282	3	8515.11	I	24339 - 36079
12	6065.49	I	21039 - 37521	6	8611.81	I	22947 - 34556
30	6136.62	I	19788 - 36079	35	8661.91	I	17927 - 29469
20	6137.70	I	20875 - 37163	9	8674.75	I	22838 - 34363
20	6191.56	I	19621 - 35768	70	8688.63	I	17550 - 29056
20	6230.73	I	20641 - 36686	8	8757.19	I	22947 - 34363
7	6246.34	I	29056 - 45061	8	8764.00	I	37521 - 48928
12	6252.56	I	19390 - 35379	6	8793.38	I	37163 - 48532
5	6265.14	I	17550 - 33507	40	8824.23	I	17727 - 29056
				10	8866.96	I	36686 - 47961
				25	8999.56	I	22838 - 33947

## Lanthanum

$$\text{La, } Z = 57, M = 138.905, \text{ Ratio } \frac{\text{La}}{\text{Cu}} = 2.186$$

La I Normal state of valence electrons  $5d6s^2\ ^2D_{1/2} = 0$ . I.P. = 44981  $\text{cm}^{-1}$ .

La II Normal state of valence electrons  $5d^2\ ^3F_2 = 0$ . I.P. = 89200  $\text{cm}^{-1}$ .

La III Normal state of valence electrons  $5d^2D_{1/2} = 0$ . I.P. = 154675  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945), below 7550 Å.

G. R. Harrison, *Massachusetts Institute of Technology Wavelength Tables* (John Wiley & Sons, New York, 1939), above 7550 Å.

#### Classification:

La I, La II and La III, H. N. Russell and W. F. Meggers, *J. Research NBS* **9**, 625 (1932) RP 497.

La I, A. Giachetti and M. Wilson, *J. Opt. Soc. Am.* **58**, 740A (1968).

#### Molecular Spectra:

LaO, W. F. Meggers and J. A. Wheeler, *J. Research NBS* **6**, 239 (1931) RP 273.

### *Strong lines of lanthanum*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
9000	3949.10	II	3250 - 28565	2200	3929.22	II	1394 - 26838
5500	4086.72	II	0 - 24463	2000	4429.90	II	1895 - 24463
4600	4333.74	II	1394 - 24463	1700	3886.37	II	2592 - 28315
4400	3988.52	II	3250 - 28315	1600	3849.02	II	0 - 25973
4400	4123.23	II	2592 - 26838	1600	4238.38	II	3250 - 26838
3900	3794.78	II	1971 - 28315	1500	3337.49	II	3250 - 33204
3700	3790.83	II	1016 - 27388	1500	3380.91	II	2592 - 32161
3600	3995.75	II	1394 - 26414	1500	4196.55	II	2592 - 26414
3400	3871.64	II	1016 - 26838	1300	3916.05	II	1895 - 27424
3000	4042.91	II	7473 - 32201	1100	2297.78	III	1603 - 45111
2800	4031.69	II	2592 - 27388	1100	3921.54	II	1895 - 27388
2800	4077.35	II	1895 - 26414	1100	4151.97	II	1895 - 25973
2400	3759.08	II	1971 - 28565				



Lanthanum—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	2187.87	II	0 - 45692	1000	3645.42	II	0 - 27424
770	2256.76	II	1394 - 45692	90	3649.53	I	0 - 27393
1100	2297.78	III	1603 - 45111	390	3650.18	II	0 - 27388
90	2317.82	II	18895 - 62026	170	3662.08	II	1016 - 28315
200	2319.44	II	2592 - 45692				
75	2328.75	II	16599 - 59528	17	3672.02	I	0 - 27225
1000	2379.38	III	0 - 42015	35	3701.81	II	28315 - 55321
20	2438.01	II	18895 - 59900	120	3704.54	I	1053 - 28040
65	2471.90	II	5250 - 45692	320	3705.82	II	6227 - 33204
35	2472.44	II	17826 - 58259	550	3713.54	II	1394 - 28315
35	2479.85	II	19215 - 59528	140	3714.87	II	5250 - 32161
65	2487.59	II	17212 - 57400	270	3715.53	II	2592 - 29498
45	2533.14	II	6227 - 45692	90	3725.05	II	0 - 26838
45	2560.37	II	19215 - 58259	35	3735.85	II	1394 - 28155
18	2580.82	II	15699 - 54435	2400	3759.08	II	1971 - 28565
22	2582.56	II	14148 - 52858	75	3773.12	II	26838 - 53333
35	2596.09	II	16599 - 55107	120	3780.67	II	5718 - 32161
400	2610.34	II	7395 - 45692	65	3784.81	II	0 - 26414
55	2672.91	II	18580 - 55982	3700	3790.83	II	1016 - 27388
60	2695.47	II	19750 - 56838	3900	3794.78	II	1971 - 28315
55	2725.58	I	1053 - 37732	65	3808.79	II	3250 - 29498
55	2791.51	II	22106 - 57919	190	3835.08	II	5718 - 31786
55	2798.56	II	22537 - 58259	600	3840.72	II	1394 - 27424
420	2808.39	II	10095 - 45692	120	3846.00	II	1394 - 27388
11	2838.45	II	19215 - 54435	1600	3849.02	II	0 - 25973
16	2840.51	II	29498 - 64693	130	3854.91	II	6227 - 32161
45	2855.90	II	24523 - 59528	80	3864.49	II	28565 - 54435
26	2862.98	II	20403 - 55321	3400	3871.64	II	1016 - 26838
90	2880.65	II	20403 - 55107	1700	3886.37	II	2592 - 28315
130	2885.14	II	21332 - 55982	50	3898.60	I	0 - 25643
160	2893.07	II	22283 - 56838	35	3902.58	I	0 - 25617
110	2950.50	II	28526 - 62408	40	3910.81	II	2592 - 28155
180	3104.59	II	0 - 32201	1300	3916.05	II	1895 - 27424
60	3108.46	II	0 - 32161	1100	3921.54	II	1895 - 27388
130	3142.76	II	1394 - 33204	160	3927.56	I	0 - 25454
150	3171.68	III	13591 - 45110	2200	3929.22	II	1394 - 26838
75	3193.02	II	1895 - 33204	180	3936.22	II	1016 - 26414
35	3215.81	I	1053 - 32141	9000	3949.10	II	3250 - 28565
510	3245.13	II	1394 - 32201	40	3953.68	I	1053 - 26339
260	3249.35	II	1394 - 32161	4400	3988.52	II	3250 - 28315
550	3265.67	II	2592 - 33204	3600	3995.75	II	1394 - 26414
800	3303.11	II	1895 - 32161	180	4015.39	I	1053 - 25950
1500	3337.49	II	3250 - 33204	90	4023.59	II	14376 - 39222
95	3342.23	I	1053 - 30965	250	4025.88	II	2592 - 27424
870	3344.56	II	1895 - 31786	2800	4031.69	II	2592 - 27388
200	3376.33	II	2592 - 32201	40	4036.59	II	7395 - 32161
1500	3380.91	II	2592 - 32161	140	4037.21	I	0 - 24763
130	3452.18	II	1394 - 30353	3000	4042.91	II	7473 - 32201
180	3453.17	II	3250 - 32201	320	4050.08	II	15774 - 40458
65	3461.18	I	1053 - 29937	220	4060.33	I	4122 - 28743
75	3510.00	II	1016 - 29498	160	4064.79	I	3495 - 28089
75	3512.93	II	1895 - 30353	60	4065.58	I	1053 - 25643
45	3514.07	I	1053 - 29502	850	4067.39	II	1394 - 25973
75	3517.14	III	13591 - 42015	110	4076.71	II	0 - 24523
45	3550.82	II	0 - 28155	2800	4077.35	II	1895 - 26414
65	3557.26	II	1394 - 29498	120	4079.18	I	0 - 24508
200	3574.43	I	0 - 27969	5500	4086.72	II	0 - 24463
65	3601.06	II	2592 - 30353	180	4089.61	I	3010 - 27455
50	3610.25	II		280	4099.54	II	14148 - 38534
75	3612.34	II	24463 - 52138	110	4104.87	I	2668 - 27023
75	3613.08	I	0 - 27669	50	4109.80	I	1053 - 25378
320	3628.83	II	1016 - 28565	50	4117.68	I	
35	3636.67	I	1053 - 28543	4400	4123.23	II	2592 - 26838
120	3637.15	II	5718 - 33204	110	4137.04	I	1053 - 25218
170	3641.53	I	1053 - 28506	550	4141.74	II	3250 - 27388
	3641.66	II	27388 - 54840				

Lanthanum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1100	4151.97	II	1895 - 25973	200	4570.02	I	4122 - 25997
220	4152.78	II	14148 - 38221	400	4574.88	II	1394 - 23247
40	4157.52	I	0 - 24046	200	4580.06	II	5718 - 27546
100	4160.26	I	1053 - 25083	35	4602.05	I	8052 - 29776
50	4172.32	I	3495 - 27455	160	4605.78	II	5718 - 27424
70	4177.48	I	1053 - 24984	410	4613.39	II	5718 - 27388
280	4187.32	I	0 - 23875	23	4615.07	I	7231 - 28893
280	4192.36	II	14375 - 38221	410	4619.88	II	14148 - 35788
1500	4196.55	II	2592 - 26414	40	4636.43	II	18895 - 40458
240	4204.04	II	5718 - 29498	110	4645.28	II	1016 - 22537
300	4217.56	II	15699 - 39403	45	4646.34	I	9961 - 31477
200	4230.95	II	15774 - 39403	70	4647.51	II	15699 - 37210
1600	4238.38	II	3250 - 26838	80	4648.65	I	2668 - 24174
140	4249.99	II	15699 - 39222	35	4650.33	I	3010 - 24508
50	4262.34	I	1053 - 24508	45	4652.08	I	3495 - 24984
320	4263.59	II	15774 - 39222	540	4655.50	II	15699 - 37173
480	4269.50	II	14375 - 37791	35	4660.70	I	8052 - 29502
240	4275.64	II	2592 - 25973	360	4662.51	II	0 - 21442
300	4280.27	I	1053 - 24410	230	4663.76	II	15774 - 37210
600	4286.97	II	15699 - 39019	200	4668.91	II	14375 - 35788
600	4296.05	II	6227 - 29498	160	4671.83	II	15774 - 37173
120	4300.44	II	0 - 23247	90	4691.18	II	1394 - 22705
50	4315.90	II	3250 - 26414	230	4692.50	II	14148 - 35453
440	4322.51	II	1394 - 24523	90	4699.63	II	3250 - 24523
4600	4333.74	II	1394 - 24463	35	4700.26	I	13260 - 34530
20	4334.96	II	14148 - 37210	35	4702.64	I	4122 - 25380
40	4340.73	I	8446 - 31477	140	4703.28	II	15699 - 36955
550	4354.40	II	7395 - 30353	35	4708.19	I	9184 - 30417
60	4354.80	I	9184 - 32141	70	4712.93	II	3250 - 24463
110	4364.67	II	5250 - 28155	170	4716.44	II	6227 - 27424
110 bl	4371.97	La O		35	4717.59	II	16599 - 37791
110 bl	4375.84	La O		140	4719.94	II	15774 - 36955
110	4378.10	II	14375 - 37210	35	4724.43	II	6227 - 27388
60 bl	4379.72	La O		230	4728.42	II	1394 - 22537
280	4383.44	II	14148 - 36955	500	4740.28	II	1016 - 22106
100	4385.20	II	14375 - 37173	390	4743.09	II	14375 - 35453
60	4389.87	I	9719 - 32493	320	4748.73	II	7473 - 28526
50	4402.65	I	9044 - 31752	45	4750.41	I	9920 - 30965
50	4411.21	II	28565 - 51229	160	4766.89	I	0 - 20972
220 bl	4418.24	La O		35	4770.43	I	7012 - 27969
80	4419.16	II	16599 - 39222	28	4796.69	II	7473 - 28315
160 bl	4423.17	La O		28	4800.00	I	9961 - 30788
160	4423.90	I	9920 - 32518	23	4800.25	I	7680 - 28506
260	4427.55	II	14375 - 36955	160	4804.04	II	1895 - 22705
100 bl	4428.10	La O		160	4809.01	II	1895 - 22684
2000	4429.90	II	1895 - 24463	28	4817.17	I	9184 - 29937
160 bl	4432.98	La O		200	4824.06	II	5250 - 25973
50	4435.85	II	0 - 22537	23	4826.88	II	1394 - 22106
100 bl	4438.01	La O		70	4839.52	I	7012 - 27669
50 bl	4443.00	La O		45	4840.01	II	2592 - 23247
100	4452.15	I		45	4850.58	II	6227 - 26838
100	4455.80	II	5718 - 28155	70	4850.82	I	1053 - 21663
40	4468.97	I	3010 - 25380	23	4854.95	I	9184 - 29776
40	4486.06	I	7490 - 29776	320	4860.91	II	1971 - 22537
40	4493.11	I	1053 - 23303	35	4870.56	I	8446 - 28972
40	4494.71	I	2668 - 24910	65	4878.86	I	8052 - 28543
90	4500.22	I	7680 - 29895	26	4887.61	I	8052 - 28506
850	4522.37	II	10095 - 32201	850	4899.92	II	0 - 20403
170	4525.31	II	15699 - 37791	65	4901.87	I	1053 - 21448
420	4526.12	II	6227 - 28315	26	4905.13	I	7012 - 27393
30	4541.79	I	7490 - 29502	1000	4920.98	II	1016 - 21332
80	4549.50	I	3010 - 24984	1000	4921.79	II	1971 - 22283
400	4558.46	II	2592 - 24523	140	4934.83	II	10095 - 30353
110	4559.29	II	6227 - 28155	26	4935.62	II	5718 - 25973
160	4567.91	I	3495 - 25380	26	4945.85	I	7012 - 27225

Lanthanum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	4946.47	II	1895 - 22106	130	5377.09	II	18580 - 37173
370	4949.77	I	0 - 20197	21	5380.01	I	9961 - 28543
65	4952.07	II	19215 - 39403	140	5380.99	II	7395 - 25973
340	4970.39	II	2592 - 22705	80	5381.92	II	17212 - 35788
35	4977.95	I	0 - 20083	21	bl	LaO	
370	4986.83	II	1394 - 21442	24	bl	LaO	
140	4991.28	II	7395 - 27424	26			7490 - 25950
65	4993.88	I	0 - 20019	40			7231 - 25643
35	4996.82	II	19215 - 39222	21			7231 - 25617
720	4999.47	II	3250 - 23247	500			1053 - 19379
50	5001.79	I	8052 - 28040	35			18895 - 37210
35	5002.13	II	18236 - 38221	45			6227 - 24523
35	h	I		13			8052 - 26339
140	5019.51	I		40			
26	5046.88	I	3495 - 23303	40			
	5048.04	II	19215 - 39019	26			17212 - 35453
210	5050.57	I	3010 - 22804	65			0 - 18236
170	5056.46	I	2668 - 22439	26			7012 - 25218
45	5062.92	II	6227 - 25973	40			1016 - 19215
45	5067.90	I	3495 - 23221	470			0 - 18172
24	5078.92	I	15197 - 34881	26			9920 - 28089
35	5079.38	I		18			3495 - 21663
35	h	II	15774 - 35453	90			4122 - 22286
24	5103.13	I	15197 - 34787	50			0 - 18157
200	5106.23	I	2668 - 22247	40			7490 - 25617
470	5114.56	II	1895 - 21442	65			9920 - 28040
45	5120.88	I	8446 - 27969	18			9961 - 28040
470	5122.99	II	2592 - 22106	13			7012 - 25083
21	5135.44	I	15197 - 34664	90			10095 - 28155
24	5139.16	I	16099 - 35552	65			9184 - 27225
450	5145.42	I	3010 - 22439	24			9719 - 27749
180	5156.74	II	1016 - 20403	50			7680 - 25643
180	5157.43	II	17826 - 37210	40			3010 - 20972
290	5158.69	I	0 - 19379	24			19215 - 37173
120	5163.62	II	1971 - 21332	80			3495 - 21448
80	5167.79	I	4122 - 23467	16			0 - 17947
26	5172.91	II	18895 - 38221	80			3495 - 21384
80	5173.84	II	32201 - 51524	80	bl	LaO	
580	5177.31	I	3495 - 22804	110	bl	LaO	
24	5179.12	I	8446 - 27749	35	bl	LaO	
850	5183.42	II	3250 - 22537	45	bl	LaO	
90	5183.92	I	1053 - 20338	160			3010 - 20763
260	5188.22	II	19750 - 39019	65			7012 - 24763
170	5204.15	II	18580 - 37791	40			7490 - 25218
720	5211.86	I	4122 - 23303	240			9920 - 27620
35	5226.21	II	17826 - 36955	35	b	LaO	
520	5234.27	I	4122 - 23221			I	7231 - 24910
35	5239.55	I	8052 - 27133	16			9719 - 27393
26	5240.83	I	15197 - 34272	130			2668 - 20338
340	5253.46	I	1053 - 20083	50			17826 - 35453
35	5257.85	I	16538 - 35552	90			1053 - 18604
110	5259.39	II	1394 - 20403	13			4122 - 21663
370	5271.19	I	1053 - 20019	45			5718 - 23247
50	5276.42	I	8446 - 27393	10			9719 - 27225
26	5279.13	II	18236 - 37173	65			1394 - 18895
140	5290.84	II	0 - 18895	40			7012 - 24508
370	5301.98	II	3250 - 22106	13			9961 - 27455
140	5302.62	II	16599 - 35453	45			3495 - 20972
180	5303.55	II	2592 - 21442	26			5250 - 22705
45	5304.02	I	7490 - 26339	40			9961 - 27393
24	5307.53	I	15197 - 34033	180			2668 - 20083
16	5320.16	I	3495 - 22286	18			7231 - 24639
35	5323.57	I	8446 - 27225	160			7680 - 25083
110	5340.67	II	18236 - 36955	160			2668 - 20019
110	5357.86	I	7680 - 26339	160			10095 - 27424
21	5365.89	I	7012 - 25643	370			3010 - 20338

Lanthanum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	5769.99	I	8052 - 25378	80	6129.56	II	6227 - 22537
320	5789.24	I	3495 - 20763	50	6134.39	I	7231 - 23528
450	5791.34	I	4122 - 21384	24	6142.98	I	
220	5797.58	II	1971 - 19215	13	6145.30	I	15020 - 31288
160	5805.78	II	1016 - 18236	18	6146.53	II	1971 - 18236
10	5808.06	I	9920 - 27132	80	6165.70	I	7490 - 23705
50	5808.32	II	0 - 17212	35	6172.73	II	1016 - 17212
140	5821.99	I	9961 - 27132	26	6188.09	II	23247 - 39403
50	5823.83	I	8052 - 25218	16	6203.51	II	22106 - 38221
24	5827.56	I	9184 - 26339	13	6218.20	I	9920 - 25997
80	5829.72	I	7490 - 24639	35	6233.51	I	7490 - 23528
16	5839.79	I	1053 - 18172	35	6234.86	I	9184 - 25218
24	5845.03	I	1053 - 18157	18	6236.17	I	
65	5848.38	I	13260 - 30354	13	6236.74	I	7231 - 23261
13	5848.95	II	21442 - 38534	18	6238.59	I	7680 - 23705
35	5852.27	I	7680 - 24763	720	6249.93	I	4122 - 20117
80	5855.58	I	3010 - 20083	260	6262.30	II	3250 - 19215
80	5863.71	II	7473 - 24523	90	6266.02	I	9920 - 25875
16	5866.42	La O		13	6273.76	II	24523 - 40458
16	5869.50	La O		18	6287.74	I	9184 - 25083
16	5869.95	I	8052 - 25083	16	6288.56	I	9719 - 25617
21	5874.00	II	6227 - 23247	65	6293.57	I	3495 - 19379
45	5874.73	I	7490 - 24508	180	6296.09	II	10095 - 25973
21	5877.63	I	3010 - 20019	21	6305.46	II	1971 - 17826
16	5877.99	I	8446 - 25454	16	6310.14	I	17910 - 33753
65	5880.64	II	1895 - 18895	35	6310.92	II	21332 - 37173
16	5893.57	La O		16	6318.26	I	8052 - 23875
65	5894.85	I	7680 - 24639	160	6320.39	II	1394 - 17212
16	5896.67	La O		110	6325.91	I	1053 - 16857
10	5900.75	I	7231 - 24174	35	6358.13	II	5718 - 21442
16	5901.96	II	22283 - 39222	35	6360.22	I	9044 - 24763
16	5904.30	I	8052 - 24984	170	6390.48	II	2592 - 18236
45	5917.63	I	1053 - 17947	450	6394.23	I	3495 - 19129
16	5920.84	La O		50	6399.05	II	21332 - 36955
16	5923.97	La O		210	6410.99	I	3010 - 18604
16	5927.71	II	22537 - 39403	35	6446.61	II	22283 - 37791
21	5928.49	I	7012 - 23875	21	6448.11	I	2668 - 18172
320	5930.62	I	1053 - 17910	13	6450.34	I	9719 - 25218
	5930.68	I	0 - 16857	90	6454.52	I	2668 - 18157
65	5935.24	I	3495 - 20338	250	6455.99	I	1053 - 16538
50	5936.22	II	1394 - 18236	13	6468.44	I	9184 - 24639
13	5940.83	I	7680 - 24508	24	6485.55	I	8052 - 23467
18	5948.30	II	20403 - 37210	40	6498.19	II	20403 - 35788
26	5960.59	I	8446 - 25218	10	6506.23	I	14096 - 29461
16	5962.60	I	9184 - 25950	21	6520.74	I	
16	5965.30	I		110	6526.99	II	1895 - 17212
13	5971.09	II	10095 - 26838	10	6529.73	II	7395 - 22705
45	5973.53	II	22283 - 39019	130	6543.16	I	2668 - 17947
18	5975.75	I	7680 - 24410	26	6565.44	I	1053 - 16280
26	5982.35	I	2668 - 19379	8	6570.96	II	6227 - 21442
16	5992.36	I	7490 - 24174	140	6578.51	I	0 - 15197
65	6007.36	I	4122 - 20763	10	6582.19	I	16099 - 31288
16	6017.16	I	13260 - 29875	45	6593.46	I	3010 - 18172
50	6038.59	I	7490 - 24046	35	6600.17	I	3010 - 18157
13	6041.55	I	14804 - 31352	45	6608.26	I	9961 - 25090
13	6067.14	II	6227 - 22705	50	6616.59	I	3495 - 18604
45	6068.68	I	7231 - 23705	10	6631.21	I	
13	6072.05	I	8446 - 24910	10	6636.53	II	7473 - 22537
16	6084.89	I	16857 - 33287	26	6642.79	II	20403 - 35453
40	6100.38	II	5718 - 22106	35	6644.41	I	1053 - 16099
16	6107.27	I	3010 - 19379	18	6645.16	I	16243 - 31288
80	6108.48	I	7680 - 24046	70	6650.81	I	0 - 15032
45	6111.72	I	8052 - 24410	80	6661.40	I	4122 - 19129
80	6126.09	II	10095 - 26414	35	6671.40	II	3250 - 18236
26	6127.05	I	8446 - 24763	40	6692.87	I	3010 - 17947

Lanthanum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
8	6699.25	I		50 h	7463.08	I	8052 - 21448
9	6699.85	I		50 bl	7465.25	LaO	
180	6709.50	I	3010 - 17910	95 bl	7465.48	LaO	
19	6714.09	II	22283 - 37173	75 cw	7483.50	II	1016 - 14375
7	6718.68	II	24523 - 39403	40 bl	7496.50	LaO	
7	6732.78	II	22106 - 36955	95 bl	7496.78	LaO	
35	6748.13	I	8446 - 23261	50	7498.83	I	8052 - 21384
60	6753.04	I	0 - 14804	30 b	7506.79	LaO	
120	6774.26	II	1016 - 15774	19 bl	7528.21	LaO	
7	6796.73	I	0 - 14709	50 bl	7528.39	LaO	
29 h	6808.86	II	1016 - 15699	30	7533.59	I	3010 - 16280
14	6813.66	II	22537 - 37210	85	7539.23	I	0 - 13260
45	6823.78	I	7012 - 21663	35 bl	7560.09	LaO	
35	6834.05	II	1971 - 16599	35 bl	7592.26	LaO	
23	6837.90	II	2592 - 17212	19 h	7612.94	II	1016 - 14148
8 h	6859.03	II	3250 - 17826	19 b	7624.99	LaO	
21	6917.24	I	3495 - 17947	21	7664.34	I	3495 - 16538
12	6918.30	I	1053 - 15504	15 h	7841.80	I	3495 - 16243
70	6925.24	I	7012 - 21448	21 b	7876.87	LaO	
45	6935.01	I	3495 - 17910	75 bl	7877.22	LaO	
8 h	6952.51	II	1394 - 15774	75 bl	7910.19	LaO	
21 h	6954.52	II	0 - 14375	150 bl	7910.54	LaO	
35	6958.10	II	10095 - 24463	50 b	7944.61	LaO	
10	6976.86	I		110 bl	7944.95	LaO	
13 b	6996.89	LaO		40	7964.83	I	2668 - 15220
13 b	7011.22	LaO		35 b	7979.34	LaO	
75	7023.67	I	8052 - 22286	75 bl	7979.70	LaO	
26	7032.05	I	9044 - 23261	35 h	8001.89	I	3010 - 15504
26 b	7040.84	LaO		21 b	8014.43	LaO	
110	7045.96	I	2668 - 16857	65 bl	8014.79	LaO	
13 b	7054.80	LaO		30 b	8019.48	LaO	
160	7066.23	II	0 - 14148	35 hc	8051.39	I	4122 - 16538
65	7068.37	I	1053 - 15197	75	8086.05	I	2668 - 15031
21 bl	7070.79	LaO		15 b	8122.20	LaO	
13	7076.38	I	9961 - 24088	15 b	8159.02	LaO	
21 bl	7085.40	LaO		7 h	8203.38	I	3010 - 15197
26 bl	7101.02	LaO		50	8247.44	I	4122 - 16243
10 h	7116.8	II	7395 - 21442	13 h	8316.04	I	3010 - 15031
19 bl	7131.58	LaO		85	8324.69	I	3495 - 15504
10	7149.77	I	7680 - 21663	95	8346.53	I	4122 - 16099
40 h	7158.08	I	1053 - 15020	8 h	8379.80	I	19129 - 31060
50	7161.25	I	7012 - 20972	8 b	8453.55	LaO	
10	7162.60	LaO		8 h	8467.62	I	20117 - 31924
21	7219.91	I	3010 - 16857	26	8476.48	I	3010 - 14804
10 b	7257.16	LaO		13 h	8507.37	I	8446 - 20197
26	7270.09	I	7012 - 20763	13 h	8513.57	I	9920 - 21663
10	7270.30	I	1053 - 14804	8 h	8514.65	II	7473 - 19215
110 cw	7282.34	II	1971 - 15699	17 b	8526.59	LaO	
10	7320.91	I	1053 - 14709	17 c	8543.46	I	9961 - 21663
110 cw	7334.18	I	0 - 13631	65	8545.44	I	3010 - 14709
65	7345.34	I	8052 - 21663	15 b	8563.54	LaO	
50 bl	7379.71	LaO		9 h	8590.94	I	8446 - 20083
85 bl	7380.08	LaO		9 b	8600.81	LaO	
35	7382.73	I	9719 - 23261	7 h	8624.22	I	7012 - 18604
110 bl	7403.52	LaO		15	8638.47	I	8446 - 20019
210 bl	7403.75	LaO		19 hw	8672.11	I	9920 - 21448
50 b	7411.34	LaO		40	8674.43	I	3495 - 15020
65 bl	7434.28	LaO		13 h	8720.41	I	9920 - 21384
110 bl	7434.36	LaO		35	8748.38	I	2668 - 14096
30 b	7442.92	LaO		19	8818.93	I	13747 - 25083
				35	8825.82	I	8052 - 19379
				21	8839.63	I	3495 - 14804

## Lead

$$\text{Pb, } Z = 82, M = 207.2, \text{ Ratio } \frac{\text{Pb}}{\text{Cu}} = 3.261$$

Pb I Normal state of valence electrons  $6s^2 6p^2 \ ^3P_0 = 0$ . I.P. = 59820  $\text{cm}^{-1}$ .

Pb II Normal state of valence electrons  $6s^2 6p^2 \ ^3P_{1/2}^o = 0$ . I.P. = 121243  $\text{cm}^{-1}$ .

### References

Wavelengths:

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Classification:

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Pb II, L. T. Earls and R. A. Sawyer, Phys. Rev. **47**, 115 (1935).

### Lead—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
6000	2022.02	I	0 - 49440	3000	2663.16	I	10650 - 48189
7000	2053.27	I	0 - 48687	10000	2801.99	I	10650 - 46329
5500	2169.99	I	0 - 46069	4100	2823.20	I	10650 - 46061
1400	2203.53	II	14081 - 59448	9500	2833.06	I	0 - 35287
200	2246.88	I	7819 - 52312	2800	2873.32	I	10650 - 45443
70	2332.44	I	10650 - 53511	30	3220.57	I	21458 - 52500
35	2388.80	I	10650 - 52500	1100	3572.74	I	21458 - 49440
1700	2393.79	I	10650 - 52412	5500	3639.58	I	7819 - 35287
30	2399.60	I	10650 - 52312	340	3671.51	I	21458 - 48687
600	2401.95	I	7819 - 49440	14000	3683.48	I	7819 - 34960
130	2411.73	I	10650 - 52102	2800	3739.95	I	21458 - 48189
20	2428.63	I	21458 - 62621	400	4019.64	I	21458 - 46329
380	2443.84	I	7819 - 48726	34000	4057.83	I	10650 - 35287
700	2446.19	I	7819 - 48687	550	4062.14	I	21458 - 46069
1300	2476.38	I	7819 - 48189	130	4168.03	I	21458 - 45443
1100	2577.27	I	10650 - 49440	90	5005.44	I	29467 - 49440
500	2613.65	I	7819 - 46069	35	5201.47	I	29467 - 48687
7000	2614.18	I	7819 - 46061	8	6001.93	I	35287 - 51944
240	2628.28	I	10650 - 48687	140	7229.00	I	21458 - 35287
16	2657.09	I	7819 - 45443				

# Lithium

$$\text{Li, } Z = 3, M = 6.94, \text{ Ratio } \frac{\text{Li}}{\text{Cu}} = 0.1092$$

Li I Normal state of valence electrons  $1s^2 2s^2 S_{1/2} = 0$ . I.P. = 43487  $\text{cm}^{-1}$ .

Li II Normal state of valence electrons  $1s^2 ^1S_0 = 0$ . I.P. = 610079  $\text{cm}^{-1}$ .

## References

Wavelengths and Classification:

Li I, I. Johansson, Ark. for Fysik **15**, 169 (1958).

*Lithium— all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
50	2741.18	I	0 - 36470	3200	6103.62	I	14904 - 31283
170	3232.63	I	0 - 30925	36000	6707.84	I	0 - 14904
130 hl	4602.86	I	14904 - 36623	480	8126.34	I	14904 - 27206
80 h	4971.70	I	14904 - 35012				

## Lutetium

$$\text{Lu, } Z = 71, M = 174.97, \text{ Ratio } \frac{\text{Lu}}{\text{Cu}} = 2.753$$

- Lu I Normal state of valence electrons  $5d6s^2\ ^2D_{1,1/2} = 0$ . I.P. = 43762  $\text{cm}^{-1}$ .  
 Lu II Normal state of valence electrons  $6s^2\ ^1S_0 = 0$ . I.P. = 112000  $\text{cm}^{-1}$ .  
 Lu III Normal state of valence electrons  $6s\ ^2S_1 = 0$ . I.P. = 169049  $\text{cm}^{-1}$ .

### References

Wavelengths, Spectrum Assignments and Molecular Spectra (LuO):

W. F. Meggers and B. F. Scribner, J. Research NBS **19**, 31 (1937) RP 1008.

Classification:

Lu I, P. F. A. Klinkenberg, Physica **21**, 53 (1954).

Lu II, L. F. H. Bovey and R. W. B. Pearse, Atomic Energy Research Establishment C/R 1976 (Harwell, 1956).

Lu III, W. F. Meggers and B. F. Scribner, J. Research NBS **5**, 73 (1930) RP 187.

A. Steudel, Zeits. Physik **152**, 599 (1958).

### *Strong lines of lutetium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
18000	2615.42	II	0 - 38223	4800	3567.84	I	0 - 28020
9000	2911.39	II	14199 - 48537	4500	2900.30	II	12435 - 46904
8300	3507.39	II	0 - 28503				
7600	3281.74	I	1994 - 32457	4200	2701.71	II	14199 - 51202
7600	3359.56	I	1994 - 31751	4200	2963.32	II	11796 - 45532
7500	3077.60	II	12435 - 44919	4100	3397.07	II	11796 - 41225
6300	2894.84	II	14199 - 48733	3800	3278.97	I	0 - 30489
6200	3312.11	I	0 - 30184	3600	2754.17	II	12435 - 48733
6200	3376.50	I	0 - 29608				
5100	3081.47	I	1994 - 34436	3300	4518.57	I	0 - 22125
				3100	4124.73	I	7476 - 31714
4800	3254.31	II	14199 - 44919	3000	2847.51	II	11796 - 46904
4800	3472.48	II	12435 - 41225	3000	3020.54	II	12435 - 45532
4800	3554.43	II	17332 - 45458	3000	3118.43	I	



Lutetium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1700 h	2195.54	II	0 - 45532	3800	3278.97	I	0 - 30489
580	2236.17	III	0 - 44705	7600	3281.74	I	1994 - 32457
95	2276.94	II	27264 - 71169	6200	3312.11	I	0 - 30184
190	2297.41	II	28503 - 72017	7600	3359.56	I	1994 - 31751
1300	2392.19	II	17332 - 59122	6200	3376.50	I	0 - 29608
120	2399.14	II	32453 - 74122	950	3385.50	I	1994 - 31523
80	2419.21	II	38223 - 79547	160 h	3391.55	I	
55	2430.26	II	32453 - 73588	1400	3396.82	I	
130	2459.64	II	12435 - 53079	4100	3397.07	II	11796 - 41225
80	2469.27	II	28503 - 68989	4800	3472.48	II	12435 - 41225
21 h	2481.72	II	32453 - 72736	8300 c	3507.39	II	0 - 28503
370	2536.95	II	11796 - 51202	1600	3508.42	I	1994 - 30489
40	2546.87	II	32453 - 71705	4800	3554.43	II	17332 - 45458
20	2549.44	I	0 - 39212	4800	3567.84	I	0 - 28020
20	2549.72	I	4136 - 43344	340	3596.34	I	7476 - 35275
35	2561.80	II	12435 - 51458	800	3623.99	II	17332 - 44919
930	2571.23	II	14199 - 53079	680	3636.25	I	0 - 27493
1700	2578.79	II	12435 - 51202	2600	3647.77	I	4136 - 31542
80 h	2582.13	II	32453 - 71169	60	3684.32	I	
570 c	2603.33	III	0 - 38400	60	3710.95	I	
1800	2613.40	II	11796 - 50049	110	3756.70	I	4136 - 30748
18000	2615.42	II	0 - 38223	110	3756.79	I	4136 - 30747
1800	2619.26	II	11796 - 49963	30 h	3786.18	I	
90	2657.05			150	3800.67	I	
2700	2657.80	II	12435 - 50049	75 h	3829.07	I	
90 h	2677.25	I	7476 - 44816	2700	3841.18	I	1994 - 28020
570 h	2685.08	I	4136 - 41368	75	3843.61	I	
90 h	2685.54	I	1993 - 39220	95	3853.29	I	
4200	2701.71	II	14199 - 51202	40	3874.61	I	4136 - 29938
90 h	2715.91	I		530	3876.65	II	12435 - 38223
180 d	2719.09	I	4136 - 40901	29	3911.77	I	
480 h	2728.95	I	0 - 36633	50	3918.86	I	
75 c	2738.17	II	27264 - 63774	35 h	3926.62	I	
3600	2754.17	II	12435 - 48733	480	3968.46	I	0 - 25192
750 h	2765.74	I	4136 - 40282	50	3991.38	I	
390	2772.58	III	8648 - 44705	670	4054.45	I	4136 - 28793
2700	2796.63	II	17332 - 53079	75 bl	4096.13	LuO	
35	2821.23	III		35 h	4107.44	I	
270 c	2834.35	II	28503 - 63774	95 h	4112.67	I	0 - 24308
330 h	2845.13	I	1994 - 37131	310	4122.49	I	
3000	2847.51	II	11796 - 46904	3100	4124.73	I	7476 - 31714
570 h	2885.14	I		150 c	4131.79	I	
6300	2894.84	II	14199 - 48733	460	4154.08	I	7476 - 31542
4500	2900.30	II	12435 - 46904	24	4158.98	I	
300	2903.05	I	0 - 34436	1600	4184.25	II	17332 - 41225
9000	2911.39	II	14199 - 48537	150	4277.50	I	
270 h	2949.73	I	7476 - 41368	250	4281.03	I	
1200	2951.69	II	17332 - 51202	330 d	4295.97	I	7476 - 30748
60	2955.78	II			4296.09	I	7476 - 30747
4200	2963.32	II	11796 - 45532	150	4309.57	I	1994 - 25192
2400	2969.82	II	11796 - 45458	75	4332.72	I	
1800	2989.27	I	0 - 33443	29	4341.98	II	36098 - 59122
3000	3020.54	II	12435 - 45532	65 h	4420.96	I	21462 - 44076
120	3027.29	II	12435 - 45458	190 c	4430.48	I	
2100	3056.72	II	14199 - 46904	35	4438.79	I	
140	3057.90	III	5708 - 38400	190	4450.81	I	7476 - 29938
7500	3077.60	II	12435 - 44919	50 h	4471.55	I	
390	3080.11	I	0 - 32457	60 h	4498.85	I	0 - 22222
5100 h	3081.47	I	1994 - 34436	3300	4518.57	I	0 - 22125
3000	3118.43	I		24 b	4560.95	LuO	
2400	3171.36	I	0 - 31523	24 b	4575.31	LuO	
100	3183.73	II	17332 - 48733	85 c	4605.39	I	18851 - 40559
260	3191.80	II	32453 - 63774	95 h	4645.47	I	
1400	3198.12	II	14199 - 45458	100 h	4648.21	I	
4800	3254.31	II	14199 - 44919	95 h	4648.85	I	

Lutetium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65 b	4654.03	LuO		11	6140.71	I	21462 - 37743
1000	4658.02	I	0 - 21462	150	6159.94	II	32504 - 48733
85 h	4659.03	I		160	6199.66	II	29407 - 45532
630 bl	4661.75	LuO		2100	6221.87	II	12435 - 28503
310 bl	4672.31	LuO		35	6228.14	II	29407 - 45458
420 bl	4684.16	LuO		80	6235.36	II	32504 - 48537
270 bl	4695.46	LuO		160	6242.34	II	30889 - 46904
190 bl	4708.00	LuO		16 h	6248.80	I	21195 - 37194
30	4716.70	I	0 - 21195	70 h	6345.35	I	23524 - 39279
65 b	4720.86	LuO		18 h	6354.85	I	21462 - 37194
65 h	4726.20	I		9	6365.79	I	21195 - 36900
100 bl	4735.00	LuO		16	6366.00	I	
75 bl	4749.11	LuO		22	6441.14	I	22222 - 37743
40 bl	4764.22	LuO		11	6444.89	II	29407 - 44919
150	4785.42	II	17332 - 38223	1100	6463.12	II	11796 - 27264
85	4815.05	I	0 - 20762	29	6477.67	I	1994 - 17427
50 c	4839.62	II	11796 - 32453	55 c	6523.18	I	
18	4865.36	II	38575 - 59122	35 cw	6611.28	II	17332 - 32453
460	4904.88	I	4136 - 24518		6611.58	II	
180	4942.34	I	1994 - 22222		6611.80	II	
800	4994.13	II	12435 - 32453		6611.95	II	
800	5001.14	I	4136 - 24126	11	6612.04	II	36098 - 51202
55 h	5057.60	I	17427 - 37194	23 c	6677.14	I	22222 - 37194
140	5134.05	I	17427 - 36900	9 h	6735.76	I	20433 - 35275
2700	5135.09	I	1994 - 21462	30 c	6793.77	I	4136 - 18851
130 bl	5170.11	LuO		11	6826.59	II	36557 - 51202
170	5196.61	I	18505 - 37743	45	6917.31	I	
90	5206.47	I	1994 - 21195	8	6943.96	II	35652 - 50049
40	5304.40	I	20433 - 39279	23	7031.24	I	23524 - 37743
80	5349.12	I	18505 - 37194	14 c	7096.34	I	25192 - 39279
500	5402.57	I	0 - 18505	45	7125.84	II	30889 - 44919
140 c	5421.90	I	1994 - 20433	9	7142.79	I	
100	5437.88	I		7	7143.10	I	
35	5453.57	I	4136 - 22468	8	7165.94	II	36098 - 50049
2100	5476.69	II	14199 - 32453	14 ch	7237.98	I	21462 - 35275
9	5664.89	II	30889 - 48537	5	7409.70	II	36557 - 50049
14	5713.49	II	29407 - 46904	11 c	7441.52	I	24308 - 37743
550	5736.55	I	0 - 17427	8	7456.96	II	36557 - 49963
55	5775.40	I	20433 - 37743	7 ch	7640.08	I	24109 - 37194
80	5800.59	I		7 cw	7758.30	I	24308 - 37194
40 h	5860.79	I	22222 - 39279	7 h	7815.9	I	24109 - 36900
9	5866.30	I	7476 - 24518	9 c	8178.16	I	
690 cw	5983.9	II	11796 - 28503	17	8382.08	I	7476 - 19403
140	5997.13	I	22609 - 39279	35	8459.19	II	29407 - 41225
1400	6004.52	I	7476 - 24125	10 d	8478.50	I	
35 h	6041.66	I	21195 - 37743	29 c	8508.08	I	23524 - 35275
440	6055.03	I	1994 - 18505	35 c	8610.98	I	22222 - 33832

# Magnesium

Mg,  $Z = 12$ ,  $M = 24.305$ , Ratio  $\frac{\text{Mg}}{\text{Cu}} = 0.3825$

MgI Normal state of valence electrons  $2p^63s^2^1S_0 = 0$ . I.P. = 61671  $\text{cm}^{-1}$ .

MgII Normal state of valence electrons  $2p^63s^2^2S_{1/2} = 0$ . I.P. = 121268  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

MgI, F. Paschen, Sitzber. Preuss. Akad. Wiss., Physik. math. Kl. **32**, 709 (1931).

MgII, A. Fowler, Report on Series in Line Spectra, p. 118 (Fleetway Press, London, 1922).

*Magnesium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
380	2776.69	I	21870 - 57874	20 h	2942.11	I	21911 - 55892
320	2778.29	I	21850 - 57833	140 hl	3096.90	I	21911 - 54192
900	2779.83	I	21911 - 57874	60	3332.15	I	21870 - 51872
		I	21870 - 57833	90	3336.68	I	21911 - 51872
320	2781.42	I	21870 - 57813	1400	3829.35	I	21850 - 47957
360	2782.97	I	21911 - 57833	3000	3832.31	I	21870 - 47957
130	2790.79	II	35669 - 71491	5000	3838.26	I	21911 - 47957
10000	2795.53	II	0 - 35761	70	4703.02	I	35051 - 56308
160	2798.06	II	35761 - 71490	750	5167.34	I	21850 - 41197
6000	2802.70	II	0 - 35669	2200	5172.70	I	21870 - 41197
60000	2852.13	I	0 - 35051	4000	5183.62	I	21911 - 41197
16	2928.75	II	35669 - 69805	60 h	5528.46	I	35051 - 53135
30	2936.54	II	35761 - 69805	140	8806.79	I	35051 - 46403

## Manganese

$$\text{Mn, } Z = 25, M = 54.9380, \text{ Ratio } \frac{\text{Mn}}{\text{Cu}} = 0.865$$

Mn I Normal state of valence electrons  $3d^5 4s^2 \ ^6S_{21/2} = 0$ . I.P. = 59970  $\text{cm}^{-1}$ .

Mn II Normal state of valence electrons  $3d^5 4s \ ^7S_3 = 0$ . I.P. = 126145  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

#### Classification:

Mn I, M. A. Catalan, W. F. Meggers, and O. Garcia-Riquelme, J. Res. Nat. Bur. Stand. (U.S.), **68A** (Phys. and Chem.), No. 1, 9-59 (Jan.-Feb. 1964).

Mn II, L. Iglesias and R. Velasco, Publ. Inst. de Optica de Madrid, No. **23** (1964).

#### *Strong lines of manganese*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
27000	4030.76	I	0 - 24802	3700	2801.06	I	0 - 35690
19000	4033.07	I	0 - 24788	3200	3806.72	I	17052 - 43314
18000	2003.85	I	0 - 49888	2200	3569.49	I	18705 - 46713
14000	1998.86	I	0 - 50013	2100	3823.51	I	17282 - 43429
12000	2576.10	II	0 - 38807	1900	2949.20	II	9473 - 43370
11000	4034.49	I	0 - 24779	1900	4055.54	I	17282 - 41933
9700	1995.41	I	0 - 50099	1700	2109.58	I	0 - 47388
6200	2593.73	II	0 - 38543	1500	2092.16	I	0 - 47782
6200	2794.82	I	0 - 35770	1500	2939.30	II	9473 - 43485
5600	4041.36	I	17052 - 41790	1500	4018.10	I	17052 - 41933
5100	2798.27	I	0 - 35726	1500	4035.73	I	17282 - 42054
4300	2605.69	II	0 - 38366	1400	3577.88	I	17052 - 44994

Manganese—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	
9700	1995.41	I	0 - 50099	45	h	2760.93	I	17052 - 53261
14000	1998.86	I	0 - 50013	30		2771.44	I	17052 - 53124
18000	2003.85	I	0 - 49888	30	h	2776.23	I	17282 - 53291
1500	2092.16	I	0 - 47782	30		2780.00	I	23297 - 59257
1700	2109.58	I	0 - 47388	55		2789.20	I	17282 - 53124
290	2208.81	I	0 - 45259	60		2790.36	I	17282 - 53109
540	2213.85	I	0 - 45156	60		2791.08	I	17052 - 52870
770	2221.84	I	0 - 44994	6200		2794.82	I	0 - 35770
75	2533.06	I	25266 - 64732	5100		2798.27	I	0 - 35726
50	2543.45	II	27589 - 66894	220		2799.84	I	17052 - 52758
75	2556.57	II	27583 - 66686	3700		2801.06	I	0 - 35690
95	2558.59	II	27571 - 66643	70		2804.10	I	17452 - 53103
150	2563.65	II	27547 - 66542	60		2806.14	I	25266 - 60891
580	2572.76	I	18532 - 57389	55		2808.02	I	17282 - 52884
480	2575.51	I	18402 - 57218	110		2809.11	I	17282 - 52870
12000	2576.10	II	0 - 38807	60		2812.84	I	17568 - 53109
550	2584.31	I	18705 - 57389	70		2813.47	I	17568 - 53101
45	2589.71	II	32788 - 71390	60		2815.02	II	35004 - 70518
250	2592.94	I	18532 - 57086	85		2817.97	I	17282 - 52758
6200	2593.73	II	0 - 38543	40		2818.77	I	17637 - 53103
250	2595.76	I	18705 - 57218	55		2821.45	I	17452 - 52884
95	2598.90	II	29951 - 68417	55		2822.55	I	17452 - 52870
		II	32857 - 71323	80		2830.79	I	17568 - 52884
40	2602.14	I		27		2836.31	I	17637 - 52884
45	2603.72	II	29889 - 68284	60		2870.08	II	44315 - 79147
4300	2605.69	II	0 - 38366	80		2879.49	II	33147 - 67866
190	2610.20	II	27547 - 65847	40		2882.90	I	17452 - 52129
140	2622.90	I	25281 - 63395	70		2886.68	II	33278 - 67910
150	2624.04	I	25266 - 63363	160		2889.58	II	33248 - 67846
40	2624.80	II	27571 - 65658	55		2892.39	II	33248 - 67812
200	2625.58	II	27583 - 65658	80		2900.16	II	36274 - 70745
95	2626.64	I	18402 - 56462	40		2907.22	I	25266 - 59653
30	2630.26	I	25281 - 63289	140	h	2914.60	I	18402 - 52702
60	2630.57	I	25285 - 63289	190	h	2925.57	I	18532 - 52703
190	2632.35	II	27588 - 65566	27		2928.68	I	25281 - 59416
130	2638.17	II	27589 - 65483	1100		2933.06	II	9473 - 43557
80	2639.84	II	32788 - 70657	27		2934.02	I	25288 - 59361
27	2650.99	II	32788 - 70497	1500		2939.30	II	9473 - 43485
60	2655.91	II	32857 - 70497	250	h	2940.39	I	18705 - 52705
45	2667.00	I	18705 - 56190			2940.48	I	18705 - 52703
110	2672.59	II	29889 - 67295	60		2941.04	I	25266 - 59257
55	2673.37	II	32836 - 70231	1900		2949.20	II	9473 - 43370
55	2674.43	II	33147 - 70527	40		3007.66	I	25281 - 58520
30	2676.33	I	23549 - 60903	40		3011.16	I	25286 - 58486
45	2680.34	II	33248 - 70546	40		3011.38	I	25288 - 58486
40	2681.72	I		40		3014.67	I	25266 - 58427
45	2683.02	I		60		3016.45	I	25286 - 58427
23	2683.75	I		70		3022.75	I	25266 - 58339
55	2684.55	II	33278 - 70518	55		3031.06	II	34762 - 67744
55	2685.94	II	30523 - 67744	95		3040.60	I	25281 - 58160
110	2688.25	II	52383 - 89572	27		3042.73	I	25281 - 58137
85	2692.66	I	25266 - 62393	85		3043.36	I	25288 - 58137
27	2693.19	II	29889 - 67009	330		3044.57	I	17052 - 49888
55	2695.36	II	29919 - 67009	120		3045.59	I	25286 - 58110
27	2698.97	II	29889 - 66929	200		3047.04	I	25266 - 58075
85	2701.00	II	29889 - 66901	40		3048.86	I	25286 - 58075
160	2701.70	II	27547 - 64550	250		3054.36	I	17282 - 50012
130	2705.74	II	27571 - 64519	140		3062.12	I	17452 - 50099
80	2707.53	II	27571 - 64494	170		3066.02	I	17282 - 49888
110	2708.45	II	27583 - 64494	170		3070.27	I	17452 - 50012
45	2709.96	II	27583 - 64473	160		3073.13	I	17569 - 50099
80	2710.33	II	27588 - 64473	90		3079.63	I	17637 - 50099
110	2711.58	II	27588 - 64456	50		3081.33	I	17569 - 50012
55	2728.61	II	41182 - 77820	23		3082.05	I	17452 - 49888
30	2738.86	I	30354 - 66855	40		3097.06	I	27248 - 59527

Manganese— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	3110.68	I	27201 - 59339	700	3809.59	I	17282 - 43524
60	h 3148.18	I	18403 - 50158	55	3810.69	I	25281 - 51516
90	h 3161.04	I	18532 - 50158	90	3816.75	I	17452 - 43644
140	h 3178.50	I	18705 - 50158	2100	3823.51	I	17282 - 43429
220	3212.88	I	17052 - 48168	390	3823.89	I	17452 - 43596
65	3216.95	I	0 - 31076	200	3829.68	I	17568 - 43673
1000	3228.09	I	17052 - 48021	480	3833.86	I	17568 - 43644
300	3230.72	I	17282 - 48226	1300	3834.36	I	17452 - 43524
850	3236.78	I	17282 - 48168	350	3839.78	I	17637 - 43673
330	3243.78	I	17452 - 48271	670	3841.08	I	17568 - 43596
650	3248.52	I	17452 - 48226	350	3843.98	I	17637 - 43644
100	3251.14	I	17569 - 48318	65	3918.32	I	34139 - 59653
310	3252.95	I	17569 - 48301	120	3926.47	I	31001 - 56462
65	3254.04	I	17052 - 47774	65	3952.84	I	33825 - 59117
310	3256.14	I	17569 - 48271	55	3975.89	I	34845 - 59990
220	3258.41	I	17637 - 48318	65	3977.08	I	34463 - 59600
180	3260.23	I	17637 - 48301	130	3982.58	I	25281 - 50383
180	3264.71	I	17282 - 47904	150	3985.24	I	25288 - 50373
65	3296.88	I	17452 - 47774	190	3986.83	I	25266 - 50341
65	3298.22	I	27201 - 57512	150	3987.10	I	25286 - 50359
65	3320.69	I	17282 - 47388	1500	4018.10	I	17052 - 41933
70	3330.67	I	17452 - 47467	150	4026.44	I	25266 - 50095
720	3441.99	II	14326 - 43370	27000	4030.76	I	0 - 24802
360	3460.33	II	14594 - 43485	19000	4033.07	I	0 - 24788
360	h 3474.04	II	14594 - 43370	11000	4034.49	I	0 - 24779
	3474.13	II	14781 - 43557	1500	4035.73	I	17282 - 42054
290	3482.91	II	14781 - 43485	55	4038.73	I	30354 - 55108
180	3488.68	II	14901 - 43557	5600	4041.36	I	17052 - 41790
140	3495.84	II	14960 - 43557	210	d 4045.13	I	34939 - 59653
50	3496.81	II	14781 - 43370		4045.21	I	34139 - 58853
100	3497.54	II	14901 - 43485	1100	4048.76	I	17452 - 42144
360	3531.85	I	18402 - 46708	80	4049.00	I	35041 - 59732
	3532.00	I	18402 - 46707	55	4051.73	I	
1100	3532.12	I	18402 - 46706	65	4052.47	I	35115 - 59784
1300	3547.80	I	18532 - 46710	150	4055.21	I	35165 - 59818
1100	3548.03	I	18532 - 46708	1900	4055.54	I	17282 - 41933
390	3548.20	I	18532 - 46707	210	4057.95	I	24779 - 49415
2200	3569.49	I	18705 - 46713	1100	4058.93	I	17569 - 42199
720	3569.80	I	18705 - 46710	150	4059.39	I	24788 - 49415
	3570.04	I	18705 - 46708	730	4061.74	I	24802 - 49415
1400	3577.88	I	17052 - 44994	730	4063.53	I	17452 - 42054
720	3586.54	I	17282 - 45156	80	4065.08	I	34251 - 58843
290	3595.12	I	17452 - 45259	80	4068.00	I	17569 - 42144
420	3607.54	I	17282 - 44994	290	4070.28	I	17637 - 42199
420	3608.49	I	17452 - 45156	730	4079.24	I	17282 - 41790
360	3610.30	I	17569 - 45259	730	4079.42	I	17637 - 42144
290	3619.28	I	17637 - 45259	1100	4082.94	I	17569 - 42054
220	3623.79	I	17569 - 45156	1100	4083.63	I	17452 - 41933
140	3629.74	I	17452 - 44994	65	4089.94	I	34423 - 58867
100	3660.40	I	37420 - 64732	55	4105.36	I	34939 - 59290
70	3670.52	I	17052 - 44289	200	4110.90	I	34939 - 59257
70	3676.96	I	37631 - 64820	150	4131.12	I	34139 - 58339
50	3682.09	I	37737 - 64888	120	4135.04	I	34251 - 58427
280	3693.67	I	34139 - 61205	80	4141.06	I	34344 - 58486
180	3696.57	I	23297 - 50341	55	4147.53	I	27202 - 51306
70	3701.73	I	17282 - 44289	80	4148.80	I	34423 - 58520
210	3706.08	I	34251 - 61226	150	4176.60	I	34139 - 58075
130	3718.93	I	34344 - 61226	120	4189.99	I	34251 - 58110
55	3728.89	I	23549 - 50359	65	4201.76	I	34344 - 58136
130	3731.93	I	41404 - 68192	65	4211.75	I	34423 - 58160
260	3790.22	I	17052 - 43429	370	4235.14	I	23549 - 47155
55	3799.26	I	17282 - 43596	510	4235.29	I	23297 - 46901
110	3800.55	I	31001 - 57306	190	4239.72	I	23720 - 47299
55	3801.91	I	25266 - 51561	290	4257.66	I	23819 - 47299
3200	3806.72	I	17052 - 43314	290	4265.92	I	23720 - 47155

Manganese— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
270	4281.10	I	23549 - 46901	19	5349.88	I	43314 - 62001
65	4284.08	I	23819 - 47155	95	5377.63	I	31001 - 49591
65	4312.55	I	23720 - 46901	95	5394.67	I	0 - 18532
45	4374.95	I	27248 - 50099	50	5399.49	I	31076 - 49591
45	4381.70	I	38670 - 61485	95	5407.42	I	17282 - 35770
55	4411.88	I	38009 - 60668	35	5413.69	I	31125 - 49591
350	4414.88	I	23297 - 45941	85	5420.36	I	17282 - 35726
55	4419.78	I	38120 - 60739	35	5432.55	I	0 - 18402
210	4436.35	I	23549 - 46084	12	5457.47	I	17452 - 35770
800	4451.59	I	23297 - 45754	60	5470.64	I	17452 - 35726
160	4453.00	I	23720 - 46170	40	5481.40	I	17452 - 35690
130	4455.01	I	24779 - 47220	30	5505.87	I	17568 - 35726
160	4455.32	I	24779 - 47218	50	5516.77	I	17568 - 35690
110	4455.82	I	24779 - 47216	40	5537.76	I	17637 - 35690
55	4457.04	I	24788 - 47218	21	5551.98	I	44289 - 62295
210	4457.55	I	24788 - 47216	8	5567.76	I	44523 - 62479
270	4458.26	I	24788 - 47212	7	5573.01	I	35165 - 53103
55	4460.38	I	24802 - 47216	8	5573.68	I	35165 - 53101
150	4461.08	I	24802 - 47212	7	5738.29	I	34139 - 51561
510	4462.02	I	24802 - 47207	7	5780.19	I	34251 - 51546
290	4464.68	I	23549 - 45941	7	5816.84	I	34344 - 51531
200	4470.14	I	23720 - 46084	140	6013.50	I	24779 - 41404
130	4472.79	I	23819 - 46170	200	6016.64	I	24788 - 41404
40	4479.40	I	41230 - 63548	290	6021.80	I	24802 - 41404
170	4490.08	I	23819 - 46084	7	6384.67	I	30426 - 46084
240	4498.90	I	23720 - 45941	17	6440.97	I	30420 - 45941
240	4502.22	I	23549 - 45754	24	6491.71	I	30354 - 45754
80	4605.36	I	38120 - 59828	14	6942.52	I	41789 - 56190
80	4626.54	I	38009 - 59617	12	6989.96	I	42054 - 56356
35	4671.69	I	23297 - 44696	14	7069.84	I	37420 - 51561
50	4701.16	I	23549 - 44815	12	7184.25	I	37631 - 51546
160	4709.72	I	23297 - 44524	10	7247.82	I	37737 - 51531
180	4727.48	I	23549 - 44696	24	7283.82	I	35690 - 49415
130	4739.11	I	23720 - 44815	35	7302.89	I	35726 - 49415
1000	4754.04	I	18403 - 39431	50	7326.51	I	35770 - 49415
180	4761.53	I	23819 - 44815	12	7680.20	I	44289 - 57306
750	4762.38	I	23297 - 44289	10	7712.42	I	44524 - 57486
300	4765.86	I	23720 - 44696	10	7764.72	I	43314 - 56190
500	4766.43	I	23549 - 44524	10	8670.92	I	35690 - 47220
940	4783.42	I	18532 - 39431	12	8672.06	I	35690 - 47218
1000	4823.52	I	18705 - 39431	10	8673.97	I	35690 - 47216
25	4844.32	I	31001 - 51638	12	8701.05	I	35726 - 47216
35	4965.88	I	23297 - 43429	17	8703.76	I	35726 - 47212
19	5001.91	I	23549 - 43524	30	8740.93	I	35770 - 47207
30	5074.79	I	27202 - 46901				
60	5117.94	I	25281 - 44815				
50	5150.89	I	25288 - 44696				
50	5196.59	I	25286 - 44524				
85	5255.32	I	25266 - 44289				
160	5341.06	I	17052 - 35770				

## Mercury

$$\text{Hg, } Z = 80, M = 200.6, \text{ Ratio } \frac{\text{Hg}}{\text{Cu}} = 3.157$$

Hg I Normal state of valence electrons  $5d^{10}6s^2\ ^1S_0 = 0$ . I.P. = 84184  $\text{cm}^{-1}$ .

Hg II Normal state of valence electrons  $5d^{10}6s^2\ ^2S_{1/2} = 0$ . I.P. = 151280  $\text{cm}^{-1}$ .

### References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Classification:

Hg I, K. Burns, K. B. Adams, and J. Longwell, J. Opt. Soc. Am. **40**, 339 (1950).

*Mercury—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
15000	2536.52	I	0 - 39412	300	3654.83	I	44043 - 71396
60	2752.78	I	37645 - 73961	80	3662.88	I	44043 - 71336
100	2893.60	I	39412 - 73961	240	3663.28	I	44043 - 71333
1200	2967.28	I	37645 - 71336	1800	4046.56	I	37645 - 62350
200	3021.50	I	44043 - 77129	120	4077.81	I	39412 - 63928
400	3125.66	I	39412 - 71396	4000	4358.35	I	39412 - 62350
320	3131.55	I	39412 - 71336	3200	5460.74	I	44043 - 62350
320	3131.83	I	39412 - 71333	240	5769.59	I	54069 - 71396
60	3341.48	I	44043 - 73961	280	5790.65	I	54069 - 71333
2800	3650.15	I	44043 - 71431				



# Molybdenum

Mo,  $Z = 42$ ,  $M = 95.9$ , Ratio  $\frac{Mo}{Cu} = 1.510$

Mo I Normal state of valence electrons  $4d^5 5s^1 S_3 = 0$ . I.P. = 57260  $\text{cm}^{-1}$ .

Mo II Normal state of valence electrons  $4d^5 6s^1 S_{21/2} = 0$ . I.P. = 130300  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented by Kiess, cited below.

### Classification:

Mo I, C. C. Kiess, unpublished material (1966).

Mo II, C. C. Kiess, J. Research NBS **60**, 375 (1958). RP 2856.

### *Strong lines of molybdenum*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
40000	2020.30	II	0 - 49481	2500	5570.45	I	10768 - 28715
29000	3798.25	I	0 - 26321	2400	2089.52	II	15199 - 63041
29000	3864.11	I	0 - 25872	2300	4069.88	I	16784 - 41348
21000	2038.44	II	0 - 49041				
19000	2015.11	II	0 - 49609	2200	2092.50	II	15331 - 63105
19000	3902.96	I	0 - 25614	1900	3384.62	I	11859 - 41396
17000	2045.98	II	0 - 48861	1900	4381.64	I	16784 - 39600
14000	3132.59	I	0 - 31913	1700	2775.40	II	13461 - 49481
8700	3170.35	I	0 - 31533	1700	2816.15	II	13461 - 48960
7800	5506.49	I	10768 - 28924	1700	2848.23	II	12900 - 47999
7600	3193.97	I	0 - 31300	1700	2871.51	II	12417 - 47232
6000	3158.16	I	0 - 31655	1700	3833.75	I	12346 - 38423
5200	5533.05	I	10768 - 28837	1600	3358.12	I	11454 - 41224
4800	2081.68	II	0 - 48022	1500	2104.29	II	15447 - 62954
4000	2093.11	II	15447 - 63207	1500	4232.59	I	16748 - 40367
3200	3447.12	I	12346 - 41348	1400	2108.02	II	23248 - 70670
3000	3208.83	I	0 - 31155	1400	3112.12	I	0 - 32123
2900	4143.55	I		1400	3581.89	I	16785 - 44695
2700	2100.84	II	15428 - 63012	1400	3624.46	I	16748 - 44330
2500	4188.32	I		1400	3694.94	I	16641 - 43698
2500	4411.57	I	16784 - 39445	1400	4062.08	I	16785 - 41396
	4411.70	I	16785 - 39445	1400	4288.64	I	11859 - 35169

Molybdenum—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	
19000	2015.11	II	0 - 49609	95	h	2524.81	I	11454 - 51049
40000	2020.30	II	0 - 49481	70		2527.14	II	24836 - 64395
21000	2038.44	II	0 - 49041	50		2530.34	II	24659 - 64168
17000	2045.98	II	0 - 48861	70		2532.31	II	22864 - 62342
4800	2081.68	II	0 - 48022	70		2536.85	I	12346 - 51753
2400	2089.52	II	15199 - 63041	440		2538.46	II	13461 - 52843
2200	2092.50	II	15331 - 63105	50		2539.44	II	24509 - 63877
4000	2093.11	II	15447 - 63207	110	h	2540.45	I	11859 - 51210
2700	2100.84	II	15428 - 63012	330		2542.67	II	12900 - 52217
1500	2104.29	II	15447 - 62954	65		2543.35	I	11859 - 51165
1400	2108.02	II	23248 - 70670	40		2543.61	II	22444 - 61746
400	2269.69	II	15447 - 59492	330		2548.22	I	10768 - 49999
160	2304.25	II	27627 - 71011	110	h	2550.85	I	11859 - 51049
160	2306.97	II	15427 - 58761	65		2555.42	II	23833 - 62954
130	2325.94	I	12346 - 55328	40		2556.75	II	23853 - 62954
240	2330.46	I		80		2558.88	II	24836 - 63904
110	2332.12	II	15330 - 58197			2558.94	I	11858 - 50926
190	2340.47	I		65		2562.08	II	27725 - 66744
190	2341.59	II	15199 - 57892	85		2564.34	II	25342 - 64326
80	2352.61	I	12346 - 54839	40		2566.26	II	12417 - 51373
80	2355.22	I	11143 - 53589	250		2567.05	I	10768 - 49712
80	2355.42	II	15699 - 58141	20		2571.45	II	26406 - 65282
70	2364.37	I	11454 - 53736	320		2572.34	I	12346 - 51210
50	2366.09	II	15890 - 58141	50		2574.42	II	12900 - 51732
140	2372.27	I	11454 - 53595	40		2575.77	I	11858 - 50670
100	2380.41	I	11859 - 53855	40		2576.56	II	24138 - 62937
150	2383.52	I	11859 - 53800	40		2578.36	II	26488 - 65261
110	2389.20	II	23853 - 65695	95		2578.77	I	11858 - 50625
140	2403.61	II	23833 - 65425	250		2582.16	I	10768 - 49484
80	2404.66	II	24509 - 66082	30		2585.95	II	23833 - 62492
140	2405.86	I		65		2588.78	II	23934 - 62551
40	2408.39	I	12346 - 53855	40		2591.77	II	23853 - 62425
40	2412.84	II	22444 - 63877	70		2591.98	I	11143 - 49712
120	2413.01	II	15890 - 57320	250		2593.70	II	12034 - 50577
70	2415.33	I	12346 - 53736	100		2595.40	I	10966 - 49484
80	2417.96	II	16796 - 58141	40		2596.77	I	21343 - 59841
65	2419.01	II	23934 - 65261	30		2597.22	I	10768 - 49259
80	2420.18	II	24138 - 65444	40		2597.38	II	23853 - 62342
70	2424.00	II	23833 - 65075	50		2599.64	I	12346 - 50802
65	2430.43	I	12346 - 53479	80		2601.69	I	
65	2435.96	II	22864 - 63904	250		2602.80	II	11783 - 50192
65	2440.28	II	17174 - 58141	28		2603.32	I	10768 - 49169
40	2461.81	II	24836 - 65444	40		2605.08	II	26739 - 65115
50	2466.68	II	22864 - 63392	40		2605.93	II	17344 - 55706
50	2466.97	II	16796 - 57320	250		2607.37	I	11143 - 49484
50	2468.78	II	23833 - 64326	30		2608.86	I	20930 - 59250
30	2470.04	II	23853 - 64326	190		2611.20	I	20951 - 59236
150	h 2471.97	I	10768 - 51210	290		2613.08	I	11454 - 49712
70		II	26041 - 66391	130		2615.39	I	10966 - 49190
70	h 2481.81	I	10768 - 51049	400		2616.78	I	11143 - 49346
65		II	23934 - 64203	70		2619.34	II	11783 - 49949
40		II	23934 - 64168	140		2621.07	I	11859 - 49999
40	h 2485.31	I		320		2627.55	I	11143 - 49190
24		II	22444 - 62492	160		2628.74	I	11454 - 49484
85		II	15691 - 55706	80		2628.97	I	11143 - 49169
40		II	22444 - 62425	440		2629.85	I	11454 - 49468
65		II	12900 - 52843	65		2631.50	I	10966 - 48956
50	h 2508.67	I		70		2635.57	I	11859 - 49790
50		I	12346 - 52182	330		2636.67	II	12034 - 49949
50		II	12417 - 52217	250		2638.30	I	11454 - 49346
30		I		720		2638.76	II	12417 - 50302
65		II	22980 - 62728	30		2639.49	I	
24		I	12346 - 52085	30		2639.68	I	
50	h 2517.46	I	11454 - 51165	80		2640.28	I	
24		I		410		2640.99	I	11859 - 49712

Molybdenum—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	2643.81	I	11143 - 48956	250	2733.39	I	11454 - 48028
600	2644.35	II	12900 - 50706	28	2735.65	I	16784 - 53327
30	2645.79	I		24	2735.88	I	11858 - 48399
370	2646.49	II	12417 - 50192	28	2736.42	I	18356 - 54889
30	2647.25	I	10768 - 48532	160	2736.96	II	15691 - 52217
30	2649.25	I	11454 - 49190	80	h 2737.88	II	35406 - 71920
640	2649.46	I	11859 - 49591	50	2738.60	II	27627 - 64130
40	2650.68	I	11454 - 49169	40	2741.32	II	26739 - 63207
480	2653.35	II	12900 - 50577	55	2741.62	II	24509 - 60973
560	h 2655.03	I	12346 - 49999	240	2743.07	I	11143 - 47588
40	2655.93	I	10768 - 48409	95	2743.71	I	10966 - 47402
40	2656.49	I	11143 - 48775	80	2745.09	I	10768 - 47186
290	2658.11	I	11859 - 49468	40	2745.38	I	16784 - 53198
640	2660.58	II	12034 - 49609	290	2746.30	II	15330 - 51732
110	2665.10	I	11859 - 49370	55	2748.49	I	11454 - 47827
50	2666.75	I	11859 - 49346	320	2751.47	I	11859 - 48192
65	2670.32	I	10768 - 48206	30	2754.29	I	10768 - 47064
55	2671.83	II	15427 - 52843	30	2755.37	I	10966 - 47248
720	2672.84	II	12900 - 50302	110	2756.07	II	
250	2673.27	II	15447 - 52843	65	d 2758.63	II	11783 - 48022
20	2673.84	I		28	2759.58	I	11859 - 48085
30	2678.67	I	11454 - 48775	20	2760.53	II	26739 - 62954
1000	2679.85	I	12346 - 49651	190	2761.53	I	12346 - 48547
95	2681.36	II	23833 - 61116	65	2762.70	I	12346 - 48532
30	2682.62	I	11143 - 48409	65	2763.03	I	11143 - 47324
640	2683.23	II	11783 - 49041	220	2763.62	II	15199 - 51373
880	2684.14	II	13461 - 50706	40	2763.93	I	11859 - 48028
560	2687.99	II	12417 - 49609	110	2766.26	I	11143 - 47282
50	2688.64	I	21343 - 58526	40	2766.72	I	11454 - 47588
30	2692.61	II	27725 - 64852	30	2767.22	I	10768 - 46895
28	2693.04	I	12346 - 49468	40	2768.09	I	
20	2693.53	I		240	2769.76	II	27114 - 63207
55	2695.22	II	23833 - 60925	28	2771.36	I	10966 - 47039
65	2696.07	I	10768 - 47848	160	2773.78	II	15691 - 51732
30	2696.83	II	33601 - 70671	190	2774.39	II	15699 - 51732
85	2697.81	I	10966 - 48022	1700	2775.40	II	13461 - 49481
55	2699.41	II	22444 - 59478	130	2777.74	I	11858 - 47848
65	2700.21	I	12346 - 49370	65	2777.86	II	12034 - 48022
140	2701.03	I	11858 - 48870	70	2779.48	I	11143 - 47110
480	2701.42	II	12034 - 49041	880	2780.04	II	12900 - 48861
30	2701.87	II	26041 - 63041	400	2784.99	II	16947 - 52843
30	2704.93	II	33045 - 70004	30	2786.11	I	
50	2705.24	I	11454 - 48409	180	2787.83	I	12346 - 48206
95	2706.12	I	11143 - 48085	70	2788.94	I	12346 - 48192
50	2709.25	I		24	2790.01	I	16748 - 52579
40	2710.19	II	15330 - 52217	95	2790.31	I	11454 - 47282
65	2710.74	I	11143 - 48022		2790.41	II	23853 - 59680
30	2711.49	II	23833 - 60702	40	2791.54	II	30019 - 65831
50	2712.35	II	33146 - 70004	80	2792.96	I	11454 - 47248
190	2713.51	II	13461 - 50302	30	2796.78	I	24096 - 59841
50	2715.17	I	10768 - 47588	240	d 2797.93	I	11454 - 47184
80	2717.16	I			2798.01	I	11859 - 47588
290	2717.35	II	15428 - 52217	220	2801.47	I	10768 - 46453
80	2720.17	I	11454 - 48206		2801.55	I	
110	2724.41	I	16784 - 53479	30	2807.36	I	11454 - 47064
180	2725.15	I	11143 - 47827	400	2807.76	II	12417 - 48022
50	2725.95	I	11859 - 48532	70	2808.37	I	11454 - 47052
28	2726.65	I	21154 - 57818	30	2809.96	I	11143 - 46720
85	2726.97	II	26069 - 62728	24	2810.43	I	18229 - 53800
16	2728.34	I		30	2811.50	I	
85	2728.70	I	11143 - 47779	28	2812.58	II	23934 - 59478
55	2729.13	I	11454 - 48085	24	2814.67	II	28877 - 64395
140	2729.68	II	12417 - 49041	30	2815.54	I	18229 - 53736
80	2730.20	II	26488 - 63105	70	2815.91	I	11454 - 46956
330	2732.88	II	12900 - 49481	1700	2816.15	II	13461 - 48960

*Molybdenum— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
220	2817.44	II	15890 - 51373	950	2894.45	II	13461 - 47999
	2817.50	I	23516 - 58999	28	2896.44	I	12346 - 46861
40	2818.30	I	11454 - 46926	28	2896.97	I	
50	2822.03	II	11783 - 47208	140	2897.63	II	15691 - 50192
30	2822.43	I	11454 - 46874	80	2898.65	I	20350 - 54839
24	2822.86	I	18229 - 53644	70	2900.80	II	29034 - 63498
50	2825.67	I	18356 - 53736	290	2903.07	II	26488 - 60924
240	2826.54	I	24823 - 60191	160	2905.27	I	12346 - 46756
50	2826.75	I	18229 - 53595	65	2906.06	I	20130 - 54531
80	2827.74	II	27627 - 62980	80	2907.12	II	17344 - 51732
40	2828.79	I	24096 - 59437	28	2907.78	I	11454 - 45835
40	2829.79	I	11858 - 47186	24	2908.16	I	21154 - 55530
70	2829.94	I	11858 - 47184	600	2909.12	II	11783 - 46148
40	2831.44	II	33601 - 68909	1100	2911.92	II	12900 - 47232
30	2832.07	II	24836 - 60135	70	2913.52	I	10768 - 45081
80	2834.39	II	16947 - 52217	55	2913.81	II	28989 - 63298
80	2835.33	II	15447 - 50706	50	2915.26	I	25549 - 59841
20	2835.91	I	11858 - 47110	55	2915.38	I	20281 - 54572
10	2836.03	I	16641 - 51891	50	2916.10	I	11143 - 45425
40	h 2837.32	I		120	2918.83	II	15699 - 49949
50	2837.90	I	21154 - 56381	24	2919.20	I	11143 - 45389
55	2839.58	I	11858 - 47064	55	2919.38	I	12346 - 46590
160	2842.15	II	12034 - 47208	1300	2923.39	II	12417 - 46614
65	2842.37	I		140	2924.32	II	26041 - 60227
24	2843.73	II	33895 - 69050	65	2927.54	II	30019 - 64168
220	2844.39	I	24466 - 59612	50	2930.06	II	28883 - 63002
1700	2848.23	II	12900 - 47999	1100	2930.50	II	12034 - 46148
160	2849.38	I		55	2930.77	II	30019 - 64130
65	d 2850.79	I	11859 - 46926	50	2931.08	I	12346 - 46453
	2850.90	I	10768 - 45835	800	2934.30	II	11783 - 45853
30	2851.18	I	12346 - 47409	65	2934.84	I	25549 - 59612
370	2853.23	II	27114 - 62152	65	2935.20	II	15890 - 49949
40	2853.58	I	16641 - 51675	80	2936.50	I	21343 - 55387
40	d 2854.87	I	24823 - 59841	120	2937.66	I	
50	2856.00	II	27724 - 62728	40	2938.30	II	28989 - 63012
50	2859.57	I	20948 - 55908	95	2940.10	II	27114 - 61116
30	2862.84	I		50	2940.98	I	20350 - 54343
24	2863.20	II	24138 - 59053	110	2941.22	II	30213 - 64203
370	2863.81	II	26739 - 61648	55	2942.85	I	11454 - 45425
160	2864.31	I	24096 - 58998	140	2944.21	I	0 - 33955
140	2864.66	I	11859 - 46756	150	2944.82	II	35099 - 69047
10	2865.62	II	15691 - 50577	80	2945.43	I	20948 - 54889
220	2866.69	II	17344 - 52217	140	2945.66	I	11143 - 45080
40	2868.11	II	26069 - 60924	190	2945.95	II	30391 - 64326
40	2868.32	II	26604 - 61457	190	2946.01	I	11454 - 45389
70	2869.56	I	12346 - 47184	140	2946.42	I	
28	2870.18	I	12346 - 47177	140	2946.69	II	30213 - 64140
28	2870.90	I	21154 - 55976	95	2947.28	II	29034 - 62954
1700	2871.51	II	12417 - 47232	50	2953.56	I	16784 - 50631
28	2871.89	I		95	2955.84	II	26406 - 60227
85	2872.88	II	27628 - 62425	240	2956.06	II	12034 - 45853
40	2873.64	I	24823 - 59612	70	2956.90	II	35099 - 68909
50	2876.54	I	21154 - 55908	85	h 2957.75	I	
40	2878.38	I	11858 - 46590	80	2959.48	I	20158 - 53938
220	2879.05	II	30391 - 65115	80	2959.80	I	11859 - 45635
40	2882.54	I	20158 - 54839	95	2960.24	II	13461 - 47232
65	2885.74	I	25549 - 60192	140	2962.89	I	
85	2886.61	I	21343 - 55976	250	2963.79	II	12417 - 46148
28	2887.62	I	10768 - 45389	50	2964.96	II	28877 - 62595
65	2888.15	II	33146 - 67760	210	2965.27	II	12900 - 46614
40	2889.84	I	11858 - 46453	70	2971.91	II	26041 - 59680
1300	2890.99	II	12034 - 46614	250	2972.61	II	16947 - 50577
95	2891.28	II	16796 - 51373	80	2972.96	I	11454 - 45081
190	2892.81	II	17174 - 51732	80	2975.40	II	29699 - 63298
65	2893.23	I	25639 - 60192	50	2977.27	I	20158 - 53736

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
180	2978.28	I	11859 - 45425	95	3163.90	I	16641 - 48238
120	2981.52	I	11858 - 45389	120	3164.53	I	11454 - 43046
50	2983.04	I	19970 - 53483	8700	3170.35	I	0 - 31533
65	2983.81	I	20350 - 53855	55	3171.38	I	
50	2985.16	I	12346 - 45836	95	3172.03	II	17344 - 48860
50	2985.84	I	25517 - 58999	40	3172.37	I	16693 - 48206
110	2987.92	I	20130 - 53588	160	3172.74	II	15699 - 47208
80	2988.23	I	20281 - 53736	95	3177.90	I	16748 - 48206
160	2988.68	I	20350 - 53800	95	3179.77	I	
190	2989.80	I	20158 - 53595	370	3183.03	I	16785 - 48192
95	2992.84	II	17174 - 50577	120	3184.57	I	16693 - 48085
50	2993.52	II	16796 - 50192	370	3185.10	I	11858 - 43246
50	3000.23	I	20158 - 53479	180	3185.71	I	16641 - 48022
190	3002.21	I	0 - 33299	120	3187.59	II	23853 - 55216
40	3004.46	II	26406 - 59680		3187.68	I	18229 - 49591
50	3010.26	I	12346 - 45556	65	3188.09	I	23668 - 55026
130	3013.39	I	18229 - 51405	65	3188.40	I	23534 - 54889
140	3013.76	I		95	3191.52	I	21343 - 52667
80	3016.78	I	21154 - 54292	95	3192.80	I	21154 - 52465
250	3025.00	I	18356 - 51405	7600	3193.97	I	0 - 31300
95	3027.77	II	17174 - 50192	65	3194.87	I	24096 - 55387
50	3035.33	I	18229 - 51165	290	3195.96	I	16748 - 48028
100	3036.31	I	18480 - 51405	120	3198.85	I	12346 - 43598
50	3039.82	I	25639 - 58526	65	3200.21	I	18229 - 49468
300	3041.70	I	16784 - 49650	65	3200.89	I	18480 - 49712
150	3046.80	I	16784 - 49596	40	3201.50	II	16796 - 48022
210	3047.31	I	16785 - 49591	330	3205.22	I	10966 - 42156
210	3055.32	I	16748 - 49468	120	3205.54	I	11858 - 43046
100	3060.78	II	16947 - 49609	880	3205.88	I	12346 - 43530
160	3061.59	I	16693 - 49346	3000	3208.83	I	0 - 31155
800	3064.28	I	16784 - 49408	240	3210.97	I	16693 - 47827
250	3065.04	II	38054 - 70670	120	3212.59	I	
100	3068.00	I	16785 - 49370	65	3213.32	I	11858 - 42970
250	3070.90	I	16748 - 49302	120	3214.44	I	16748 - 47848
85	3071.44	I	16641 - 49190	560	3215.07	I	11143 - 42237
800	3074.37	I	16784 - 49302	65	3220.86	I	10768 - 41807
85	3077.66	II	35406 - 67889	350	3221.74	I	18229 - 49259
150	3079.88	I	23515 - 55975	65	3223.49	I	11143 - 42156
210	3080.41	I	16693 - 49147	880	3228.22	I	11454 - 42422
40	3081.16	I	18480 - 50926	600	3229.79	I	12346 - 43299
800	3085.62	I	16748 - 49147	1100	3233.14	I	16784 - 47705
270	3087.62	II	27114 - 59492	190	3235.38	I	12346 - 43246
100	3089.12	I	16784 - 49147	950	3237.08	I	20281 - 51165
100	3089.71	I	16641 - 48997	110	3237.98	I	16784 - 47659
190	3092.07	II	15691 - 48022	190	3240.49	I	12346 - 43197
560	3094.66	I	16693 - 48997	65	3240.71	II	17174 - 48022
110	3099.93	I	16748 - 48999	50	3244.47	I	18356 - 49169
110	3100.88	I	23668 - 55908	65	3245.92	I	27727 - 58526
560	3101.34	I	16641 - 48876	65	3249.92	I	16641 - 47402
55	3106.34	I	16693 - 48876	950	3256.21	I	11454 - 42156
1400	3112.12	I	0 - 32123	110	3259.16	I	24466 - 55140
55	3117.54	I	24823 - 56891	65	3260.48	I	16748 - 47409
290	3122.00	II	26740 - 58761	300	3262.63	I	16641 - 47282
14000	3132.59	I	0 - 31913	110	3263.83	I	10768 - 41398
40	3135.60	I		480	3264.40	I	16785 - 47409
55	3135.89	I	24096 - 55976	130	3265.14	I	
95	3136.46	I	16748 - 48622	800	3270.90	I	11859 - 42422
50	3136.75	I	23516 - 55387	65	3279.44	I	16692 - 47177
110	3138.72	II	26041 - 57892	240	3285.02	I	10966 - 41398
55	3144.34	I		320	3285.36	I	16748 - 47177
220	3147.35	I	16784 - 48547	65	3287.38	I	16641 - 47052
220	3152.82	II	26488 - 58197	1100	3289.02	I	11454 - 41850
55	3155.64	II	29022 - 60702	190	3289.84	I	16784 - 47172
55	3156.51	I	11858 - 43530	950	3290.82	I	11858 - 42237
6000	3158.16	I	0 - 31655	190	3292.31	II	25342 - 55706

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
130	3294.85	I	11143 - 41484	95	3434.04	I	11454 - 40566
100	3296.40	I	11858 - 42186	380	3434.79	I	11859 - 40964
100	3303.34	I	16693 - 46956	320	3435.45	I	25639 - 54739
180	3304.22	I	11143 - 41398	640	3437.22	I	16785 - 45870
320	3305.56	I	10768 - 41012	250	3438.87	I	10966 - 40037
130	3305.90	I	21619 - 51859	250	3441.44	I	12346 - 41396
320	3307.12	I	11859 - 42088	65	3442.66	I	20130 - 49169
160	3310.77	I	10768 - 40964	250	3443.26	I	11454 - 40488
95	3312.33	I	16693 - 46874	95	3445.04	I	20350 - 49370
100	3313.62	II	28884 - 59053	190	3445.26	I	16693 - 45710
130	3319.59	I	16693 - 46808	130	3446.08	II	23833 - 52843
130	3319.79	I	16641 - 46755	3200	3447.12	I	12346 - 41348
190	3320.90	II	25112 - 55216	640	3449.07	I	11859 - 40844
640	3323.95	I	12346 - 42422	95	3449.85	I	20281 - 49259
360	3325.67	I	10768 - 40829	300	3451.75	I	
360	3327.30	I	10966 - 41012	250	3452.60	I	18229 - 47184
65	3329.04	I	11454 - 41485	100	3454.22	I	16693 - 45635
65	3331.40	I	16748 - 46756	190	3456.15	I	18356 - 47282
130	3336.51	I	18229 - 48192	950	3456.39	I	0 - 28924
240	3340.17	I	10768 - 40698	65	3458.15	I	20281 - 49190
95	3343.72	I		160	3459.92	I	11143 - 40037
1300	3344.75	I	11143 - 41032	130	3460.23	I	18356 - 47248
95	3346.40	II	25342 - 55216	640	3460.78	I	16748 - 45635
320	3347.02	I	11143 - 41012	320	3466.83	I	0 - 28836
65	3349.19	I	18356 - 48206	65	3466.97	I	18229 - 47064
130	3350.30	I	12346 - 42186	250	3467.85	I	18356 - 47184
130	3354.99	I	10768 - 40566	320	3469.22	I	16641 - 45458
1600	3358.12	I	11454 - 41224	65	3469.63	I	24823 - 53637
250	3361.37	I	12346 - 42088	190	3470.92	I	18480 - 47282
130	3362.37	I	10966 - 40698	65	3473.22	I	16641 - 45425
950	3363.78	I	10768 - 40488	190	3475.03	I	18480 - 47248
65	3369.25	I	18356 - 48028	180	3479.43	I	16693 - 45425
65	3375.22	I	18229 - 47848	100	3480.09	I	18229 - 46956
65	3375.65	I	21619 - 51234	100	3481.79	I	20158 - 48870
130	3378.20	I	11143 - 40736	190	3482.40	I	11859 - 40566
130	3378.46	I	25549 - 55140	95	3483.67	I	18229 - 46926
950	3379.97	I	11454 - 41032	190	3483.84	I	18356 - 47052
65	3382.29	I	11454 - 41012	240	3485.93	I	11143 - 39821
320	3382.48	I	11143 - 40699	130	3491.77	I	18480 - 47110
1900	3384.62	I	11859 - 41396		3491.87	I	11858 - 40488
65	3385.88	I	26636 - 56162	130	3493.34	I	12346 - 40964
95	3387.75	I	11454 - 40964	800	3504.41	I	18229 - 46756
160	3389.80	I	18356 - 47848	240	3505.32	I	20350 - 48870
95	3392.17	I	21154 - 50625	560	3508.12	I	12346 - 40844
160	3393.65	I	21343 - 50802	100	3510.78	I	28241 - 56717
130	3395.36	II	36289 - 65732	100	3513.70	I	18356 - 46808
160	3397.69	I	11143 - 40566	130	3517.56	I	25517 - 53938
130	3402.81	I	27766 - 57144	130	3518.22	I	18480 - 46895
65	3403.35	I	11454 - 40829	480	3521.41	I	20158 - 48547
640	3404.34	I	11859 - 41224	65	3522.37	I	11859 - 40241
65	3405.20	I	18229 - 47588	100	3524.23	I	11454 - 39821
1300	3405.94	I		190	3524.65	I	25821 - 54184
240	3418.52	I	11454 - 40698	240	3524.98	I	18229 - 46590
50	3418.96	I	20350 - 49591	640	3537.28	I	21619 - 49880
250	3420.04	I	18356 - 47588	320	3542.17	I	18229 - 46452
190	3421.25	I	10768 - 39989	95	3554.20	I	20281 - 48409
250	3422.31	I	20158 - 49370	65	3555.43	I	20281 - 48399
190	3424.60	I	10768 - 39960	520	3558.10	I	18356 - 46453
95	3424.76	I	16748 - 45939	400	3563.14	I	11859 - 39916
95	3425.19	I	20281 - 49468	65	3563.76	I	19970 - 48022
130	3425.48	I	16784 - 45969	300	3566.05	I	20158 - 48192
130	3426.00	I	18229 - 47409	240	3570.65	I	25639 - 53637
160	3426.79	I	11859 - 41032	320	3573.88	I	18480 - 46452
80	3427.90	I	27727 - 56891	110	3580.54	I	28241 - 56162
95	3432.87	I	16748 - 45870	1400	3581.89	I	16785 - 44695

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	3586.86	I	25456 - 53327	90	3696.04	I	29982 - 57030
100	3588.95	I	20350 - 48206	55	3698.53	I	20281 - 47311
200	3590.74	I	20350 - 48192	70	3700.01	I	20158 - 47177
65	3592.02	I	16693 - 44525	220	3702.03	I	16693 - 43698
100	3595.55	I	20281 - 48085	180	3702.55	I	20281 - 47282
65	3595.71	I	20608 - 48411	55	3705.41	I	20130 - 47110
210	3598.88	I	25549 - 53327	80	3707.17	I	20281 - 47248
95	3600.28	I	16693 - 44461	80	3708.56	I	23668 - 50625
270	3602.94	I	20281 - 48028	55	3710.14	I	18480 - 45425
65	3604.07	I	25997 - 53736	27	3711.51	I	10966 - 37902
210	3608.37	I	11454 - 39160	80	3712.95	I	19970 - 46895
140	3612.00	I	20350 - 48028	80	3713.47	I	20130 - 47052
100	3612.45	I	20948 - 48622	70	3714.55	I	21619 - 48532
140	3613.37	I	11454 - 39122	220	3715.65	I	16693 - 43598
100	3613.64	I	21154 - 48819	140	3716.07	I	
65	3615.15	I	26639 - 54292	80	3716.87	I	20281 - 47177
65	3615.74	I	20130 - 47779	55	3718.48	I	26759 - 53644
70	3616.84	I	18229 - 45870	120	3719.55	I	
200	3623.23	I			3719.74	I	20951 - 47827
1400	3624.46	I	16748 - 44330	70	3720.25	I	25707 - 52579
330	3626.18	I	12346 - 39916	70	3723.51	I	20930 - 47779
65	3628.35	I	20158 - 47711	35	3723.81	I	21343 - 48189
100	3628.66	I	16641 - 44192	180	3725.56	I	20350 - 47184
24	3629.31	I	25639 - 53184	140	3726.22	I	20281 - 47110
28	3635.14	II	25342 - 52843		3726.32	I	20951 - 47779
1000	3635.43	I	16693 - 44192	500	3727.69	I	
65	3637.52	I	11143 - 38626	160	3728.30	I	23668 - 50482
160	3638.20	I	18356 - 45835	150	3728.50	I	
140	3640.62	I	20951 - 48411	27	3730.56	I	20158 - 46956
95	3640.99	I	20130 - 47588	330	3732.71	I	
70	3642.20	I	20951 - 48399		3732.80	I	16748 - 43530
70	3648.61	I	16641 - 44041	120	3733.03	I	21619 - 48399
140	3651.35	I	11143 - 38522	80	3733.40	I	21343 - 48121
400	3657.35	I	16641 - 43975	80	3734.37	I	20281 - 47052
70	3660.92	I	26336 - 53644	80	3735.62	I	25906 - 52667
180	3661.78	I	11858 - 39160	90	3735.91	I	20350 - 47110
140	3662.99	I	25906 - 53198	27	3736.17	I	20281 - 47039
140	3663.30	I	20948 - 48238	180	3737.91	I	16784 - 43530
80	3664.30	I	16693 - 43975	27	3740.76	I	18356 - 45081
540	3664.81	I	18356 - 45635	240	3742.28	I	20350 - 47064
290	3666.72	I	16748 - 44012	55	3743.81	I	20158 - 46861
110	3666.94	I	11858 - 39122	27	3744.10	I	20350 - 47052
65	3668.00	I	20951 - 48206	80	3744.37	II	
70	3668.49	I	20158 - 47409	27	3744.94	I	
220	3669.34	I	21154 - 48399	90	3745.48	I	18229 - 44921
35	3670.42	I	20350 - 47588	110	3747.19	I	
590	3672.82	I	26636 - 53855	150	3748.49	I	26636 - 53306
90	3675.36	I	25997 - 53198	130	3751.20	I	20158 - 46808
23	3675.98	I	18229 - 45425	140	3755.10	I	25821 - 52444
90	3676.24	I	20130 - 47324	30	3755.54	I	21619 - 48238
90	3677.70	I		30	3755.84	I	23516 - 50134
1300	3680.60	I	16784 - 43946	180	3758.52	I	20158 - 46756
	3680.68	I	16785 - 43946	30	3759.60	I	26636 - 53227
90	3681.55	I	20930 - 48085	90	3760.88	I	25997 - 52579
	3681.72	I	20158 - 47311	90	3761.76	I	20350 - 46926
45	3684.22	II	36741 - 63877	55	3762.09	I	21619 - 48192
	3684.33	I	20951 - 48085	150	3763.35	I	11859 - 38423
35	3686.11	I	20281 - 47402	55	3764.44	I	21154 - 47711
65	3688.31	II	25112 - 52217	90	3765.22	I	16748 - 43299
70	3688.97	I	25906 - 53006	55	3765.74	I	
240	3690.59	I	20951 - 48039	30	3767.73	I	21343 - 47877
23	3692.08	I	18480 - 45556	65	3768.62	I	20281 - 46808
180	3692.64	II	24659 - 51732	65	3768.74	I	27766 - 54292
160	3693.38	I	11454 - 38522	65	3770.00	I	27774 - 54292
1400	3694.94	I	16641 - 43698	360	3770.45	I	16784 - 43299
					3770.52	I	11454 - 37968

Molybdenum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
180	3771.95	I	16693 - 43197	110	3915.44	I	22876 - 48409
150	3772.82	I	16748 - 43246	75	3916.92	I	22876 - 48399
30	3775.65	I	19970 - 46448	150	3917.54	I	20350 - 45870
30	3776.10	I	25707 - 52182	75	3917.78	I	20930 - 46448
				75	3922.32	I	19970 - 45458
30	3776.55	I	20930 - 47402	120	3923.75	I	23668 - 49147
65	3777.72	I	28241 - 54704	65	3928.79	I	21619 - 47064
55	3777.96	I	20948 - 47409	30	3931.40	I	20281 - 45710
220	3779.77	I	16748 - 43197	35	3935.02	I	23516 - 48922
360	3781.59	I	11143 - 37579	65	3941.48	II	25342 - 50706
65	3782.19	I	20158 - 46590	230	3943.04	I	20281 - 45635
55	3783.53	I		35	3943.51	I	20951 - 46302
90	3785.03	I	16785 - 43197	75	3945.25	I	16748 - 42088
55	3785.51	I	26336 - 52747	35	3947.17	I	20130 - 45458
90	3788.26	I	26189 - 52579	75	3950.99	I	16784 - 42088
110	3793.62	I	16693 - 43046	120	3953.93	I	20350 - 45635
90	3794.43	I	23516 - 49864	65	3955.49	I	30113 - 55387
55	3796.04	I	24466 - 50802	35	3958.60	I	24096 - 49351
250	3797.30	I	10966 - 37293	30	3963.53	I	26636 - 51859
29000	3798.25	I	0 - 26321	30	3963.99	I	26639 - 51859
290	3801.84	I	20158 - 46453	35	3965.76	I	16641 - 41850
110	3804.52	I	16693 - 42970	75	3968.75	I	21619 - 46808
110	3805.93	I	25821 - 52088	150	3973.77	I	29982 - 55140
	3805.99	I	23534 - 49801	120	3973.93	I	16693 - 41850
65	3807.65	I	21154 - 47409	65	3975.96	I	20281 - 45425
110	3811.39	I	21619 - 47848	65	3977.90	I	
110	3812.47	I	16748 - 42970	35	3979.22	I	27342 - 52465
75	3818.66	I	20930 - 47110	75	3980.20	I	26759 - 51876
140	3819.87	I	20281 - 46452	75	3982.05	I	23516 - 48622
190	3822.98	I	11143 - 37293	35	3982.60	I	16748 - 41850
75	3825.32	I	23516 - 49651	140	3986.20	I	25517 - 50596
520	3826.70	I	11454 - 37579	35	3991.39	I	25549 - 50596
95	3827.16	I	23668 - 49790	35	3991.85	I	20930 - 45974
940	3828.87	I	11859 - 37968	35	3993.93	I	23516 - 48547
75	3830.82	I	25795 - 51891	35	3998.29	I	22244 - 47248
35	3831.07	I	27384 - 53479	65	4000.39	I	20948 - 45938
35	3831.76	I	16693 - 42783	120	4000.50	I	26415 - 51405
150	3832.11	I	25997 - 52085	75	4006.05	I	26321 - 51276
1700	3833.75	I	12346 - 38423	30	4008.05	I	24466 - 49408
40	3834.97	I	25517 - 51585	120	4009.37	I	24466 - 49400
75	3835.31	I	21343 - 47409	65	4011.97	I	25872 - 50791
65	3843.90	I	20948 - 46956	40	4017.38	I	24466 - 49351
120	3845.95	I	16748 - 42742	130	4021.02	I	29842 - 54704
380	3847.25	I	11143 - 37128	170	4024.09	I	16641 - 41484
190	3848.30	I	24823 - 50802	65	4028.65	I	21154 - 45969
75	3851.99	I	25906 - 51859	40	4032.50	I	16693 - 41484
29000	3864.11	I	0 - 25872	40	4033.63	I	21154 - 45938
35	3866.69	I	25821 - 51675	40	4037.30	I	20948 - 45710
580	3869.08	I	11454 - 37293	85	4037.78	I	20951 - 45710
580	3886.82	I	11859 - 37579	130	4038.08	I	16641 - 41398
75	3888.18	I	20158 - 45870	30	4041.12	I	27727 - 52465
75	3888.88	I	21154 - 46861	130	4042.87	I	25549 - 50277
35	3890.71	I	26189 - 51884	30	4050.09	I	20951 - 45635
35	3893.32	I	20158 - 45836	270	4056.01	I	16748 - 41396
35	3896.38	I	20281 - 45938	75	4056.32	I	26759 - 51405
35	3896.85	I	21154 - 46808	40	4057.58	I	25639 - 50277
380	3901.77	I	12346 - 37968	190	4059.61	I	21343 - 45969
19000	3902.96	I	0 - 25614	1400	4062.08	I	16785 - 41396
75	3906.92	I		85	4066.37	I	24823 - 49408
	3906.98	I	25997 - 51585	2300	4069.88	I	16784 - 41348
140	3908.25	I	20130 - 45710	190	4075.25	I	16693 - 41224
75	3909.55	I		50	4075.54	I	
75	3911.09	I	16784 - 42345	190	4076.19	I	24096 - 48622
35	3911.94	I	26336 - 51891	1300	4081.44	I	20930 - 45425
75	3913.36	I	26636 - 52182	940	4084.38	I	16748 - 41224



Molybdenum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	4086.02	I	20948 - 45415	30	4272.06	I	26189 - 49591
180	4096.81	I	21154 - 45556	130	4273.07	I	16641 - 40037
50	4098.18	I	20130 - 44525	890	4276.91	I	16693 - 40068
150	4098.74	I	16641 - 41032	1200	4277.24	I	12346 - 35719
250	4102.15	I	16641 - 41012	40	4281.83	I	16641 - 39989
150	4105.08	I	24466 - 48819	85	h 4284.60	I	
50	4105.53	I	21619 - 45969	120	4287.08	I	16641 - 39960
730	4107.47	I	16693 - 41032	1400	4288.64	I	11859 - 35169
85	4114.93	I		140	4289.42	I	21154 - 44461
95	4118.96	I	16693 - 40964	40	h 4290.18	I	25517 - 48819
630	4120.10	I		40	4291.20	I	26415 - 49712
140	4123.65	I	20281 - 44525	680	4292.13	I	11143 - 34435
140	4124.54	I	24823 - 49062	890	4293.21	I	11454 - 34740
50	4126.53	I		360	4293.88	I	10966 - 34248
150	4128.28	I	16748 - 40964	40	4296.16	I	25549 - 48819
75	4128.83	I	21343 - 45556	30	4296.62	I	16693 - 39960
180	4131.92	I	25456 - 49651	30	4298.90	I	18229 - 41484
75	4132.23	I	18229 - 42422	30	4301.26	I	
40	4135.38	I		40	4304.92	I	16693 - 39916
2900	4143.55	I		85	4310.39	I	24466 - 47659
230	4148.94	I	16748 - 40844	40	4312.80	I	16641 - 39821
75	4151.88	I	25517 - 49596	40	4312.97	I	20350 - 43530
250	4155.28	I	16785 - 40844	170	4317.93	I	
180	4155.58	I	16641 - 40698	75	4321.97	I	16785 - 39916
40	4156.79	I	22876 - 46926	840	4326.14	I	16641 - 39750
200	4157.40	I	25549 - 49596	250	4326.74	I	11143 - 34248
180	4162.68	I	25549 - 49565	30	4329.63	I	20951 - 44041
40	4164.08	I	18229 - 42237	40	4332.51	I	27727 - 50802
40	4166.28	I	24823 - 48819	120	4334.81	I	26284 - 49346
85	4169.82	I	23516 - 47492	40	4338.71	I	18356 - 41398
85	4171.07	I		40	4339.82	I	27767 - 50802
150	4177.26	I	22876 - 46808	85	4340.75	I	26759 - 49790
200	4178.27	I	25639 - 49565	130	4341.42	I	20948 - 43975
85	4181.05	I	20130 - 44041	30	4344.66	I	26336 - 49346
40	4184.39	I	25517 - 49408	230	4350.34	I	11454 - 34435
480	4185.82	I	25517 - 49400	30	4351.55	I	
50	4186.28	I	18356 - 42237	75	4353.31	I	20281 - 43246
2500	4188.32	I		40	4357.34	I	24466 - 47409
95	4190.00	I	25549 - 49408	30	4359.62	I	26415 - 49346
250	4194.56	I	25517 - 49351	40	4362.02	I	18480 - 41398
50	4200.57	I	18356 - 42156	40	4362.71	I	11858 - 34774
50	4201.32	I	16693 - 40488	85	4364.47	I	26284 - 49190
95	4205.81	I	25639 - 49408	75	4366.54	I	20350 - 43246
50	4211.02	I	16748 - 40488	230	4369.04	I	11859 - 34740
40	4219.40	I	18480 - 42173	35	4373.32	I	24096 - 46956
35	4222.41	I	18480 - 42156	40	4374.89	I	25549 - 48400
1500	4232.59	I	16748 - 40367	75	4375.01	I	27774 - 50625
40	4233.49	I	24096 - 47711	150	4380.29	I	12346 - 35169
35	4235.03	I	21154 - 44760	35	4380.59	I	16641 - 39463
85	4237.16	I	20930 - 44525	1900	4381.64	I	16784 - 39600
95	d 4239.07	I	16784 - 40367	75	4382.41	I	20158 - 42970
	4239.19	I	16785 - 40367	26	4385.89	I	11454 - 34248
140	4240.08	I	18229 - 41807	75	4391.54	I	24096 - 46861
140	4240.28	I	24823 - 48400	75	4392.12	I	25639 - 48400
190	4240.83	I	20951 - 44525	50	4394.32	I	27384 - 50134
35	4242.80	I	24096 - 47659	50	4394.47	I	20948 - 43697
190	4246.02	I	25517 - 49062	140	4396.66	I	16784 - 39522
170	4251.87	I	28241 - 51753	150	4397.29	I	18229 - 40964
140	4254.96	I	26639 - 50134	35	4402.49	I	27774 - 50482
95	4260.36	I	26336 - 49801	75	4402.90	I	24466 - 47172
40	4260.66	I	25906 - 49370	30	4404.55	I	16748 - 39445
30	4261.44	I	27342 - 50802	35	4406.87	I	29982 - 52667
95	4266.18	I	20608 - 44041	35	4409.44	I	25517 - 48189
75	4268.08	I	25639 - 49062	75	4409.95	I	24823 - 47493
270	4269.28	I	21343 - 44760	2500	4411.57	I	16784 - 39445
					4411.70	I	16785 - 39445

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	4412.77	I	18356 - 41012	21	4586.79	I	
35	4422.06	I	18356 - 40964	26	4590.38	I	
210	4423.62	I	18229 - 40829	40	4592.21	I	26639 - 48409
170	4426.67	I	20158 - 42742	170	4595.16	I	11143 - 32899
				30	4597.88	I	30113 - 51856
990	4434.95	I	16748 - 39290	26	4598.25	I	27867 - 49608
110	4436.89	I	18480 - 41012	50	4599.16	I	20350 - 42088
65	4438.96	I	27342 - 49864	30	4608.71	I	20158 - 41850
200	4442.20	I	16784 - 39290	360	4609.88	I	18229 - 39916
110	4443.07	I	11454 - 33955	50	4611.15	I	18356 - 40037
85	4446.43	I	29982 - 52465	30	4616.62	I	25517 - 47172
21	4447.23	I	27384 - 49864	30	4617.95	I	22876 - 44525
340	4449.74	I	16693 - 39160	100	4621.38	I	18356 - 39989
30	4452.56	I	23516 - 45969	30	4623.46	I	25549 - 47172
21	4455.30	I	27363 - 49801	30	4624.24	I	29171 - 50790
480	4457.36	I	16693 - 39122	460	4626.47	I	12346 - 33955
30	4458.65	I	23516 - 45938	100	4627.48	I	18356 - 39960
65	4460.62	I	16748 - 39160	50	4630.02	I	18229 - 39821
65	4464.77	I	20350 - 42742	45	4633.10	I	28274 - 49852
190	4468.28	I	16748 - 39122	30	4642.70	I	25639 - 47172
50	4471.66	I	21619 - 43975	75	4647.81	I	18480 - 39989
50	4472.04	I	28241 - 50596	30	4649.12	I	25906 - 47409
130	4473.18	I	18480 - 40829	65	4651.05	I	29781 - 51276
630	4474.56	I	16641 - 38983	75	4661.93	I	11454 - 32899
	4474.65	I	18356 - 40698	220	4662.76	I	11859 - 33299
95	4475.62	I	18229 - 40566	130	4671.90	I	21343 - 42742
150	4484.97	I	16693 - 38983	30	4683.83	I	25517 - 46861
85	4487.05	I	22244 - 44525	30	4685.81	I	27727 - 49062
30	4489.00	I	23668 - 45938	26	4686.10	I	28274 - 49608
65	4490.19	I	20158 - 42422	130	4688.22	I	28241 - 49565
230	4491.28	I	18229 - 40488	40	4690.86	I	25549 - 46861
30	4491.66	I	33904 - 56162	40	4693.93	I	
50	4499.44	I	18480 - 40698	30	4696.51	I	20951 - 42237
50	4501.29	I	18356 - 40566	50	4700.49	I	28837 - 50105
120	4504.90	I	25997 - 48189	75	4706.06	I	23516 - 44760
50	4506.67	I	26636 - 48819	640	4707.26	I	20158 - 41396
140	4512.15	I	11143 - 33299	150	4708.22	I	18229 - 39463
85	4515.18	I	20281 - 42422	30	4714.51	I	20951 - 42156
230	4517.13	I	18356 - 40488	220	4717.92	I	20158 - 41348
50	4517.41	I	10768 - 32899	40	4718.88	I	28667 - 49852
21	4518.44	I	20158 - 42282	26	4723.06	I	32688 - 53855
50	4522.19	I	20130 - 42237	20	4725.34	I	27766 - 48922
230	4524.34	I	11859 - 33955	100	4729.14	I	20948 - 42088
85	4526.37	I	18480 - 40566	700	4731.44	I	21154 - 42283
30	h 4528.62	I	27093 - 49169	100	4750.39	I	20350 - 41396
120	4529.40	I	20350 - 42422	45	4758.50	I	29781 - 50790
40	4535.38	I	20130 - 42173	770	4760.19	I	21343 - 42345
400	4536.80	I	28241 - 50277	75	4764.42	I	18480 - 39463
40	4541.56	I		75	4773.44	I	20281 - 41224
50	4553.32	I	21343 - 43299	40	4774.22	I	21343 - 42283
26	4553.80	I	25456 - 47409	65	4775.66	I	21154 - 42088
110	4558.11	I	10966 - 32899	150	4776.34	I	18229 - 39160
26	4558.74	I	20158 - 42088	50	4782.94	I	20130 - 41032
85	4560.13	I	23534 - 45458				20948 - 41850
85	4567.68	I	20350 - 42237	90	4785.12	I	18229 - 39122
21	4569.02	I	23668 - 45548	40	4786.46	I	10768 - 31655
50	4570.13	I	20281 - 42156	20	4788.18	I	18480 - 39358
40	4574.48	I	25639 - 47493	65	4792.74	I	20948 - 41807
	4574.61	I	21343 - 43197	65	4793.41	I	20951 - 41807
210	4576.50	I	11454 - 33299	20	4793.82	I	27384 - 48238
26	4577.78	I	18229 - 40068	100	4796.52	I	21343 - 42186
26	4582.35	I	31510 - 53327	18	4804.91	I	20158 - 40964
26	4582.50	I	21154 - 42970	30	4805.58	I	18356 - 39160
26	4586.06	I	25906 - 47705	30	4808.09	I	23668 - 44461
26	4586.57	I	22244 - 44041	90	4811.06	I	30496 - 51276

Molybdenum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18	4814.47	I	10768 - 31533	110	5147.39	I	18480 - 37902
26	4817.70	I	20281 - 41032	80	5163.19	I	31913 - 51276
410	4819.25	I	21343 - 42088	100	5167.76	I	21619 - 40964
18	4822.42	I	20281 - 41012	160	5171.08	I	25614 - 44947
26	4828.47	I			5171.25	I	20130 - 39463
410	4830.51	I	21154 - 41850	230	5172.94	I	25614 - 44941
40	4832.92	I	20158 - 40844	160	5174.18	I	25614 - 44936
26	4833.96	I	20350 - 41032	40	5191.44	I	31533 - 50790
15	4838.11	I	24096 - 44760	110	5200.17	I	21619 - 40844
18	4839.59	I		50	5200.74	I	18356 - 37579
20	4845.17	I	27766 - 48399	26	5210.44	I	12346 - 31533
45	4858.22	I	28241 - 48819	50	5211.86	I	20281 - 39463
26	4860.05	I		80	5219.40	I	22244 - 41398
360	4868.00	I	20948 - 41484	65	5231.06	I	27342 - 46453
50	4869.20	I	10768 - 31300	26	5232.36	I	20930 - 40037
23	4878.37	I	20350 - 40844	100	5234.26	I	18480 - 37579
26	4886.47	I	23516 - 43975	460	5238.20	I	25872 - 44957
20	4889.22	I	20951 - 41398	230	5240.88	I	25872 - 44947
20	4897.26	I	25456 - 45870	110	5242.81	I	25872 - 44941
65	4903.81	I	10768 - 31155	100	5245.51	I	20930 - 39989
26	4907.43	I	31485 - 51856	150	5259.04	I	20951 - 39961
20	4909.19	I	24096 - 44461	16	5260.17	I	30847 - 49852
23	4924.78	I	30502 - 50802	65	5261.14	I	20158 - 39160
40	4926.19	I	24466 - 44760	20	5268.95	I	
40	4926.43	I	18229 - 38522	35	5271.80	I	20158 - 39122
80	4933.10	I	12346 - 32612	35	5276.28	I	21619 - 40566
80	4941.66	I	25906 - 46136	65	5279.65	I	16784 - 35719
110	4950.62	I	18229 - 38423	210	5280.86	I	22876 - 41807
150	4957.54	I	18356 - 38522	20	5283.84	I	26636 - 45556
26	4964.19	I	25997 - 46136	55	5292.08	I	16828 - 35719
40	4964.41	I	20350 - 40488	35	5293.46	I	18480 - 37366
23	4973.36	I	20930 - 41032	55	5295.47	I	20281 - 39160
210	4979.12	I	10768 - 30847	16	5302.35	I	25906 - 44760
26	4985.56	I	21343 - 41395	20	5306.26	I	20281 - 39122
23	4995.32	I	23516 - 43530	55	5313.89	I	18480 - 37293
110	4999.91	I	24466 - 44461	35	5315.04	I	20350 - 39160
20	5010.81	I	26639 - 46590	20	5319.89	I	31485 - 50277
180	5014.60	I	24823 - 44760	20	5324.47	I	26639 - 45415
26	5016.78	I	27384 - 47311	35	5327.06	I	23516 - 42283
20	5019.85	I	25795 - 45710	16	5334.79	I	23668 - 42408
80	5029.00	I	24096 - 43975	16	5337.20	I	24466 - 43197
65	5030.78	I	25997 - 45870	16	5349.79	I	27766 - 46453
23	5038.91	I	25795 - 45635	20	5352.35	I	27774 - 46453
26	5046.52	I	21154 - 40964	80	5354.88	I	23516 - 42186
100	5047.71	I	20930 - 40736	35	5355.51	I	32123 - 50790
50	5055.00	I	12346 - 32123	65	5356.48	I	32612 - 51276
35	5058.07	I	27727 - 47492	560	5360.56	I	26321 - 44970
200	5059.88	I	20157 - 39916	110	5364.28	I	26321 - 44957
35	5062.52	I	20951 - 40699	35	5367.11	I	26321 - 44947
29	5064.64	I	18229 - 37968	35	5372.40	I	22876 - 41484
35	5079.87	I	26189 - 45870	26	5388.69	I	31300 - 49852
100	5080.02	I	20281 - 39960	65	5394.52	I	20930 - 39463
35	5081.26	I	11859 - 31533	35	5397.38	I	22876 - 41398
40	5090.97	I	25997 - 45635	50	5400.47	I	20951 - 39463
35	5091.34	I	20930 - 40566	35	5405.79	I	27342 - 45836
35	5092.16	I		35	5406.39	I	22244 - 40736
40	5095.89	I	20948 - 40566	16	5414.67	I	
100	5096.65	I	20951 - 40566	40	5417.38	I	22244 - 40699
130	5097.52	I	18356 - 37968	23	5426.89	I	16748 - 35169
35	5098.03	I	20350 - 39960	11	5427.55	I	23668 - 42088
130	5109.71	I	20350 - 39916	16	5431.02	I	20951 - 39359
80	5114.97	I	18356 - 37902	55	5435.68	I	20130 - 38522
35	5116.97	I	20951 - 40488	65	5437.75	I	16785 - 35169
29	5123.83	I	27415 - 46926	15	5439.71	I	34912 - 53291
150	5145.38	I	20608 - 40037	40	5450.51	I	21619 - 39961

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
15	5453.03	I	23516 - 41850	23	5699.28	I	21619 - 39160
35	5456.46	I	22244 - 40566	11	5702.11	I	25997 - 43530
26	5460.53	I	31300 - 49608	80	5705.72	I	24823 - 42345
23	5465.57	I	21154 - 39445	23	5711.80	I	21619 - 39122
13	5473.37	I	20157 - 38423	210	5722.74	I	11454 - 28924
35	5475.90	I		11	5723.11	I	29642 - 47110
13	5488.67	I	27342 - 45556	23	5728.77	I	25795 - 43246
35	5490.28	I	20951 - 39160	26	5729.45	I	20130 - 37579
20	5492.17	I	21619 - 39821		5729.59	I	
26	h 5493.80	I	31655 - 49852	15	5729.87	I	23516 - 40964
13	h 5496.94	I	24096 - 42283	16	5734.06	I	12346 - 29781
26	5498.49	I	23668 - 41850	11	5739.66	I	27342 - 44760
50	5501.54	I	20350 - 38522	15	5741.71	I	31510 - 48922
23	5501.87	I	20951 - 39122	16	5747.67	I	25906 - 43299
26	h 5503.54	I		620	5751.40	I	11454 - 28837
7800	5506.49	I	10768 - 28924	10	5769.75	I	23517 - 40844
11	5511.49	I	23668 - 41807	10	5771.05	I	19970 - 37293
23	5520.04	I	31485 - 49596	23	5774.55	I	11858 - 29171
26	5520.64	I	27727 - 45836	10	5778.19	I	25997 - 43299
13	5521.17	I	25906 - 44012	40	5779.36	I	20281 - 37579
40	5526.52	I	24096 - 42186	10	5780.11	I	23668 - 40964
40	5526.97	I	22876 - 40964	23	h 5783.33	I	25456 - 42742
5200	5533.05	I	10768 - 28837	10	5785.69	I	
40	5539.41	I	16692 - 34740	520	5791.85	I	11454 - 28715
13	5541.65	I	25906 - 43946	23	h 5795.77	I	34740 - 51990
50	5543.12	I	20948 - 38983	26	5800.46	I	20130 - 37366
40	5544.49	I	27384 - 45415	35	5802.67	I	20350 - 37579
10	5552.19	I	21154 - 39160	8	5803.98	I	25821 - 43046
55	5556.28	I	16748 - 34740	10	5806.19	I	22244 - 39463
26	5556.72	I	24096 - 42088	16	5806.69	I	26759 - 43975
11	5562.49	I		10	5808.23	I	11454 - 28667
20	5564.05	I	21154 - 39121	8	5809.03	I	34435 - 51644
40	5568.62	I	22876 - 40829	10	5813.86	I	39521 - 56717
26	5569.48	I	23534 - 41484	16	5815.52	I	
2500	5570.45	I	10768 - 28715	10	5815.74	I	29982 - 47172
35	5575.19	I	19970 - 37902	10	5820.69	I	23668 - 40844
20	5591.58	I	24466 - 42345	23	5825.20	I	20130 - 37293
10	5596.32	I	23534 - 41398	23	5835.59	I	11143 - 28274
8	5598.47	I	34810 - 52667	20	5839.99	I	27342 - 44461
15	5601.05	I	33904 - 51753	20	h 5848.86	I	28715 - 45806
40	5602.76	I	25456 - 43299	55	h 5849.73	I	28715 - 45805
23	5608.62	I	26636 - 44461	50	h 5851.52	I	28715 - 45800
23	5609.23	I	26189 - 44012	520	5858.27	I	11859 - 28924
100	5610.93	I	24466 - 42283	20	5861.38	I	26189 - 43246
23	5613.07	I	20158 - 37968	13	5868.76	I	25707 - 42742
20	5618.45	I	16641 - 34435	50	5869.33	I	27727 - 44760
10	5618.77	I	22244 - 40037	26	5876.59	I	20281 - 37293
23	5619.38	I	27766 - 45556	10	5881.53	I	20130 - 37128
330	5632.47	I	10966 - 28715	10	5882.72	I	27766 - 44760
50	5634.86	I	16693 - 34435	820	5888.33	I	11859 - 28837
230	5650.13	I	11143 - 28837	11	h 5891.56	I	28837 - 45806
11	5651.87	I	30160 - 47848	23	5892.29	I	25456 - 42422
11	5664.34	I	29842 - 47492	50	h 5893.38	I	28837 - 45800
	5664.38	I	27766 - 45415	20	5898.78	I	
13	5667.30	I	27774 - 45415		5898.82	I	27093 - 44041
10	5672.07	I	35042 - 52667	40	5901.47	I	18229 - 35169
23	5673.63	I	20281 - 37902	8	5912.12	I	26336 - 43246
55	5674.47	I	20350 - 37968	10	h 5923.79	I	28924 - 45800
40	5677.89	I	16641 - 34248	40	h 5926.36	I	28924 - 45793
35	5682.89	I	20930 - 38522	160	h 5928.88	I	28924 - 45786
10	5687.64	I	22244 - 39821	16	5937.91	I	25906 - 42742
460	5689.14	I	11143 - 28715	10	5965.57	I	35719 - 52478
10	5694.39	I	23668 - 41224	8	5968.48	I	27774 - 44525
13	5696.03	I	30160 - 47711	15	5974.26	I	27727 - 44461
11	5698.27	I	29642 - 47186	16	5982.93	I	26336 - 43046

Molybdenum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	5988.17	I	27767 - 44461	35	6914.01	I	20281 - 34740
16	5989.47	I	33904 - 50596	9	6931.40	I	20350 - 34774
10	5990.01	I		13	6934.10	I	11454 - 25872
10	5991.35	I	27774 - 44461	5	6946.75	I	27093 - 41484
35	6025.49	I	27384 - 43976	10	6947.39	I	20350 - 34740
16	6027.27	I	22876 - 39463	8	6953.78	I	26189 - 40566
1300	6030.66	I	12346 - 28924	10	6960.64	I	26336 - 40698
20	6047.83	I	25707 - 42237	8	6961.48	I	25707 - 40068
20	6054.81	I	18229 - 34740	16	6978.71	I	26639 - 40964
20	6079.58	I	23516 - 39960	8	6980.37	I	27766 - 42088
10	6081.27	I	25906 - 42345	7	6984.67	I	27774 - 42087
40	6101.87	I	18356 - 34740	26	6988.94	I	20130 - 34435
10	6130.63	I		9	6991.69	I	26189 - 40488
10	6197.66	I	32688 - 48819	12	6999.13	I	26415 - 40699
20	6217.89	I	18356 - 34435	8	6999.88	I	25707 - 39989
10	6264.27	I	33904 - 49864	16	7001.60	I	19970 - 34248
16	6265.88	I	18480 - 34435	9	7016.44	I	26450 - 40698
15	6290.74	I	18356 - 34248	7	7018.43	I	
13	6301.75	I	24096 - 39961	7	7025.32	I	26336 - 40566
11	6323.54	I	30160 - 45969	22	7037.98	I	26639 - 40844
40	6357.22	I	18229 - 33955	9	7045.29	I	26639 - 40829
16	6389.11	I	26636 - 42283	22	7060.21	I	11454 - 25614
11	6391.12	I		13	7063.34	I	20281 - 34435
35	6401.07	I		13	7081.22	I	20130 - 34248
26	6409.11	I	18356 - 33955	9	7102.65	I	27774 - 41850
10	6412.39	I		110	7109.87	I	25614 - 39675
100	6424.37	I	20158 - 35719	8	7122.65	I	27363 - 41398
20	6446.34	I	25456 - 40964	27	7134.08	I	11858 - 25872
20	6471.20	I	23534 - 38983	8	7240.46	I	26759 - 40566
20	6473.99	I	25906 - 41348	150	7242.50	I	25872 - 39675
10	6493.13	I	30160 - 45556	40	7245.85	I	20158 - 33955
23	6519.84	I	30502 - 45836	22	7267.62	I	11858 - 25614
7	6590.90	I	26639 - 41807	7	7281.53	I	25906 - 39635
15	h 6611.20	I	25707 - 40829	17	7300.19	I	
230	6619.13	I	10768 - 25872	8	7322.25	I	26336 - 39989
10	6624.57	I	26759 - 41850	8	7322.79	I	
5	6637.16	I	26336 - 41398	8	7333.71	I	26189 - 39821
50	6650.38	I	25456 - 40488	13	7348.49	I	20350 - 33955
13	6659.68	I	20158 - 35169	5	7360.38	I	25707 - 39290
4	h 6678.89	I	25872 - 40840	13	7361.65	I	27384 - 40964
5	6687.87	I	26450 - 41398	10	h 7364.41	I	
18	6690.47	I	18356 - 33299	8	7365.25	I	
4	6691.08	I	27342 - 42283	40	7391.36	I	12346 - 25872
9	6728.04	I	25707 - 40566	10	7434.10	I	25997 - 39445
110	6733.98	I	10768 - 25614	13	7447.34	I	31533 - 44957
21	6746.08	I	18480 - 33299	13	h 7452.85	I	25707 - 39122
50	6746.27	I	20350 - 35169	7	7475.43	I	27363 - 40736
35	6753.97	I	27384 - 42186	140	7485.74	I	26320 - 39675
13	6763.50	I	25707 - 40488	5	7501.62	I	25795 - 39122
4	6764.92	I	29982 - 44760	13	7504.47	I	26639 - 39960
8	6787.98	I	26284 - 41012	7	7571.53	I	27363 - 40566
8	6788.94	I	26759 - 41484	11	7572.64	I	26759 - 39960
10	h 6799.88	I		7	7579.58	I	27774 - 40964
10	6802.62	I	26336 - 41032	7	7591.66	I	20130 - 33299
10	6812.03	I	26336 - 41012	11	h 7595.16	I	25997 - 39160
13	6825.63	I	30113 - 44760	11	7601.84	I	27415 - 40566
18	d 6828.87	I	26759 - 41398	7	7649.52	I	27774 - 40844
	6829.05	I	26189 - 40829	5	7653.26	I	26759 - 39821
40	6838.88	I	27727 - 42345	17	h 7656.76	I	31913 - 44970
16	6848.92	I	26415 - 41012	13	7679.49	I	20281 - 33299
21	6886.28	I	27766 - 42283	9	7709.54	I	25456 - 38423
16	6892.36	I	25456 - 39960	27	7720.77	I	20350 - 33299
10	6898.01	I	31300 - 45793	9	7723.63	I	27093 - 40037
10	6898.98	I	25997 - 40488	9	7732.49	I	19970 - 32899
13	6908.20	I	11143 - 25614	4	7752.34	I	27093 - 39989

*Molybdenum – all observed lines – Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	7829.65	I	20130 – 32899	4	8058.22	I	45786 – 58193
15	7854.45	I	27093 – 39821	5	8104.67	I	39521 – 51856
8	7887.74	I	27363 – 40037	9	8153.45	I	25707 – 37968
5	7917.62	I	27363 – 39989	4 h	8192.60	I	23516 – 35719
11	7923.15	I	20281 – 32899	22 h	8245.06	I	28715 – 40840
9	7968.85	I	27415 – 39960	40 h	8328.44	I	28836 – 40840
4	7984.35	I	26639 – 39160	9	8351.15	I	25997 – 37968
15	7986.60	I	25906 – 38423	45 h	8389.32	I	28924 – 40840
7	8027.32	I	20158 – 32612	45 h	8483.39	I	25795 – 37579

# Neodymium

$$\text{Nd, } Z = 60, M = 144.2, \text{ Ratio } \frac{\text{Nd}}{\text{Cu}} = 2.270$$

Nd I Normal state of valence electrons  $4f^4 6s^2 \ ^5I_4 = 0$ . I.P. = 44270  $\text{cm}^{-1}$ .  
 Nd II Normal state of valence electrons  $4f^4 6s \ ^6I_{3/2} = 0$ . I.P. = 86500  $\text{cm}^{-1}$ .

## References

### Wavelengths:

Below 5000 Å:

A. S. King, *Astrophys. J.* **78**, 9 (1933).

Supplemented by A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945).

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From 5000 to 6900 Å:

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945).

Supplemented by C. C. Kiess, *Sci. Papers BS* **18**, 201 (1922).

Above 6900 Å:

J. F. Wyart, Thesis, Univ. Paris (Orsay) (1968).

C. C. Kiess, *Sci. Papers BS* **18**, 201 (1922).

Supplemented by G. R. Harrison, *Massachusetts Institute of Technology Wavelength Tables* (John Wiley & Sons, New York, 1939).

W. Albertson, G. R. Harrison, and J. R. McNally, *Phys. Rev.* **61**, 167 (1942).

### Classification:

Nd I, F. W. Paul, *Phys. Rev.* **49**, 156 (1936) (Spectrum assignment only).

P. F. A. Klinkenberg, Thesis, Univ. of Amsterdam (1955).

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J. F. Wyart, Thesis, Univ. Paris (Orsay) (1968).

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Nd II, W. E. Albertson, G. R. Harrison, and J. R. McNally, *Phys. Rev.* **61**, 167 (1942).

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### *Strong lines of neodymium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5400	4303.58	II	0 - 23230	1700	3905.89	II	1650 - 27245
4700	4061.09	II	3802 - 28419	1500	3848.52	II	3066 - 29043
3700 d	3863.33	II	0 - 25877	1400	3775.50	II	5985 - 32464
	3863.40	II	0 - 25876	1400	3963.12	II	3802 - 29027
3700	4012.25	II	5086 - 30002				
				1400	3990.10	II	3802 - 28857
3000	4040.80	II	1470 - 26211	1400	4109.08	II	513 - 24843
3000	4156.08	II	1470 - 25524	1400	4451.57	II	3067 - 25524
2500	3805.36	II	2585 - 28856	1300	3889.93	II	2585 - 28285
2500	4109.46	II	2585 - 26913	1300	3890.58	II	5085 - 30781
2400	3784.25	II	3066 - 29484				
				1300	3890.94	II	513 - 26206
2400 d	3851.66	II	2585 - 28540	1300	3901.84	II	5085 - 30707
	3851.74	II	1470 - 27425	1300	4232.38	II	513 - 24134
2400	4177.32	II	513 - 24445	1200	3685.80	II	9228 - 36352
2000	3900.21	II	3801 - 29434	1200	3803.47	II	1650 - 27934
2000	3911.16	II	3801 - 29362				
				1200	3826.42	II	513 - 26640
2000	3941.51	II	513 - 25877	1200	3880.78	II	513 - 26274
2000	3951.16	II	1470 - 26772	1200	4023.00	II	1650 - 26500
2000	4247.38	II	0 - 23537	1200	4031.82	II	5985 - 30781
1700	3838.98	II	0 - 26041				
1700 d	3848.24	II	1470 - 27449				
	3848.31	II	2585 - 28563				

Neodymium— all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	2702.46			170	3267.25	II	3801 - 34399
75	2704.54			100	3273.18	II	1650 - 32192
75	2764.98	I		320	3275.22	II	5085 - 35609
60	2785.79	I		50	3281.49	II	12861 - 43326
50	2863.95			50	3282.78	II	0 - 30453
50	2921.26			290	3285.10	II	0 - 30431
55	2962.88	II		100	3286.62	II	2585 - 33003
65	2963.58	II		50	3289.52		
80	2993.20	II	11939 - 45338	100	3290.65	II	513 - 30893
40	2994.73			70	3293.84	II	12861 - 43212
95	3007.97	II	10091 - 43326	70	3294.68	II	1650 - 31993
95	3014.19	II	1650 - 34817	70	3298.61		
95	3018.35	II	10091 - 43212	300	3300.16	II	0 - 30293
80	3026.47	II	12306 - 45338	140	3300.91	II	3801 - 34087
50	3038.98	II		70	3304.66	II	
50	3043.29			85	3305.33		
50	3051.11	II		100	3310.38	II	3801 - 34001
80	3052.15	II		140	3310.91	II	1650 - 31844
140	3056.71	II		200	3312.75	II	0 - 30177
130	3069.73	II		100	3313.16	II	2585 - 32759
65	d 3071.43	II		100	3316.02	II	1470 - 31618
	3071.50	II		200	3325.90	II	513 - 30571
160	3075.38	II	3801 - 36308	70	h 3326.26		
95	3079.38	II	13337 - 45802	50	3327.69		
95	3080.94	II		410	3328.28	II	0 - 30037
95	3092.73			250	3331.57	II	3801 - 33809
240	3092.92	II	1470 - 33792	290	3334.48	II	1470 - 31451
140	3098.48	II	3066 - 35331	290	3339.07	II	513 - 30453
55	3099.52	II	0 - 32253	85	3345.71	II	513 - 30393
130	3105.43	II	12013 - 44205	85	3347.56	II	1650 - 31513
95	3106.18	II	14835 - 47020	100	3347.89		
65	3108.01	II	11939 - 44104	170	3348.17	II	2585 - 32444
260	3115.18	II	12013 - 44104	320	3353.59	II	5085 - 34895
190	3116.15	II	11273 - 43354	85	3354.60	II	1650 - 31451
50	3119.75	II	11310 - 43354	200	3355.93	II	2585 - 32374
160	3123.06	II		85	3356.55		
190	3124.58	II		170	3359.76	II	5085 - 34840
290	3133.60	II	11273 - 43176	270	3364.96	II	1470 - 31179
220	3134.90	II	15130 - 47020	85	3375.23	II	15420 - 45039
100	3137.24	II	11310 - 43176	70	3386.29	II	13804 - 43326
170	3141.46	II		100	3386.52	II	1470 - 30990
170	3142.44	II		100	3388.03	II	9228 - 38736
100	3144.55	II		70	3389.33		
100	3144.82	II	11273 - 43062	70	3392.31	II	5085 - 34555
100	3148.51	II	11310 - 43062	290	3393.63	II	3801 - 33260
100	3149.29	II		150	3410.25	II	2585 - 31900
100	3149.51	II	11273 - 43014	70	3412.39	II	4512 - 33809
100	3162.62	II	513 - 32123	50	3415.55	II	1650 - 30919
100	3175.99	II	11273 - 42750	190	3425.22	II	3066 - 32253
50	3181.54	II	11273 - 42695	170	3428.93	II	1650 - 30805
50	3188.73	II		100	3432.99	II	5985 - 35106
50	3200.62	II	13804 - 45039	50	3435.43	II	1470 - 30570
150	3203.47	II	2585 - 33792	100	3443.32	II	5085 - 34119
85	3211.00	II		50	3454.38	II	4512 - 33452
100	3217.12	II		50	3461.83	II	3066 - 31944
50	3222.62	I		120	3468.42	II	513 - 29336
50	3228.04	II		120	3470.86	II	1650 - 30453
60	3234.62			150	3481.44	II	
40	3237.91	II		120	h 3484.88	I	
100	3254.08	II	1470 - 32191	120	3510.70	II	12306 - 40783
50	3256.91	II	1470 - 32165	120	3522.05	II	3067 - 31451
220	3259.24	II	513 - 31186	200	3527.53	II	0 - 28340
100	3260.66	II	0 - 30659	85	h 3531.71	II	
220	3265.12	II		170	3533.59	II	3801 - 32093
50	3265.38	II	513 - 31128	190	3541.60	II	2585 - 30813



## Neodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
290	3543.35	II	0 - 28213	540	3672.36	II	10667 - 37890
70	3553.99	II	5085 - 33215	580	3673.54	II	10091 - 37305
200	3555.77	II	2585 - 30700	100	3674.65		
410	3560.75	II	3801 - 31878	85	3677.60		
70	3561.61	II	513 - 28582	240	3678.18	II	0 - 27179
340	3568.87	II	5085 - 33097	100	3678.88	II	16325 - 43499
70	3576.16	II	1470 - 29425	85	3684.29		
190	3582.63			1200	3685.80	II	9228 - 36352
100	3582.88			120	3686.07	II	11310 - 38431
85	3586.82	II	1650 - 29521	440	3687.30	II	1470 - 28582
470	3587.51	II	1470 - 29336	410	3689.69	II	3066 - 30161
120	3588.23	II	3066 - 30927	300	3694.81	II	
85	3592.09	II	13337 - 41168	120	3697.17	II	12861 - 39901
300	3592.59	II	513 - 28340	410	3697.56	II	13819 - 40857
120	3595.41	II	0 - 27805	100	3701.75		
120	3595.91	II	15130 - 42931	240	3702.84		
340	3598.02	II	513 - 28298	120	3703.88		
70	3600.12			240	3704.95	II	16192 - 43176
300	3600.91	II	2585 - 30348	200	3712.81		
70	3606.30			470	3713.70	II	5985 - 32905
120	3607.72			370	3714.20	II	14835 - 41751
320	3609.79	II	0 - 27694	640	3714.73	II	
85	3612.75	II	12013 - 39685		3714.81	II	513 - 27425
370	3615.82	II	1650 - 29298	250	3715.04	II	13337 - 40247
300	3618.96	II	3066 - 30691	200	3715.39	II	0 - 26907
190	3624.65	II	4512 - 32093	470	3715.68	II	3801 - 30707
120	3626.18	II	7524 - 35094	85	3716.58	II	3801 - 30700
120	3627.41	II	3801 - 31362	410	3718.54	II	1470 - 28354
85	3629.59	II	16395 - 43938	85	3719.21		
170	3629.94	II	5985 - 33526	140	3720.54	I	6764 - 33634
300	3631.02	II	13819 - 41352	410	3721.35	II	10667 - 37531
70	3633.47			220	3722.42	II	15348 - 42205
340	3634.30	II		780	3723.50	II	2585 - 29434
170	3634.87	II	3066 - 30570	410	3724.87	II	513 - 27352
70	3635.11			250	3726.90	II	11310 - 38134
240	3637.00	II	15518 - 43005	710	3728.13	II	1470 - 28285
240	3637.23	II	12199 - 39685	470	3730.58	II	3066 - 29864
190	3637.79	II		170	3731.22	II	0 - 26793
70	3638.70			85	3731.63	II	12013 - 38803
240	3640.24	II	11273 - 38736	100	3732.02	II	11273 - 38060
190	3641.50	II	13804 - 41257	270	3732.78	II	15130 - 41912
70	3642.46	II	17356 - 44803	1000	3735.54	II	4512 - 31274
190	3643.63	II			3735.60	II	
70	3645.63	II	8716 - 36138	440	3737.10	II	2585 - 29336
240	3645.78	II	513 - 27934	1000	3738.06	II	4512 - 31256
120	3647.93			270	3741.42	II	513 - 27233
340	3648.20	II	12199 - 39602	120	3742.59	II	11273 - 37985
240	3649.46			140	3744.24	II	1470 - 28170
240	3650.42	II	1650 - 29036	150	3749.10	II	3801 - 30467
50	3650.69			200	3749.85	II	1470 - 28129
190	3651.59	II	13479 - 40857	320	3750.31	II	13479 - 40136
120	3652.45	II	11273 - 38644	100	3750.74	II	2585 - 29239
410	3653.15	II	10667 - 38033	120	3752.29	I	
240	3654.16			580	3752.49	II	4512 - 31153
120	3655.03	II	3801 - 31153	370	3752.67	II	0 - 26640
120	3659.94	II	1470 - 28785	250	3754.83	II	11310 - 37935
120	3660.97			370	3755.60	II	1470 - 28089
470	3662.26	II	15518 - 42816	100	3756.83	II	513 - 27124
85	3663.03	II	513 - 27805	510	3757.82	II	3801 - 30405
540	3665.18	II	1650 - 28926	930	3758.95	II	
150	3668.79			300	3759.79	II	5085 - 31675
190	3669.45			140	3761.58	II	12306 - 38883
85	3669.75			85	3762.09	II	4512 - 31085
150	3670.92	II	0 - 27233	930	3763.47	II	1650 - 28213
120	3671.66	II	2585 - 29813	120	3765.34	II	16395 - 42945

## Neodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
120	3765.92	II	3801 - 30348	1500	3848.52	II	3066 - 29043
300	3766.59	II	12199 - 38741	470	3850.22	II	
100	3768.71	II	11310 - 37836	2400	3851.66	II	2585 - 28540
510	3769.65	II	1650 - 28170		3851.74	II	1470 - 27425
140	3772.40	II	513 - 27014				
140	3772.93	II	12306 - 38803	340	3858.55	II	513 - 26422
190	3773.18	II	14673 - 41168	120	3859.42	II	1650 - 27553
100	3774.93	II	4512 - 30995	270	3860.94	II	4512 - 30405
1400	3775.50	II	5985 - 32464	300	3862.52	II	1470 - 27352
250	3776.34	II	12013 - 38486	3700	3863.33	II	0 - 25877
					3863.40	II	0 - 25876
140	3777.00	II	11273 - 37741	170	3865.98	II	3066 - 28926
710	3779.47	II	1470 - 27921	240	3866.52	II	513 - 26369
580	3780.40	II	3802 - 30247	220	3866.81	II	1650 - 27504
510	3781.32	II	5985 - 32424	850	3869.07	II	1470 - 27309
300	3783.78	II	16395 - 42816				
2400	3784.25	II	3066 - 29484	240	3875.74	II	1650 - 27444
270	3784.73	II	13819 - 40234	470	3875.87	II	3066 - 28860
190	3784.85	II	513 - 26926	1100	3878.58	II	1470 - 27245
150	3785.11	II	5985 - 32397	1000	3879.55	II	2585 - 28354
120	3785.40	II	13247 - 39657	780	3880.38	II	1470 - 27233
				1200	3880.78	II	513 - 26274
120	3788.97			200	3881.59		
340	3791.50	II	3066 - 29434	100	3883.76		
150	3792.81	II	3066 - 29425	100	3884.08	II	13804 - 39543
340	3795.45	II	1650 - 27990	100	3884.74	II	
120	3796.49	II	14835 - 41168				
170	3799.24	II	2585 - 28899	85	3886.09	II	11939 - 37664
240	3799.55	II	1470 - 27781	540	3887.87	II	513 - 26227
370	3801.12	II	4512 - 30813	370	3889.66	II	1650 - 27352
200	3801.38	II	1470 - 27769	1300	3889.93	II	2585 - 28285
340	3802.30	II	0 - 26292	170	3890.22	II	4512 - 30210
1200	3803.47	II	1650 - 27934	1300	3890.58	II	5085 - 30781
200	3804.10	II	513 - 26793	1300	3890.94	II	513 - 26206
2500	3805.36	II	2585 - 28856	580	3891.51	II	5985 - 31675
340	3805.55	II	3066 - 29336	470	3892.06	II	11748 - 37434
470	3807.23	II	513 - 26772	810	3894.63	II	513 - 26182
140	3808.25	II	1470 - 27721	140	3895.37	II	11377 - 37041
540	3808.77	II	513 - 26761	85	3895.91		
440	3809.06	II	513 - 26759	270	3896.13	II	3066 - 28725
580	3810.49	II	5985 - 32221	440	3897.63	II	1650 - 27299
240	3811.06	II	3067 - 29298	2000	3900.21	II	3801 - 29434
270	3811.77	II	0 - 26227	1300	3901.84	II	5085 - 30707
200	3812.53	II	15130 - 41352	140	3902.51	I	
710	3814.73	II	0 - 26206	120	3903.51	II	2585 - 28196
190	3817.38	II	513 - 26702	100	3905.56		
100	3818.84	II	10256 - 36434	1700	3905.89	II	1650 - 27245
240	3819.70	II	3066 - 29239	140	3906.09	II	1650 - 27244
410	3822.47	II	3801 - 29955	100	3907.50		
85	3823.26	II	1650 - 27798	200	3907.70	II	1650 - 27233
1200	3826.42	II	513 - 26640	510	3907.84	II	4512 - 30094
240	3828.00	II	0 - 26115	2000	3911.16	II	3801 - 29362
540	3828.85	II		850	3912.23	II	9228 - 34782
440	3829.16	II	5985 - 32093	340	3913.69	II	1470 - 27014
510	3830.47	II	16906 - 43005	440	3915.13	II	
100	3832.76	II	1470 - 27553	610	3915.95	II	1650 - 27179
740	3836.54	II	4512 - 30570	340	3917.65	II	12013 - 37531
340	3837.91	II	1470 - 27518	85	3918.90	II	11939 - 37449
1700	3838.98	II	0 - 26041	220	3919.92	II	5985 - 31489
340	3839.51	II	10667 - 36704	1100	3920.96	II	3066 - 28563
410	3841.82	II	3066 - 29088	140	3924.49	II	1650 - 27124
	3841.88	II	14835 - 40857	85	3924.98	I	0 - 25470
100	3844.18			85	3925.63	II	13337 - 38803
100	3845.74	II	11310 - 37305	70	3926.62	II	
190	3846.71	II	1650 - 27638	510	3927.10	II	1470 - 26926
100	3846.97	II	513 - 26500	200	3929.26	II	4512 - 29955
1700	3848.24	II	1470 - 27449	150	3934.09	II	14835 - 40247
	3848.31	II	2585 - 28563				

Neodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
610	3934.82	II	2585 - 27992	100	4010.45	II	3801 - 28729
410	3936.11	II	12087 - 37485	150	4011.09	II	3801 - 28725
140	3937.00	I		3700	4012.25	II	5086 - 30002
70	3937.57	II	0 - 25389	540	4012.70	II	0 - 24913
510	3938.86	II	13048 - 38429	140	4013.22	II	1470 - 26380
140	3939.52	II	5985 - 31362	70	4015.56	II	13971 - 38867
2000	3941.51	II	513 - 25877	370	4018.81	II	513 - 25389
85	3942.12	II	513 - 25873	120	4019.79	II	5085 - 29955
150	3942.62	II	16395 - 41751	85	4020.05	II	10256 - 35124
70	3946.81	II	11377 - 36707	1000	4020.87	II	2585 - 27449
100	3947.61	I	2366 - 27691	1000	4021.34	II	2585 - 27446
150	3948.32	II	5085 - 30405	1000	4021.78	II	1470 - 26328
70	3950.42			1200	4023.00	II	1650 - 26500
2000	3951.16	II	1470 - 26772	340	4024.78	II	513 - 25352
810	3952.20	II	0 - 25295	410	4030.47	II	1470 - 26274
320	3952.87	II	1470 - 26761	1200	4031.82	II	5985 - 30781
85	3953.40	II	3066 - 28354	120	4033.50		
320	3953.52	II	3801 - 29088	100	4033.90	II	11939 - 36722
100	3954.41			70	4034.01	II	513 - 25295
60	3955.09	II	1650 - 26926	270	4038.12	II	1470 - 26227
120	3955.95	II	5985 - 31256	3000	4040.80	II	1470 - 26211
240	3957.45	II	13479 - 38741	200	4041.06	II	3801 - 28540
590	3958.00	II	513 - 25772	85	4042.51	II	1650 - 26380
510	3962.21	II	2585 - 27816	85	4043.05	II	10439 - 35165
1400	3963.12	II	3802 - 29027	410	4043.59	II	2585 - 27309
270	3963.90	II	5085 - 30306	85	4044.35	II	1650 - 26369
120	3967.06	II	1470 - 26670	410	4048.81	II	12013 - 36704
150	3967.75	II	2585 - 27781	850	4051.15	II	3067 - 27744
170	3968.88	II	4512 - 29701	85	4054.86	II	3066 - 27721
120	3969.67	II	2585 - 27769	85	4056.83	II	13247 - 37890
1100	3973.30	II	5086 - 30247	850	4059.96	II	1650 - 26274
740	3973.69	II	2585 - 27744	4700	4061.09	II	3802 - 28419
150	3975.20	II	10786 - 35935	85	4067.73	II	1650 - 26227
120	3976.09	II	1650 - 26793	1100	4069.28	II	513 - 25081
740	3976.85	II	0 - 25138	100	4071.46	II	13479 - 38033
100	3977.29	II	513 - 25648	140	4074.42	II	5085 - 29622
60	3977.99	II	13048 - 38179	710	4075.12	II	1650 - 26182
70	3979.03			470	4075.28	II	513 - 25045
740	3979.49	II	1650 - 26772	240	4077.62	II	10091 - 34608
60	3980.98			470	4080.23	II	513 - 25014
140	3981.24	II	1650 - 26761	140	4082.55	II	13545 - 38033
320	3982.36	II	3067 - 28170	240	4085.82	II	0 - 24468
85	3983.41	II	3801 - 28899	70	4086.82	II	16395 - 40857
70	3983.58	II	10786 - 35882	85	4088.56	II	3066 - 27518
470	3986.25	II	11273 - 36352	70	4089.12	II	1470 - 25918
60	3987.25	II	12232 - 37305	120	4089.68	II	
50	3987.81	II	4512 - 29581	85	4091.00	II	13048 - 37485
70	3988.82	II	3066 - 28129	140	4094.62	II	12306 - 36722
1400	3990.10	II	3802 - 28857	85	4095.43	II	13479 - 37890
1000	3991.74	II	0 - 25045	270	4096.13	II	2585 - 26991
85	3992.16	II	11310 - 36352	100	4096.71	II	1470 - 25873
85	3992.28	II	12087 - 37128	220	4098.18	II	3801 - 28196
170	3992.60	II	11377 - 36416	100	4098.91	II	11748 - 36138
1100	3994.68	II	2585 - 27611	190	4100.24	II	3067 - 27449
140	3995.26	II	3066 - 28089	85	4101.45	II	
70	3997.44	II	5085 - 30094	85	4102.53	II	13063 - 37431
70	3997.78	II	13479 - 38486	150	4104.23	II	3066 - 27425
170	3997.93	II	15130 - 40136	50	4104.54	II	
85	3998.16			200	4106.59	II	4512 - 28857
170	3998.69			120	4107.44	II	12013 - 36352
410	4000.50	II	1650 - 26640	120	4107.96	II	15348 - 39685
540	4004.02	II	513 - 25481	1400	4109.08	II	513 - 24843
100	4004.26			2500	4109.46	II	2585 - 26913
410	4007.43	II	3801 - 28748	510	4110.48	II	0 - 24321
85	4008.75	II	12861 - 37799	300	4113.83	II	1470 - 25772

Neodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
70	4116.34	II	13550 - 37836	70	4226.99	II	14835 - 38486
35	4116.77	II	513 - 24797	440	4227.73	II	3802 - 27449
85	4120.66	II	5986 - 30247	190	4228.03	II	1650 - 25295
85	4121.94	II	15348 - 39602	190	4228.20	II	3802 - 27446
410	4123.88	II	3067 - 27309	100	4229.50	II	0 - 23636
50	4125.05	II		1300	4232.38	II	513 - 24134
85	4128.70	II	5487 - 29701	100	4233.15	II	11273 - 34889
50	4129.87	II	17544 - 41751	250	4234.19	II	1470 - 25081
50	4130.72	II	13247 - 37449	290	4235.24	II	11310 - 34915
85	4132.56	II	3801 - 27993	290	4239.84	II	11310 - 34889
470	4133.36	II	2585 - 26772	140	4241.21	II	15348 - 38920
85	4134.72	II	3066 - 27245	85	4244.56		
510	4135.33	II	5085 - 29260	85	4244.96	II	1650 - 25200
100	4136.76	II	3066 - 27233	120	4246.88	II	513 - 24053
170	4144.56	II	1650 - 25772	2000	4247.38	II	0 - 23537
140	4146.13	II	13337 - 37449	85	4248.15		
170	4151.68	II	3066 - 27146	850	4252.44	II	
100	4153.73	II	14673 - 38741	120	4252.88	h	
3000	4156.08	II	1470 - 25524	100	4253.87	II	10439 - 33940
510	4156.26	II	0 - 24053	290	4254.29		
70	4157.58	II	12306 - 36352	70	4256.24	II	1650 - 25138
140	4159.57	II	19465 - 43499	100	4256.47	I	0 - 23487
340	4160.57	II	4512 - 28540	100	4256.82	II	1470 - 24955
60	4164.41	II	11440 - 35446	170	4257.79	II	4512 - 27992
60	4164.85	II	0 - 24003	70	4259.62	II	2585 - 26055
150	4165.04	II	17349 - 41352	410	4261.84	II	13247 - 36704
410	4168.00	II	11748 - 35734	150	4262.24	II	5085 - 28540
70	4168.76	II	13550 - 37531	150	4263.44	II	5985 - 29434
100	4170.46	II		150	4263.91	h	2585 - 26031
100	4170.76	II	5985 - 29955		4264.00	II	14049 - 37495
100	4173.38	II	513 - 24468	340	4266.71	II	1650 - 25081
60	4174.46	II	12087 - 36035	240	4270.56	II	0 - 23410
810	4175.61	II	5086 - 29027	340	4272.79	II	0 - 23397
2400	4177.32	II	513 - 24445	340	4275.09	II	13337 - 36722
170	4178.44	II	16906 - 40832	140	4277.29	II	1470 - 24843
	4178.53	II	3066 - 26991	70	4280.17	II	12087 - 35444
200	4178.64	II	1470 - 25394	470	4282.44	II	3801 - 27146
640	4179.59	II	1470 - 25389	240	4282.57	II	513 - 23857
85	4182.52	II	11377 - 35279	710	4284.52	II	5086 - 28419
70	4183.13	I	5048 - 28947	120	4290.96	II	11310 - 34608
250	4184.98	II	11939 - 35827	85	4294.19	h	7524 - 30805
85	4185.77	II	18029 - 41912	70	4297.36	II	1650 - 24913
140	4186.04	II	1470 - 25352	270	4297.80	II	3066 - 26328
70	4187.11			85	4299.71	II	1470 - 24721
70	4188.26	II	2585 - 26455	70	4301.22	I	2367 - 25609
35	4195.03	II	1650 - 25481	5400	4303.58	II	0 - 23230
85	4198.17	II	14673 - 38486	340	4304.45	II	13479 - 36704
120	4199.11	II	513 - 24321	70	4305.48	II	
70	4200.04	II	513 - 24315	120	4306.75	II	14049 - 37262
70	4203.43	II		200	4307.78	II	3067 - 26274
120	4205.25	II	5487 - 29260	100	4310.51	II	1650 - 24843
470	4205.60	II	5086 - 28857	85	4311.25	I	2366 - 25555
470	4211.29	II	1650 - 25389	85	4313.36	II	15309 - 38486
70	4212.75	II	1470 - 25200	170	4314.38	II	13550 - 36722
85	4213.07	II	10786 - 34515	470	4314.52	II	0 - 23171
85	4213.22	II	12091 - 35819	1100	4325.76	II	3802 - 26913
100	4214.22	II	11377 - 35099	510	4327.93	II	4512 - 27611
100	4214.60	II	1470 - 25190	540	4338.70	II	5986 - 29027
120	4217.28	II	3067 - 26772	140	4342.07	II	513 - 23537
70	4218.55	II	11748 - 35446	70	4343.50	I	0 - 23016
70	4219.56	II	3066 - 26759	85	4349.10	II	13048 - 36035
290	4220.25	II	2585 - 26274	70	4350.21	II	
170	4221.14	II	4512 - 28196	680	4351.29	II	1470 - 24445
120	4223.21	II	3066 - 26738	150	4356.02	II	11939 - 34889
140	4224.84	II	5085 - 28748	850	4358.17	II	2585 - 25524

Neodymium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	4358.70	II	4512 - 27449	40	4523.58	II	2585 - 24685
70	4359.25	II	4512 - 27446	120	4527.25	I	
70	4360.87	II	9198 - 32123	70	4529.94	I	3681 - 25750
50	4361.40	II	15013 - 37935	340	4541.27	II	3067 - 25081
120	4364.14	II	5085 - 27993	85	4542.06	I	0 - 22010
240	4366.38	II	2585 - 25481	340	4542.61	II	5985 - 27993
340	4368.64	II	513 - 23397	40	4544.26	II	
60	4372.14	II		35	4545.33	II	6931 - 28926
60	4372.28	II	513 - 23378	85	4548.24	I	3682 - 25662
60	4372.73	II		40	4549.02	II	4512 - 26489
470	4374.93	II	1470 - 24321	35	4554.97	II	3067 - 25014
	4375.04	II	0 - 22851	50	4555.14	II	4512 - 26459
50	4376.45	II	11939 - 34782	100	4556.14	II	513 - 22456
60	4377.40	II	7868 - 30707	85	4556.74	II	1470 - 23410
120	4382.74	II	3067 - 25877	170	4559.67	I	2367 - 24292
710	4385.66	II	1650 - 24445	60	4560.42	I	1128 - 23049
250	4390.66	II	12013 - 34782	60	4561.18	II	0 - 21918
70	4391.10	II	2585 - 25352	70	4561.86	I	3681 - 25596
40	4392.12	II	14387 - 37149	340	4563.22	II	1470 - 23378
40	4394.18	II		85	4567.61	II	1650 - 23537
40	4395.50	II	5985 - 28729	200	4578.89	II	2585 - 24418
40	4395.89	II	4437 - 27179	200	4579.32	II	5985 - 27816
50	4398.03	II	5085 - 27816	40	4584.04	II	1650 - 23458
40	4399.58			100	4586.62	I	3681 - 25478
540	4400.83	II	513 - 23230	60	4586.96	I	
120	4407.08	II	513 - 23197	85	4594.45	II	1650 - 23410
510	4411.06	II	1470 - 24134	200	4597.02	II	1650 - 23397
140	4412.27	II	513 - 23171	100	4603.82	I	5049 - 26764
70	4414.44	II	513 - 23160	40	4607.38	II	4512 - 26211
140	4416.89	II	4512 - 27146	100	4609.87	I	1128 - 22815
50	4420.11	I	2366 - 24984	35	4612.47	II	513 - 22188
40	4420.52	II	2585 - 25200	300	4621.94	I	2367 - 23996
35	4426.83	II	1470 - 24053	85	4624.21	I	2366 - 23985
60	4432.30	II	5985 - 28540	85	4626.50	I	1128 - 22737
85	4439.00	II	1470 - 23991	100	4627.98	I	2366 - 23968
35	4444.29	II	3066 - 25561	60	4629.91	II	3801 - 25394
60	4444.99	I	0 - 22491	60	4631.29	I	5048 - 26634
580	4446.39	II	1650 - 24134	50	4632.64	II	1650 - 23230
1400	4451.57	II	3067 - 25524	510	4634.24	I	0 - 21572
200	4451.99	II	0 - 22456	60	4637.20	I	0 - 21559
300	4456.40	II	5986 - 28419	85	4638.72	II	3801 - 25353
170	4462.42	II	1650 - 24053	85	4639.14	I	1128 - 22678
740	4462.99	II	4512 - 26913	340	4641.10	I	5048 - 26589
100	4465.07	II	0 - 22390	250	4645.77	II	4512 - 26031
120	4465.60	II	1470 - 23857	200	4646.40	I	3681 - 25197
85	4467.85	II	12232 - 34608	300	4649.67	I	
140	4469.26	II	5985 - 28554	60	4652.39	I	0 - 21488
85	4470.97	II	5086 - 27446	200	4654.73	I	1128 - 22606
85	4471.41	II	0 - 22358	70	4664.45	II	
40	4475.57	II	513 - 22851	130	4670.56	II	513 - 21918
30	4475.84	I	2367 - 24703	45	4671.10	I	1128 - 22530
50	4477.46	II	3066 - 25394	24	4673.97	I	2367 - 23756
140	4477.88	I	5048 - 27374	60	4675.52	I	3682 - 25064
140	4480.97	I	1128 - 23438	170	4680.74	II	513 - 21871
70	4481.90	I	1128 - 23434	310	4683.45	I	0 - 21346
40	4485.95	II	3067 - 25352	110	4684.04	I	1128 - 22471
85	4493.42	II	4512 - 26761	14	4688.55	I	6764 - 28086
40	4497.27	II	3801 - 26031	110	4690.35	I	0 - 21314
40	4497.40	I	0 - 22228	190	4696.44	I	3682 - 24968
85	4497.93	II	4512 - 26738	130	4703.57	II	3067 - 24321
410	4501.82	II	1650 - 23857	470	4706.54	II	0 - 21241
200	4506.59	II	513 - 22697	140	4706.96	I	1128 - 22367
170	4513.34	II	513 - 22663	190	4709.71	II	1470 - 22697
250	4516.36	II	2585 - 24721	190	4715.59	II	1650 - 22851
70	4522.84	II	5985 - 28089	60	4717.08	II	1470 - 22663

## Neodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	4719.02	I	0 - 21184	280	4896.93	I	1128 - 21543
190	4724.35	II	5985 - 27146	120	4901.53	I	3681 - 24077
29	4726.55	I	2366 - 23517	210	4901.84	I	2366 - 22761
140	4731.77	I	1128 - 22256	110	4902.03	II	513 - 20907
35	4734.90	I	1128 - 22241	29	4907.26	I	2367 - 22739
19	4736.20	II	1470 - 22578	29	4907.78	I	2367 - 22737
29	4749.03			60	4910.05	I	0 - 20361
29	4749.56	II	4512 - 25561	190	4913.41	I	
70	4749.75	I	3682 - 24730	170	4914.37	II	3067 - 23410
45	4755.85	I	3682 - 24703	330	4920.68	II	513 - 20830
24	4759.10	I	3682 - 24688	35	4921.14	I	3682 - 23996
21	4760.45	I	1128 - 22129	35	4922.45	I	3681 - 23991
45	4763.62	II	3067 - 24053	470	4924.53	I	0 - 20301
80	4763.87	II	1470 - 22456	35	4930.72	II	6637 - 26913
70	4770.20	I	2366 - 23324	35	4942.95	II	5986 - 26211
24	4771.73			60	4943.90	II	1650 - 21871
19	4772.26	I	1128 - 22076	260	4944.83	I	1128 - 21345
40	4772.88	II	5085 - 26031	65	4947.02	II	4512 - 24721
40	4777.72	II	3066 - 23991	35	4949.03	II	5085 - 25286
14	4778.40	I	1128 - 22049	35	4950.29	I	3681 - 23876
120	4779.46	I	2366 - 23283	27	4950.67	I	2366 - 22560
70	4783.80	II	513 - 21411	55	4952.46	I	1128 - 21314
40	4786.06	II	1470 - 22358	290	4954.78	I	0 - 20177
21	4787.40	I	1128 - 22010	55	4958.10	II	3067 - 23230
170	4789.41	II	2585 - 23459	290	4959.13	II	513 - 20673
120	4797.15	II	4512 - 25352	150	4961.39	II	5086 - 25235
60	4799.42	II	0 - 20830	80	4963.33	I	5048 - 25190
40	4806.62	I	1128 - 21927	35	4969.75	I	2366 - 22482
240	4811.34	II	513 - 21292	35	4970.93	II	2585 - 22697
35	4817.17	II	5985 - 26738	35	4972.82		
24	4818.96	II	3801 - 24547	23	4973.40	I	
14	4819.64	II	1470 - 22212	90	4975.50	I	5048 - 25141
140	4820.34	II	1650 - 22390	27	4980.88	I	6764 - 26835
14	4824.18	II	4512 - 25235	70	4981.28	II	5985 - 26055
350	4825.48	II	1470 - 22188	35	4982.89	I	3681 - 23744
24	d 4827.57	I		90	4987.17	II	5985 - 26031
	4827.74	II	1650 - 22358	23	4989.41	II	5487 - 25524
45	4828.58	II	3066 - 23771	13	4989.51	II	1470 - 21506
130	4832.28	II	4512 - 25200	250	4989.94	II	5085 - 25120
29	4835.66	I	2367 - 23040	90	4998.55	II	3801 - 23802
70	4835.98	II	0 - 20673	70	5000.44	II	2585 - 22578
60	4836.62	I	1128 - 21797	55	5011.67	II	7868 - 27816
110	4849.06	II	3801 - 24418	65	5014.55	I	2366 - 22303
80	4853.33	I	1128 - 21727	18	5015.40	II	5985 - 25918
35	4855.31	I	1128 - 21718	18	5022.67	I	6764 - 26668
280	4859.02	II	2585 - 23160	90	5027.15	I	5048 - 24935
29	4859.58	I	2366 - 22938	65	5027.85	II	4438 - 24321
24	4861.77	I		90	5029.45	I	1128 - 21005
45	4864.78	II	7868 - 28419	150	5033.52	II	9166 - 29027
190	4866.74	I	0 - 20542	27	5039.92	I	3681 - 23517
45	4867.84	II	1650 - 22188	55	5040.20	I	1128 - 20963
45	4869.27	I	3682 - 24213	45	5051.06	I	3681 - 23474
35	4871.44	I	8411 - 28933	90	5056.89	I	0 - 19770
35	4874.37	I	8800 - 29310	27	5060.04	I	2366 - 22123
60	d 4875.73	I	2366 - 22870	110	5063.73	II	7868 - 27611
	4875.84	II	5985 - 26489	35	5066.85	II	4512 - 24243
24	4876.12	II	4512 - 25014	65	5071.87	I	1128 - 20839
45	4879.79	I	3682 - 24168	35	5073.87	I	3682 - 23385
29	4882.88	II	5985 - 26459	35	5074.52	I	0 - 19700
350	4883.81	I	5048 - 25518	360	5076.59	II	5985 - 25678
45	4885.01	I	5048 - 25513	70	5077.16	II	6637 - 26327
140	4889.10	II	1470 - 21918	55	5079.09	I	2366 - 22049
220	4890.70	II	3801 - 24243	30	5081.89		
240	4891.07	I	3681 - 24121	150	h 5089.84	II	1650 - 21292
45	4893.23	I	1128 - 21559	360	5092.80	II	3067 - 22697

Neodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	5096.52	II	4438 - 24053	27	5308.42	II	10195 - 29027
180	5102.39	II	5488 - 25081	45	5310.01	II	9166 - 27993
70	5103.11	I	0 - 19590	220	5311.46	II	7950 - 26772
150	5105.21	II	9166 - 28748	35	5314.55	II	7950 - 26761
	5105.35	I		55	5316.60	II	3066 - 21870
360	5107.59	II	6637 - 26211	45	5319.11		
27	5114.53	I		500	5319.82	II	4438 - 23230
35	5119.61	II	5488 - 25014	27	5320.79	I	8800 - 27589
35	5121.30	II	9042 - 28563	35	5324.59	I	
340	5123.79	II	3066 - 22578	27	5329.11	II	10941 - 29701
680	5130.60	II	10517 - 30002	18	5329.88	I	11887 - 30644
170	5132.33	II	4512 - 23991	27	5332.43	I	9692 - 28440
23	5134.23			27	5334.33	I	0 - 18741
45	5136.83	II	5085 - 24547	90	5336.55	II	4438 - 23171
80	5143.33	II	1470 - 20907	45	5338.01	II	26369 - 45097
45	5156.01	II	11392 - 30781	16	5343.65	I	10898 - 29606
70	5161.71	II	5985 - 25353	80	5345.71	II	9043 - 27744
170	5165.14	II	5488 - 24843	23	5349.26	I	
90	5167.92	II	4512 - 23857	35	5349.58	I	1128 - 19816
23	5170.91	II	4437 - 23771	180	5356.98	II	10195 - 28857
80	5176.79	II	9042 - 28354	45	5361.17	II	4512 - 23160
18	5178.75	I	1128 - 20432	290	5361.47	II	5488 - 24134
30	5179.78	II	5985 - 25286	35	5365.12	II	
130	5181.17	II	6932 - 26227	14	5370.16	II	24134 - 42750
120	5182.60	II	6005 - 25295	150	5371.94	II	11392 - 30002
18	5187.05	I	2366 - 21640	35	5377.79	I	0 - 18589
500	5191.45	II	1650 - 20907	23	5378.23	I	8411 - 27000
630	5192.62	II	9166 - 28419	30	5383.85	II	9042 - 27611
55	5195.60	I	2367 - 21608	110	5385.90	II	5985 - 24547
55	5198.07	I	1128 - 20361	23	5388.23	II	10194 - 28748
330	5200.12	II	4512 - 23737	18	5396.72	II	
65	5204.38	I	0 - 19209	23	5399.12	II	7525 - 26041
310	5212.37	II	1650 - 20830	30	5400.20	I	513 - 19026
150	5213.23	I	2367 - 21543	27	5402.90	I	
90	5215.65	II	10194 - 29362	45	5406.17	II	10942 - 29434
65	5221.57	II	3066 - 22212	18	5411.93	I	2367 - 20839
130	5225.05	II	6005 - 25138	30	5414.80	II	6005 - 24468
130	5228.43	II	3067 - 22188	18	5415.31	I	2366 - 20827
450	5234.20	II	4438 - 23537	70	5416.38	II	6932 - 25389
250	5239.79	II		18	5420.66	I	6764 - 25207
720	5249.59	II	7869 - 26913	80	5421.56	II	3066 - 21506
200	5250.82	II	6005 - 25045	18	5424.07	I	
360	5255.51	II	1650 - 20673	18	5429.30	I	9692 - 28105
23	5257.35			70	5430.79	II	9877 - 28285
35	5264.22	I	1128 - 20119	160	5431.53	II	9043 - 27449
27	5265.74			35	5432.36	II	9043 - 27446
23	5266.64	I	6764 - 25746	35	5441.26	II	12334 - 30707
120	5269.48	II	4437 - 23409	90	5442.27	II	5488 - 23857
90	5269.78	II		27	5447.28	I	
55	5270.09	I	8411 - 27381	35	5447.56	II	8420 - 26772
55	5270.69	II	1650 - 20617	55	5449.21	II	10194 - 28541
27	5272.00	II	7950 - 26912	110	5451.12	II	
590	5273.43	II	5488 - 24445	70	5455.82	II	7950 - 26274
150	5276.88	II	6932 - 25877	30	5456.56	II	12459 - 30781
55	5286.68	II		18	5458.60		
35	5287.13	II	6005 - 24913	35	5473.08	II	9043 - 27309
110	5291.67	I	6853 - 25746	45	5474.73	II	7950 - 26211
680	5293.17	II	6637 - 25524	27	5478.61	I	9814 - 28062
23	5298.88	I	1128 - 19994	18	5483.12	II	7950 - 26182
27	5300.58	I	1128 - 19989	45	5485.10	II	4437 - 22664
160	5302.28	II	11392 - 30247	170	5485.70	II	10195 - 28419
27	5302.61	I	8475 - 27328	23	5487.03	II	8420 - 26640
65	5303.21	II	3066 - 21918	35	5492.30	I	
110	5306.47	II	6932 - 25772	14	5493.34	I	11812 - 30011
27	5308.28	I	8800 - 27633	65	5494.01	II	

Neodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18	5496.42	I		160	5708.28	II	6932 - 24445
13	5498.86	I		80	5718.12	II	11373 - 28857
35	5501.47	I	0 - 18172	30	5719.09	II	4437 - 21918
18	5507.66	II	16700 - 34851	65	5726.83	II	8420 - 25877
35	5508.40	II	6932 - 25081	100	5729.29	I	2366 - 19816
18	5516.29	I	9692 - 27815	16	5731.05	I	
27	d 5520.60	II	24315 - 42424	23	5734.55		
13	5522.17	I	12065 - 30169	45	5739.96	II	10194 - 27611
18	5523.82	I	1128 - 19226	70	5740.86	II	9358 - 26772
45	5525.72	I	6764 - 24856	27	5741.28	II	12021 - 29434
35	5528.33	II	6637 - 24721	45	5742.08	II	8796 - 26206
18	5529.07	I	1128 - 19209	27	5742.76	II	13298 - 30707
90	5533.82	I	2367 - 20432	30	5743.20	II	10337 - 27744
55	5535.27	II	11373 - 29434	11	5744.14	II	6005 - 23410
23	5537.77	II	1650 - 19703	45	5744.77	II	7950 - 25352
27	5539.21	II	6005 - 24053	30	5748.15	II	6005 - 23397
55	5543.24	I	8800 - 26835	27	5749.06	II	6931 - 24321
45	5545.91	II		55	5749.19	I	8475 - 25864
55	5548.47	II	4438 - 22456	27	5749.66	I	0 - 17387
27	5548.68	II	10337 - 28354	27	5753.53	II	1650 - 19026
27	5550.09	II	9908 - 27921	18	5760.00	II	11392 - 28748
35	5557.62	II		30	5761.70	II	8420 - 25772
55	5561.17	I	0 - 17977	14	5762.08	I	11959 - 29309
35	5569.96	II	10337 - 28285	11	5764.23	II	10942 - 28285
27	5575.50	I	8402 - 26333	23	5767.33	I	2366 - 19700
27	5576.70	I	3682 - 21608	35	5769.87	II	10887 - 28214
27	5577.70	I	10898 - 28821	45	5770.50	II	8717 - 26041
23	5578.66	II	4437 - 22358	45	5776.12	I	1128 - 18436
30	5581.60	II	6932 - 24843	45	5784.96	I	2367 - 19648
27	5587.61	I	13101 - 30993	45	5788.22	I	5048 - 22320
18	5587.96	II	5487 - 23378	27	5795.17	II	10194 - 27445
30	5588.91	II	9357 - 27245	45	5800.09	I	3681 - 20918
18	5592.67	II	9357 - 27233	160	5804.02	II	6005 - 23230
240	5594.43	II	9043 - 26913	45	5809.25	II	5487 - 22696
18	5595.81	II	6931 - 24797	80	5811.57	II	6931 - 24134
55	5601.43	I		45	5813.89	I	
45	5601.92	I	9939 - 27785	16	5815.44	I	8402 - 25593
35	5602.68	II	8796 - 26640	27	5820.37	I	1128 - 18304
27	5603.65	II	3067 - 20907	14	5823.18	II	9042 - 26210
35	5614.30	II	8420 - 26227	30	5823.35	II	11373 - 28541
18	5615.35	I	14304 - 32107	14	5823.72	I	
35	5617.71	II		14	5823.91	II	6005 - 23171
27	5619.00	II	14301 - 32093	70	5825.87	II	8717 - 25877
220	5620.54	I	0 - 17787	30	5826.74	I	3682 - 20839
11	5623.62	I	11108 - 28885	16	5830.72	I	8475 - 25621
35	5625.72	II	7525 - 25295	80	5842.39	II	10337 - 27449
65	5635.76	I		16	5843.23	II	10883 - 27992
45	5639.54	I	9115 - 26842	30	5844.66	I	10160 - 27265
18	5647.98	I		23	5845.95	I	11959 - 29061
35	5653.57	I	11887 - 29570	16	5846.36	II	12334 - 29434
35	5659.78	II	12906 - 30570	13	5847.59	I	10784 - 27881
18	5662.46	I	10784 - 28440	30	5857.52	II	
11	5665.26	I	11918 - 29564	55	5858.91	I	10898 - 27961
70	5668.87	II	11392 - 29027	35	5865.06	II	11373 - 28419
65	5669.77	I	3681 - 21314	35	5867.08	I	13953 - 30993
140	d 5675.97	I	1128 - 18741	30	5868.90	I	15073 - 32107
55	5676.33	I		27	5871.04	I	11486 - 28514
11	5681.16	I	8475 - 26072	27	5877.83	II	9198 - 26206
220	5688.53	II	7950 - 25524	27	5882.78	II	4512 - 21506
23	5689.51	I	11109 - 28680	30	5883.29	I	10785 - 27777
11	5695.23	I	8475 - 26029	23	5886.24	I	12902 - 29886
45	5698.93	II	12460 - 30002	30	5887.91	I	0 - 16979
30	5701.57	I		35	5891.53	II	8420 - 25389
130	5702.24	II	6005 - 23537	18	5899.49	I	8800 - 25746
80	5706.21	II	7525 - 25045	23	5900.43	II	7525 - 24468



Neodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	5906.65	II	6932 - 23857	18	6362.09	II	8420 - 24134
35	5909.87	II	9357 - 26274	18	6365.55	II	7525 - 23230
9	5914.40	I	11918 - 28821	11	6375.97	I	13101 - 28781
27	5921.22	I		23	6382.07	II	11580 - 27245
9	5922.79	I	11001 - 27880	65	6385.20	II	9358 - 25014
27	5934.75	II	6005 - 22851	18	6390.00	II	12276 - 27921
30	5943.22	II		13	6403.20	I	10898 - 26510
14	5949.64	I	9115 - 25918	18	6425.79	II	13298 - 28856
27	5955.87	I		18	6428.65	II	1650 - 17201
14	5961.16	I	9115 - 25885	6	6429.84	I	10785 - 26333
30	5989.34	II	6005 - 22697	16	6432.65	I	10376 - 25918
30	5994.76	I	11109 - 27785	9	6445.79	II	
27	5996.47	I	9939 - 26611	14	6451.23	I	10898 - 26394
45	6007.67	I	9692 - 26333	7	6454.80	I	13333 - 28821
14	6009.30	II	3066 - 19703	13	6457.13	I	9939 - 25422
9	6025.54	I	5048 - 21640	14	6463.58	I	9115 - 24582
35	6031.27	II	10337 - 26913	11	6465.24	II	17001 - 32464
27	6033.29	I	14304 - 30874	13	6480.21	II	14327 - 29754
45	6034.24	II	12460 - 29027	5	6482.28	II	2585 - 18008
55	6066.03	I	12902 - 29383	35	6485.69	I	9115 - 24529
27	6071.70	I	10376 - 26842	16	6492.35	II	12887 - 28285
30	6073.97	I	8475 - 24934	7	6495.59	II	10883 - 26274
14	6101.75	I	11959 - 28344	16	6500.16	I	10774 - 26155
14	6108.41	II	9674 - 26041	8	6504.46	II	9675 - 25045
23	d 6133.47	II	14481 - 30781	16	6514.96	II	1470 - 16815
	6133.58	II	14957 - 31256	13	6519.86	II	15923 - 31256
27	6149.28	I	9814 - 26072	7	6523.15	II	7525 - 22851
27	6155.06	I	11918 - 28160	13	6539.94	II	6005 - 21292
14	6156.16	I	9115 - 25354	14	6549.54	II	513 - 15777
35	6157.83	II	4437 - 20672	14	6550.19	II	2585 - 17848
23	6166.67	II	11709 - 27921	13	6553.07	II	6932 - 22188
35	6170.49	II	9674 - 25877	13	6558.97	II	12276 - 27518
45	6178.59	I	14304 - 30484	7	6568.47	II	17001 - 32221
27	6183.91	II	9358 - 25524	13	6572.65	II	10666 - 25877
18	6201.74	II		18	h 6580.94	II	11580 - 26772
13	6208.01	II	14301 - 30405	18	6585.71	II	11580 - 26761
27	6208.24	I	10774 - 26878	16	6588.03	II	14259 - 29434
9	6210.68	II	9198 - 25295	11	6591.43	II	1650 - 16817
13	6216.69	I	9115 - 25196	16	6601.76	I	10774 - 25918
45	6223.39	I	13101 - 29165	18	6611.99	I	9814 - 24934
27	6226.50	I	8800 - 24856	11	6615.88	I	10774 - 25885
23	6238.50	II	8420 - 24445	16	c 6618.53	I	11918 - 27023
35	6244.08	I	11959 - 27970	18	6619.35	I	8475 - 23578
13	6248.28	II	9877 - 25877	45	6630.14	I	8475 - 23553
9	6250.43	II	9357 - 25352	9	6636.15	II	16610 - 31675
23	6257.49	I	9815 - 25791	18	6637.19	II	11709 - 26772
27	6258.73	II	10666 - 26640	35	6637.96	II	
18	6263.23	II	13298 - 29260	45	6650.57	II	15749 - 30781
18	6269.42	I	9939 - 25885	30	6655.67	I	8475 - 23496
13	6270.27	I		10	6669.65	II	8420 - 23410
23	6277.29	II	15749 - 31675	10	6670.37	I	12056 - 27044
18	6282.00	I	11109 - 27023	11	6678.52	II	12276 - 27245
27	6285.79	I	12056 - 27961	19	6680.14	II	13597 - 28563
23	6292.84	II	1470 - 17356	6	6698.65	II	13246 - 28170
23	6297.07	I	11959 - 27835	10	6712.27	I	14687 - 29581
16	6298.42	II	7525 - 23397	6	6714.15	II	15923 - 30813
18	h 6301.97	I		19	6727.74	II	14624 - 29484
11	6308.26	I	12065 - 27913	25	6737.79	II	12906 - 27744
55	6310.49	I	10898 - 26740	40	6740.11	II	513 - 15345
18	6319.69	II		25	6742.54	I	13333 - 28160
11	6321.22	I	8402 - 24218	10	6763.01	I	9083 - 23866
18	6330.17	II	14301 - 30094	9	6763.78	I	11959 - 26740
27	6341.51	II	14481 - 30246	9	6764.61	II	14481 - 29260
9	6355.95	I	12056 - 27785	30	6790.37	II	1470 - 16192
18	6361.43	II	11709 - 27425	11	6801.34	I	10898 - 25596

Neodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
16	6803.06	I	14687 - 29383	12	7316.81	II	3801 - 17465
30	6804.00	II	11580 - 26274	7 h	7321.43	I	13726 - 27381
13 h	6812.30	II	13246 - 27921	7	7323.12	II	2585 - 16237
13	6816.02	II	6005 - 20673	6	7334.54	I	0 - 13630
9	6825.35	I	10774 - 25422	6	7357.10	I	14438 - 28027
16	6842.66	II		6	7374.04	II	14259 - 27816
25	6846.72	II	11580 - 26182	7	7381.79	II	1470 - 15013
11	6846.94	II	8796 - 23397	9	7401.31	I	6764 - 20271
11	6852.23	I	9939 - 24529	10	7406.62	II	8420 - 21918
10	6857.00	I	10774 - 25354	6	7411.20	II	1650 - 15139
10	6873.05	II	14481 - 29027	10	7418.18	II	10942 - 24418
14	6874.66	II	12906 - 27448	9	7427.41	II	12021 - 25481
8	6876.00	II	10942 - 25481	9	7448.71	II	12906 - 26328
10	6886.78	I	16092 - 30608	5	7481.28	II	1650 - 15013
14	6896.65	I	12276 - 26772	12	7511.16	II	14301 - 27611
13	6897.29	II	1650 - 16144	17	7513.73	II	7525 - 20830
40	6900.43	II	0 - 14487	7 h	7514.44	II	12906 - 26210
11	6901.42	II	16295 - 30781	7	7516.02	II	10942 - 24243
10	6906.03	I	6764 - 21240	9	7526.45	II	9877 - 23160
17	6923.86	I	0 - 14438	12	7528.99	II	15749 - 29027
12	6926.87	II		10	7538.26	II	11580 - 24842
7	6932.16	I	8800 - 23221	5	7540.97	II	9198 - 22455
9	6936.44	II	9908 - 24321	7	7547.00	II	5985 - 19232
12	6938.67	II	10887 - 25295	5	7577.54	II	1650 - 14843
17	6940.14	II	14957 - 29362	7	7587.65	II	9675 - 22851
24	6941.39	II	12906 - 27308	6	7590.75	II	3066 - 16237
5	6964.50	I	13672 - 28027	6	7603.73	II	7525 - 20673
8	6964.71			5	7605.92	II	14301 - 27445
9	6982.65			5	7614.72	I	12611 - 25740
7 h	6985.25	I	0 - 14312	9	7639.79	II	5085 - 18171
9 h	6995.19	I	3681 - 17973	8	7646.00	II	8796 - 21871
17 h	7010.80	II	12887 - 27146	6	7663.52	II	11373 - 24418
8	7018.85	II	8420 - 22663	12	7696.56	II	9198 - 22187
17	7020.92	II	14301 - 28540	6	7718.20	II	4512 - 17465
17	7024.58	II	2585 - 16817	4	7743.90	II	
10	7033.21			4	7748.92	II	12334 - 25235
35	7037.30	II	3801 - 18008	10	7750.95	II	3801 - 16700
7	7052.14	II	9877 - 24053	6	7773.06	II	0 - 12861
7	7054.74	II	16610 - 30781	7	7792.22	II	9358 - 22188
7	7061.47	II	10887 - 25044	6	7796.40	II	10337 - 23160
40	7066.89	II	5085 - 19232	8	7797.32	II	
8	7082.93	II	2585 - 16700	5	7798.32	II	9877 - 22696
12 h	7089.71	II	9357 - 23459	10	7808.47	II	5085 - 17888
12 h	7092.09			7	7818.83	II	12334 - 25120
12 h	7092.74	II	9908 - 24003	5	7825.20	II	10516 - 23292
12 h	7092.94			12	7863.04	II	2585 - 15299
17 h	7093.98	I	1128 - 15220	5 h	7872.03	I	11108 - 23808
20 h	7095.42	I	11360 - 25450	7	7886.60	II	13597 - 26274
29	7129.35	II	1470 - 15492	4 h	7896.50	II	12459 - 25120
12 h	7142.04	II	12276 - 26274	9	7900.40	II	10883 - 23537
10	7143.72			5 h	7906.03	I	15382 - 28027
8	7151.03	II	11373 - 25353	12	7917.01	II	1470 - 14097
6	7153.09	I	10774 - 24751	10	7925.03	II	8796 - 21411
6 h	7185.01			5	7947.93	II	9877 - 22455
10	7189.09	II	10337 - 24243	10	7949.68	II	10883 - 23459
24	7189.42	II	2585 - 16490	5 h	7955.38	II	12276 - 24842
20	7192.01	II	11580 - 25481	12	7958.95	I	8800 - 21361
10	7199.00	II	0 - 13887	12	7965.73	II	513 - 13063
8 h	7227.01	I	14327 - 28160	15	7982.09	II	8717 - 21241
15	7236.54	II	513 - 14328	12	7982.68	II	3801 - 16325
7 h	7261.64	II	8420 - 22188	12	8000.76	II	8796 - 21291
9	7285.29	II	9675 - 23397	9	8007.70	I	10785 - 23269
9	7288.56	II	7525 - 21241	4 h	8020.07		
6	7291.38	II	13597 - 27308	8	8026.35		
7	7298.72	II	12334 - 26031	10	8043.24	I	9692 - 22121

Neodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
8	8051.33	II	1470 - 13887	6	8324.50	II	9908 - 21918
5	8064.00	II	12021 - 24418	4	8332.01	II	15148 - 27146
10	8099.17	I	11887 - 24231	12	8346.36	II	513 - 12491
10	8120.93	II	9877 - 22187	4	8375.16	II	13298 - 25235
12	8122.07	II	2585 - 14894	4	8375.33	II	4437 - 16374
12	8141.75	II	9908 - 22187	4	8394.71	II	12334 - 24243
12	8143.27	II	10883 - 23160	7	8400.85	II	11392 - 23292
7	8164.97	I		5	8456.87	II	13298 - 25120
8	8172.56	II	0 - 12232	4	8530.53	II	513 - 12232
9	8179.83	II	12021 - 24243	5	8582.03	II	13703 - 25352
9	8182.41	II	10942 - 23159	5	8591.53	II	10942 - 22578
4	8185.58	II	12334 - 24547	7	8594.87	II	9198 - 20830
7	8205.38	II	10666 - 22850	8	8643.43	II	9675 - 21241
10	8231.52	II	1470 - 13615	5	8667.07	II	10194 - 21729
4	8248.76	II	6637 - 18757	5	8677.48		
5	8249.68	II	5487 - 17606	6	8691.29	II	10887 - 22389
4	8262.80	II	12222 - 24321	6	8695.07	II	13703 - 25200
7	8266.72	II	9198 - 21291	6	8712.82	II	9198 - 20672
4	8272.79	II	12334 - 24418	6	8715.03	I	8800 - 20271
4	8302.74	II	9877 - 21918	17	8839.10	II	0 - 11310
10	8307.72	II	8796 - 20830				

# Nickel

$$\text{Ni, } Z = 28, M = 58.7, \text{ Ratio } \frac{\text{Ni}}{\text{Cu}} = 0.924$$

Ni I Normal state of valence electrons  $3d^8 4s^2 {}^3F_4 = 0$ . I.P. =  $61579 \text{ cm}^{-1}$ .

Ni II Normal state of valence electrons  $3d^9 {}^2D_{3/2} = 0$ . I.P. =  $146532 \text{ cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939), below  $6000 \text{ \AA}$ .

K. Burns and F. Sullivan, Sci. Studies St. Bonaventure Coll. **13**, 2 (1947), above  $6000 \text{ \AA}$ .

### Classification:

Ni I, H. N. Russell, Phys. Rev. **34**, 821 (1940).

Ni II, A. G. Shenstone, Phys. Rev. **30**, 255 (1927).

### *Strong lines of nickel*

Intensity and Character	Wavelength in $\text{\AA}$	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in $\text{\AA}$	Spectrum	Energy levels in $\text{cm}^{-1}$
8200	3414.76	I	205 - 29481	3700	3012.00	I	3410 - 36601
8200	3524.54	I	205 - 28569	3500	3050.82	I	205 - 32973
6600	3515.05	I	880 - 29321	3300	3380.57	I	3410 - 32982
6600	3619.39	I	3410 - 31031	3300	3392.99	I	205 - 29669
5500	3492.96	I	880 - 29501	2900	3134.11	I	1713 - 33611
5000	3458.47	I	1713 - 30619	2900	3369.57	I	0 - 29669
5000	3461.65	I	205 - 29084	2600	2320.03	I	0 - 43090
5000	3566.37	I	3410 - 31442	2600	3101.55	I	880 - 33112
4800	3446.26	I	880 - 29888	2600	3433.56	I	205 - 29321
4000	3002.49	I	205 - 33501	2600	3510.34	I	1713 - 30192

Nickel — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1600	2289.98	I	0 - 43655	55	3195.57	I	2217 - 33501
630	2300.78	I	205 - 43655	150	3197.11	I	1713 - 32982
2000	2310.96	I	0 - 43259	55	3202.14	I	25754 - 56974
1700	2312.34	I	1332 - 44565	180	3214.06	I	25754 - 56858
1400	2313.66	I		180	3217.83	I	25754 - 56821
1400	2313.98	I	2217 - 45419	100	3221.27	I	30923 - 61958
430	2316.04	II	8394 - 51558	150	3221.65	I	0 - 31031
1400	2317.16	I	1332 - 44475	210	3225.02	I	3410 - 34409
2600	2320.03	I	0 - 43090	1100	3232.96	I	0 - 30923
1900	2321.38	I	2217 - 45281	290	3234.65	I	880 - 31786
240	2322.68	I		600	3243.06	I	205 - 31031
1400	2325.79	I	1332 - 44315	100	3248.46	I	205 - 30980
940	2329.96	I	2217 - 45122	120	3250.74	I	3410 - 34163
460	2337.49	I	0 - 42768	100	3271.12	I	880 - 31442
160	2337.82	I	1713 - 44475	120	3282.70	I	1332 - 31786
1200	2345.54	I	0 - 42621	660	3315.66	I	880 - 31031
190	2346.63	I	1332 - 43933	330	3320.26	I	1332 - 31442
400	2347.52	I	0 - 42585	310	3322.31	I	3410 - 33501
160	2360.63	I	2217 - 44565	330	3361.56	I	880 - 30619
200	2362.06	I	1332 - 43655	330	3365.77	I	3410 - 33112
240	2386.58	I	880 - 42768	330	3366.17	I	1332 - 31031
320	2394.52	II	13550 - 55300	65	3366.81	I	27261 - 56954
220	2416.14	II	14995 - 56371	65	3367.89	I	205 - 29888
240	2419.31	I	1332 - 42654	2900	3369.57	I	0 - 29669
85	2421.23	I	1332 - 42621	400	3371.99	I	1332 - 30980
70	2423.33	I	1332 - 42585	260	3374.22	I	205 - 29833
70	2423.66	I	2217 - 43464	130	3374.64	I	27261 - 56885
70	2424.03	I	1713 - 42954	3300	3380.57	I	3410 - 32982
100	2437.89	II	13550 - 54557	240	3380.85	I	2217 - 31786
85	2453.99	I	2217 - 42954	1300	3391.05	I	0 - 29481
160	2472.06	I	2217 - 42656	3300	3392.99	I	205 - 29669
85	2476.87	I	0 - 40361	130	3409.58	I	0 - 29321
45	2696.49	I	3410 - 40484	330	3413.48	I	1332 - 30619
150	2798.65	I	880 - 36601			I	28542 - 57829
250	2821.29	I	205 - 35639	330	3413.94	I	880 - 30163
50	2865.50	I	1713 - 36601	8200	3414.76	I	205 - 29481
60	2907.46	I	2217 - 36601	1600	3423.71	I	1713 - 30913
25	2914.01	I	1332 - 35639	2600	3433.56	I	205 - 29321
500	2943.91	I	205 - 34163	990	3437.28	I	0 - 29084
570	2981.65	I	880 - 34409	4800	3446.26	I	880 - 29888
250	2984.13	I	0 - 33501	1300	3452.89	I	880 - 29833
500	2992.60	I	205 - 33611	5000	3458.47	I	1713 - 30619
1000	2994.46	I	205 - 33590	5000	3461.65	I	205 - 29084
4000	3002.49	I	205 - 33501	200	3467.50	I	1332 - 30163
2200	3003.63	I	880 - 34163	240	3469.49	I	2217 - 31031
3700	3012.00	I	3410 - 36601	1600	3472.54	I	880 - 29669
350	3019.14	I	0 - 33112	550	3483.77	I	2217 - 30913
120	3031.87	I	0 - 32973	130	3485.89	I	1713 - 30392
1700	3037.94	I	205 - 33112	5500	3492.96	I	880 - 29501
150	3045.01	I	1332 - 34163	660	3500.85	I	1332 - 29888
3500	3050.82	I	205 - 32973	65	3502.60	I	0 - 28542
1500	3054.32	I	880 - 33611	55	3507.69	I	1332 - 29833
1900	3057.64	I	1713 - 34409	2600	3510.34	I	1713 - 30192
500	3064.62	I	880 - 33501	260	3513.93	I	1713 - 30163
420	3080.76	I	1713 - 34163	6600	3515.05	I	880 - 29321
260	3097.12	I	1332 - 33611	660	3519.77	I	2217 - 30619
210	3099.12	I	1332 - 33590	8200	3524.54	I	205 - 28569
2600	3101.55	I	880 - 33112	110	3527.98	I	1332 - 29669
1300	3101.88	I	3410 - 35639	330	3548.18	I	2217 - 30392
220	3105.47	I	2217 - 34409	55	3551.53	I	1332 - 29481
270	3114.12	I	880 - 32982	65	3561.75	I	0 - 28068
2900	3134.11	I	1713 - 33611	5000	3566.37	I	3410 - 31442
55	3145.72	I	1332 - 33112	990	3571.87	I	1332 - 29321
55	3181.74	I	15610 - 47030	130	3587.93	I	205 - 28068
100	3184.37	I	2217 - 33611	1300	3597.70	I	1713 - 29501

Nickel— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1300	3610.46	I	880 - 28569	23	5137.08	I	13521 - 32982
530	3612.74	I	2217 - 29888	23	5142.77	I	29888 - 49328
6600	3619.39	I	3410 - 31031	40	5146.48	I	29888 - 49314
130	3624.73	I	0 - 27580	40	5155.76	I	31442 - 50832
200	3664.10	I	2217 - 29501	16	5168.66	I	29833 - 49175
				13	5176.56	I	31442 - 50754
130	3669.24	I	1332 - 28578				
180	3670.43	I	1332 - 28569	8	5435.87	I	16017 - 34409
260	3674.15	I	3410 - 30619	180	5476.91	I	14729 - 32982
160	3688.42	I	2217 - 29321	6	5510.00	I	31031 - 49175
80	3693.93	I	880 - 27944	6	5578.73	I	13521 - 31442
				9	5587.86	I	15610 - 33501
120	3722.48	I	1713 - 28569				
150	3736.81	I	3410 - 30163	13	5592.28	I	15734 - 33611
60	3739.23	I	1332 - 28068	9	5614.79	I	33501 - 51306
600	3775.57	I	3410 - 29888	5	5625.33	I	32982 - 50754
700	3783.53	I	3410 - 29833	4	5649.70	I	33611 - 51306
				5	5664.02	I	36601 - 54251
700	3807.14	I	3410 - 29669				
110	3831.69	I	3410 - 29501	12	5682.20	I	33112 - 50706
1200	3858.30	I	3410 - 29321	8	5695.00	I	32982 - 50537
30	3889.67	I	1713 - 27415	23	5709.56	I	13521 - 31031
35	3972.17	I	3410 - 28578	10	5711.90	I	15610 - 33112
				10	5715.09	I	32973 - 50466
110	3973.56	I	3410 - 28569				
110	4401.55	I	25754 - 48467	16	5754.68	I	15610 - 32982
85	4459.04	I	26666 - 49086	8	5760.85	I	33112 - 50466
18	4462.46	I	27944 - 50346	10	5857.76	I	33611 - 50678
55	4470.48	I	27415 - 49778	10	5892.88	I	16017 - 32982
				10	6108.12	I	13521 - 29888
35	4592.53	I	28578 - 50346				
18	4600.37	I	29013 - 50745	10	6176.81	I	32973 - 49158
65	4605.00	I	28068 - 49778	10	6191.18	I	13521 - 29669
18	4606.23	I	29013 - 50717	13	6256.36	I	13521 - 29501
75	4648.66	I	27580 - 49086	10	6314.66	I	15610 - 31442
				16	6643.64	I	13521 - 28569
23	4686.22	I	29013 - 50346				
110	4714.42	I	27261 - 48467	22	6767.77	I	14729 - 29501
22	4715.78	I	28578 - 49778	9	6772.32	I	29501 - 44263
30	4756.52	I	28068 - 49086	10	6914.56	I	15734 - 30192
15	4763.95	I	29481 - 50466	5	7110.90	I	15610 - 29669
				26	7122.20	I	28569 - 42606
45	4786.54	I	27580 - 48467				
22	4807.00	I	29669 - 50466	6	7182.00	I	30192 - 44112
22	h 4829.03	I	28569 - 49271	5	7197.02	I	15610 - 29501
19	4831.18	I	29084 - 49778	5	7261.93	I	15734 - 29501
45	4855.41	I	28569 - 49159	5	7291.45	I	15610 - 29321
				4	7385.24	I	22102 - 35639
30	4866.27	I	28542 - 49086				
17	4873.44	I	29833 - 50346	16	7393.60	I	29084 - 42606
40	4904.41	I	28569 - 48953	16	7409.35	I	30619 - 44112
22	4918.36	I	30980 - 51306	5	7414.51	I	16017 - 29501
16	4935.83	I	31786 - 52040	23	7422.28	I	29321 - 42790
				13	7522.76	I	29501 - 42790
45	4980.16	I	29084 - 49158				
45	4984.13	I	30619 - 50678	9	7525.12	I	29321 - 42606
16	h 5000.34	I	29321 - 49314	19	7555.60	I	31031 - 44263
18	5012.46	I	29833 - 49778	8	7574.05	I	30913 - 44112
50	5017.59	I	28542 - 48467	23	7617.00	I	29481 - 42606
				9	7619.21	I	29669 - 42790
100	5035.37	I	29321 - 49175				
16	5048.85	I	31031 - 50832	16	7714.32	I	15610 - 28569
100	5080.52	I	29481 - 49158	5	7715.58	I	29833 - 42790
65	5081.11	I	31031 - 50706	19	7727.61	I	29669 - 42606
26	h 5084.08	I	29669 - 49333	19	7748.89	I	29888 - 42790
				10	7788.94	I	15734 - 28569
18	5099.32	I	29481 - 49086				
26	h 5099.95	I	29669 - 49271	13	7797.59	I	31442 - 44263
21	5115.40	I	30923 - 50466	2	7917.44	I	30163 - 42790
18	h 5129.38	I	29669 - 49159	2	8809.42	I	31442 - 42790
				9	8862.55	I	32982 - 44263

# Niobium

Nb,  $Z = 41$ ,  $M = 92.9064$ , Ratio  $\frac{\text{Nb}}{\text{Cu}} = 1.462$

Nb I Normal state of valence electrons  $4d^4 5s^1 {}^6D_{1/2} = 0$ . I.P. = 55000  $\text{cm}^{-1}$ .

Nb II Normal state of valence electrons  $4d^4 {}^5D_0 = 0$ . I.P. = 115000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented by Humphreys' and Meggers' paper cited below.

### Classification:

Nb I and Nb II, C. J. Humphreys and W. F. Meggers, J. Research NBS **34**, 477 (1945). RP1656.

### *Strong lines of niobium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
16000 c	4058.94	I	1050 - 25680	2000	3535.30	I	0 - 28278
12000	4079.73	I	695 - 25200			I	695 - 28973
6700	4100.92	I	392 - 24770	1800	3094.18	II	4146 - 36455
5300	4123.81	I	154 - 24397	1700	2125.21	II	3030 - 50069
5000	3580.27	I	1050 - 28973	1700	3349.06	I	2154 - 32005
4400	4152.58	I	695 - 24770	1700	3358.42	I	2805 - 32573
4400	4163.66	I	154 - 24165	1700	3742.39	I	0 - 26713
4000	4164.66	I	392 - 24397	1700	3787.06	I	154 - 26552
3500	3791.21	I	1050 - 27420	1500	2131.18	II	2629 - 49537
3500	4168.13	I	0 - 23985	1500	3130.79	II	3542 - 35474
3300	2029.32	II		1500	3575.85	I	695 - 28653
3300	3713.01	I	1050 - 27975	1500	3697.85	I	392 - 27427
3000	2032.99	II	3542 - 52715	1300	3341.97	I	1143 - 31057
2700	3726.24	I	154 - 26983	1300	3343.71	I	1587 - 31485
2700	3739.80	I	695 - 27427	1300	3537.48	I	392 - 28653
2700	3798.12	I	392 - 26713	1300	3790.15	I	1050 - 27427
2700	3802.92	I	695 - 26983	1300	4195.66	I	8827 - 32654
2700	4139.71	I	1050 - 25200	1200	3163.40	II	3030 - 34632
2300	4137.10	I	0 - 24165	1200	4190.88	I	1050 - 24905
2000	2109.42	II	4146 - 51537	1200	4606.77	I	2805 - 24507

*Niobium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
3300	2029.32	II		45	2583.22	I	2154 - 40854
3000	2032.99	II	3542 - 52715	390	2583.99	II	9813 - 48501
2000	2109.42	II	4146 - 51537	28	2589.27	I	
1700	2125.21	II	3030 - 50069	390	2590.94	II	10186 - 48771
1100	2126.54	II	3542 - 50552	270	2592.20	I	2805 - 41371
1500	2131.18	II	2629 - 49537	45	2594.34	II	801 - 39335
370	2295.68	II	1225 - 44771	95	2594.74	II	7901 - 46429
280	2302.08	II	801 - 44227	55	2597.14	I	1587 - 40079
170	2376.40	II	801 - 42869	85	2601.29	II	10186 - 48617
110	2387.09	II	10836 - 52715	40	2601.84	I	1587 - 40010
140	2387.52	II	7901 - 49772	35	2602.01	I	
45	2388.27	II	7901 - 49759	27	2603.31	I	2154 - 40555
160	2398.48	II	10247 - 51927	35	2608.84	I	2154 - 40474
55	2405.34	II	10653 - 52215	35	2608.96	II	9813 - 48130
55	2405.85	II	10836 - 52389	85	2610.28	I	1587 - 39886
140	2412.46	II	8320 - 49759	75	2612.38	I	2154 - 40422
160	2416.99	II	10919 - 52280	13	2613.85	II	438 - 38685
140	2418.69	II	10604 - 51936	130	2616.48	I	2154 - 40362
75	2433.80	II	9510 - 50585	80	2620.45	II	7506 - 45656
40	2435.95	II	9813 - 50852	13	2622.00	I	8827 - 46954
35	2436.33	I	2154 - 43187	130	2623.51	I	1143 - 39248
45	2437.42	II	7506 - 48520	130	2627.44	I	2805 - 40854
40	2442.14	II	10247 - 51182	130	2628.49	I	1587 - 39620
28	2442.68	II	16219 - 57145	95	2632.52	II	8320 - 46296
65	2451.87	II	12263 - 53036	40	2634.71	I	1587 - 39530
65	2453.95	II	13690 - 54429	35	2637.98	II	10604 - 48501
55	2458.09	II	14791 - 55461	95	2640.92	I	2154 - 40009
65	2462.89	I	2805 - 43396	27	2641.06	II	10919 - 48771
35	2466.73	I	2805 - 43333	200	2642.24	II	9510 - 47345
55	2469.08	I	2154 - 42643	320	2646.26	II	438 - 38216
110	2477.38	II	6192 - 46545	330	2647.50	I	1143 - 38903
65	2478.29	II	10247 - 50585	240	2649.52	I	2154 - 39886
65	2479.94	II	10186 - 50498	85	2651.12	II	10919 - 48627
35	2483.88	II	10604 - 50852	35	2652.94	I	8827 - 46510
28	2502.49	II	10604 - 50552	95	2653.38	I	2805 - 40482
110	2504.65	I	2805 - 42719	330	2654.45	I	1587 - 39248
110	2511.00	II	5562 - 45375	40	2655.70	I	8827 - 46471
40	2520.51	I		310	2656.08	II	159 - 37797
110	2521.40	II	9510 - 49158	65	2656.98	I	9329 - 46954
28	2524.99	I	1143 - 40735	160	2657.62	I	2805 - 40422
90	2525.81	II	10919 - 50498	27	2658.88	II	8320 - 45919
55	2530.97	II	14626 - 54125	27	2660.04	II	10919 - 48501
28	2531.25	II	14678 - 54173	40	2661.86	I	2805 - 40362
90	2540.62	II	14661 - 54010	27	2663.56	II	9813 - 47315
90	2541.42	II	1225 - 40561	110	2665.25	II	10247 - 47756
390	2544.80	II	7261 - 46545	110	2666.59	II	801 - 38291
28	2548.63	II	13055 - 52280	40	2667.15	II	8320 - 45802
110	2551.38	II	6192 - 45375	110	2667.30	II	0 - 37480
55	2555.63	II	9510 - 48627	85	2667.76	II	10604 - 48078
130	2556.94	II	7261 - 46359	130	2668.29	I	2154 - 39620
75	2558.94	I	1143 - 40210	400	2671.93	II	801 - 38216
130	2562.41	II	6192 - 45207	200	2673.57	II	15396 - 52788
130	2565.41	I	1587 - 40555	200	2675.94	II	438 - 37797
70	2567.51	I	1143 - 40079	27	2677.66	II	10919 - 48253
100	2569.03	I	9329 - 48242	65	2678.66	II	159 - 37480
28	2570.78	I	1587 - 40474	95	2679.01	I	1587 - 38903
28	2571.05	I	1587 - 40470	45	2680.06	II	8320 - 45622
110	2571.33	II	1225 - 40104	27	2682.13	I	2154 - 39427
70	2572.10	I	1143 - 40010	65	2686.39	II	18508 - 55722
45	2574.84	II	159 - 38984	130	2687.15	I	2805 - 40009
55	2576.60	I	2154 - 40953	160	2691.77	II	159 - 37298
55	2578.20	I	1587 - 40362	95	2695.04	I	2154 - 39248
200	2578.74	I	2154 - 40921	40	2696.05	I	2805 - 39886
45	2580.28	II	9510 - 48253	1000	2697.06	II	1225 - 38291
60	2583.11	I	8827 - 47528	320	2698.86	II	438 - 37480



Niobium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	2700.15	II	7901 - 44925	80	2791.74	II	9813 - 45622
20	2700.56	II	3542 - 40561	110	2793.05	II	3542 - 39335
320	2702.20	II	801 - 37797	27	2795.14	II	13480 - 49246
150	2702.52	II	1225 - 38216	20	2795.86	I	1587 - 37344
40	2704.26	II	13480 - 50447	60	2797.69	II	11340 - 47073
95	2706.40	II	438 - 37377	45	2798.91	II	7901 - 43618
35	2707.83	II	9510 - 46429	35	2799.36	I	2154 - 37866
20	2714.20	I	2805 - 39638	40	2800.32	I	1587 - 37287
27	2715.34	II	16219 - 53036	20	2802.07	I	2154 - 37832
27	2715.50	I	2805 - 39620	60	2803.81	II	3030 - 38685
27	2715.69	I	1143 - 37955	40	2808.05	I	1587 - 37188
40	2715.88	II	13055 - 49864	27	2809.17	II	2629 - 38216
65	2716.10	I	1587 - 38393	75	2810.81	II	8320 - 43887
60	2716.31	II	159 - 36963	40	2811.63	I	11525 - 47081
470	2716.62	II	1225 - 38024	27	2816.68	II	13666 - 49158
35	2717.33	II		55	2819.21	I	
27	2717.63	II	9510 - 46296	40	2820.80	II	2357 - 37797
27	2720.02	I	5965 - 42719	20	2821.92	I	2805 - 38232
27	2720.26	II	3030 - 39780	75	2825.18	I	2154 - 37540
40	2721.63	II	0 - 36732	23	2825.86	II	10919 - 46296
470	2721.98	II	801 - 37528	65	2826.48	I	2154 - 37524
27	2722.31	I	1143 - 37865	190	2827.08	II	159 - 35521
35	2723.66	II	13055 - 49759	40	2829.75	II	1225 - 36553
60	2723.98	I	2154 - 38854	95	2835.12	II	3030 - 38291
55	2726.08	I	1143 - 37815	150	2836.24	I	
27	2727.43	II	13119 - 49772	110	2840.94	I	2154 - 37344
35	2728.08	I	1587 - 38232	250	2841.15	II	3030 - 38216
27	2729.83	I	2805 - 39427	23	2842.02	I	5298 - 40474
55	2730.32	II	13119 - 49733	280	2842.65	II	2629 - 37797
310	2733.26	II	801 - 37377	27	2843.64	II	10186 - 45342
80	2733.46	II	159 - 36732	27	2844.44	II	14626 - 49772
20	2734.35	II	7506 - 44067	55	2845.80	II	9510 - 44639
110	2737.09	II	438 - 36963	160	2846.28	II	2357 - 37480
85	2740.18	II	9813 - 46296	23	2847.24	II	14661 - 49772
40	2741.15	I	8827 - 45297	65	2848.30	II	14661 - 49759
27	2744.96	II	10653 - 47073	75	2849.56	II	438 - 35521
60	2745.30	II	4146 - 40561	110	2851.45	I	10238 - 45297
65	2745.73	II	9510 - 45919	85	2851.98	I	12102 - 47155
200	2746.91	I	1143 - 37537	65	2854.17	I	2805 - 37832
200	2748.85	I	1587 - 37955	45	2857.29	I	5965 - 40953
190	2753.01	I		40	2859.04	II	10836 - 45802
75	2753.14	II	15396 - 51707	95	2859.96	I	2805 - 37761
27	2754.07	I		240	2861.09	II	2357 - 37298
65	2754.52	II	438 - 36732	100	2864.32	I	
95	2755.29	I	8827 - 45110	100	2865.61	II	0 - 34886
80	2755.64	I	1587 - 37865	40	2866.67	I	1143 - 36016
60	2757.26	II	12263 - 48520	500	2868.52	II	2629 - 37480
280	2758.61	I	2154 - 38393	95	2874.57	I	1143 - 35920
27	2758.78	II	10836 - 47073	800	2875.39	II	3030 - 37797
55	2761.00	I		270	2876.95	II	3542 - 38291
80	2763.38	I	2805 - 38982	530	2877.03	II	2629 - 37377
55	2764.56	II	801 - 36963	65	2878.74	II	159 - 34886
65	2765.28	II	1225 - 37377	45	2879.36	II	801 - 35521
35	2765.93	II	7506 - 43649	45	2879.49	I	2805 - 37524
17	2766.18	I	12102 - 48242	100	2880.72	II	10919 - 45622
240	2768.13	II	438 - 36553	570	2883.18	II	3542 - 38216
17	2769.57	II	10247 - 46343	65	2884.97	I	12503 - 47155
65	2771.40	II	21073 - 57145	23	2887.69	II	14626 - 49246
20	2771.65	II	13690 - 49759	280	2888.83	II	2357 - 36963
310	2773.20	I	2805 - 38854	35	2889.90	I	1587 - 36180
55	2779.36	I	1143 - 37112	40	2894.42	II	10836 - 45375
65	2779.72	I		470	2897.81	II	3030 - 37528
270	2780.24	II	4146 - 40104	400	2899.24	II	3542 - 38024
130	2782.36	I	9329 - 45259	95	2903.65	I	1587 - 36016
27	2790.57	II	10604 - 46429	470	2908.24	II	2357 - 36732

Niobium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	2908.88	II	14791 - 49158	35	3066.10	II	13690 - 46296
670	2910.59	II	3030 - 37377	110	3069.68	II	13055 - 45622
470	2911.74	II	2629 - 36963	100	3070.90	II	14791 - 47345
65	2917.05	II	10653 - 44925	35	3071.18	II	15949 - 48501
1100	2927.81	II	4146 - 38291	110	3071.56	II	11340 - 43887
110	2931.47	II	2629 - 36732	40	3072.41	I	4998 - 37537
35	2932.66	II	10836 - 44925	65	3072.51	II	13119 - 45656
27	2935.29	II	9510 - 43568	100	3073.24	II	2357 - 34886
35	2937.33	II	10604 - 44639	400	3076.87	II	3030 - 35521
95	2938.07	I	2154 - 36180	110	3080.35	II	10836 - 43290
870	2941.54	II	3542 - 37528	75	3087.86	II	12263 - 44639
110	2945.88	II	10836 - 44771	1800	3094.18	II	4146 - 36455
110	2946.12	II	3030 - 36963	65	3096.50	I	1587 - 33872
110	2946.90	II	2629 - 36553	140	3099.19	II	2629 - 34886
1100	2950.88	II	4146 - 38024	150	3111.45	I	1587 - 33717
20	2954.02	II	14678 - 48520	75	3116.36	I	10238 - 42317
40	2954.53	II	14791 - 48627	65	3122.65	I	2154 - 34169
35	2955.45	I	10238 - 44063	270	3127.53	II	17425 - 49390
40	2956.89	II	7901 - 41710	35	3129.64	II	10653 - 42597
20	2959.97	I	2154 - 35928	1500	3130.79	II	3542 - 35474
40	2963.68	I	4998 - 38730	75	3133.08	I	8827 - 40735
80	2965.48	I	4998 - 38710	75	3136.97	I	1143 - 33011
35	2970.40	II	12263 - 45919	75	3140.50	II	12806 - 44639
	2970.47	II	13690 - 47345	390	3145.40	II	8320 - 40104
400	2972.57	II	11340 - 44971	140	3151.87	I	2154 - 33872
320	2974.10	II	10919 - 44532	65	3152.16	II	21073 - 52788
210	2977.68	II	10653 - 44227	1200	3163.40	II	3030 - 34632
60	2978.94	II	17292 - 50852	40	3172.51	I	1143 - 32654
55	2979.88	II	21473 - 55021	75	3173.20	II	14791 - 46296
95	2980.72	II	12263 - 45802	150	3175.78	II	10653 - 42133
65	2981.64	I	2805 - 36334		3175.86	II	7506 - 38984
200	2982.11	II	3030 - 36553	390	3180.29	II	7901 - 39335
40	2983.14	I	1143 - 34655	65	3181.40	II	7261 - 38685
55	2985.05	II	13055 - 46545	75	3184.22	II	15949 - 47345
85	2987.29	I	5298 - 38763	75	3186.54	I	4998 - 36371
65	2988.69	I	9439 - 42889	200	3187.49	I	2805 - 34169
	2988.79	I	4998 - 38447	75	3189.28	II	17425 - 48771
330	2990.26	II	11340 - 44771	300	3191.10	II	4146 - 35474
80	2991.95	II	10653 - 44067	150	3191.43	II	17292 - 48617
470	2994.73	II	4146 - 37528	1000	3194.98	II	2629 - 33919
27	3000.12	I		65	3200.53	I	2154 - 33390
65	3002.21	II	11340 - 44639	120	3203.35	II	17292 - 48501
40	3005.14	I	1587 - 34854	300	3206.34	II	7506 - 38685
65	3005.77	II	17292 - 50552	75	3210.29	I	9329 - 40470
40	3010.38	II	15949 - 49158	390	3215.60	II	3542 - 34632
40	3010.69	II	17292 - 50498	90	3217.29	I	5298 - 36371
65	3020.67	I	5298 - 38393	65	3217.86	I	1587 - 32654
65	3022.74	II	17425 - 50498	75	3223.32	II	8320 - 39335
140	3024.74	II	10836 - 43887	800	3225.48	II	2357 - 33351
350	3028.44	II	3542 - 36553	140	3229.56	II	7261 - 38216
35	3029.74	II	12806 - 45802	400	3236.40	II	3030 - 33919
300	3032.77	II	10604 - 43568	40	3246.78	I	1143 - 31934
35	3039.41	II	2629 - 35521	200	3247.47	II	7901 - 38685
65	3039.68	I	5965 - 38854	120	3248.94	II	6192 - 36963
40	3039.82	II	11340 - 44227	160	3249.52	I	1143 - 31908
100	3044.76	II	13666 - 46500	75	3251.62	I	2154 - 32899
150	3048.10	I	5965 - 38763	320	3254.07	II	2629 - 33351
110	3053.09	I	5965 - 38710	75	3260.14	I	1143 - 31808
100	3055.52	II	16053 - 48771	230	3260.56	II	17470 - 48130
75	3056.62	I		160	3263.37	II	21073 - 51707
35	3061.11	I	9329 - 41987	160	3264.59	I	2805 - 33428
35	3061.24	I	5298 - 37955	75	3267.05	I	8827 - 39427
75	3063.79	II	13666 - 46296	120	3270.47	I	
220	3064.53	II	10247 - 42869	100	3270.76	I	1143 - 31708
75	3065.26	II	10836 - 43450	200	3272.07	I	1587 - 32140

Niobium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	3272.22	II	14791 - 45342	130	3406.13	I	9043 - 38393
160	3277.67	I	1587 - 32088	270	3408.38	I	2154 - 31485
200	3283.46	II	16053 - 46500	230	3408.68	II	6192 - 35521
230	3285.66	I	1587 - 32013	180	3409.19	II	5562 - 34886
200	3287.59	I	1143 - 31551	75	3409.91	I	11044 - 40362
160	3287.92	I	5965 - 36371	230	3412.94	II	7261 - 36553
85	3291.06	II	3542 - 33919	90	3414.07	I	2805 - 32088
160	3292.02	II	15551 - 45919	180	3415.97	I	9498 - 38763
85	3294.36	II	15949 - 46296	90	3417.86	I	8705 - 37955
320	3296.01	I	2805 - 33136	90	3420.63	II	7506 - 36732
160	3299.61	I	2154 - 32452	180	3423.76	I	2805 - 32005
120	3304.83	I	13146 - 43396	230	3425.42	II	10919 - 40104
120	3308.05	I	1587 - 31808	130	3425.85	I	13012 - 42194
120	3310.47	I	2805 - 33004	230	3426.57	II	10604 - 39780
85	3311.34	I	12982 - 43173	230	3427.45	I	2805 - 31973
400	3312.60	I	2154 - 32333	40	3428.79	I	10923 - 40079
200	3315.22	I	8827 - 38982	130	3429.04	I	5965 - 35120
200	3318.98	I	1587 - 31708	40	3432.42	I	8411 - 37537
120	3319.26	I	2805 - 32924	180	3432.70	II	16219 - 45342
120	3319.58	II	7261 - 37377	75	3433.09	I	9329 - 38449
40	3320.81	II	15551 - 45656	90	3436.96	II	15551 - 44639
240	3326.62	I	9329 - 39381	90	3439.92	II	7901 - 36963
170	3329.36	I	8827 - 38854	180	3440.59	II	8320 - 37377
110	3332.16	I	2154 - 32156	65	3442.65	I	8827 - 37866
130	3341.60	II	10186 - 40104	35	3442.79	I	12102 - 41140
1300	3341.97	I	1143 - 31057	90	3445.68	I	12358 - 41371
1300	3343.71	I	1587 - 31485	90	3452.35	II	14661 - 43618
85	3343.96	II	8320 - 38216	90	3452.37	I	11525 - 40482
130	3346.93	I	4998 - 34868	75	3456.54	I	9329 - 38251
1700	3349.06	I	2154 - 32005	90	3457.79	I	9043 - 37955
420	3349.52	I	11525 - 41371	75	3458.95	I	5965 - 34868
40	3352.59	I	2154 - 31973	90	3459.70	I	9498 - 38393
340	3354.74	I	2805 - 32605	50	3462.65	I	2154 - 31026
130	3357.04	I	2154 - 31934	170	3463.81	I	13012 - 41874
1700	3358.42	I	2805 - 32573	180	3465.86	I	1143 - 29987
130	3365.58	II	8320 - 38024	90	3467.47	I	8705 - 37537
340	3366.96	I	9329 - 39021	130	3469.44	I	9329 - 38144
85	3367.38	I	8705 - 38393	100	3471.19	I	16919 - 45719
130	3369.16	II	15949 - 45622	140	3473.02	I	13146 - 41931
65	3369.83	I	9043 - 38710	50	3475.58	I	12982 - 41746
170	3371.33	I	2154 - 31808	290	3478.69	I	5965 - 34704
65	3372.09	I	2805 - 32452		3478.78	II	10247 - 38984
65	3372.56	II	10919 - 40561	200	3479.56	II	10604 - 39335
40	3374.25	II	7901 - 37528	50	3481.05	I	4998 - 33717
350	3374.92	I	8827 - 38449	100	3484.05	II	6192 - 34886
65	3376.34	I	12137 - 41746	50	3485.93	I	13515 - 42194
85	3376.73	I	11248 - 40854	75	3489.09	II	7901 - 36553
65	3380.05	I	2805 - 32382	230	3491.03	I	1143 - 29779
270	3380.41	I	1143 - 30716	50	3491.48	I	1143 - 29776
130	3380.86	I	5298 - 34868	75	3496.03	I	12358 - 40953
	3380.93	II	16053 - 45622	200	3497.81	I	392 - 28973
85	3383.80	I	8411 - 37955	500	3498.63	I	5298 - 33872
85	3384.66	I	12018 - 41555	100	3503.20	I	9329 - 37866
170	3386.24	II	9813 - 39335	50	3505.81	I	9439 - 37955
85	3387.75	I	5298 - 34808	460	3507.96	I	154 - 28653
85	3390.63	I	9498 - 38982	200	3510.26	II	16053 - 44532
40	3391.33	I	12137 - 41615	85	3511.19	II	10238 - 38710
350	3392.34	I	1587 - 31057	200	3515.42	II	10247 - 38685
40	3394.98	II	12263 - 41710	50	3516.20	I	9329 - 37761
170	3395.93	I	1587 - 31026	85	3516.86	I	9439 - 37865
85	3398.25	I		200	3517.67	II	16219 - 44639
120	3399.40	I	2805 - 32214		3517.76	I	5298 - 33717
85	3399.71	II	14661 - 44067	200	3520.06	I	1587 - 29987
85	3403.02	I		85	3525.23	I	13012 - 41371
230	3405.41	I	9498 - 38854	100	3533.66	I	154 - 28445

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	3534.12	I	5965 - 34253	100	3655.98	I	154 - 27499
2000	3535.30	I	0 - 28278	100	3657.11	I	13146 - 40482
		I	695 - 28973	200	3659.61	II	15551 - 42869
1300	3537.48	I	392 - 28653	630	3660.37	I	2805 - 30117
100	3539.65	I	9043 - 37287	55	3661.68	I	10238 - 37540
250	3540.96	II	8320 - 36553	90	3662.05	I	1143 - 28442
100	3541.90	I	13146 - 41371	900	3664.70	I	695 - 27975
50	3542.56	I	2805 - 31026	55	3666.53	I	11248 - 38514
90	3542.98	I	1143 - 29360	45	3667.00	I	12358 - 39620
500	3544.02	I	0 - 28208	55	d 3667.66	I	10923 - 38180
250	3544.65	I	5965 - 34169		3667.76	I	
100	3548.13	I	1587 - 29763	130	3668.62	I	4998 - 32249
50	3549.26	I	13405 - 41572	220	3669.01	I	5298 - 32546
300	3550.45	I	392 - 28549	100	3669.74	I	12288 - 39530
250	3554.52	I	2154 - 30279	35	3671.37	I	12018 - 39248
1000	3554.66	I	154 - 28278	55	hc 3672.44	I	392 - 27614
50	3559.12	I	4998 - 33087	27	3673.23	I	13146 - 40362
630	3563.50	I	154 - 28208	270	3674.78	I	392 - 27597
630	3563.62	I	392 - 28445	27	3675.17	I	
50	3568.51	II	7506 - 35521	90	3676.31	I	12692 - 39886
100	3568.72	I	4998 - 33011	90	3677.08	I	11044 - 38232
180	3569.47	I	2154 - 30162	110	3677.78	I	9329 - 36511
50	3575.13	I	12018 - 39981	29	3678.72	I	15467 - 42643
1500	3575.85	I	695 - 28653	85	3686.56	I	2154 - 29272
200	3577.72	I	10238 - 38180	29	3687.44	I	12137 - 39248
5000	3580.27	I	1050 - 28973	120	3687.97	II	17425 - 44532
85	3582.36	I	5965 - 33872	85	3688.18	II	10919 - 38024
500	3584.97	I	392 - 28278	120	3688.70	I	695 - 27797
750	3589.11	I	695 - 28549	85	3689.04	I	11044 - 38144
500	3589.36	I	2805 - 30658	150	3693.37	I	4998 - 32066
500	3593.97	I	392 - 28208	150	3694.67	I	11525 - 38583
50	3597.26	I	12288 - 40079	95	3695.90	II	14661 - 41710
50	3598.35	I	0 - 27783	130	3697.39	I	5965 - 33004
150	3599.28	I	13146 - 40921	1500	3697.85	I	392 - 27427
150	3599.63	I	1587 - 29360	95	3699.93	I	
500	3602.56	I	695 - 28445	130	3703.16	I	13012 - 40008
50	3604.08	I	695 - 28434	130	3703.91	I	13012 - 40003
150	3615.50	I	12358 - 40009	140	3704.14	I	11525 - 38514
90	3617.71	I	17476 - 45110	65	3707.80	I	1587 - 28549
50	3618.44	I	154 - 27783	190	3709.25	II	11340 - 38291
90	3618.90	I	4998 - 32623		3709.42	I	5298 - 32249
300	3619.51	II	7901 - 35521	65	3710.45	I	10923 - 37866
50	3619.73	II	15949 - 43568	330	3711.34	I	0 - 26937
200	3621.03	I	2154 - 29763	50	3711.78	I	5965 - 32899
140	3625.17	I	10238 - 37815	3300	3713.01	I	1050 - 27975
140	3625.71	I	12982 - 40555	190	3713.82	I	695 - 27614
150	3630.62	I	12102 - 39638	85	3716.21	I	695 - 27597
100	3633.00	I	12692 - 40210	480	3716.99	I	11248 - 38144
90	3633.31	II	16053 - 43568		3717.06	II	13666 - 40561
150	3633.71	I	154 - 27666	140	3717.54	I	10923 - 37815
100	3634.44	I	8827 - 36334	85	3720.46	II	13690 - 40561
100	3635.32	I	12503 - 40003	65	3721.52	I	12982 - 39846
100	3636.96	I	12358 - 39846	95	3722.32	I	13146 - 40003
100	3637.54	I	12137 - 39620	95	3722.95	I	
150	3637.83	I		65	3725.22	I	9498 - 36334
100	3638.79	I	2805 - 30279	2700	3726.24	I	154 - 26983
200	3639.33	I	13012 - 40482	140	3727.23	I	11044 - 37866
150	3640.64	I	154 - 27614	95	3732.03	I	11044 - 37832
85	3643.34	I	12982 - 40422	65	3733.32	I	18332 - 45110
85	3643.72	I	15282 - 42719	65	3733.62	I	1143 - 27919
100	3644.94	I	9439 - 36867	270	3738.42	I	10238 - 36979
50	3647.31	I	13012 - 40422	2700	3739.80	I	695 - 27427
420	3649.85	I	392 - 27783	670	3740.73	II	13055 - 39780
250	3650.81	I	1050 - 28434		3740.84	I	695 - 27420
400	3651.19	II	7506 - 34886	270	3741.78	I	0 - 26718

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1700	3742.39	I	0 - 26713	250	3836.45	I	9439 - 35497
190	3744.00	I	10923 - 37625	65	3837.08	I	14899 - 40953
140	3746.91	I		170	3841.81	I	13405 - 39427
170	3748.55	I	8827 - 35496	140	3842.71	I	9329 - 35345
65	3750.63	I	1143 - 27797	35	3843.93	I	5965 - 31973
250	3753.18	I	695 - 27332	65	3844.08	I	11248 - 37254
40	3755.28	I	1587 - 28208	210	3845.90	I	392 - 26386
210	3755.77	I	11248 - 37866	110	3853.38	I	10923 - 36867
140	3759.55	I	392 - 26983	35	3854.70	I	11044 - 36979
40	3760.64	I	11248 - 37832	65	3855.15	I	11044 - 36976
170	3761.13	I	11044 - 37625	65	3855.45	I	0 - 25930
40	3762.45	I		290	3858.95	I	154 - 26061
530	3763.49	I	154 - 26718	35	3860.86	I	12358 - 38251
150	3764.12	I	154 - 26713	140	3862.93	I	0 - 25880
350	3765.08	I	0 - 26552		3863.05	II	12806 - 38685
250	3766.13	I	392 - 26937	350	3863.38	I	5298 - 31175
170	3769.15	I	1143 - 27666	65	3865.02	II	13119 - 38984
140	3769.98	I	12503 - 39021		3865.04	I	13515 - 39381
75	3770.71	I	11248 - 37761	270	3867.92	I	1050 - 26897
140	3770.87	I		65	3871.19	I	9043 - 34868
530	3771.85	I	392 - 26897	35	3875.42	I	12018 - 37815
110	3773.15	I	11044 - 37540	170	3875.76	I	1143 - 26937
65	3774.44	I	5965 - 32452	140	3876.96	I	12358 - 38144
140	3775.45	I	11044 - 37524	530	3877.56	I	1050 - 26832
40	3776.60	I	1143 - 27614	870	3878.82	I	392 - 26166
50	3777.28	I	2805 - 29272		3878.97	I	1587 - 27360
60	3777.67	I	15282 - 41746	65	3879.35	II	14791 - 40561
870	3781.01	I	392 - 26832	670	3883.14	I	695 - 26440
110	3781.38	II	13666 - 40104	1100	3885.44	I	11525 - 37254
140	3783.84	I	10923 - 37344	670	3885.68	I	11248 - 36976
140	3786.22	I	2805 - 29209	210	3886.07	I	154 - 25880
1700	3787.06	I	154 - 26552	40	3889.63	I	
65	3787.18	I	2154 - 28549	29	3889.80	I	2154 - 27855
65	3789.50	I	2154 - 28535	580	3891.30	I	695 - 26386
1300	3790.15	I	1050 - 27427	50	3893.73	I	392 - 26067
3500	3791.21	I	1050 - 27420	50	3894.03	I	11044 - 36717
85	3794.17	I	12102 - 38449	40	3894.70	I	392 - 26061
140	3795.54	I		170	3895.90	I	9439 - 35100
110	3796.44	I	15282 - 41615	110	3898.28	II	13690 - 39335
110	3796.59	I	1587 - 27919	110	3898.56	I	2154 - 27797
110	3796.85	I	13515 - 39846	65	3899.25	I	15282 - 40921
2700	3798.12	I	392 - 26713	120	3904.18	I	12018 - 37625
170	3800.94	I	9329 - 35631	85	3906.91	I	8827 - 34416
270	3801.30	I	11044 - 37344	40	3908.59	I	13405 - 38982
2700	3802.92	I	695 - 26983	210	3908.97	I	1143 - 26718
670	3803.88	I	1050 - 27332	65	3909.60	I	13012 - 38583
530	3804.74	I	11248 - 37524	130	3913.01	I	11318 - 36867
		II	17292 - 43568	670	3914.70	I	10923 - 36460
170	3806.20	I	10923 - 37188	65	3919.00	I	9329 - 34838
60	3806.63	I	14211 - 40474	65	3919.16	I	12358 - 37866
670	3810.19	I	11525 - 37761	35	3919.72	II	13480 - 38984
530	3811.03	I	154 - 26386	530	3920.20	I	13012 - 38514
35	3813.17	I		110	3922.35	I	12137 - 37625
530	3815.51	I	695 - 26897	65	3924.49	I	12358 - 37832
65	3816.34	I	1587 - 27783	170	3925.00	I	695 - 26166
210	3818.86	II	12806 - 38984	65	3926.61	I	2154 - 27614
210	3819.15	I	4998 - 31175	130	3929.29	I	2154 - 27597
35	3821.19	I	8705 - 34868	35	3931.46	I	9439 - 34868
670	3824.88	I	695 - 26832	35	3934.14	I	10923 - 36334
110	3827.01	I	13515 - 39638	95	3934.41	I	1143 - 26552
35	3828.24	II	13666 - 39780	85	3935.45	I	12137 - 37540
35	3830.00	I	8705 - 34808	60	3936.45	I	1587 - 26983
170	3831.84	II	13690 - 39780	670	3937.44	I	1050 - 26440
35	3833.26	I	12503 - 38583	95	3937.96	I	12137 - 37524
350	3835.18	I	0 - 26067	170	3941.27	I	695 - 26061

Niobium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
520	3943.67	I	1587 - 26937	29	4057.27	I	15439 - 40079
95	3947.53	I	12018 - 37344	16000 c	4058.94	I	1050 - 25680
65	3949.33	I	9439 - 34753	210	4059.51	I	10126 - 34753
	3949.46	II	14791 - 40104	120	4060.31	I	2805 - 27427
60	3949.94	I	1587 - 26897	350	4060.79	I	154 - 24773
65	3952.37	II	13690 - 38984	40	4061.26	I	10238 - 34854
95	3953.08	I	11044 - 36334	140	4061.54	I	2805 - 27420
110	3955.68	I	2154 - 27427	85	4064.81	I	12692 - 37287
65	3959.36	I	12982 - 38232	85	4066.12	I	11044 - 35631
35	3960.98	I	13012 - 38251	170	4067.16	I	12137 - 36717
35	3964.66	I	9439 - 34655	210	4068.26	I	10923 - 35496
250	3965.69	I	5965 - 31175	29	4070.04	I	
910	3966.09	I	12137 - 37344	140	4070.96	I	12982 - 37540
	3966.25	I	2154 - 27360	40	4072.07	II	13666 - 38216
65	3970.65	I	2154 - 27332	85	4073.51	I	15439 - 39981
					4073.64	I	12982 - 37524
210	3971.85	I	12018 - 37188				
	3971.93	I	2805 - 27975	60	4076.09	I	2805 - 27332
170	3972.52	I	12358 - 37524	75	4077.09	I	15461 - 39981
110	3973.62	I	16829 - 41987	50	4078.35	I	392 - 24905
130	3976.67	I	15282 - 40422	40	4078.60	I	13012 - 37524
110	3977.94	I	13012 - 38144	12000	4079.73	I	695 - 25200
110	3978.75	I	1587 - 26713	40	4083.78	I	1587 - 26067
65	3979.37	I	12692 - 37815	85	4084.18	I	5298 - 29776
40	3980.48	I	1050 - 26166	270	4084.86	I	1587 - 26061
35	3982.06	I	13146 - 38251	85	4086.63	I	9439 - 33902
29	3984.81	I	15467 - 40555	40	4087.05	I	13405 - 37865
60	3985.18	I	11248 - 36334	140	4090.16	I	12018 - 36460
110	3988.16	I	16829 - 41896	50	4095.56	I	13405 - 37815
29	3990.67	I	12137 - 37188	40	4097.64	I	17476 - 41874
110	3991.68	I		50	4098.22	I	13146 - 37540
29	3994.43	I	11248 - 36276	170	4099.07	I	154 - 24543
140	3999.18	I	13146 - 38144	440	4100.40	I	392 - 24773
40	4000.60	II	14791 - 39780	6700	4100.92	I	392 - 24770
75	4001.13	I	12358 - 37344	75	4106.18	I	9043 - 33390
29	4002.26	I		35	4106.78	I	1587 - 25930
40	4005.93	I		40	4109.88	I	5298 - 29623
140	4008.28	I	10238 - 35179	140	4112.13	I	16829 - 41140
140	4009.71	I	12692 - 37625	50	4113.35	I	12982 - 37287
65	4012.06	I	1143 - 26061	170	4113.94	I	11044 - 35345
190	4013.27	I	16919 - 41829	310	4116.90	I	0 - 24283
29	4014.93	I	12288 - 37188	85	4119.28	II	21073 - 45342
40	4016.08	I		120	4122.81	I	11248 - 35496
120	4017.56	I	12982 - 37866	5300	4123.81	I	154 - 24397
29	4020.24	I		75	4125.25	I	10923 - 35157
29	4022.39	I	13012 - 37866	50	4125.58	I	2154 - 26386
150	4023.14	I	12982 - 37832	50	4126.90	I	
65	4027.31	I	12288 - 37112	85	4127.45	I	16919 - 41140
65	4027.98	I	13012 - 37832	670	4129.43	I	695 - 24905
29	4029.22	I		770	4129.93	I	
40	4030.35	I		85	4131.53	I	12137 - 36334
1100	4032.52	I	2805 - 27597	170	4134.59	I	11318 - 35497
29	4033.20	I	1143 - 25930	75	4135.42	I	12692 - 36867
65	4035.10	I	13405 - 38180	2300	4137.10	I	0 - 24165
65	4035.93	I	15439 - 40210	75	4137.59	I	12018 - 36180
40	4038.18	I		50	4138.30	I	18036 - 42194
85	4039.10	I	11525 - 36276	440	4139.44	I	392 - 24543
250	4039.53	I	13012 - 37761	2700	4139.71	I	1050 - 25200
65	4040.47	I	2154 - 26897	50	4142.24	I	11044 - 35179
85	4042.57	I	12137 - 36867	350	4143.21	I	154 - 24283
85	4043.16	I	15282 - 40009	50	4146.00	I	11044 - 35157
160	4044.10	I	13146 - 37866	160	4147.19	I	11525 - 35631
130	4044.71	I	13515 - 38232	85	4148.74	I	8827 - 32924
170	4049.76	I	13146 - 37832	870	4150.12	I	
170	4051.52	I	9329 - 34004	120	4152.04	I	695 - 24773
35	4056.94	I	12982 - 37625	4400	4152.58	I	695 - 24770

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	4156.68	II	16053 - 40104	290	4270.69	I	9043 - 32452
170	4158.01	I	12137 - 36180	35	4272.97	I	10923 - 34319
50	4160.80	I	2805 - 26832	29	4273.36	I	12102 - 35496
75	4161.25	I	13515 - 37540	75	4274.69	I	8827 - 32214
50	4162.81	I	10238 - 34253	130	4277.50	I	154 - 23526
870	4163.47	I	2154 - 26166	75	4279.50	I	8705 - 32066
4400	4163.66	I	154 - 24165	40	4279.71	I	12137 - 35496
4000	4164.66	I	392 - 24397	160	4280.60	I	5298 - 28653
85	4165.85	I	12018 - 36016	75	4286.22	I	12692 - 36016
3500	4168.13	I	0 - 23985	400	4286.99	I	695 - 24015
170	4169.57	I	12358 - 36334	190	4289.44	I	5965 - 29272
120	4173.95	I	18036 - 41987	140	4291.19	I	8411 - 31708
85	4174.34	I	8705 - 32654	75	4292.04	I	392 - 23684
50	4177.44	I	10238 - 34169	140	4292.48	I	9043 - 32333
85	4179.76	I	12358 - 36276	110	4295.62	I	12358 - 35631
85	4181.34	I	11248 - 35157	120	4296.16	I	
310	4184.44	I	392 - 24283	580	4299.60	I	5298 - 28549
75	4186.10	I	13405 - 37287	580	4300.99	I	5965 - 29209
60	4189.99	I	18036 - 41896	29	4303.88	I	8705 - 31934
85	4190.65	I	9043 - 32899	75	4306.28	I	9439 - 32654
1200	4190.88	I	1050 - 24905	40	4308.12	I	9043 - 32249
870	4192.07	I	695 - 24543	75	4308.69	I	8705 - 31908
60	4193.83	I	8411 - 32249	120	4309.56	I	12982 - 36180
870	4195.09	I	154 - 23985	390	4311.27	I	13146 - 36334
1300	4195.66	I	8827 - 32654		4311.39	I	13146 - 36334
50	4196.95	I	11525 - 35345	65	4311.70	I	1587 - 24773
50	4197.61	I	16919 - 40735	120	4312.45	I	392 - 23574
310	4198.51	I	695 - 24507	40	4313.88	I	16829 - 40003
75	4198.85	I	11044 - 34854	40	4316.48	I	12018 - 35179
35	4200.99	I	5965 - 29763	40	4318.01	I	10238 - 33390
350	4201.52	I	11044 - 34838	29	4323.47	I	9329 - 32452
65	4203.41	I	13405 - 37188	350	4326.33	I	9498 - 32605
65	4204.32	I	8827 - 32605	120	4327.38	I	8705 - 31808
870	4205.31	I	392 - 24165	95	4328.43	I	9043 - 32140
85	4206.13	I	12692 - 36460	75	4329.73	I	154 - 23244
150	4208.16	I	154 - 23911	390	4331.37	I	4998 - 28079
85	4212.04	I	12982 - 36717	29	4337.56	I	9498 - 32546
85	4212.53	I	10923 - 34655	29	4338.70	I	12137 - 35179
85	4213.26	I	12288 - 36016	140	4342.82	I	12137 - 35157
40	4213.46	I	16829 - 40555	95	4345.32	I	0 - 23007
350	4214.73	I	1050 - 24770	40	4346.12	I	8705 - 31708
420	4217.94	I	695 - 24397	40	4347.31	I	13515 - 36511
40	4222.68	I	9329 - 33004	140	4348.65	I	695 - 23684
75	4226.22	I	8411 - 32066	110	4349.03	I	12358 - 35345
40	4227.51	I	9438 - 33087	40	4350.30	I	8827 - 31808
420	4229.15	I	9498 - 33136	290	4351.57	I	8827 - 31801
170	4229.83	I	2805 - 26440	60	4353.27	I	1050 - 24015
130	4230.32	I	12288 - 35920	29	4354.19	I	11044 - 34004
170	4231.95	I	392 - 24015	29	4356.85	I	12982 - 35928
75	4237.81	I	11248 - 34838	65	4359.85	I	9043 - 31973
85	4241.45	I	9329 - 32899	35	4361.65	I	4998 - 27919
120	4242.63	I	18332 - 41896	40	4367.97	II	13666 - 36553
130	4246.30	I	8705 - 32249	210	4368.43	I	9329 - 32214
29	4248.66	I	154 - 23684	24	4369.62	I	695 - 23574
130	4249.46	I	0 - 23526	60	4370.36	I	2805 - 25680
160	4252.97	I	9498 - 33004	40	4374.78	I	391 - 23244
140	4253.70	I	9043 - 32546	29	4375.25	I	10238 - 33087
130	4254.69	I	8411 - 31908	140	4377.96	I	12018 - 34854
250	4255.44	I	10923 - 34416	65	4379.52	I	9329 - 32156
40	4255.94	I		40	4381.13	I	13515 - 36334
85	4258.91	I	9329 - 32802	24	4382.49	I	12288 - 35100
85	4261.71	I	9043 - 32501	35	4382.84	I	1587 - 24397
770	4262.05	I	1050 - 24507	65	4384.86	I	12358 - 35157
420	4266.02	I	8705 - 32140	65	4387.74	I	4998 - 27783
85	4268.67	I	154 - 23574	130	4388.36	I	5298 - 28079

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
160	4392.69	I	9329 - 32088	480	4581.62	I	12503 - 34323
65	4397.04	I	12102 - 34838	75	4582.29	I	5965 - 27783
35	4400.35	I	16919 - 39638	24	4599.48	I	9439 - 31175
60	4400.83	I	12137 - 34854	95	4600.21	I	12503 - 34235
35	4402.05	I		19	4602.86	I	4998 - 26718
35	4406.55	I	5965 - 28653	1200	4606.77	I	2805 - 24507
330	4410.21	I	4998 - 27666	24	4608.58	I	13146 - 34838
95	4411.52	I	10238 - 32899	19	4610.69	I	10923 - 32605
24	4412.18	I	8827 - 31485	29	4612.12	I	11248 - 32924
29	4414.88	I	9043 - 31688	170	4616.17	I	1587 - 23244
24	4416.41	I	12018 - 34655	19	4627.48	I	
190	4419.44	I	5298 - 27919	450	4630.11	I	11525 - 33116
60	4419.83	I	2154 - 24773	65	4638.10	I	11248 - 32802
60	4420.45	I	2154 - 24770	26	4643.31	I	2154 - 23684
95	4420.64	I	392 - 23007	65	c 4643.68	I	11044 - 32573
29	4423.87	I	16829 - 39427	55	4646.95	I	18332 - 39846
95	4426.68	I	5965 - 28549	450	4648.95	I	1143 - 22647
95	4429.44	I	5965 - 28535	110	4649.27	I	
230	c 4437.22	I		35	4658.18	I	5965 - 27427
24	4437.90	I	17476 - 40003	450	4663.83	I	1587 - 23023
19	4440.43	I	12982 - 35496	26	4665.33	I	12288 - 33717
60	4441.81	I	9498 - 32005	340	4666.24	I	11248 - 32672
60	4445.85	I	1050 - 23537	240	4667.22	I	2154 - 23574
75	4446.17	I	13146 - 35631	35	4669.87	I	11044 - 32452
290	4447.18	I	5965 - 28445	580	4672.09	I	2805 - 24203
140	4456.80	I	1143 - 23574	35	4673.59	I	18036 - 39427
140	4457.42	I	1587 - 24015	530	4675.37	I	2154 - 23537
60	4458.12	I	13405 - 35829	110	4678.48	I	8411 - 29779
50	4460.20	I		26	4682.66	I	16672 - 38021
85	4460.42	I	13515 - 35928	320	4685.14	I	11044 - 32382
85	4464.15	I	2805 - 25200	65	4694.51	I	16981 - 38277
24	4465.92	I	10238 - 32623	65	4695.47	I	10923 - 32214
24	4466.42	I	1143 - 23526	90	4697.47	I	8705 - 29987
50	4469.32	I	5298 - 27666	130	c 4706.14	I	
140	4469.71	I	12288 - 34655	260	4708.29	I	10923 - 32156
140	4471.29	I	9329 - 31688	35	4713.05	I	8411 - 29623
140	4472.53	I	2154 - 24507	150	4713.50	I	2805 - 24015
29	4475.28	I		65	4715.83	I	16672 - 37871
29	4481.44	I	10238 - 32546	65	4718.02	I	
19	4492.96	II	21040 - 43290	55	4723.80	I	17937 - 39101
50	4494.57	I	5965 - 28208	55	4727.33	I	11525 - 32672
19	4497.25	I	8827 - 31057	65	4730.31	I	11248 - 32382
75	4499.80	I	12102 - 34319	80	4733.48	I	392 - 21512
150	4503.04	I	5298 - 27499	110	c 4733.89	I	9043 - 30162
24	4503.42	I	13146 - 35345	55	4735.33	I	11044 - 32156
50	4508.41	I	12982 - 35157	65	4736.49	I	17476 - 38583
75	4511.09	I	17476 - 39638	65	4740.61	I	5298 - 26386
19	4512.13	I	9329 - 31485	65	4743.84	I	8705 - 29779
530	4523.41	I	1143 - 23244	80	4744.62	I	12358 - 33428
75	4524.12	I	1587 - 23684	220	c 4749.70	I	11525 - 32573
24	4527.65	II	12806 - 34886	65	4751.42	I	16981 - 38021
24	4529.42	I	11318 - 33390	26	4755.32	I	13146 - 34169
40	4542.80	I	0 - 22007	65	4766.81	I	17304 - 38277
480	4546.82	I	1587 - 23574	35	4771.85	I	9329 - 30279
24	4547.85	I	9043 - 31026	80	4773.25	I	9043 - 29987
85	4553.84	I	5965 - 27919	21	4777.62	I	12503 - 33428
40	4556.84	I	4998 - 26937	26	4785.70	I	12982 - 33872
19	4559.42	I		65	4789.96	II	19690 - 40561
370	4564.53	I	12102 - 34004	26	4802.45	I	695 - 21512
24	4570.95	I	12982 - 34854	40	4807.06	I	12102 - 32899
720	4573.08	I	2154 - 24015	55	4809.37	I	12137 - 32924
19	4574.33	I	11044 - 32899	80	c 4810.60	I	9498 - 30279
75	4574.84	I	154 - 22007	110	4816.38	I	11248 - 32005
40	4575.37	I	10238 - 32088	55	4829.30	I	17937 - 38638
24	4579.45	II	13690 - 35521	65	4833.37	I	154 - 20838



*Niobium — all observed lines — Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
26	4837.62	I	18435 - 39101	75	5253.03	I	11248 - 30279
26	4837.99	I	9498 - 30162	85	5253.93	I	8827 - 27855
55	4842.15	I	12358 - 33004	50	5269.92	I	8827 - 27797
55	4845.17	I	12503 - 33136	270	5271.53	I	1143 - 20107
110	4848.37	I	9498 - 30117	25	5272.48	I	8705 - 27666
80	4868.99	I	18876 - 39409	130	5276.20	I	9498 - 28445
90	4890.75	I	11044 - 31485	29	5279.43	I	9498 - 28434
55	4892.50	I	12018 - 32452	50	5285.26	I	
26	4895.58	I	5965 - 26386	35	5296.34	I	14211 - 33087
65	4900.79	I	12102 - 32501	50	5315.55	I	5965 - 24773
65	4904.53	I	0 - 20384	17	5317.01	I	11044 - 29846
80	4910.95	I	13515 - 33872	250	5318.60	I	1587 - 20384
50	4928.98	I	13146 - 33428	50	5319.49	I	8705 - 27499
29	4941.52	I	12102 - 32333	75	5334.87	I	9043 - 27783
29	4953.13	I	9439 - 29623	25	5336.81	I	695 - 19428
85	4965.37	I	10923 - 31057	50	5340.80	I	11044 - 29763
130	4967.78	I	13012 - 33136	25	5343.58	I	
50	4971.93	I	0 - 20107	460	5344.17	I	2805 - 21512
110	4973.14	I	12503 - 32605	340	5350.74	I	2154 - 20838
50	4975.14	I	12358 - 32452	40	5353.28	I	20734 - 39409
190	4988.97	I	695 - 20734	25	5355.31	I	12358 - 31026
65	4994.30	I		40	5355.70	I	11525 - 30191
75	4997.88	I	12137 - 32140	29	5359.19	I	8705 - 27360
85	5000.95	I	13146 - 33136	17	5362.01	I	392 - 19037
65	5002.25	I	12102 - 32088	40	5375.27	I	11248 - 29846
40	5013.27	I	12982 - 32924	40	5381.34	I	5965 - 24543
230	5017.75	I	392 - 20316	17	5388.30	I	9043 - 27597
40	5019.51	I	12982 - 32899	21	5395.86	I	4998 - 23526
150	5026.36	I	12018 - 31908	29	5396.33	I	8411 - 26937
40	5030.13	I	13515 - 33390	29	5411.24	I	11044 - 29519
210	5039.04	I	154 - 19994	21	5416.30	I	11318 - 29776
40	5047.96	I	14899 - 34704	65	5422.44	I	10923 - 29360
170	5058.01	I	0 - 19765	21	5431.26	I	1587 - 19994
65	5059.35	I	12692 - 32452	110	5437.27	I	5298 - 23684
130	5065.25	I	695 - 20432	19	5448.31	I	10923 - 29272
40	5077.40	I	12018 - 31708	19	5456.19	I	20316 - 38638
750	5078.96	I	1050 - 20734	40	5458.04	I	9043 - 27360
40	5094.41	I	0 - 19624	19	5468.10	I	19994 - 38277
420	5095.30	I	695 - 20316	40	5481.00	I	18036 - 36276
170	5100.16	I	392 - 19994	13	5483.09	I	
170	5120.30	I	392 - 19917	19	5483.49	I	8705 - 26937
85	5121.80	I	12982 - 32501	13	5491.06	I	20432 - 38638
85	5127.66	I	10126 - 29623	17	5499.53	I	1587 - 19765
40	5133.34	I	5298 - 24773	40	5504.58	I	2154 - 20316
210	5134.75	I	154 - 19624	17	5509.12	I	13405 - 31551
75	5140.58	I	12692 - 32140	35	5512.82	I	
75	5147.54	I	15282 - 34704	17	5517.39	I	
40	5150.64	I	11248 - 30658	50	5523.57	I	9498 - 27597
75	5152.63	I	9043 - 28445	25	5541.47	I	10238 - 28278
250	5160.33	I	392 - 19765	85	5551.35	I	4998 - 23007
250	5164.38	I	2154 - 21512	29	5563.00	I	10238 - 28208
230	5180.31	I	695 - 19994	17	5571.44	I	18332 - 36276
110	5186.98	I	154 - 19428	35	5576.16	I	2805 - 20734
190	5189.20	I	1050 - 20316	35	5578.29	I	12358 - 30279
170	5193.08	I	1587 - 20838	50	5586.97	I	1143 - 19037
150	5195.84	I	1143 - 20384	17	5590.95	I	
65	5203.22	I	8705 - 27919	13	5594.89	I	17476 - 35345
35	5205.13	I	9329 - 28535	17	5599.59	I	9043 - 26897
85	5219.10	I	9498 - 28653	40	5603.52	I	1587 - 19428
65	5225.16	I	11525 - 30658	13	5603.93	I	2154 - 19994
150	5232.81	I	9329 - 28434	25	5628.26	I	2154 - 19917
85	5237.43	I	8411 - 27499	65	5629.17	I	12358 - 30117
29	5240.39	I	8705 - 27783	35	5635.42	I	
150	5251.62	I	0 - 19037	170	5642.11	I	5965 - 23684
	5251.81	I	392 - 19428	35	5645.30	I	5298 - 23007

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	5654.14	I	10238 - 27919	65	6544.61	I	9498 - 24773
130	5664.71	I	1143 - 18791	15	6574.73	I	8705 - 23911
170	5665.63	I	13012 - 30658	19	6591.00	I	
17	5666.86	I	15282 - 32924	19	6606.16	I	
65	5671.02	I	11345 - 28973	19	6607.28	I	13405 - 28535
85	5671.91	I	12137 - 29763	35	6614.15	I	8411 - 23526
25	5677.47	I	5965 - 23574	19	6626.98	I	5298 - 20384
25	5693.09	I	5965 - 23526	210	6660.84	I	9498 - 24507
35	5697.90	I	13629 - 31175	150	6677.33	I	9043 - 24015
	5698.03	I	10238 - 27783	65	6701.20	I	13515 - 28434
40	5706.16	I	15282 - 32802	130	6723.62	I	8705 - 23574
85	5706.48	I	8411 - 25930	75	6739.88	I	8411 - 23244
29	5709.33	I	13515 - 31026	25	6795.31	I	
17	5715.59	I	12288 - 29779	85	6828.11	I	9043 - 23684
65	5716.35	I	12358 - 29846	25	6849.35	I	8411 - 23007
25	5725.66	I	18036 - 35496	19	6870.92	I	
130	5729.19	I	1587 - 19037	40	6876.36	I	8705 - 23244
21	5737.36	I		25	6902.89	I	9043 - 23526
13	5738.20	I		35	6908.07	I	9439 - 23911
85	5751.44	I	12137 - 29519	40	6918.32	I	13405 - 27855
110	5760.34	I	8705 - 26061	17	6946.07	I	13405 - 27797
65	5764.99	I	12018 - 29360	17	6972.49	I	14211 - 28549
29	5771.08	I	15282 - 32605	25	6986.09	I	14899 - 29209
50	5776.07	I	11345 - 28653	85	6990.32	I	8705 - 23007
17	5780.34	I	12692 - 29987	17	6996.11	I	13629 - 27919
85	5787.54	I	2154 - 19428	21	7023.48	I	14211 - 28445
17	5789.79	I	13012 - 30279	17	7038.04	I	12692 - 26897
50	5794.24	I	12018 - 29272	190	7046.81	I	9498 - 23684
50	5804.03	I	8705 - 25930	8	7066.41	I	12018 - 26166
29	5815.33	I	12018 - 29209	8	7075.23	I	5298 - 19428
110	5819.43	I	13012 - 30191	40	7098.94	I	12358 - 26440
35	5820.62	I	16829 - 34004	17	7102.01	I	9498 - 23574
75	5834.90	I	13146 - 30279	19	7119.31	I	12018 - 26061
25	5838.15	I	11318 - 28442	15	7122.95	I	
130	5838.64	I	9043 - 26166	35	7126.17	I	12137 - 26166
50	5842.47	I	2805 - 19917	17	7130.06	I	12692 - 26713
17	5846.09	I	11345 - 28445	130	7159.43	I	9043 - 23007
65	5866.47	I	5965 - 23007	17	7191.37	I	
35	5874.70	I	9043 - 26061	19	7208.94	I	14211 - 28079
17	5877.79	I	4998 - 22007	50	7252.35	I	10126 - 23911
40	5893.44	I	14211 - 31175	15	7274.81	I	15467 - 29209
190	5900.62	I	9498 - 26440	13	7317.03	I	24905 - 38568
40	5903.80	I	11345 - 28278	17	7323.92	I	14899 - 28549
29	5927.41	I	15467 - 32333	29	7328.38	I	12288 - 25930
40	5934.16	I	17476 - 34323	65	7353.16	I	8411 - 22007
40	5957.70	I	12982 - 29763	190	7372.50	I	11345 - 24905
150	5983.22	I	5298 - 22007	13	7419.83	I	12692 - 26166
65	5986.08	I	13146 - 29846	15	7436.02	I	
85	5997.93	I	9498 - 26166	19	7478.20	I	12692 - 26061
50	6029.75	I	12692 - 29272	65	7515.93	I	8705 - 22007
50	6031.84	I	15439 - 32013	29	7519.77	I	13146 - 26440
50	6045.50	I	12982 - 29519	170	7574.58	I	11345 - 24543
25	6048.72	I	17476 - 34004	17	7583.21	I	12982 - 26166
29	6056.65	I	15467 - 31973	13	7639.81	I	
29	6107.71	I	15439 - 31808	13	7647.71	I	24770 - 37842
40	6142.51	I	14899 - 31175	25	7703.33	I	25200 - 38178
50	6148.13	I	13515 - 29776	75	7726.68	I	11345 - 24283
50	6164.32	I	13405 - 29623	25	7757.31	I	25680 - 38568
29	6213.06	I	15461 - 31551	6	7787.11	I	
75	6221.96	I	8705 - 24773	13	7873.41	I	14899 - 27597
40	6251.76	I	18332 - 34323	35	7885.31	I	11525 - 24203
21	6260.77	I	18036 - 34004	25	7938.89	I	11318 - 23911
85	6430.46	I	5965 - 21512	8	7954.76	I	9439 - 22007
50	6433.22	I	5298 - 20838	40	8135.20	I	11248 - 23537
17	6497.84	I	4998 - 20384	13	8240.00	I	8705 - 20838

*Niobium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
29 cw	8320.93	I	9498 - 21512	17 c	8560.54	I	8705 - 20384
29	8346.08	I	11044 - 23023	17	8575.87	I	12358 - 24015
10	8350.04	I	8411 - 20384	21 c	8697.55	I	13012 - 24507
17	8439.77	I	12358 - 24203				
17 cw	8475.98	I	9043 - 20838	21	8740.96	I	12137 - 23574
				21	8767.97	I	8705 - 20107
25	8526.99	I	10923 - 22647	29 cw	8815.56	I	9498 - 20838
13 c	8547.25	I	8411 - 20107	35	8905.78	I	12018 - 23244

# Osmium

$$\text{Os, } Z = 76, M = 190.2, \text{ Ratio } \frac{\text{Os}}{\text{Cu}} = 2.993$$

Os I Normal state of valence electrons  $5d^6 6s^2 \text{ } ^5D_4 = 0$ . I.P. = 69000  $\text{cm}^{-1}$ .

Os II Normal state of valence electrons  $5d^6 6s \text{ } ^6D_{4/2} = 0$ .

## References

Wavelengths:

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Th. A. M. van Kleef, Proc. Koninkl. Ned. Akad. Wetenschap. B. **63**, 501-601 (1960).

Classification:

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G. G. Gluck, Y. Bordarier, J. Bauche, and Th. A. M. van Kleef, Physica **30**, 2068 (1964).

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## Strong lines of osmium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
29000	2018.14	I	0 - 49534	7800	2067.21	II	3593 - 51952
29000	2020.26			7600	3301.56	I	0 - 30280
26000	2045.36	I	0 - 48875	7200	2076.95	I	0 - 48132
18000	2034.44	I	0 - 49138	7200	2078.09		
17000	2010.15	I	0 - 49731	6600	2119.79		
14000	2022.76	I	2740 - 52162	6000	2097.60	I	5144 - 52802
14000	2028.23	I	4159 - 53447	5300	2100.63	I	2740 - 50330
14000	2079.97	I	0 - 48062	5300	2137.11	I	4159 - 50937
13000	2003.73	I	4159 - 54050	5100	2838.63	I	5144 - 40362
13000	2061.69	I	2740 - 51229	4900	4260.85	I	0 - 23463
9600	2001.45	I	0 - 49947	4900	4420.47	I	0 - 22616
9600	2909.06	I	0 - 34365	4800	2117.96	I	0 - 47200
9000	2004.78			4500	2488.55	I	5144 - 45316
8600	2058.69	I	0 - 48559	4400	3018.04	I	0 - 33124
	2058.78	I	4159 - 52716	4200	2070.67	II	3929 - 52206
8600	3058.66	I	0 - 32685	3800	2637.13	I	0 - 37909
7800	2048.28	I	2740 - 51546	3700	3752.52	I	2740 - 29382
7800	2049.42	I	4159 - 52938				

*Osmium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
9600	2001.45	I	0 - 49947	430	2347.38	I	8743 - 51329
13000	2003.73	I	4159 - 54050	230	2350.23	II	5592 - 48128
9000	2004.78			60	2351.55	I	10166 - 52678
17000	2010.15	I	0 - 49731	60	2351.72	I	11378 - 53887
29000	2018.14	I	0 - 49534	360	2352.99	I	8743 - 51229
29000	2020.26			120	2355.28	II	3929 - 46374
14000	2022.76	I	2740 - 52162	240	2356.92	I	
14000	2028.23	I	4159 - 53447	240	2357.25	I	8743 - 51152
18000	2034.44	I	0 - 49138	310	2362.41	I	0 - 42317
26000	2045.36	I	0 - 48875	900	2362.77	I	0 - 42310
7800	2048.28	I	2740 - 51546	190	2363.33	I	8743 - 51043
7800	2049.42	I	4159 - 52938	500	2367.35	II	3929 - 46157
8600	2058.69	I	0 - 48559	290	2369.24	I	8743 - 50937
	2058.78	I	4159 - 52716	500	2370.70	I	4159 - 46328
13000	2061.69	I	2740 - 51229	480	2371.18	I	8743 - 50903
7800	2067.21	II	3593 - 51952	85	2374.33	I	4159 - 46264
4200	2070.67	II	3929 - 52206	95	2374.51	I	11031 - 53131
7200	2076.95	I	0 - 48132	95	2375.06	II	
7200	2078.09			2600	2377.03	I	5144 - 47200
14000	2079.97	I	0 - 48062	260	2377.61	I	11378 - 53424
2900	2082.54	I	4159 - 52162	95	2378.14	I	5766 - 47802
2900	2089.03	I	0 - 47854	95	2378.74	I	12774 - 54800
2900	2089.21	I	2740 - 50589	900	2379.39	I	5144 - 47158
6000	2097.60	I	5144 - 52802	180	2379.64	I	4159 - 46170
5300	2100.63	I	2740 - 50330	180	2379.84		
2100	2117.66	I	2740 - 49947	95	2380.82	I	2740 - 44730
4800	2117.96	I	0 - 47200	180	2382.46	I	11378 - 53338
6600	2119.79			240	2384.62	I	2740 - 44663
1900	2123.84	I	4159 - 51229	1700	2387.29	I	0 - 41876
5300	2137.11	I	4159 - 50937	330	2394.29	I	11378 - 53131
2400	2149.97			290	2395.39	I	2740 - 44475
2600	2154.59	I	2740 - 49138	1100	2395.88	I	0 - 41726
1300	2157.84	I	0 - 46328	220	2396.78	I	12774 - 54484
1200	2158.53	I	2740 - 49054	60	2397.61	I	11378 - 53073
2400	2161.00			110	2398.18	I	11031 - 52716
3100	2166.90	I	4159 - 50294	960	2401.13	I	8743 - 50377
1100	2167.75	I	0 - 46117	260	2402.23	I	4159 - 45775
2100	2171.65	I	2740 - 48773	200	2403.54	I	10166 - 51759
960	2184.68	I	0 - 45759	330	2403.85	I	8743 - 50330
840	2194.39	II	3593 - 49149	95	2405.08	II	
760	2202.49	I	0 - 45389	290	2405.45	I	11378 - 52938
600	2227.98	I	0 - 44870	200	2405.96	I	8743 - 50294
1100	2234.61	I	2740 - 47477	360	2408.67	I	11031 - 52535
1300	2252.15	I	8743 - 53131	240	2410.98	I	13020 - 54484
2000	2255.85	II	0 - 44315	95	2411.90		
1400	2264.60	I	4159 - 48303	95	2414.10	I	8743 - 50154
360	2268.28	I	2740 - 46813	290	2414.52	I	2740 - 44144
960	2270.17	I	2740 - 46776	180	2415.32	I	14091 - 55481
1400	2282.26	II	0 - 43802	530	2417.99	I	4159 - 45503
840	2283.67	I	4159 - 47935	85	2418.35	I	11378 - 52716
570	2289.32	I	4159 - 47828	530	2418.53	I	2740 - 44075
380	2297.31	I	0 - 43516	50	2419.63		
660	2308.31	I	5144 - 48452	95	2420.02	II	13137 - 54445
190	2313.75	II	5592 - 48799	50	2421.15	I	12774 - 54064
550	2320.18	I		85	2421.86	I	14091 - 55369
310	2323.98	I		85	2421.94		
660	2324.24	I	0 - 43011	200	2423.07	II	7892 - 49149
170	2325.51	I	5144 - 48132	70	2424.02	II	13204 - 54445
330	2326.99	I	6093 - 49054	50	2424.19	I	12774 - 54013
310	2334.56	I	2740 - 45562	500	2424.56	I	0 - 41232
720	2336.80	II	3593 - 46374	1400	2424.97	I	0 - 41225
430	2338.63	I	0 - 42747	60	2426.19	I	8743 - 49947
290	2340.69	I	5144 - 47854	240	2426.81	I	11031 - 52224
430	2343.74	I	4159 - 46813	70	2427.90	II	13204 - 54379
260	2345.75	I	4159 - 46776	50	2429.67	I	10166 - 51311

*Osmium—all observed lines—Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
380	2431.19	I	5144 - 46264	660	2515.04	I	5144 - 44893
380	2431.61	I	11378 - 52491	35	2517.61	I	13365 - 53073
140	2435.51	I	5766 - 46813	500	2517.92	I	4159 - 43863
140	2435.65	I	13020 - 54064	660	2518.44	I	5144 - 44839
30	2436.51	I	13020 - 54050	200	2519.29	I	2740 - 42422
70	2437.73			330	2519.79	I	
40	2440.68	I	11378 - 52338	70	2524.79	I	4159 - 43755
85	2442.00	I	13365 - 54302	170	2526.01	I	2740 - 42317
70	2445.88	I	12774 - 53647	70	2526.83	I	12774 - 52338
360	2446.02	I	2740 - 43611	130	2527.09	I	8743 - 48303
35	2449.88			200	2532.44	I	14852 - 54328
900	2450.74	I	8743 - 49534	120	2534.17	I	10166 - 49615
70	2451.19	I	11378 - 52162	780	2538.00	II	0 - 39390
530	2451.73	I	2740 - 43516	240	2538.10	I	12774 - 52162
60	2453.29	I	5766 - 46515	130	2539.73	I	14091 - 53454
530	2453.90	I	8743 - 49483	170	2540.14	I	4159 - 43516
110	2454.91	II	3593 - 44315	180	2540.74	I	11031 - 50377
530	2456.46	I	2740 - 43437	70	2541.65	I	14091 - 53424
70	2457.16	I	13365 - 54050	1000	2542.51	I	8743 - 48062
70	2458.76			130	2543.80	I	11031 - 50330
110	2459.84	I	5766 - 46407	160	2546.17	I	11031 - 50294
1800	2461.42	I	5144 - 45759	140	2547.70	I	13365 - 52604
110	2464.00			160	2548.10	I	14339 - 53572
180	2464.50	I	12774 - 53338	30	2548.83	II	17569 - 56791
70	2465.16			310	2554.46	I	2740 - 41876
110	2468.09	I	10166 - 50671	160	2555.11	I	11378 - 50503
110	2468.90	II	11460 - 51952	120	2555.27	I	11031 - 50154
60	2470.82	I	16212 - 56673	160	2555.80	I	14339 - 53454
290	2472.28	I	5766 - 46202	110	2556.08	I	8743 - 47854
290	2474.78	I	8743 - 49138	95	2557.77	I	8743 - 47828
110	2475.69	I	11378 - 51759	120	2558.09	I	15223 - 54302
900	2476.84	I	0 - 40362	50	2560.19	I	14848 - 53896
30	2480.71	I	11031 - 51329	50	2560.47	I	14852 - 53896
180	2481.79	I	14852 - 55134	160	2562.66	I	13365 - 52375
360	2482.43	I	2740 - 43011	190	2563.16	II	13204 - 52206
35	2484.04	I	5144 - 45389	120	2564.37	I	12774 - 51759
60	2485.32	I	15391 - 55615	130	2565.17	I	10166 - 49138
530	2486.24	II	3593 - 43802	60	2565.72	I	5766 - 44730
4500	2488.55	I	5144 - 45316	600	2566.49	I	11378 - 50330
70	2489.04	I	10166 - 50330	290	2566.88	I	10166 - 49112
290	2491.02	I	8743 - 48875	480	2568.83	I	11031 - 49947
290	2491.69	I	11031 - 51152	75	2571.14	I	12774 - 51656
360	2492.42	I	6093 - 46202	340	2571.78	I	8743 - 47615
180	2493.62	I	15391 - 55481	75	2572.48		
60	2493.83	I	0 - 40087	75	2573.09	I	4159 - 43011
70	2496.45			40	2573.48	I	14091 - 52938
60	2496.61	I	14852 - 54895	27	2574.74	I	15223 - 54050
2600	2498.41	I	8743 - 48756	85	2578.16	I	11378 - 50154
330	2499.92	I	14339 - 54328	150	2578.32	II	15606 - 54379
95	2500.72			130	2580.03	II	13204 - 51952
95	2500.91	I	14091 - 54064	360	2581.05	I	5144 - 43876
60	2501.84	I	14091 - 54050	740	2581.96	I	5144 - 43863
330	2502.29	I	11378 - 51329	110	2582.62	I	5766 - 44475
35	2503.16			130	2586.08		
95	2503.67			130	2587.49	I	13020 - 51656
500	2504.39	I	2740 - 42658	40	2588.26	I	14091 - 52716
260	2504.51	I	4159 - 44075	85	2588.44	I	15391 - 54013
85	2506.38			85	2589.39	I	10166 - 48774
85	2506.66			55	2589.51	I	14848 - 53454
35	2507.18	II	3929 - 43802	1000	2590.76	I	4159 - 42747
170	2508.61	I	11378 - 51229	200	2591.98	I	11378 - 49947
70	2509.71	II	17569 - 57403	30	2593.90	I	16212 - 54753
170	2509.94	I	12774 - 52604	150	2594.14	I	12774 - 51311
660	2512.87	I	8743 - 48526	170	2596.00	II	24466 - 62974
2400	2513.25	I	5144 - 44921	27	2596.37	I	11031 - 49534

Osmium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	2596.69	I	4159 - 42658	110	2682.19	I	11031 - 48303
150	2597.20	I	2740 - 41232	75	2684.36	I	16212 - 53454
	2597.29	I	14848 - 53338		2684.41		
130	2597.58	I	0 - 38486	110	2688.08	I	14852 - 52043
110	2599.13	I	14339 - 52802	110	2689.35	I	12774 - 49947
150	2599.91	I	11031 - 49482	2100	2689.82	I	5144 - 42310
110	2600.45	I	12774 - 51218	150	2692.70	I	14091 - 51218
65	2600.75	I		140	2694.52	I	11031 - 48132
95	2602.33	I	8743 - 47158	65	2694.75	I	12774 - 49873
65	2603.22			40	2696.61	I	4159 - 41232
65	2603.80	I	13365 - 51759	85	2697.24	I	18417 - 55481
190	2604.60	I	6093 - 44475	510	2699.59	I	2740 - 39772
40	2604.96	I	14339 - 52716	110	2700.75	I	8743 - 45759
210	2609.20	I	8743 - 47057	75	2702.83	I	13020 - 50007
380	2609.56	I	5766 - 44075	75	2704.45	I	13365 - 50330
400	2610.78	I	13365 - 51656	580	2706.70	I	2740 - 39675
110	2611.33	I	14848 - 53131	180	2707.42	I	11378 - 48302
470	2612.63	I	0 - 38264	110	2708.18		
1800	2613.06	I	5144 - 43402	190	2709.86	I	10166 - 47057
55	2614.06	I	10166 - 48409	3000	2714.64	I	0 - 36826
27	2614.50	I	11378 - 49615	580	2715.36	I	5766 - 42583
65	2615.96	I	12774 - 50990	150	2715.64	I	14339 - 51152
55	2617.18	I	13020 - 51218	65	2716.80	I	11031 - 47828
55	2619.28			110	2718.71	I	15391 - 52162
800	2619.94	I	4159 - 42317	110	2718.91	I	18417 - 55186
230	2620.62	I	2740 - 40888	1300	2720.04	I	2740 - 39494
530	2621.82	I	0 - 38130	850	2721.86	I	4159 - 40888
65	2623.61	I	11378 - 49482	65	2722.60		
65	2624.57	I	16212 - 54302	150	2727.94	I	10166 - 46813
380	2628.48	I	8743 - 46776	120	2728.27	I	2740 - 39383
27	2631.22	II	24981 - 62974	580	2730.61	I	5144 - 41754
110	2632.89	I	13020 - 50990	40	2731.36	II	15606 - 52206
65	2634.29	I	14852 - 52802	580	2732.80	I	5144 - 41726
65	2634.44	I	15391 - 53338	85	2736.39	I	5766 - 42300
3800	2637.13	I	0 - 37909	55	2738.33	I	13365 - 49873
65	2637.98	I	12774 - 50671	65	2738.46	I	15391 - 51897
27	2639.98	I	14848 - 52716	170	2740.32	I	14848 - 51329
65	2641.17	I	15223 - 53073	140	2740.61	I	18417 - 54895
170	2641.60	I	11031 - 48875	130	2740.75	I	11378 - 47854
85	2643.63	I	12774 - 50590	65	2741.38	I	11378 - 47845
1900	2644.11	I	0 - 37809	40	2742.69	I	11378 - 47828
340	2646.89	I	10166 - 47935	150	2747.91	I	14848 - 51229
380	2647.73	I	2740 - 40498	130	2748.86	I	15391 - 51759
380	2649.34	I	11378 - 49112	130	2749.18	I	12774 - 49138
65	2650.68	I	15223 - 52938	85	2751.15	I	12774 - 49112
150	2652.98	I	15391 - 53073	65	2753.72	I	14848 - 51152
150	2653.78	I	5766 - 43437	110	2755.59	I	12774 - 49054
65	2655.19	I	13020 - 50671	170	2757.81	I	13365 - 49615
55	2655.78	I	14848 - 52491	140	2758.82	I	11378 - 47615
490	2656.68	I	10166 - 47796	150	2761.08	I	6093 - 42300
1900	2658.60	I	5144 - 42747	690	2761.42	I	4159 - 40362
640	2659.83	I	8743 - 46328	470	2763.27	I	8743 - 44921
95	2660.92	I	13020 - 50590	150	2763.94	I	11031 - 47200
380	2661.18	I	4159 - 41726	340	2765.04	I	15391 - 51546
40	2661.93	I	12774 - 50330	65	2765.45	I	8743 - 44893
110	2662.55	I	15391 - 52938	130	2767.12	I	11031 - 47158
110	2663.22	I	12774 - 50312	160	2769.88	I	13020 - 49112
40	2664.29	II	25452 - 62974	110	2770.10	I	14848 - 50937
120	2665.99			960	2770.71	I	5144 - 41225
120	2666.21	I	11031 - 48526	40	2771.04	I	19109 - 55186
150	2669.53	I	10166 - 47615	120	2773.07	I	14852 - 50903
580	2674.57	I	11378 - 48756	120	2774.02	I	14339 - 50377
400	2674.88	I	10166 - 47540	110	2774.38	I	13020 - 49054
55	2679.38	I	15391 - 52702	110	2774.90	I	11031 - 47057
75	2679.74	I	13365 - 50671	300	2776.91	I	2740 - 38741

Osmium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	2778.57	I	21124 - 57103	30	2880.20	II	17242 - 51952
740	2782.55	I	4159 - 40087	30	2883.94	I	14091 - 48756
40	2783.88	II	7892 - 43802	85	2884.41	I	8743 - 43402
40	2785.04			21	2886.06	I	19411 - 54050
640	2786.31	I	5144 - 41023	40	2886.50	I	14848 - 49482
130	2786.80	I	2740 - 38614	40	2890.85	I	4159 - 38741
65	2790.90	I	15223 - 51043	55	2891.83	I	25013 - 59583
230	2793.99	I	11378 - 47158	85	2892.35	I	10166 - 44730
230	2794.19	I	14852 - 50630	95	2895.06	I	11031 - 45562
21	2796.11	I	13020 - 48774	260	2896.06	I	13020 - 47540
530	2796.73	I	2740 - 38486	65	2901.32	I	13020 - 47477
35	2799.53			65	2903.07	I	18902 - 53338
95	2801.93	I	11378 - 47057	130	2903.21	I	14091 - 48526
320	2804.07	I	15391 - 51043	190	2905.73	I	6093 - 40498
2800	2806.91	I	0 - 35616	110	2905.97	I	24223 - 58625
40	2807.48	I	10166 - 45775	30	2908.03	I	16212 - 50590
40	2807.80			9600	2909.06	I	0 - 34365
30	2808.24	I	15391 - 50990	110	2909.67	I	11031 - 45389
470	2808.94	I	2740 - 38331	35	2911.34	I	19109 - 53447
21	2811.56	I		2100	2912.33	I	4159 - 38486
420	2813.84	I	14848 - 50377	140	2913.84	I	10166 - 44475
740	2814.20	I	2740 - 38264	75	2914.71	I	18417 - 52716
40	2814.84	I	4159 - 39675	530	2917.26	I	8743 - 43011
40	2815.27	I	13365 - 48875	130	2917.83	I	5144 - 39406
300	2815.78	I	2740 - 38244	2100	2919.79	I	15223 - 49461
40	2817.51	I	14848 - 50330	55	2921.07	I	15391 - 49615
140	2820.18	I	15223 - 50671	35	2923.18		
95	2820.56	I	14091 - 49534	110	2924.49	I	11378 - 45562
190	2821.25	I	11378 - 46813	40	2925.28	I	13365 - 47540
130	2824.17	I	11378 - 46776	300	2925.57	I	4159 - 38331
40	2824.67	I	14339 - 49731	360	2929.51	I	0 - 34126
21	2829.03	I	10166 - 45503	110	2930.19	I	18417 - 52535
420	2829.27	I	4159 - 39494	120	2930.57	I	22616 - 56729
21	2831.59	I	14848 - 50154	510	2931.28	I	4159 - 38264
130	2832.24	I	11031 - 46328	40	2932.45	I	15391 - 49482
230	2837.42	I	11031 - 46264	40	2933.98	I	18301 - 52375
470	2838.17	I	4159 - 39383	260	2934.64	I	2740 - 36806
5100	2838.63	I	5144 - 40362	27	2936.81	I	14091 - 48132
110	2840.44	I	14339 - 49534	130	2936.99	I	12774 - 46813
740	2841.60	I	2740 - 37922	40	2938.38	I	19109 - 53131
2300	2844.10	I	5144 - 40291	110	2942.20	I	10166 - 44144
85	2844.68	I	14339 - 49482	200	2942.85	I	4159 - 38130
420	2846.39	I	5766 - 40888	1100	2948.23	I	5766 - 39675
150	2846.55	I	8743 - 43863	1400	2949.53	I	2740 - 36634
420	2848.25	I	14848 - 49947	210	2949.81	I	11031 - 44921
95	2849.05	I	15223 - 50312		2949.90	I	15223 - 49112
40	2849.30	I	10166 - 45252	130	2952.34	I	11031 - 44893
1500	2850.76	I	2740 - 37809	85	2955.00	I	15223 - 49054
130	2855.34	I	8743 - 43755	95	2957.08	I	18417 - 52224
55	2857.54	I	18902 - 53887	55	2958.34	I	14339 - 48132
110	2860.06	I	16212 - 51166	300	2961.01	I	4159 - 37922
1500	2860.96	I	5144 - 40087	530	2962.15	I	4159 - 37909
35	2863.37	II	11460 - 46374	110	2962.33	I	15391 - 49138
40	2864.26	I	15391 - 50294	450	2964.06	I	5766 - 39494
85	2865.68	I	11378 - 46264	55	2964.62	I	15391 - 49112
40	2867.59			35	2965.10		
40	2869.39	I	12774 - 47615	30	2968.45	I	14848 - 48526
170	2872.40	I	0 - 34804	35	2970.69	I	15223 - 48875
170	2873.42	I	11378 - 46170	740	2970.97	I	4159 - 37809
95	2874.15	I	13020 - 47802	110	2972.25	I	25013 - 58648
40	2874.59	I	16212 - 50990	130	2973.06	I	18417 - 52043
360	2874.96	I	8743 - 43516	110	2975.34	I	14852 - 48452
190	2877.35	I	11031 - 45775	450	2977.64	I	8743 - 42317
300	2878.40	I	5766 - 40498	110	2978.21	I	8743 - 42310
35	2879.39	II	11654 - 46374	95	2978.53	I	21303 - 54868



Osmium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	2979.43	I	12774 - 46328	95	3118.12	I	22616 - 54677
75	2982.56			310	3118.33	I	11378 - 43437
510	2982.90	I	11378 - 44893	120	3129.23	I	17667 - 49615
340	2983.49			480	3131.12	I	14848 - 46776
130	2985.61	I	15391 - 48875	95	3140.31	I	15223 - 47057
65	2988.26	I	14848 - 48303	95	3152.07	I	11031 - 42747
110	2989.13	I	19893 - 53338	250	3152.67	I	10166 - 41876
150	2992.11	I	13365 - 46776	290	3153.61	I	12774 - 44475
110	2993.57	I	12774 - 46170	3100	3156.25	I	5144 - 36818
260	2997.65	I	10166 - 43516	250	3156.78	I	23463 - 55132
170	3003.48	I	11378 - 44663	130	3157.24	I	23463 - 55127
95	3007.90	I	18902 - 52138	120	3161.44	I	19049 - 50671
330	3013.07	I	2740 - 35920	120	3161.73	I	8743 - 40362
120	3015.65	I	13365 - 46515	85	3164.61	I	15223 - 46813
570	3017.25	I	8743 - 41876	310	3166.51	I	23463 - 55034
4400	3018.04	I	0 - 33124	120	3168.28	I	15223 - 46776
480	3019.38	I	5766 - 38876	120	3173.20	I	13365 - 44870
95	3020.86			180	3173.93	II	7892 - 39390
1100	3030.70	I	5144 - 38130	420	3178.06	I	4159 - 35616
120	3031.01	I	8743 - 41726	110	3180.12	I	19893 - 51329
75	3031.30	I	14848 - 47828	230	3181.88	I	14339 - 45758
95	3032.81	I	13365 - 46328	170	3182.57	I	14091 - 45503
2900	3040.90	I	2740 - 35616	230	3185.33	I	2740 - 34126
120	3042.74	II	11460 - 44315	310	3186.98	I	11378 - 42747
210	3043.50	I	5766 - 38614	55	3187.34	I	13365 - 44730
120	3043.64	I	10166 - 43011	310	3189.46	I	8742 - 40087
55	3044.07	I	16212 - 49054	310	3194.23	I	14091 - 45389
55	3044.41	I	13365 - 46202	190	3195.38	I	11031 - 42317
150	3044.91	I	11031 - 43863	120	3195.97	I	11378 - 42658
55	3045.32	I	23323 - 56151	150	3213.31	II	13204 - 44315
95	3049.04	I	12774 - 45562	1900	3232.06	I	4159 - 35090
230	3049.46	I	6093 - 38876	290	3238.63	I	5766 - 36634
210	3050.39	I	22616 - 55389	190	3241.04	I	11031 - 41876
120	3051.17	I	5144 - 37909	120	3248.00	I	13365 - 44144
95	3054.97	I	11031 - 43755	190	3254.91	I	14848 - 45562
150	3055.21	I	14091 - 46813	190	3256.92	I	11031 - 41726
8600	3058.66	I	0 - 32685	190	3260.30	I	8743 - 39406
290	3060.30	I	4159 - 36826	3100	3262.29	I	4159 - 34804
570	3062.19	I	4159 - 36806	380	3262.75	I	8743 - 39383
75	3066.12	I	15223 - 47828	3100	3267.94	I	0 - 30592
210	3069.94	I	5766 - 38331	620	3269.21	I	5766 - 36346
360	3074.08	I	6093 - 38614	190	3272.16	I	15223 - 45775
290	3074.96	I	22616 - 55127	530	3275.20	I	5766 - 36290
180	3077.06	I	8743 - 41232	330	3277.97	I	5766 - 36264
290	3077.44	I	11031 - 43516	65	3280.92		
1100	3077.72	I	8743 - 41225	65	3286.67	I	13020 - 43437
360	3078.11	I	5766 - 38244	190	3288.84	I	28372 - 58769
230	3078.38	I	4159 - 36634	1200	3290.26	I	2740 - 33124
150	3083.74	I	22616 - 55034	7600	3301.56	I	0 - 30280
55	3084.60	I	13365 - 45775	250	3306.23	I	12774 - 43011
55	3086.27	I	15223 - 47615	620	3310.91	I	11031 - 41225
230	3090.08	I	14848 - 47200	120	3315.42	I	5766 - 35920
140	3090.30	I	2740 - 35090	95	3315.69	I	13365 - 43516
120	3090.49	I	14852 - 47200	95	3316.69	I	18417 - 48559
55	3091.25	I	17667 - 50007	250	3324.33	I	13365 - 43437
270	3093.59	I	18902 - 51218	310	3327.42	I	14848 - 44893
310	3101.53	I	13020 - 45253	960	3336.15	I	4159 - 34126
95	3104.98	I	13365 - 45562	110	3351.74	I	6093 - 35920
360	3105.99	I	4159 - 36346	120	3353.91		
55	3107.38	I	14091 - 46264	230	3357.97	I	14091 - 43863
310	3108.98	I	5766 - 37922	250	3361.15	I	8743 - 38486
620	3109.38	I	6093 - 38244	190	3364.12	I	2740 - 32457
250	3111.09	I	10166 - 42300	120	3370.20	I	14091 - 43755
120	3114.81	I	12774 - 44870	960	3370.59	I	5144 - 34804
120	3116.48	I	14091 - 46170	160	3372.08	I	13365 - 43011

Osmium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
120	3378.68	I	19893 - 49482	120	3619.43	I	15391 - 43011
310	3384.00	I	12774 - 42317	65	3629.95	I	5144 - 32685
85	3384.60	I	14339 - 43876	450	3640.33	I	14848 - 42310
190	3385.94	I	12774 - 42300	50	3648.81	I	19760 - 47158
85	3386.14	I	14339 - 43863	230	3654.49	I	15391 - 42747
620	3387.84	I	10166 - 39675	330	3656.90	I	2740 - 30078
65	3394.59	I	19109 - 48559	120	3666.31	I	18902 - 46170
95	3395.72	I	15223 - 44663	480	3670.89	I	11031 - 38264
120	3401.17	I	23323 - 52716	120	3675.45	I	15223 - 42422
620	3401.86	I	8743 - 38130	85	3681.57	I	19109 - 46264
250	3402.51	I	0 - 29382	250	3689.06	I	11031 - 38130
95	3406.28	I	24223 - 53572	35	3698.83	I	14848 - 41876
95	3406.67	I	14091 - 43437	190	3703.25	I	17667 - 44663
120	3408.76	I	10166 - 39494	120	3706.56	I	23323 - 50294
120	3412.74	I	13365 - 42658	120	3709.14	I	11378 - 38331
120	3421.69	I	10166 - 39383	85	3712.84	I	15391 - 42317
65	3427.44	I	23323 - 52491	230	3713.73	I	15391 - 42310
150	3427.67	I	8743 - 37909	85	3718.34	I	11378 - 38264
65	3435.26	I	12774 - 41876	210	3719.52	I	14848 - 41726
95	3439.49	I	8743 - 37809	230	3720.13	I	8743 - 35616
250	3440.60	I	11031 - 40087	35	3721.96	I	24292 - 51152
120	3444.46	I	14852 - 43876	60	3729.22	I	17667 - 44475
160	3445.55	I	14848 - 43863	85	3730.73	I	14091 - 40888
310	3449.20	I	11378 - 40362	180	3746.47	I	14339 - 41023
65	3455.03	I	13365 - 42300	3700	3752.52	I	2740 - 29382
120	3458.38	I	14848 - 43755	100	3757.12	I	12774 - 39383
120	3465.44	I	17667 - 46515	130	3766.30	I	11378 - 37922
120	3478.53	I	17667 - 46407	120	3768.14	I	11378 - 37909
120	3482.11	I	10166 - 38876	120	3774.40	I	18902 - 45389
65	3482.23	I	11378 - 40087	110	3774.62	I	15391 - 41876
65	3487.25	I	14848 - 43516	120	3776.25	I	13020 - 39494
120	3487.46	I	19893 - 48559	290	3776.99	I	10166 - 36634
120	3490.33	I		2100	3782.20	I	4159 - 30592
95	3491.50	I	19893 - 48526	85	3789.11	I	14848 - 41232
50	3495.62	I		620	3790.14	I	14848 - 41225
160	3498.54	I	10166 - 38741	180	3790.73	I	14852 - 41225
250	3501.16	I	14848 - 43402	370	3793.91	I	18902 - 45252
620	3504.66	I	4159 - 32685	40	3794.66	I	28332 - 54677
440	3512.99	I	12774 - 41232	85	3795.67	I	24292 - 50630
95	3513.86	I	16212 - 44663	85	3827.14	I	22616 - 48737
65	3516.63	I	19049 - 47477	250	3836.06	I	8743 - 34804
310	3518.72	I	25602 - 54013	150	3840.30	I	29099 - 55132
120	3520.00	I	30591 - 58992	150	3841.29	I	25013 - 51039
480	3523.64	I	0 - 28372	80	3843.66	I	15223 - 41232
120	3526.04	I	11031 - 39383	190	3849.94	I	12774 - 38741
1200	3528.60	I	0 - 28332	230	3857.09	I	4159 - 30078
230	3530.06	I	10166 - 38186	230	3865.47	I	25275 - 51138
230	3532.80	I	4159 - 32457	730	3876.77	I	11031 - 36818
120	3533.41	I	15223 - 43516	250	3881.86	I	10166 - 35920
65	3541.91	I	14091 - 42317	40	3886.75	I	13020 - 38741
230	3542.71	I	14091 - 42310	40	3895.18	I	15223 - 40888
95	3555.97	I	12774 - 40888	140	3900.39	I	2740 - 28372
960	3559.79	I	8743 - 36826	190	3901.71	I	8743 - 34365
1200	3560.86	I	8743 - 36818	35	3907.65	I	14091 - 39675
120	3562.34	I	8743 - 36806	35	3911.81	I	12774 - 38331
310	3569.78	I	11378 - 39383	35	3918.97	I	27954 - 53464
120	3574.08	I	14339 - 42310	35	3922.03	I	12774 - 38264
65	3586.51	I	18902 - 46776	35	3925.10	I	12774 - 38244
120	3587.32	I	13020 - 40888	35	3926.77	I	18417 - 43876
65	3592.32	I	23323 - 51152	45	3928.41	I	11378 - 36826
620	3598.11	I	2740 - 30525	45	3928.54	I	5144 - 30592
190	3601.83	I	10166 - 37922	100	3930.00	I	14852 - 40291
95	3604.48	II	11654 - 39390	80	3931.52	I	11378 - 36806
65	3609.15	I	18417 - 46117	250	3938.59	I	8743 - 34126
250	3616.57	I	10166 - 37809	90	3939.57	I	13365 - 38741

*Osmium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	3949.78	I	13020 - 38331	55	4308.88	I	19109 - 42310
55	3952.77	I	14091 - 39383	560	4311.40	I	5144 - 28332
45	3955.37	I	15223 - 40498	110	4326.25	I	15223 - 38331
90	3960.51	I	24292 - 49534	340	4328.68	I	11031 - 34126
200	3961.02	I	14848 - 40087	100	4338.75	I	15223 - 38264
1000	3963.63	I	4159 - 29382	100	4351.53	I	18902 - 41876
100	3964.96	I	2740 - 27954	65	h 4354.46	I	10166 - 33124
150	3969.67	I	14852 - 40036	45	4357.98	I	15391 - 38331
110	h 3975.44	I	12774 - 37922	45	4358.14	I	30525 - 53464
730	3977.23	I	5144 - 30280	210	4365.67	I	13020 - 35920
45	3979.36	I	30280 - 55403	110	4370.66	I	15391 - 38264
100	3988.18	I	14339 - 39406	45	4376.90	I	37809 - 60649
40	3988.62	I	19411 - 44475	90	4391.08	I	19109 - 41876
40	3991.49	I	2740 - 27787	520	4394.86	I	11378 - 34126
45	3994.93	I	21303 - 46328	160	4397.26	I	14091 - 36826
40	3996.80	I	0 - 25013	55	4400.58	I	32685 - 55403
55	3998.93	I	19893 - 44893	160	4402.74	I	28332 - 51039
150	4003.48	I	15391 - 40362	55	4404.21	I	15223 - 37922
100	4004.02	I	11378 - 36346	40	4411.13	I	16212 - 38876
150	4005.16	I	18902 - 43863	4900	4420.47	I	0 - 22616
65	h 4015.04	I	13365 - 38264	100	4432.41	I	13365 - 35920
160	4018.26	I	13365 - 38244	290	4436.32	I	2740 - 25275
55	h 4029.32	I	30592 - 55403	50	4437.09	I	15391 - 37922
90	4032.92	I	23985 - 48773	100	4439.64	I	15391 - 37909
100	4037.84	I	5766 - 30525	40	4445.69	I	14339 - 36826
55	4038.64	I	19109 - 43863	230	4447.35	I	14339 - 36818
280	4041.92	I	19411 - 44144	80	d 4459.53	I	15391 - 37809
160	4048.05	I	15391 - 40087	35	4462.29	I	21034 - 43437
55	4051.43	I	16212 - 40888	35	4465.94	I	38264 - 60649
960	4066.69	I	22616 - 47199	90	4479.81	I	12774 - 35090
250	4070.86	I	14848 - 39406	120	4484.76	I	10166 - 32457
190	4071.56	I	14852 - 39406	40	4488.60	I	2740 - 25013
230	4074.68	I	14848 - 39383	35	4518.89	I	19109 - 41232
65	4088.44	I	15223 - 39675	35	4520.32	I	19109 - 41225
490	4091.82	I	6093 - 30525	65	4524.87	I	11031 - 33124
55	4098.10	I	14091 - 38486	65	4529.67	I	13020 - 35090
120	4100.30	I	8743 - 33124	28	4537.62	I	16212 - 38244
55	4103.62	I	27787 - 52149	65	4539.92	I	25594 - 47615
1200	4112.02	I	5766 - 30078	110	4548.66	I	14848 - 36826
180	4124.60	I	11378 - 35616	540	4550.41	I	14848 - 36818
180	4128.96	I	4159 - 28372	140	4551.30	I	14852 - 36818
2500	4135.78	I	4159 - 28332	35	4579.04	I	19893 - 41726
150	4137.84	I	15223 - 39383	90	4595.04	I	29382 - 51138
65	4158.78	I	14091 - 38130	90	4597.16	I	11378 - 33124
65	4159.96	I	12774 - 36806	28	4605.04	I	16212 - 37922
180	4172.57	I	10166 - 34126	170	4616.78	I	11031 - 32685
1200	4173.23	I	5144 - 29099	170	4631.83	I	15223 - 36806
620	4175.63	I	8743 - 32685	35	4634.77	I	23323 - 44893
120	4184.13	I	18417 - 42310	35	4641.83	I	8743 - 30280
320	4189.91	I	12774 - 36634	140	4663.82	I	15391 - 36826
55	4195.14	I	14091 - 37922	28	4682.31	I	12774 - 34126
180	4201.45	I	4159 - 27954	65	4692.06	I	11378 - 32685
250	4202.06	I	14339 - 38130	28	4732.80	I	15223 - 36346
1200	4211.86	I	23463 - 47199	22	4738.04	I	25070 - 46170
120	4213.86	I	25013 - 48737	45	4738.35	I	
100	4215.16	I	14091 - 37809	45	4743.89	I	17667 - 38741
55	4226.53	I	15223 - 38876	28	4752.16	I	34365 - 55403
170	4233.46	I	13020 - 36634	35	4763.10	I	38613 - 59602
4900	4260.85	I	0 - 23463	670	4793.99	I	4159 - 25013
100	4264.75	I	13365 - 36806	22	4813.80	I	14848 - 35616
120	4269.61	I	18902 - 42317	22	4815.50	I	13365 - 34126
55	4277.15	I	19049 - 42422	45	4815.96	I	30280 - 51039
100	4285.90	I	13020 - 36346	22	4826.66	I	14091 - 34804
560	4293.95	I	14848 - 38130	22	4843.87	I	8743 - 29382
65	4296.22	I	13365 - 36634	110	4865.60	I	30592 - 51138

Osmium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	4899.22	I	28332 - 48737	28	5680.88	I	34804 - 52402
65	4912.60	I	12774 - 33124	11	5709.37	I	37909 - 55419
28	4935.81	I	17667 - 37922	170	5721.93	I	5144 - 22616
28	4942.94	I	15391 - 35616	8	5737.89	I	17667 - 35090
40	4979.32	I	16212 - 36290	8	5739.72	I	25594 - 43011
55	5031.83	I	15223 - 35090	22	5765.05	I	11031 - 28372
45	5039.12	I	18902 - 38741	170	5780.82	I	15391 - 32685
35	5072.88	I	16212 - 35920	40	5800.60	I	15223 - 32457
35	5074.77	I	15391 - 35090	8	5842.49	I	22564 - 39675
35	5079.09	I	12774 - 32457	110	5857.76	I	15391 - 32457
90	5103.50	I	8743 - 28332	28	5860.64	I	13020 - 30078
55	5110.81	I	11031 - 30592	11	5882.92	I	11378 - 28372
22	5122.23	I	14848 - 34365	11	5903.98	I	19893 - 36826
22	5145.54	I	18902 - 38331	11	5906.84	I	19893 - 36818
140	5149.74	I	15391 - 34804	7	5908.95	I	30280 - 47199
28	5152.01	I	36818 - 56223	7	5981.36	I	18902 - 35616
28	5168.98	I	38486 - 57827	11	5983.22	I	25602 - 42310
40	5193.52	I	11031 - 30280	65	5996.00	I	34365 - 51039
270	5202.63	I	10166 - 29382	20	6015.79	I	21303 - 37922
35	5203.23	I	11378 - 30592	7	6054.63	I	27351 - 43863
20	5250.46			20	6144.53	I	8743 - 25013
45	5255.82	I	19109 - 38130	11	6158.03	I	34804 - 51039
55	5265.15	I	23323 - 42310	35	6227.70	I	32685 - 48737
20	5283.89	I	19411 - 38331	7	6241.70	I	13365 - 29382
20	5295.65	I	16212 - 35090	22	6269.41	I	43012 - 58957
40	5298.78	I	28332 - 47199	11	6274.94	I	40291 - 56222
13	5302.58	I	19411 - 38264	11	6286.83	I	18902 - 34804
18	5336.23	I	15391 - 34126	9	6398.86	I	25602 - 41225
11	5346.03	I	11378 - 30078	22	6403.15	I	33124 - 48737
13	5352.25	I	17667 - 36346	9	6448.13	I	41225 - 56729
110	5376.79	I	14091 - 32685	6	6520.85	I	21303 - 36634
16	5403.43	I	36346 - 54847	7	6528.87	I	21034 - 36346
13	5412.14	I	21033 - 39505	7	6533.14	I	15223 - 30525
120	5416.34	I	30280 - 48737	11	6538.30	I	14091 - 29382
45	5416.69	I	4159 - 22616	11	6576.83	I	15391 - 30592
28	5417.51	I	32685 - 51138	8	6614.56	I	24292 - 39406
16	5441.82	I	19893 - 38264	4	6615.43	I	40291 - 55403
55	5443.31	I	14091 - 32457	7	6661.81	I	13365 - 28372
22	5446.93	I	32685 - 51039	27	6729.56	I	15223 - 30078
11	5447.76	I	11031 - 29382	18	6791.53	I	8743 - 23463
20	5449.37	I	14339 - 32685	14	6806.61	I	15391 - 30078
20	5453.40	I	23985 - 42317	5	6878.70	I	14848 - 29382
22	5457.30	I	5144 - 23463	4	6901.58	I	25602 - 40087
28	5470.00	I	14848 - 33124	11	6956.02	I	34365 - 48737
13	5474.58	I	25602 - 43863	6	6984.95	I	16212 - 30525
13	5475.13	I	21124 - 39383	15	7060.67	I	15223 - 29382
9	5477.27	I	17667 - 35920	22	7145.54	I	15391 - 29382
16	5481.85	I	19893 - 38130	10	7149.89	I	11031 - 25013
22	5509.33	I	30592 - 48737	4	7184.10	I	38486 - 52402
9	5516.01	I	28140 - 46263	10	7206.33	I	8743 - 22616
270	5523.53	I	29099 - 47199	5	7209.96	I	16212 - 30078
22	5546.82	I	34125 - 52149	9	7251.16	I	21303 - 35090
9	5549.79	I	33124 - 51138	6	7253.49	I	18902 - 32685
13	5552.88	I	11378 - 29382	6	7375.07	I	18902 - 32457
11	5560.62	I	35616 - 53595	9	7407.95	I	23323 - 36818
16	5580.66	I	33124 - 51039	26	7602.95	I	15223 - 28372
80	5584.44	I	15223 - 33124	4	7701.46	I	15391 - 28372
8	5600.50	I	36826 - 54677	7	7789.96	I	34365 - 47199
35	5620.08	I	10166 - 27954	7	7852.17	I	15223 - 27954
9	5637.41	I	15391 - 33124	6	7981.20	I	24292 - 36818
22	5642.56	I	19109 - 36826	7	8041.29	I	11031 - 23463
28	5645.25	I	19109 - 36818				
7	5648.98	I	19109 - 36806				
9	5660.21	I	26200 - 43863				
7	5674.38	I	18301 - 35920				

# Palladium

$$\text{Pd, } Z = 46, M = 106.4, \text{ Ratio } \frac{\text{Pd}}{\text{Cu}} = 1.674$$

Pd I Normal state of valence electrons  $4d^{10} 1S_0 = 0$ . I.P. = 67236  $\text{cm}^{-1}$ .

Pd II Normal state of valence electrons  $4d^9 2D_{3/2} = 0$ . I.P. = 156700  $\text{cm}^{-1}$ .

## References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Classification:

Pd I, A. G. Shenstone, Phys. Rev. **36**, 669 (1930).

Pd II, A. G. Shenstone, Phys. Rev. **32**, 30 (1928).

### Palladium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
1100	2447.91	I	0 - 40839	2500	4212.95	I	11722 - 35451
1700	2476.42	I	0 - 40369	180	4473.59	I	11722 - 34069
50	2486.53	II	27094 - 67299	55	4788.18	I	34069 - 54948
130	2488.92	II	25081 - 65247	45	4817.51	I	34069 - 54821
60	2498.78	II	32278 - 72285	35	4875.43	I	34069 - 54574
1900	2763.09	I	0 - 36181	55	5110.81	I	35451 - 55012
24	2854.58	II	32278 - 67299	75	5117.02	I	38812 - 58349
520	2922.49	I	6564 - 40771	160	5163.84	I	35451 - 54811
650	3002.65	I	6564 - 39858	55	5234.86	I	35928 - 55025
45	3009.78	I	25101 - 58317	120	5295.63	I	35928 - 54806
1500	3027.91	I	7755 - 40771	18	5312.57	I	36181 - 54998
1100	3065.31	I	7755 - 40369	15	5345.10	I	39858 - 58562
2600	3114.04	I	7755 - 39858	35	5395.24	I	39858 - 58388
270	3142.81	I	25101 - 56911	55	5542.80	I	36976 - 55012
11000	3242.70	I	6564 - 37394	35	5547.02	I	36976 - 54998
2700	3251.64	I	10094 - 40839	27	5619.44	I	40771 - 58562
3500	3258.78	I	10094 - 40771	15	5642.69	I	40839 - 58556
460	3287.25	I	6564 - 36976	14	5655.42	I	40771 - 58448
3600	3302.13	I	10094 - 40369	75	5670.07	I	37394 - 55025
5000	3373.00	I	7755 - 37394	11	5690.14	I	40839 - 58408
24000	3404.58	I	6564 - 35928	55	5695.09	I	37394 - 54948
13000	3421.24	I	7755 - 36976	18	5736.61	I	37394 - 54821
5000	3433.45	I	11722 - 40839	23	6774.54	I	25101 - 39858
6400	3441.40	I	11722 - 40771	65	6784.52	I	34069 - 48804
7700	3460.77	I	6564 - 35451	4	6833.42	I	40369 - 54998
10000	3481.15	I	10094 - 38812	11	7016.44	I	38088 - 52336
2000	3489.77	I	11722 - 40369	13	7310.06	I	38812 - 52488
12000	3516.94	I	7755 - 36181	75	7368.12	I	35451 - 49020
12000	3553.08	I	11722 - 39858	27	7391.92	I	38812 - 52336
4500	3571.16	I	10094 - 38088	16	7486.90	I	35451 - 48804
20000	3609.55	I	7755 - 35451	120	7764.03	I	35928 - 48804
20000	3634.70	I	6564 - 34069	27	7786.67	I	36181 - 49020
5500	3690.34	I	11722 - 38812	45	7915.80	I	39858 - 52488
1400	3718.91	I	10094 - 36976	18	7961.08	I	28214 - 40771
1500	3799.19	I	7755 - 34069	55	8132.82	I	25101 - 37394
1500	3832.29	I	10094 - 36181	45	8300.83	I	36976 - 49020
2200	3894.20	I	11722 - 37394	9	8353.58	I	40369 - 52336
1500	3958.64	I	11722 - 36976	18	8532.74	I	40771 - 52488
290	4087.34	I	11722 - 36181	16	8599.10	I	37394 - 49020
90	4169.84	I	10094 - 34069	65	8761.35	I	37394 - 48804

## Phosphorus

$$P, Z = 15, M = 30.9738, \text{Ratio } \frac{P}{Cu} = 0.487$$

P I Normal state of valence electrons  $3s^2 3p^3 \ ^4S_{1/2}^{\circ} = 0$ . I.P. = 84580  $\text{cm}^{-1}$ .

P II Normal state of valence electrons  $3s^2 3p^2 \ ^3P_0 = 0$ . I.P. = 159100  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

#### Classification:

P I, C. C. Kiess, J. Research NBS **8**, 393 (1932) RP 425.

P I and P II, W. C. Martin, J. Opt. Soc. Am. **49**, 1071 (1959).

#### *Phosphorus—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
340	2135.47	I	11362 - 58174	220	2534.01	I	18722 - 58174
3400	2136.18	I	11376 - 58174	600	2535.65	I	18748 - 58174
2600	2149.14	I	11362 - 57877	380	2553.28	I	18722 - 57877
280	2152.94	I	18722 - 65157	150	2554.93	I	18748 - 57877
550	2154.08	I	18748 - 65157				

## Platinum

$$\text{Pt, } Z = 78, M = 195.1, \text{ Ratio } \frac{\text{Pt}}{\text{Cu}} = 3.070$$

Pt I Normal state of valence electrons  $5d^9 6s^1 3D_3 = 0$ . I.P. = 72300  $\text{cm}^{-1}$ .

Pt II Normal state of valence electrons  $5d^9 2D_{2\ 1/2} = 0$ . I.P. = 149700  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

#### Classification:

Pt I, A. C. Haussman, *Astrophys. J.* **66**, 333 (1927).

J. J. Livingood, *Phys. Rev.* **34**, 185 (1929).

Pt II, A. G. Shenstone, *Phil. Trans. Roy. Soc. (London)* [A]**237**, 453 (1938).

#### *Strong lines of platinum*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5500	2049.37	I	0 - 48779	1800	2733.96	I	776 - 37342
4400	2032.41	I		1800	2997.97	I	776 - 34122
3200	2030.63	I		1700	2929.79	I	0 - 34122
3200	3064.71	I	0 - 32620	1600	2705.89	I	824 - 37769
3000	2084.59	I	824 - 48779	1500	2067.50	I	0 - 48352
2800	2659.45	I	0 - 37591	1500	2174.67	I	
2000	2702.40	I	776 - 37769				
1900	2144.23	I	0 - 46622				
		II	4787 - 51408				

Platinum—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
3200	2030.63	I		40	2674.57	I	6568 - 43946
4400	2032.41	I		440	2677.15	I	0 - 37342
5500	2049.37	I	0 - 48779	200	2698.43	I	6140 - 43188
1500	2067.50	I	0 - 48352	2000	2702.40	I	776 - 37769
3000	2084.59	I	824 - 48779	1600	2705.89	I	824 - 37769
1000	2103.33	I	824 - 48352	60	2713.13	I	10117 - 46965
950	2128.61	I	776 - 47741	1300	2719.04	I	824 - 37591
1900	2144.23	I	0 - 46622	130	2729.92	I	6568 - 43188
		II	4787 - 51408	1800	2733.96	I	776 - 37342
600	2165.17	I	0 - 46170	70	2738.48	I	10117 - 46623
1500	2174.67	I		70	2747.61	I	13496 - 49881
400	2202.22	I	776 - 46170	80	2753.86	I	10132 - 46434
320	2222.61	I	6568 - 51546	200	2754.92	I	10132 - 46420
150	2249.30	I	0 - 44444	30	2769.84	I	6568 - 42660
190	2268.84	I		500	2771.67	I	776 - 36845
280	2274.38	I	776 - 44730	40	2773.24	I	13496 - 49545
150	2289.27	I	776 - 44444	20	2774.00	I	10132 - 46170
150	2292.40	I	824 - 44433	50	2793.27	I	13496 - 49286
240	2308.04	I	6568 - 49881	16	2794.21	II	13311 - 49089
90	2315.50	I		140	2803.24	I	6140 - 41803
220	2318.29	I	824 - 43946	10	2808.51	I	15502 - 51098
100	2326.10	I	6568 - 49545	50	2818.25	I	824 - 36296
170	2340.18	I	6568 - 49286	1400	2830.30	I	0 - 35322
280	2357.10	I	776 - 43188	70	2834.71	I	10132 - 45398
180	2368.28	I	6568 - 48779	16	2853.11	I	13496 - 48536
130	2383.64	I	10132 - 52072	25	2888.20	I	10117 - 44730
40	2386.81	I	776 - 42660	25	2893.22	I	15502 - 50055
120	2389.53	I	824 - 42660	600	2893.86	I	776 - 35322
35	2396.17	I	13496 - 55217	300	2897.87	I	824 - 35322
70	2401.87	I	10132 - 51752	60	2905.90	I	6568 - 40970
200	2403.09	I	6140 - 47741	120	2912.26	I	10117 - 44444
100	2418.06	I	13496 - 54839	120	2913.54	I	10132 - 44444
80	2428.04	I	6568 - 47741	70	2919.34	I	13496 - 47741
50	2428.20	I	10117 - 51287	30	2921.38	I	6568 - 40788
25	2429.10	I	10132 - 51287	1700	2929.79	I	0 - 34122
180	2436.69	I	776 - 41803	30	2942.76	I	30157 - 64129
650	2440.06	I	0 - 40970	30	2944.75	I	6568 - 40516
60	2450.97	I	0 - 40788	25	2959.10	I	15502 - 49286
440	2467.44	I	0 - 40516	60	2960.75	I	
35	2471.01	I	13496 - 53953	1800	2997.97	I	776 - 34122
1000	2487.17	I	0 - 40194	220	3002.27	I	824 - 34122
25	2488.74	II		30	3017.88	I	13496 - 46623
200	2490.12	I	824 - 40970	130	3036.45	I	13496 - 46420
160	2495.82	I	6568 - 46623	800	3042.64	I	824 - 33681
240	2498.50	I	776 - 40788	3200	3064.71	I	0 - 32620
50	2505.93	I		30	3071.94	I	10117 - 42660
120	2508.50	I	6568 - 46420	130	3100.04	I	6568 - 38816
50	2514.07	I	10117 - 49881	320	3139.39	I	776 - 32620
60	2515.03	I	10132 - 49881	140	3156.56	I	10132 - 41803
240	2515.58	I	776 - 40516	120	3200.71	I	13496 - 44730
140	2524.30	I	6568 - 46170	320	3204.04	I	6568 - 37769
40	2529.41	I	13496 - 53019	30	3230.29	I	13496 - 44444
50	2536.49	I	10132 - 49545	20	3233.42	I	15502 - 46420
160	2539.20	I	824 - 40194	20	3250.36	I	
18	2549.46	I	13496 - 52708	40	3251.98	I	10132 - 40874
50	2552.25	I	10117 - 49286	160	3255.92	I	6140 - 36845
50	2596.00	I	15502 - 54011	25	3268.42	I	
70	2603.14	I	10132 - 48536	25	3281.97	I	33681 - 64141
50	2619.57	I	6568 - 44730	120	3290.22	I	10132 - 40516
1100	2628.03	I	776 - 38816	500	3301.86	I	6568 - 36845
130	2639.35	I	6568 - 44444	60	3315.05	I	0 - 30157
1000	2646.89	I	0 - 37769	35	3323.80	I	10117 - 40194
500	2650.86	I	824 - 38536	340	3408.13	I	824 - 30157
20	2658.17	I	10132 - 47741	35	3427.93	I	13496 - 42660
2800	2659.45	I	0 - 37591	60	3483.43	I	10117 - 38816



Platinum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
160	3485.27	I	10132 - 38816	12	4520.90	I	37769 - 59882
120	3628.11	I	6568 - 34122	35	4552.42	I	33680 - 55641
70	3638.79	I	10117 - 37591	12	4879.53	I	36296 - 56784
70	3643.17	I	18567 - 46007	14	5044.04	I	15502 - 35322
50	3663.10	I	13496 - 40788	30	5059.48	I	32620 - 52379
80	3671.99	I	10116 - 37342	35	5227.66	I	13496 - 32620
80	3674.04	I	10132 - 37342	40	5301.02	I	36782 - 55641
35	3699.91	I	13496 - 40516	12	5368.99	I	15502 - 34122
18	3706.53	I		12	5390.79	I	34122 - 52667
20	3801.05			14	5475.77	I	34122 - 52379
80	3818.69	I	10117 - 36296	14	5478.50	I	38536 - 56784
40	3900.73	I	34122 - 59751	6	5763.57	I	35322 - 52667
110	3922.96	I	30157 - 55641	20	5840.12	I	15502 - 32620
35	3948.40	I	13496 - 38816	8	5844.84	I	38536 - 55641
100	3966.36	I	10117 - 35322	6	6026.04	I	40194 - 56784
20	3996.57	I	15502 - 40516	7	6318.37	I	36845 - 52667
110	4118.69	I	13496 - 37769	8	6326.58	I	21967 - 37769
80	4164.56	I	10117 - 34122	9	6523.45	I	37342 - 52667
40	4192.43	I	13496 - 37342	10	6710.42	I	37769 - 52667
18	4327.06	I	33680 - 56784	20	6760.02	I	37591 - 52379
18	4391.83	I	21967 - 44730	60	6842.60	I	37769 - 52379
80	4442.55	I	10117 - 32620	20	7113.73	I	18566 - 32620
14	4445.55	I	10132 - 32620	10	8224.74	I	21967 - 34122
25	4498.76	I	30157 - 52379				

## Potassium

K,  $Z = 19$ ,  $M = 39.10$ , Ratio  $\frac{K}{Cu} = 0.615$

K I Normal state of valence electrons  $3p^6 4s^2 S_{1/2} = 0$ . I.P. = 35010  $\text{cm}^{-1}$ .

K II Normal state of valence electrons  $3p^6 1S_0 = 0$ . I.P. = 256637  $\text{cm}^{-1}$ .

### References

Wavelengths and Classification:

P. Risberg, Ark. for Fysik **10**, 583 (1956).

*Potassium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
320	4044.14	I	0 - 24720	25 hl	6911.08	I	12985 - 27451
160	4047.21	I	0 - 24701	50 hl	6938.77	I	13043 - 27451
10 1	5782.38	I	12985 - 30274	18000	7664.90	I	0 - 13043
14 1	5801.75	I	13043 - 30274	9000	7698.96	I	0 - 12985

# Praseodymium

$$\text{Pr, } Z = 59, M = 140.9077, \text{ Ratio } \frac{\text{Pr}}{\text{Cu}} = 2.217$$

Pr I Normal state of valence electrons  $4f^3 6s^2 {}^4I_{41/2}^{\circ} = 0$ . I.P. = 43730  $\text{cm}^{-1}$ .

Pr II Normal state of valence electrons  $4f^3 6s {}^5I_4^{\circ} = 0$ . I.P. = 85100  $\text{cm}^{-1}$ .

## References

Wavelengths:

R. Zalubas, unpublished material (1973).

Classification:

Pr I and Pr II, (Spectrum assignment only)  
 A. S. King, *Astrophys. J.* **68**, 194 (1928).  
 R. Zalubas, unpublished material (1973).

Pr I and II, J. Blaise, J. Verges, J. F. Wyart, P. Camus, and R. Zalubas, unpublished material (1973).  
 Pr II, N. Rosen, G. R. Harrison, and J. R. McNally, *Phys. Rev.* **60**, 722 (1941).

Molecular Spectra:

PrO, W. W. Watson, *Phys. Rev.* **53**, 639 (1938).

### Strong lines of praseodymium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5200	4179.38	II	1649 - 25569	1500		II	442 - 23660
3800	4222.98	II	442 - 24115	1300 h	3816.02	II	
3800	4225.31	II	0 - 23660	1300 c	3918.85	II	2998 - 28509
3400	4062.83	II	3403 - 28010	1300 c	3989.69	II	442 - 25500
3100	3908.44	II	0 - 25578	1300	4044.82	II	0 - 24716
2900 c	4100.71	II	4437 - 28816	1300	4333.97	II	1649 - 24716
2700	4143.12	II	2998 - 27128	1200	3850.79	II	
2500	4189.48	II	2998 - 26861	1200	4368.33	II	0 - 22886
2500 c	4206.71	II	4437 - 28202	1200 c	4429.13	II	0 - 22571
2200	4054.86	II	1744 - 26398		4429.25	II	2998 - 25569
2200	4056.53	II	5079 - 29724	1100 c	3965.25	II	1649 - 26861
2100 c	3982.05	II	3403 - 28509	1100	4297.76	II	0 - 23261
1900	4008.70	II	5079 - 30018	1100	4351.84	II	1744 - 24716
1700 c	3877.18	II	442 - 26226	1100	4496.44	II	442 - 22675
1700 c	4118.45	II	442 - 24716	960	3830.72	II	
1700 c	4164.19	II	1649 - 25657	960	3852.80	II	
1700	4408.84	II	0 - 22675	960	3925.44	II	0 - 25468
1600 c	3964.81	II	442 - 25657	960	4033.84	II	2998 - 27782
1600	3994.79	II	442 - 25468	960	4241.02	II	4437 - 28010
1500 c	4141.21	II	4437 - 28578	960	4468.71	II	1744 - 24115

Praseodymium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
25	2558.58	II		60	3069.23	II	
25	2578.27	I		25	3074.58	I	
30	2579.31	I		35	3078.95	II	
40	2598.04	II		110	3082.11	II	
25	2608.92	II		30	3084.90	II	
25	2615.75	II			3085.02	II	
25	2648.48	II		50	3085.86	II	
30	2654.75	II		35	3091.33	II	
25	2666.70	II		50	3097.77	II	
20	2672.52	II		80	3098.50	II	
30	2685.19	II		40	d	3101.27	II
45	2685.70	II		20		3103.11	II
50	2698.92	II		40		3105.38	II
60	2700.38	II		40		3109.78	I
30	2702.25	II		40		3110.58	II
100	h	2707.37	II	100		3111.34	II
20		2714.16	II	30		3114.13	II
60		2720.17	II	30		3119.03	II
30		2721.90	II	140		3121.58	II
50		2726.50	II	40		3122.96	II
12		2731.78	II	85		3129.20	II
25		2733.12	II	25		3135.35	II
50		2734.30	II	40		3136.79	II
25		2737.90	II	50		3146.44	II
40		2742.12	II	60		3151.54	II
25		2744.66	II	60		3153.23	II
20		2746.28	II	50		3153.82	II
60		2760.35	II	85		3158.65	II
50		2769.60	II	140		3163.73	II
50	d	2775.94	II	75		3164.81	II
		2776.03	II	270		3168.24	II
40		2778.80	II	25		3169.36	II
50		2783.31	II	21		3171.23	II
30		2789.05	II	160		3172.31	II
35		2792.51	II	85		3182.44	II
50		2802.05	II	110		3191.42	II
20		2823.17	II	65		3191.74	II
20		2824.14	II	200	d	3195.99	II
20		2828.29	II			3196.09	II
20		2842.98	I	110		3199.04	II
20		2844.01	II	30		3204.81	II
20		2850.62	I	100		3207.89	II
25		2853.99	II	50		3213.58	II
30		2865.64	II	35		3214.42	II
50		2881.60	I	190		3219.48	II
30		2882.31	II	35		3230.23	II
30		2884.89	II	100		3234.27	II
30		2943.97	II	25		3235.43	II
30		2967.58	II	40		3238.86	II
30		2971.13	II	100		3245.48	II
40	d	2971.40	II	50		3276.66	II
		2971.46	II	75		3295.52	II
50		2984.98	II	25		3296.38	II
30		2986.18	II	25		3303.18	II
30		2990.22	II	40		3314.38	II
80		3013.46	II	40		3324.56	II
50		3029.27	II	21		3341.47	II
25		3032.71	II	40		3350.27	II
50		3045.16	II	140		3355.67	II
40		3046.79	II	21		3359.26	II
20		3049.17	I	40	h	3363.24	II
80		3053.25	II	40	d	3370.25	II
40		3062.06	II	40		3372.50	II
80		3063.68	II	40		3376.65	II
35		3068.66	I	40		3379.76	II

Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	3383.36	I		25	h	3607.81	II
40	3383.73	II		130		3611.94	II
40	3388.02	II		25		3612.71	II
110	3394.62	II		50		3615.16	II
21	3403.56	II		75		3616.66	II
65	3415.69	II		25		3618.08	II
65	3418.41	II		25		3619.15	II
35	3419.23	II		50		3621.07	II
21	3421.11	II		65	h	3622.32	II
40	3427.55	II		25	h	3622.64	II
85	3430.27	II				3622.74	II
40	3430.50	II		170		3630.96	II
21	3431.62	II		25		3634.47	II
85	h	3433.50	II	95		3635.28	II
30	3434.77	II		40		3637.64	II
30	3442.76	II		25		3638.58	II
35	h	3447.84	I	95		3641.62	II
40	3448.19	II		65		3643.32	II
40	3449.80	II		25		3644.55	II
25	3451.48	II		100		3645.55	II
50	3455.97	II		250		3645.66	II
25	3460.58	II		250		3646.30	II
110	3465.74	II		100		3648.30	II
40	3466.73	II		65		3650.13	II
35	3467.03	II		50		3651.04	II
65	3473.84	II		35		3652.38	II
50	3487.56	II		50		3657.42	II
25	3491.49	I		50		3658.21	II
25	3491.94	II		75		3659.05	II
25	3494.26	II		40		3660.08	II
60	3499.06	II		150	c	3660.36	II
50	3499.53	II		100		3661.62	II
65	3503.06	II		40		3662.32	II
50	3504.27	II		40		3664.64	II
50	3508.20	II		25		3667.14	II
25	3537.31	II		95		3667.67	II
50	h	3539.92	II	370		3668.83	II
35	3542.38	II		40		3669.53	II
25	3548.05	II		40		3670.26	II
25	3549.53	II		40		3671.91	II
40	3551.33	I		50		3674.14	II
8	3551.41	I	0 - 28149	21		3674.88	II
25	3551.98	II		50		3680.00	II
40	3555.24	II		50	h	3681.85	II
25	3557.70	II		25		3685.26	II
40	3562.24	II		250		3687.03	II
40	3562.56	II		150		3687.19	II
25	3568.67	II		100		3689.71	II
50	3569.56	II		50		3691.47	II
25	3570.56	I		50		3693.36	II
50	3574.96	II		50		3693.48	II
25	3575.51	II		25		3696.65	II
75	d	3577.47	II	150		3698.06	II
25	h	3579.05	II	60		3699.53	II
50	h	3579.96	I	95		3701.81	II
50	h	3582.25	II	40		3704.33	II
200	3584.21	II		230		3706.75	II
40	d	3587.93	II	170	c	3711.10	II
25	3588.64	II		60		3712.33	II
50	3589.49	II		60		3713.27	II
25	h	3593.00	II	290		3714.05	II
75	3596.18	II		60		3715.62	II
75	3600.74	II		95		3716.28	II
95	3605.05	II		60		3717.83	II
50	3605.96	II		60		3718.03	II
							5855 - 33388
							5855 - 33278
							7228 - 34323
							442 - 27380

Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
60	3719.42	II		190	3794.93	II	
29	3720.28	II		50	3795.77		
29	3722.06	II		40	3796.28	II	
40	3723.57	II		680	3800.30	II	
75	3725.01	II		95	3801.35	II	
50	3726.29	II		29	3802.30	II	
35	3729.11	II		290	3804.84	II	
50	3729.40	II		60	3806.14	II	
85	3730.55	II		140	3809.18	II	
50	3731.49	II		60	3809.97	II	
120	3733.03	II		390	3811.84	II	0 - 26226
210	3734.41	II		40	3813.89	II	7228 - 33440
60	3735.28	II		1300	3816.02	II	
250	3735.76	II		120	3817.66	II	
190	3736.49	II		95	3817.87	II	
410	3739.18	II	5854 - 32590	680	3818.28	II	
150	3740.99	II		40	3818.74	II	
120	3743.98	II		120	3819.14	II	
35	3747.26	II		310	3821.80	II	
40	3747.47	II		60	3822.78	II	
29	3748.50	II		150	3823.18	II	7832 - 33981
60	3748.82	II		40	3823.59	II	0 - 26146
75	3750.08	II		95	3824.08	II	7888 - 34031
75	3750.50	II		95	3826.20	II	
190	3750.98	II		120	3826.67	II	8198 - 34323
50	3751.59	II		40	3828.33	II	
60	3752.32	II		40	3828.74	II	
60	3753.40	II		35	3829.32	II	
50	3754.40	II		960	3830.72	II	
85	3755.00	II		60	3831.80	II	
50	3756.80	II		75	3832.97	II	441 - 26523
140	3759.60	II		75	3833.54	II	
120	3760.08	II		140	3834.93	II	
680	3761.87	II		480	3840.99	II	
35	3762.36	II		270	3842.34	II	
29	3762.56	II		60	3843.35	II	
60	3763.03	II		60	3843.78	II	
29	3764.10	II		150	3844.54	II	
230	3764.77	II		580	3846.59	II	
29	3765.98	II		95	3846.94	II	
60	3766.47	II		1200	3850.79	II	
230	3768.94	II		720	3851.55	II	
95	3769.68	II	442 - 26962	35	3852.07	II	
60	3770.46	II		960	3852.80	II	
170	3772.82	II		95	3855.88	II	
170	3774.06	II		95	3856.99	II	
75	3776.09	II			3857.13	II	
60	3777.13	II		120	3858.25	II	
140	3777.62	II		110	3859.14	II	
60	3778.75	II		75	3861.30	II	8141 - 34031
85	3780.26	II		75	3862.04	II	
170	3780.66	II		75	3864.08	II	
29	3781.91	II	7888 - 34323	480	3865.45	II	
50	3782.35	II		210	3867.52	II	
50	3783.31	II		65	3868.52	II	0 - 25842
35	3783.84	II		75	3869.17	II	
	3783.98	II		95	3869.85	II	8198 - 34031
150	3785.46	II		75	3870.41	II	
40	3786.00	II		210	3870.72	II	
150	3786.86	II		40	3872.69	II	0 - 25814
24	3788.06	II		50	3873.01	II	
40	3790.58	II		35	3873.36	II	
210	3792.51	II		95	3874.45	II	
50	3792.95	II		480	3876.19	II	
60	3793.45	II		1700	3877.18	II	442 - 26226

Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
95	3878.32	II		95	3940.16	II	442 - 25814
270	3879.20	II		29	3941.45	II	
680	3880.47	II	0 - 25763	120	3942.27	II	
75	3880.83	II		50	3942.88	II	
85	3882.28	II		55	3943.40	II	
40	3884.05	II	1649 - 27388	65	3943.75	II	
440	3885.19	II	1649 - 27380	90	3944.13	II	
35	3888.06	II		35	3944.61	II	
50	3888.29	II		65	3944.90	II	
440	3889.34	II	442 - 26146	65	3945.41	I	1377 - 26715
24	3889.97	II		110	3945.60	II	
120	3891.71	II		180	3946.89	II	
50	3892.51	II		730	3947.63	II	1649 - 26974
29	3894.14	II		900	3949.43	II	1649 - 26962
29	3894.89	II		45	3950.65	II	
50	3895.04	II		65	3951.18	II	
40	3896.82	II		35	3951.84	I	
65	3897.03	II		65	3952.11	II	
190	3897.25	II	8379 - 34031	45	3952.35	II	
40	3897.71	II		900	3953.51	II	4437 - 29724
210	3898.84	II		40	3954.99	II	
85	3899.54	II	1744 - 27380	35	3955.24	II	
250	3902.45	II		22	3955.42	II	
65	3903.92	II	7832 - 33440	22	3956.34	I	
35	3904.85	II	8379 - 33981	35	3956.55	II	
65	3906.08	II		380	3956.75	II	
29	3907.29	II		55	3957.68	II	
770	3908.05	II	4437 - 30018	65	3958.22	II	
3100	3908.44	II	0 - 25578	65	3958.49	II	
110	3909.62	II		190	3959.44	I	
40	3911.29	II		45	3959.75	II	8141 - 33388
35	3911.79	II		90	3960.49	II	
40	3911.99	II	7832 - 33388	55	3961.28	II	8379 - 33617
50	3912.25	II	8478 - 34031	470	3962.45	II	1744 - 26974
65	3912.63	II		160	3963.11	II	
630	3912.90	II	1649 - 27198	45	3963.71	II	
310	3913.55	II	0 - 25545	560	3964.26	II	1744 - 26962
210	3914.76	II		1600	3964.81	II	442 - 25657
170	3915.46	II		1100	3965.25	II	1649 - 26861
24	3916.78	II		45	3965.61	II	
95	3917.24	II		560	3966.57	II	2998 - 28202
75	3917.96	II		160	3967.15	II	
1300	3918.85	II	2998 - 28509	160	3968.14	II	
420	3919.63	II		55	3970.07	II	
250	3920.53	II	0 - 25500	500	3971.16	II	3403 - 28578
65	3922.23	II		320	3971.67	II	
95	3923.55	II		620	3972.14	II	442 - 25610
130	3924.15	II	8141 - 33617	55	3973.09	II	
50	3924.99	I		55	3973.90	II	
960	3925.47	II	0 - 25468	90	3974.30	II	
480	3927.46	II	1744 - 27198	320	3974.85	II	
120	3927.71	II		55	3976.30	II	
85	3928.69	II		80	3976.56	II	
65	3928.92	II	7832 - 33278	100	3976.79	II	8477 - 33616
370	3929.29	II		55	3977.43	II	
85	3929.88	II		40	3977.73	I	
35	3930.62	II		40	3979.68	II	
29	3932.11	II		90	3980.21	II	
130	3932.97	II	8198 - 33617	90	3980.84	II	
50	3934.27	II		65	3981.16	II	
110	3935.17	II		2100	3982.05	II	3403 - 28509
370	3935.82	II	442 - 25842	100	3982.45	II	441 - 25545
29	3936.68	II		90	3983.59	II	
29	3937.02	II		90	3984.24	II	
250	3938.30	II		90	3985.64	II	

Praseodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	3986.17	II	8198 - 33278	110	4059.37	II	
120	3987.37	II		110 h	4061.32	II	5108 - 29724
90	3988.00	II		230	4062.22	II	
1300 c	3989.68	II	442 - 25500	3400	4062.81	II	3403 - 28010
45	3991.22	II		210	4068.80	II	
230	3991.91	II		170	4070.24	II	
340	3992.16	II		190	4072.50	II	7228 - 31776
65 h	3992.90	II		90	4074.83	II	
45 c	3993.16	II	2998 - 28034	55	4076.20	II	
90	3994.01	II		500 c	4079.77	II	
1600	3994.79	II	442 - 25468	500 c	4080.98	II	1649 - 26146
270	3995.83	II		790	4081.85	II	
560 c	3997.04	II	2998 - 28010	500	4083.34	II	1744 - 26226
230	3997.96	II		100 c	4084.71	II	
320	3999.12	II		100	4085.11	II	
620 c	4000.17	II	1649 - 26641	55	4085.26	II	
110	4000.45	II		55	4086.20	II	
90 c	4000.89	II		65	4086.72	II	9212 - 33674
65	4001.43	II		200 c	4087.21	II	
45	4003.73	II		40	4088.88	II	
730	4004.70	II	1744 - 26707	40	4089.08	II	
150	4006.67	II		55	4089.46	II	
65	4007.76	II		55	4089.88	II	
1900	4008.69	II	5079 - 30018	80	4090.72	II	
90	4009.24	II		80 h	4092.61	II	
65	4009.96	I		40	4092.84	II	
620	4010.60	II		90 c	4094.96	II	1649 - 26062
90	4013.23	II		80	4095.89	II	
110	4013.38	II	5108 - 30018	80	4096.32	II	
90	4014.32	II		560	4096.82	II	1744 - 26146
730	4015.39	II	1744 - 26641	380	4098.40	II	8198 - 32591
28	4016.78	II		55	4098.65	II	
620	4020.96	II		160	4100.22	II	
90	4022.18	II		2900 c	4100.72	II	4437 - 28816
470	4022.71	II		35	4104.85	II	
110	4024.30	II		110	4105.71	II	
65	4025.18	II		28	4107.11	II	
360	4025.54	II		35	4107.52	II	9336 - 33674
230	4026.83	II		90	4107.70	II	
230	4029.00	II		65	4108.33	II	
360 c	4029.72	II		35	4109.09	II	
65	4030.47	II		35	4109.37	II	
150	4031.07	II		28 h	4110.11	II	
730 c	4031.75	II	1649 - 26445	55	4110.46	II	
230	4032.47	II	5226 - 30018	45	4110.91	II	1744 - 26062
150	4032.96	II		150 c	4111.86	II	442 - 24755
960	4033.83	II	2998 - 27782	28 h	4112.72	II	
230	4034.33	II	1744 - 26524	270 c	4113.89	II	
65 c	4036.55	II		55	4114.82	II	
65	4037.21	II		45	4115.82	II	
230	4038.22	II		1700 c	4118.46	II	442 - 24716
730	4038.45	II	0 - 24755	45	4119.33	II	
55	4039.02	II		90	4119.85	II	
470	4039.34	II	1649 - 26398	35 h	4120.11	I	
1300	4044.81	II	0 - 24716	28	4120.92	II	
230	4045.70	II		90	4124.03	II	
230	4046.63	II		90	4124.32	II	
340	4047.08	II	7888 - 32591	90	4125.03	II	
180	4048.13	II		55 h	4126.14	II	
450	4051.13	II		250	4129.15	II	8379 - 32591
90	4052.57	II		340	4130.77	II	
2200	4054.88	II	1744 - 26398	170 c	4132.20	II	1649 - 25842
2200	4056.54	II	5079 - 29724	200	4133.61	II	
140	4058.20	II		35	4137.15	II	
450	4058.80	II	3403 - 28034	35	4138.20	II	



Praseodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28 h	4140.28	II		3800	4222.93	II	442 - 24115
1500 c	4141.22	II	4437 - 28578	90	4223.46	II	
65	4141.95	II		3800	4225.35	II	0 - 23660
2700	4143.11	II	2998 - 27128	160 h	4225.59	II	
28	4144.21	II		90 c	4228.52	II	
270 c	4146.50	II		90 c	4229.10	II	
28	4147.12	II		65	4229.80	II	
45	4147.51	II		90	4230.60	II	
270	4148.44	II	1744 - 25842	320	4233.11	II	
40	4149.29	II		320 c	4236.15	II	1649 - 25249
80	4150.04	II		140	4236.60	II	
40	4150.94	II	9532 - 33617	65	4237.04	II	
28	4151.74	II		65	4238.37	II	
90	4154.01	II		270	4240.02	II	8198 - 31776
200	4156.50	II	9335 - 33387	960	4241.01	II	4437 - 28010
35	4156.82	II		170 c	4241.30	II	
55	4157.73	II		340	4243.51	II	3403 - 26962
40	4159.46	II		65	4245.46	II	
28	4159.73	II		65	4246.16	II	
45	4160.47	II		840 c	4247.63	II	442 - 23978
1700 c	4164.16	II	1649 - 25657	90	4249.08	II	0 - 23528
270	4168.04	II		90	4249.48	II	2998 - 26524
230	4169.45	II	3403 - 27380	190	4250.34	II	10802 - 34323
620	4171.82	II	2998 - 26962	160 c	4251.45	II	10466 - 33981
730	4172.25	II	1649 - 25610	65	4253.09	II	
40	4173.72	II		500	4254.40	II	5079 - 28578
250	4175.32	II	7832 - 31776	140 c	4261.78	II	3403 - 26861
250	4175.62	II	9336 - 33278	190	4262.27	II	
100	4176.32	II		90	4262.80	II	
200	4178.63	II		90	4263.14	II	
5200	4179.39	II	1649 - 25569	270 c	4263.78	II	2998 - 26445
40	4180.38	II		100	4267.74	II	
65	4180.65	II	1744 - 25657	320	4269.09	II	
40	4182.30	II		160	4271.77	II	
40	4182.58	II		790 c	4272.27	II	2998 - 26398
55	4182.90	II		90 c	4275.21	II	
110	4184.26	II		90	4275.82	II	
40	4184.60	II		120	4276.18	II	9212 - 32591
140	4185.12	II	7888 - 31776	120	4278.05	II	
45	4185.88	II		90	4279.00	II	
55	4186.38	II		470 c	4280.07	II	
65	4187.76	II		790 c	4282.42	II	4437 - 27782
2500	4189.48	II	2998 - 26861	45	4285.37	II	
45	4190.59	II	10466 - 34323	45	4286.98	II	
560 c	4191.60	II	1649 - 25500	45 c	4288.47	II	
45 c	4192.47	II		80	4289.41	II	
55	4194.57	II		120	4289.88	II	3403 - 26707
55 c	4195.49	II		55	4290.40	II	
55	4195.96	II		55	4290.99	II	8478 - 31776
110	4196.76	II		80 h	4291.59	II	
35	4197.13	II		110 c	4293.14	II	
22	4197.22	II		140	4293.58	II	
290	4201.17	II		160 c	4294.69	II	
110 c	4201.55	II		90	4295.11	II	
2500 c	4206.72	II	4437 - 28202	1100	4297.76	II	0 - 23261
120	4207.79	II		450 c	4298.98	II	
500	4208.32	II	1744 - 25500	100 c	4302.15	II	3403 - 26641
320	4211.86	II	4437 - 28173	290	4303.61	II	
45	4213.28	II		1500	4305.76	II	442 - 23660
180	4213.56	II		110	4306.04	II	
55	4214.00	II	1744 - 25468	45	4307.63	II	10466 - 33674
120 hc	4216.12	II		100 c	4308.90	II	
80	4217.19	II		80	4311.09	II	
320	4217.81	II		45	4311.92	II	
160	4219.61	II		80	4315.51	II	

## Praseodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	4316.12	II		80	4414.39	II	
45	4317.05	II		160	4419.04	II	
90	4317.82	II		190	4419.65	II	11055 - 33674
110	4319.00	II		160	4421.22	II	2998 - 25610
55	4320.15	II		22	4424.16	II	
210	4323.55	II	5079 - 28202	160	4424.58	II	
55	4328.21	II		1200	4429.13	II	0 - 22571
180	4328.40	II			4429.25	II	2998 - 25569
160	4328.98	II	5079 - 28173	22	4431.86	II	
270	4329.41	II	1744 - 24835	110	4432.28	II	
55	4330.42	II	442 - 23528	22	4434.91	II	
55	4331.28	II		90	4438.15	II	
55	4333.13	II		55	4444.03	II	
1300	4333.97	II	1649 - 24716	65	4445.85	II	
90	4334.63	II	442 - 23505	90	4446.99	II	
200	4335.74	II		730	4449.83	II	1649 - 24115
360	4338.70	II	3403 - 26445	80	4450.21	II	
65	4339.68	I		140	4451.90	II	
80	4342.63	II		65	4454.36	II	442 - 22886
	4342.82	II		140	4454.68	II	
45	4343.88	II		90	4458.30	II	4437 - 26861
620	4344.30	II		65	4461.29	II	
45	4346.87	II		100	4465.97	II	
470	4347.49	II	3403 - 26398	960	4468.66	II	1744 - 24115
340	4350.40	II		22	4469.65	II	
1100	4351.84	II	1744 - 24716	55	4472.92	II	
450	4354.91	II		55	4473.84	II	
45	4355.18	II	5079 - 28034	140	4477.26	II	1649 - 23978
45	4357.49	II	11089 - 34031	35	4483.48	II	
140	4359.09	II		45	4485.54	II	
410	4359.79	II	5079 - 28010	28	4487.79	II	442 - 22718
45	4361.24	II		65	4488.19	II	
45	4361.79	II	9671 - 32591	55	4492.42	II	3403 - 25657
100	4362.99	II		35	4492.91	I	2847 - 25098
100	4363.24	II			4493.06	II	2998 - 25249
1200	4368.33	II	0 - 22886	35	4493.70	II	
90	4370.79	II	10802 - 33674	35	4494.18	II	
320	4371.62	II		1100	4496.46	II	442 - 22675
80	4373.81	II		40	4501.82	II	3403 - 25610
120	4374.41	II		55	4504.61	II	
40	4379.34	II		790	4510.15	II	3403 - 25569
110	4380.30	II		22	4516.45	II	
160	4382.39	II		200	4517.58	II	442 - 22571
55	4382.77	II		55	4520.75	II	
110	4384.09	II		55	4531.08	II	1649 - 23713
80	4384.85	II		340	4534.15	II	5079 - 27128
40	4385.30	II		340	4535.92	II	0 - 22040
	4385.48	I		55	4539.26	II	
45	4391.50	II		65	4542.53	II	4437 - 26445
180	4394.98	II		28	4543.94	II	
180	4395.80	II	3403 - 26146	80	4548.52	II	
270	4396.08	II		40	4549.82	II	
28	4396.86	II		28	4550.08	II	0 - 21971
55	4398.27	II		35	4550.83	II	1649 - 23617
180	4399.32	II		65	4552.26	I	0 - 21961
90	4400.02	II		200	4563.12	II	1744 - 23652
80	4400.25	II		22	4568.55	II	5079 - 26962
65	4403.29	II		65	4570.54	II	1744 - 23616
170	4403.60	II	5079 - 27782	28	4571.61	II	
100	4405.12	II		22	4572.13	I	1376 - 23242
430	4405.83	II	4437 - 27128	65	4576.33	II	3403 - 25249
65	4406.68	II		55	4578.17	II	2998 - 24835
1700	4408.82	II	0 - 22675	22	4592.12	II	
80	4412.15	II	2998 - 25657	28	4593.93	II	1744 - 23505
410	4413.77	II	1744 - 24394	28	4595.88	II	5108 - 26860

## Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	4596.93	II	11927 - 33674	28	4859.00	II	3403 - 23978
22	4598.95	I		55	4865.23	II	5108 - 25656
35	4600.38	II		22	4869.34	I	
22	4603.81	II		35	4876.26	II	5108 - 25610
40	4606.45	II	4437 - 26140	90	4877.84	II	3403 - 23898
140	4612.08	II	0 - 21676	11	4879.11	II	5079 - 25569
22	4617.72	I	0 - 21650	28	4882.24	I	0 - 20476
22	4618.00	II		13	4884.47	I	0 - 20467
35	4627.07	II	3893 - 25500	28	4886.04	II	5108 - 25569
270	4628.74	II	442 - 22040	55	4890.26	II	6418 - 26861
140	4632.28	I	4381 - 25963	45	4896.13	I	1377 - 21795
140	4635.68	I	0 - 21566	28	4901.48	II	7806 - 28202
200	4639.55	I	1376 - 22924	110	4906.99	I	4381 - 24754
80	4640.21	I	1376 - 22921	55	4912.62	II	7660 - 28010
110	4643.49	II	442 - 21971	140	4914.02	I	0 - 20344
140	4646.05	II	1744 - 23261	22	4915.41	I	
55	4647.00	I	0 - 21513	200	4924.60	I	1376 - 21677
200	4651.50	II	1649 - 23141	22	4925.32	I	
28	4658.09	II	0 - 21462	28	4925.66	II	4097 - 24393
35	4658.74	I	4381 - 25840	28	4932.15	I	0 - 20269
55	4660.91	I		140	4936.00	I	4381 - 24635
140	4664.65	II	3403 - 24835	40	4938.89	I	
270	4672.09	II	1744 - 23141	320	4939.74	I	2847 - 23085
55	4678.20	II	4098 - 25468	160	4940.30	I	1377 - 21613
40	4679.09	II	5079 - 26445	28	4943.73	II	3893 - 24115
55	4684.92	II	442 - 21781	380	4951.37	I	0 - 20190
180	4687.80	I		28	4956.06	I	0 - 20171
290	4695.77	I		80	4956.64	II	5079 - 25249
55	4707.55	II	1649 - 22886	55	4960.25	I	0 - 20154
140	4708.07	II	442 - 21676	28	4967.87	I	
140	4709.52	I	4381 - 25609	28	4970.93	I	
90	4713.11	I	0 - 21212	80	4974.92	I	1376 - 21471
90	4714.15	I	4381 - 25588	110	4975.75	I	4381 - 24473
55	4728.64	II	1744 - 22886	80	4976.39	I	0 - 20089
180	4730.67	I	1377 - 22509	90	4989.29	II	1744 - 21781
22	4733.74	I	4432 - 25551	90	5002.44	II	6414 - 26398
45	4734.17	II	2998 - 24115	45	5004.59	II	7806 - 27782
250	4736.69	I	0 - 21106	28	5015.56	II	1744 - 21676
28	4741.48	I		120	5018.59	I	0 - 19920
100	4744.16	I	0 - 21072	200	5019.76	I	2847 - 22762
90	4744.91	II	1649 - 22718	200	5026.96	I	1377 - 21264
150	4746.92	II	5079 - 26140	35	5031.97	II	
65	4756.03	II	442 - 21462	100	5033.38	I	0 - 19861
80	4757.91	II	1649 - 22660	270	5034.41	II	8958 - 28816
100	4762.72	II	3403 - 24394	65	5037.46	II	1649 - 21495
65	4765.24	II	2998 - 23978	110	5043.83	I	0 - 19820
20	4775.18	I		320	5045.52	I	4381 - 24195
28	4779.23	II	7660 - 28578	160	5053.40	I	1376 - 21159
110	4783.35	II	2998 - 23898	40	5063.40	I	1376 - 21120
16	4788.28	I	0 - 20878	28	5064.90	II	3403 - 23141
13	4799.93	II	1744 - 22571	28	5070.02	II	1744 - 21462
90	4801.13	II	3893 - 24716	45	5075.71	II	
28	4808.18	I	0 - 20792	180	5087.12	I	2847 - 22499
45	4814.32	II	8958 - 29724	360	5110.38	II	4098 - 23660
90	4822.98	II	1744 - 22472	560	5110.76	II	9255 - 28816
35	4827.30	I	4432 - 25142	40	5117.29	I	
40	4832.07	II	442 - 21131	22	5118.03	II	4437 - 23970
45	4837.03	II	1649 - 22317	410	5129.52	II	5226 - 24716
40	4839.51	II	4098 - 24755	270	5133.44	I	0 - 19474
28	4840.74			270	5135.14	II	7660 - 27128
11	4845.96	I		100	5139.81	I	1377 - 20827
40	4848.53	II	442 - 21061	28	5147.48	I	1377 - 20798
35	4853.67	I	4432 - 25029	28	5149.88	I	
22	4857.36	I	4432 - 25014	100	5152.30	II	442 - 19845
16	4858.57	II		80	5156.52	II	1744 - 21131

Praseodymium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
200	5161.74	II	3893 - 23261	28 c	5437.36	I	
28	5168.33	I	0 - 19343	16 h	5445.41	I	
620	5173.90	II	7806 - 27128	18	5457.06	I	
80	5175.27	II	1744 - 21061	28	5460.26	I	0 - 18309
45 c	5175.84	II	3403 - 22718	11	5469.71	I	
45	5177.36	I	2847 - 22156	22	5469.93	I	8080 - 26357
45	5183.84	II	5108 - 24394	35 c	5475.67	II	
22	5188.22	II	7438 - 26707	40	5479.75	I	
200	5191.32	II	3403 - 22661	16	5481.77	I	0 - 18237
120	5194.43	I	1376 - 20622	16	5485.54	I	
150	5195.11	II	8958 - 28202	16	5486.61	I	6313 - 24534
200	5195.31	II	6414 - 25657	45 c	5487.58	I	
80	5195.50	I		16	5488.94	I	7630 - 25844
360	5206.55	II	7660 - 26861	16	5490.57	I	
150	5207.90	II	6414 - 25610	28	5492.37	II	
45	5216.73	II	4098 - 23261	16 c	5497.25	I	
360	5219.05	II	6414 - 25569	16	5501.50	I	
560	5220.11	II	6418 - 25569	40	5508.79	II	
110	5227.97	I	0 - 19122	65	5509.15	II	3893 - 22040
22 c	5230.21	I		16 c	5511.63	II	1743 - 19882
22 c	5242.71	II	3403 - 22472	55	5513.58	II	7446 - 25578
20	5243.69	II		28	5515.12	II	8100 - 26226
22	5249.86	I	4432 - 23475	13	5519.38	II	11611 - 29724
65 c	5251.71	II	5079 - 24115	20 c	5520.31	II	
680	5259.73	II	5108 - 24115	45 c	5522.79	II	1744 - 19845
180	5263.88	II	3893 - 22886	28 c	5524.15	I	
16	5272.72	II	7438 - 26398	28 c	5525.91	II	3403 - 21495
22 c	5277.39	II		16 c	5527.93	I	
90	5285.65	II	3403 - 22317	13	5530.21	I	
45	5289.34	I	4866 - 23767	45	5531.16	I	
340 c	5292.02	II	5079 - 23970	150	5535.17	II	7438 - 25500
340	5292.62	II	5226 - 24115	28	5538.37	I	8734 - 26784
230	5298.09	II	5108 - 23978	20	5538.78	II	
22	5308.96	II	6418 - 25249	55	5545.01	II	7438 - 25467
90	5311.11	II	8958 - 27782	20	5548.33	II	7744 - 25763
65 cw	5312.37	II	5079 - 23898	11	5553.42	II	9378 - 27380
28	5313.41	II		22	5561.46	II	
16	5316.56	I		45 c	5562.06	I	
90	5321.07	II	4098 - 22886	13	5565.52	I	
40	5321.81	II	7660 - 26445	13	5566.91	II	
430	5322.76	II	3893 - 22675	45	5571.83	II	4098 - 22040
65 cw	5331.48	II	5226 - 23978	11	5574.61	II	8465 - 26398
16	5341.55	I		11	5578.81	I	4866 - 22786
20	5342.58	II		13	5582.35	II	8490 - 26398
55	5343.89	II	7438 - 26146	11	5584.02	II	
200	5352.40	II	3893 - 22571	22	5594.92	I	
35	5358.99	I	4432 - 23087	22	5597.29	II	
18	5372.37	I	4866 - 23475	13	5601.30	II	10730 - 28578
18	5374.24	I		90	5605.65	II	7744 - 25578
13	5377.45	II		13	5606.68	I	
18	5381.26	II	4098 - 22675	28	5608.93	II	1744 - 19567
18	5381.70	II		55	5610.22	II	9379 - 27198
28 c	5395.83	I		11	5620.06	II	16243 - 34031
13	5400.95	I		20	5620.26	I	
28	5402.59	I		45 c	5621.89	II	3893 - 21676
18	5404.80	II	8465 - 26962	110	5623.05	II	10730 - 28509
45 cwd	5410.54	II		90	5624.45	II	12244 - 30018
55	5411.54	II	4098 - 22571	11 h	5633.03	I	
80 cw	5413.22	II	442 - 18910	22	5636.46	II	8490 - 26226
28	5422.36	I		55 c	5638.79	II	5079 - 22809
18	5427.24	I	8734 - 27154	16	5640.37	II	
18	5427.96	II		16 cw	5643.16	I	
28	5432.05	II	7438 - 25842	22	5645.41	II	
18	5432.58	II		35	5654.23	II	8465 - 26146
18	5432.90	I		55	5659.84	II	

Praseodymium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35 h	5661.57	I	10720 - 28378	80	5868.83	II	8465 - 25500
16	5662.19	II	8490 - 26146	22	5873.83	II	9378 - 26398
65 c	5668.46	I		35	5874.72	I	8080 - 25098
45	5669.55	II		35	5878.10	I	9647 - 26654
35	5669.99	II		35	5879.04	I	
16	5674.14	II		80	5879.25	II	11005 - 28010
16	5677.03	II	5108 - 22718	35 c	5884.72	I	5823 - 22811
55	5681.89	II	9379 - 26974	55	5892.23	II	11611 - 28578
13	5685.60	II	9379 - 26962	22	5894.22	II	
16	5686.52	I		40	5903.11	II	
22 h	5687.17	II	4098 - 21676	45	5904.45	II	10030 - 26962
65	5688.44	II		40	5908.67	II	
22	5689.21	II	11005 - 28578	11	5915.31	I	
55 h	5690.97	II		11	5915.97	I	7630 - 24529
22	5695.90	II	9647 - 27198	40	5920.76	I	9647 - 26532
22	5704.38	I	14262 - 31787	40	5930.66	II	10117 - 26973
65	5707.61	I		16	5936.33	II	
40	5711.63	II	11005 - 28509	160	5939.90	II	10030 - 26861
22	5713.83	II		65	5940.72	II	11749 - 28578
16	5716.08	II		22	5941.65	I	
45	5719.08	II	6418 - 23898	35	5947.16	II	10163 - 26973
45 d	5719.63	II	8100 - 25578	22 c	5949.76	I	
	5719.80	II		55	5951.27	II	9647 - 26445
11	5728.38	I		20	5951.76	II	8966 - 25763
40	5731.88	II		90	5956.60	II	11794 - 28577
20	5747.13	II			5956.70	I	
11	5747.74	I	8080 - 25473	13	5959.25	I	
11	5747.95	II	5079 - 22472	20	5962.18	I	
22	5753.02	II	8465 - 25842	28	5963.00	I	8733 - 25498
90	5756.17	II	8100 - 25467	110	5967.82	II	9647 - 26398
16	5759.40	II		13 c	5976.95	I	
22	5760.20	I		13	5978.88	I	8734 - 25454
22	5769.16	II	9378 - 26707	65	5981.19	II	11794 - 28509
16	5769.79	II	9647 - 26973	40	5986.14	I	
45	5773.16	II	7438 - 24755	45 c	5987.14	I	
11	5775.91	II	7447 - 24755		5987.29	II	10163 - 26860
16	5777.29	II	10730 - 28034	13	5991.27	I	
90	5779.28	I		13 c	5994.89	I	
65 c	5785.28	II		11	5996.06	I	9684 - 26357
65	5786.17	II	7438 - 24716	29	6002.44	II	8100 - 24755
16 h	5788.29	II		90	6006.33	II	13374 - 30018
16	5788.92	II	7446 - 24716	13	6008.54	I	8835 - 25474
16	5790.86	II	10117 - 27380	55	6016.48	II	8100 - 24716
45	5791.36	II	9379 - 26641	150	6017.80	II	8966 - 25578
22	5792.95	I		28 c	6019.85	I	
40	5810.58	II	11611 - 28816	150	6025.72	II	11611 - 28202
16	5813.55	II	11005 - 28202	35	6042.87	II	10163 - 26707
160 d	5815.17	II	8465 - 25657	55	6046.66	II	9045 - 25578
	5815.33	II	12827 - 30018	35	6049.26	I	7630 - 24156
55	5818.57	II	9045 - 26226	28	6050.04	II	10117 - 26641
40	5820.62	II		11	6050.88	I	8835 - 25357
16 h	5821.36	I		140	6055.13	I	8080 - 24591
55	5822.59	II		13	6067.27	II	10163 - 26641
90	5823.72	II	1744 - 18910	13	6085.81	I	8250 - 24677
45	5830.94	II	8465 - 25610	28	6086.16	II	10536 - 26962
40	5835.13	I	4866 - 21999	65	6087.52	II	9045 - 25467
35 c	5844.65	II	5079 - 22184	20	6090.38	II	10030 - 26445
40	5844.98	II		28	6093.09	II	11794 - 28202
65	5847.13	II	10030 - 27128	18	6096.28	I	
65 c	5850.64	II	3403 - 20491	22	6106.72	II	9129 - 25500
45	5852.63	II	10117 - 27198	18	6109.08	I	8733 - 25097
11 c	5854.44	I		65	6114.38	II	13374 - 29724
45	5856.07	II		22 c	6118.02	I	8250 - 24591
55	5856.90	II		22 c	6122.15	I	
90	5859.68	II	11448 - 28509	35	6141.51	II	9379 - 25657

## Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	6148.23	I	6714 - 22974	22	c	6497.11	I
	6148.24	II	11749 - 28010	18		6498.94	II
22	6157.82	II	10163 - 26398	22		6500.72	I
13	6159.10	II	9379 - 25610	9		6504.09	I
190	6161.18	II	8490 - 24716	8		6517.14	I
18	6165.38	I	9646 - 25861	16		6518.79	II
270	6165.94	II	7447 - 23660	8		6534.52	I
55	6182.34	II	11611 - 27782	16		6540.47	I
13	6187.96	I	9684 - 25840	7	h	6553.30	I
35	6197.45	II	10730 - 26861	22		6564.62	II
35	6200.81	II	11005 - 27128	45		6566.77	II
13	6205.63	II	10117 - 26226	7		6571.03	I
13	6210.59	I	6714 - 22811	6		6578.00	I
22	6212.73	I		6		6584.56	II
18	6218.06	I		9	h	6593.74	II
20	h	6236.80	I	11		6595.48	I
20	h	6241.05	I	15		6609.86	I
45	6244.35	II	9647 - 25657	55		6616.67	I
35	6255.10	II	10163 - 26146	11		6618.34	II
40	6262.55	II	9647 - 25610	7	h	6631.00	I
18	6264.54	II	12244 - 28202	13	h	6632.06	I
22	c	6274.66	II	14		6647.12	I
	6274.81	II	1743 - 17676	75		6656.83	II
40	6278.68	II	9647 - 25569	55		6673.41	II
110	6281.28	II	7744 - 23660	75		6673.78	II
18	c	6289.02	I	5	h	6687.51	II
11	c	6298.01	I	4	h	6699.25	I
11		6302.05	I	13		6736.79	I
35		6302.35	II	35	c	6747.09	I
16		6304.05	I	19	c	6749.19	I
35		6305.23	II	7	c	6784.99	II
11	h	6318.13	II	55	cw	6798.60	I
45	c	6322.36	I	11		6811.76	II
22	h	6343.88	I	17	cw	6812.87	II
28		6347.11	II	13		6814.04	II
18	c	6350.98	I	9		6817.61	I
22	c	6357.20	I	35	cw	6827.60	II
55	c	6359.03	I	19		6830.50	II
11	h	6363.62	II	9		6844.39	I
16		6377.61	I	9	h	6845.47	II
16		6378.59	I	9		6846.59	II
11		6389.57	I	17	c	6850.46	II
18	c	6391.99	I	11		6852.77	I
40		6393.18	I	11	c	6870.44	I
45		6397.96	II	7		6884.66	I
10	h	6410.69	I	8		6892.71	I
55		6411.23	I	8	h	6970.38	
40		6413.68	II	8	c	6980.12	I
10		6415.43	I	40		7021.51	II
45		6429.63	II	10		7024.53	I
45		6431.84	II	13		7042.40	I
7	h	6442.78	II	8		7044.45	II
9	h	6443.91	II	7		7051.07	I
16	c	6453.44	I	10		7079.99	I
9		6454.84	II	11	c	7095.18	I
9		6456.18	I	20		7114.55	I
9	h	6460.19	I	10	h	7116.90	I
18		6467.72	II	11		7118.24	II
9	h	6475.26	II	7		7137.33	II
35	cw	6478.02	II	10	h	7159.88	I
45		6486.55	I	7		7167.77	II
9	h	6486.97	II	7	h	7189.95	I
40	h	6491.75	I	10	c	7208.85	II
9		6493.49	I	24		7227.70	II
11		6494.89	I	13		7231.53	I

Praseodymium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
7 c	7243.26	I		6 cw	7841.27	I	
7 c	7259.21	I	4432 - 18204	14	7871.67	I	
7 c	7287.61	I		6	7881.09	I	7630 - 20315
7 h	7289.19	I	10411 - 24126	6 cw	7888.56	II	1743 - 14416
7 cw	7324.42	I	8320 - 21970	6	7915.19	II	10030 - 22661
7	7328.47	I	10432 - 24073	6	8031.92	I	6893 - 19340
7	7344.86			6	8055.43	I	6893 - 19304
16	7407.56	II	14706 - 28202	14	8067.44	I	
20 c	7451.74	II	13029 - 26445	10 cw	8122.78	II	
11 h	7495.59	I	4866 - 18204	11	8141.10	I	
6 h	7499.42	I		5	8181.34	II	13029 - 25249
14	7541.02	II	0 - 13257	5 c	8211.93	I	
6	7574.86	I		6	8289.93	I	
20	7645.66	II	14706 - 27782	6	8379.84	I	
7	7704.98	II	11419 - 24394	6 h	8427.82	I	15470 - 27332
16	7721.84	I		6 h	8605.27	II	10163 - 21781
6 h	7786.16	II	3403 - 16243	10	8714.59	II	7438 - 18910

# Rhenium

$$\text{Re, } Z = 75, M = 186.2, \text{ Ratio } \frac{\text{Re}}{\text{Cu}} = 2.930$$

Re I Normal state of valence electrons  $5d^5 6s^2 \ ^6S_{21/2} = 0$ . I.P. = 63530  $\text{cm}^{-1}$ .

Re II Normal state of valence electrons  $5d^5 6s \ ^7S_3 = 0$ . I.P. = 134000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

W. F. Meggers, J. Research NBS **49**, 187 (1952) RP 2355.

### Classification:

Re I, P. F. A. Klinkenberg, W. F. Meggers, R. Velasco, and M. A. Catalán, J. Research NBS **59**, 319 (1957) RP 2804.

Re II, W. F. Meggers, M. A. Catalán, and M. Sales, J. Research NBS **61**, 441 (1958) RP 2914.

### Strong lines of rhenium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
55000 c	3460.46	I	0 - 28890	4000	3399.30	I	11754 - 41164
40000 c	3464.73	I	0 - 28854	4000	3725.76	I	23632 - 50464
27000	2049.08	I	0 - 48786	3700	2083.92	I	0 - 47971
25000	2003.53	I	0 - 49895	3700	2156.67	I	0 - 46353
16000	2017.87	I	0 - 49541	3600 c	4227.46	I	18950 - 42598
16000 c	3451.88	I	0 - 28962	3400	2139.04	II	
10000	2085.59	I	0 - 47932	3400	2176.21	I	0 - 45937
9800	2097.12	I	0 - 47669	2900	2287.51	I	0 - 43702
8000	3424.62	I	11754 - 40946	2900	2887.68	I	11754 - 46374
5500	2999.60	I	11754 - 45083	2700	2109.22	I	
5200 c	2275.25	II	0 - 43938	2700	2294.49	I	0 - 43569
4900	2167.94	I	0 - 46112	2600	4513.31	I	20448 - 42598
4700	2092.41	II		2500	2428.58	I	0 - 41164
4200	2074.70	I	0 - 48184	2200	2214.58	I	
4200 c	2214.26	II	0 - 45148	2200 cw	4889.14	I	0 - 20448



Rhenium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
25000	2003.53	I	0 - 49895	180	2381.14	I	11754 - 53738
16000	2017.87	I	0 - 49541	180	2383.46	I	14217 - 56160
27000	2049.08	I	0 - 48786	180	2386.90	II	20976 - 62859
4200	2074.70	I	0 - 48184	85	2387.46	I	16307 - 58180
3700	2083.92	I	0 - 47971	340	2388.57	I	
10000	2085.59	I	0 - 47932	170	2389.11	I	0 - 41844
4700	2092.41	II		170	2390.43	I	
9800	2097.12	I	0 - 47669	85	2391.28	I	11584 - 53390
2700	2109.22	I		230	2393.65	I	13826 - 55590
3400	2139.04	II		320	2394.37	I	11584 - 53336
1600	2142.74	II		320	2396.79	I	11584 - 53294
	2142.97	I	0 - 46649	200	2397.31	I	15166 - 56866
3700	2156.67	I	0 - 46353	75	2398.71	I	16619 - 58295
4900	2167.94	I	0 - 46112	75	2398.89	I	
3400	2176.21	I	0 - 45937	210	2400.72	I	15058 - 56699
					2400.89	I	
4200	c 2214.26	II	0 - 45148	210	2401.68	I	11754 - 53379
2200	2214.58	I		150	2402.60	I	
1700	2226.42	I	0 - 44901	75	2403.04	II	23341 - 64942
920	2235.44	I	0 - 44720	150	2404.34	I	
440	2255.73	I	11584 - 55902	1500	2405.06	I	11754 - 53321
860	2256.19	I	0 - 44309	740	2405.60	I	0 - 41557
2000	2264.39	I	0 - 44148	320	2406.70	I	
2100	2274.62	I	0 - 43950	270	2410.37	I	11584 - 53059
5200	c 2275.25	II	0 - 43938	120	2410.99	I	
1600	2281.62	I	0 - 43815	180	2413.22	I	
2900	2287.51	I	0 - 43702	120	2414.59	I	15770 - 57173
2700	2294.49	I	0 - 43569	120	2416.30	I	
390	2298.09	II	27628 - 71128	120	2416.44	I	11584 - 52954
390	2299.77	I	11755 - 55224	120	2417.66	I	16307 - 57657
610	2302.99	I	0 - 43408	60	2418.20	II	25988 - 67328
680	2306.54	I	0 - 43342	170	2419.40	I	15770 - 57090
230	2312.97	I	15058 - 58280	1200	2419.81	I	0 - 41313
220	2313.34	I		170	2421.38	I	15166 - 56452
220	2319.19	I	16307 - 59412	300	2421.73	I	14621 - 55901
370	2320.16	I	16307 - 59394	300	2421.88	I	
800	2322.49	I	0 - 43044	60	2423.50	I	15058 - 56308
300	2328.66	I	11584 - 54514	60	2423.84	II	
270	2334.33	I	11584 - 54410	60	2425.38	I	
270	2335.73	I	11754 - 54554	100	2426.64	I	16328 - 57524
220	2336.10	I	16619 - 59412	2500	2428.58	I	0 - 41164
270	2337.95	I	11754 - 54514	110	2429.65	I	16307 - 57453
860	2344.78	I		490	2431.54	I	
140	2345.28	I	13826 - 56452	420	2432.18	I	11754 - 52857
140	2347.06	I	11584 - 54177	150	2432.70	I	15166 - 56260
230	2349.39	I	14621 - 57173	170	2433.28	I	16307 - 57391
220	d 2350.46	I		100	2433.61	I	
680	2352.07	I	11584 - 54087	100	2436.05	I	16619 - 57657
210	d 2353.95	I		180	2438.46	I	13826 - 54823
	2354.08	I	11754 - 54221	140	2439.06	I	11754 - 52741
250	2356.50	I	11754 - 54177	75	2440.41	I	
200	2365.32	I		75	2440.58	I	
1200	2365.90	I	0 - 42254	340	c 2441.47	I	0 - 40946
570	2367.68	I	15058 - 57281	230	2442.51	I	15770 - 56699
180	2368.53	II	14930 - 57139	85	2444.09	I	
520	2369.27	I	11755 - 53949	250	2444.94	I	11584 - 52472
220	2370.76	II	14883 - 57050	610	2446.98	I	15058 - 55912
210	2371.52	I	11584 - 53738	120	2448.20	I	
150	2373.48	II	14930 - 57050	85	2449.03	II	18846 - 59666
320	2375.07	I	14217 - 56308	85	2449.52	II	26237 - 67049
150	2375.82	I	11584 - 53662	610	2449.71	I	0 - 40809
100	2377.33	I		85	2450.89	I	11584 - 52373
75	2378.53	II	27746 - 69776	85	2453.14	I	16619 - 57372
370	2379.77	I		200	2455.83	II	14352 - 55059
180	2380.22	I	16619 - 58619	60	2455.99	I	
75	2380.89	I	16307 - 58295				

Rhenium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	2460.24	I	11584 - 52218	300	2552.02	I	14217 - 53390
390	2461.20	I	11754 - 52373	35	2552.73	I	14217 - 53379
800	2461.84	II		150	2553.59	II	17224 - 56372
85	2462.54	I		75	2554.18	I	
110	2463.31	I	13826 - 54410	370	2554.63	II	20463 - 59596
120	2465.13	I	16619 - 57173	60	2554.93	I	13826 - 52954
200	2467.57	II	14930 - 55444	1000	2556.51	I	14217 - 53321
120	2467.85	II	26768 - 67276	150	2558.06	I	17331 - 56411
150	2469.36	II	18846 - 59330	250	2559.08	I	0 - 39065
60	2470.05	I		75	2559.71	I	13826 - 52881
120	2470.61	II	20463 - 60927	75	2559.88	I	15770 - 54823
75	2471.05	II	19140 - 59596	150	2561.46	I	15058 - 54087
150	2473.72	II		150	2563.01	I	
160	2474.73	I	15058 - 55454	340	2564.19	I	11584 - 50571
160	2475.17	II	23894 - 64282	75	2565.84	I	21775 - 60737
75	2476.28	I	11584 - 51955	35	2566.57	I	
75	2477.43	II		540	2568.64	II	14883 - 53802
200	2479.02	I	17331 - 57657	150	2571.26	I	11584 - 50464
180	2480.82	I	14217 - 54514	370	2571.81	II	14930 - 53802
1200	2483.92	I	11754 - 52001	150	2573.76	I	14217 - 53059
390	2485.81	I	16307 - 56523	50	2574.21	I	16619 - 55454
120	2486.78	I	11754 - 51955	75	2576.32	I	17331 - 56134
60	2486.97	I		50	2578.12	I	
980	2487.33	I	11755 - 51946	150	2579.01	I	15166 - 53929
75	2490.16	II	30982 - 71128	100	2580.31	I	15770 - 54514
200	2492.84	I	13826 - 53929	150	2581.44	I	11584 - 50311
150	2495.26	I	11584 - 51648	110	2582.77	I	
370	2496.04	I	14217 - 54268	75	2584.77	I	15166 - 53842
35	2496.70	I	17331 - 57372	380	2586.79	I	11754 - 50401
200	2498.22	I	13826 - 53843	65	2587.00	I	13826 - 52469
110	2498.86	I	11584 - 51590	65	2591.13	I	17331 - 55912
75	2500.31	I	22160 - 62143	180	2591.59	I	11584 - 50159
140	2500.57	I	23956 - 63935	90	2592.84	I	11755 - 50311
370	2501.72	I	14217 - 54177	160	2594.85	I	11584 - 50110
570	2502.35	II	20976 - 60927	180	2595.23	I	0 - 38521
230	2504.60	II	17224 - 57139	110	2596.40	I	
75	2505.43	I		160	2596.78	I	15770 - 54268
270	2505.94	I	11754 - 51648	110	2596.95	I	16327 - 54823
150	2507.40	I	14217 - 54087	65	2597.96	I	
1800	2508.99	I	0 - 39845	290	2599.86	I	13826 - 52278
75	2512.55	I	14621 - 54410	65	2600.87	I	14621 - 53059
75	2514.51	I		90	2601.87	I	16307 - 54730
60	2515.47	I		55	2602.55	I	
120	2516.12	I	11754 - 51486	90	2602.93	I	15770 - 54177
50	2517.08	I		130	2603.46	I	
570	2520.01	I	0 - 39670	290	2603.89	I	
540	2521.50	I	14621 - 54268	55	2607.32	I	
110	2525.55	I		660	2608.50	II	14352 - 52677
60	2526.81	I	13826 - 53390	610	2611.54	I	
140	2529.50	I	14217 - 53738		2611.60	I	11584 - 49863
150	2533.31	I	13826 - 53288	110	2613.74	I	15770 - 54018
150	2534.10	II	14352 - 53802	160	2614.56	I	14621 - 52857
370	2534.80	I	11754 - 51193	55	2615.68	I	
110	2539.33	I	17331 - 56699	160	2616.72	II	18846 - 57050
570	2540.51	I	11584 - 50934	100	2617.11	I	
110	2543.67	I	15166 - 54467	90	2617.44	I	16619 - 54813
60	2543.84	I	13826 - 53125	170	2620.03	I	14217 - 52373
110	2544.22	I	16619 - 55912	170	2620.34	I	21775 - 59927
740	2544.74	I	11584 - 50869	200	2622.76	I	
	2544.88	I		90	2623.28	I	11754 - 49863
370	2545.48	I	11754 - 51028	45	2625.04	I	11584 - 49667
110	2548.14	I	13826 - 53059	55	2630.75	I	15058 - 53059
150	2548.88	I	14621 - 53842	90	2631.57	I	11584 - 49573
60	2549.37	I	17238 - 56452	45	2633.01	I	15770 - 53738
160	2550.09	II	20463 - 59666	130	2633.61	I	15166 - 53125

Rhenium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
310	2635.83	II	17224 - 55151	65	2741.97	I	22160 - 58619
550	2636.64	I	0 - 37916	65 d	2742.74	I	
190	2637.01	II	19140 - 57050		2742.86	I	15770 - 52218
90	2641.02	II	14824 - 52677	90	2743.87	I	16307 - 52741
270	2642.75	I	11754 - 49583	140	2747.44	I	11584 - 47971
160	2647.13	I	0 - 37766	75	2752.85	I	11584 - 47899
65	2648.46	II	14930 - 52677	130	2753.05	I	14621 - 50934
270	2649.05	I	14217 - 51955	110 h	2753.64	II	19140 - 55444
45	2649.58	I	17238 - 54969	55	2755.21	I	13826 - 50110
660	2651.90	I	0 - 37698	55	2757.49	I	
130	2652.91	I	15058 - 52741	220	2758.00	I	14621 - 50869
400	2654.12	I	11584 - 49250	55	2758.71	I	16619 - 52857
45	2655.18	I	13826 - 51477	110	2761.93	I	11584 - 47780
45	2655.84	I	16307 - 53949	90	2763.30	I	11754 - 47932
65	2659.02	I	14621 - 52218	210	2763.79	I	15058 - 51230
65	2659.79	I	26349 - 63935	200	2766.39	I	27130 - 63268
45	2660.54	I		310	2767.74	I	11584 - 47704
220	2663.63	I	11755 - 49286	220	2768.85	I	11754 - 47860
65	2664.22	I	15770 - 53294	220	2769.32	I	
65	2664.81	I	16327 - 53842	350	2770.42	I	11584 - 47669
65	2667.13	I	17331 - 54813	170	2773.11	I	17238 - 53288
65	2670.24	I	11584 - 49023	75	2777.71	I	17331 - 53321
110	2670.79	I	14217 - 51648	90	2778.09	I	
160	2671.84	I	11754 - 49171	75	2778.50	I	14218 - 50197
75	2672.77	I		180	2781.43	I	14217 - 50159
940	2674.34	I	0 - 37381	550	2783.57	I	11754 - 47669
160	2677.03	I		160	2785.21	I	14217 - 50110
130	2677.76	I	14621 - 51955	55	2786.14	I	21775 - 57657
130	2679.10	I	15058 - 52373	120	2786.56	I	15058 - 50934
160	2679.91	I	22160 - 59464	90 c	2789.27	I	13826 - 49667
130	2683.56	I	22160 - 59412	140	2790.94	I	15770 - 51590
65	2685.31	I		220	2791.29	I	16307 - 52122
220	2688.53	I	15770 - 52954	45	2793.66	I	
110 h	2690.25	I	16307 - 53467	100	2798.10	I	17331 - 53059
45 h	2690.79	I		140 h	2800.75	I	
75	2694.39	I	11754 - 48858	55 h	2802.25	I	
160	2695.56	I	15770 - 52857	120	2803.28	II	13777 - 49439
90	2697.26	I	0 - 37064	100	2807.86	I	11754 - 47358
45	2698.79	I	16619 - 53662	55	2812.07	I	17331 - 52881
35	2699.58	I	11754 - 48786	75	2812.36	I	16328 - 51874
75	2702.67	I		55	2813.11	I	14621 - 50159
130	2704.37	I	16327 - 53294	170	2813.96	I	17331 - 52857
45	2706.06	I	15058 - 52001	220	2814.68	I	11584 - 47102
35	2707.40	I		170	2816.32	I	22160 - 57657
45	2710.22	I		100	2816.96	I	14621 - 50110
65	2712.48	I	14621 - 51477	75	2819.78	II	17224 - 52677
90	2713.02	I	16619 - 53467	880	2819.95	I	11754 - 47206
65	2713.16	I	17331 - 54177	110	2822.12	I	13826 - 49250
1300	2715.47	I	11754 - 48570	110	2824.25	I	21775 - 57173
180	2715.77	I	14217 - 51028	100	2825.46	I	16619 - 52001
65	2716.75	I	16327 - 53125	110	2827.52	I	14217 - 49573
45	2719.54	I	16619 - 53379	55	2830.35	I	
180	2722.21	I		310	2834.08	I	14621 - 49896
190	2722.70	I	14217 - 50934	200	2837.55	I	22160 - 57391
100	2723.84	I	15770 - 52472	200	2840.35	I	13826 - 49023
110	2727.55	I	14217 - 50869	220	2843.00	I	15770 - 50934
45	2728.63	I	13826 - 50464	100	2844.16	I	11584 - 46733
65	2729.64	I	16327 - 52952	100	2846.97	I	
45	2730.83	I	14621 - 51230	270	2850.98	I	11584 - 46649
200	2731.56	II	18846 - 55444	90	2852.84	I	17331 - 52373
220	2732.21	I	15058 - 51648	55	2860.07	I	14217 - 49171
610	2733.04	II	17224 - 53802	55	2860.25	I	14621 - 49573
55	2734.31	I	14621 - 51183	55	2864.56	I	27244 - 62143
90	2738.32	I	15770 - 52278	240	2867.19	I	16619 - 51486
120	2739.94	I		160	2871.82	I	14217 - 49028

Rhenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	2872.30	I	15058 - 49863	170	2995.40	I	30560 - 63935
45	2872.67	I	15770 - 50571	5500	2999.60	I	11754 - 45083
200	2875.28	I	11584 - 46353	350	3001.14	I	14621 - 47932
65	2879.27	I	16307 - 51028	220	3004.14	I	14621 - 47899
200	2883.44	I	17331 - 52001	65	3004.34	I	13826 - 47102
65	2884.04	I	23956 - 58619	200	3006.42	I	15770 - 49023
110	2884.64	I		130	3011.92	I	11754 - 44946
65	2887.31	I	17331 - 51955	190	3013.14	I	13826 - 47004
2900	2887.68	I	11754 - 46374	500	3016.02	I	11754 - 44901
130	c 2888.06	II	14824 - 49439	300	3016.49	I	14217 - 47358
90	2889.45	I	11754 - 46353	40	3016.97	I	11584 - 44720
100	2891.48	I	16619 - 51193	120	3021.88	I	14621 - 47704
180	2891.88	I	14217 - 48786	60	3022.99	I	17331 - 50401
160	2892.63	I	19458 - 54018	380	3030.45	I	14217 - 47206
110	2894.32	I	15770 - 50311	60	3031.27	I	23155 - 56134
45	2895.65	I	15058 - 49583	60	3032.79	I	16619 - 49583
490	2896.01	I	0 - 34520	130	3034.55	I	20448 - 53392
35	2898.79	I	20482 - 54969	60	3036.55	I	16327 - 49250
830	c 2902.48	I	18950 - 53392	100	3037.96	I	13826 - 46733
210	2905.58	I	14621 - 49028	130	3040.03	I	14217 - 47102
180	2906.02	I	14621 - 49023	100	3041.00	I	15058 - 47932
100	2908.34	I		60	3041.99	I	16307 - 49171
550	2909.82	I	16307 - 50663	60	3042.29	I	
55	2910.08	I	11584 - 45937	100	3044.08	I	15058 - 47899
65	2913.15	I	17331 - 51648	240	3047.25	I	28030 - 60837
65	h 2916.73	II	25321 - 59596	100	3053.63	I	21775 - 54514
65	2918.88	I	16619 - 50869	130	3054.90	I	11584 - 44309
100	2919.41	I	16327 - 50571	90	3057.66	I	16327 - 49023
160	2924.60	I	11754 - 45937	200	3058.78	I	13826 - 46509
120	2925.20	I	26661 - 60837	130	3060.32	I	16619 - 49286
65	2926.93	I	17331 - 51486	100	3061.61	I	22160 - 54813
830	c 2927.42	I	11754 - 45904	70	3064.60	I	17238 - 49860
180	2929.53	I	15770 - 49895	1600	3067.40	I	0 - 32592
270	2930.61	I	15058 - 49171	320	3069.94	I	11584 - 44148
65	2932.31	I	15770 - 49863	260	3071.16	I	16619 - 49171
130	2936.50	I	16619 - 50663	200	3072.96	I	17331 - 49863
45	2941.56	I	20482 - 54467	90	3076.14	I	15166 - 47665
440	2943.14	I	14217 - 48184	100	3078.86	I	11754 - 44225
65	2944.32	I	13826 - 47780	550	3082.43	I	14217 - 46649
65	2946.57	I	20482 - 54410	180	3084.21	I	15770 - 48184
120	2949.09	I	17331 - 51230	90	3087.15	I	14621 - 47004
65	2949.88	I	16307 - 50197	340	3088.76	I	11584 - 43950
130	2950.83	I	11584 - 45463	110	3089.94	I	22160 - 54514
120	2954.34	I	13826 - 47665	200	3093.64	I	13826 - 46141
130	h 2957.91	II	23341 - 57139	200	3095.06	I	15058 - 47358
140	2961.74	I	14217 - 47971	180	3095.79	I	14217 - 46509
270	2962.27	I	11584 - 45332	100	3096.41	I	13826 - 46112
65	2962.87	I	22160 - 55901	700	3100.67	I	16327 - 48569
720	2965.11	I	14217 - 47932	140	3103.06	II	17224 - 49439
1500	2965.76	I	11754 - 45463	140	3103.26	II	
90	2967.25	I	16619 - 50311	140	3104.65	I	15770 - 47971
180	2968.04	I	14217 - 47899	700	3108.81	I	14217 - 46374
90	2968.98	II		340	3110.86	I	14217 - 46353
75	2975.02	I	17331 - 50934	140	3111.56	I	15770 - 47899
120	2975.25	I	19458 - 53059	340	c 3118.19	I	11754 - 43815
310	2976.29	I	0 - 33589	340	3121.36	I	14621 - 46649
65	2977.30	I	16619 - 50197	70	3123.16	I	15770 - 47780
210	2978.15	I	16327 - 49895	70	3125.52	I	11584 - 43569
220	2980.82	I	11584 - 45122	420	3128.94	I	16619 - 48569
65	2981.01	I	19758 - 53294	260	3134.02	I	15770 - 47669
220	2982.19	I		70	3139.79	I	17331 - 49171
65	2984.75	I	19458 - 52952	70	3139.94	I	15166 - 47004
220	2988.47	I	14217 - 47669	250	3141.38	I	11584 - 43408
1800	2992.36	I	0 - 33409	140	3142.65	I	
65	2992.82	I		70	3151.16	I	19458 - 51183

Rhenium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
440	3151.64	I	14217 - 45937	2000	3338.18	I	20448 - 50396
330	3153.79	I	11754 - 43453	140	3339.68	I	17238 - 47173
360	3158.31	I	11754 - 43408	1600	3342.24	I	20448 - 50359
220	3164.52	I	15058 - 46649	810	3344.32	I	20448 - 50341
50	3167.16	I	16619 - 48184	320	3346.20	I	13826 - 43702
700	3168.37	I	16307 - 47860	130	3353.21	I	16327 - 46141
140	3173.09	I	13826 - 45332	160	3355.29	I	22423 - 52218
220	3174.61	I	14621 - 46112	240	d 3356.33	I	22160 - 51946
140	3174.78	I	27130 - 58619		3356.46	I	16327 - 46112
440	3177.71	I	11584 - 43044	200	3358.02	I	17331 - 47102
260	3178.61	I	15058 - 46509	160	3359.22	I	23632 - 53392
70	3182.66	I	19458 - 50869	160	3361.14	I	13826 - 43569
600	3182.87	I	18950 - 50359	200	3362.74	I	11584 - 41313
1100	3184.76	I	18950 - 50341	160	d 3365.73	I	23155 - 52857
1100	3185.57	I	18950 - 50333		3365.84	I	21775 - 51477
120	3186.29	I	27244 - 58619	240	3377.74	I	16307 - 45904
150	3190.17	I	16328 - 47665	320	3379.06	II	14352 - 43938
260	3190.78	I	17238 - 48569	320	3379.70	I	11584 - 41164
260	3192.36	I	14621 - 45937	160	3384.45	I	27161 - 56699
140	3193.20	I	22160 - 53467	200	3385.76	I	14621 - 44148
200	3194.50	I	15058 - 46353	240	3389.43	I	17238 - 46733
220	3198.58	I	14621 - 45876	200	3390.25	I	22160 - 51648
70	3199.49	I	14217 - 45463	80	3394.12	I	21775 - 51230
150	3200.04	I	16619 - 47860	80	3397.21	I	26349 - 55777
100	3200.72	I	15770 - 47004	4000	3399.30	I	11754 - 41164
1100	c 3204.25	I	16307 - 47507	80	3401.17	I	
70	3205.42	I	24724 - 55912	650	3404.72	I	11584 - 40946
140	3211.75	I	14217 - 45343	650	3405.89	I	14217 - 43569
120	3212.94	I	14217 - 45332	240	3408.67	I	14621 - 43950
70	3213.49	I		320	3409.83	I	17331 - 46649
120	3214.11	I	26349 - 57453	80	3413.74	I	16619 - 45904
150	3227.46	I	15166 - 46141	320	3417.77	I	15058 - 44309
70	3228.73	I	15770 - 46733	810	3419.41	I	14217 - 43453
380	3235.94	I	13826 - 44720	160	3420.75	I	11584 - 40809
150	3237.51	I	15058 - 45937	8000	3424.62	I	11754 - 40946
80	3241.47	I	14621 - 45463	400	3426.19	I	17331 - 46509
80	3248.55	I	16327 - 47102	300	3427.61	I	15058 - 44225
150	3252.26	I	15770 - 46509	320	3437.71	I	14621 - 43702
600	3258.85	I	16327 - 47004	80	3441.25	I	
600	3259.55	I	11584 - 42254	60	3442.97	I	16307 - 45343
200	3261.56	I	15166 - 45817	400	3449.37	I	15166 - 44148
120	3262.77	I	17331 - 47971	16000	c 3451.88	I	0 - 28962
120	3266.85	I	17331 - 47932	80	3453.28	I	15770 - 44720
150	3268.48	I	16619 - 47206	240	3453.50	I	14621 - 43569
300	3268.89	I	15770 - 46353	160	3458.88	I	17238 - 46141
160	3277.71	I	14621 - 45122	55000	c 3460.46	I	0 - 28890
160	3285.64	I	17238 - 47665	40000	c 3464.73	I	0 - 28854
80	3287.13	I	27244 - 57657	400	3467.96	I	20448 - 49275
200	3294.83	I	15770 - 46112	160	3472.72	I	14621 - 43409
280	3296.70	I	18950 - 49275	240	3476.44	I	15058 - 43815
280	3296.99	I	16327 - 46649	80	3477.14	I	27161 - 55912
80	3300.97	I	15058 - 45343	400	3480.38	I	16619 - 45343
280	3301.60	I	14621 - 44901	320	3480.85	I	14621 - 43342
240	3302.23	I	15058 - 45332	240	3482.23	I	22160 - 50869
320	3303.21	II	14883 - 45148	110	3490.86	I	17238 - 45876
280	3303.75	I	11584 - 41844	80	3494.72	I	17331 - 45937
80	3307.01	I	27161 - 57391	130	c 3495.90	I	
80	3308.25	I		80	3502.73	I	20482 - 49023
80	3312.29	I	16327 - 46509	560	3503.06	I	15770 - 44309
240	3313.95	I	15770 - 45937	100	c 3512.28	I	16619 - 45083
160	3318.67	I	13826 - 43950	320	3516.65	I	13826 - 42254
600	3322.48	I	11754 - 41844	320	3517.33	I	14621 - 43044
70	3324.93	I	16307 - 46374	80	c 3520.72	I	15058 - 43453
200	3331.52	I	14217 - 44225	80	3524.54	I	
160	3335.36	I	11584 - 41557	60	3529.21	I	16619 - 44946

Rhenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
120	3534.82	I	16619 - 44901	140	3777.66	I	17238 - 43702
320	3537.46	I	11584 - 39845	700	3787.52	I	15058 - 41453
160	3539.33	I	19458 - 47704	160	3796.59	I	11584 - 37916
60	3539.94	I	22160 - 50401	160	3797.59	I	14621 - 40946
240	3549.89	I	11754 - 39916	190	3807.74	I	15058 - 41313
160	3551.29	I	22160 - 50311	120	3815.66	I	14621 - 40822
160	3553.65	I	17331 - 45463	120	3836.30	I	14434 - 40494
160	3558.94	I	11754 - 39845	240	3869.94	I	16307 - 42140
80	3564.73	I	15770 - 43815	240	3875.26	I	11584 - 37381
160	3568.23	I	24724 - 52741	240	3876.86	I	15770 - 41557
240	3570.26	I	17331 - 45332	80	3887.49	I	27141 - 52857
360	3579.12	I	15770 - 43702	80	3887.95	I	17331 - 43044
810	3580.15	II	17224 - 45148	70	3889.96	I	22160 - 47860
650	3580.97	I	16307 - 44225	80	3896.11	I	20482 - 46141
810	3583.02	I	11754 - 39656	80	3900.91	I	14217 - 39845
70	3590.88	I	22423 - 50263	40	3901.09	I	11754 - 37381
80	3595.16	I	21775 - 49583	100	3908.21	I	27161 - 52741
160	3596.39	I	11754 - 39552	130	3913.92	I	15770 - 41313
80	3598.77	I	23155 - 50934	380	3917.27	I	16619 - 42140
80	3604.39	I	22423 - 50159	60	3920.85	I	27244 - 52741
160	3610.49	I	16307 - 43996	70	3927.59	I	14217 - 39670
320	3617.08	I	15770 - 43409	550	3929.85	I	14217 - 39656
80	3617.25	I	15770 - 43408	60	3931.20	I	21775 - 47206
160	3621.46	I	16619 - 44225	140	3936.90	I	15770 - 41164
160	3625.91	I	15770 - 43342	60	3941.54	I	19758 - 45122
60	3629.20	I	19458 - 47004	110	3944.72	I	27514 - 52857
140	3637.06	I	13826 - 41313	180	3945.91	I	14217 - 39552
810	3637.84	I	11584 - 39065	70	3950.64	I	14621 - 39927
35	3642.99	I	11754 - 39197	35	3954.43	I	22423 - 47704
80	3651.66	I	16619 - 43996	280	3961.04	I	13826 - 39065
440	3651.97	I	16327 - 43702	350	3962.48	I	16327 - 41557
80	3653.62	I	23632 - 50994	60	3963.27	I	16619 - 41844
60	3660.52	I	27244 - 54554	30	3964.81	I	23956 - 49171
40	3662.13	I	27514 - 54813	70	3967.39	I	22160 - 47358
120	3669.78	I	16327 - 43569	35	3975.65	I	16307 - 41453
80	3670.36	I	23956 - 51193	35	3983.91	I	
320	3670.53	I	14217 - 41453	40	3984.25	I	
80	3672.41	I	14621 - 41844	35	3991.03	I	14621 - 39670
60	3676.00	I	16619 - 43815	100	4004.93	I	19758 - 44720
35	3680.21	I	24425 - 51590	60	4012.26	I	26661 - 51578
35	3681.28	I	26132 - 53288	35	4018.40	I	27244 - 52122
860	3689.50	I	14217 - 41313	140	4022.96	I	18950 - 43801
1500	3691.48	I	16327 - 43409	100	4023.31	I	14217 - 39065
100	3697.71	I	27141 - 54177	60	4028.53	I	23155 - 47971
35	3700.37	I		110	4029.63	I	13826 - 38635
520	3703.24	I	13826 - 40822	220	4033.31	I	15058 - 39845
70	3704.45	I		110	4037.49	I	15166 - 39927
60	3704.84	I	13826 - 40810	200	4048.99	I	16307 - 40998
100	3705.02	I	13826 - 40809	50	4061.86	I	15058 - 39670
240	3709.93	I	14217 - 41164	240	4081.43	I	16327 - 40822
35	3715.02	I	17238 - 44148	50	4083.36	I	16327 - 40810
360	3717.28	I	17331 - 44225	50	4083.58	I	16327 - 40809
4000	3725.76	I	23632 - 50464	40	4089.92	I	14621 - 39065
140	3731.87	I	16619 - 43408	140	4104.42	I	19458 - 43815
140	3732.28	I	15058 - 41844	240	4110.89	I	17238 - 41557
240	3735.01	I	11754 - 38521	50	4113.40	I	14217 - 38521
810	3735.31	I	23632 - 50396	190	4121.64	I	20448 - 44703
40	3736.84	I	24724 - 51477	50	4132.28	I	13826 - 38019
910	3740.10	I	14217 - 40946	240	4133.42	I	16307 - 40494
140	3740.41	I	23632 - 50359	1800	4136.45	I	11754 - 35923
130	3742.26	II	17224 - 43938	50	4137.60	I	21775 - 45937
300	3745.44	I	14621 - 41313	700	4144.36	I	17331 - 41453
80	3755.62	I	17331 - 43950	140	4149.96	I	13826 - 37916
140	3766.48	I	14621 - 41164	70	4152.29	I	33589 - 57665
120	3768.26	I		50	4152.63	I	15770 - 39845

Rhenium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
90	4159.92	I	27161 - 51193	25 cw	4614.66	I	17331 - 38995
160	4170.40	I	27514 - 51486	100	4621.38	I	21775 - 43408
220	4182.90	I	15770 - 39670	25 h	4625.96	I	15770 - 37381
220	4183.06	I	14621 - 38521	80 c	4630.82	I	16327 - 37916
90	4194.67	I	17331 - 41164	90	4652.33	I	14434 - 35923
90	4204.52	I	22160 - 45937	40	4662.49	I	13826 - 35268
70	4213.27	I	27141 - 50869	50	4682.32	I	19458 - 40809
650	4221.08	I	11584 - 35268	25	4687.86	I	27244 - 48570
35	4223.18	I		25 c	4694.99	I	15770 - 37064
3600 c	4227.46	I	18950 - 42598	40	4700.44	I	21775 - 43044
35	4232.96	I	17695 - 41313	60	4705.04	I	22160 - 43408
40	4236.24	I	16327 - 39927	25	4725.93	I	23155 - 44309
30	4238.59	I	18950 - 42536	60	4727.60	I	16619 - 37766
90	4241.16	I	17238 - 40810	60	4748.38	I	16327 - 37381
150	4241.39	I	17238 - 40809	25	4749.03	I	14217 - 35268
70	4246.82	I	34520 - 58061	40	4758.83	I	11584 - 32592
40	4255.75	I	17331 - 40822	20	4763.67	I	17238 - 38225
260 c	4257.60	I	14217 - 37698	190 c	4791.42	I	15058 - 35923
120 c	4291.17	I	16619 - 39916	2200 cw	4889.14	I	0 - 20448
80	4291.65	I	14621 - 37916	50	4915.02	I	12251 - 32592
30	4299.92	I	23956 - 47206	220	4923.90	I	14217 - 34520
200	4304.40	I	16619 - 39845	80	4946.72	I	15058 - 35268
30	4314.58	I	21775 - 44946	50	4956.76	I	23632 - 43801
80	4318.58	I	27514 - 50663	80	4985.98	I	17331 - 37381
40	4319.53	I	14621 - 37766	40	5058.56	I	13826 - 33589
200	4332.25	I	14621 - 37698	70	5096.50	I	16307 - 35923
40	4357.98	II		20	5120.32	I	24425 - 43950
380	4358.69	I	11584 - 34520	25	5161.65	I	17695 - 37064
190	4367.58	I	16307 - 39197	40 c	5178.89	I	16619 - 35923
140	4391.34	I	11754 - 34520	20	5181.74	I	22160 - 41453
70 cw	4392.45	I	14621 - 37381	35	5234.31	I	23155 - 42254
360 cw	4394.38	I	15770 - 38521	50	5248.86	I	21775 - 40822
60	4396.80	I	16327 - 39065	1300	5270.95	I	23632 - 42598
80	4402.60	I	15058 - 37766	1600 cw	5275.56	I	0 - 18950
110 cw	4406.40	I	16307 - 38995	100	5278.24	I	16327 - 35268
180	4415.82	I	15058 - 37698	30	5305.56	I	
60	4440.44	I	17331 - 39845	20	5317.28	I	26661 - 45463
30 c	4453.92	I	35923 - 58369	35	5321.28	I	14621 - 33409
30	4454.62	I	14621 - 37064	50	5327.46	I	13826 - 32592
30	4463.53	I	35268 - 57665	20	5331.90	I	15770 - 34520
30	4467.54	I	24724 - 47102	20	5332.76	I	
80	4467.92	I	16619 - 38995	20	5333.85	I	27161 - 45904
150	4475.08	I	17331 - 39670	35	5369.48	I	24425 - 43044
80	4477.99	I	17331 - 39656	50 c	5369.80	I	13826 - 32444
120	4478.39	I	15058 - 37381	100 c	5377.10	I	17331 - 35923
25	4496.43	I	19758 - 41991	25	5431.90	I	39656 - 58061
120 c	4507.04	I	28854 - 51035	14	5437.03	I	22423 - 40810
50	4508.01	I	28854 - 51031	14	5447.92	I	15058 - 33409
2600	4513.31	I	20448 - 42598	25	5460.64	I	19458 - 37766
260	4516.64	I	28854 - 50988	14 h	5520.05	I	28030 - 46141
80	4519.76	I	28854 - 50973	25	5521.10	I	28542 - 46649
500	4522.73	I	28890 - 50994	50 c	5532.68	I	21775 - 39845
120	4523.88	I	28890 - 50988	50 c	5563.24	I	14621 - 32592
80	4526.01	I	20448 - 42536	25	5573.47	I	17331 - 35268
70	4528.97	I	28962 - 51035	25	5584.72	I	16619 - 34520
120	4529.95	I	28962 - 51031	10 h	5607.21	I	27514 - 45343
50	4530.89	I	22160 - 44225	12 h	5612.27	I	
40	4541.80	I	28962 - 50973	100	5667.88	I	15770 - 33409
100	4545.17	I	15770 - 37766	25	5711.43	I	22423 - 39927
50	4559.27	I	15770 - 37698	18	5716.95	I	26661 - 44148
70	4559.68	I	13826 - 35751	110 c	5752.93	I	11584 - 28962
50 c	4565.30	I	15166 - 37064	110 cw	5776.83	I	11584 - 28890
120	4580.68	I	11584 - 33409	18	5791.60	I	16327 - 33589
25	4591.68	I	20482 - 42254	10 c	5815.92	I	17331 - 34520
120	4605.73	I	14217 - 35923	550	5834.31	I	11754 - 28890

Rhenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
10	5919.86	I	24425 - 41313	12	6544.91	I	22423 - 37698
60	5943.24	I	15770 - 32592	35 c	6577.11	I	28854 - 44054
10	5950.21	I	28542 - 45343	40 cw	6592.52	I	28890 - 44054
18 h	5969.77	I	26661 - 43408	100 cw	6605.19	I	13826 - 28962
10	5989.99	I	23155 - 39845				
18 h	5995.73	I	27141 - 43815	30 c	6623.91	I	28962 - 44054
30	6114.22	I	17238 - 33589	10 c	6637.25	I	19458 - 34520
35 c	6145.81	I	27141 - 43408	27 cw	6652.39	I	13826 - 28854
50	6146.82	I	16327 - 32592	15 h	6683.28	I	22423 - 37381
18	6203.24	I	16327 - 32444	9 c	6711.30	I	17695 - 32592
25	6217.97	I	17331 - 33409	30	6751.22	I	
30 cw	6229.42	I	28854 - 44903	5 c	6761.19	I	20482 - 35268
35 cw	6243.24	I	28890 - 44903	180 c	6813.41	I	14217 - 28890
35 d	6260.02	I		260	6829.90	I	14217 - 28854
	6260.24	I		85	6971.53	I	14621 - 28962
18 c	6271.37	I	28962 - 44903	35 cw	7006.63	I	14621 - 28890
18	6278.76	I	21775 - 37698	65 cw	7024.15	I	14621 - 28854
10	6286.41	I	27141 - 43044	65 cw	7246.67	I	15058 - 28854
10	6303.42	I	26132 - 41992	13 cw	7292.72	I	28890 - 42598
200	6307.70	I	28854 - 44703	40 cw	7578.73	I	15770 - 28962
200	6321.90	I	28890 - 44703	13	7611.89	I	19458 - 32592
80 d	6350.75	I	28962 - 44703	7 cw	7620.25	I	15770 - 28890
16 h	6382.94	I	29800 - 45463	50 cw	7640.94	I	15770 - 28854
14	6411.47	I	26661 - 42254	65 cw	7912.94	I	16327 - 28962
50	6511.47	I	17238 - 32592	35 cw	7980.77	I	16327 - 28854
14	6515.25	I	30560 - 45904	40	8417.13	I	11754 - 23632
				29 cw	8527.73	I	17238 - 28962



## Rhodium

$$\text{Rh, } Z = 45, M = 102.9055, \text{ Ratio } \frac{\text{Rh}}{\text{Cu}} = 1.619$$

Rh I Normal state of valence electrons  $4d^8 5s^1 4F_{41/2} = 0$ . I.P. = 60197  $\text{cm}^{-1}$ .

Rh II Normal state of valence electrons  $4d^8 3F_4 = 0$ . I.P. = 145800  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

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#### Classification:

Rh I, J. P. Molnar and W. J. Hitchcock, J. Opt. Soc. Am. **30**, 523 (1940).

Rh II, F. J. Sancho, Anales Real. Soc. Esp. Fis. y Quim. **54A**, 41 (1958).

### *Strong lines of rhodium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
9400	3692.36	I	0 - 27075	4900	3799.31	I	5691 - 32004
8800	3528.02	I	1530 - 29866	4700	3470.66	I	3473 - 32277
8200	3434.89	I	0 - 29105	4700	3474.78	I	3473 - 32243
8200	3657.99	I	1530 - 28860	4700	3583.10	I	1530 - 29431
7600	3700.91	I	1530 - 28543	4700	3596.19	I	2598 - 30397
5900	3462.04	I	2598 - 31474	4200	3323.09	I	1530 - 31614
5900	3502.52	I	0 - 28543	4200	4374.80	I	5691 - 28543
5900	3597.15	I	3310 - 31102	3800	3793.22	I	5691 - 32046
5900	3856.52	I	5691 - 31614	3800	3822.26	I	7791 - 33946
5600	3396.82	I	0 - 29431	3800	3958.86	I	7791 - 33044

Rhodium—*all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	2276.21	II	27439 - 71359	300	2511.03	II	34726 - 74538
140	2288.57	I	2598 - 46280	75	2513.36	II	36366 - 76141
110	2309.82	I	3473 - 46753	200	2515.75	I	3310 - 43048
55	2318.36	I	5691 - 48811	130	2520.53	II	16885 - 56547
95	2319.10	I	5691 - 48798	13	2525.99	I	9221 - 48798
95	2321.73	I	1530 - 44588	13	2531.74	I	5691 - 45178
350	2322.58	I	0 - 43042	50	2532.66		
140	2326.47	I	3310 - 46280	13	2533.59		
80	2328.64	I	7791 - 50721	50	2534.07		
190	2334.77	II	16885 - 59702	110	2536.71		
55	2345.41	I		110	2537.04	II	
55	2352.47	I	0 - 42495	30	2539.72		
55	2359.18	I	1530 - 43905	40	2544.22		
300	2361.92	I	0 - 42325	350	2545.70	I	
110	2368.34	I	3473 - 45683	13	2548.60		
270	2382.89	I	0 - 41953	550	2555.36	I	3310 - 42431
230	2383.40	I	0 - 41944	25	2558.62	I	
40	2384.65	I	7791 - 49713	50	2565.79	I	5658 - 44621
270	2386.14	II	16885 - 58780	45	2566.04	I	3473 - 42431
80	2407.88	I	1530 - 43048	25	2566.92	II	38688 - 77633
27	2408.19	I	1530 - 43042	50	2567.28		
27	2410.25	I	3310 - 44787	25	2574.66		
80	2415.84	II	19793 - 61173	25	2575.75	I	14788 - 53600
55	2418.64			13	2576.23		
45	2419.75	I	3473 - 44787	40	2587.29	II	27439 - 66078
45	2420.18	II	33845 - 75152	30	2598.07		
65	2420.98	II	20647 - 61940	30	2603.32	II	32605 - 71006
75	2423.94			75	2606.44	II	
65	2427.11	II	18540 - 59729	75	2613.60		
130	2427.68	I	2598 - 43777	150	2622.58	I	5658 - 43777
230	2429.52	I	3473 - 44621	230	2625.88	I	5658 - 43729
40	2431.85	II	21180 - 62288	100	2630.42	I	2598 - 40603
40	2432.66	I	5658 - 46753	40	2634.99	I	
18	2437.08	I	7791 - 48811	30	2638.74	II	34243 - 72128
110	2437.90	I	7791 - 48797	75	2643.00	I	
330	2440.34	I	1530 - 42495	110	2647.28	I	5658 - 43421
50	2444.27	I		400	2652.66	I	2598 - 40285
65	2448.84	I	2598 - 43421	30	2659.01	I	1530 - 39127
50	2449.04	I	5691 - 46511	30	2671.06	I	3473 - 40900
75	2450.56	I		65	2676.11	I	5691 - 43048
30	2455.70	II	20647 - 61356	25	2680.28	I	
65	2458.90	II	19792 - 60448	100	2680.63	I	3310 - 40603
90	2461.04	II	18540 - 59161	30	2681.78	I	14788 - 52065
30	2463.61	I		30	2686.50		
75	2470.39	I	3310 - 43777	30	2686.91	h	
90	2471.47	I	2598 - 43048	50	2694.31	I	3473 - 40577
30	2472.51	I		400	2703.73	I	3310 - 40285
130	2473.09	I	1530 - 41953	40	2705.63	II	25377 - 62326
15	2475.64	II	31730 - 72112	40	2707.23	I	2598 - 39525
15	2477.54	II		75	2714.41	I	7791 - 44620
25	2482.04	I		100	2715.31	II	25377 - 62194
50	2483.33	I	3473 - 43729	75	2717.51	I	0 - 36787
150	2487.47	I		180	2718.54	I	5658 - 42431
100	2490.77	II	16885 - 57021	65	2720.14	I	
30	2492.30	I	3310 - 43421	30	2720.52	I	13975 - 50721
75	2494.51	h		160	2728.94	I	2598 - 39231
15	2499.02	I		40	2736.76	I	2598 - 39127
40	2500.58			75	2741.75	I	9221 - 45683
130	2502.46	I	3473 - 43421	50	2767.73	I	2598 - 38718
15	2503.84	II	20647 - 60573	100	2771.51	I	2598 - 38669
300	2504.29	II		50	2778.06	I	7791 - 43777
40	2505.10	II	19792 - 59699	75	2779.54	I	10313 - 46280
150	2505.67	I	2598 - 42495	130	2783.03	I	3310 - 39231
350	2509.70	I	2598 - 42431	25	2791.16	I	3310 - 39127
50	2510.66	II	18540 - 58358	75	2796.63	I	11006 - 46753

## Rhodium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	2826.43	I	10313 - 45683	2300	3283.57	I	2598 - 33044
180	2826.68	I	9221 - 44588	280	3289.14	I	3473 - 33867
30	2827.31	I	3310 - 38669	45	3289.64	I	14788 - 45178
75	2834.12	I	11006 - 46280	210	3294.28	I	12723 - 43070
45	2835.44	I	1530 - 36787	45	3296.72	I	12723 - 43048
75	2836.69	I	5658 - 40900	260	3300.46	I	10313 - 40603
50	2856.16	I	3473 - 38474	4200	3323.09	I	1530 - 31614
50	d 2860.68	I	5658 - 40605	60	3331.09	I	5658 - 35670
	2860.76	I	5658 - 40603	45	3331.24	I	9221 - 39231
280	2862.94	I	5658 - 40577	330	3338.54	I	1530 - 31474
65	2864.40	I	3310 - 38211	70	3342.90	I	9221 - 39127
50	2871.35	I		80	3344.20	I	11006 - 40900
30	2873.62	I		60	3359.90	I	13975 - 43729
110	2878.66	I	3310 - 38038	280	3360.80	I	5658 - 35404
75	2880.76	I	3310 - 38013	60	3362.18	I	3310 - 33044
140	2882.37	I	9221 - 43905	420	3368.38	I	2598 - 32277
75	2885.97	I	7791 - 42431	45	3369.68	I	10313 - 39981
75	2889.11	I	1530 - 36133	1100	3372.25	I	2598 - 32243
75	2889.84	I	5691 - 40285	110	3377.14	I	12723 - 42325
65	2899.96	I	10313 - 44787	80	3377.71	I	11006 - 40603
25	2904.81	I	14382 - 48798	110	3385.78	I	13521 - 43048
160	2907.21	I	2598 - 36985	5600	3396.82	I	0 - 29431
65	2910.17	II	25377 - 59729	820	3399.70	I	2598 - 32004
75	2912.62	I	5658 - 39981	160	3406.55	I	14382 - 43729
90	2915.42	I	5691 - 39981	820	3412.27	I	16018 - 45316
30	2923.10	I	9221 - 43421	60	3420.16	I	12723 - 41953
180	2924.02	I	2598 - 36787	330	3421.22	I	12723 - 41944
130	2929.11	I	5658 - 39788	120	d 3424.38	I	7791 - 36985
130	2931.94	I	5691 - 39788	8200	3434.89	I	0 - 29105
30	2955.41	I	9221 - 43048	1400	3440.53	I	16121 - 45178
230	2968.66	I	3310 - 36985	35	3442.63	I	14382 - 43421
25	2974.03	I	11006 - 44621	120	3447.74	I	7791 - 36787
160	2977.68	I	5658 - 39231	60	3448.58	I	14788 - 43777
450	2986.20	I	3310 - 36787	120	3450.29	I	13521 - 42495
90	2986.99	I	5658 - 39127	60	3451.15	I	3310 - 32277
50	2987.45	I	10313 - 43777	400	3455.22	I	3310 - 32243
110	3004.46	I	9221 - 42495	60	3455.42	I	11968 - 40900
50	3019.54	I	10313 - 43421	180	3457.07	I	10313 - 39231
130	3023.91	I	5658 - 38718	220	3457.93	I	13521 - 42431
50	3028.43	I	5658 - 38669	5900	3462.04	I	2598 - 31474
30	3045.77	I	3310 - 36133	180	3469.62	I	10313 - 39127
30	3046.76	I	7791 - 40603	4700	3470.66	I	3473 - 32277
25	3057.89	I	16119 - 48811	120	3472.25	I	9221 - 38013
65	3067.30	I	12723 - 45316	4700	3474.78	I	3473 - 32243
180	3083.96	I	1530 - 33946	2100	3478.91	I	3310 - 32046
29	3087.42	I	5658 - 38038	95	3484.04	I	3310 - 32004
70	3114.91	I	3310 - 35404	80	3491.07	I	11968 - 40605
140	3121.76	I	3310 - 35334	110	3494.44	I	11968 - 40577
240	3123.70	I	0 - 32004	1200	3498.73	I	3473 - 32046
35	3130.79	I	3473 - 35404	5900	3502.52	I	0 - 28543
95	3137.71	I	3473 - 35334	60	3505.41	I	11006 - 39525
45	3151.36	I	14788 - 46511	2800	3507.32	I	2598 - 31102
45	3152.60	I	5658 - 37369	60	3511.78	I	16121 - 44588
130	3155.78	I	9221 - 40900	60	3513.10	I	13975 - 42431
70	3179.73	I	7791 - 39231	60	3519.54	I	10313 - 38718
80	3185.59	I	9221 - 40603	8800	d 3528.02	I	1530 - 29866
140	3189.05	I	2598 - 33946	880	3538.14	I	5691 - 33946
470	3191.19	I	5658 - 36985		3538.26	I	14788 - 43042
190	3197.13	I	2598 - 33867	280	3541.91	I	11006 - 39231
70	3214.32	I	0 - 31102	1200	3543.95	I	5658 - 33867
80	3237.66	I	7791 - 38669	1800	3549.54	I	3310 - 31474
520	3263.14	I	3310 - 33946	240	3564.13	I	14382 - 42431
520	3271.61	I	3310 - 33867	1200	3570.18	I	3473 - 31474
2300	3280.55	I	1530 - 32004	4700	3583.10	I	1530 - 29431
110	3281.70	I	11968 - 42431	120	3583.53	I	10313 - 38211

## Rhodium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
4700	3596.19	I	2598 - 30397	50	3935.84	I	11968 - 37369
5900	3597.15	I	3310 - 31102	590	3942.72	I	10313 - 35670
310	3605.86	I	10313 - 38038	95	3958.24	I	13975 - 39231
3100	3612.47	I	3473 - 31147	3800	3958.86	I	7791 - 33044
240	3614.78	I	16121 - 43777	45	3964.54	II	35787 - 61003
200	3620.46	I	7791 - 35404	380	3975.31	I	13521 - 38669
1800	3626.59	I	9221 - 36787	240	3984.40	I	10313 - 35404
95	3627.80	I	11968 - 39525	240	3995.61	I	10313 - 35334
310	3639.51	I	11006 - 38474	380	3996.15	I	11968 - 36985
350	3654.87	I	5691 - 33044	120	4023.14	I	14382 - 39231
8200	3657.99	I	1530 - 28860	60	4048.41	I	13975 - 38669
280	3661.86	I	16121 - 43421	23	4049.04	I	13521 - 38211
1300	3666.22	I	2598 - 29866	40	4053.44	I	11006 - 35670
180	3666.91	I	11968 - 39231	23	4056.34	I	9221 - 33867
140	3674.76	I	11006 - 38211	70	4077.57	I	13521 - 38038
560	3681.04	I	11968 - 39127	560	4082.78	I	7791 - 32277
1900	3690.70	I	3310 - 30397	19	4084.28	I	2598 - 27075
9400	3692.36	I	0 - 27075	45	4087.79	I	16121 - 40577
60	3694.95	I	13521 - 40577	60	4088.50	I	7791 - 32243
940	3695.52	I	16018 - 43070	140	4097.52	I	11006 - 35404
280	3698.26	I	11006 - 38038	45	4107.49	I	14788 - 39127
380	3698.60	I	16018 - 43048	70	4116.33	I	14382 - 38669
7600	3700.91	I	1530 - 28543	120	4119.68	I	16018 - 40285
940	3713.02	I	3473 - 30397	1100	4121.68	I	7791 - 32046
60	3713.43	I	16121 - 43042	1500	4128.87	I	7791 - 32004
45	3714.83	I	9221 - 36133	2100	4135.27	I	5691 - 29866
16	3724.94	I	11968 - 38807	240	4154.37	I	12723 - 36787
650	3735.28	I	13521 - 40285	330	4196.50	I	9221 - 33044
420	3737.27	I	11968 - 38718	70	4206.62	I	3310 - 27075
420	3744.17	I	11968 - 38669	3300	4211.14	I	5691 - 29431
1200	3748.22	I	10313 - 36985	29	4230.20	I	10313 - 33946
240	3754.12	I	13975 - 40605	40	4244.44	I	10313 - 33867
380	3754.27	I	13975 - 40603	60	4273.43	I	13975 - 37369
490	3755.58	I	5658 - 32277	60	4278.60	I	11968 - 35334
1000	3760.40	I	5658 - 32243	820	4288.71	I	7791 - 31102
2300	3765.08	I	5691 - 32243	70	4296.77	I	13521 - 36787
490	3769.97	I	14382 - 40900	23	4342.44	I	9221 - 32243
70	3775.72	I	16018 - 42495	45	4373.04	I	11006 - 33867
380	3778.13	I	13521 - 39981	4200	4374.80	I	5691 - 28543
1000	3788.47	I	5658 - 32046	95	4379.92	I	9221 - 32046
1300	3792.18	I	11006 - 37369	23	4433.32	I	16119 - 38669
3800	3793.22	I	5691 - 32046	35	4492.47	I	9221 - 31474
4900	3799.31	I	5691 - 32004	29	4503.78	I	14788 - 36985
760	3805.92	I	13521 - 39788	23	4528.72	I	7791 - 29866
1300	3806.76	I	2598 - 28860	16	4544.27	I	14788 - 36787
45	3809.50	I	11968 - 38211	35	4548.73	I	11968 - 33946
95	3812.45	I	14382 - 40605	40	4551.64	I	10313 - 32277
470	3815.01	I	16121 - 42325	19	4560.89	I	16119 - 38038
760	3816.47	I	14382 - 40577	16	4565.19	I	11968 - 33867
1300	3818.19	I	9221 - 35404	130	4569.00	I	9221 - 31102
3800	3822.26	I	7791 - 33946	14	4571.31	I	
2300	3828.48	I	9221 - 35334	29	4608.12	I	13975 - 35670
2000	3833.89	I	7791 - 33867	14	4619.91	I	
45	3834.75	I	11968 - 38038	23	4643.18	I	16944 - 38474
5900	3856.52	I	5691 - 31614	150	4675.03	I	5691 - 27075
490	3870.01	I	16121 - 41953	19	4721.00	I	9221 - 30397
70	3872.39	I	5658 - 31474	70	4745.11	I	7791 - 28860
380	3877.34	I	5691 - 31474	12	4755.58	I	14382 - 35404
70	3888.34	I	13521 - 39231	23	4810.49	I	27075 - 47857
29	3904.22	I	13521 - 39127	21	4842.43	I	9221 - 29866
23	3912.83	I	3310 - 28860	45	4843.99	I	27075 - 47714
120	3913.51	I	1530 - 27075	60	4851.63	I	
240	3922.19	I	5658 - 31147	60	4963.71	I	11006 - 31147
2000	3934.23	I	5691 - 31102	60	4977.75	I	10313 - 30397
45	3934.98	I	14382 - 39788	40	4979.18	I	11968 - 32046

Rhodium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
14	5085.52	I		7	5907.31	I	16121 - 33044
70	5090.63	I	9221 - 28860	9	5918.54	I	11968 - 28860
23	5120.69	I	13521 - 33044	7	5941.46	I	31102 - 47928
19	5130.76	I	14382 - 33867	130	5983.60	I	12723 - 29431
60	5155.54	I	11006 - 30397	9	5991.19	I	14788 - 31474
14	5157.09	I	28543 - 47928	35	6102.72	I	12723 - 29105
40	5158.69	I	28860 - 48239	6	6116.15	I	13521 - 29866
60	5175.97	I	28543 - 47857	8	6128.06	I	14788 - 31102
12	5177.27	I	32046 - 51356	8	6186.89	I	16119 - 32277
35	5184.19	I	7791 - 27075	14	6199.99	I	16119 - 32243
95	5193.14	I	28543 - 47793	16	6253.72	I	16018 - 32004
16	5206.95	I		5	6276.66	I	16119 - 32046
16	5211.52	I	31102 - 50285	8	6277.46	I	16121 - 32046
19	5212.73	I	11968 - 31147	6	6293.38	I	16119 - 32004
16	5214.79	I	28543 - 47714	29	6319.53	I	12723 - 28543
19	5222.66	I	32277 - 51419	12	6414.72	I	28860 - 44445
19	5230.62	I	32243 - 51356	16	6510.41	I	16119 - 31474
45	5237.16	I	31102 - 50191	19	6519.70	I	16944 - 32277
9	5237.80	I		9	6627.80	I	16018 - 31102
14	5269.27	I	28860 - 47832	19	6630.16	I	14788 - 29866
11	h 5280.12	I	31474 - 50408	40	6752.35	I	27075 - 41881
14	5292.14	I	12723 - 31614	9	6796.65	I	35334 - 50043
14	5314.79	I	31474 - 50285	13	6827.33	I	14788 - 29431
40	h 5329.74	I	29105 - 47862	11	6857.68	I	29866 - 44445
14	h 5331.08	I	29105 - 47857	20	6879.94	I	16944 - 31474
9	5349.31	I	29105 - 47794	65	6965.67	I	12723 - 27075
130	5354.40	I	31614 - 50285	8	6972.91	I	31474 - 45812
23	5356.47	I	31614 - 50278	16	6979.15	I	31147 - 45471
45	5379.10	I	31614 - 50199	16	7001.58	I	16119 - 30397
95	5390.44	I	10313 - 28860	11	7038.76	I	16944 - 31147
23	h 5404.73	I	29431 - 47928	18	7101.64	I	30397 - 44475
60	h 5424.07	I	29431 - 47862	15	7104.45	I	14788 - 28860
19	5424.72	I	11968 - 30397	6	7142.55	I	31474 - 45471
19	h 5425.45	I	29431 - 47857	9	7219.06	I	16018 - 29866
12	5439.58	I	12723 - 31102	18	7268.18	I	14788 - 28543
12	h 5441.36	I	29866 - 48239	35	7270.82	I	28543 - 42293
9	h 5444.32	I	29431 - 47794	12	7271.94	I	16119 - 29866
35	h 5445.23	I		5	7273.03	I	16121 - 29866
23	h 5468.11	I	29431 - 47714	9	7375.57	I	13521 - 27075
35	h 5470.85	I	32004 - 50278	5	h 7386.64	I	32277 - 45812
12	5476.12	I	14788 - 33044	9	7430.80	I	16944 - 30397
12	5481.42	I	32046 - 50285	18	h 7442.39	I	28860 - 42293
16	5484.23	I	32004 - 50233	7	7446.77	I	32046 - 45471
9	5504.65	I	32046 - 50208	12	7475.74	I	31102 - 44475
29	5535.04	I	29866 - 47928	12	7495.24	I	28543 - 41881
21	l 5544.58	I	29866 - 47897	8	7542.02	I	36787 - 50043
160	5599.42	I	9221 - 27075	11	7557.67	I	32243 - 45471
7	5607.71	I	16119 - 33946	8	7577.22	I	32277 - 45471
16	5608.35	I	16121 - 33946	11	7690.05	I	31474 - 44475
5	5632.77	I	16119 - 33867	18	7772.90	I	29431 - 42293
9	5659.62	I	14382 - 32046	29	7791.61	I	31614 - 44445
40	5686.38	I	13521 - 31102	55	7824.91	I	29105 - 41881
9	h 5702.47	I	33946 - 51478	15	7830.05	I	
6	5727.30	I	14788 - 32243	15	7846.50	I	16119 - 28860
29	5792.66	I	14788 - 32046	21	8029.91	I	29431 - 41881
9	5795.79	I	25820 - 43070	11	h 8036.09	I	32004 - 44445
9	5803.34	I	25820 - 43047	29	8045.36	I	29866 - 42293
40	5806.91	I	14788 - 32004	7	8063.50	I	32046 - 44445
6	5821.84	I	13975 - 31147	15	8136.20	I	14788 - 27075
35	5831.58	I	12723 - 29866	7	h 8193.67	I	32243 - 44445
				5	h 8369.67	I	33867 - 45812
				8	8425.59	I	33946 - 45812

## Rubidium

$$\text{Rb}, Z = 37, M = 85.467, \text{Ratio } \frac{\text{Rb}}{\text{Cu}} = 1.345$$

Rb I Normal state of valence electrons  $4p^6 5s^2 S_{1/2} = 0$ . I.P. = 33691  $\text{cm}^{-1}$ .

Rb II Normal state of valence electrons  $4p^6 \ ^1S_0 = 0$ . I.P. = 220105  $\text{cm}^{-1}$ .

### References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Classification:

Rb I, A. Fowler, Report on Series in Line Spectra (Fleetway Press, London, 1922).

*Rubidium – all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
320	4201.85	I	0 - 23793	50	7408.17	I	12817 - 26311
160	4215.56	I	0 - 23715	70	7618.93	I	12579 - 25701
12 h	5648.10	I	12579 - 30280	110 hl	7757.65	I	12817 - 25704
20 l	5724.45	I	12817 - 30282	20	7759.43	I	12817 - 25701
25	6206.31	I	12579 - 28687	30000	7800.23	I	0 - 12817
40 h	6298.33	I	12817 - 28689	15000	7947.60	I	0 - 12579
35 hl	7280.00	I	12579 - 26311				

## Ruthenium

Ru,  $Z = 44$ ,  $M = 101.1$ , Ratio  $\frac{\text{Ru}}{\text{Cu}} = 1.590$

Ru I Normal state of valence electrons  $4d^7 5s^1 F_5 = 0$ . I.P. = 59410  $\text{cm}^{-1}$ .

Ru II Normal state of valence electrons  $4d^7^4 F_{4/2} = 0$ . I.P. = 135200  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented by K. G. Kessler and W. F. Meggers, J. Research NBS **55**, 97 (1955) RP 2609.

#### Classification:

Ru I, K. G. Kessler, J. Res. Nat. Bur. Stand. (U.S.), **63A** (Phys. and Chem.), No. 3, 213–251 (Nov.–Dec. 1959).

Ru II, A. G. Shenstone and W. F. Meggers, J. Research NBS **61**, 373 (1959) RP 2908.

### *Strong lines of ruthenium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
11000	3728.03	I	0 - 26816	5400	4554.51	I	6545 - 28495
8700	3726.93	I	1191 - 28015	4900	3428.31	I	0 - 29161
8300	3498.94	I	0 - 28572	3900	3786.06	I	2713 - 29119
7600	3798.90	I	1191 - 27507	3700	4297.71	I	8084 - 31346
7600	3799.35	I	0 - 26313	3500	3742.28	I	2713 - 29427
7600	4199.90	I	6545 - 30348	3300	3925.92	I	0 - 25465
7100	3730.43	I	2092 - 28891	3100	3417.35	I	2092 - 31346
6900	3593.02	I	2713 - 30537	3100	3634.93	I	2092 - 29595
6400	3436.74	I	1191 - 30280	2800	3745.59	I	12207 - 38898
6400	3589.22	I	3105 - 30959	2600	2083.77	I	1191 - 49165
6400	3596.18	I	2092 - 29891	2400	2076.43	I	0 - 48144
6200	3661.35	I	1191 - 28495	2400	2090.89	I	
6000	3790.51	I	2092 - 28466	2400	4372.21	I	7483 - 30348
6000	4080.60	I	6545 - 31044	2000	4144.16	I	8084 - 32208
5400	4212.06	I	6545 - 30280	1900	4112.74	I	8084 - 32392

Ruthenium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
2400	2076.43	I	0 - 48144	65	2515.28	I	8044 - 47789
2600	2083.77	I	1191 - 49165	110	2517.32	II	11604 - 51317
2400	2090.89	I		55	2517.62	I	9058 - 48766
690	2255.52	I	0 - 44322	30	2519.95	I	
290	2259.53	I	0 - 44243	55	2521.61	I	9121 - 48766
780	2272.09	I	0 - 43999	28	2525.17	I	8575 - 48165
240	2278.19	I	1191 - 45071	75	2526.83	I	7483 - 47047
780	2279.57	I		55	2528.88	I	9073 - 48604
170	2285.38	I	0 - 43743	55	2530.64	I	8044 - 47547
290	2302.54	I	1191 - 44608	45	2533.24	I	7483 - 46947
480	2317.80	I	1191 - 44322	150	2535.59	II	26911 - 66338
150	2322.01	I	1191 - 44243	45	2541.28	I	8771 - 48109
120	2334.96	II	10151 - 52964	65	2543.25	II	25952 - 65260
240	2340.69	I	2092 - 44801	280	2544.22	I	8575 - 47868
190	2342.85	II	10151 - 52820	120	2546.67	I	8084 - 47339
190	2349.34	I	1191 - 43743	280	2549.48	I	7483 - 46695
310	2351.33	I	2092 - 44608	550	2549.58	I	6545 - 45756
170	2357.91	II	9152 - 51549	23	2555.86	I	
140	2360.56	I	2092 - 44442	30	2556.00	I	9492 - 48604
170	2370.17	I	2713 - 44891	35	2556.31	I	9058 - 48165
240	2375.27	I	2713 - 44801	45	2558.54	I	8084 - 47157
80	2375.63	II	11604 - 53685	130	2560.26	I	8771 - 47818
160	2392.42	I	3105 - 44891	120	2560.83	I	
95	2396.71	II	9152 - 50863	110	2563.15	I	8044 - 47047
780	2402.72	II	9152 - 50758	28	2564.58	I	9184 - 48165
150	2407.92	II	11304 - 52820	55	2566.59	I	8575 - 47526
55	2410.89	I		160	2568.77	I	7483 - 46401
55	2414.82	II	10151 - 51549	28	2569.74	I	8044 - 46947
130	2420.82	I		100	2570.97	I	
55	2422.92	I		28	2572.28	I	8771 - 47635
45	2429.60	I	8575 - 49722	55	2572.41	I	8084 - 46947
65	2432.93	I	6545 - 47635	28	2575.24	I	6545 - 45365
30	2447.45	I	9492 - 50339	100	2578.57	I	8575 - 47345
30	2450.58	I	6545 - 47339	55	2578.95	I	8575 - 47339
65	2454.92	I	8044 - 48766	45	2579.22	I	8044 - 46804
180	2455.53	II	10151 - 50863	100	2579.53	I	8771 - 47526
150	2456.44	II	10852 - 51549	90	2580.80	I	9073 - 47809
370	2456.57	II	10151 - 50845	75	2581.14	I	9058 - 47789
65	2458.62	I	7483 - 48144	65	2581.91	I	8084 - 46804
55	2462.94	I	8575 - 49165	55	2583.04	I	8044 - 46746
85	2464.70	I	8044 - 48604	75	2584.14	I	8575 - 47262
30	2474.04	I	9620 - 50028	45	2585.74	I	8084 - 46746
110	2475.41	I	7483 - 47868	100	2589.57	I	9184 - 47789
100	2476.88	I	8044 - 48405	65	2590.97	I	7483 - 46067
280	2478.93	II	10852 - 51179	170	2591.12	I	8575 - 47157
28	2481.11	II	29019 - 69311	35	2591.64	I	8771 - 47345
30	2489.91	I	6545 - 46695	120	2592.02	I	8771 - 47339
18	2491.78	I	9184 - 49304	100	2593.70	I	12817 - 51360
65	2493.69	II	26109 - 66199	110	2594.85	I	6545 - 45071
85	2494.02	I	9058 - 49141	45	2597.33	I	9058 - 47547
45	2494.48	II	11304 - 51380	85	2601.46	I	
85	2495.69	II	27545 - 67602	75	2605.35	I	8575 - 46947
65	2496.56	I	7483 - 47526	65	2605.86	I	9184 - 47547
140	2498.42	II	11304 - 51317	370	2609.06	I	8084 - 46401
140	2498.57	II	10852 - 50863	45	2609.48	I	10624 - 48934
85	2499.78	I		85	2611.05	I	9058 - 47345
30	2500.84	I	9073 - 49048	830	2612.07	I	7483 - 45756
75	2501.48	I	9073 - 49037	90	2614.07	I	1191 - 39434
55	2501.89	I	9184 - 49141	55	2614.59	I	2713 - 40949
260	2507.01	II	11304 - 51179	100	2615.09	I	8575 - 46804
130	2508.27	I	7483 - 47339	75	2617.79	I	9620 - 47809
110	2509.07	I	9121 - 48964	90	2619.67	I	9184 - 47345
30	2511.56	I		85	2620.61	I	8044 - 46191
110	2512.81	I	8084 - 47868	28	2623.83	I	16191 - 54292
110	2513.32	II	11604 - 51380	55	2627.65	I	7483 - 45529



Ruthenium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
220	2631.30	I	7483 - 45476	90	2753.44	I	
55	2631.57	I	9058 - 47047	35	2762.31	I	8044 - 44235
45	2632.13	I	10624 - 48604	260	2763.42	I	1191 - 37367
45	2632.50	I	8771 - 46746	35	2765.44	II	20515 - 56665
28	2633.46	I	11447 - 49409	90	2768.93	II	11604 - 47708
220	2635.86	I	9620 - 47547	35	2774.48	I	
170	2636.67	I	12207 - 50122	100	2778.38	II	11304 - 47285
90	2638.51	I	9058 - 46947	55	2785.65	I	9184 - 45071
75	2639.12	I	9620 - 47501	110	2787.83	II	10852 - 46711
110	2640.33	I	9184 - 47047	35	2792.64	I	8044 - 43842
460	2642.96	I	8575 - 46401	140	2802.81	I	8575 - 44243
28	2646.02	I	10624 - 48405	35	2806.74	II	21646 - 57263
110	2647.32	I	9184 - 46947	350	2810.03	I	2092 - 37668
30	2648.45	I	8044 - 45790	1700	2810.55	I	1191 - 36760
28	2648.78	I	12207 - 49949	55	2812.82	I	
65	2649.51	I	9058 - 46789	75	2817.09	I	2713 - 38200
110	2651.29	I	8084 - 45790	350	2818.36	I	0 - 35471
330	2651.84	I	6545 - 44243	35	2818.95	I	8771 - 44235
28	2656.25	II	25952 - 63588	110	2822.03	I	8084 - 43509
13	2656.56	I		200	2827.87	I	1191 - 36543
13	2656.69	I	8771 - 46401	400	2829.16	I	6545 - 41881
45	2658.40	I	9184 - 46789	130	2834.00	I	2092 - 37367
400	2659.62	I	7483 - 45071	35	2836.57	I	9058 - 44301
23	2661.17	II	25952 - 63518	150	2840.54	I	6545 - 41739
330	2661.61	II	9152 - 46711	35	2841.68	II	20515 - 55695
200	2664.76	I	1191 - 38706	75	2843.17	I	9073 - 44235
30	2667.40	II	26109 - 63588	35	2846.32	I	9121 - 44244
35	2667.97	I	9058 - 46528	85	2848.58	I	3105 - 38200
55	2673.48	I	9073 - 46466	640	2854.07	I	2092 - 37119
45	2673.60	I	8084 - 45476	180	2860.02	I	2713 - 37668
690	2678.76	II	9152 - 46471	420	2861.41	I	6545 - 41483
220	2686.29	I	8575 - 45790	550	2866.64	I	2092 - 36965
28	2687.50	II	26109 - 63308	85	2868.19	I	9121 - 43976
30	2688.11	I	26118 - 63308	110	2868.31	I	
	2688.16	II		90	2871.64	I	
18	2689.90	I	10624 - 47789	1800	2874.98	I	0 - 34773
330	2692.06	II	10151 - 47285	220	2879.76	I	6545 - 41260
35	2693.29	I	9073 - 46191	45	2881.28	I	3105 - 37802
90	2699.88	I	8044 - 45071	55	2882.12	II	19379 - 54065
110	2701.34	I	9184 - 46191	130	2883.60	I	2092 - 36760
110	2702.83	I	8084 - 45071	65	2884.51	I	9184 - 43842
35	2707.97	I	2092 - 39009	740	2886.54	I	2713 - 37347
170	2709.20	I	8575 - 45476	75	2888.00	I	1191 - 35807
200	2712.41	II	10852 - 47708	35	2891.65	I	15550 - 50122
75	2713.19	I	9620 - 46466	180	2892.56	I	
45	2717.40	I	3105 - 39895	75	2896.53	I	3105 - 37620
23	2718.83	I		55	2898.54	I	8044 - 42534
690	2719.52	I	7483 - 44243	110	2901.94	I	8084 - 42534
90	2721.56	I	9058 - 45790	55	2902.10	I	10624 - 45071
130	2722.65	I	9073 - 45790	18	2903.08	I	9073 - 43509
75	2724.06	I	9492 - 46191	140	2905.65	I	2713 - 37119
140	2725.47	II	11304 - 47984	65	2905.83	I	6545 - 40949
55	2728.83	I	9121 - 45756	75	2906.32	I	7483 - 41881
23	2729.46	I	8575 - 45202	370	2908.88	I	3105 - 37473
55	2730.33	I	2092 - 38706	30	2909.22	I	8575 - 42939
90	2730.93	I	9183 - 45790	35	2913.17	I	11786 - 46103
45	2733.59	I	9620 - 46191	35	2914.30	I	11753 - 46056
310	2734.35	II	10151 - 46711	1100	2916.26	I	1191 - 35471
1800	2735.72	I	0 - 36543	28	2917.77	I	8084 - 42347
170	2739.22	I	8575 - 45071	150	2919.61	I	3105 - 37347
75	2743.94	I	6545 - 42978	28	2927.12	I	14700 - 48854
130	2744.45	I	8771 - 45197	35	2927.54	II	20515 - 54663
35	2747.97	II	11604 - 47984	35	2939.94	I	11786 - 45790
75	2752.45	II	10151 - 46471	55	2940.36	I	7483 - 41483
75	2752.77	II	19379 - 55695	75	2943.92	I	8575 - 42534

Ruthenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
180	2945.67	II	19379 - 53317	60	3124.17	I	2092 - 34091
180	2946.99	I	8084 - 42007	120	3125.96	I	2092 - 34072
370	2949.50	I	6545 - 40439	90	3132.88	I	10624 - 42534
35	2952.50	I	3105 - 36965	90	3136.56	I	8044 - 39917
150	2954.49	I	8043 - 41881	90	3140.97	I	9121 - 40949
75	2958.00	I	8084 - 41881	90	3144.26	I	14700 - 46495
28	2959.74	I	7483 - 41260	60	3150.69	I	8044 - 39774
75	2961.69	I	11447 - 45202	120	3153.82	I	8044 - 39742
18	2963.40	II	21246 - 54981	60	3158.89	I	9121 - 40768
55	2963.72	I	6545 - 40277	290	3159.92	I	2092 - 33729
550	2965.16	I	2092 - 35807	200	3168.52	I	11447 - 42998
170	2965.55	II	20515 - 54225	60	3177.05	II	19379 - 50845
55	2968.48	I	10624 - 44301	180	3186.04	I	2713 - 34091
85	2968.95	I	8084 - 41756	240	3188.34	I	2092 - 33447
35	2973.99	I	9492 - 43108	240	3189.98	I	2092 - 33431
28	2974.34	I	10624 - 44235	180	3196.59	I	3105 - 34380
140	2976.59	II	19379 - 52964	60	3212.97	I	9121 - 40235
550	2976.92	I	1191 - 34773	60	3216.52	I	2092 - 33172
45	2977.23	II	21646 - 55224	180	3223.27	I	2713 - 33729
75	2979.72	I	15054 - 48604	110	3226.37	I	3105 - 34091
		II	20515 - 54065	100	3227.88	I	8771 - 39742
75	2979.96	II	21246 - 54794	220	3228.53	I	8044 - 39009
55	2981.94	I	2713 - 36239	220	3238.53	I	15054 - 45923
1400	2988.95	I	0 - 33447	120	3241.24	I	9073 - 39917
35	2989.66	I	8044 - 41483	120	3243.50	I	6545 - 37367
35	2991.62	II	21246 - 54663	80	3254.54	I	2713 - 33431
110	2993.27	I	8084 - 41483	60	3254.71	I	9058 - 39774
460	2994.96	I	2092 - 35471	280	3260.35	I	1191 - 31853
55	2996.90	I	9058 - 42416	120	3264.55	I	3105 - 33729
28	2997.43	I	10624 - 43976		3264.66	I	8084 - 38706
90	2998.35	I		120	3266.44	I	10655 - 41260
55	3001.64	I	8575 - 41881	200	3268.21	I	13646 - 44235
440	3006.59	I	2713 - 35964	200	3273.08	I	8044 - 38587
35	3008.26	I	9184 - 42416	200	3274.71	I	10655 - 41183
55	3008.80	I	9121 - 42347	100	3277.57	I	14700 - 45202
55	3012.92	I	8575 - 41756	490	3294.11	I	0 - 30348
55	3013.36	I	8084 - 41260	60	3296.11	I	13646 - 43976
330	3017.24	I	3105 - 36239	60	3297.96	I	9121 - 39434
18	3019.37	I	8771 - 41881	370	3301.59	I	0 - 30280
310	3020.88	I	2713 - 35807	220	3306.17	I	8771 - 39009
240	3033.45	I	7483 - 40439	60	3315.05	I	8044 - 38200
65	3034.06	I	9058 - 42007	290	3315.23	I	1191 - 31346
60	3035.47	I	9073 - 42007	290	3316.39	I	10624 - 40768
60	3038.18	I	8044 - 40949	60	3317.89	I	8575 - 38706
200	3040.31	I	1191 - 34072	60	3318.82	I	14700 - 44823
220	3042.48	I	3105 - 35964		3318.91	I	9620 - 39742
60	3042.83	I	10655 - 43510	100	3325.00	I	3105 - 33172
110	3045.71	I	9184 - 42007	40	3332.05	I	31385 - 61388
60	3048.50	I	7483 - 40277	120	3335.69	I	11786 - 41756
110	3048.78	I	2092 - 34882	930	3339.55	I	8771 - 38706
150	3054.94	I	8044 - 40768	240	3341.66	I	9121 - 39037
390	3064.84	I	9121 - 41739	60	3344.53	I	0 - 29891
90	3068.26	I		200	3361.15	I	17046 - 46789
90	3073.34	I	11447 - 43976	60	3362.00	I	11447 - 41183
90	3080.90	I	11786 - 44235	370	3368.45	I	2713 - 32392
60	3086.07	I	11447 - 43842	100	3371.86	I	9058 - 38706
170	3089.14	I	9121 - 41483	130	3374.65	I	8044 - 37668
120	3089.80	I	8084 - 40439	120	3378.02	I	0 - 29595
60	3090.23	I	17097 - 49448	100	3379.60	I	10655 - 40235
60	3091.87	I	2713 - 35047	130	3380.18	I	8044 - 37620
330	3096.57	I	12207 - 44492	130	3385.14	I	12207 - 41739
120	3097.60	I	10624 - 42897	130	3388.71	I	11447 - 40949
830	3099.28	I	1191 - 33447	100	3389.50	I	2713 - 32208
740	3100.84	I	1191 - 33431	60	3391.89	I	14828 - 44301
90	3110.55	I	9121 - 41260	370	3392.54	I	0 - 29468

Ruthenium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
310	3401.74	I	9620 - 39009	40	3638.02	I	15054 - 42534
310	3409.28	I	8044 - 37367	200	3640.64	I	12817 - 40277
190	3411.64	I	8044 - 37347	170	3646.11	I	12817 - 40235
3100	3417.35	I	2092 - 31346	290	3650.32	I	8084 - 35471
70	3420.08	I	11786 - 41017	60	3652.32	I	2713 - 30085
4900	3428.31	I	0 - 29161	310	3654.40	I	16240 - 43597
130	3428.63	I	1191 - 30348	50	3660.81	I	16240 - 43549
190	3429.54	I	10624 - 39774	6200	3661.35	I	1191 - 28495
490	3430.77	I	2713 - 31853	830	3663.37	I	7483 - 34773
100	3432.21	I	9073 - 38200	650	3669.49	I	12207 - 39451
310	3432.74	I	9121 - 38243	240	3678.32	I	2713 - 29892
190	3433.26	I	10624 - 39742	45	3685.95	I	13646 - 40768
160	3435.19	I	3105 - 32208	260	3696.59	I	10624 - 37668
6400	3436.74	I	1191 - 30280	110	3697.76	I	8771 - 35807
260	3438.37	I	8044 - 37119	130	3700.99	I	17097 - 44109
220	3440.20	I	7483 - 36543	27	3702.24	I	8044 - 35047
160	3448.95	I	11447 - 40433	110	3712.30	I	17046 - 43976
100	3452.90	I	2092 - 31044	55	3715.56	I	9058 - 35964
70	3456.62	I	15054 - 43976	110	3716.18	I	6545 - 33447
70	3463.14	I	2092 - 30959	410	3717.00	I	8575 - 35471
260	3473.75	I	10655 - 39434	260	3719.33	I	17097 - 43976
240	3481.30	I	8044 - 36760	170	3724.97	I	8044 - 34882
130	3483.16	I	1191 - 29892	55	3725.49	I	11753 - 38587
130	3483.29	I	1191 - 29891	550	3726.10	I	12207 - 39037
130	3494.25	I	9058 - 37668	8700	3726.93	I	1191 - 28015
130	3495.97	I	8771 - 37367	11000	3728.03	I	0 - 26816
8300	3498.94	I	0 - 28572	7100	3730.43	I	2092 - 28891
70	3502.42	I	8575 - 37119	85	3732.03	I	13646 - 40433
640	3514.49	I	2092 - 30537	85	3733.05	I	9184 - 35964
330	3519.64	I	1191 - 29595	280	3737.40	I	9058 - 35807
200	3528.68	I	2713 - 31044	55	3737.74	I	9492 - 36239
130	3531.39	I	9058 - 37367	45	3738.63	I	13699 - 40439
240	3532.81	I	14700 - 42998	110	3738.91	I	16240 - 42978
100	3535.37	I	1191 - 29468	410	3739.46	I	13699 - 40433
130	3535.83	I	9073 - 37347	3500	3742.28	I	2713 - 29427
390	3537.95	I	2092 - 30348	870	3742.78	I	15550 - 42261
790	3539.37	I	2713 - 30959	280	3744.22	I	8771 - 35471
200	3541.63	I	6545 - 34773	410	3744.40	I	16240 - 42939
130	3550.27	I	2092 - 30250	2800	3745.59	I	12207 - 38898
130	3553.85	I	11786 - 39917	760	3753.54	I	12817 - 39451
100	3556.63	I	11786 - 39895	310	3755.09	I	9184 - 35807
130	3564.56	I	9073 - 37119	870	3755.93	I	12817 - 39434
130	3567.16	I	13982 - 42007	1200	3759.84	I	7483 - 34072
690	3570.59	I	15550 - 43549	370	3760.03	I	3105 - 29694
200	3574.58	I	8575 - 36543	600	3761.51	I	13699 - 40277
70	3579.77	I	2092 - 30018	600	3767.35	I	13699 - 40235
390	3587.20	I	16240 - 44109	55	3773.17	I	10624 - 37119
6400	3589.22	I	3105 - 30959	1500	3777.59	I	3105 - 29570
6900	3593.02	I	2713 - 30537	150	3778.70	I	12817 - 39273
6400	3596.18	I	2092 - 29891	460	3781.18	I	20056 - 46495
1300	3599.76	I	8771 - 36543	600	3782.74	I	27289 - 53718
130	3605.64	I	9620 - 37347	3900	3786.06	I	2713 - 29119
100	3608.73	I	9058 - 36760	6000	3790.51	I	2092 - 28466
60	3616.95	I	9121 - 36760	240	3794.92	I	16191 - 42534
100	3619.20	I	12817 - 40439			I	9620 - 35964
60	3620.28	I	13646 - 41260	85	3795.18	I	10624 - 36965
60	3623.64	I	10655 - 38243	760	3798.05	I	3105 - 29427
350	3625.20	I	10624 - 38200	7600	3798.90	I	1191 - 27507
370	3626.74	I	17097 - 44662	7600	3799.35	I	0 - 26313
40	3627.29	I	13699 - 41260	310	3800.26	I	8575 - 34882
180	3631.71	I	6545 - 34072	85	3803.20	I	20242 - 46528
85	3633.92	I	17097 - 44608	310	3808.68	I	14700 - 40949
3100	3634.93	I	2092 - 29595	600	3812.72	I	12817 - 39037
120	3635.52	I	9620 - 37119	150	3814.86	I	15054 - 41260
210	3637.47	I	13699 - 41183	760	3817.27	I	15550 - 41739

Ruthenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
760	3819.03	I	2713 - 28891	55	3993.53	I	9058 - 34091
55	3819.77	I	11447 - 37620	280	3995.98	I	9073 - 34091
650	3822.09	I	16191 - 42347	27	3996.51	I	9058 - 34072
550	3824.93	I	10624 - 36760	140	4005.64	I	8771 - 33729
130	3828.71	I	8771 - 34882	85	4006.60	I	9120 - 34073
760	3831.80	I	12207 - 38297	55	4007.54	I	14827 - 39774
220	3835.05	I	14700 - 40768	85	4008.27	I	13646 - 38587
310	3838.07	I	8044 - 34091	85	4013.50	I	7483 - 32392
930	3839.70	I	12207 - 38243	55	4021.00	I	15054 - 39917
150	3840.82	I	8044 - 34072	1500	4022.16	I	8575 - 33431
85	3843.16	I	3105 - 29119	600	4023.83	I	1191 - 26036
480	3846.68	I	9058 - 35047	85	4031.00	I	6545 - 31346
760	3850.43	I	7483 - 33447	150	4032.20	I	2713 - 27507
130	3852.14	I	17046 - 42998	40	4037.74	I	9620 - 34380
480	3856.46	I	2092 - 28015	310	4039.21	I	14700 - 39451
1300	3857.55	I	14700 - 40616	35	4040.48	I	22519 - 47262
220	3860.72	I	15054 - 40949	170	4045.76	I	17046 - 41756
650	3862.69	I	17097 - 42978	65	4049.41	I	15054 - 39742
130	3865.40	I	9184 - 35047	1400	4051.40	I	8771 - 33447
1300	3867.84	I	6545 - 32392	170	4052.20	I	9058 - 33729
260	3873.52	I	9073 - 34882	710	4054.05	I	8771 - 33431
35	3876.08	I	13982 - 39774	55	4062.85	I	20056 - 44662
100	3882.01	I	2713 - 28466	120	4062.99	I	13982 - 38587
130	3884.02	I	14700 - 40439	110	4064.10	I	9492 - 34091
100	3884.68	I	13699 - 39434	370	4064.46	I	8575 - 33172
100	3887.77	I	15054 - 40768	200	4067.61	I	16191 - 40768
150	3890.20	I	9184 - 34882	760	4068.37	I	14700 - 39273
65	3891.41	I	16191 - 41881	150	4071.40	I	13646 - 38200
650	3892.21	I	8044 - 33729	200	4073.00	I	9184 - 33729
35	3892.77	I	20242 - 45923	980	4076.73	I	9058 - 33580
35	3894.24	I	11447 - 37119	6000	4080.60	I	6545 - 31044
100	3897.24	I	9121 - 34773	75	4082.79	I	11753 - 36239
100	3898.36	I	8084 - 33729	310	4085.43	I	16713 - 41183
150	3901.24	I	1191 - 26816	110	4091.06	I	17046 - 41483
130	3908.76	I	14700 - 40277	110	4097.03	I	8771 - 33172
760	3909.08	I	13699 - 39273	930	4097.79	I	9184 - 33580
100	3912.11	I	9492 - 35047	75	4100.37	I	2092 - 26473
150	3914.85	I	8044 - 33580	350	4101.74	I	9058 - 33431
260	3920.92	I	8575 - 34072	75	4102.28	I	7483 - 31853
1500	3923.47	I	12817 - 38297	130	4107.84	I	14700 - 39037
65	3924.63	I	20056 - 45529	27	4109.65	I	9120 - 33447
3300	3925.92	I	0 - 25465	1900	4112.74	I	8084 - 32392
600	3931.76	I	9620 - 35047	160	4113.38	I	16713 - 41017
		I	12817 - 38243	35	4114.13	I	8044 - 32343
310	3933.55	I	2092 - 27507	65	4118.50	I	1191 - 25464
120	3937.90	I	8044 - 33431	160	4120.99	I	8084 - 32343
65	3941.65	I	8084 - 33447	160	4123.06	I	9184 - 33431
85	3942.06	I	3105 - 28466	65	4123.81	I	16191 - 40433
65	3944.19	I	8084 - 33431	120	4127.44	I	2092 - 26313
760	3945.57	I	16240 - 41578	120	4127.87	I	13982 - 38200
40	3946.31	I	11786 - 37119	100	4137.23	I	8044 - 32208
65	3949.42	I	11447 - 36760	2000	4144.16	I	8084 - 32208
120	3950.04	I	20056 - 45365	650	4145.74	I	9058 - 33172
460	3950.21	I	6545 - 31853	260	4146.77	I	9620 - 33729
150	3950.41	I	9073 - 34380	85	4148.38	I	9073 - 33172
65	3951.21	I	8771 - 34072	55	4150.30	I	9492 - 33580
310	3952.68	I	16191 - 41483	35	4159.17	I	16240 - 40277
40	3957.45	I	9620 - 34882	130	4161.66	I	13646 - 37668
460	3964.90	I	0 - 25214	110	4166.88	I	6545 - 30537
35	3969.79	I	10624 - 35807	870	4167.51	I	9184 - 33172
85	3974.50	I	8575 - 33729	110	4170.05	I	13646 - 37620
600	3978.44	I	8044 - 33172	55	4175.43	I	20056 - 43999
600	3979.42	I	1191 - 26313	110	4182.46	I	17046 - 40949
870	3984.86	I	8084 - 33172	65	4182.64	I	7483 - 31385
27	3987.80	I	16191 - 41260	35	4189.46	I	7483 - 31346

Ruthenium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	4196.87	I	13982 - 37802	100	4383.36	I	10624 - 33431
550	4197.58	I	8575 - 32392	870	4385.39	I	7483 - 30280
550	4198.88	I	8044 - 31853	1300	4385.65	I	9058 - 31853
7600	4199.90	I	6545 - 30348	100	4386.27	I	14827 - 37620
1500	4206.02	I	8084 - 31853	27	4388.99	I	22419 - 45197
190	4207.64	I	14828 - 38587	1700	4390.44	I	8575 - 31346
5400	4212.06	I	6545 - 30280	85	4391.03	I	7483 - 30250
760	4214.44	I	13646 - 37367	35	4394.96	I	15550 - 38297
930	4217.27	I	6545 - 30250	170	4397.80	I	9121 - 31853
370	4220.68	I	13982 - 37668	40	4399.59	I	9620 - 32343
110	4225.09	I	20242 - 43903	35	4404.82	I	17046 - 39742
75	4226.66	I	15054 - 38706	1600	4410.03	I	9184 - 31853
190	4229.31	I	13982 - 37620	65	4420.84	I	8771 - 31385
550	4230.31	I	8575 - 32208	160	4421.46	I	8575 - 31186
150	4232.32	I	8771 - 32392	40	4424.78	I	11786 - 34380
110	4236.67	I	14700 - 38297	330	4428.46	I	8771 - 31346
760	4241.05	I	8771 - 32343	460	4439.76	I	10655 - 33172
760	4243.06	I	7483 - 31044	85	4444.51	I	8044 - 30537
110	4244.83	I	9620 - 33172	440	4449.34	I	8575 - 31044
190	4246.33	I	14700 - 38243	1100	4460.04	I	8771 - 31186
370	4246.73	I	20056 - 43597	22	4467.26	I	20242 - 42621
40	4248.14	I	15054 - 38587	190	4473.93	I	6545 - 28891
310	4258.99	I	13646 - 37119	27	4479.41	I	13646 - 35964
75	4260.00	I	10624 - 34091	150	4480.45	I	15054 - 37367
35	4263.40	I	10624 - 34072	35	4482.03	I	11786 - 34091
75	4265.61	I	10655 - 34091	85	4488.39	I	8771 - 31044
35	4277.26	I	14827 - 38200	55	4490.24	I	8084 - 30348
40	4278.69	I	13982 - 37347	45	4491.68	I	13982 - 36239
45	4281.93	I	15550 - 38898	350	4498.14	I	9121 - 31346
75	4282.22	I	6545 - 29891	120	4510.10	I	8084 - 30250
760	4284.33	I	9058 - 32392	85	4511.20	I	13646 - 35807
190	4287.05	I	13646 - 36965	220	4516.89	I	11447 - 33580
220	4293.28	I	9058 - 32343	220	4517.82	I	9058 - 31186
260	4294.79	I	8575 - 31853	110	4520.95	I	9073 - 31186
550	4295.93	I	9121 - 32392	65	4530.85	I	15054 - 37119
3700	4297.71	I	8084 - 31346			I	20934 - 42998
930	4307.60	I	9183 - 32392	27	4543.69	I	9184 - 31186
40	4309.21	I	26036 - 49235	170	4547.33	I	7483 - 29468
110	4314.30	I	25214 - 48386	110	4547.85	I	13982 - 35964
75	4316.64	I	9184 - 32343	27	4549.43	I	8044 - 30018
370	4318.43	I	9058 - 32208	45	4549.96	I	23393 - 45365
550	4319.87	I	8044 - 31186	45	4552.11	I	8575 - 30537
40	4320.58	I	17097 - 40235	5400	4554.51	I	6545 - 28495
35	4321.30	I	9073 - 32208	110	4559.98	I	9121 - 31044
35	4322.96	I	25201 - 48327	22	4562.60	I	15054 - 36965
170	4325.05	I	13646 - 36760	40	4564.69	I	9058 - 30959
170	4326.82	I	10624 - 33729	65	4580.07	I	11753 - 33580
110	4327.43	I	8084 - 31186	1700	4584.44	I	8084 - 29891
100	4331.16	I	8771 - 31853	45	4587.10	I	11786 - 33580
40	4332.50	I	23453 - 46528	110	4591.10	I	9184 - 30959
75	4336.42	I	7483 - 30537	150	4592.52	I	10624 - 32392
170	4337.27	I	6545 - 29595	65	4596.71	I	23453 - 45202
35	4338.68	I	20934 - 43976	330	4599.08	I	10655 - 32392
45	4340.34	I	16240 - 39273	55	4601.76	I	11447 - 33172
40	4341.04	I	16713 - 39742	40	4605.66	I	15054 - 36760
550	4342.07	I	9184 - 32208	22	4612.32	I	8575 - 30250
110	4346.48	I	8044 - 31044	170	4635.69	I	9620 - 31186
350	4349.70	I	13982 - 36965	200	4645.09	I	20056 - 41578
710	4354.13	I	8084 - 31044	720	4647.61	I	8084 - 29595
140	4354.80	I	10624 - 33580	290	4654.32	I	9058 - 30537
870	4361.21	I	6545 - 29468	24	4669.14	I	14827 - 36239
35	4370.42	I	8084 - 30959	70	4669.98	I	7483 - 28891
65	4371.20	I	17046 - 39917	95	4674.65	I	11786 - 33172
2400	4372.21	I	7483 - 30348	290	4681.79	I	9184 - 30537
35	4381.27	I	16191 - 39009	190	4684.02	I	8084 - 29427

Ruthenium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
290	4690.11	I	8575 - 29891	55	5153.20	I	11786 - 31186
1400	4709.48	I	9121 - 30348	500	5155.14	I	9073 - 28466
30	4720.92	I	16191 - 37367	55	5160.00	I	9121 - 28495
140	4731.33	I	9121 - 30250	920	5171.03	I	7483 - 26816
120	4733.52	I	8771 - 29891	180	5195.02	I	8771 - 28015
30	4738.40	I		80	5199.87	I	29160 - 48386
35	4743.02	I	22519 - 43597	45	5202.12	I	20056 - 39273
70	4756.23	I	8575 - 29595	45	5213.43	I	28495 - 47671
500	4757.84	I	7483 - 28495	65	5223.55	I	12207 - 31346
21	4764.40	I	27507 - 48490	40	5242.38	I	10624 - 29694
95	4769.30	I	6545 - 27507	55	5251.67	I	12817 - 31853
21	4773.15	I	11447 - 32392	40	5257.07	I	30537 - 49554
35	4774.00	I	20242 - 41183	40	5266.47	I	20934 - 39917
50	4784.27	I	11447 - 32343	40	5266.83	I	20056 - 39037
35	4794.38	I	8575 - 29427	40	5280.82	I	8575 - 27507
35	4795.57	I	8044 - 28891	130	5284.08	I	6545 - 25465
50	4798.44	I	9058 - 29892	40	5291.16	I	9121 - 28015
60	4804.88	I	8084 - 28891	80	5304.86	I	9620 - 28466
19	4806.19	I		260	5309.27	I	7483 - 26313
260	4815.52	I	11447 - 32208	13	5315.33	I	20934 - 39742
19	4817.34	I	15054 - 35807	40	5332.93	I	13646 - 32392
70	4833.00	I		45	5334.70	I	
50	4839.01	I	26313 - 46972	110	5335.93	I	8771 - 27507
19	4839.77	I	8771 - 29427	130	5361.77	I	
120	4844.56	I	9058 - 29694	65	5377.84	I	28495 - 47085
24	4854.56	I	26313 - 46906	65	5385.88	I	13646 - 32208
85	4861.87	I	10624 - 31186	110	5401.04	I	
550	4869.15	I	7483 - 28015	40	5401.39	I	13699 - 32208
80	4895.32	I	8044 - 28466	40	5418.86	I	9058 - 27507
160	4895.60	I	10624 - 31044	55	5427.59	I	28572 - 46991
80	4899.25	I	11447 - 31853	26	5439.21	I	
470	4903.05	I	10655 - 31044	13	5452.71	I	28572 - 46906
40	4905.02	I	8084 - 28466	80	5454.82	I	31186 - 49513
120	4907.89	I	9058 - 29427	90	5456.13	I	9184 - 27507
260	4921.07	I	8575 - 28891	13	5475.18	I	31346 - 49605
180	4938.43	I	9184 - 29427	55	5479.40	I	31346 - 49591
90	4955.26	I	26816 - 46991	26	5480.30	I	30280 - 48522
45	4959.86	I	26816 - 46972	80	5484.32	I	8084 - 26313
160	4968.90	I	8771 - 28891	18	5484.64	I	12817 - 31044
35	4974.12	I	22162 - 42261	26	5496.69	I	20056 - 38243
90	4976.20	I	26816 - 46906	13	5501.02	I	30348 - 48522
160	4980.35	I	9620 - 29694	130	5510.71	I	12207 - 30348
55	4983.45	I	9058 - 29119	20	5512.37	I	30250 - 48386
55	4987.26	I	9073 - 29119	8	5517.86	I	15054 - 33172
120	4992.74	I	7483 - 27507	12	5521.78	I	31186 - 49291
160	5011.23	I	9620 - 29570	12	5530.99	I	20934 - 39009
90	5014.95	I	9184 - 29119	24	5540.66	I	12207 - 30250
90	5026.18	I	8575 - 28466	12	5556.52	I	8044 - 26036
65	5028.16	I	10655 - 30537	90	5559.75	I	7483 - 25465
35	5040.35	I	20934 - 40768	11	5569.03	I	8084 - 26036
35	5040.74	I	9058 - 28891	21	5578.40	I	
65	5047.31	I	9620 - 29427	21	5603.14	I	10624 - 28466
450	5057.33	I	6545 - 26313	8	5603.55	I	
21	5062.64	I	13982 - 33729	13	5606.73	I	29160 - 46991
90	5072.97	I	9184 - 28891	11	5629.79	I	22519 - 40277
120	5076.32	I	10655 - 30348	290	5636.24	I	8575 - 26313
200	5093.83	I	9492 - 29119	11	5641.66	I	12817 - 30537
80	5107.07	I	12817 - 32392	7	5649.56	I	9121 - 26816
24	5123.73	I	11447 - 30959	7	5653.30	I	12207 - 29891
55	5127.26	I	9620 - 29119	11	5665.20	I	13699 - 31346
65	5133.89	I	13699 - 33172	16	5679.63	I	22293 - 39894
530	5136.55	I	8044 - 27507	180	5699.05	I	8771 - 26313
170	5142.76	I	8575 - 28015	13	5724.82	I	12817 - 30280
250	5147.24	I	8084 - 27507	13	5725.73	I	8575 - 26036
110	5151.07	I	9058 - 28466	16	5745.99	I	13646 - 31044

Ruthenium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
16	5747.47	I	21643 - 39037	21	6824.17	I	28466 - 43116
11	5752.02	I	8084 - 25465	7	6831.52	I	25643 - 40277
11	5756.83	I	11753 - 29119	26	6911.48	I	29427 - 43892
11	5767.92	I	11786 - 29119	110	6923.23	I	26816 - 41256
16	5804.39	I	23393 - 40616	26	6982.01	I	27507 - 41825
65	5814.98	I	9121 - 26313	26	7027.98	I	28891 - 43116
8	5828.06	I	15054 - 32208	9	7086.06	I	16240 - 30348
16	h 5833.21	I	30348 - 47487	12	7087.35	I	12207 - 26313
55	5919.34	I	8575 - 25465	4	7141.72	I	17046 - 31044
80	5921.45	I	10624 - 27507	6	7219.26	I	25603 - 39451
21	5926.87	I	16713 - 33580	35	7238.92	I	28015 - 41825
26	5932.38	I	9184 - 26036	7	7266.96	I	
8	5936.65	I	30348 - 47188	8	7323.56	I	16240 - 29891
8	5951.15	I	15054 - 31853	16	7393.93	I	29595 - 43116
21	h 5973.38	I	30348 - 47085	18	7468.91	I	30959 - 44344
8	5974.17	I	20934 - 37668	12	7475.40	I	
16	5988.67	I	8771 - 25465	26	7485.79	I	30537 - 43892
35	5993.65	I	11786 - 28466	70	7499.75	I	28495 - 41825
18	6116.77	I	9121 - 25465	7	7532.07	I	24927 - 38200
26	6199.42	I	17046 - 33172	26	7559.61	I	29891 - 43116
26	6225.20	I	11447 - 27507	5	7612.94	I	31044 - 44176
9	6284.49	I	22293 - 38200	18	7621.50	I	31853 - 44970
18	6295.22	I	23393 - 39273	18	7722.87	I	15550 - 28495
13	6330.62	I	25465 - 41256	5	7729.91	I	30959 - 43892
9	6336.12	I	22519 - 38297	22	7791.86	I	31346 - 44176
9	h 6363.41	I	28466 - 44176	4	7797.89	I	
9	6376.45	I	12817 - 28495	4	7806.82	I	37367 - 50173
16	6390.23	I	23393 - 39037	3	7813.43	I	20934 - 33729
8	6417.57	I	34773 - 50351	4	7829.81	I	30250 - 43019
26	h 6444.84	I	27507 - 43019	5	h 7833.39	I	32208 44970
8	6496.44	I	27507 - 42895	6	h 7841.90	I	36543 49291
11	6528.74	I		30	7847.80	I	30280 43019
4	6560.45	I	23005 - 38243	80	7881.19	I	28572 41256
4	6593.74	I	17046 - 32208	16	7890.37	I	30348 43019
9	6618.20	I	16240 - 31346	16	7924.43	I	30280 42896
21	6663.14	I	28015 - 43019	5	7948.15	I	32392 44970
55	6690.00	I	26313 - 41256	9	7967.84	I	30348 42895
11	6707.52	I	23393 - 38297	9	8112.47	I	31853 44176
15	6718.30	I	28015 - 42895	18	8264.96	I	29161 41256
15	6730.45	I	16191 - 31044	11	8348.98	I	31044 43019
7	6756.54	I	32392 - 47188	6	8352.94	I	32208 44176
21	6766.95	I	29119 - 43892	4	8435.77	I	31044 - 42895
30	6775.02	I	17097 - 31853	11	8473.64	I	33172 - 44970
13	6787.23	I	15550 - 30280	11	8483.56	I	32392 - 44176
8	6813.51	I	22293 - 36965	22	8710.84	I	30348 - 41825
15	6823.88	I	29694 - 44344	14	8724.98	I	20934 - 32392
				9	8777.36	I	33580 - 44970

## Samarium

$$\text{Sm, } Z = 62, M = 150.4, \text{ Ratio } \frac{\text{Sm}}{\text{Cu}} = 2.367$$

Sm I Normal state of valence electrons  $4f^6 6s^2 {}^7F_0 = 0$ . I.P. = 45400  $\text{cm}^{-1}$ .  
 Sm II Normal state of valence electrons  $4f^6 6s {}^8F_{1/2} = 0$ . I.P. = 89300  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

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 A. S. King, *Astrophys. J.* **82**, 140 (1935), above 2900 Å.

#### Classification:

Sm I, W. Albertson, *Phys. Rev.* **47**, 370 (1935).  
 W. Albertson, *Phys. Rev.* **52**, 644 (1937).  
 Sm II, W. Albertson, *Astrophys. J.* **84**, 26 (1936).  
 Sm I and II, A. Carlier, Thesis, Univ. of Paris. (Orsay) (1967).  
 J. Blaise, C. Morillon, M. G. Schweighofer, and J. Verges, *Spectrochimica Acta* **24B**, 405 (1969).

#### *Strong lines of samarium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
4200	3568.27	II	3910 - 31926	1800	4434.32	II	3053 - 25598
4200	3592.60	II	3053 - 30880	1700	3306.39	II	3910 - 34145
3700	3885.29	II	3910 - 29641	1700	3604.28	II	3910 - 31646
3400	3609.49	II	2238 - 29935	1700	3621.23	II	838 - 28445
3400	3634.29	II	1489 - 28997	1600	3728.47	II	5318 - 32131
2900	3739.12	II	326 - 27063	1600	3735.98	II	2238 - 28997
	3739.20	II	4386 - 31122	1600	3793.97	II	838 - 27188
2900	4424.34	II	3910 - 26506	1600	3797.73	II	4386 - 30710
2700	3854.21	II	5317 - 31255	1600	3826.20	II	4386 - 30514
2500	3922.40	II	3053 - 28540	1600	3843.50	II	3499 - 29510
2200	3661.36	II	327 - 27631	1600	3896.98	II	327 - 25980
2200	3670.84	II	838 - 28073	1600	4296.74	I	4021 - 27288
2200	4280.79	II	3910 - 27263	1600	4390.86	II	1489 - 24257
2200	4467.34	II	5318 - 27696	1600	4433.88	II	3499 - 26046
2100	3731.26	II	838 - 27631	1500	3788.12	II	2003 - 28394
2100	4256.39	II	3053 - 26540	1500	3963.00	II	326 - 25552
1900	3760.69	II	1489 - 28072	1500	3971.40	II	3499 - 28672
1900	3928.28	II	1489 - 26938	1500	3990.00	II	0 - 25056
1900	4118.55	II	5318 - 29591	1500	3990.02	I	3125 - 28181
1900	4318.94	II	2238 - 25385	1500	4420.53	II	2689 - 25304
1800	4329.02	II	1489 - 24583				



## Samarium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	2610.07			85	3134.18	II	
90	2640.27			270	3136.30	II	1489 - 33364
35	2649.17			150	3139.97	II	3052 - 34890
45	2657.68			85	3143.30	II	3499 - 35303
70	2662.42			150	3147.19	II	2689 - 34454
120	2675.15			180	3152.10	II	3053 - 34768
100	2688.60			410	3152.52	II	838 - 32549
45	2690.90	II	4386 - 41537	85	3162.15	II	2238 - 33853
130	2693.34			150	3162.30	II	838 - 32451
45	2693.74			360	3169.88	II	2238 - 33776
60	2696.08			85	3170.21	II	2238 - 33773
85	2707.96			180	3178.12	II	1489 - 32945
50	2732.42			720	3183.92	II	326 - 31725
35	2739.87			85	3186.02	II	2688 - 34066
29	2762.28			310	3187.01	II	1489 - 32858
35	2764.18			430	3187.22	II	3053 - 34419
85	2767.85	II	838 - 36956	360	3187.79	II	2238 - 33599
60	2774.77			85	3188.72	II	2689 - 34040
85	2776.11			360	3193.01	II	0 - 31309
85	2779.23	II	1518 - 37488	360	3196.18	II	3053 - 34331
85	2786.64			150	3201.80	II	3499 - 34722
150	2789.38	II	2003 - 37842	150	3204.90	II	2689 - 33882
130	2796.70			360	3207.18	II	0 - 31171
85	2807.36			180	3208.17	II	4386 - 35547
150	2809.50			600	3211.73	II	2237 - 33364
120	2810.86	II	2003 - 37569	150	3214.12	II	2003 - 33107
85	2817.20	II	2003 - 37488	270	3215.26	II	3053 - 34145
29	2820.96	II	1518 - 36956	530	3216.85	II	838 - 31916
220	2830.94			600	3218.61	II	1489 - 32549
60	2840.30			150	3219.43	II	0 - 31052
60	2847.49	II	10214 - 45322	270	3226.84	II	3909 - 34890
60	2851.35			180	3228.50	II	
120	2866.09	II	2688 - 37569	270	3228.78	II	4386 - 35349
70	2868.40	II	2003 - 36855	720	3230.56	II	1489 - 32435
70	2881.34			360	3231.53	II	838 - 31775
85	2881.68			150	3231.95	II	2003 - 32935
60	2883.09			430	3233.68	II	2237 - 33153
45	2889.06			720	3236.64	II	838 - 31725
60	2891.34			150	3237.89	II	3499 - 34375
85	2907.88			720	3239.66	II	3910 - 34768
	2907.99	II	10960 - 45337	530	3241.16	II	327 - 31171
130	2910.28	II		180	3241.59	II	1518 - 32359
85	2937.48	II		180	3242.04	II	3909 - 34745
70	2943.49	II	2003 - 35966	150	3244.69	II	1489 - 32299
150	2953.19	II		85	3245.80	I	1490 - 32290
85	2962.74	II		240	3249.75	II	326 - 31089
160	2969.02	II		720	3250.37	II	0 - 30757
100	2983.43	II		360	3253.40	II	838 - 31566
60	2991.57	II		270	3253.94	II	3053 - 33776
100	3021.01			850	3254.38	II	327 - 31045
150	3034.84	II	5317 - 38258	110	3255.63	II	2238 - 32945
100	3039.13	II	2688 - 35583	85	3258.25	II	2003 - 32686
120	3046.93	II		360	3262.28	II	2689 - 33333
45	3050.80	II		430	3264.94	II	2238 - 32858
85	3065.78	II	327 - 32935	180	3270.49	II	3499 - 34066
150	3067.54			180	3270.68	II	
120	3071.29	II		430	3272.48	II	1518 - 32067
100	3086.45	II			3272.60	II	3909 - 34457
85	3096.68	II	1489 - 33773	430	3272.81	II	3052 - 33599
120	3096.88	II		85	3273.32	II	3499 - 34040
100	3102.30	II		430	3273.48	II	0 - 30539
250	3106.52	II	2238 - 34419	85	3275.87	II	1489 - 32007
220	3110.20	II	1518 - 33661	430	3276.75	II	3910 - 34419
60	3115.05	II	2238 - 34331	270	3280.84	II	838 - 31309
200	3117.72	II		180	3285.66	II	1489 - 31916

Samarium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
430	3286.23	II	3910 - 34331	150	3397.76	II	0 - 29422
85	3286.54	II	2689 - 33107	150	3399.84	II	5317 - 34722
720	d 3290.28	II	1518 - 31902	600	3402.46	II	3053 - 32435
	3290.39	II	3499 - 33882	210	3403.09	II	3909 - 33286
180	3290.65	II	2688 - 33069	850	3408.68	II	2237 - 31566
240	3293.37	II	2003 - 32359	85	3411.28	II	2003 - 31309
360	3295.44	II	4386 - 34722	85	3413.90	II	2238 - 31522
430	3295.81	II	838 - 31171	270	3418.15	II	3052 - 32299
720	3298.10	II	2237 - 32549	430	3418.51	II	3910 - 33154
170	3300.98	II	1489 - 31775	170	3419.77	II	3052 - 32286
340	3301.68	II	3910 - 34189	120	3424.78	II	4386 - 33576
340	3304.52	II	0 - 30253	170	3426.20	II	5317 - 34496
340	3305.18	II	2689 - 32935	85	3427.97	II	1489 - 30652
1700	3306.39	II	3910 - 34145	95	3429.75	II	838 - 29986
170	3306.61	II	3052 - 33286	170	3433.68	II	2237 - 31352
850	3307.02	II	5317 - 35547	60	3435.27	II	5318 - 34419
340	3309.52	II	838 - 31045	150	3437.10	II	2689 - 31775
850	3310.66	II	2238 - 32435	170	3438.06	II	3053 - 32131
600	3312.42	II	1489 - 31670	240	3440.50	II	5318 - 34375
410	3316.58	II	2237 - 32380	85	3444.62	II	1489 - 30511
85	3319.56	II	838 - 30954	70	3449.56	II	2689 - 31670
430	3320.16	II	1489 - 31600	85	3452.78	II	3053 - 32007
110	3320.59	II		170	3453.56	II	4386 - 33333
1200	3321.18	II	3053 - 33154	85	3454.97	II	3499 - 32435
340	3323.77	II	3499 - 33576	170	3459.20	II	4386 - 33286
340	3325.26	II	2003 - 32067	120	3459.42	II	3499 - 32397
170	3325.48	II	2237 - 32299	240	3461.13	II	2237 - 31122
340	3327.88	II	3499 - 33539	85	3462.69	II	5318 - 34189
85	3329.62	II	3910 - 33935	120	3464.07	II	1489 - 30348
85	3332.70	II	2689 - 32686	70	3464.43	II	1489 - 30346
170	3333.64	II	4386 - 34375	170	3467.87	II	5318 - 34145
85	3335.03	II	326 - 30302	130	3473.96	II	3053 - 31830
170	3336.12	II	2238 - 32204	130	3479.53	II	2238 - 30969
850	3340.58	II	327 - 30253	130	3480.26	II	
85	3341.43	II	838 - 30757	170	3480.56	II	5317 - 34040
240	3343.49	II	3909 - 33809	170	3487.41	II	2003 - 30669
110	3343.64	II	2003 - 31902	85	3492.62	II	1489 - 30113
240	3344.35	II	3053 - 32945	170	3493.61	II	1489 - 30104
85	3346.35	II	5318 - 35192	60	3495.92	II	2003 - 30599
85	3346.91	II		220	3499.84	II	1518 - 30082
170	3347.30	II	3910 - 33776	170	3500.54	II	4386 - 32945
240	3348.68	II	3910 - 33763	120	3506.85	II	3499 - 32007
220	3350.88	II	3499 - 33333	120	3507.09	II	
410	d 3354.18	II	3053 - 32858	130	3509.10	II	
	3354.30	II	2688 - 32492	340	3511.23	II	838 - 29310
170	3354.72	II	3052 - 32852	170	d 3512.93	II	5318 - 33776
85	3361.43	II	2237 - 31978		3513.06	II	
85	3364.80	II		85	3516.30		
1200	3365.86	II	838 - 30539	130	3523.12	II	
150	3367.27	II	3910 - 33599	85	3525.51	II	2689 - 31045
340	3368.57	II	2238 - 31916	310	3530.60	II	1489 - 29805
85	3369.04	II	838 - 30511	220	3532.57	II	3052 - 31352
340	3369.46	II	2689 - 32359	270	3535.65	II	3499 - 31775
170	3370.59	II	327 - 29986	85	3536.77	II	
340	3371.21	II	4386 - 34040	85	3542.46	II	3910 - 32131
150	3376.48	II	3499 - 33107	120	3552.30	II	0 - 28143
70	3377.81	II	2003 - 31600	240	3554.15	II	2689 - 30817
1200	3382.40	II	1489 - 31045	170	3556.74	II	2238 - 30346
510	3384.66	II	3053 - 32589	170	3557.38	II	327 - 28429
150	3384.86			510	3559.10	II	3909 - 31998
60	3385.39	II	2238 - 31768	85	3560.27	II	2003 - 30082
150	3387.66	II	838 - 30348	170	3561.59	II	3052 - 31122
410	3389.32	II	4386 - 33882	220	3566.84	II	2003 - 30031
150	3391.11	II	1489 - 30969	4200	3568.27	II	3910 - 31926
410	3396.19	II	3499 - 32935	270	3577.79	II	0 - 27942

## Samarium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	3579.67			110	3707.17	II	2689 - 29656
390	3580.94	II	3052 - 30970	480	3708.41	II	327 - 27285
85	3582.67	II	1518 - 29422	930	3708.65	II	1489 - 28445
310	3583.39	II	1489 - 29388	130	3709.52	II	
170	3584.26	II	838 - 28730	160	3710.87	II	1489 - 28429
170	3585.83			480	3711.54	II	2003 - 28939
130	3587.46	II	2237 - 30104	240	3712.11	II	2688 - 29619
85	3589.50	II	2688 - 30539	350	3712.76	II	2003 - 28930
85	3591.74	II	838 - 28672	930	3718.88	II	3053 - 29935
4200	3592.60	II	3053 - 30880	130	3720.57	II	4386 - 31255
85	3593.73	II	4386 - 32204	95	3721.03	I	1490 - 28356
340	3601.69	II	1489 - 29246	930	3721.85	II	3052 - 29913
1700	3604.28	II	3910 - 31646	40	3724.02	II	2688 - 29533
3400	3609.49	II	2238 - 29935	420	3724.90	II	327 - 27165
110	3612.43	II	11791 - 39465	19	3726.24	II	
170	3613.58	II		190	3726.80	II	1489 - 28314
130	3615.24	II	2003 - 29656	55	3727.38	II	2689 - 29510
170	3620.10	II	327 - 27942	1600	3728.47	II	5318 - 32131
240	3620.58	II	3910 - 31522	95	3728.93	II	2003 - 28812
1700	3621.23	II	838 - 28445	210	3729.75	II	4386 - 31189
170	3622.50	II	327 - 27924	55	3730.74	I	2273 - 29070
240	3623.32	II	838 - 28429	2100	3731.26	II	838 - 27631
850	3627.01	II	2238 - 29801	1600	3735.98	II	2238 - 28997
170	3627.97	II	838 - 28394	800	3737.14	II	2238 - 28988
170	3630.67	II	5317 - 32852	320	3737.48	II	3053 - 29801
850	3631.13	II	3909 - 31441	190	3738.27	II	
3400	3634.29	II	1489 - 28997	2900	3739.12	II	326 - 27063
240	3634.93	II	327 - 27830		3739.20	II	4386 - 31122
120	3636.11	II	3052 - 30546	800	3741.29	II	1518 - 28239
410	3638.77	II		1200	3743.87	II	2689 - 29391
170	3642.76	II	4386 - 31830	930	3745.46	I	1490 - 28181
360	3645.29	II	1489 - 28914		3745.60	II	0 - 26690
300	3645.39	II	2689 - 30113	480	3747.62	II	2238 - 28914
170	3645.90	II	1518 - 28939	160	d 3748.52	I	293 - 26962
85	3647.29	II			3748.63	II	2003 - 28672
660	3649.53	II	3053 - 30446	80	3750.66	II	12841 - 39495
340	3650.19	II	2003 - 29391	160	3751.57	II	327 - 26974
170	3651.00	II	4386 - 31768	21	3753.09	II	3909 - 30546
130	3654.86	II	2238 - 29591	160	3754.86	II	1518 - 28143
340	3656.22	II	2688 - 30031	800	3755.28	II	2689 - 29310
170	3659.62	II	3499 - 30817	800	3756.41	I	812 - 27426
2200	3661.36	II	327 - 27631	290	3756.53	II	2237 - 28850
170	3662.27	II	2689 - 29986			II	3499 - 30113
220	3662.69	II	1518 - 28812	1200	3757.53	II	3499 - 30104
170	3662.90	II	3053 - 30346	450	3758.45	II	0 - 26599
340	3667.93	II	2238 - 29494	660	3758.97	II	4386 - 30981
340	3670.66	II	2003 - 29238	350	3760.04	II	3053 - 29641
2200	3670.84	II	838 - 28073	1900	3760.69	II	1489 - 28072
170	3674.07	II	0 - 27210	660	3762.59	II	2003 - 28573
340	3677.79	II	1489 - 28672	1100	3764.37	II	2689 - 29246
130	3680.98	I	3125 - 30284	130	3765.43	II	2688 - 29238
270	3681.73	II	3499 - 30652	480	3767.36	II	3910 - 30446
85	3687.10	II		480	3767.76	II	1489 - 28022
270	3688.42	II	838 - 27942	130	3770.73	II	5318 - 31830
85	3690.08	I	2273 - 29365	80	3771.35	II	13777 - 40285
85	3690.93	II	838 - 27924	210	d 3772.64	II	3499 - 29998
270	3692.22	II	2238 - 29314	370	3773.33	I	292 - 26786
120	3692.76	II	2237 - 29310		3773.42	II	1518 - 28012
1100	3693.99	II	0 - 27063	290	3774.29	II	3499 - 29986
190	3694.30	II	3909 - 30970	190	3774.68	II	0 - 26485
290	3700.60	II	3499 - 30514	95	3777.08	II	
290	3700.92	II	3499 - 30511	130	3777.84	II	
110	3701.56	II	2238 - 29246	1100	3778.14	II	12045 - 38505
480	3706.75	II	3910 - 30880	130	3779.56	II	5318 - 31768
480	3706.98	II	5317 - 32286	660	3780.76	II	0 - 26442

Samarium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
420	3780.93	II	3053 - 29494	150	3864.05	II	5317 - 31189
95	3782.42	II	4386 - 30817	320	3865.24	II	327 - 26191
45	3782.68	I	293 - 26721	80	3865.69	II	3053 - 28914
95	3783.06	II	2003 - 28429	800	3871.78	II	1489 - 27310
130	3783.36	II	1518 - 27942	130	3873.22	II	3499 - 29310
190	3785.35	II		190	3873.47	II	7524 - 33333
320	3787.20	II	327 - 26724	27	3874.39	II	
1500	3788.12	II	2003 - 28394	400	3875.19	II	3052 - 28850
270	3791.28	II		560	3875.54	II	1489 - 27285
270	3792.02	II	327 - 26690	160	3877.20	II	2237 - 28022
1600	3793.97	II	838 - 27188	240	3877.49	I	4021 - 29803
420	3797.28	II	838 - 27165	800	3880.77	II	838 - 26599
1600	3797.73	II	4386 - 30710	450	3881.38	II	2689 - 28445
500	3799.54	II	1518 - 27830	450	3881.79	II	
270	3800.37	II	3499 - 29805	320	3882.50	II	2237 - 27987
800	3800.89	II	2238 - 28540	27	3883.80	II	2689 - 28429
160	3803.94	I	0 - 26281	3700	3885.29	II	3910 - 29641
320	3805.63	II	838 - 27108	240	3885.91	II	4386 - 30113
27	3806.04	II	4386 - 30652	65	3887.11	II	4386 - 30104
190	3806.47	I	4021 - 30284	660	3889.16	II	2689 - 28394
					3889.22	II	
130	3806.77	II	3053 - 29314	610	3890.08	II	1489 - 27188
190	3807.92	II	0 - 26254	320	3891.21	II	1518 - 27210
420	3808.46	II	2689 - 28939	400	3894.05	II	3053 - 28726
320	3809.75	II	2689 - 28930	45	3895.09	II	
320	3809.88	II	838 - 27078	45	3895.42	II	5317 - 30981
420	3810.43	II	2003 - 28239	1600	3896.98	II	327 - 25980
500	3812.07	II	838 - 27063	45	3897.26	II	5318 - 30969
480	3813.63	II	3909 - 30123	270	3900.89	II	2003 - 27631
110	3813.83	I	4021 - 30234	65	3902.32	II	1489 - 27108
420	3814.63	II	2238 - 28445	1300	3903.42	II	2237 - 27849
45	3818.36	I	1490 - 27671	60	3906.81	II	1489 - 27078
930	d 3820.82			90	3909.95	I	3125 - 28694
530	3824.18	II	1489 - 27631	90	3910.09	II	2689 - 28256
1600	3826.20	II	4386 - 30514	50	3910.92	II	5318 - 30880
130	3826.56	II	4386 - 30511	120	3912.98	II	4386 - 29935
240	3828.05	II	326 - 26442	120	3913.37	II	
530	3830.29	II	838 - 26938	90	3913.62	II	7524 - 33069
1100	3831.50	II	3499 - 29591	60	3916.36	II	8679 - 34205
110	3832.81	I	2273 - 28356	620	3917.44	II	838 - 26358
530	3833.83	II	2238 - 28314	190	3918.62	II	1489 - 27001
560	3834.48	I	4021 - 30093	50	3920.10	II	13604 - 39106
560	3834.60	II	3052 - 29123	190	3922.05	II	2003 - 27493
370	3835.72	II	1489 - 27553	2500	3922.40	II	3053 - 28540
500	3838.94	II	2689 - 28730	90	3922.70	II	1489 - 26974
400	3840.45	II	327 - 26358	290	3925.22	I	812 - 26281
80	3840.61	II		1900	3928.28	II	1489 - 26938
270	3842.36	II	2238 - 28256	35	3931.16	II	3499 - 28930
1600	3843.50	II	3499 - 29510	90	3932.97	II	4386 - 29805
270	3843.77	II	2003 - 28012	290	3933.58	II	4386 - 29801
110	h 3844.50	II	1489 - 27493	50	3935.18	II	3910 - 29314
65	3846.28	I	812 - 26803	470	3935.76	II	2238 - 27638
160	3846.76	I	293 - 26281	290	3937.06	II	5317 - 30710
530	3847.51	II	2689 - 28672	29	3938.43	II	2689 - 28073
640	3848.78	II	1489 - 27464	50	3939.64	II	838 - 26214
420	3851.88	II	2238 - 28192	1300	3941.87	II	0 - 25361
530	3853.30	I	3125 - 29070	620	3943.24	II	838 - 26191
2700	3854.21	II	5317 - 31255	500	3946.51	II	1489 - 26821
480	3854.56	I	1490 - 27426	290	3947.84	II	2689 - 28012
800	3855.90	II	327 - 26254	740	3948.11	II	838 - 26160
480	3857.91	II	2238 - 28151	50	3949.85	I	2273 - 27583
190	3858.52	I	1490 - 27399	470	3951.89	I	1489 - 26786
400	3858.74	I	2273 - 28181	120	3954.20	II	1489 - 26772
660	3862.05	II	838 - 26724	29	3954.97		
350	3862.23	II	2689 - 28573	50	3957.52	II	3052 - 28314
190	h 3863.42	II					

Samarium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
120	3958.72	II	2689 - 27942	710	4068.33	II	3499 - 28073
370	3959.53	II	838 - 26086	810	4075.84	II	4386 - 28914
190	3961.80	II	4386 - 29619	280	4076.65	II	838 - 25361
90	3962.13	I	1489 - 26721	90	4076.86	II	327 - 24848
90	3962.24	II	3499 - 28730	100	4079.83	I	2273 - 26777
1500	3963.00	II	326 - 25552	240	4080.56	II	2689 - 27188
620	3966.04	II	2003 - 27210	130	4081.97	II	1489 - 25980
90	3966.34	II	4386 - 29591	410	4082.60	II	5318 - 29805
470	3967.68	II	5318 - 30514	90	4083.24	II	5318 - 29801
740	3970.53	II	0 - 25178	280	4083.58	II	2003 - 26485
1500	3971.40	II	3499 - 28672	220	4084.40	II	2689 - 27165
190	3974.45	II		45	4086.16	II	838 - 25304
620	3974.66	I	2273 - 27426	29	4089.48	II	9406 - 33852
160	3975.22	II	2238 - 27387	1000	4092.27	II	0 - 24430
960	3976.27	II	838 - 25980	50	4093.04	II	3499 - 27924
1000	3976.43	II	2689 - 27830	290	4094.05	II	2689 - 27108
960	3979.20	II	4386 - 29510	120	4098.97	II	2689 - 27078
50	3980.88	II		60	4099.96	I	3125 - 27509
740	3983.14	II	3053 - 28151	240	4104.13	II	327 - 24686
150	3986.00	II	1518 - 26599	90	4106.62	II	4386 - 28730
29	3986.23	II	3909 - 28988	810	4107.28	II	838 - 25178
740	3986.68	II	1489 - 26566		4107.39	II	4386 - 28726
150	3986.90	II	2003 - 27078	60	4107.80	II	838 - 25175
370	3987.43	II	2238 - 27310	130	4108.32	II	3053 - 27387
1500	3990.00	II	0 - 25056	410	4109.40	II	2238 - 26566
	3990.02	I	3125 - 28181	280	4110.19	II	5318 - 29641
150	3991.02	I	4020 - 29069	410	4113.90	II	1489 - 25790
740	3993.31	II	327 - 25361	190	4116.46	II	2689 - 26974
90	3995.59	II		1900	4118.55	II	5318 - 29591
190	3998.35	I	4020 - 29023	150	4119.57	II	2238 - 26506
280	4003.46	II	2003 - 26974	410	4121.36	II	3053 - 27310
90	4003.72	II	3052 - 28022	120	4121.54	II	327 - 24583
50	4004.26	II	1518 - 26485	280	4122.51	II	2003 - 26254
190	4006.60	II	838 - 25790	710	4123.96	II	3910 - 28151
90	4006.82	II	2238 - 27188	60	4125.23	I	2273 - 26507
470	4007.48	II	3499 - 28445	90	4125.85	II	
150	4008.10	II	2689 - 27631	29	4128.12	II	838 - 25055
150	4008.33	II	3909 - 28850	280	4129.23	II	2003 - 26214
90	4011.73	II	0 - 24920	100	4133.19	II	2003 - 26191
60	4015.77	II	3499 - 28394	250	4135.14	II	5318 - 29494
120	4019.84	II	2238 - 27108	45	4135.50	I	1490 - 25664
280	4019.98	II	1489 - 26358	50	4138.97	II	4386 - 28540
90	4022.73	II	327 - 25178	75	4142.67	II	3499 - 27631
880	4023.23	II	327 - 25175	75	4145.24	I	4020 - 28137
150	4032.98	II	326 - 25115	160	4146.75	II	1489 - 25598
740	4035.11	II	2689 - 27464	320	4147.71	II	327 - 24430
180	4037.10	II	2238 - 27001	810	4149.83	II	838 - 24929
150	4038.10	II	3499 - 28256	1200	4152.21	II	1489 - 25566
590	4041.68	II	1518 - 26254	530	4153.33	II	5318 - 29388
740	4042.72	II	327 - 25056	560	4155.22	II	4386 - 28445
880	4042.90	II	838 - 25566	130	4156.25	II	3499 - 27553
240	4044.11	II	2003 - 26723	100	4159.40	II	2689 - 26724
560	4045.05	II	838 - 25553	100	4159.51	II	1518 - 25553
440	4046.16	II	838 - 25546	160	4163.14	II	0 - 24013
740	4047.16	II	1489 - 26191	100	4163.72	II	838 - 24848
100	4047.35	II	2238 - 26938	45	4165.54	II	12987 - 36987
210	4048.62	II	3499 - 28192	50	4166.34	II	
75	4049.58	II	2003 - 26690	810	4169.48	II	2003 - 25980
590	4049.81	II	0 - 24686	410	4171.57	II	3499 - 27464
440	4058.87	II	3910 - 28540	190	4174.43	II	3053 - 27001
560	4063.54	II	327 - 24929	440	4178.02	II	4386 - 28314
280	4064.32	II	1489 - 26086		4178.02	II	1489 - 25417
1400	4064.58	II	2689 - 27285	530	4181.10	II	2689 - 26599
	4064.58	II	2003 - 26599	210	4183.33	I	1490 - 25387
810	4066.74	II	2238 - 26821	530	4183.76	II	327 - 24222

Samarium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1000	4188.13	II	4386 - 28256	45	4301.28	I	4020 - 27263
410	4191.93	II	2237 - 26086	320	4304.94	II	5318 - 28540
160	4192.16	II	838 - 24686	880	4309.01	II	1489 - 24690
45	4197.90	II	1489 - 25304	240	4312.85	I	2273 - 25453
270	4199.45	II	4386 - 28192	180	4313.73	II	2003 - 25178
26	4201.22	II	2689 - 26485		4313.73	II	838 - 24013
650	4202.92	II	3910 - 27696	75	d 4315.35	II	4386 - 27552
1100	4203.05	II	3499 - 27285		4315.38	II	4386 - 27553
50	4204.82	II	3053 - 26828	1900	4318.94	II	2238 - 25385
160	4205.78	I	4020 - 27790	470	4319.53	I	1490 - 24634
660	4206.13	II	3053 - 26821	590	4323.28	II	838 - 23962
270	4206.62	II	4386 - 28151	240	4324.46	I	2273 - 25391
660	4210.35	II	838 - 24583	45	4327.51	II	2689 - 25790
100	4213.05	II	3910 - 27639	1800	4329.02	II	1489 - 24583
26	4213.94	II		440	4330.02	I	293 - 23381
100	4218.63	I	4020 - 27718	120	4331.45	I	1489 - 24570
50	4219.31	I	293 - 23986	1300	4334.15	II	2238 - 25304
180	4220.14	II	3499 - 27188	880	4336.14	I	3125 - 26182
740	4220.66	II	4386 - 28072	45	4336.74	II	2003 - 25055
150	4223.70	II	2689 - 26358	90	4338.96	I	812 - 23852
50	4224.23	II	3499 - 27165	35	4339.92	I	812 - 23847
1000	4225.33	II	1518 - 25178	35	h 4342.38	II	
	4225.33	II	0 - 23659	560	4345.86	II	838 - 23842
150	4226.18	I	812 - 24467	90	4346.49	II	4386 - 27387
740	4229.70	II	327 - 23962	1100	4347.80	II	3053 - 26046
50	4230.73	I	0 - 23630	560	4350.46	II	3910 - 26889
620	4234.57	II	3499 - 27108	24	4350.82	I	1490 - 24467
1200	4236.74	II	5318 - 28914	560	4352.10	II	3909 - 26880
500	4237.66	II	838 - 24430	24	4357.90	I	3125 - 26066
45	4240.45	I	1490 - 25065	560	4360.72	II	2003 - 24929
620	4244.70	II	2238 - 25790	220	4361.07	II	4386 - 27310
120	4245.18	II	2003 - 25553	810	4362.04	II	3910 - 26828
50	4247.39	II	1518 - 25056	440	4362.91	I	0 - 22914
210	4249.55	II	2689 - 26214	220	4363.45	II	1518 - 24430
250	4251.78	II	3053 - 26566	24	4364.05	II	8046 - 30954
60	4253.72	II	2688 - 26190	45	4365.95	I	812 - 23710
2100	4256.39	II	3053 - 26540	500	4368.03	II	3053 - 25940
210	4258.58	II	3499 - 26974	210	4369.92	II	2689 - 25566
50	4259.39	II	2689 - 26160	45	4370.48	II	5318 - 28192
1300	4262.68	II	3053 - 26506	440	4373.46	II	3499 - 26358
500	4265.08	II	1489 - 24930	320	4374.98	II	327 - 23177
120	4266.31	I	812 - 24245	880	4378.24	II	5318 - 28151
35	4269.77	II	2003 - 25417	530	4380.42	I	1490 - 24312
50	4270.73	II	1489 - 24898	290	4384.29	II	4386 - 27188
150	4270.84	II	5318 - 28726	120	4386.22	I	2273 - 25065
50	4271.86	I	2273 - 25676	21	4388.99	II	7524 - 30302
50	4272.01	II	1518 - 24920	1600	4390.86	II	1489 - 24257
1200	4279.68	II	2238 - 25598	21	4392.60	II	7135 - 29894
	4279.75	II	1489 - 24848	210	4393.35	I	1490 - 24245
240	4279.94	II	2003 - 25361	290	4397.34	I	812 - 23547
90	4280.32	II	838 - 24194	90	4399.88	II	4386 - 27108
2200	4280.79	II	3910 - 27263	410	4401.17	I	3125 - 25840
190	4281.01	II	0 - 23352	810	d 4403.06	II	1489 - 24194
710	4282.21	I	3125 - 26471		4403.13	I	2273 - 24978
470	4282.83	I	2273 - 25616	410	4403.36	II	1518 - 24222
240	4283.50	I	812 - 24151	35	4405.67	II	3499 - 26191
35	4284.50	II	326 - 23659	60	4407.52	II	2003 - 24686
50	4285.50	II	2238 - 25566	520	4409.33	II	2689 - 25361
350	4286.64	II	3499 - 26821	290	4411.58	I	1490 - 24151
35	4291.62	II		120	4411.83	II	2238 - 24898
350	4292.18	II	2689 - 25980	380	4417.58	II	3910 - 26540
60	4295.74	II	3499 - 26772	470	4419.33	I	293 - 22914
1600	4296.74	I	4021 - 27288	1500	4420.53	II	2689 - 25304
90	4299.14	I	293 - 23547	960	4421.14	II	3053 - 25665
90	4299.34	II	4386 - 27639	75	4423.38	I	293 - 22893

## Samarium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
2900	4424.34	II	3910 - 26506	240	4560.43	II	327 - 22248
35	4425.99	II	3499 - 26086	18	4561.19	II	3499 - 25417
180	4427.58	II	2003 - 24583	60	4564.10	II	0 - 21904
75	4427.81	II	2238 - 24816	470	4566.21	II	2689 - 24583
470	4429.66	I	812 - 23381	60	4566.77	I	1490 - 23381
120	4433.08	I	293 - 22844	35	4569.58	I	2273 - 24151
1600	4433.88	II	3499 - 26046	590	4577.69	II	2003 - 23842
1800	4434.32	II	3053 - 25598	45	4578.72	II	1518 - 23352
530	4441.81	I	1490 - 23997	75	4579.09	II	1489 - 23321
440	4442.28	I	812 - 23317	290	4581.58	I	812 - 22632
100	4442.47	II	3909 - 26413	440	4581.73	I	4021 - 25840
50	4443.27	I	2273 - 24773	560	4584.83	II	3499 - 25304
710	4444.26	II	4386 - 26880	45	4589.43	II	9406 - 31189
710	4445.15	I	3125 - 25616	290	4591.82	II	1489 - 23261
35	4445.84	II	2688 - 25175	380	4593.54	II	3053 - 24816
45	4446.96	II	3499 - 25980	35	4594.59	II	11094 - 32852
1300	4452.73	II	2238 - 24690	560	4595.29	II	3910 - 25665
250	4452.95	I	4021 - 26471	240	4596.74	I	292 - 22041
1200	4454.63	II	4386 - 26828	90	4598.35	II	2689 - 24430
90	4456.11	II	4386 - 26821	60	4603.12	II	12044 - 33763
1000	4458.52	II	838 - 23261	220	4604.18	II	327 - 22040
250	4459.29	I	812 - 23231	290	4606.51	II	0 - 21702
29	4463.90	I	2273 - 24669	45	4606.88	II	4386 - 26086
2200	4467.34	II	5318 - 27696	75	4611.25	I	812 - 22492
90	4469.66	II	2688 - 25055	75	4613.50	II	2689 - 24358
810	4470.89	I	2273 - 24634	290	4615.44	II	4386 - 26046
470	4472.43	II	1489 - 23842	470	4615.69	II	1518 - 23177
620	4473.02	II	2238 - 24588	29	4616.49	II	0 - 21655
75	4475.18	II	838 - 23177	15	4620.25	II	
50	4477.50	I	3125 - 25453	24	4624.97	II	10214 - 31830
740	4478.66	II	5317 - 27639	29	4629.43	I	4021 - 25616
120	4480.32	I	0 - 22314	150	4630.21	II	838 - 22429
29	4485.57	II	7135 - 29422	90	4636.26	II	5317 - 26880
26	4490.02	I	3125 - 25391	880	4642.24	II	3053 - 24588
24	4495.14	II	2689 - 24929	290	4645.40	I	293 - 21813
370	4499.11	I	1490 - 23710	290	4646.68	II	2238 - 23753
370	4499.48	II	2003 - 24222	90	4647.53	II	5318 - 26828
60	4501.38	II	2689 - 24898	240	4648.16	II	0 - 21508
240	4503.38	I	293 - 22492	380	4649.49	I	812 - 22314
180	4505.05	II	2003 - 24194	150	4655.13	II	3910 - 25385
120	4511.33	I	4021 - 26182	290	4663.56	I	2273 - 23710
560	4511.83	II	1489 - 23647	75	4665.13	II	3499 - 24929
440	4515.09	II	1518 - 23659	740	4669.40	II	838 - 22248
29	4517.27	II	7524 - 29656	620	4669.65	II	2238 - 23647
880	4519.63	II	4386 - 26506	470	4670.75	I	1490 - 22894
60	4522.55	I	1490 - 23595		4670.83	I	1490 - 22893
440	4523.04	II	327 - 22429	1100	4674.60	II	1489 - 22875
	4523.18	I	812 - 22914	680	4676.91	II	327 - 21702
650	4523.91	II	3499 - 25598	210	4681.55	I	1490 - 22844
60	4527.42	I	812 - 22893	75	4682.69	II	3499 - 24848
75	4532.44	I	1490 - 23547	370	4687.18	II	327 - 21655
290	4533.80	I	2273 - 24324	370	4688.73	I	2273 - 23595
270	4536.51	II	838 - 22875	40	4689.57	II	2003 - 23321
710	4537.95	II	3910 - 25940	130	4693.63	II	1489 - 22789
150	4538.53	II	4386 - 26413	120	4699.34	II	2689 - 23962
290	4540.19	II	2238 - 24257	530	4704.40	II	0 - 21251
380	4542.06	II	2003 - 24013	60	4710.64	II	5318 - 26540
810	4543.95	II	2689 - 24690	270	4713.06	II	4386 - 25598
100	4544.83	II	2689 - 24686	75	4714.62	II	3053 - 24257
29	4545.81	II	5318 - 27310	130	4715.26	II	838 - 22040
45	4550.03	I	2273 - 24245	730	4716.10	I	3125 - 24324
410	4552.66	II	2003 - 23962	270	4717.07	I	0 - 21194
270	4554.45	II	838 - 22789	210	4717.72	II	3499 - 24690
90	d 4556.50	II	8046 - 29986	190	4718.33	II	5318 - 26506
	4556.63	I	3125 - 25065	29	4718.64	I	3125 - 24312

Samarium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
270	4719.84	II	327 - 21508	35	4989.44	II	2003 - 22040
35	4720.12	II	4386 - 25566	70	4992.02	II	8046 - 28072
29	4721.39	II	2003 - 23177	45	5001.22	II	1518 - 21508
130	4726.02	II	2689 - 23842	45	5016.61	II	7135 - 27063
770	4728.42	I	1490 - 22632	60	5023.50	II	2003 - 21904
50	4741.72	II	3499 - 24583	140	5028.44	II	12045 - 31926
470	4745.68	II	838 - 21904	29	5031.18	II	12045 - 31916
150	4750.72	I	2273 - 23317	400	5044.28	I	3125 - 22944
40	4755.37	II	2238 - 23261	45	5049.51	I	293 - 20091
730	4760.27	I	812 - 21813	200	5052.76	II	11094 - 30880
110	4770.20	I	2273 - 23231	65	5057.74	II	8679 - 28445
110	4774.15	II	1489 - 22429	60	5059.85	I	15418 - 35176
190	4777.85	II	327 - 21251	70	5060.93	I	1490 - 21243
70	4781.84	II	3910 - 24816	29	5064.24	II	2689 - 22429
580	4783.10	I	293 - 21194	22	5066.86	II	11791 - 31522
350	4785.86	I	812 - 21701	170	5069.46	II	10214 - 29935
160	4789.96	I	3125 - 23997	540	5071.20	I	4020 - 23734
230	4791.58	II	838 - 21702	65	5076.69	I	13814 - 33507
15	h 4804.90	II	14084 - 34890	60	5079.86	I	
430	4815.81	II	1489 - 22248	29	5087.08	II	2003 - 21655
85	4816.01	II	3499 - 24257	29	5087.65	II	11395 - 31045
130	4829.57	II	3053 - 23753	60	5088.32	I	812 - 20459
40	4833.32	II		22	5088.97	II	12790 - 32435
75	4834.62	II	3910 - 24588	170	5100.22	II	12045 - 31646
35	4836.67	II	838 - 21508		5100.39	I	13095 - 32696
40	4837.65	II	10214 - 30880	260	5103.09	II	9407 - 28997
970	4841.70	I	4021 - 24669	140	5104.48	II	8046 - 27631
310	4844.21	II	2238 - 22875	140	5116.70	II	7525 - 27063
140	4847.76	II	5318 - 25940	510	5117.16	I	2273 - 21809
270	4848.32	I	2273 - 22893	350	5122.14	I	3125 - 22643
120	4854.36	II	3053 - 23647	50	5124.86	II	9406 - 28913
85	4859.55	II	2689 - 23261	35	5132.21	I	12445 - 31924
75	4869.98	II	9407 - 29935	35	5135.86	I	11877 - 31342
8	4873.20	II	11155 - 31669	60	5154.23	II	12045 - 31441
210	4883.77	I	293 - 20763	360	5155.03	II	8679 - 28072
730	4883.97	I	3125 - 23595	60	5155.86	I	11044 - 30435
12	4891.94	II	10873 - 31309	65	5157.07	II	10960 - 30346
75	4893.35	II	4386 - 24816		5157.23	I	293 - 19677
35	4894.30	II	2003 - 22429	29	5162.86	II	8578 - 27942
40	4900.73	II	8046 - 28445	22	5164.62	I	11877 - 31234
24	4901.90	II	9407 - 29801	80	5166.06	II	11094 - 30446
170	4904.97	I	812 - 21194	50	5168.35	I	15418 - 34761
630	4910.40	I	2273 - 22632	50	5169.57	II	
350	4913.25	II	5318 - 25665	250	5172.74	I	2273 - 21600
14	4914.30	II	3499 - 23842	470	5175.42	I	4020 - 23337
430	4918.99	I	1490 - 21813	70	h 5178.01	II	7135 - 26442
75	4920.38	II	8679 - 28997	45	5187.09	I	1490 - 20763
60	4923.83	II	4386 - 24690	45	5194.73	I	13095 - 32340
110	4924.04	I	4021 - 24324	250	5200.59	I	1490 - 20713
29	4929.56	II	5318 - 25598	29	5201.45	I	12445 - 31665
45	4936.03	II	3499 - 23753	60	5202.73	II	2689 - 21904
120	4938.10	II	2003 - 22248	60	5209.92	I	13095 - 32284
95	4946.32	I	1490 - 21701	60	5218.40	I	
170	4948.63	II	4386 - 24588	29	5221.12	I	14591 - 33739
120	4952.37	II	2689 - 22875	60	h 5228.80	II	8046 - 27165
45	4953.03	II	1518 - 21702	45	h 5234.18	II	10214 - 29314
29	d 4955.95	II	10873 - 31045	29	h 5237.58	I	12846 - 31934
	4956.13	II	13604 - 33776	260	5251.92	I	2273 - 21308
170	4961.94	II	3499 - 23647	35	5252.77	II	8046 - 27078
45	4964.56	II	1518 - 21655	22	5253.80	I	11406 - 30435
60	4972.16	II	7525 - 27631	25	5265.67	I	0 - 18986
35	4973.74	II	2689 - 22789	400	5271.40	I	812 - 19777
170	4975.98	I	0 - 20091	25	5272.82	II	7524 - 26484
45	4981.73	II	5318 - 25385	250	5282.91	I	4020 - 22944
29	4983.38	II	14084 - 34145	25	h 5289.94	I	



Samarium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	5294.65	I	13814 - 32696	120	5696.73	I	
35	5303.23	I	14056 - 32907	85	5706.20	I	1490 - 19010
22	5309.50	I	13095 - 31924	22	5706.75	I	292 - 17810
35	5312.23	II	2689 - 21508	22	5709.73	I	13050 - 30559
22	5313.76	I		35	5710.93	I	
190	5320.60	I	2273 - 21063	14	5711.45	I	2273 - 19777
18	5321.82	I		29	5717.92	I	12445 - 29929
22	5324.99	I		14	5719.12	II	8679 - 26159
18	5332.09	I	12313 - 31062	29	5720.19	I	293 - 17770
110	5341.29	I	293 - 19010	22	5721.38	I	13095 - 30569
29	5348.08	I	293 - 18986	12	5724.45	I	15617 - 33081
45	5348.74	I	13458 - 32149	14	5729.30	I	11406 - 28855
35	5349.14	I	812 - 19501	10	5730.13	I	11406 - 28853
45	5350.62	I	3125 - 21809	50	5732.95	I	4021 - 21459
35	5355.88	I	14202 - 32868	22	5736.84	I	13050 - 30476
22	5364.39	II	10214 - 28850	29	5738.01	II	14504 - 31926
140	5368.36	I	4021 - 22643	22	5740.89	I	14154 - 31568
14	5369.18	II		10	5741.19	I	812 - 18225
22	5370.06	I		50	5743.35	II	14115 - 31522
14	5378.09	I		9	5745.50	I	11044 - 28445
35	5387.97	I	13369 - 31923	29	5748.09	I	13814 - 31207
22	5389.85	I		22	5757.97	I	12445 - 29807
22	5392.69	I	14920 - 33458	45	5759.52	II	12988 - 30346
29	5394.48	II	9410 - 27942	29	5763.91	I	
95	5403.70	I	1490 - 19990	70	5773.77	I	13815 - 31129
130	5405.23	I	293 - 18788	60	5778.33	I	
60	5411.39	I	3125 - 21600	45	5779.24	I	1490 - 18788
35	5415.98	II	17005 - 35463	45	5781.93	II	8046 - 25336
9	5419.07	I	4020 - 22468	70	5786.98	II	13604 - 30880
45	5421.57	I	2273 - 20713		5787.15	I	11877 - 29152
18	5425.63	I		14	5787.53	I	11877 - 29151
18	5433.55	I	13687 - 32086	60	5788.38	I	3125 - 20397
18	5433.82	I	812 - 19210	60	5800.52	I	13095 - 30330
29	5436.33	I	15418 - 33808	14	5801.24	I	13542 - 30775
220	5453.00	I	3125 - 21459	9	5801.66	II	10960 - 28192
18	5461.55	I	14563 - 32868	65	5802.84	I	2273 - 19501
140	5466.72	I	1490 - 19777	14	5806.77	I	13095 - 30312
25	5478.29	II	10181 - 28429	45	5814.89	I	11877 - 29069
65	5485.42	I	0 - 18225	12	5816.34	I	11044 - 28233
230	5493.72	I	812 - 19010	13	5818.32	I	13095 - 30278
80	5498.21	I	293 - 18475	18	5820.68	II	
29	5511.09	I	4020 - 22160	29	5830.51	I	11877 - 29023
80	5512.10	I	812 - 18949	45	5831.02	II	12790 - 29935
230	5516.09	I	2273 - 20397	22	5831.74	II	14504 - 31646
10	5525.61	I	14056 - 32149	45	5836.37	II	8046 - 25175
29	5537.07	II	13466 - 31522	22	5842.60	II	8679 - 25790
50	5548.95	I	292 - 18309	22	5843.76	I	14591 - 31699
140	5550.40	I	1490 - 19501	22	5848.67	II	12842 - 29935
14	5561.37	I	812 - 18788	14	5860.27	II	7135 - 24194
45	5573.42	I	3125 - 21063	35	5860.78	I	3125 - 20183
29	5574.89	I	293 - 18225	65	5867.79	I	3125 - 20163
35	5588.20	I	2273 - 20163	45	5868.61	I	4021 - 21056
50	5600.86	II	11791 - 29641	35	5871.06	I	3125 - 20153
50	5621.79	I	293 - 18076	50	5874.21	I	812 - 17831
70	5626.01	I	0 - 17770	9	5875.10	I	13542 - 30559
14	5637.30	II	8679 - 26413	13	5875.92	I	1490 - 18503
85	5644.10	I		13	5878.11	II	10181 - 27188
22	5656.34	I	13095 - 30770	25	5891.41	I	12313 - 29282
140	5659.86	I	812 - 18475	22	5895.16	I	13458 - 30416
9	5661.54	II		45	5897.39	II	12045 - 28997
22	5663.91	I	14591 - 32242	50	5898.96	I	11044 - 27992
29	5686.75	II	10960 - 28540	29	5902.60	I	2273 - 19210
14	5686.98	I	4021 - 21600	29	5903.50	I	12445 - 29379
9	5692.05	I	13095 - 30659	18	5906.05	I	1490 - 18417
22	5696.24	II	7135 - 24685	22	5909.04	I	2273 - 19191

## Samarium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
9	5910.83	I	12313 - 29226	14	6156.90	II	11047 - 27284
29	5912.61	I	10801 - 27709	14 h	6157.55	II	11395 - 27631
22	5913.56	I	14202 - 31108	45 h	6159.56	I	2273 - 18503
14	5915.56	I		22	6160.42	II	10960 - 27188
14	5916.36	I	293 - 17190	12	6164.51	II	7135 - 23352
22	5919.33	II	10960 - 27849	18	6165.84	I	14202 - 30416
22	5921.01	I	12846 - 29731	12 h	6168.33	II	12790 - 28997
22	5923.34	I	15082 - 31960	18	6173.95	I	12313 - 28505
22	5924.66	I	13458 - 30332	18	6174.45	I	4020 - 20211
25	5932.18	I	13095 - 29948	18	6174.96	II	10873 - 27063
25	5932.90	II	12790 - 29641	18	6179.41	I	14591 - 30770
35	5938.90	II	7525 - 24358	22 h	6179.82	II	10181 - 26358
22	5942.33	I	15418 - 32242	18	6181.05	II	13466 - 29641
25	5946.37	I	14202 - 31015	29 h	6182.89	II	11094 - 27263
25 h	5955.82	II	11659 - 28445	22	6188.00	II	9410 - 25566
25	5956.76	I	15082 - 31865	29	6192.64	II	11798 - 27942
22	5957.52	II	9410 - 26191	18	6194.39	I	3125 - 19265
25	5960.09	I	11044 - 27818	10	6198.14	II	11155 - 27284
25	5963.22	II	12232 - 28997	18	6201.13	I	11044 - 27166
65	5965.71	II	10180 - 26938	25	6203.86	I	13814 - 29929
35 h	5968.82	II	11791 - 28540	22	6206.87	I	14591 - 30698
13	5969.49	I	13687 - 30435	10	6207.13	I	13542 - 29648
25	5979.38	I	1490 - 18210	18	6217.17	I	13050 - 29130
35	5984.29	I	12445 - 29151	10	6225.48		
13 h	5993.85	II	10873 - 27552	18	6226.70	I	2273 - 18329
25	5994.64	II	11395 - 28072	29	6237.66	II	12045 - 28072
29	5995.09	I	2273 - 18949	18	6238.30	I	15082 - 31108
22	6001.94	I	11877 - 28534	25 h	6244.21	II	8679 - 24690
22	6004.18	I	812 - 17462	45	6246.76	II	8579 - 24583
25	6011.22	II	11799 - 28429	14	6248.11	I	11406 - 27406
12	6016.80	I	14591 - 31207	45	6256.54	I	15955 - 31934
18	6017.39	II	10214 - 26828	45	6256.66	II	9407 - 25385
25	6027.16	I	3125 - 19712	100	6267.28	II	9410 - 25361
18	6033.23	II	9410 - 25980	10	6279.49	II	10960 - 26880
29	6041.40	I	11877 - 28425	25	6289.90	II	9410 - 25304
18	6042.84	I	14612 - 31156	50	6291.82	II	11395 - 27285
50	6045.00	I	2273 - 18811	14	6292.94	I	14202 - 30089
45	6045.39	I	10801 - 27338	29	6294.68	II	10371 - 26253
9 h	6053.88	I	11406 - 27920	22	6301.12	II	10181 - 26046
12	6067.78	II	11155 - 27631	18	6302.40	II	12567 - 28429
50	6070.06	I	1490 - 17959	29	6303.15	II	10960 - 26820
12 h	6075.72	I	11877 - 28331	13	6305.19	II	10743 - 26599
45	6084.12	I	812 - 17244	35	6307.06	II	8579 - 24430
12	6088.62	I	12445 - 28864	13	6315.78	II	14084 - 29913
35 h	6091.40	I	11406 - 27818	25	6321.75	II	13777 - 29591
14	6096.78	I	13458 - 29855	13	6322.51	I	13814 - 29627
14 h	6099.90	I	293 - 16682	18	6325.54	II	11659 - 27464
18	6101.96	I	14202 - 30586	70	6327.47	II	10181 - 25980
22	6103.37	I	13095 - 29475	13	6328.01	I	15524 - 31322
45	6110.66	II	11791 - 28151	25	6340.10	I	13458 - 29226
12	6112.98	I	14856 - 31210	22	6353.54	II	10518 - 26253
18	6114.58	II	8578 - 24928	13	6355.35	I	14856 - 30586
22	6114.73	I		29	6357.18	II	10873 - 26599
18	6122.75	I	15418 - 31746	14	6367.41	I	1490 - 17190
22	6123.60	II	10214 - 26540	22	6368.28	II	12842 - 28540
14	6124.88	II	12988 - 29310	6	6371.01	I	4021 - 19712
14	6126.33	I	14856 - 31175	5	6380.05	I	11044 - 26714
12	6130.62	I	12445 - 28752	14 h	6386.77	I	14202 - 29856
22	6135.85	I	11044 - 27338	29	6389.85	II	9410 - 25056
18	6138.05	I	11877 - 28164	25	6390.81	II	8579 - 24222
18	6139.33	I	13095 - 29379	9 h	6403.98	II	13777 - 29387
22	6140.60	I	15418 - 31699	12 h	6406.24	II	10960 - 26566
18	6143.09	I		29	6417.50	II	8679 - 24257
12	6143.59	I	13458 - 29731	45	6426.64	II	14085 - 29641
29	6149.10	II	12988 - 29246	22	6428.32	II	11047 - 26599

## Samarium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>		
10	6428.94	I	15082 - 30633	55	6741.47	II	8046 - 22875		
22	6431.00	II	10960 - 26506	17	6754.68	II	11799 - 26599		
10	6431.96	II	11395 - 26938		6754.85	I	16131 - 30931		
10	6435.34	I		17	6759.25	I	16131 - 30921		
7	6447.56	II	12566 - 28072	14	6766.52	II	11791 - 26566		
12	6452.08	I	14154 - 29648	20	6778.19	II	11791 - 26540		
14	6455.60	II	11799 - 27285	40	6778.61	II	10181 - 24929		
10	6456.25	II	10873 - 26357	14	6780.03	II	14193 - 28938		
10	6457.55	I	14856 - 30337	17	6781.17	II	8046 - 22789		
4	6459.36	I	15082 - 30560	20	6782.95	II	17391 - 32130		
18	h	6470.46	II	10214 - 25665	60	6790.00	II	7525 - 22248	
10		6471.59	I	14154 - 29602	14	h	6792.55	II	12567 - 27285
45		6472.34	II	11094 - 26540	95		6794.20	II	11791 - 26506
35		6484.52	II	10181 - 25598	20	h	6802.96	I	812 - 15507
29		6487.62	II	9407 - 24816			6803.1	I	
29		6490.82	II	12790 - 28192	10		6807.50	I	14380 - 29066
35		6498.67	II	8579 - 23962	20	h	6808.31	I	15507 - 30191
9		6502.00	II	12567 - 27942	8		6813.48	II	10873 - 25546
13	h	6507.70			14	h	6820.91	I	14380 - 29037
29	hl	6509.44	I, SmO	293 - 15651	27		6829.86	II	10960 - 25598
13	h	6526.64	II	10873 - 26190	17		6830.54	I	14916 - 29552
18	h	6528.02	I	2273 - 17587	12	h	6837.20	I	13542 - 28164
18	h	6529.70	I	13542 - 28853	17		6838.33	I	14856 - 29475
18	h	6532.25	I	812 - 16116	10	h	6839.64	II	15897 - 30514
		6533.96	I	812 - 16112	20	h	6841.75	I	15579 - 30191
50		6542.76	II	9410 - 24689	55		6844.71	II	10960 - 25566
18		6544.57	II	9410 - 24686	27	d	6846.54	II	10214 - 24816
18	h	6549.77	II	8579 - 23842	14		6848.16	II	
13	h	6551.80	I	1490 - 16748			6848.31	I	14154 - 28752
140		6569.31	II	12045 - 27263	10	h	6853.54	I	16344 - 30931
35	h	6570.67	II	8046 - 23261	14	h	6854.50	II	11395 - 25980
27		6574.38	II	11047 - 26253	75		6856.03	II	8679 - 23261
40	h	6585.21	II	9407 - 24588	10	h	6858.12	I	16345 - 30922
7	h	6587.54	I		120		6860.93	I	293 - 14864
27		6588.91	I	3125 - 18298			6861.10	II	11094 - 25665
110		6589.72	II	10214 - 25385	40		6862.82	II	7135 - 21702
12		6591.50	II		8		6867.11	I	13814 - 28373
40		6601.83	II	12045 - 27188	27	h	6872.43	II	13604 - 28151
95		6604.56	II	13777 - 28913	10	h	6875.27	II	12567 - 27108
11		6617.61	II	10873 - 25980	12	h	6877.10	II	10518 - 25055
6		6625.28	II	11791 - 26880	14		6879.50	I	17194 - 31726
20	h	6628.88	II	8578 - 23659	27	h	6885.16	II	12790 - 27310
14	h	6630.61	II	12232 - 27310	17	h	6887.42	II	7524 - 22039
40	h	6632.28	II	13466 - 28540	10		6900.28	II	10874 - 25361
12	h	6646.22	I	15617 - 30659	10		6904.51	II	13777 - 28256
20	h	6649.02	II	11155 - 26190	17		6906.22	I	17270 - 31746
20		6651.61	II	11791 - 26821	14		6909.81	II	12842 - 27310
27		6656.19	II	9410 - 24430	13	d	6918.78	I	13542 - 27992
17	h	6667.22	II	10181 - 25175			6919.03	I	18119 - 32568
50		6671.51	I	4021 - 19006	16		6927.03	II	9410 - 23842
70		6679.21	II	8679 - 23647	12		6929.60	II	11659 - 26086
17	h	6681.53	II	11395 - 26358	16		6930.41	II	10960 - 25385
17	h	6687.79	II	13777 - 28725	16		6941.56	II	10181 - 24583
70		6693.55	II	13604 - 28540	12		6949.23	II	
11	h	6694.69	II	11047 - 25980	30		6950.51	II	8046 - 22429
14		6703.61	I	17655 - 32568	120		6955.29	II	10214 - 24588
20	h	6707.45	II	7525 - 22429	9		6958.97	II	16615 - 30981
14		6712.62	II	12045 - 26938	16		6968.65	II	9407 - 23753
40	d	6723.07	I	13050 - 27920	13		6984.16	II	11047 - 25361
		6723.26	I		13		6988.36	I	16392 - 30698
27		6724.73	I	16859 - 31726	13		6993.40	II	13777 - 28072
20		6725.88	I	0 - 14864	90		7020.44	II	9407 - 23647
120	d	6731.84	II	9407 - 24257	13		7036.73	II	15897 - 30104
70	d	6734.06	II	11094 - 25940	90		7039.22	II	8046 - 22248
40	d	6734.81	II	12045 - 26889	90		7042.24	II	8679 - 22875

## Samarium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
13	7049.15	II	10873 - 25055	12	7613.94	II	11799 - 24929
90	7051.52	II	7525 - 21702	10	7631.77	II	15897 - 28997
16	7054.97	II	11395 - 25566	23	7637.94	II	10874 - 23962
19	7074.67	I	14365 - 28496	45	7645.09	II	8579 - 21655
90	7082.37	II	7135 - 21251	12	7645.82	I	13095 - 26171
40	d 7085.52	II	8679 - 22789	19	7648.02	II	12232 - 25304
26	7088.30	I	812 - 14916	10	7655.78	II	12988 - 26046
16	7091.16	I	4021 - 18119	19	7667.20	II	13466 - 26506
30	7095.50	I	1490 - 15579	8	7672.49	II	11659 - 24689
16	7096.33	I	293 - 14380	10	h 7678.79	II	9410 - 22429
30	7104.54	I	2273 - 16345	10	h 7695.78	I	20211 - 33202
19	7106.23	I	3125 - 17194	23	7712.04	II	14667 - 27631
26	7115.96	I	15418 - 29467	30	7728.56	II	13604 - 26540
23	7117.51	II	14193 - 28239	30	7736.26	II	11659 - 24582
26	h 7119.81	II	12045 - 26086	30	7749.30	II	13604 - 26506
12	7122.40	II	14115 - 28151	23	7755.20	II	11799 - 24690
23	h 7125.11	II	12790 - 26821	10	7794.50	I	16211 - 29037
13	7131.80	I	1490 - 15507	10	7801.54	I	12445 - 25259
10	7136.01	I	15617 - 29627	8	h 7812.75	II	14084 - 26880
12	7139.39	II	15243 - 29246	16	7820.15	II	11799 - 24583
40	d 7143.98	II	8046 - 22040	10	7831.40	II	14115 - 26880
85	d 7149.60	II	7525 - 21508	40	w 7835.08	II	14504 - 27263
10	7172.67	I	2273 - 16211	26	7837.27	II	12842 - 25598
10	7189.57	II	14667 - 28573	10	7844.82	II	14085 - 26828
9	7210.95	I	13542 - 27406	6	7859.53	I	19006 - 31726
23	7213.82	I	2273 - 16132	19	7863.65	II	14115 - 26828
26	d 7218.09	II	10371 - 24221	10	h 7880.01	II	11155 - 23842
13	7220.07	I	16345 - 30191	16	7895.96	I	16891 - 29552
13	7237.02	II	12232 - 26046	26	7914.96	II	11799 - 24430
60	7240.90	II	11791 - 25598	90	7928.14	II	12988 - 25598
9	7257.11	II	12790 - 26566	9	7931.92	I	17587 - 30191
9	d 7261.52	II	11798 - 25565	19	7937.09	II	12790 - 25385
13	7279.25	I	3125 - 16859	16	7948.12	II	12988 - 25566
26	7281.47	II	10960 - 24690	19	w 8001.61	II	9410 - 21904
8	7282.21	I	17194 - 30922	19	w 8014.92	II	13466 - 25940
19	7283.33	II	14667 - 28394	23	8025.12	II	12232 - 24690
16	7288.92	II	12790 - 26506	23	w 8026.32	II	14085 - 26540
13	7290.23	I	14591 - 28305	16	8032.03	II	11395 - 23842
26	h 7300.72	II	15897 - 29591	40	8048.70	II	14085 - 26506
13	7327.08	II	11659 - 25304	16	8065.16	I	11406 - 23802
13	7332.65	I	4021 - 17655	45	8068.46	II	14115 - 26506
8	7338.04	I	13542 - 27166	9	w 8117.16	II	12988 - 25304
26	7347.30	I	18119 - 31726	9	8125.12	II	10874 - 23177
26	7376.69	II	12045 - 25598	26	8161.82	II	17391 - 29640
13	7393.98	II	12045 - 25565	19	w 8195.50	II	13466 - 25665
30	7444.56	I	19138 - 32567	6	8206.30	II	11659 - 23842
26	7445.41	I	18298 - 31725	26	w 8218.76	II	11799 - 23962
26	d 7453.03	II	12567 - 25980	9	8230.33	I	21055 - 33202
13	7470.76	I	13814 - 27196	16	8240.98	II	13466 - 25598
26	7481.99	II	13466 - 26828	19	w 8289.26	II	13604 - 25665
23	h 7502.39	II	8579 - 21904	10	8300.88	II	11799 - 23842
10	h 7517.00	II	14193 - 27492	40	w 8305.79	II	14504 - 26540
23	h 7541.42	II	12790 - 26046	10	8315.45	I	12445 - 24467
9	7544.74	I	17504 - 30755	19	w 8348.68	II	12842 - 24816
10	7546.57	I	15617 - 28864	19	8383.71	I	11877 - 23802
12	h 7560.03	II	13604 - 26828	19	8387.77	II	13466 - 25385
19	7562.94	II	10743 - 23962	30	w 8432.64	II	14085 - 25940
23	7570.95	II	12842 - 26046	19	w 8473.54	II	12790 - 24588
23	7572.29	II	15242 - 28445	45	w 8485.99	II	13604 - 25385
19	7578.09	II	14504 - 27696	30	w 8510.90	II	12842 - 24588
30	7585.85	II	14085 - 27263	23	8543.22	II	12988 - 24690
23	7588.31	II	11047 - 24221	23	w 8617.03	II	12045 - 23647
10	7598.01	I	18350 - 31508	23	w 8632.82	II	14085 - 25665
23	d 7607.48	II	10518 - 23659	12	w 8677.81	II	12232 - 23752
	7607.74	I	15567 - 28708	13	8706.32	II	14115 - 25598

*Samarium – all observed lines – Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45 w	8708.43	II	11395 – 22875	26	8859.76	II	10371 – 21655
30 w	8717.89	II	12790 – 24257	95	8913.66	II	12045 – 23261
30 w	8758.28	II	12232 – 23647				
16 w	8780.59	II	10518 – 21904				
23 w	8788.83	II	10874 – 22248				

## Scandium

$$\text{Sc, } Z = 21, M = 44.9559, \text{ Ratio } \frac{\text{Sc}}{\text{Cu}} = 0.707$$

Sc I Normal state of valence electrons  $3d4s^2 \ ^2D_{1/2} = 0$ . I.P. = 52920  $\text{cm}^{-1}$ .

Sc II Normal state of valence electrons  $3d4s \ ^3D_1 = 0$ . I.P. = 103240  $\text{cm}^{-1}$ .

Sc III Normal state of valence electrons  $3d \ ^2D_{1/2} = 0$ . I.P. = 199677  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945), below 7000 Å.

G. R. Harrison, *Massachusetts Institute of Technology Wavelength Tables* (John Wiley & Sons, New York, 1939), above 7000 Å.

The last five lines in the table are observed for the first time on our plates.

#### Classification:

Sc I and Sc II, H. N. Russell and W. F. Meggers, *Sci. Papers NBS* **22**, 329 (1927)

#### Molecular Spectra:

ScO, W. F. Meggers, and J. A. Wheeler, *J. Research NBS* **6**, 239 (1931) RP 273.

### *Strong lines of scandium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
28000	3613.84	II	178 - 27841	9900	3576.35	II	68 - 28021
23000	3911.81	I	168 - 25725	7700	3580.94	II	0 - 27918
20000	3630.75	II	68 - 27602	6600	3372.15	II	178 - 29824
20000	3907.49	I	0 - 25585	6600	3558.55	II	68 - 28161
20000	4020.40	I	0 - 24866	6600	3645.31	II	178 - 27602
20000	4023.69	I	168 - 25014	6100	3567.70	II	0 - 28021
15000	4246.83	II	2541 - 26081	6100	4082.40	I	168 - 24657
13000	3572.53	II	178 - 28161	5500	3273.63	I	168 - 30707
13000	3642.79	II	0 - 27444	5500	3996.61	I	0 - 25014
9900	3353.73	II	2541 - 32350	5500	4054.55	I	0 - 24657

Scandium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
65	2429.16	I		4000	3590.48	II	178 - 28021
110	2438.62	I		28000	3613.84	II	178 - 27841
560	2545.22	II	68 - 39345	110	3617.43	I	
2900	2552.37	II	178 - 39345	20000	3630.75	II	68 - 27602
560	2555.82	II	0 - 39114	13000	3642.79	II	0 - 27444
2300	2560.25	II	68 - 39114	6600	3645.31	II	178 - 27602
1100	2563.21	II	0 - 39002	110	3646.90	I	
40	2611.22	II	26081 - 64366	5300	3651.80	II	68 - 27444
19	2684.23	II	39345 - 76588	110	3664.25	II	2541 - 29824
120	2692.78	I	0 - 37126	290	3666.54	II	178 - 27444
60	2699.11	III	25537 - 62576	55	3675.26	II	2541 - 29742
360	2706.77	I	0 - 36934	40	3678.35	II	32350 - 59528
210	2707.95	I	168 - 37086	75	3717.10	I	
580	2711.35	I	168 - 37040	270	3833.07	II	0 - 26081
30	2819.54	II	27918 - 63374	610	3843.03	II	68 - 26081
35	2822.15	II	28021 - 63444	90	3894.97	I	
60	2826.68	II	28161 - 63528	20000	3907.49	I	0 - 25585
340	2965.86	I	0 - 33707	23000	3911.81	I	168 - 25725
1200	2974.01	I	0 - 33615	45	3923.51	II	2541 - 28021
1400	2980.75	I	168 - 33707	4400	3933.38	I	168 - 25585
340	2988.95	I	168 - 33615	45	3952.27	I	16210 - 41505
2200	3015.36	I	0 - 33154	45	3989.06	II	2541 - 27602
2700	3019.34	I	168 - 33279	5500	3996.61	I	0 - 25014
360	3030.76	I	168 - 33154	530	4014.49	II	2541 - 27444
30	3039.93	II	32350 - 65236	20000	4020.40	I	0 - 24866
70	3045.72	II	27444 - 60267	20000	4023.69	I	168 - 25014
85	3052.93	II	27602 - 60348	220	4030.67	I	16023 - 40826
120	3056.31	I		140	4031.39	I	15757 - 40555
130	3065.11	II	27841 - 60457	100	4034.23	I	16022 - 40803
45	3139.75	II	28161 - 60002	220	4043.80	I	15882 - 40604
990	3251.32	II	68 - 30816	200	4046.48	I	16097 - 40803
1500	3255.69	I	0 - 30707	2700	4047.79	I	168 - 24866
4400	3269.91	I	0 - 30573	120	4049.95	I	16141 - 40826
5500	3273.63	I	168 - 30707	5500	4054.55	I	0 - 24657
110	3343.28	II	27841 - 57743	220	4056.59	I	16027 - 40671
270	3352.05	II	0 - 29824	160	4074.97	I	16022 - 40555
9900	3353.73	II	2541 - 32350	160	4078.57	I	16010 - 40521
65	3357.30	II		6100	4082.40	I	168 - 24657
2000	3359.68	II	68 - 29824	200	4086.67	I	16141 - 40604
1700	3361.27	II	0 - 29742	400	4087.16	I	16211 - 40671
1700	3361.94	II	0 - 29736	40	4093.13	I	16097 - 40521
4000	3368.95	II	68 - 29742	65	4094.85	I	16141 - 40555
6600	3372.15	II	178 - 29824	55	4098.35	I	16211 - 40604
90	3416.68	I	15757 - 45016	65	4100.33	I	15042 - 39424
130	3418.51	I	15882 - 45126	440	4133.00	I	15673 - 39861
65	3419.36	I	15673 - 44910	530	4140.30	I	15757 - 39903
200	3429.21	I	15757 - 44910	65	4147.40	I	15757 - 39861
200	3429.48	I	15673 - 44823	720	4152.36	I	15882 - 39958
270	3431.36	I	15882 - 45016	55	4154.72	h	
530	3435.56	I	16027 - 45126	90	4161.88	hd	
90	3439.41	I	15757 - 44823	1100	4165.19	h	
65	3440.18	I		65	4171.56	h	
65	3448.49	I	16027 - 45016	45	4186.45	h	
270	3457.45	I	16211 - 45126	65	4187.62	h	
180	3462.19	I	16141 - 45016	75	4205.20	h	
130	3469.65	I	16010 - 44823	65	4212.34	h	
110	3471.13	I	16022 - 44823	45	4212.49	h	
200	3498.91	I	16027 - 44599	75	4216.10	h	
2700	3535.73	II	2541 - 30816	110	4218.26	h	
6600	3558.55	II	68 - 28161	110	4219.73	h	
6100	3567.70	II	0 - 28021	40	4221.88	h	
13000	3572.53	II	178 - 28161	90	4225.59	d	
9900	3576.35	II	68 - 28021	180	4231.93	d	
7700	3580.94	II	0 - 27918	200	4233.61	d	
4000	3589.64	II	68 - 27918	100	4237.82	d	

Scandium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
400	4238.05	I	16211 - 39800	140	4991.92	I	17013 - 37040
90	4239.57	I	16141 - 39722	80	5018.39	I	17013 - 36934
100	4246.12	I	16211 - 39755	70	5020.14	I	
15000	4246.83	II	2541 - 26081	80	5021.51	I	17025 - 36934
55	4283.56			530	5031.02	II	10945 - 30816
290	4294.77	II	4883 - 28161	55	5032.74	I	
350	4305.71	II	4803 - 28021	250	5064.32	I	11610 - 31351
4200	4314.09	II	4988 - 28161	80	5068.86	I	16023 - 35746
3300	4320.74	II	4883 - 28021	530	5070.23	I	11558 - 31275
2400	4325.01	II	4803 - 27918	250	5075.81	I	11520 - 31216
28	4348.53	I	15882 - 38872	2100	5081.56	I	11677 - 31351
180	4354.61	II	4883 - 27841	1200	5083.72	I	11610 - 31275
110	4358.64	I	16023 - 38959	1100	5085.55	I	11558 - 31216
55	4359.08	I	18571 - 41505	750	5086.95	I	11520 - 31173
28	4364.92	I	18571 - 41474	390	5087.14	I	20237 - 39889
2000	4374.46	II	4988 - 27841	270	5089.89	I	20240 - 39881
130	4384.81	II	4803 - 27602	45	5092.46	I	
45	4389.60	I	16097 - 38872	390	5096.73	I	11558 - 31173
1100	4400.37	II	4883 - 27602	620	5099.23	I	11610 - 31216
880	4415.56	II	4803 - 27444	370	5101.12	I	11677 - 31275
28	4420.66	II	4988 - 27602	180	5109.06	I	17918 - 37486
45	4431.36	II	4883 - 27444	150	5112.86	I	18000 - 37553
65	4542.55	I	14926 - 36934	320	5116.69	I	17947 - 37486
90	4544.68	I	15042 - 37040	70	5133.68	Sc O	
120	4557.24	I	21400 - 43337	45	5171.06	Sc O	
160	4573.99	I	21480 - 43337	390	5210.52	I	20237 - 39424
65	4592.94	I	21400 - 43167	45	5211.28	I	20239 - 39423
65	4598.45	I	21480 - 43221	280	5219.67	I	20240 - 39392
55	4604.72	I		350	5239.82	II	11736 - 30816
45	4609.53	I		280	5258.33	I	20237 - 39249
45	4609.95	I	21480 - 43167	35	5284.97	I	20237 - 39153
350	4670.40	II	10945 - 32350	210	5285.76	I	20240 - 39153
40	4680.49	I		35	5301.94	I	0 - 18856
50	4698.29	II	4803 - 26081	22	5318.35	II	10945 - 29742
120	4706.97	I	18516 - 39755	70	5331.77	I	15673 - 34423
120	4709.34	I	18571 - 39800	14	5334.23	II	12074 - 30816
200	4728.77	I	11610 - 32752	95	5339.41	I	15757 - 34480
490	4729.23	I	11558 - 32697	120	5341.05	I	15673 - 34390
40	4732.30	I	16023 - 37148	95	5342.96	I	0 - 18711
590	4734.10	I	11520 - 32637	350	5349.30	I	14926 - 33615
60	4735.08			120	5349.71	I	168 - 18856
690	4737.65	I	11558 - 32659	60	5350.30	I	15882 - 34567
790	4741.02	I	11610 - 32697	210	5355.75	I	15757 - 34423
1200	4743.81	I	11677 - 32752	530	5356.10	I	15042 - 33707
200	4753.16	I	0 - 21033	14	5357.19	II	12154 - 30816
220	4779.35	I	168 - 21086	270	5375.35	I	15882 - 34480
90	4791.50	I	168 - 21033	370	5392.08	I	16027 - 34567
100	4827.28	I	17948 - 38658	45	5416.12	I	16022 - 34480
100	4833.67	I	17919 - 38602	45	5425.57	I	16141 - 34567
170	4839.44	I	18000 - 38658	45	5429.41	I	16010 - 34423
40	4840.47	I	17948 - 38602	35	5432.94	I	16022 - 34423
80	4847.68	I	17948 - 38571	55	5433.23	I	16023 - 34423
80	4852.68	I	18000 - 38602	45	5438.22	I	16097 - 34480
140	4857.79	Sc O		55	5439.03	I	16010 - 34390
	4858.09	Sc O		55	5442.60	I	16022 - 34390
80	4906.67	I	16141 - 36516	270	5446.20	I	16211 - 34567
90	4909.76	I	16211 - 36573	18	5447.39	I	14926 - 33279
90	4922.84	I	16023 - 36330	120	5451.34	I	16141 - 34480
90	4934.25	I	17919 - 38180	30	5455.21	I	16097 - 34423
45	4935.74	I	16022 - 36277	18	5465.20	I	18856 - 37148
70	4941.33	I	17948 - 38180	55	5468.40	I	16141 - 34423
170	4954.06	I	18000 - 38180	60	5472.19	I	16211 - 34480
120	4973.66	I	17025 - 37126	18	5474.64	I	
150	4980.37	I	17013 - 37086	750	5481.99	I	15042 - 33279
80	4983.45	I	17025 - 37086	530	5484.62	I	14926 - 33154



Scandium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
570	5514.22	I	14926 - 33056	320	6239.78	I	0 - 16022
16	5515.39	I	15673 - 33799	120	6245.63	II	12154 - 28161
660	5520.50	I	15042 - 33151	110	6249.96	I	18571 - 34567
45	5526.06	I	15673 - 33764	250	6258.96	I	168 - 16141
660	5526.82	II	14261 - 32350	60	6262.25	I	18516 - 34480
55	5541.04	I	15757 - 33799	55	6276.31	I	168 - 16097
30	5546.40	I	15882 - 33906	45	6279.76	II	12101 - 28021
18	5550.40	I	18504 - 36516	18	6300.70	II	12154 - 28021
5	5552.25	II	11736 - 29742	750	6305.67	I	168 - 16023
35	5553.59	I	18571 - 36573	26	6309.90	II	12074 - 27918
16	5561.10	I	18516 - 36493	16	6320.85	II	12101 - 27918
70	5564.86	I	15882 - 33847	26	6344.83	I	0 - 15757
18	5571.24	I	18571 - 36516	60	6378.82	I	0 - 15673
14	5579.76	I	15882 - 33799	55	6408.41	Sc O	
110	5591.33	I	16027 - 33906	90	6413.35	I	168 - 15757
35	5593.38	I	21086 - 38959	26	6437.08	Sc O	
22	5604.19	I	21033 - 38872	55	6446.24	Sc O	
22	5631.02	I	16010 - 33764	26	6457.78	Sc O	
80	5640.98	II	12101 - 29824	35	6485.40	Sc O	
45	5646.36	I	16141 - 33847	26	6495.90	Sc O	
16	5647.60	I	16097 - 33799	55	6525.62	Sc O	
55	5649.56	I	16211 - 33906	22	6535.30	Sc O	
250	5657.88	II	12154 - 29824	45	6557.84	Sc O	
60	5658.34	II	12074 - 29742	35	6566.88	Sc O	
55	5667.16	II	12101 - 29742	18	6575.85	Sc O	
70	5669.04	II	12101 - 29736	60	6604.60	II	10945 - 26081
1500	5671.81	I	11677 - 29304	26	6609.99	Sc O	
95	5684.20	II	12154 - 29742	18	6617.94	Sc O	
1200	5686.84	I	11610 - 29190	18	6645.08	Sc O	
1100	5700.21	I	11558 - 29096	22	6654.42	Sc O	
190	5708.61	I	11677 - 29190	26	6661.01	Sc O	
880	5711.75	I	11520 - 29023	18	6700.48	Sc O	
230	5717.28	I	11610 - 29096	18	6705.93	Sc O	
180	5724.08	I	11558 - 29023	65	6737.87	I	
55	5736.85	Sc O		35	6739.40	I	
55	5764.45	Sc O		35	6817.08	I	
95	5772.74	Sc O		50	6819.52	I	21086 - 35746
55	5775.32	Sc O		29	6829.54	I	21033 - 35671
70	5809.84	Sc O		50	6835.03	I	
70	5811.60	Sc O		5	6963.12	Sc O	
95	5847.73	Sc O		5	6990.68	Sc O	
70	5849.07	Sc O		5	7025.72	Sc O	
70	5887.38	Sc O		8	7035.77	Sc O	
35	5918.04	Sc O		5	7072.37	Sc O	
30	5919.11	I	18856 - 35746	5	7094.38	Sc O	
60	5928.10	Sc O		12	7138.14	I	24866 - 38872
35	5961.49	I	21086 - 37856	14	7169.13	I	25014 - 38959
60	5968.25	Sc O		12	7257.57	I	31351 - 45126
35	5969.19	I	21033 - 37781	8	7275.57	I	31275 - 45016
90	5988.42	I	17013 - 33707	3	7300.62	I	31216 - 44910
160	6017.07	Sc O		12	7524.13	I	25585 - 38872
60	6026.18	I	17025 - 33615	14	7553.96	I	25725 - 38959
620	6036.17	Sc O		15	7574.44	I	24657 - 37856
490	6064.31	Sc O		11	7617.45	I	24657 - 37781
440	6072.65	Sc O		14	7665.72	I	20237 - 33279
620	6079.30	Sc O		30	7697.73	I	25585 - 38572
320	6101.87	Sc O		18	7729.72	I	25725 - 38658
370	6109.93	Sc O		55	7741.17	I	20237 - 33151
370	6115.97	Sc O		5	7750.37	I	29023 - 41922
180	6148.70	Sc O		5	7752.72	I	29190 - 42085
150	6153.93	Sc O		6	7771.06	I	29096 - 41961
150	6188.09	Sc O		15	7785.17	I	25014 - 37856
150	6192.90	Sc O		8	7794.68	I	29190 - 42016
620	6210.68	I	0 - 16097	30	7800.44	I	20240 - 33056
90	6239.41	I	0 - 16023	11	7821.64	I	29304 - 42085

Scandium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
11 h	8196.98	I	25585 - 37781	15 h	8823.8	I	
15	8241.13	I	25725 - 37856	30 h	8834.35	I	25014 - 36330
19 h	8761.40	I	24866 - 36277				
11 h	8774.8						
15 h	8794.72	I	29304 - 40671				

## Selenium

Se,  $Z = 34$ ,  $M = 78.9$ , Ratio  $\frac{\text{Se}}{\text{Cu}} = 1.243$

Se I Normal state of valence electrons  $4s^2 4p^4 \ ^3P_2 = 0$ . I.P. = 78658  $\text{cm}^{-1}$ .

Se II Normal state of valence electrons  $4s^2 4p^3 \ ^4S_{1/2}^o = 0$ . I.P. = 171000  $\text{cm}^{-1}$ .

### References

#### Wavelengths and Classification:

Se I, J. E. Ruedy and R. C. Gibbs, Phys. Rev. **46**, 880 (1934).

*Selenium— all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
90000	1960.26	I	0 - 50997	50	8918.80	I	48182 - 59391
40000	2039.85	I	1989 - 50997				
11000	2062.79	I	2534 - 50997				
2000	2074.79	I	0 - 48182				

## Silicon

Si,  $Z = 14$ ,  $M = 28.086$  Ratio  $\frac{\text{Si}}{\text{Cu}} = 0.442$

Si I Normal state of valence electrons  $3s^23p^2\ ^3P_0 = 0$ . I.P. =  $65747\ \text{cm}^{-1}$ .  
 Si II Normal state of valence electrons  $3s^23p\ ^2P_{1/2} = 0$ . I.P. =  $131838\ \text{cm}^{-1}$ .

### References

Wavelengths and Classification:

L. J. Radziemski, Jr. and K. L. Andrew, J. Opt. Soc. Am. **55**, 474 (1965).

*Silicon—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
2200	2124.12	I	6299 - 53362	1200	2519.20	I	77 - 39760
300	2207.98	I	0 - 45276	2400	2524.11	I	77 - 39683
300	2210.89	I	77 - 45294				
480	2216.67	I	223 - 45322	2000	2528.51	I	223 - 39760
320	2435.15	I	6299 - 47352	240	2631.28	I	15394 - 53387
1700	2506.90	I	77 - 39955	2600	2881.58	I	6299 - 40992
1600	2514.32	I	0 - 39760	150	2987.65	I	6299 - 39760
3600	2516.11	I	223 - 39955	110	3905.52	I	15394 - 40992

## Silver

Ag,  $Z = 47$ ,  $M = 107.868$ , Ratio  $\frac{Ag}{Cu} = 1.697$

Ag I Normal state of valence electrons  $4d^{10}5s^2S_{1/2} = 0$ . I.P. =  $61106 \text{ cm}^{-1}$ .

Ag II Normal state of valence electrons  $4d^{10}1S_0 = 0$ . I.P. =  $173300 \text{ cm}^{-1}$ .

### References

**Wavelengths:**

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

**Classification:**

Ag I, A. G. Shenstone, Phys. Rev. **57**, 894 (1940).

Ag II, A. G. Shenstone, Phys. Rev. **31**, 317 (1928).

*Silver—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
80	2331.37	II	40741 - 83621	50 hl	4476.08	I	29552 - 51887
150	2413.18	II	40741 - 82168	60 hl	4668.48	I	30473 - 51887
90	2437.79	II	39164 - 80172				
30	2447.93	II	46046 - 86884	1000	5209.07	I	29552 - 48744
60	2721.77	I	30242 - 66972	1000	5465.49	I	30473 - 48764
55000	3280.68	I	0 - 30473	100	5471.55	I	30473 - 48744
28000	3382.89	I	0 - 29552	320	7687.78	I	29552 - 42556
90 hs	4210.94	I	30473 - 54214	500	8273.52	I	30473 - 42556

## Sodium

$$\text{Na, } Z = 11, M = 22.9898, \text{ Ratio } \frac{\text{Na}}{\text{Cu}} = 0.3618$$

Na I Normal state of valence electrons  $2p^6 3s^2 S_{1/2} = 0$ . I.P. = 41449  $\text{cm}^{-1}$ .

Na II Normal state of valence electrons  $2p^6 1S_0 = 0$ . I.P. = 381528  $\text{cm}^{-1}$ .

### References

**Wavelengths and Classification:**

P. Risberg, Ark. for Fysik **10**, 583 (1956).

*Sodium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
300	3302.37	I	0 - 30273	20000	5889.95	I	0 - 16973
150	3302.98	I	0 - 30267	10000	5895.92	I	0 - 16956
10	5148.84	I	16956 - 36373	30	6154.23	I	16956 - 33201
20	5153.40	I	16973 - 36373	60	6160.75	I	16973 - 33201
70	5682.63	I	16956 - 34549	1100	8183.26	I	16956 - 29173
140	5688.20	I	16973 - 34549	2200	8194.82	I	16973 - 29173

# Strontium

$$\text{Sr, } Z = 38, M = 87.62, \text{ Ratio } \frac{\text{Sr}}{\text{Cu}} = 1.379$$

Sr I Normal state of valence electrons  $4p^65s^2\ ^1S_0 = 0$ . I.P. = 45932  $\text{cm}^{-1}$ .

Sr II Normal state of valence electrons  $4p^65s\ ^2S_{1/2} = 0$ . I.P. = 88964  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Classification:

Sr I, F. J. Sullivan, Univ. of Pittsburgh Bull. **35**, 1 (1938).

Sr II, F. A. Saunders, E. G. Schneider and E. Buckingham, Proc. Nat. Acad. Sci. U.S. **20**, 291 (1934).

### *Strontium — all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
1400	2152.84	II	14556 - 60992	200	5229.27	I	18219 - 37336
1400	2165.96	II	14836 - 60992	280	5238.55	I	18219 - 37302
16	2428.10	I	0 - 41172	480	5256.90	I	18319 - 37336
12	2569.47	I	0 - 38907	35	5329.82	I	20150 - 38907
20	2931.83	I	0 - 34098	150	5450.84	I	18219 - 36560
30	3301.73	I	14318 - 44596	700	5480.84	I	18319 - 36560
30	3329.99	I	14504 - 44526	110	5486.12	I	18159 - 36382
40	3351.25	I	14899 - 44730	350	5504.17	I	18219 - 36382
30	3366.33	I	14899 - 44596	260	5521.83	I	18159 - 36264
650	3380.71	II	23715 - 53286	200	5534.81	I	18319 - 36382
950	3464.46	II	24517 - 53373	200	5540.05	I	18219 - 36264
120	3474.89	II	24517 - 53286	25	5543.36	I	21698 - 39733
30	3940.80	h	14318 - 39686	20	5970.10	I	21698 - 38444
60	3969.26	I	14504 - 39691	25	6345.75	I	18219 - 33973
30	3970.04	I	14504 - 39686	25	6363.94	I	18159 - 33868
130	4030.38	I	14899 - 39703	35	6369.96	I	18159 - 33853
30	4032.38	I	14899 - 39691	100	6380.75	I	18159 - 33827
46000	4077.71	II	0 - 24517	90	6386.50	I	18319 - 33973
200	4161.80	II	23715 - 47737	60	6388.24	I	18219 - 33868
32000	4215.52	II	0 - 23715	900	6408.47	I	18319 - 33919
340	4305.45	II	24517 - 47737	25	6446.68	I	18319 - 33827
35	4438.04	h	14899 - 37425	25	6465.79	I	21698 - 37160
6500	4607.33	I	0 - 21698	550	6504.00	I	18219 - 33590
320	4722.28	I	14504 - 35675	100	6546.79	I	18319 - 33590
220	4741.92	I	14318 - 35400	170	6550.26	I	21698 - 36961
140	4784.32	I	14504 - 35400	300	6617.26	I	18159 - 33267
480	4811.88	I	14899 - 35675	80	6643.54	I	18219 - 33267
360	4832.08	I	14504 - 35194	180	6791.05	I	14318 - 29039
		I	14318 - 35007	480	6878.38	I	14504 - 29039
50	4855.04	I	18159 - 38750	120	6892.59	I	0 - 14503
60	4868.70	I	18219 - 38752	550	7070.10	I	14899 - 29039
300	4872.49	I	14504 - 35022	6	7153.09	I	21698 - 35675
60	4876.06	I	14504 - 35007	25	7167.24	I	20150 - 34098
200	4876.32	I	14899 - 35400	20	7232.27	I	20150 - 33973
100	4891.98	I	18319 - 38755	250	7309.41	I	20150 - 33827
800	4962.26	i	14899 - 35045	50	7621.50	I	20150 - 33267
130	4967.94	I	14899 - 35022	40	7673.06	I	21698 - 34727
80	5156.07	h	20150 - 39539				
140	5222.20	I	18159 - 37302				
200	5225.11	I	18159 - 37292				

# Tantalum

$$\text{Ta, } Z = 73, M = 180.948, \text{ Ratio } \frac{\text{Ta}}{\text{Cu}} = 2.848$$

Ta I Normal state of valence electrons  $5d^36s^2\ ^4F_{1/2} = 0$ . I.P. = 63600  $\text{cm}^{-1}$ .

Ta II Normal state of valence electrons  $5d^36s\ ^5F_1 = 0$ . I.P. = 130000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

C. C. Kiess, unpublished material (1961).

### Classification:

Ta I, P. F. A. Klinkenberg, G. J. van den Berg, and J. C. van den Bosch, *Physica* **16**, 861 (1950).

G. J. van den Berg, P. F. A. Klinkenberg, and J. C. van den Bosch, *Physica* **18**, 221 (1952).

C. C. Kiess and H. K. Kiess, unpublished material (1961).

Ta II, C. C. Kiess, *J. Res. Nat. Bur. Stand. (U.S.)*, **66A** (Phys. and Chem.), No. 2, 111-161 (Mar.-Apr. 1962).

### *Strong lines of tantalum*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
2600	2653.27	I	2010 - 39688	1400	2239.48	II	2642 - 47281
2600	2714.67	I	0 - 36826	1400	2387.06	II	4416 - 46295
2400	2400.63	II	6187 - 47830				
2400	2647.47	I	0 - 37761	1400	2608.63	I	2010 - 40333
1900	2656.61	I	0 - 37630	1200	2182.71	II	1031 - 46831
				1200	2250.76	II	1031 - 45447
1900	2850.98	I	5621 - 40686	1200	2526.35	I	2010 - 41581
		II	14581 - 49647		2526.45	I	3964 - 43533
1800	3012.54	II	5331 - 38516				
1700	2933.55	I	0 - 34078	1200	2559.43	I	0 - 39060
1500	2146.87	II	1031 - 47596	1200	2635.58	II	1031 - 38962
				1200	2710.13	I	3964 - 40851
1500	2196.03	II	4416 - 49938	1200	2748.78	I	3964 - 40333
1500	2199.67	II	0 - 45447	1200	2940.22	I	0 - 34001
1500	2661.34	I	5621 - 43185				
1500	2685.17	II	4125 - 41355	1100	2193.88	II	6187 - 51754
1500	2850.49	I		1100	3311.16	I	5621 - 35813
				1100	2140.13	II	
1500	2963.32	I	2010 - 35746	1000	2698.30	I	2010 - 39060
1400	d 2210.03	II	0 - 45234	1000	2758.31	I	2010 - 38253
	2210.19	II	4416 - 49647				



Tantalum—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1100	2140.13	II		130	2363.32	II	
1500	2146.87	II	1031 - 47596	600	2364.24	II	6187 - 48470
740	2150.62	II	1031 - 47515	50	2367.24	II	4416 - 46646
600	2165.01	II	0 - 46175	150	2369.32	II	2642 - 44835
740	2178.03	II	3180 - 49080	300	2370.76	II	5658 - 47825
1200	2182.71	II	1031 - 46831	320	2371.58	I	3964 - 46117
540	2193.20	II	2642 - 48223			II	0 - 42153
1100	2193.88	II	6187 - 51754	70	2372.80	II	6831 - 48963
1500	2196.03	II	4416 - 49938	100	2373.94	II	10713 - 52825
1500	2199.67	II	0 - 45447	70	2375.91	I	
500	2207.14	II		150	2378.31	II	1031 - 43065
1400	d 2210.03	II	0 - 45234	440	2381.13	II	2642 - 44626
	2210.19	II	4416 - 49647	240	2381.52	II	0 - 41977
420	2215.60	II	4416 - 49536	170	2383.72	II	5658 - 47596
1400	2239.48	II	2642 - 47281	240	2384.28	II	1031 - 42960
240	2248.48	II	9746 - 54207	130	2385.73	I	0 - 41902
480	2249.79	II	0 - 44435	1400	2387.06	II	4416 - 46295
1200	2250.76	II	1031 - 45447	80	2388.37	II	5658 - 47515
260	2254.86	II	3180 - 47515	160	2389.11	II	9690 - 51534
440	2255.77	II	12436 - 56753	70	2396.30	I	5621 - 47340
360	2256.51	II	9746 - 54048	110	2399.15	I	
500	2258.71	II	0 - 44259	50	2399.92	II	3180 - 44835
840	2261.42	II	0 - 44206	2400	2400.63	II	6187 - 47830
260	2261.62	II	1031 - 45234	140	2402.13	II	2642 - 44259
990	2262.30	II	2642 - 46831	100	2403.68	II	11875 - 53466
220	2269.56	II	12705 - 56753	130	2406.55	I	2010 - 43551
740	2271.85	II	2642 - 46646	40	2407.57	I	2010 - 43533
990	2272.59	II	3180 - 47169	130	2408.26	II	5658 - 47169
200	2279.85	I		40	d 2412.53	II	14581 - 56019
320	2282.19	II	1031 - 44835		2412.67	I	
130	2285.02	II	5331 - 49080	120	2414.32	I	9253 - 50660
790	2285.25	II	2642 - 46387	240	2415.21	II	6831 - 48223
600	2286.59	II	9746 - 53466	320	2416.89	II	2642 - 44005
240	2287.27	II	12436 - 56142	80	2417.33	II	0 - 41355
990	2289.16	II	3180 - 46851	220	2417.86	II	
180	2292.54	II	0 - 43606	150	2418.77	II	
160	2295.18			140	2421.03	I	3964 - 45256
160	2301.47	II	12705 - 56142	150	2421.85	II	14581 - 55859
440	2302.24	II	5658 - 49080	170	2423.48	II	3180 - 44430
440	2302.93	II	4416 - 47825	130	2425.91	II	12436 - 53645
300	2303.49	II	1031 - 44430	360	2427.64	I	0 - 41180
100	2308.46	II	5658 - 48963	60	2428.00	II	5658 - 46831
440	2312.60	II	1031 - 44259	360	2429.71	II	0 - 41145
420	2315.46	II	1031 - 44206	170	2431.06	II	1031 - 42153
260	2319.16	II	12436 - 55543	60	2431.66	I	11796 - 52907
100	2331.29	II	11767 - 54649	480	2432.70	II	6187 - 47281
690	2331.98	II		130	2433.59	II	3180 - 44259
550	2332.19	II	4416 - 47281	130	2436.51	II	12436 - 53466
110	2334.13	II		110	2437.07	I	
180	2334.88	II	6831 - 49647	90	2437.67	I	0 - 41010
140	2335.75	II	12705 - 55505	110	2438.64	II	6831 - 47825
300	2338.28	II	6988 - 49741	200	2439.91	I	2010 - 42983
200	2340.94	II	6831 - 49536	130	2442.39	I	5621 - 46552
200	2341.61	II	12436 - 55128	100	2444.13	II	2642 - 43544
130	2343.64	II		90	2444.67	II	
100	2346.42	II		50	2445.53	II	
90	2351.99	II		100	2447.17	I	
170	2353.86	II	5331 - 47801	80	2449.44	II	6988 - 47801
120	2355.22	II		80	2454.21	I	9705 - 50439
170	2356.05	II	9690 - 52121	100	2454.48	I	3964 - 44693
140	2356.90	II	4416 - 46831	50	2454.70	II	11767 - 52493
250	2357.30	I	0 - 42408	100	2458.68	I	
170	2359.16	II	9746 - 52121	100	2460.55	I	9253 - 49882
260	2361.09	I	2010 - 44350	80	d 2461.06	II	10713 - 51334
160	2362.78	II		160	2463.82	II	12436 - 53011

Tantalum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	2465.26	I	5621 - 46172	180	2557.71	II	9690 - 48776
130	2466.99	II	1031 - 41555	1200	2559.43	I	0 - 39060
130	2467.37	II	5658 - 46175	180	2560.68	I	
50	2468.41	II	15851 - 56351	460	2562.10	I	3964 - 42983
380	2470.90	II	6187 - 46646	80	2563.33	I	2010 - 41010
120	2471.38	I		140	2563.70	I	0 - 38994
120	2472.13	I	3964 - 44403	120	2569.13	II	2642 - 41555
150	2473.13	I	3964 - 44386	340	2571.51	II	5331 - 44206
120	2473.31	II	4416 - 44835	430	2573.54	I	0 - 38845
600	2474.62	I	2010 - 42408	390	2573.79	I	2010 - 40852
120	2475.33	I	9759 - 50146	150	2574.38	I	9976 - 48809
200	2476.67	II	3180 - 43544	150	2575.47	I	9253 - 48070
150	2478.22	I	0 - 40339	600	2577.37	II	11099 - 49887
80	2479.58	II	2642 - 42960	340	2577.78	I	5621 - 44403
120	2481.86	II	11875 - 52156	70	2578.24	II	12705 - 51480
100	2482.10	I		100	2579.62	I	0 - 38754
100	2482.58	II		210	2580.16	I	2010 - 40756
80	2483.46	II		35	2581.60	II	9746 - 48470
100	2484.04	II		340	2584.03	II	
80	2484.72	II	0 - 40234	140	2584.49	II	13475 - 52156
500	2484.95	I	0 - 40230	150	2584.69	I	9253 - 47931
120	2486.70	I	3964 - 44166	100	2585.61	I	9705 - 48369
600	2488.70	II	4416 - 44585	35	2588.88	II	6831 - 45447
500	2490.46	I		75	2589.81	II	5658 - 44259
50	2496.24	I	6069 - 46117	21	2590.20	II	13560 - 52156
70	2496.64	I	12865 - 52907	70	d 2592.44	I	
50	2497.77	II	0 - 40024			II	13560 - 52121
90	2498.33	II	4416 - 44430	430	2593.08	I	5621 - 44174
140	2501.98	II	9690 - 49647	410	2593.66	II	4416 - 42960
100	2503.01	II		310	2594.25	II	0 - 38535
600	2504.45	I	3964 - 43881	560	2595.26	I	5621 - 44141
100	2505.32	II	5331 - 45234	120	2595.59	II	0 - 38516
600	2507.45	I	2010 - 41879	85	2596.12	I	0 - 38508
100	2508.92	II	9690 - 49536	310	l 2596.45	II	2642 - 41145
100	2510.71	II	15726 - 55544	60	2596.61	I	
50	d 2511.69	II		100	2598.21	II	
240	2512.65	I	0 - 39787	45	2598.75	I	6049 - 44518
100	2513.10	II	3180 - 42960	220	2600.14	I	0 - 38448
70	2513.88	II	11767 - 51534	70	2600.73	II	6187 - 44626
100	2519.78	I	6049 - 45724	140	2601.06	I	6049 - 44484
140	2526.02	II	5658 - 45234	85	2602.38	I	6069 - 44484
1200	d 2526.35	I	2010 - 41581	600	2603.49	II	6187 - 44585
	2526.45	I	3964 - 43533	60	2603.82	I	9976 - 48369
50	2531.29	I	5621 - 45115	60	2605.32	I	9253 - 47625
600	2532.12	II	2642 - 42123	70	2606.43	II	15851 - 54206
120	2533.00	I		120	2607.84	II	
70	2534.16	I		50	2608.20	I	2010 - 40339
50	2534.47	I	9705 - 49149	1400	2608.63	I	2010 - 40333
120	2534.97	I	5621 - 45058	210	2609.00	I	6069 - 44386
160	2537.94	II	9690 - 49080	35	2610.13	I	6049 - 44350
90	d 2542.23	I	10690 - 50014	310	d 2611.34	I	3964 - 42247
	2542.35	II	11875 - 51197			I	6068 - 44350
50	2544.27	I		110	2612.61	II	1031 - 39296
	2544.37	II	12831 - 52121	70	2615.25	I	9705 - 47931
240	2545.49	II	1031 - 40305	340	2615.46	I	9705 - 47928
240	2546.80	I	0 - 39253	310	2615.66	I	2010 - 40230
140	2549.38	I	3964 - 43177	50	2620.18	I	
460	d 2551.07	I	2010 - 41198	170	2624.12	I	6049 - 44146
	2551.19	I	5621 - 44807	85	2625.46	I	6069 - 44146
140	2551.73	II	5658 - 44835	45	2627.43	I	
70	2553.18	II		70	2628.85	II	18494 - 56522
460	2554.62	II	2642 - 41775	75	2630.53	II	6831 - 44835
120	2554.91	II	4416 - 43544	100	2632.27	II	
240	2555.05	I	3964 - 43090	85	2633.79	II	18494 - 56451
140	2556.51	II	5331 - 44435	1200	2635.58	II	1031 - 38962

Tantalum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
70	2635.93	I	2010 - 39936	45	2695.54	II	10713 - 47801
50	2636.37	I	9705 - 47625	26	2695.71	II	9746 - 46831
470	2636.67	I	3964 - 41879	240	2696.81	I	9253 - 46323
860	2636.90	I	5621 - 43533	1000	2698.30	I	2010 - 39060
50	2637.93	II	0 - 37897	50	2700.70	I	12866 - 49882
85	2638.67	II	5658 - 43544	120	2702.80	II	0 - 36988
50	2639.19	II	11767 - 49647	85	2703.06	I	2010 - 38994
170	2643.89	I	6069 - 43880	85	2704.31	I	
120	2644.60	II	2642 - 40444	470	2706.69	I	10690 - 47625
120	2645.10	II	6831 - 44626	30	2706.92	I	10690 - 47621
510	2646.22	I	10690 - 48468	310	2709.27	II	9746 - 46646
600	2646.37	I	2010 - 39787	1200	2710.13	I	3964 - 40851
150	2646.74	II	11875 - 49647	26	2710.72	II	24226 - 61106
	2646.89	II	11767 - 49536	2600	2714.67	I	0 - 36826
2400	2647.47	I	0 - 37761	240	2717.18	I	3964 - 40756
50	2650.02	I		150	2718.38	I	6069 - 42845
70	2650.28	I	9253 - 46974	470	2720.76	I	2010 - 38754
270	2651.22	II	4416 - 42123	170	2721.83	I	6049 - 42779
45	2652.32	I	9705 - 47397	110	2725.42	II	
2600	2653.27	I	2010 - 39688	26	2726.32	I	2010 - 38679
21	2654.01	I		470	2727.44	II	5331 - 41984
35	2655.68	I		410	2727.78	I	10690 - 47340
45	2656.08	I		50	2730.73	II	28044 - 64653
1900	2656.61	I	0 - 37630	85	2732.06	I	15391 - 51982
70	2657.30	I	3964 - 41585	70	2732.92	I	0 - 36580
50	2658.14	II		30	2733.34	II	18554 - 55128
120	2658.86	II	6831 - 44430	100	2735.26	II	9746 - 46295
85	2659.41	II	2642 - 40234	310	2736.25	II	
35	2659.66	I		210	2739.26	II	5658 - 42153
1500	2661.34	I	5621 - 43185	30	2740.70	II	17168 - 53645
150	2661.89	I	5621 - 43177	150	2741.17	I	9253 - 45724
130	2662.10	I		26	2742.92	I	10950 - 47397
26	2663.88	II	14628 - 52156	210	2743.59	I	2010 - 38448
50	2664.24	II	17982 - 55505	510	2746.68	I	5621 - 42018
220	2665.60	II	1031 - 38535	120	2746.83	II	15726 - 52121
35	2665.94	I		85	2747.25	I	
45	2667.00	II	1031 - 38516	30	2747.85	I	11244 - 47625
50	2667.17	I	6069 - 43551	1200	2748.78	I	3964 - 40333
220	2668.07	I	5621 - 43090	860	2749.83	I	9705 - 46061
600	2668.62	I	0 - 37461	70	2750.41	II	11875 - 48223
150	2669.58	II	24870 - 62318	150	2752.30	I	10690 - 47013
100	2671.63	I	10950 - 48369	410	2752.49	II	2642 - 38962
100	2672.50	II	5658 - 43065	70	2757.26	II	12705 - 48963
50	2674.18	II	15851 - 53235	1000	2758.31	I	2010 - 38253
35	2674.49	I	10690 - 48070	70	2759.06	II	6831 - 43065
770	2675.90	II	4416 - 41775	430	2761.68	II	1031 - 37231
50	2676.48	II	10713 - 48064	60	2762.05	II	
70	2678.80	II	18186 - 55505	110	2763.37	II	0 - 36177
270	2680.06	II	5658 - 42960	50	2768.09	II	3180 - 39296
220	2680.66	II	4416 - 41709	70	2771.83	II	
26	2681.63	I	12865 - 50145	100	2774.88	I	15391 - 51418
110	2681.87	I		130	2775.11	II	5331 - 41355
600	2684.28	I	2010 - 39253	35	2775.35	II	18186 - 54207
1500	2685.17	II	4125 - 41355	770	2775.88	I	0 - 36014
35	2686.29	I	9759 - 46974	26	2776.71	II	17231 - 53235
100	2689.24	II	6831 - 44005	50	2778.82	II	13560 - 49536
35	2690.54	I	9253 - 46410	100	2779.10	I	3964 - 39936
340	2691.31	I	0 - 37146	50	2779.70	I	9759 - 45724
50	2691.80	II	4416 - 41555	100	2780.34	II	1031 - 36988
260	2692.40	I	5621 - 42752	30	2780.89		
45	2692.83	II	3180 - 40305	100	2781.37	I	9705 - 45648
95	2693.34	I	6049 - 43167	26	2781.79	I	10950 - 46888
50	2693.50	I	5621 - 42737	150	2784.97	II	5658 - 41555
470	2694.52	II	2642 - 39744	60	2786.77	II	2642 - 38516
150	2694.76	I	6069 - 43167	390	2787.69	I	9253 - 45115

Tantalum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
130	2788.30	I	6049 - 41902	75	2865.32	II	17231 - 52121
50	2789.15	II	17168 - 53011	70	2866.14	I	
50	2789.77	I	12235 - 48070	100	2867.41	II	17982 - 52846
100	2790.71	I	3964 - 39787	310	2868.65	I	3964 - 38813
140	2791.37	II	5331 - 41145	470	2871.42	I	2010 - 36826
120	2791.67	I	6069 - 41879	270	2873.36	I	0 - 34792
50	2793.86	II	3180 - 38962	260	2873.56	I	3964 - 38754
50	2795.20	II	12705 - 48470	210	2874.17	I	6069 - 40852
680	2796.34	I	2010 - 37761	140	2876.11	I	9759 - 44518
75	2796.56	I	9976 - 45724	85	2877.05	II	13475 - 48223
680	2797.76	II	1031 - 36764	100	2877.69	II	9690 - 44430
190	2798.40	I	3963 - 39688	70	2879.05	II	6831 - 41555
50	2800.57	I	12235 - 47931	35	2879.52	I	13352 - 48070
380	2802.07	I	3964 - 39641	120	2879.74	I	3964 - 38679
50	2804.76	I	6049 - 41693	380	2880.02	I	5621 - 40333
430	2806.30	I	6069 - 41693	35	2881.23	I	9705 - 44403
510	2806.58	I	2010 - 37630	35	2882.33	II	9746 - 44430
140	2810.92	I	12235 - 47800	85	2885.40	II	5658 - 40305
70	2811.72	II		95	2889.38	I	17383 - 51982
100	2814.31	II	6187 - 41709	75	2890.25	II	2642 - 37231
95	2814.80	I	6069 - 41585	85	2891.04	I	13352 - 47931
95	2815.01	I	2010 - 37524	770	2891.84	I	2010 - 36580
95	2815.12	I	6069 - 41581	100	2894.15	I	9976 - 44518
260	2817.10	II	5658 - 41145	140	2895.10	I	12866 - 47397
50	2817.50	I	10690 - 46172	35	2896.41	I	
45	2819.14	II	10713 - 46175	35	2898.42	I	15391 - 49882
95	2819.37	I	3964 - 39422	260	2899.04	I	3964 - 38448
50	2821.99	I	26363 - 61789	170	2900.36	I	9705 - 44174
45	2824.81	I	12235 - 47625	60	2900.75	II	12705 - 47169
70	2826.18	I	10950 - 46323	45	2901.05	I	9705 - 44166
35	2826.42	I	10690 - 46061	560	2902.05	I	13352 - 47800
95	2827.18	I	5621 - 40982	150	2904.07	I	10690 - 45115
95	d 2827.48	II	14581 - 49938	170	2905.24	II	4125 - 38535
	2827.60	II	3180 - 38535	170	2908.91	I	10690 - 45058
150	2828.58	II	31267 - 66610	35	2913.32	I	5621 - 39936
35	2829.79	II	4416 - 39744	35	2913.45	II	6831 - 41145
70	2832.70	II	6831 - 42123	210	2914.12	I	10950 - 45256
170	2833.64	I	9976 - 45256	26	2914.94	I	10950 - 45246
70	2834.41	I	9976 - 45246	170	2915.34	I	10950 - 45241
35	2836.62	I	0 - 35243	310	2915.49	I	3964 - 38253
50	2837.94	I	10950 - 46177	35	2917.12	I	6069 - 40339
85	2838.24	II	15851 - 51074	35	2917.56	II	13560 - 47825
75	2840.39	II		95	2918.96	II	17231 - 51480
260	2842.82	I	11244 - 46410	35	2922.11	II	15726 - 49938
70	2843.51	II	18186 - 53344	70	2922.84	II	
640	2844.25	I	6049 - 41198	410	2925.19	I	6069 - 40245
290	2844.46	II	1031 - 36177	35	2925.66	I	9976 - 44146
170	2844.76	I		100	2926.46	I	6069 - 40230
290	c 2845.35	I	5621 - 40756	35	2930.99	I	12866 - 46974
35	2845.84	I	6069 - 41198	310	2932.70	I	12235 - 46323
70	2846.75	I	13351 - 48468	1700	2933.55	I	0 - 34078
150	2848.05	I	9705 - 44807	70	2934.85	I	9705 - 43769
560	2848.52	I	3964 - 39060	35	2938.00	II	18554 - 52580
100	2849.82	I	11244 - 46323	35	2938.43	I	12866 - 46888
1500	2850.49	I		150	2939.28	I	11244 - 45256
1900	2850.98	I	5621 - 40686	470	2940.06	I	10690 - 44693
		II	14581 - 49647	1200	2940.22	I	0 - 34001
60	2852.36	II	18186 - 53235	150	2941.37	I	13352 - 47340
70	2856.69	II	12601 - 47596	60	2941.50		
100	2857.28	II	9705 - 44693	240	2942.14	I	3964 - 37943
220	2858.44	II	5331 - 40305	35	2943.77	I	
60	2860.88	II	6831 - 41775	35	2945.69	I	12235 - 46172
50	2861.12	I	6069 - 41010	150	2946.91	I	9253 - 43177
360	2861.98	I	9759 - 44689	35	2949.92	II	14581 - 48470
150	2864.50	I	15114 - 50014	510	2951.92	I	2010 - 35877
						II	15726 - 49593

Tantalum—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	2952.99	II	9690 - 43544	40	3076.38	I	6049 - 38546
340	2953.56	I	5621 - 39468	360	3077.24	I	10690 - 43177
100	2955.32	II		140	3078.23	I	6069 - 38546
120	2956.84	II	15726 - 49536	110	3079.96	I	12235 - 44693
				180	3081.85	I	6069 - 38508
170	2957.60	I	5621 - 39422	170	3085.54	I	10690 - 43090
35	2957.88	II	9746 - 43544	140	3087.53	I	6069 - 38448
35	2963.06	I	10950 - 44689	60	3087.76	II	9746 - 42123
1500	2963.32	I	2010 - 35746	30	3092.06	I	9253 - 41585
120	2963.91	I	9253 - 42983	180	3092.44	I	9253 - 41581
770	2965.13	II	0 - 33715	40	3092.99	I	5621 - 37943
770	2965.54	I	2010 - 35721	150	3093.87	I	9705 - 42018
95	2965.92	II	0 - 33706	180	3095.39	I	13352 - 45648
35	2968.28	II	11767 - 45447	75	3101.03	II	11767 - 44005
340	2969.47	I	3964 - 37630	40	3101.72	I	15391 - 47621
70	2969.90	I	13352 - 47013	560	3103.25	I	0 - 32215
430	2975.56	I	3964 - 37561	40	3104.42	I	9975 - 42178
85	2976.10	I	9253 - 42845	75	3107.21	I	9705 - 41879
85	2976.26	II	12705 - 46295	40	3110.82	II	
60	2976.76	I		100	3113.90	I	
100	2978.18	II	18554 - 52121	75	3115.86	I	2010 - 34095
170	2978.75	I		150	3117.44	I	2010 - 34078
60	2981.19	I	9705 - 43239	75	3119.59	I	10690 - 42737
60	2984.36	I	9253 - 42752	40	3120.92	I	10950 - 42983
120	2986.81	II	2642 - 36113	380	3124.97	I	2010 - 34001
190	2988.58	I	10690 - 44141	150	3127.76	II	9746 - 41709
60	2989.05	I	11243 - 44689	60	3129.55	I	9253 - 41198
190	2989.50	I	6049 - 39490	110	3129.95	I	5621 - 37561
100	2991.25	I	6069 - 39490	380	3130.58	I	11244 - 43177
70	2999.37	II	14495 - 47825	270	3132.64	I	3964 - 35877
50	3001.54	I	12866 - 46172	40	3133.55	I	9976 - 41879
35	3002.98	II	13560 - 46851	75	3133.89	II	5331 - 37231
70	3004.15	I	9705 - 42983	180	3135.89	I	9705 - 41585
75	3004.92	II	9690 - 42960			II	12705 - 44585
40	3006.56	I	12865 - 46116	60	3137.44	II	9690 - 41555
110	3010.84	II	5331 - 38535	60	3142.96	II	9746 - 41555
180	3011.12	I	13352 - 46552	75	3147.37	I	13352 - 45115
210	3011.88	I	5621 - 38813	140	3148.04	I	9253 - 41010
1800	3012.54	II	5331 - 38516	40	3150.85	I	9253 - 40982
70	3016.37	I	11244 - 44386	40	3155.25	II	6831 - 38516
60	3019.67	I	11244 - 44350	40	3156.76	II	11875 - 43544
90	3024.09	I	5621 - 38679	75	3157.96	II	5331 - 36988
180	3025.16	I	9705 - 42752	40	3159.05	I	12235 - 43881
290	3027.48	I	12235 - 45256	75	3162.72	I	9976 - 41585
	3027.61	II	14495 - 47515	140	3163.13	I	9976 - 41581
90	3028.78	I	9976 - 42983	70	3163.82	I	9253 - 40852
110	3030.29	I	6069 - 39059	75	3167.53	I	6068 - 37630
110	3037.50	II	6831 - 39744	70	3168.18	II	15726 - 47281
40	3040.70	II	5658 - 38535	320	3170.29	I	3963 - 35497
75	3040.98	I		75	3172.87	I	11244 - 42752
290	3042.06	II	4125 - 36988	270	3173.59	I	0 - 31501
110	3042.44	II	11767 - 44626	200	3176.29	I	6049 - 37524
75	3043.92	I	10690 - 43533	140	3178.16	I	5621 - 37077
110	3045.96	I	13352 - 46172		3178.27	I	6069 - 37524
180	3048.86	I	2010 - 34800	600	3180.95	I	0 - 31428
530	3049.56	I	2010 - 34792	110	3181.69	I	9759 - 41180
110	3050.10	I	6069 - 38845	110	3182.57	I	6049 - 37461
75	3056.62	II	17231 - 49938	240	3184.55	I	6069 - 37461
110	3057.22	II	14581 - 47281	120	3191.16	I	10690 - 42018
140	3058.64	I	6069 - 38754	75	3192.25	I	
140	3060.29	I	3964 - 36631	200	3198.67	I	3964 - 35218
180	3063.56	I	5621 - 38253	40	3201.98	I	9976 - 41198
40	3063.88	I		75	3205.00		
530	3069.24	I	12235 - 44807	150	3206.39	I	5621 - 36800
60	3073.39	I	10950 - 43478	45	3207.85	I	11244 - 42408

## Tantalum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
200	3213.91	II	5658 - 36764	45	3438.40		
150	3216.93	I	6069 - 37146	90	3440.24	II	14495 - 43554
75	3221.32	I	9976 - 41010	45	3445.10	I	9976 - 38994
300	3223.83	I	5621 - 36631	70	3445.91	I	15391 - 44402
180	3227.32	I	9253 - 40230	75	3446.91	II	12705 - 41709
230	3229.24	I		90	3447.29	I	9253 - 38253
85	3229.88	II	14495 - 45447	230	3463.77	I	0 - 28862
120	3230.86	I	12235 - 43177	45	3472.52	I	17383 - 46172
85	3234.69	I	17384 - 48290	45	3473.90	I	9976 - 38754
40	3236.40	I		45	3477.22	I	15391 - 44141
70	3239.99	I	12235 - 43090	100	3477.45	I	9759 - 38508
120	3240.94	II	5331 - 36177	490	3480.52	I	6069 - 34792
200	3242.05	I	3964 - 34800	45	3484.62	I	0 - 28689
200	3242.83	I	3964 - 34792	75	3490.93	I	10950 - 39588
40	3248.52	I	11244 - 42018	380	3497.85	I	2010 - 30591
40	3250.36	I	6069 - 36826	75	3502.50	I	11244 - 39787
70	3260.18	I	0 - 30665	130	3502.87	I	10950 - 39490
210	3274.95	II	3180 - 33706	240	3503.87	I	9976 - 38508
85	3275.68	II	5658 - 36177	130	3504.98	I	3964 - 32487
70	3279.29	I	9759 - 40245	75	3505.18	I	12235 - 40756
70	3280.87	I	9759 - 40230	490	3511.04	I	5621 - 34095
30	3292.48	I	9976 - 40339	200	3513.61	I	11792 - 40245
40	3293.93	I		55	3527.06	I	11244 - 39588
140	3295.33	I	11244 - 41581	75	3528.61	I	12866 - 41198
120	3299.77	I	6049 - 36346	150	3531.58	I	9253 - 37561
70	3304.38	I	9976 - 40230	40	3532.21	I	10950 - 39253
75	3309.78	I	2010 - 32215	75	3536.30	I	9253 - 37524
1100	3311.16	I	5621 - 35813	55	3540.82	I	
210	3317.93	I	3964 - 34095	100	3541.88	II	1031 - 29257
70	3318.53	I	5621 - 35746	120	3549.05	I	3964 - 32132
680	3318.84	I	2010 - 32132	55	3553.42	I	0 - 28134
330	3330.99	II		55	3557.95	I	12235 - 40333
	3331.02	I	12235 - 42247	55	3564.79	I	10950 - 38994
85	3332.41	I	9253 - 39253	180	3566.72	I	6049 - 34078
70	3337.80	I	2010 - 31961	150	3571.85	I	10690 - 38679
85	3338.49	I	6069 - 36014	150	3573.44	I	15114 - 43090
130	3339.91	II	6831 - 36764	110	3584.21	I	9253 - 37146
30	3343.47	I	11792 - 41693	85	3584.51	I	12866 - 40756
130	3349.21	II	14581 - 44430	150	3586.29	I	5621 - 33497
90	3350.96	I	13352 - 43185	150	3595.64	I	10950 - 38754
130	3351.51	I	9759 - 39588	55	3602.48	I	11244 - 38994
230	3358.47	I		750	3607.41	I	2010 - 29723
170	3361.64	I	13352 - 43090	55	3625.23	I	5621 - 33198
40	3362.53	I	9759 - 39490	980	3626.62	I	3964 - 31530
45	3366.66	I		55	3633.75	I	
110	3369.28	I	6049 - 35721	500	3642.06	I	5621 - 33070
640	3371.54	I	3964 - 33615	40	3653.39	I	12866 - 40230
130	3376.05	I	9976 - 39588	21	3653.83	I	15391 - 42752
45	3376.49	II		40	3656.89	I	
140	3379.52	II	4125 - 33706	60	3657.27	I	13352 - 40686
360	3385.05	I	3964 - 33497	60	3657.49	I	2010 - 29344
40	3387.46	I	11244 - 40756	85	3658.78	I	
40	3388.82	I	9253 - 38754	65	3661.69	I	11244 - 38546
230	3398.33	I	2010 - 31428	65	3662.34	II	9690 - 36988
170	3406.66	II	6831 - 36177	35	3667.82	I	
450	3406.94	I	0 - 29344	65	3674.83	I	11244 - 38448
90	3412.89	I	9253 - 38546	35	3675.12	I	11792 - 38994
140	3414.14	II	6831 - 36113	40	3681.04	I	13352 - 40510
45	3417.03	II	0 - 29257	40	3681.24	I	
75	3419.74	I	3964 - 33198	60	3683.06	I	
140	3424.45	I	6049 - 35243	100	3686.18	I	9705 - 36826
90	3426.73	I	6069 - 35243	100	3689.73	I	9705 - 36800
180	3430.94	I		75	3693.05	I	12866 - 39936
75	3434.50	I	9705 - 38813	60	3694.52	II	14495 - 41555
140	3436.00	I	11244 - 40339	60	3695.38	I	11792 - 38845

Tantalum— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
21	3701.34	I	11244 - 38253	65	4013.19	I	12235 - 37146
17	3710.79	I		190	4026.94	I	6069 - 30895
40	3723.07	I	2010 - 28862	140	4029.94	I	10690 - 35497
130	3731.02	I	0 - 26795	85	4033.07	I	11792 - 36580
140	3736.76	I	11792 - 38546	19	4033.38	I	19178 - 43964
130	3746.36	I		17	4033.63	I	2010 - 26795
110	3754.52	I	3964 - 30591	65	4035.89	I	10950 - 35721
75	3755.11	I	9253 - 35877	35	4039.63	I	9253 - 34001
23	3757.75	I	9976 - 36580	120	4040.87	I	5621 - 30361
45	3759.75	I	0 - 26590	85	4041.06	I	0 - 24739
23	3760.21	I	9759 - 36346	65	4058.46	I	11244 - 35876
45	3762.11	I	10950 - 37524	410	4061.40	I	6049 - 30665
40	3770.52	I		210	4064.63	I	6069 - 30665
45	3770.93	I	5621 - 32132	100	4067.24	I	2010 - 26590
110	3777.10	I	9253 - 35721	310	4067.91	I	2010 - 26586
19	3784.25	I	6069 - 32487	40	4073.00	I	15391 - 39936
110	3792.02	I	0 - 26364	65	4079.19	I	17993 - 42501
95	3823.60	I	6069 - 32215	19	4081.13	I	17383 - 41879
40	3826.17	I	12866 - 38994	40	4085.80	I	17224 - 41693
85	3826.85	I	2010 - 28134	40	4091.26	I	15904 - 40339
95	3828.95	I	10690 - 36800	19	h 4095.55	II	11767 - 36177
35	3830.00	II	5658 - 31760	40	4097.19	I	5621 - 30021
210	3833.74	II	3180 - 29257	120	4105.02	I	2010 - 26364
65	3836.60	I	3964 - 30021	19	4114.77	I	9705 - 34001
85	3839.03	I	9705 - 35746	19	4118.07	I	
40	3844.04	I		55	4123.17	I	15114 - 39360
40	3846.64	I	9253 - 35243	85	4127.88	I	3964 - 28183
100	3848.05	I	5621 - 31601	210	4129.38	I	13351 - 37561
40	3849.42	I		230	4136.20	I	3964 - 28134
40	3859.80	I	9976 - 35877	230	4147.89	I	5621 - 29723
100	3885.20	I	11792 - 37524	75	h 4161.00	I	
19	3893.03	I	12866 - 38546	210	4175.21	I	9253 - 33198
19	bl 3896.43	Ta O		75	4176.90	II	14581 - 38516
35	3898.78	I		75	4176.99	I	12866 - 36800
65	3909.33	I		100	4177.92	I	11792 - 35721
40	3912.13	I	17224 - 42779	130	4181.15	I	9705 - 33615
40	3912.44	I	21381 - 46933	85	4191.20	I	6049 - 29902
210	3918.51	I	0 - 25513	55	4193.10	I	10950 - 34792
40	3919.47	I		300	4205.88	I	3964 - 27734
55	3922.42	II	6831 - 32318	120	4206.40	I	17384 - 41151
140	3922.78	I	6069 - 31554	95	4228.61	I	12235 - 35877
140	3922.92	I	9759 - 35243	35	4232.94	I	
65	3930.94	I	6069 - 31501	55	4235.94	II	24870 - 48470
40	3936.55	I	10950 - 36345	28	4243.99	I	11244 - 34800
85	3937.84	I	12866 - 38253	130	4245.35	I	11244 - 34792
19	3942.24	I	6069 - 31428	130	4268.26	I	15391 - 38813
65	3952.16	I	15391 - 40686	65	4271.51	I	10690 - 34095
40	3954.29	I		95	4279.06	I	0 - 23363
65	3956.57	I	9976 - 35243	65	4286.38	I	19178 - 42502
19	3956.82	I		55	4294.36	I	13352 - 36631
28	3959.73	I		160	c 4302.98	I	9253 - 32487
210	3970.10	I	0 - 25181	95	4314.52	I	2010 - 25181
65	3979.28	I	10690 - 35813	65	4318.81	I	12866 - 36014
19	3981.01	II	11875 - 36988	65	4322.68	I	17383 - 40510
85	3981.95	I	15904 - 41010	85	4329.57	I	15904 - 38994
19	3983.82	I	9705 - 34800	35	4336.20	I	23927 - 46982
17	3984.98	I	9705 - 34792	85	4344.31	I	21153 - 44165
85	3988.70	I	10950 - 36014	110	4355.14	I	22682 - 45637
40	3990.40	I	24546 - 49599	45	4360.83	I	10690 - 33615
210	3996.17	I	6049 - 31066	45	4364.84	I	
100	3999.28	I	6069 - 31066	55	4369.35	I	12866 - 35746
65	4003.70	I	5621 - 30591	28	4374.21	I	12866 - 35721
190	4005.84	I	2010 - 26960	45	4375.14	I	15904 - 38754
35	4007.23	I	15904 - 40852	28	4376.31	I	19657 - 42501
65	4012.11	I	19178 - 44095	28	4377.98	I	24982 - 47817

Tantalum—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	4378.82	I	3964 - 26795	21	4786.64	I	9705 - 30591
23	4381.88	I	21168 - 43982	220	4812.75	I	0 - 20772
150	4386.07	I	6069 - 28862	85	4819.53	I	13352 - 34095
110	4398.45	I	2010 - 24739	85	4825.43	I	11244 - 31961
180	4402.50	I	9253 - 31961	55	4832.18	I	9976 - 30665
130	4415.74	I	6049 - 28689	65	4846.45	I	25009 - 45637
45	4419.55	I	6069 - 28689	30	4852.17	I	10950 - 31554
35	4424.96	I	20647 - 43239	19	4871.70	I	6069 - 26590
65	4430.41	I	12235 - 34800	13	4879.14	I	23913 - 44403
35	4431.09	I	5621 - 28183	11	4881.94	I	10950 - 31428
40	4432.98	I	15391 - 37943	75	4883.95	I	9253 - 29723
55	4441.03	I	9976 - 32487	65	4904.59	I	15114 - 35497
75	4441.68	I	10690 - 33198	40	4907.73	I	2010 - 22380
75	4450.72	I	13352 - 35813	30	4914.96	I	0 - 20340
19	h 4451.87	I	9759 - 32215	110	4920.11	I	12866 - 33185
95	4459.76	I	19178 - 41595	100	4921.27	I	6049 - 26364
95	4473.52	I	9253 - 31601	20	4923.47	I	5621 - 25926
45	4480.93	I	25009 - 47319	25	4924.96	I	17224 - 37524
40	4494.97	I	21855 - 44095	110	4926.00	I	6069 - 26364
40	4496.50	I	2010 - 24243	150	4936.42	I	12235 - 32487
360	c 4510.98	I	5621 - 27783	50	4937.63	I	17383 - 37630
75	4511.50	I	5621 - 27781	18	4958.11	I	
55	4521.09	I	5621 - 27734	25	4968.53	I	22380 - 42502
35	4521.71	I	21855 - 43964	45	4969.73	I	10950 - 31066
65	4527.50	I	22380 - 44461	18	4972.06	I	15391 - 35497
190	4530.85	I	6069 - 28134	25	4976.20	I	9253 - 29344
28	4547.15	I	9976 - 31961	75	5012.52	I	10950 - 30895
130	4551.95	I	3964 - 25926	200	5037.37	I	13352 - 33198
45	4553.69	I	11244 - 33198	90	5037.66	I	2010 - 21855
85	4556.35	I	11244 - 33185	90	5043.32	I	11244 - 31066
45	4559.46	I	12866 - 34792	18	h 5044.42	I	22428 - 42247
17	4561.48	I	2010 - 23927	25	5058.70	I	17383 - 37146
170	4565.85	I	9705 - 31601	100	5067.87	I	12235 - 31961
28	4566.86	I	25926 - 47817	45	5076.37	I	17383 - 37077
45	4573.29	I	12235 - 34095	30	5082.25	I	10690 - 30361
340	4574.31	I	0 - 21855	65	5087.37	I	11244 - 30895
28	4580.69	I	9705 - 31530	90	5090.71	I	9705 - 29344
19	4583.17	I	9253 - 31066	40	5095.27	I	12866 - 32487
40	4601.42	I	15904 - 37630	25	c 5109.37	II	9690 - 29257
45	4602.19	I	9705 - 31428	20	5109.77	I	5621 - 25186
17	h 4604.28	I	22429 - 44141	110	5115.84	I	26575 - 46116
35	h 4604.85	I	23927 - 45637	40	5117.25	I	27783 - 47319
260	4619.51	I	9253 - 30895	45	5132.12	I	24981 - 44461
30	4622.96	I	22761 - 44386	30	5136.47	I	6049 - 25513
17	4624.84	I	21622 - 43239	100	5141.62	I	6069 - 25513
45	4633.06	I	9976 - 31554	100	5143.69	I	9253 - 28689
85	4661.12	I	13352 - 34800	75	5147.62	I	11244 - 30665
130	4669.14	I	9253 - 30665	25	5148.78	I	17383 - 36800
450	4681.88	I	2010 - 23363	25	5150.87	I	15391 - 34800
45	4684.87	I	5621 - 26960	75	5153.42	I	3964 - 23363
40	4685.27	I	9253 - 30591	330	5156.56	I	5621 - 25009
19	4688.84	I	17224 - 38546	75	5161.81	I	9976 - 29344
130	4691.90	I	9759 - 31066	65	5163.65	I	5621 - 24982
85	4693.35	I	22682 - 43982	25	5166.79	I	12866 - 32215
65	4701.32	I	10950 - 32215	20	5171.63	I	10690 - 30021
65	4706.09	I	11244 - 32487	40	c 5180.98	I	21855 - 41151
45	4722.88	I	0 - 21168	20	5188.93	I	12866 - 32132
85	4730.12	I	12866 - 34001	20	c 5193.99	I	17383 - 36631
27	h 4738.35	I	23363 - 44461	20	5206.26	I	14875 - 34078
150	4740.16	I	9976 - 31066	110	5212.74	I	0 - 19178
40	4745.93	I	17383 - 38448	110	d 5218.45	I	2010 - 21168
220	4756.51	I	3964 - 24982		5218.66	I	9705 - 28862
45	4758.03	I	10950 - 31961	40	5230.80	I	6069 - 25181
120	4768.98	I	12235 - 33198	30	5235.39	I	12866 - 31961
85	4780.94	I	10690 - 31601	30	5237.53	II	14628 - 33715



Tantalum - all observed lines - Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18	5244.78	I	9705 - 28767	30	5755.81	I	23141 - 40510
30	5275.02	I	10950 - 29902	15	5761.61	I	24243 - 41595
18	5279.82	I	17224 - 36159	25	5766.56	I	9253 - 26590
18	5281.02	I	9759 - 28689	30	5767.91	I	9253 - 26586
90	5295.01	I	9253 - 28134	10	5771.93	I	25181 - 42502
40	5318.67	I	25186 - 43983	130	5776.77	I	6049 - 23355
75	5328.38	I	2010 - 20772	25	5780.02	I	20647 - 37943
30	5336.13	I	12866 - 31601	90	5780.71	I	6069 - 23363
140	5341.05	I	3964 - 22682	130	5811.10	I	3964 - 21168
25	5342.25	I	9976 - 28689	25	5816.51	I	26795 - 43983
50	5349.09	I	6049 - 24739	45	5843.94	I	9759 - 26866
50	5349.57	I	12866 - 31554	13	5849.68	I	10690 - 27781
65	5354.68	I	6069 - 24739	15	5866.61	I	21153 - 38194
15	5365.95	I	17383 - 36014	240	5877.36	I	13352 - 30361
20	5373.01	I		130	5882.30	I	23515 - 40510
25	5388.51	I	28767 - 47319	90	5901.91	I	11244 - 28183
90	5389.30	I	2010 - 20560	30	5916.51	I	11792 - 28689
40	5395.99	I	9253 - 27781	90	5918.95	I	9976 - 26866
25	5397.56	I	17224 - 35746	15	5925.90	I	28766 - 45636
200	5402.51	I	0 - 18505	15	5930.62	I	12866 - 29723
13	5403.54	I	15114 - 33615	23	5931.05	I	24739 - 41595
45	5404.96	I	17224 - 35721	20	5931.68	I	17224 - 34078
13	5405.80	I	17383 - 35877	18	5935.54	I	23913 - 40756
30	5408.78	I	22428 - 40911	130	5939.76	I	9759 - 26590
18	5410.55	I	9705 - 28183	240	5944.02	I	9976 - 26795
25	5413.48	I	6049 - 24517	25	5951.78	I	39253 - 56050
130	5419.19	I	6069 - 24517	18	5960.13	I	23913 - 40686
23	5431.66	I	21381 - 39786	190	5997.23	I	13352 - 30021
65	5435.27	I	10950 - 29344	25	6009.89	I	24517 - 41151
25	5458.41	I	21153 - 39468	25	6015.90	I	17383 - 34001
90	5461.29	I	5621 - 23927	100	6020.72	I	9759 - 26364
13	5471.56	I		250	6045.39	I	11244 - 27781
30	5475.57	I	22428 - 40686	100	6047.25	I	12235 - 28767
15	5481.16	I	23355 - 41595	25	6053.70	I	9705 - 26220
20	5483.43	I	23363 - 41595	30	6090.82	I	25181 - 41595
40	5490.11	I		18	6092.06	I	22842 - 39253
20	5494.78	I	6049 - 24243	100	6101.58	I	22429 - 38813
50	5499.44	I	13352 - 31530	25	6140.07	I	26220 - 42502
18	5500.68	I	6069 - 24243	65	6144.56	I	10690 - 26960
20	5505.66	I	9976 - 28134	30	6152.54	I	27734 - 43983
15	5516.27	I		130	6154.50	I	9976 - 26220
90	5518.91	I	17383 - 35498	40	6158.84	I	17383 - 33615
9	5521.15	I	20647 - 38754	15	6170.46	I	27781 - 43983
10	5523.98	I	26363 - 44461	15	6189.66	I	22842 - 38994
13	5528.36	I	3964 - 22047	15	6193.11	I	21381 - 37523
10	5545.20	I	12866 - 30895	25	6208.37	I	25478 - 41581
20	5548.32	I	17224 - 35243	40	6249.79	I	12866 - 28862
30	5584.02	I	27734 - 45637	150	6256.68	I	6069 - 22047
15	5598.75	I	27781 - 45637	150	6268.70	I	12235 - 28183
30	5599.52	I	27783 - 45637	50	6278.34	I	21153 - 37076
9	5605.50	I	17383 - 35218	65	6281.33	I	10950 - 26866
9	5617.71	I	23355 - 41151	15	6287.36	I	21622 - 37523
40	5620.68	I	12235 - 30021	40	6287.91	I	12235 - 28134
13	5628.20	I	26219 - 43982	40	6289.34	I	10690 - 26586
20	5635.71	I	10950 - 28689	50	6309.06	I	23514 - 39360
40	5640.18	I	12866 - 30591	150	6309.58	I	10950 - 26795
150	5645.91	I	9253 - 26960	25	6312.22	I	24917 - 40755
130	5664.90	I	2010 - 19658	75	6325.08	I	6049 - 21855
30	5688.25	I	17224 - 34800	50	6332.91	I	6069 - 21855
40	5699.24	I	9253 - 26795	65	6341.17	I	22428 - 38194
15	5704.31	I	21153 - 38679	30	6346.02	I	9759 - 25513
25	5706.28	I	24982 - 42502	75	6356.16	I	9253 - 24982
30	5715.24	I	10690 - 28183	65	6360.84	I	11244 - 26960
8	5716.53	I	12235 - 29723	40	6373.06	I	22761 - 38448
23	5746.71	I	26586 - 43983	15	6379.07	I	26575 - 42247

Tantalum — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
90	6389.45	I	21153 - 36800	20	7000.21	I	23912 - 38194
23	6392.21	I	10950 - 26590	40	7005.07	I	6069 - 20340
65	6428.60	I	11244 - 26795	75	7006.96	I	9976 - 24243
250	6430.79	I	12235 - 27781	50	7025.03	I	10950 - 25181
13	6437.36	I					
40	6444.61	I	20646 - 36159	13	7031.51	I	17383 - 31601
30	6445.87	I	23912 - 39422	40	7039.07	I	22429 - 36631
200	6450.36	I	12235 - 27734	15	7081.30	h	23512 - 37630
20	6455.83	I	9253 - 24739	20	7085.40	I	9253 - 23363
30	6459.92	I	9705 - 25181	23	7093.02	I	12866 - 26960
380	6485.37	I	13352 - 28767	8	7108.05	I	22761 - 36826
18	6502.43	I	2010 - 17384	15	7117.52	c	25376 - 39422
65	6505.52	I	20646 - 36013	20	7121.27	I	22761 - 36800
100	6514.39	I	11244 - 26590	40	7125.72	I	3963 - 17993
100	6516.10	I	11244 - 26586	150	7148.63	I	12235 - 26220
25	6561.60	I	10690 - 25926	110	7172.90	I	11244 - 25181
25	6564.26	I	20646 - 35876	13	7174.91	c	
100	6574.84	I	9976 - 25181	13	7191.35	I	24546 - 38447
10	6585.13	I	22761 - 37943	8	7233.45	I	
15	6587.16	I	21622 - 36799	30	7250.27	h	10950 - 24739
110	6611.95	I	11244 - 26364	11	7264.82	h	24917 - 38679
75	6621.30	I	6069 - 21168	6	7272.29	I	
15	6662.24	I	21153 - 36159	30	7276.96	I	11244 - 24982
100	6673.73	I	9759 - 24739	5	7277.54	I	22842 - 36580
180	6675.53	I	11244 - 26220	9	7286.36	I	11792 - 25513
30	6684.00	I	21622 - 36580	13	7296.32	c	
15	6693.61	I	23512 - 38447	140	7301.74	I	12235 - 25926
15	6706.46	I	15114 - 30021	20	7319.84	I	9705 - 23363
25	6709.39	I	23913 - 38813	11	7322.72	c	15114 - 28767
10	6714.44	I	26022 - 40911	13	7325.95	I	21153 - 34799
15	6723.61	I	22761 - 37630	11	7340.19	cw	21622 - 35242
75	6740.73	I	13352 - 28183	160	7346.41	I	6049 - 19658
40	6754.91	I	26795 - 41595	140	7352.86	c	9759 - 23355
13	6755.85	I	11792 - 26590	100	7356.96	I	6069 - 19658
13	6770.37	I	23913 - 38679	90	7369.09	cw	10950 - 24517
75	6771.74	I	9976 - 24739	160	7407.89	I	11244 - 24739
40	6774.25	I	9759 - 24517	11	7435.19	c	26022 - 39468
40	6788.99	I	12235 - 26960	23	7440.17	I	25376 - 38813
13	6790.06	I	24917 - 39641	30	7467.75	I	9976 - 23363
13	6799.27	I	6069 - 20772	23	7486.01	I	20646 - 34001
40	6810.46	I	23514 - 38194	30	7520.56	I	10950 - 24243
160	6813.25	I	9253 - 23927	6	7569.23	I	17383 - 30591
20	6819.36	I	21153 - 35813	9	7590.22	I	22842 - 36013
18	6824.96	I	22428 - 37076	6	7649.62	I	22428 - 35497
13	6832.00	I	21381 - 36013	11	7722.02	h	12235 - 25181
15	6850.83	I	21153 - 35746	11	7763.11	I	
15	6865.13	I	10950 - 25513	9	7779.67	c	20646 - 33497
210	6866.23	I	12235 - 26795	20	7842.76	c	12235 - 24982
180	6875.27	I	9976 - 24517	100	7882.37	I	11244 - 23927
40	6877.49	I	21622 - 36159	30	7950.19	I	13352 - 25926
15	6896.77	I	10690 - 25186	5	7952.07	I	
40	6900.55	I	26022 - 40510	6	7998.75	I	17224 - 29723
150	6902.10	I	9759 - 24243	6	8022.09	I	21153 - 33615
140	6927.38	I	13352 - 27783	75	8026.50	I	6049 - 18505
140	6928.54	I	13352 - 27781	5	8029.04	I	11792 - 24243
8	6939.33	I	26575 - 40981	15	8039.08	I	6069 - 18505
20	6946.87	I	21622 - 36013	8	8053.93	I	10950 - 23363
65	6951.26	I	13352 - 27734	15	8068.98	I	15391 - 27781
45	6953.88	I	17224 - 31601	5	8100.11	I	9705 - 22047
180	6966.13	I	12235 - 26586	13	8128.76	I	23514 - 35813
8	6969.49	I	21153 - 35497	9	8158.54	I	24546 - 36799
8	6971.31	I	23912 - 38253	5	8180.74	c	
9	6971.53	I	21381 - 35721	13	8248.95	c	11244 - 23363
23	6983.52	I	22761 - 37077	20	8264.85	d	9759 - 21855
110	6995.22	I	10690 - 24982	75	8281.62	I	9976 - 22047
	6995.49	I	6049 - 20340				

*Tantalum— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
11	8389.06	I	21153 - 33070	11 h	8550.49	I	12235 - 23927
5	8415.73	I	9976 - 21855	15	8575.92	I	13352 - 25009
25 cw	8447.62	I	13352 - 25186	10 cw	8595.84	I	13352 - 24982

## Tellurium

$$\text{Te, } Z = 52, M = 127.6, \text{ Ratio } \frac{\text{Te}}{\text{Cu}} = 2.008$$

Te I Normal state of valence electrons  $5s^25p^4\ ^3P_2 = 0$ . I.P. = 72667  $\text{cm}^{-1}$ .

Te II Normal state of valence electrons  $5s^25p^3\ ^4S_{1/2}^o = 0$ . I.P. = 150000  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

J. F. Ward, unpublished material (1969).

#### Classification:

Te I, O. Bartelt, Z. Physik **88**, 522 (1934).

*Tellurium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
14000	1994.18	I	4751 - 54877	500	2259.02	I	0 - 44253
26000	2002.02	I	4751 - 54685	1200	2383.26	I	4706 - 46653
6500	2081.16	I	10559 - 58596	1500	2385.78	I	4751 - 46653
18000	2142.81	I	0 - 46653	120	2530.72	I	4751 - 44253
3200	2147.25	I	10559 - 57116	110	2677.13	I	
360	2159.85	I	10559 - 56845	100	3175.14	I	23199 - 54685

# Terbium

$$\text{Tb, } Z = 65, M = 158.9254, \text{ Ratio } \frac{\text{Tb}}{\text{Cu}} = 2.501$$

Tb I Normal state of valence electrons  $4f^9 6s^2 {}^6\text{H}_{7/2}^{\circ} = 0$ . I.P. = 47200  $\text{cm}^{-1}$ .

Tb II Normal state of valence electrons  $4f^9 6s {}^7\text{H}_8 = 0$ . I.P. = 92900  $\text{cm}^{-1}$ .

## References

### Wavelengths:

A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945).

Supplemented by:

J. M. Eder, Sitzber. Akad. Wiss. Wien, Math. naturw. Kl. **131**, 199 (1922).

A. S. King, *Astrophys. J.* **72**, 221 (1930).

P. F. A. Klinkenberg and E. Meinders (see below).

About 70 lines above 7000 Å were measured on our plates.

### Classification:

Tb I, P. F. A. Klinkenberg and E. Meinders, *Physica* **32**, 1113, 1617 (1966); **37**, 197 (1967); **38**, 253 (1968); **42**, 213 (1969); **50**, 625 (1970); **57**, 594 (1972).

Tb II, E. Meinders, *Physica* **42**, 427 (1969) and unpublished material (1969).

### Spectrum Assignments:

From 3837 to 4677 Å the assignment of spectrum is from A. S. King, *Astrophys. J.* **72**, 221 (1930).

The rest of the assignments are from our plates.

### *Strong lines of terbium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5700	3509.17	II	0 - 28488	1600	3568.98	II	
4700	3702.86	II	1016 - 28014	1600	3600.44	II	
4200	3568.52	II	0 - 28014	1600	3901.33	I	462 - 26087
3800	3324.40	II		1500	3293.07	II	6372 - 36731
3800	3676.35	II	1016 - 28209	1500	3830.26	I	285 - 26386
3700	3848.73	II	0 - 25975	1300	3523.66	II	
3500	w 3874.17	II	0 - 25804	1300	4061.58	I	462 - 25076
3200	3561.74	II	3010 - 31078	1200	3219.98	II	
3000	4326.43	I	0 - 23107	1100	3218.93	II	
2400	3703.92	II		1100	3540.24	II	
2400	3899.20	II	3010 - 28649	1100	3579.20	II	
2300	d 3650.40	II		1100	3755.24	II	
2200	3976.84	II	0 - 25138	1100	4144.41	II	1016 - 25138
2200	4318.83	I	0 - 23147	1000	3285.04	II	
2100	3776.49	II		1000	d 3711.76	II	3542 - 30476
2100	4033.03	II	1016 - 25804	970	4002.59	II	5171 - 30148
2000	3658.88	II	1016 - 28339	870	3747.17	II	
1900	4005.47	II	1016 - 25975	870	3747.34	II	
1800	3981.87	II	3542 - 28649	870	4032.28	I	2310 - 27103
1700	3765.14	I	509 - 27061	870	4336.43	I	2771 - 25825
1700	4338.41	I	0 - 23043	870	4356.81	I	2771 - 25717

Terbium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
29	2577.73	II		190	2852.14	II	
110	2584.61	II		75	2854.20	II	
29	2590.31	II		75	2854.96	II	
29	2591.42	II		75	2855.65	II	0 - 35007
24	2592.64	II		110	2857.68	II	
55	2597.71	II		95	2861.34	II	
40	2602.93	II		40	2864.48	II	
110	2608.57	II		50	2867.42	II	
40	2616.90			50	2872.32	II	0 - 34804
130	2628.69	II	0 - 38030	40	2872.55	II	
55	2655.96	II		75	2881.25	II	
50	2661.40	II		95	2884.68	II	
24	2661.64	II		75	2885.90	II	
55	2667.64	II		230	2886.29	II	
50	2668.86	II		75	2887.44	II	
140	2669.29	II		50	2888.10	II	
40	2674.13	II		40	2888.31	II	
40	2674.69	II		40	2888.82	II	
29	2678.15	II		75	2889.66	II	
40	2683.97	II		40	2892.49	II	
35	2687.82	II	0 - 37193	160	2894.45	II	
50	2691.90	II		55	2896.04	II	
35	2693.05	II		320	2897.44	II	
55	2693.41	II		160	2898.86	II	
35	2695.46	II		110	2901.54	II	
50	2696.83	II		65	2903.24	II	
35	2701.52	II		40	2907.10	II	
190	2704.07	II		110	2910.30	II	
95	2706.28	II		75	2911.77	II	
50	2713.22	II		40	2912.65	II	
35	2720.89	II		40	2913.39	II	
35	2724.29	II		160	2914.75	II	
35	2726.49	II		160	2915.30	II	
65	d 2730.21	II		190	2915.60	II	
35	2733.90	II		120	2916.24	II	
35	2735.45	II		120	2918.89	II	
35	2735.99	II		65	2919.00	II	
130	2736.24	II		120	2924.16	II	
65	2742.26	II		120	2924.53	II	3010 - 37193
85	2743.50	II		65	2925.94	II	
35	2757.41	II		75	2931.41	II	
160	2759.47	II		160	2932.89	II	
65	2760.96	II		75	2933.79	II	
35	2766.57	II		55	2934.80	II	1016 - 35080
35	2767.02	II		55	2936.39	II	
270	2769.53	II		150	2940.05	II	
35	2782.35	II		85	2941.70	II	
35	2783.00	II		85	2944.90	II	
130	2784.49	II		95	2945.70	II	
35	2785.50	II		75	2946.87	II	
40	2796.95	II		55	2949.04	II	
180	2800.51	II		55	2950.04	II	
75	2800.63	II		250	2956.21	II	
250	2802.75	II		40	2957.32		
250	2809.30	II	1016 - 36601	40	2957.70	II	
180	2812.64	II		65	2960.58	II	0 - 33767
40	2818.48	II		55	2962.78	II	
40	2819.78	II		95	2963.97	II	
85	2827.41	II		85	2964.76	II	
75	2833.03	II		55	2965.32	II	
85	2838.72	II		170	2968.87	II	
40	2842.00	II		40	2974.15	II	
75	2843.95	II		170	2977.78	II	
75	2845.93	II		40	2981.99	II	
55	2851.04	II		110	2987.03	II	

## Terbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	2988.57	II		95 d	3091.62	II	
40	2989.84	II		95	3092.96	II	
85	2991.96	II		65	3093.20	II	
50	2992.54	II		95	3096.86	II	
130	2996.00	II		50	3097.40	II	
110	2999.03	II		230	3102.54	II	
75	3002.45	II		480	3102.96	II	
85	3004.58	II		95	3108.41	II	
130	3005.52	II		65	3109.15	II	
55	3007.11	II		65	3109.82	II	
170	3009.30	II		65	3112.43	II	
55	3010.12	II		50	3112.53	II	
230	3010.59	II		75	3113.62	II	
65	3013.61	II		50	3116.66	II	
230	3016.18	II		75	3117.26	II	3010 - 35080
130	3019.17	II		290	3117.89	II	
170	3020.29	II		290	3119.62	II	
55	3021.95	II		95	3121.43	II	
110	3023.43	II		230	3121.94	II	
75	3023.70	II		75	3122.83	II	
170	3027.33	II		230	3123.05	II	
50	3027.58	II		50	3124.02	II	
85	3029.23	II		160	3124.54	II	
230	3031.60	II		95	3126.16	II	
85	3032.83	II		50	3128.88	II	
75	3034.09	II		110	3131.35	II	
85	3034.91	II		250	3134.26	II	
50	3037.04	II		95	3135.35	II	
85	3038.66	II		95	3137.22	II	
50	3042.07	II		50	3138.63	II	
50	3042.50	II		440	3139.64	II	
40	3042.83	II		190	3140.06	II	1016 - 32853
95	3043.65	II		85	3143.38	II	
230	3044.96	II		230	3145.22	II	
50	3047.00	II		150	3146.67	II	
50	3050.57	II		310	3147.04	II	
190	3051.13	II		310	3147.15	II	
95	3052.18	II		65	3148.21	II	
130	3053.24	II		310	3148.71	II	
460	3053.55	II		65	3154.69	II	
50	3061.80	II		65	3155.10	II	
130	3062.78	II		120	3155.62	II	
230	3064.09	II		50	3156.52	II	
50	3064.51	II		50	3157.49	II	
50 h	3065.17	II		75	3158.66	II	
110	3065.69	II		95	3159.22	II	
75	3065.86	II		95	3159.39	II	
230	3067.20	II		130	3162.42	II	
270	3069.03	II		290	3162.93	II	
460	3070.05	II		95	3163.85	II	
270	3072.60	II		75	3164.10	II	
55	3074.71	II		95	3164.77	II	
95	3076.06	II		190	3165.74	II	
670	3078.86	II		380	3167.52	II	
65	3080.11	II		140	3168.32	II	
95	3081.55	II		50	3168.59	II	
65	3082.01	II		230	3169.84	II	
480	3082.36	II		95	3171.19	II	
75	3083.81	II		190	3173.76	II	
65	3085.99	II		380	3174.66	II	
120	3086.78	II		75	3175.45	II	
65	3087.54	II		50	3179.84	II	
250	3088.43	II		380	3180.54	II	
50	3089.10	II		50	3181.22	II	
480	3089.58	II		95	3183.28	II	

Terbium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
95	3183.64	II		230	3264.90	II	
140	3183.88	II		75	3265.93	II	
95	3186.23	II		400	3266.40	II	
480	3187.26	II	0 - 31365	190	3268.10	II	
290	3188.03	II		150	3268.52	II	
95	3188.55	II		75	3270.63	II	
50	3188.83	II		150	3272.35	II	1016 - 31566
95	3189.97	II		250	3274.14	II	
50	3190.72	II		250	3274.33	II	
65	3192.76	II		65	3275.66	II	
50	3194.18	II		210	3277.32	II	
190	3194.69	II		110	3277.73	II	
380	3195.60	II		760	3280.31	II	0 - 30476
50	3198.02	II		760	3281.40	II	
480	3199.56	II		520	3283.10	II	
150	3200.73	II		50	3283.81	II	
95	3202.70	II		1000	3285.04	II	
65	3202.95	II		150	3285.21	II	
75	3207.09	II		50	3286.98	II	
130	3207.53	II		310	3287.55	II	
95	3207.96	II		310	3291.56	II	
65	3209.54	II		1500	3293.07	II	6372 - 36731
50	3210.01	II		110	3294.00	II	1016 - 31365
150	3210.22	II		210	3295.33	II	
95	3215.01	II		110	3298.20	II	
1100	3218.93	II		310	3298.66	II	
1200	3219.98	II		110	3304.10	II	
95	3220.17	II		110	3304.26	II	
50	3222.37	II		210	3304.95	II	
95	3222.97	II		110	3305.37	II	
50	3227.48	II		75	3306.41	II	
150	3229.19	II		420	3307.44	II	
250	3230.03	II		85	3307.80	II	
250	3231.06	II		210	3308.51	II	
95	3231.46	II		110	3309.17	II	
85	3232.00	II		50	3310.10	II	
50	3232.73	II		75	3310.37	II	
95	3234.50	II		110	3310.80	II	
110	3235.78	II	0 - 30895	150	3312.53	II	
95	3236.20	II		150	3312.78	II	
210	d 3239.60	II		210	3314.38	II	
250	3240.00	II		50	3314.70	II	
190	3240.65	II		110	3315.07	II	
75	3243.20	II		50	3317.58	II	
50	3244.60	II		110	3319.16	I	0 - 30119
95	3245.17	II		340	d 3321.15	II	
50	3245.42	II		420	3322.28	II	
50	3247.18	II		210	3323.38	II	
65	3249.61	II		210	3323.89	II	
50	3250.75	II		3800	3324.40	II	
50	3250.95	II		150	3325.49	II	1016 - 31078
150	3251.25	II		110	3327.11	II	
480	3252.32	II		520	3329.08	II	
65	3253.54	II		110	3333.21	II	
65	3255.22	II		120	3333.93	II	
95	3259.38	II		110	3334.25	II	
190	3260.05	II		210	3334.48	II	
50	3260.66	II		110	3335.42	II	
95	3260.83	II		250	3336.70	II	
190	3261.74	II		310	3338.03	II	
95	3262.68	II		250	3339.00	II	
250	3262.97	II		120	3339.61	II	
50	3263.65	II		50	3342.98	II	
230	d 3263.87	II		120	3343.77	II	
50	3264.06	II		50	3343.93	II	



Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>		
50	3346.32	II	1016 - 30476	210	3410.68	II	3542 - 32853		
210	3347.27	II		520	3413.76	II			
210	3348.07	II		270	3416.24	II			
85	3348.23	II		85	3417.72	II			
150	3348.54	II		55	3417.91	II			
760	3349.42	II		55	3418.86	II			
180	3351.44	II		55	3418.95	II			
180	3352.89	II		85	3419.54	II			
50	3356.18	II		400	d	3420.34		II	
120	3357.37	II		190		3422.44		II	
50	3358.46	II		75		3423.05		II	
110	3359.86	II		110		3423.96		II	
50	3360.05	II		190	d	3424.35		II	
50	3360.29	II		110		3424.66		II	
320	3362.25	II		55		3425.92		II	
110	3364.24	II		110	d	3428.16		II	
85	3364.36	II		55		3428.71		II	
760	3364.93	II		55		3429.09		II	
110	3365.27	II		210		3430.61		II	
150	3367.18	II		55		3431.86		II	
230	d	3370.61		II	110			3432.35	II
320		3371.50		II	110			3432.90	II
520		3372.36		II	320			3433.26	II
460	d	3372.72		II	55			3434.54	II
190		3374.41		II	75			3434.92	II
520		3375.03		II	75			3435.53	II
110		3376.36		II	85			3436.97	II
160		3376.66		II	190			3438.57	II
190		3377.66		II	75			3439.05	II
110		3378.40		II	270			3439.72	II
320		3378.73		II	520			3440.37	II
520		3378.86		II	75			3441.68	II
85		3379.15		II	320			3444.58	II
160		3380.60		II	210			3446.40	II
85		3380.89		II	270			3449.46	II
320		3382.80		II	110			3450.30	II
110	d	3386.49		II	110			3452.37	II
85		3388.37		II	75			3453.46	II
55		3388.63		II	810			3454.06	II
110		3390.02		II	110			3455.35	II
210		3390.60		II	55			3455.99	II
380		3391.28		II	110			3456.55	II
75		3391.72		II	160	h		3457.03	II
160		3392.01		II	190			3458.71	II
55		3393.01		II	380			3460.38	II
160		3393.49		II	190			3461.00	II
110		3394.77		II	230	d		3462.97	II
160		3395.02		II	55			3464.63	II
55		3397.60		II	110			3465.98	II
270		3398.35		II	75			3466.92	II
85		3398.58		II	620			3468.03	II
320		3399.10		II	110			3469.70	II
85		3399.30		II	75			3469.85	II
110		3399.97		II	160			3470.36	II
270		3400.53		II	270			3471.73	II
210	d	3400.86		II	270			3472.37	II
420		3402.33		II	810	d		3472.79	II
55		3402.78		II	210			3473.00	II
55		3404.24		II	55			3473.28	II
160		3404.71		II	75			3473.79	II
190		3406.01		II	55			3475.72	II
40		3407.10		II	110			3476.12	II
85		3408.86		II	110			3476.29	II
160	d	3409.94		II	55			3479.29	II
210		3410.40		II	380			3480.17	II

## Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	3481.50	II		55	3549.21		
75	3482.80	II		150	3549.36	II	
230	3483.04	II		310	d 3551.03		
230	3483.69	II		320	3551.96	II	
110	3487.28	II		160	3555.29		
85	3487.62	II		55	3556.05		
290	d 3489.51	II	0 - 28649	110	3556.25		
110	3489.78	II		75	3558.09		
75	3491.24	II	6372 - 35007	460	d 3558.77		
210	d 3492.00	II		55	3559.14		
160	3492.56	II		290	3559.39	I	285 - 28372
110	3492.99	II		230	3559.76	II	
270	3494.21	II		3200	3561.74	II	3010 - 31078
160	3494.92	I	285 - 28890	480	3562.90	II	
270	3495.36	II		160	3565.34		
55	3496.20	II		570	3565.74		
160	3499.33	I		810	3567.35	II	3542 - 31566
160	3500.28	II	0 - 28561	4200	3568.52	II	0 - 28014
810	3500.84	II	3010 - 31566	1600	3568.98	II	
95	3504.04	II		320	3572.07	II	
140	3504.75	II		160	3575.90	I	3174 - 31131
110	3505.09	II		160	3576.64		
270	d 3505.90	II		230	3576.83	I	2840 - 30789
75	3506.56	II		230	3577.08		
570	3507.45	II	6372 - 34875	110	3578.70		
5700	3509.17	II	0 - 28488	1100	3579.20	II	
380	3510.10	II		710	3585.03	II	3010 - 30895
95	3511.04	II		570	3587.44	II	
160	3512.60	II		110	3587.76	I	5484 - 33348
320	3513.10	II		110	3589.53		
290	3513.86	II		55	3591.39		
290	3515.04	II		110	3591.66	II	
110	3515.44	II		230	cw 3593.07	II	3542 - 31365
210	3516.14	II	6372 - 34804	110	3593.75		
160	3516.63	I	462 - 28890	75	3594.65	I	285 - 28096
160	3518.97	I	509 - 28919	110	3594.98	II	
570	3519.76	II		810	3596.38	II	
160	3520.79	II		440	3598.06	II	
55	3522.92	II		190	3600.04		
55	3523.20	II		1600	3600.44	II	
1300	3523.66	II		110	3601.75	II	
380	3525.14	II		320	3604.90	II	
440	3525.61	II	3010 - 31365	290	3606.04	II	
160	3525.79	II		290	3606.16	II	
85	3526.73	II		55	3608.25	II	
110	3529.76	II		320	3611.33	II	
210	3531.70	II		270	3611.41	II	5171 - 32853
160	3532.70	II		160	3613.06	II	
140	3533.86	II		95	3613.36	II	
440	3536.32	II		230	3613.68	II	6912 - 34577
85	3536.62	I	1371 - 29638	320	3614.63	II	
230	3537.11	II		320	d 3615.66	II	
110	3537.69			320	3616.58	II	
570	3537.94	II		380	3617.86	II	1016 - 28649
140	3538.90			160	3618.18	II	
140	3539.81			110	3618.90	II	
1100	3540.24	II		380	3619.73	II	5234 - 32853
110	3541.75			130	3622.11	II	
290	3543.23	II		290	3623.92	II	
810	3543.89	II	0 - 28209	110	3624.80	II	
95	3544.36	II		810	3625.54	II	
55	3545.40	II		570	3626.50	II	
75	3546.05	II		160	3626.87	II	
290	3546.52			290	d 3628.20	II	
110	3548.82			380	3629.44	II	1016 - 28561

## Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
290	3630.28	II		370	3709.30	II	
110	3631.46	II		1000	d 3711.76	II	3542 - 30476
670	3633.29	II	5171 - 32687	80	3714.37	II	
190	3635.42	II		140	3716.08	II	
670	3638.46	II		200	3716.43	II	
160	3638.89	I	462 - 27935	100	3717.47	II	
290	3639.82	II	3010 - 30476	80	3717.90	I	509 - 27399
670	3641.66	II	5234 - 32687	40	3718.24	II	
290	3642.68	II		180	3718.44	II	
75	3643.26	II		300	3719.45	II	
75	3643.76	II		140	3723.04	II	5171 - 32023
95	3644.13	II		45	3723.84	II	
230	3645.38	II		140	3724.92	I	
110	3645.82	II		85	3725.32	II	
95	3646.46	II		75	3728.65		
440	3647.06	II		130	3728.96		
570	3647.75	II		650	3729.91	II	
95	3649.41	II		85	3731.00	I	
2300	3650.40	II		150	3731.52	I	2419 - 29210
290	3650.93	II		430	3732.39	II	
230	3651.86	II		85	3732.65	I	6989 - 33772
230	3652.26	II		130	d 3734.80		
190	3652.97	II			3735.04		
160	3653.87	II		45	3738.45		
810	3654.88	II	3542 - 30895	170	3740.32		
240	3658.22	II		220	3741.24		
2000	3658.88	II	1016 - 28339	220	3741.58	II	
120	3659.45	II		260	3741.89		
100	3660.44	II		170	d 3742.43		
200	3660.75	II		430	3743.09		
450	3663.12	II		170	3743.64	I	
90	3665.60	II		650	3745.04	I	1371 - 28065
40	3668.00	II		75	3746.30	I	3719 - 30405
80	3668.50	II		220	3746.54		
260	3669.64	I	285 - 27528	870	3747.17	II	
100	3674.05	II		870	3747.34	II	
220	3675.78	II	5171 - 32369	85	3748.80	II	
3800	3676.35	II	1016 - 28209	130	3749.70	I	2310 - 28971
300	3677.89	II		75	d 3750.24	I	3174 - 29832
100	3678.78	II		45	3751.35	I	6989 - 33638
810	3682.26	II		45	3751.62		
220	3684.81	II		85	3753.00	I	4695 - 31333
320	3688.15	II		85	3753.52		
240	3689.12	II		1100	3755.24	II	
120	3689.72	II		45	3757.05	I	2310 - 28919
610	3691.15	II		430	3757.44	II	3542 - 30148
300	3692.95	II		430	d 3757.90	II	
450	3693.58	I	462 - 27528	650	3759.35	I	2840 - 29433
140	3694.75	II		85	3760.02	I	1371 - 27959
170	3696.30	II		120	3760.13	I	5484 - 32071
320	3696.85	II		350	3761.14	I	2310 - 28890
200	3699.33	II		65	3762.51	I	
450	3700.12	I	509 - 27528	65	3762.74		
200	3701.15	I	462 - 27473	85	3763.96	I	6351 - 32911
150	3701.33	I	285 - 27295	1700	3765.14	I	509 - 27061
80	3701.50	II		200	3767.50	II	
4700	3702.86	II	1016 - 28014	85	3769.43	I	
300	3703.12	I		45	3771.03		
80	3703.50	II		160	3775.26	II	6372 - 32853
2400	3703.92	II		2100	3776.49	II	
240	3705.06	I	509 - 27492	120	3777.48		
280	3706.34	II		330	3779.22		
100	3706.80	I	3819 - 30789	65	3782.18		
100	3708.42	I	462 - 27420	55	3782.62	I	
180	3708.76	II		600	3783.53	I	285 - 26708

## Terbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	3784.15	I		260	3886.82	II	
120	3785.38			160	3887.64	II	1016 - 26731
410	3787.22	II	3010 - 29407	160	3887.88	I	2840 - 28554
120	3787.60			480	3888.22	I	
85	3787.71	I		95	3889.84	II	
160	3789.00			65	3890.95	I	
120	3789.68			160	3893.38	II	
410	3789.92	I		65	3893.69	I	6488 - 32163
120	3791.05	I	2840 - 29210	160	3894.46	II	
390	3792.20	I	5353 - 31715	490	3894.64	I	3719 - 29388
75	3793.25			65	3895.08	I	4646 - 30313
600	3793.55			65	3895.37	I	6351 - 32016
130	3796.25	I	3719 - 30054	330	3895.99	I	2840 - 28500
75	3797.00	I	5829 - 32159	330	3896.58	II	
160	3798.59			45	3897.26	I	1371 - 27023
200	3798.95	II		330	3897.89	I	509 - 26157
75	3801.36			2400	3899.20	II	3010 - 28649
330	3801.80	II		160	3899.57	II	
160	3802.17	II		130	3900.74	I	2419 - 28048
120	3804.42	I	509 - 26787	1600	3901.33	I	462 - 26087
95	3806.26			95	3901.68	II	
760	3806.85	II	3542 - 29803	95	3902.00	II	
40	3810.57			30	3903.08	I	3819 - 29433
240	3811.65	I		75	3904.17	I	3719 - 29326
240	3812.73			55	3906.54	II	
240	3813.16			480	3908.06	I	462 - 26043
150	3814.96	d		65	3908.68	I	285 - 25862
120	3816.27			380	3909.14	I	285 - 25859
240	3816.89			330	3909.55	I	5830 - 31401
150	3820.11	II		95	3910.14	II	
75	3821.00	I	509 - 26673	160	3910.40	I	
120	3823.12	I	2840 - 28989	160	3910.84	I	
65	3824.14			110	3912.26		0 - 25553
75	3826.74	h		75	3912.77	II	
65	3828.74	I	2310 - 28421	280	3913.48	I	7060 - 32605
1500	3830.26	I	285 - 26386	150	3914.63	I	2310 - 27848
75	3832.63	I	2419 - 28503	650	3915.43	I	285 - 25818
540	3833.42	I	2840 - 28919	65	3916.64	I	3719 - 29244
180	3834.02	I	509 - 26584	45	3916.94	I	5425 - 30948
75	3837.18	I		75	3917.30	I	285 - 25806
150	3837.83	I	285 - 26334	95	3918.78	II	
920	3842.50	d		75	3919.02	I	3174 - 28684
180	3842.98			480	3919.52	II	6372 - 31879
370	3845.61	d	6372 - 32369	150	3920.72	II	
180	3847.88	I	5425 - 31406	300	3922.10	II	
3700	3848.73	II	0 - 25975	480	3922.74	II	
45	3849.59	I	509 - 26479	150	3923.31	II	
110	3851.37	w		65	3924.42	II	
260	3851.86	II		110	3924.81	II	
75	3855.38	I	4646 - 30577	760	3925.45	II	5171 - 30639
170	3855.58	II		65	3929.75	I	
140	3868.90	II		75	3929.89	I	285 - 25724
450	3869.75	II		55	3930.76	II	
85	3873.00	I	285 - 26098	220	3932.35	I	3719 - 29142
210	3873.78	II		130	3934.38	I	
3500	3874.17	w	0 - 25804	650	3935.24	II	
240	3875.22	II		65	3937.13	I	5829 - 31221
65	3876.69	I	509 - 26297	160	3937.61	I	2310 - 27699
130	3878.23	II		65	3938.07	I	1371 - 26757
95	3879.99	I		810	3939.52	II	0 - 25376
95	3880.35	I		260	3941.21	II	
95	3881.29	I	285 - 26043	220	3942.21	II	
260	3881.76	II		110	3942.93	I	2310 - 27664
330	3883.34	I	509 - 26253	95	3943.66	I	509 - 25860
200	3885.09	I	1371 - 27103	160	3944.88	II	

## Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
650	3946.89	II	3010 - 28339	110	4018.45	I	6488 - 31366
45	3947.25	I	7824 - 33151	370	4019.14	II	
260	3948.35	II		540	4020.47	II	
65	3949.51	II		220	4022.88	I	
210	3950.13	I	509 - 25818	180	4024.10	II	
210	3950.43	I	3819 - 29126	370	4024.77	I	509 - 25349
65	3951.87	I		170	4025.73	II	5234 - 30068
210	3954.05	I		170	4028.31	II	
45	3955.65	I		85	4028.59	I	
65	3956.18	II		520	4031.66	II	
170	3957.35	I	462 - 25724	870	4032.28	I	2310 - 27103
280	3957.97	II		140	4032.62	I	285 - 25076
350	3958.36	II			4032.70	I	3174 - 27964
30	3960.12	II		2100	4033.03	II	1016 - 25804
65	3960.29	I	509 - 25753	350	4036.22	I	3719 - 28488
95	3960.69	I		45	4036.46	II	
30	3962.61	I		210	4038.86	I	1371 - 26123
170	3965.10	I	4646 - 29859	30	4039.21	II	
170	3965.95	II		150	4039.48	I	462 - 25210
95	3967.22	II	3010 - 28209	150	4040.10	I	
220	3967.65	I	5353 - 30550	130	4040.41	II	
55	3969.93	I	2310 - 27492	65	4041.84	I	8097 - 32832
170	3970.19	II		95	4042.34	II	
220	3971.77	I	3719 - 28890	45	4043.67	II	
170	3972.06	II		65	4045.35	I	2024 - 26737
170	3974.29	II		150	4047.14	I	509 - 25211
170	3974.67	I	5425 - 30577	65	4048.80	I	2840 - 27532
2200	3976.84	II	0 - 25138	55	4049.87	II	
260	3981.16	II	6912 - 32023	65	4051.49	II	
1800	3981.87	II	3542 - 28649	300	4051.86	II	
300	3983.85	II		300	4052.87	II	3542 - 28209
260	3984.05	II		150	4053.96	I	462 - 25122
150	3984.84	II		430	4054.12	I	
150	3985.12	II		410	4060.37	I	509 - 25131
260	3986.35	II		220	4060.87	II	
150	3987.66	I	1371 - 26441	1300	4061.58	I	462 - 25076
75	3989.48	I		220	4063.89	II	
55	3990.22	I	6352 - 31406	390	4066.22	II	
220	3990.63	I	5353 - 30405	150	4070.10	I	2840 - 27402
75	3991.58	I	3174 - 28220	110	4070.54	II	
180	3993.54	I		55	4070.71	I	8097 - 32656
85	3995.12	I	1371 - 26394	110	4071.21	I	509 - 25065
75	3995.80	II		130	4072.69	I	2419 - 26966
150	3997.43	II		110	4073.75	II	
150	3998.40	II		75	4073.94	I	285 - 24824
110	3998.87	I	509 - 25509	130	4074.16	I	3819 - 28358
65	3999.24	II		260	4075.22	I	
350	3999.40	II		95	4078.47	II	
150	4000.01	II	6372 - 31365	55	4078.79	I	3174 - 27684
180	4001.26	I	2310 - 27295	390	4081.24	I	
350	4002.19	II		27	4082.24	II	
970	4002.59	II	5171 - 30148	130	4082.79	I	3819 - 28306
110	4003.78	II		110	4083.21	I	285 - 24769
65	4003.91	II		110	4084.27	I	2310 - 26787
75	4004.52	II		110	4084.82	I	2840 - 27314
1900	4005.47	II	1016 - 25975	210	4086.60	I	
110	4005.97	II		45	4087.70	II	
150	4009.18	I	2419 - 27355	120	4089.34	I	2310 - 26757
150	4009.56	II		55	4089.51	II	
300	4010.04	I	1371 - 26301	65	4091.30	I	4018 - 28453
150	4010.85	I	285 - 25210		4091.42	I	5425 - 29859
760	4012.75	II	5234 - 30148	210	4092.19	I	7839 - 32270
150	4012.86	II		130	4094.03	I	2840 - 27259
330	4013.26	I	2310 - 27220	260	4094.37	II	
75	4017.85	II		260	4094.49	I	285 - 24701

## Terbium— all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
120	4095.91	I	4018 - 28426	150	4171.80	I	5425 - 29388
95	4097.36	II		240	4172.60	I	6989 - 30948
110	4097.48	II		240	4172.82	I	285 - 24243
55	4098.62	II		260	4173.47	I	
45	4099.15			65	4175.05	I	3719 - 27664
75	4099.48	II		85	4175.85	I	
130	4100.90	I		150	4178.98	II	
130	4101.65	I		65	4179.79	II	
85	4102.53	II		180	4180.40	I	
75	4103.21	I	3705 - 28070	85	4181.33	II	
170	4103.36	I	2310 - 26673	180	4184.29	I	3719 - 27611
85	4103.46	I	462 - 24824	65	4185.91	I	509 - 24392
260	4103.90	II	1016 - 25376	240	4186.21	I	
650	4105.37	I	285 - 24637	300	4187.16	I	
45	4106.35	I	3719 - 28065	180	4188.11	I	1371 - 25241
55	4107.79	I	3819 - 28157	75	4188.51	II	
55	4110.09	I	7839 - 32163	150	4191.08	I	509 - 24363
55	4110.86	I	7839 - 32159	180	4191.59	I	3174 - 27025
300	4112.50	I	509 - 24819	55	4193.35	I	1371 - 25211
130	4112.88	I	462 - 24769	75	4194.01	I	6989 - 30826
55	4114.13	II		390	4196.74	I	
55	4115.36	II		85	4198.43	I	2419 - 26231
110	4117.23	I	1371 - 25652	65	4198.98	I	3719 - 27528
55	4118.36	I	2310 - 26584	65	4199.05	I	2310 - 26118
260	4119.92	I	509 - 24775	450	4201.00	II	
110	4120.51	II		650	4203.74	I	2310 - 26091
85	4121.03	I	3705 - 27964	600	4206.49	I	
110	4122.47	I	3819 - 28070	65	4206.90	I	285 - 24049
85	4126.71	I	6351 - 30577	120	4207.54	I	1371 - 25131
140	4127.29	I	3719 - 27942	65	4208.65	I	2840 - 26594
140	4130.14	I	285 - 24491	55	4208.73	I	3719 - 27473
55	4131.11	I		300	4213.50	I	4695 - 28422
140	4131.45	I		300	4214.42	II	3010 - 26731
45	4132.23			480	4215.09	I	5425 - 29142
140	4132.48	I	509 - 24701	95	4216.67	I	
85	4132.83	I	5353 - 29543	300	4217.56	I	
55	4133.51	I	8646 - 32832	95	4218.84	I	2310 - 26006
55	4134.32	I	3174 - 27355	260	4219.16	I	1371 - 25065
130	4135.37	I	462 - 24637	85	4220.10	II	
40	4136.47	I		55	4221.37	I	2840 - 26522
40	4137.03			95	4222.70	I	1371 - 25046
55	4139.06	I	285 - 24438	75	4223.32	II	
140	4139.78	I	509 - 24658	260	4224.28	I	285 - 23951
140	4141.55	I	1371 - 25509	480	4226.45	II	0 - 23653
55	4142.43	I	3174 - 27308	85	4230.62	I	3819 - 27450
55	4143.24	I	3719 - 27848	65	4231.35	I	462 - 24088
280	4143.51	I	509 - 24637	260	4231.89	I	462 - 24085
140	4143.63	I	2840 - 26966	180	4232.19	II	
1100	4144.41	II	1016 - 25138	480	4232.82	I	5353 - 28972
110	4146.96	I	285 - 24392	65	4234.22	I	4695 - 28306
45	4148.21	II		300	4235.35	I	285 - 23889
110	4149.17	II		160	4239.28	I	509 - 24092
55	4150.54			95	4239.91	I	509 - 24088
55	4150.87	I	3174 - 27259	95	4242.56	II	
85	4152.24	I	2840 - 26916	95	4245.14	I	2310 - 25860
85	4156.28	I	6351 - 30405	130	4246.59	I	462 - 24003
55	4158.28	II		65	4248.57	II	
350	4158.53	I	285 - 24325	55	4250.26	II	
120	4161.35	I		130	4251.33	I	6351 - 29867
55	4166.51			130	4251.72	II	
240	4169.09	I	3719 - 27699	95	4252.70	I	6351 - 29859
240	4169.32	I	1371 - 25349	65	4254.04	I	3719 - 27220
120	4169.91	I	4695 - 28670	370	4255.24	I	509 - 24003
85	4170.48	I		95	4256.10	I	2419 - 25908
240	4171.05	I	2840 - 26808	480	4258.23	II	5171 - 28649

## Terbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	4261.84	I	2840 - 26297	55	4350.74	I	2840 - 25818
260	4263.66	I	509 - 23957	55	4351.60	II	
65	4264.72	I	509 - 23951	55	4351.72	II	
75	4264.98	I	2840 - 26280	430	4353.20	II	3010 - 25975
650	4266.34	I		280	4356.09	I	7839 - 30789
330	4269.69	I	2310 - 25724	870	4356.81	I	2771 - 25717
95	4271.53	I	285 - 23689	45	4357.46	I	285 - 23228
95	4272.21	I	2840 - 26240	280	4360.16	I	509 - 23438
220	4275.21	I		55	4362.44	I	2310 - 25226
110	4276.75	II	3010 - 26385	45	4366.00	II	
95	4277.77	I		220	4367.30	II	6912 - 29803
760	4278.52	II		220	4372.02	I	2771 - 25637
300	4285.13	II		55	4374.43	I	3819 - 26673
65	4285.75	II		55	4376.43	II	3542 - 26385
65	4286.13	II		85	4381.29	I	285 - 23103
120	4286.91	II		330	4382.45	I	4646 - 27458
150	4287.11	I		45	4384.06	II	
300	4289.70	I		130	4385.68	I	
65	4293.13	I	6351 - 29638	130	4386.08	II	
65	4294.04	I		300	4388.23	I	2771 - 25553
150	4295.34	I	2310 - 25584	55	4389.81	I	
85	4296.30	I	7824 - 31093	260	4390.91	I	509 - 23277
370	4298.36	I	462 - 23720	45	4392.96	I	8190 - 30948
300	4299.90	I		55	4394.03	I	462 - 23213
65	4301.15	I		45	4394.92	II	
240	4302.95	I		180	4396.56	I	
120	4304.00	I	462 - 23689	45	4401.54	II	
65	4304.27	I		75	4403.18	I	2310 - 25014
240	4307.18	I	509 - 23720	75	4405.40	II	
150	4308.68	II		55	4406.76	I	
450	4310.42	I	6674 - 29867	95	4409.52	II	
75	4310.96	II		55	4411.14	I	
85	4311.29	I		55	4411.93	I	4695 - 27355
300	4311.56	I	462 - 23649	55	4413.63	I	
110	4312.08	II		200	4416.27	II	1016 - 23653
370	4313.25	I		140	4420.19	I	
120	4313.41	I		350	4423.10	I	2771 - 25373
150	4315.73	I		45	4427.34	I	1371 - 23951
2200	4318.83	I	0 - 23147	45	4430.13	II	
150	4320.26	I	285 - 23425	95	4430.66	I	
55	4321.49	I		110	4432.72	I	6488 - 29041
600	4322.23	I		95	4434.47	II	
170	4322.87	I	462 - 23588	75	4435.01	I	
85	4323.66	II		75	4435.55	II	
120	4325.50	I		240	4436.12	I	
600	4325.83	II		95	4438.97	II	
85	4326.14	I	285 - 23394	110	4439.38	I	
3000	4326.43	I	0 - 23107	45	4441.27	II	
240	4328.90	I		75	4441.45	I	2840 - 25349
85	4330.31	I	5829 - 28916	240	4448.04	I	
600	4332.12	I		85	4451.63	I	
55	4333.69	I	2840 - 25908	85	4452.82	I	
150	4334.65	I	5425 - 28488	45	4459.38	II	
870	4336.43	I	2771 - 25825	45	4461.27	I	
600	4337.64	I		110	4467.69	I	
1700	4338.41	I	0 - 23043	65	4469.12	I	
150	4339.62	I	6351 - 29388	45	4471.72	II	
85	4339.87	I		40	4485.68	I	
700	4340.62	I		85	4488.16	I	
110	4341.00	I		65	4491.01	I	
430	4342.53	I	1371 - 24392	430	4493.07	I	
55	4343.85	I	2419 - 25433	45	4499.47	I	
45	4344.21	II		45	4509.04	II	
55	4346.49	I		150	4511.52	I	
110	4349.60	I		45	4512.96	II	

Terbium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	4514.31	II		25	4840.39	I	
45	4519.72	II		30	4842.69	II	
45	4525.01	II		30	4844.89	II	
45	4529.76			30	4854.81	I	9145 - 29737
45	4531.83	II		20	4856.54	II	
45	4534.13	I	8646 - 30695	30	4858.87	II	
45	4537.14	I	6488 - 28522	80	4875.57	II	1016 - 21521
45	4537.23	I	3719 - 25753	25	4876.12	II	
110	4549.07	I	3819 - 25796	80	4881.15	II	
45	4549.72	II		29	4894.33		
110	4550.45	I		95	4915.90	I	
110	4556.46	I		35	4924.09	I	
55	4562.24	II		35	4926.83	I	4646 - 24938
110	4563.69	II		50	4928.93	I	
30	4564.85	II		65	4931.79	I	285 - 20556
55	4573.19	II		19	4940.72	II	
210	4578.69	II	3542 - 25376	19	4959.93	II	
65	4584.84	II		19	4962.28	II	
65	4591.56	II		29	4970.99	II	
45	4592.38	I	509 - 22279	29	4971.42	I	
45	4604.10	II		29	4973.04	I	
30	4611.96	I	8190 - 29867	29	4980.16	II	
45	4615.92	II		29	4980.56	I	462 - 20534
27	4617.49	I	2840 - 24491	85	4993.82	II	1016 - 21035
30	4619.36	II		50	4995.84	II	
75	4626.32	II		55	4997.95	I	2840 - 22843
95	4626.94	II		19	5004.84	I	2419 - 22394
65	4632.07	I	8277 - 29859	29	5006.10	II	
65	4636.59	I	8506 - 30068	50	5022.16	I	6488 - 26394
30	4636.99	II	5171 - 26731	29	5024.24	II	
85	4641.00	II		29	5024.65	I	9145 - 29041
210	4641.98	II		50	5033.12	I	
260	4645.31	II	0 - 21521	50	5042.06	II	
80	4647.23	I	8190 - 29702	55	5054.30	I	
60	4658.38	I	8277 - 29737	55	5065.79	I	6351 - 26086
20	4658.73			110	5078.25	I	
80	4662.79	I	4646 - 26087	24	5080.05	II	
50	4665.45	I	4695 - 26123	24	5081.11	I	
40	4669.40	I	2310 - 23720	19	5081.80	I	3819 - 23492
80	4676.90	I		75	5089.12	II	
70	4681.87	I	8506 - 29859	24	5089.66	I	
50	4682.52	I	462 - 21812	24	5101.09	I	
25	4682.79	II		24	5108.56	I	
80	4688.63	II		35	5118.39	I	3175 - 22707
80	4693.11	II		24	5120.18	I	509 - 20035
30	4693.39	II		19	5121.61	II	
200	4702.41	II		50	5131.69	I	
110	4707.94	II		50	5141.08	II	
40	4716.07	II		50	5147.58	I	8190 - 27611
40	4728.16	II		24	5164.27	I	9145 - 28503
60	4734.20	I	2840 - 23957	29	5170.13	I	4695 - 24032
80	4739.93	I	8646 - 29737	24	5170.61	I	8277 - 27611
70	4747.80	I	8646 - 29702	50	5176.51	I	285 - 19598
410	4752.53	II	0 - 21035	50	5179.97	I	8277 - 27576
40	4758.44	II		50	5184.59	I	8190 - 27473
40	4760.19	II		85	5186.13	I	8646 - 27923
30	4762.37	II	1016 - 22008	50	5188.48	I	8190 - 27458
25	4764.47	II		50	5198.86	I	8190 - 27420
35	4778.36	II		35	5202.77	I	8277 - 27492
35	4778.80	II		40	5204.55	I	8190 - 27399
180	4786.78	I	2840 - 23725	40	5207.97	I	8277 - 27473
40	4789.91	II	6372 - 27244	19	5209.34	II	
30	4801.87	II		40	5214.28	I	
100	4813.77	I		40	5221.99	I	462 - 19606
60	4837.59	II		120	5228.12	I	8277 - 27399



## Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	5235.11	I	509 - 19606	17	5712.45	II	
75	5248.71	I	285 - 19332	85 c	5747.58	I	
75 w	5262.11	II	3010 - 22008	9	5761.62	II	
13	5264.92			24	5762.66	I	285 - 17634
19 w	5272.07	II		24	5785.18	II	6372 - 23653
24	5275.03	I	8506 - 27458	75	5795.64	I	
75	5281.05	I	8646 - 27576	75	5803.13	II	11261 - 28488
13	5287.30	I	2310 - 21218	65	5815.36	I	
65	5304.72	I	8646 - 27492	29	5842.97	I	
29	5308.19	I		65	5851.07	I	
29	5309.46	I	5829 - 24658	65	5870.62	I	
110	5319.23	I	285 - 19080	35	5898.84	I	
15	5322.11	II		24	5902.40	I	
15	5323.92	I	9145 - 27923	35	5904.71	I	
15	5329.05	I	4695 - 23455	15	5910.10	I	
35	5331.04	I	8646 - 27399	65 c	5920.78	I	
11	5332.58	I	10456 - 29204	15	5937.09	I	
65 w	5337.90	I		50 c	5939.38	I	
35 d	5338.59	I		35	5940.17	I	
15	5346.04	I	462 - 19162	24	5951.17	I	2840 - 19639
24	5347.83	II	1016 - 19710	15	5951.78	I	
160	5354.88	I	462 - 19131	19	5961.00	II	
10	5363.62	I	2840 - 21479	75	5967.34	II	11261 - 28014
75	5369.72	I	462 - 19080	15 c	5979.83	I	
75	5375.98	I	285 - 18882	11	6010.65	II	
19 w	5377.88	II		15	6019.24	I	509 - 17118
15	5397.90			29	6038.97	I	
29 d	5402.06	II	5171 - 23678	29	6039.38	I	
15	5403.82	II		15	6061.83	I	8277 - 24769
29	5413.65	I		15	6077.84	II	12200 - 28649
29	5416.20	I		15	6084.34	I	7839 - 24271
50	5424.10	II		15	6093.99	II	
19	5425.00	I		24	6104.29	II	
29 c	5426.43	I		13	6106.03	I	5829 - 22202
13	5427.47	I	462 - 18882	13	6134.39	I	2310 - 18607
13	5432.45	II		13	6137.00	II	
13	5437.10	I		13 c	6156.29	I	3719 - 19958
13	5438.12	I	2840 - 21223	11	6171.88	II	13605 - 29803
35	5443.38	I		11	6193.64	I	6351 - 22493
29	5457.00	I	1371 - 19691	11	6194.52	II	12200 - 28339
55	5459.81	I		11 c	6195.14	I	10456 - 26594
19	5464.39	I	509 - 18805	10	6218.4	II	
29 w	5470.34	II		13	6222.25	I	4695 - 20762
11	5476.96	I		10	6225.95	II	
24	5481.45	I		11 h	6272.36	I	3719 - 19658
11	5488.26	II		24 c	6292.43	I	4646 - 20534
11	5500.10	I	285 - 18461	19	6303.78	II	
55	5509.61	I	462 - 18607	10	6317.82	I	462 - 16286
50	5514.54	I		19	6321.59	II	12200 - 28014
65	5524.12	I	509 - 18607	19	6322.33	II	
24 c	5525.62	I	3719 - 21812	35	6331.68	II	
11	5536.26	II		24	6334.91	II	
11	5556.30	II		10	6336.83	I	509 - 16286
35	5565.93	I	1371 - 19332	11	6337.85	II	
11	5572.82	I	1371 - 19310	9	6356.40	II	
19	5586.96	I		9	6359.88	II	
19	5589.56	I		17 c	6405.97	II	
11	5591.62	II		13	6424.43	II	
11	5621.55	II		10 c	6441.03	I	6351 - 21873
19	5636.56	I		24	6446.87	II	
29 c	5638.80	I		10 c	6461.74	II	
19 c	5645.75	I		13	6470.86	II	
19	5671.84	I	510 - 18136	8 c	6501.33	I	6801 - 22178
29 c	5685.74	II		9	6512.19	II	
40 c	5686.48	I	8506 - 26087	35 cw	6518.68	I	

## Terbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	6527.63	II		45	7496.12	I	
9	6562.50	II		17	7499.69	II	
24	6574.04	II		27	7511.40	I	
35	6581.82	I		9	7519.77	II	
14	6593.66	I	3719 - 18882	6	7557.59	II	
30	6607.17	II		27	7582.03	II	
16	6640.14	II		27	7587.49	I	
8	6642.27	II		45	7590.24	I	
18	6645.41	II	13605 - 28649	65	7596.44	I	462 - 13622
6	6665.94	I	2419 - 17417	17	7601.18	II	
90	6677.94	II		17	7616.01	II	
8	6689.51	II		22	7624.05	I	509 - 13622
18	6693.38	II		30	7627.81	I	509 - 13616
40	6702.61	I	8932 - 23847	9	7639.05	II	
20	6706.79	II		8	7672.72	II	
12	6714.98	II		8	7694.74	II	
7	6727.21	I	8097 - 22959	22	7706.16	II	
7	6734.86	II		22	7726.97	II	
7	6754.29	I		30	7737.63	I	2419 - 15339
14	6755.01	II		22	7793.20	I	
14	6769.81	II		8	7807.33	II	
30	6785.12	II	13605 - 28339	16	7832.91	II	
13	6792.48	II		30	7855.79	II	
130	6794.58	II	11261 - 25975	15	7864.99	I	
40	6874.18	II	11261 - 25804	6	7885.70	I	
55	6896.37	II		6	7913.11	I	3819 - 16453
45	6899.95	I	6488 - 20977	27	7927.90	II	
40	6901.98	I	4647 - 19131	13	7955.31	I	3719 - 16286
13	6916.69	I	8190 - 22644	11	7998.03	I	2840 - 15339
13	6923.09	II		17	8001.04	I	
11	6989.60	II		13	8010.16	II	
9	7005.99	II		30	8025.42	II	
17	7082.85	II		6	8053.80	I	
11	7089.22	II		19	8067.35	II	
11	7112.69	I		30	8085.06	II	
10	7187.48	I		27	8164.17	I	1371 - 13616
10	7195.89	II		13	8171.70	I	3720 - 15954
65	7204.28	I		65	8194.82	II	13605 - 25804
19	7234.98	I	1371 - 15189	95	8212.57	I	
40	7257.73	I		11	8214.33	I	
17	7311.57	I		8	8259.08	I	
45	7348.88	II		40	8450.06	II	
10	7398.27	II		8	8465.80	II	
15	7424.24	II		13	8502.70	I	4695 - 16453
10	7429.62	II		30	8511.80	I	7060 - 18805
9	7472.15	I		45	8583.45	II	
22	7484.54	I		30	8603.40	I	
9	7495.45	I	285 - 13622	9	8678.25	I	3819 - 15339
				65	8765.74	II	

## Thallium

$$\text{Tl}, Z = 81, M = 204.4, \text{Ratio } \frac{\text{Tl}}{\text{Cu}} = 3.216$$

Tl I Normal state of valence electrons  $6s^2 6p \ ^2P_{1/2}^o = 0$ . I.P. =  $49267 \text{ cm}^{-1}$ .

Tl II Normal state of valence electrons  $6s^2 \ ^1S_0 = 0$ . I.P. =  $164765 \text{ cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

A. Fowler, Report on Series in Line Spectra (Fleetway Press, London, 1922).

#### Classification:

Tl I, A. Fowler, Report on Series in Line Spectra (Fleetway Press, London, 1922).

*Thallium—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
140	2315.98	I	0 - 43166	2800	2918.32	I	7793 - 42049
900 h	2379.69	I	0 - 42011	440	2921.52	I	7793 - 42011
700	2580.14	I	0 - 38746	1200	3229.75	I	7793 - 38746
60	2608.99	I	7793 - 46110	20000	3519.24	I	7793 - 36200
80	2665.57	I	7793 - 45296	5000	3529.43	I	7793 - 36118
420	2709.23	I	7793 - 44693	12000 cw	3775.72	I	0 - 26478
50 h	2710.67	I	7793 - 44673	18000	5350.46	I	7793 - 26478
4400 d	2767.87	I	0 - 36118	16 h	6549.77	I	26478 - 41741
280	2826.16	I	7793 - 43166	6 h	6713.69	I	26478 - 41368

# Thorium

$$\text{Th, } Z = 90, M = 232.0381, \text{ Ratio } \frac{\text{Th}}{\text{Cu}} = 3.651$$

Th I Normal state of valence electrons  $6d^2 7s^2 \ ^3F_2 = 0$ . I.P. = 49000  $\text{cm}^{-1}$ .

Th II Normal state of valence electrons  $6d^2 7s \ ^4F_{11/2} = 0$ . I.P. = 96000  $\text{cm}^{-1}$ .

## References

Wavelengths and Spectrum Assignments:

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Th II, R. Zalubas and C. H. Corliss, J. Res. Nat. Bur. Stand. (U.S.), **78A** (Phys. and Chem.), No. 2, 163-246 (Mar.-Apr. 1974).

Th III, P. F. A. Klinkenberg, Physica **16**, 618 (1950);

U. Litzen, Phys. Scr. **10**, 103 (1974).

### Strong lines of thorium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
4200	4019.13	II	0 - 24874	670	3539.59	II	0 - 28244
1300	3392.04	II	1522 - 30994	670	d 3617.02	II	15305 - 42944
1300	3469.92	II	4147 - 32957		3617.12	II	10855 - 38494
1300	3741.18	II	1522 - 28244	650	3752.57	II	9238 - 35879
1300	4381.86	II	6700 - 29515	620	3287.79	II	1522 - 31929
1200	2837.30	II	6214 - 41448	620	3292.52	II	6700 - 37063
1100	3180.20	II	1522 - 32957	620	3334.60	II	6214 - 36194
1100	4116.71	II	6168 - 30453	620	3337.87	II	1860 - 31811
1100	4391.11	II	4490 - 27257	620	3358.60	II	1860 - 31626
980	3351.23	II	1522 - 31353	620	4178.06	II	7332 - 31259
980	3402.70	II	6214 - 35594	620	4208.89	II	6700 - 30453
980	3434.00	II	1860 - 30972	590	3238.12	II	4113 - 34987
980	3609.44	II	4113 - 31811	590	3719.44	I	0 - 26878
910	3256.27	II	9238 - 39939	590	3803.08	I	0 - 26287
910	3262.67	II	6168 - 36809	590	3929.67	II	0 - 25440
910	3291.74	II	6214 - 36584	560	3221.29	II	10189 - 41223
910	4069.20	II	6691 - 31259	560	3229.01	II	7332 - 38292
840	3325.12	II	4147 - 34212	560	3659.51	II	13407 - 40725
840	3839.74	II	6700 - 32736	550	2870.41	II	1860 - 36688
840	4108.42	II	4490 - 28824	530	3439.71	II	10379 - 39443
800	2832.31	II	4147 - 39443	530	3559.45	II	6244 - 34330
770	3188.23	II	6213 - 37569	530	3575.32	II	6700 - 34662
770	3435.98	II	0 - 29095	530	3994.55	II	0 - 25027
770	3721.82	II	1860 - 28721	520	2747.16	II	0 - 36390
700	3675.57	II	1522 - 28721	510	3108.30	II	6700 - 38863
700	4085.04	II	10189 - 34662	510	3119.53	II	4147 - 36194
700	4086.52	II	0 - 24464	510	3122.96	II	6168 - 38180
700	4094.75	II	0 - 24415	510	3321.45	II	4113 - 34212
700	4282.04	II	6168 - 29515	510	3762.88	II	6168 - 32736
670	3078.83	II	4113 - 36584		3762.94	I	3688 - 30255
670	d 3511.56	II	4490 - 32960	500	2565.59	II	1860 - 40826
	3511.67	II	15305 - 43733				

Thorium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	2326.93	II	1860 - 44822	11	2576.32	II	13468 - 52272
85	2354.03	II	9061 - 51529	200	2576.69	II	4147 - 42944
85	2356.76	II	0 - 42418	100	2579.43	II	4490 - 43247
40	2366.04	II	1522 - 43774	23	2580.35	II	10379 - 49121
95	2366.99	II	9712 - 51947	55	2580.70	II	4490 - 43228
40	2368.05	II	4490 - 46706	35	2583.45	II	13250 - 51947
130	2373.84	II	0 - 42113	14	2586.15	II	10189 - 48844
85	2375.08	II	4490 - 46582	11	2587.24	II	6168 - 44808
190	2377.84	II	4113 - 46156	230	2589.06	II	1860 - 40472
55	2384.36	II	12570 - 54497	55	2595.03	II	8379 - 46903
55	2388.14	II	1522 - 43383	230	2597.05	II	0 - 38494
55	2393.11	II	4490 - 46264	230	2600.88	II	9238 - 47675
90	2404.17	II	8379 - 49961	28	2607.48	II	1522 - 39862
90	2404.50	II	4113 - 45689	23	2608.32	II	8379 - 46706
45	2411.30	II	8378 - 49837	100	2609.85	II	4113 - 42418
100	2413.41	II	1522 - 42944	23	2611.62	I	0 - 38279
45	2423.01	II		230	2618.91	II	4147 - 42319
90	2423.68	II	13250 - 54498	270	2623.45	II	4113 - 42220
28	2431.15	II	4490 - 45611	270	2625.74	II	4147 - 42220
55	2432.85	II	10855 - 51947	28	2626.40	II	7331 - 45395
45	2437.54	II	14484 - 55496	55	2628.81	II	4490 - 42519
35	2443.96	II	4490 - 45395	18	2630.02	II	9720 - 47731
28	2444.47	II	1522 - 42418	45	2633.33	II	8460 - 46424
28	2450.79	II		40	2639.51	II	1522 - 39397
90	2456.30	II	4490 - 45190	14	2639.88	II	7829 - 45698
23	2456.87	II	8378 - 49068	14	2640.27	II	13818 - 51681
28	2459.01	II	0 - 40655	14	2640.39	II	4490 - 42352
90	2466.13	II	4113 - 44651	270	2641.49	II	0 - 37846
55	2468.15	II	4147 - 44651	14	2642.60	II	
45	2470.13	II		14	2643.28	II	7001 - 44822
35	2476.97	II	1860 - 42220	45	2649.48	II	4490 - 42222
14	2485.06	II	9061 - 49289	45	2649.87	II	10572 - 48299
70	2489.62	II	6214 - 46368	170	2650.58	II	0 - 37716
35	2494.62	II		150	2658.66	II	0 - 37602
70	2495.35	II	4490 - 44553	35	2661.39	II	9585 - 47148
20	2497.56	III	9953 - 49980	55	2662.35	II	8606 - 46156
55	2498.40	II	4490 - 44504	40	2662.86	II	10189 - 47731
55	2498.87	II	6700 - 46706	23	2664.06	II	8379 - 45904
35	2502.88	II		18	2665.89	II	6244 - 43744
100	2504.28	II	8379 - 48299	11	2667.55	II	7331 - 44808
40	2505.60	II	4490 - 44389	18	2669.46	II	13818 - 51268
55	2507.92	II	0 - 39862	18	2671.48	II	8378 - 45800
28	2509.96	II	9585 - 49415	18	2672.94	II	9202 - 46603
28	2516.43	II	12220 - 51947	35	2675.68	II	9061 - 46424
80	2520.66	II	4113 - 43773	18	2678.94	II	9585 - 46903
14	2525.92	II	9712 - 49289	360	2684.29	II	1522 - 38765
28	d 2526.22	II	6691 - 46264	130	2687.13	II	8018 - 45221
	2526.34	II	7331 - 46903	18	2688.34	II	4490 - 41677
45	2532.43	II	6214 - 45689	23	2691.06	I	0 - 37149
45	2535.87	II	7001 - 46424	45	2691.18	II	9238 - 46385
35	2542.64	II	4490 - 43808	480	2692.42	II	0 - 37130
55	2545.34	II	6214 - 45489	18	2693.96	II	6700 - 43809
35	2545.74	II	4113 - 43383	18	2695.02	II	9061 - 46156
150	2547.90	II	4147 - 43383	80	2695.21	II	8606 - 45698
35	2548.13	II	9585 - 48818	110	2695.55	II	10379 - 47466
11	2549.98	II	6700 - 45904	28	2695.82	II	8606 - 45689
14	2551.23	II	1522 - 40707	40	2696.83	II	12220 - 49289
11	2554.65	II	1522 - 40655	45	2697.55	II	1522 - 38582
20	2555.17	III	3188 - 42312	70	2698.74	II	6244 - 43288
8	2560.93	II	14484 - 53520	18	2700.60	II	9585 - 46603
80	2561.94	II	6168 - 45190	28	2701.82	II	13469 - 50470
500	2565.59	II	1860 - 40826	270	2703.96	II	1522 - 38494
270	2566.59	II	1522 - 40472	170	2708.18	II	1522 - 38436
28	2567.94	II		11	2710.48	II	9720 - 46603
70	2574.48	II	4113 - 42944	35	2711.45	II	12488 - 49357

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	2714.62	II		45	2790.42	II	12472 - 48299
40	2715.09	II	15349 - 52170	70	2791.01	II	6700 - 42519
90	2716.31	II	8018 - 44822	35	2791.43	II	10572 - 46385
35	2719.46	II	8460 - 45221	90	2794.26	II	9712 - 45489
55	2719.93	II	11116 - 47871	70	2797.02	II	1860 - 37602
230	2721.69	II	6214 - 42944	70	2797.74	II	4490 - 40223
170	2722.38	II	10189 - 46910	55	2798.27	II	8018 - 43744
18	2723.32	II	17460 - 54169	28	2798.67	II	9585 - 45306
70	2724.88	II	0 - 36688	55	2799.11	II	4147 - 39862
40	2726.49	II	9238 - 45904	70	2800.57	II	9202 - 44899
28	2727.24	II	9712 - 46368	35	2803.38	II	9238 - 44898
45	2728.91	II	1860 - 38494	55	2807.72	II	9202 - 44808
250	2729.33	II	9061 - 45689	110	2807.83	II	9585 - 45190
100	2730.26	II	8606 - 45221	180	2808.99	II	9061 - 44651
40	2731.58	II		20	2812.42	II	10189 - 45735
35	2731.92	II	4113 - 40706	70	2814.32	II	6700 - 42222
250	2732.81	II	0 - 36582	45	2814.58	II	15144 - 50663
11	2733.21	II	1860 - 38436	45	2816.07	II	6700 - 42200
160	2734.40	II	4146 - 40706	18	2817.14	II	11117 - 46603
28	2735.83	II	4113 - 40655	100	2819.32	II	7829 - 43288
23	2736.44	II	9720 - 46253	45	2820.34	II	6700 - 42147
70	2737.42	II	8379 - 44899	40	2821.60	II	8379 - 43809
45	2738.32	II	4147 - 40655	100	2822.02	II	8379 - 43804
23	2738.82	II	4490 - 40992	35	2822.36	II	9401 - 44822
18	2740.47	II	14545 - 51024	20	2822.56	II	12902 - 48320
180	2743.06	II	0 - 36445	20	2822.69	II	7001 - 42418
520	2747.16	II	0 - 36390	20	2823.55	II	9720 - 45126
18	2747.59	II	17460 - 53845	170	2826.86	II	8018 - 43383
45	2747.85	II	7001 - 43383	20	2827.76	II	14484 - 49837
40	2748.80	II	13468 - 49837	45	2827.99	II	9202 - 44553
100	2749.53	II	4113 - 40472	20	2829.93	II	11576 - 46903
18	2749.71	II	12488 - 48844	70	2830.44	II	6168 - 41488
410	2752.17	II	1522 - 37846	800	2832.31	II	4147 - 39443
18	2753.09	II	12219 - 48532	55	2833.33	II	8460 - 43744
18	2755.96	II	16033 - 52307	160	2834.48	II	8018 - 43288
18	2758.96	II	1521 - 37756	130	2836.05	II	4147 - 39397
45	2759.41	II	15453 - 51681	45	2836.44	II	6691 - 41936
130	2760.39	II	8606 - 44822	1200	2837.30	II	6214 - 41448
150	2763.61	II	6244 - 42418	80	2839.24	II	4490 - 39701
100	2764.64	II	9061 - 45221	14	2839.34	II	6700 - 41909
100	2765.12	II	4490 - 40644	70	2840.15	II	0 - 35199
270	2768.84	II	6214 - 42319	90	2841.16	II	9202 - 44389
200	2770.82	II	1522 - 37602	20	2841.81	II	9720 - 44899
200	2771.51	II	4113 - 40184	320	2842.81	II	1522 - 36688
18	2772.01	II	10189 - 46253	20	2843.30	II	6168 - 41328
18	2773.02	II	6700 - 42751	20	2845.19	II	11116 - 46253
140	d 2773.95	II	13251 - 49289	20	2845.84	II	16818 - 51947
	2774.07	II	4147 - 40184	90	2847.35	II	10379 - 45489
45	2774.84	II	10189 - 46217	20	2848.01	II	17460 - 52562
20	2775.05	III	6288 - 42313	270	2851.26	II	1522 - 36584
70	2777.80	II	10379 - 46368	80	2851.44	II	1522 - 36582
40	2778.02	II	1860 - 37846	23	2852.50	II	14790 - 49837
70	2778.71	II	9712 - 45689	45	2854.13	II	13818 - 48844
45	2780.70	II	13406 - 49357	23	2854.92	II	15453 - 50470
18	2782.37	II	10673 - 46603	55	2855.90	II	11576 - 46582
110	2783.05	II	4490 - 40412	55	d 2857.49	II	6691 - 41677
70	2783.49	II	7828 - 43744	320	2861.33	II	9712 - 44651
45	2784.06	II	10673 - 46581		2861.42	II	10673 - 45611
70	2784.98	II	7332 - 43228	55	2862.61	II	1522 - 36445
35	2785.61	II	9238 - 45126	70	2864.66	II	17272 - 52170
18	2786.24	II	15145 - 51025	35	2866.41	II	4490 - 39367
70	2786.91	II	13250 - 49121	35	2866.65	II	14484 - 49357
100	2787.13	II	6244 - 42113	35	2868.46	I	0 - 34852
35	2787.67	II	14545 - 50407	45	2868.68	II	8379 - 43228
35	2788.68	II	12472 - 48320	70	2869.92	II	10855 - 45689

Thorium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
550	2870.41	II	1860 - 36688	35	2940.67	II	17272 - 51268
28	2870.82	II	10572 - 45395	28	2941.34	II	10189 - 44177
70	2876.42	II	6168 - 40924	23	2941.89	II	9401 - 43383
40	2879.20	II	1860 - 36582	130	2942.63	II	8379 - 42352
23	2879.53	II	8379 - 43097	340	2942.86	II	6214 - 40184
45	2881.14	II	6700 - 41399	23	2944.95	II	14545 - 48492
45	2882.01	II	11576 - 46264	28	2946.26	I	2869 - 36800
40	2882.51	II	8606 - 43288	28	2946.61	II	16033 - 49960
23	2883.62	II	9720 - 44389	150	2949.07	II	4490 - 38389
320	2884.29	II	4490 - 39151	90	2949.93	II	9238 - 43127
360	2885.05	II	4113 - 38765	80	2950.44	II	9061 - 42944
45	2886.24	II	6691 - 41328	70	2951.20	II	6700 - 40575
45	2886.51	II	10855 - 45489	45	2954.89	II	6691 - 40524
360	2887.82	II	4147 - 38765	55	2955.04	II	10673 - 44504
160	2891.25	II	8379 - 42956	55	2955.60	II	7001 - 40826
160	d 2891.73	II	9238 - 43809	35	2955.85	II	8379 - 42200
	2891.82	II	9202 - 43772	170	2957.58	II	4490 - 38292
40	2892.17	II	9238 - 43804	90	2957.92	II	12570 - 46368
23	2894.50	II	10189 - 44727	70	2958.14	II	10855 - 44651
130	2895.14	II	1860 - 36390	28	2959.88	II	14545 - 48320
70	2897.07	II	15453 - 49961	28	2963.61	II	4113 - 37846
35	2898.26	II	6213 - 40706	28	2963.88	II	11576 - 45306
45	2899.37	II	13818 - 48299	28	2964.00	II	12488 - 46217
250	2899.72	II	6168 - 40644	55	2964.11	II	6168 - 39895
45	2903.17	II	4147 - 38582	110	2964.92	II	9238 - 42956
23	2904.27	II	12902 - 47324	110	2965.50	II	6700 - 40412
45	2905.93	II	6168 - 40570	270	2968.69	II	4490 - 38165
28	2906.12	II	8018 - 42418	28	2969.38	II	6700 - 40367
80	2908.36	II	4490 - 38864	45	2969.82	I	0 - 33662
23	2909.77	II	7332 - 41688	110	2971.48	II	4113 - 37756
200	2910.60	II	4147 - 38494	80	2972.22	II	1522 - 35157
90	2911.32	II	8606 - 42944	110	2973.54	II	10189 - 43809
90	2912.01	II	0 - 34330	220	2974.01	II	4490 - 38105
90	d 2912.66	II	4113 - 38436	110	2976.02	II	7332 - 40924
	2912.76	II	9061 - 43383	28	2976.65	II	12571 - 46156
40	2916.37	I	2558 - 36837	28	2980.11	I	3688 - 37234
45	2917.03	II	10379 - 44651	55	2980.33	II	9401 - 42944
160	2917.41	II	4490 - 38757	160	2981.34	II	6168 - 39701
55	2917.79	II	13468 - 47731	160	2981.49	II	8379 - 41909
45	2917.90	II	10189 - 44450	28	2981.84	II	9720 - 43247
140	2919.84	II	4490 - 38729	28	2982.00	II	6691 - 40216
45	2920.37	II	6691 - 40924	28	2983.02	II	9238 - 42751
45	2920.93	II	10673 - 44899	55	2983.57	II	8606 - 42113
23	2921.37	II	12485 - 46706	140	2983.82	II	13407 - 46911
160	2921.53	II	9585 - 43803	160	2985.24	II	4113 - 37602
	2921.62	II	13248 - 47466	80	2986.79	II	7001 - 40472
70	2922.60	II	13468 - 47675	28	2987.67	I	3688 - 37149
45	2922.80	II	12220 - 46424	360	2988.23	II	4490 - 37945
23	2922.99	II	8018 - 42220	150	2991.06	II	4147 - 37570
23	2924.10	II	13818 - 48006	90	2991.70	II	12488 - 45904
250	2925.05	II	15349 - 49527	70	2993.63	II	10379 - 43774
250	2928.25	II	8379 - 42519	160	2993.80	II	13468 - 46861
40	2928.70	III	9953 - 44088	28	2995.27	II	9720 - 43097
40	2929.30	II	14484 - 48612	110	2996.99	II	9061 - 42418
45	2930.91	II	12472 - 46581	28	2997.20	I	
28	2932.64	II	9720 - 43809	180	2999.09	II	11116 - 44450
55	2933.10	II	9720 - 43804	28	2999.27	II	4490 - 37822
55	2934.14	II	1522 - 35594	45	2999.80	II	14546 - 47871
130	2936.19	II	6168 - 40216	70	3000.97	II	7331 - 40644
170	2936.47	II	9202 - 43246	180	3001.26	II	8379 - 41688
70	2937.44	II	12902 - 46936	220	3002.40	II	1860 - 35157
28	2938.10	II	9202 - 43228	35	3006.00	II	6691 - 39949
100	2939.56	II	9238 - 43246	110	3006.93	II	12488 - 45735
	2939.62	II	15349 - 49357	130	3007.62	II	6700 - 39939
35	2940.59	II	7332 - 41328	110	3007.80	II	10572 - 43809

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
70	3007.95	II	9720 - 42956	130	3090.09	II	1860 - 34212
70	3008.28	II	10572 - 43804	85	3093.05	II	1521 - 33843
180	3008.50	II	6214 - 39443	50	3096.26	II	16033 - 48320
70	3009.77	II	0 - 33216	100	3096.43	II	9202 - 41488
55	3011.60	II	6700 - 39895	140	3097.27	II	4113 - 36390
85	3012.71	II	6214 - 39397	100	d 3099.74	II	12571 - 44822
70	3013.60	II	13250 - 46424			II	9238 - 41488
40	3014.93	II	9061 - 42220	200	d 3100.79	II	13249 - 45489
85	3015.72	II	9202 - 42352			II	12488 - 44727
85	3017.13	II	10673 - 43808	50	3101.69	II	11576 - 43808
110	3018.49	II	13249 - 46368	200	3102.66	II	6168 - 38389
110	3019.42	II	8379 - 41488	85	d 3104.97	I	0 - 32197
40	3021.49	II	13468 - 46555			II	9202 - 41399
110	3022.09	II	7332 - 40412	280	3105.05	II	9720 - 41909
40	3024.67	II	9061 - 42113	50	3105.75	II	10572 - 42751
150	3026.57	II	9720 - 42751	200	3106.69	II	6691 - 38867
130	3028.58	II	6691 - 39701	510	3107.03	II	6700 - 38863
40	3030.49	I	4962 - 37950	250	3108.30	II	6691 - 38836
40	3030.86	II	9238 - 42222	50	3110.02	II	6168 - 38292
85	d 3031.20	I	3688 - 36669	50	3112.09	II	9585 - 41688
	3031.29	II	11116 - 44096			II	8605 - 40706
40	3031.70	II	4490 - 37465	50	3114.27	II	12571 - 44650
70	3031.96	II	13406 - 46378	250	3116.30	II	10673 - 42751
370	3034.06	II	8379 - 41328	100	3116.48	II	6691 - 38758
170	3035.11	II	10189 - 43127	140	3117.68	II	8605 - 40654
40	3035.54	II	9585 - 42518	100	3119.35	II	4147 - 36194
85	3038.60	II	6168 - 39069	510	3119.53	II	2558 - 34591
70	3040.05	II	7332 - 40216	50	3120.88	I	6168 - 38180
130	3043.06	II	6700 - 39552	510	3122.96	II	6168 - 38165
130	3045.56	II	10189 - 43014	370	3124.39	II	8379 - 40367
170	3046.95	II	13407 - 46217	220	3125.21	II	9238 - 41223
420	3049.09	II	4490 - 37277	480	3125.51	II	1859 - 33843
85	3049.64	II	15710 - 48492	140	3125.74	II	9720 - 41688
40	3049.86	II	14546 - 47324	85	3127.21	II	10379 - 42318
85	3050.98	II	10189 - 42956	50	3129.97	II	0 - 31929
85	3051.79	II	6700 - 39458	150	3131.07	II	9585 - 41488
40	3057.64	II	6168 - 38864	85	3133.62	II	14484 - 46379
28	3057.90	II	11117 - 43809	150	3134.42	II	4962 - 36838
85	3058.43	II	14484 - 47171	100	3136.22	I	0 - 31870
180	3060.18	II	8379 - 41047	50	3136.83	I	9202 - 41047
85	3060.44	I	0 - 32666	420	3139.31	II	11117 - 42956
220	3061.70	II	6700 - 39352	100	3139.87	II	2869 - 34704
220	d 3063.03	II	12488 - 45126	100	3140.27	I	7332 - 39151
	3063.13	II	9585 - 42222	210	3141.85	II	9238 - 41047
85	3065.93	II	9712 - 42319	420	3142.84	II	0 - 31781
40	3066.41	II	12220 - 44822	50	3145.64	I	6168 - 37945
450	3067.73	II	13250 - 45838	310	3146.04	II	14484 - 46217
220	d 3068.91	I	0 - 32575	150	3150.46	II	10189 - 41909
	3068.98	II	4113 - 36688	100	3151.65	II	1522 - 33216
40	3069.26	II	10673 - 43244	310	3154.30	II	13406 - 45095
270	3070.82	II	10572 - 43127	310	3154.77	II	9720 - 41399
370	3072.11	II	4147 - 36688	100	3155.83	II	6168 - 37841
85	3072.82	II	13818 - 46352	100	3156.40	II	10572 - 42222
28	3075.84	II	9720 - 42222	50	3158.62	II	9061 - 40706
85	3077.34	II	9202 - 41688	50	3159.07	II	6168 - 37788
70	3077.93	II	9720 - 42200	70	3161.69	II	9720 - 41328
670	3078.83	II	4113 - 36584	110	3162.84	II	6700 - 38292
50	3079.89	II	6691 - 39151	110	3164.48	II	7001 - 38582
480	3080.22	II	10189 - 42645	55	3165.62	II	8606 - 40184
50	3081.66	II	13249 - 45689	110	3165.82	II	4490 - 36066
200	3081.98	II	4147 - 36584	140	3166.10	II	15350 - 46911
140	3082.15	II	13469 - 45904	85	3167.56	II	6213 - 37756
140	3082.99	II	12472 - 44899	110	3169.33	II	7331 - 38864
140	3083.30	II	10673 - 43097	55	3170.43	II	0 - 31524
240	3088.47	II	7332 - 39701	55	3171.28	I	11725 - 43244
				40	3171.73	II	



Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	3173.43	I	2869 - 34372	280	3245.76	II	9061 - 39862
110	3174.20	II	1859 - 33354	110	3247.59	II	9400 - 40184
420	3175.73	II	6700 - 38180	110	3248.49	II	12472 - 43246
55	3176.50	II	6244 - 37716	100	3249.86	I	0 - 30762
55	3177.20	II	6700 - 38165	280	3251.92	I	3688 - 34430
85	3178.24	I	2869 - 34324	140	3252.72	II	17272 - 48006
270	3179.05	II	4147 - 35594	140	3254.81	II	7001 - 37716
1100	3180.20	II	1522 - 32957	140	3255.51	II	13469 - 44177
110	3181.19	II	7331 - 38757	910	3256.27	II	9238 - 39939
55	3181.67	I	4962 - 36383	180	3257.16	II	9585 - 40278
85	3182.40	II	6691 - 38105	180	3257.37	I	2869 - 33560
110	3182.64	II	9061 - 40472	110	3259.06	I	7280 - 37955
55	3183.56	II	11117 - 42519	110	3259.62	II	11576 - 42246
55	3183.79	II	13251 - 44651	110	3260.92	II	9238 - 39895
310	3184.95	II	4490 - 35879	110	3261.54	II	10572 - 41223
55	3187.00	II	9202 - 40570	910	3262.67	II	6168 - 36809
55	3187.40	II	10855 - 42220	110	3263.03	II	9585 - 40223
770	3188.23	II	6213 - 37569	110	3264.43	II	12472 - 43097
270	d 3190.07	II	9585 - 40924	110	3265.58	II	7332 - 37945
	3190.16	II	10572 - 41909	180	3267.00	II	7001 - 37602
110	3191.09	II	1522 - 32850	110	3269.47	II	6700 - 37277
85	3191.22	II	9720 - 41047	110	3270.82	II	0 - 30565
55	3192.59	I	4962 - 36275	110	3272.03	I	0 - 30553
55	3193.16	II	13818 - 45126	310	3273.92	II	10189 - 40725
55	3195.69	I	0 - 31283	310	3275.07	II	13249 - 43774
110	3198.23	II	13468 - 44727	310	3280.37	II	8018 - 38494
110	3198.48	II	8606 - 39862	55	3282.98	II	15453 - 45904
110	3198.69	II	6691 - 37945	130	3285.75	I	2869 - 33295
85	3198.97	II	4490 - 35741	310	3286.58	II	8018 - 38436
55	3203.23	II	10189 - 41398	620	3287.79	II	1522 - 31929
40	3203.62	II	15349 - 46555	130	3290.13	II	15350 - 45735
55	3203.88	II	12570 - 43773	910	3291.74	II	6214 - 36584
55	3205.29	II	15236 - 46426	620	3292.52	II	6700 - 37063
55	3206.93	II	8379 - 39552	130	3293.60	II	14546 - 44899
55	3207.78	II	9202 - 40367	240	3293.95	II	9202 - 39552
55	3208.03	II	12220 - 43383	130	3295.00	II	13469 - 43809
170	3210.31	II	6700 - 37841	180	3295.32	II	6244 - 36582
55	3211.20	I	2869 - 34001	130	3295.52	II	9061 - 39397
170	3213.57	II	6168 - 37277	150	3296.61	II	12902 - 43228
55	3214.08	I	2558 - 33662	130	3297.37	II	10673 - 40992
55	3214.38	I	4962 - 36063	240	3297.83	II	9238 - 39552
55	3215.78	II	6700 - 37788	55	3298.05	I	4962 - 35274
170	3217.46	II	9401 - 40472	55	3300.62	II	1522 - 31811
55	3217.73	II	10379 - 41448	240	3301.26	II	11725 - 42008
170	3220.35	II	4113 - 35157		3301.35	II	11117 - 41399
560	3221.29	II	10189 - 41223	240	3301.65	I	4961 - 35240
280	3225.41	II	9711 - 40706	130	3303.48	II	14546 - 44808
55	3225.66	II	17460 - 48453	480	3304.24	I	0 - 30255
55	3225.90	II	1860 - 32850	55	3305.30	I	3865 - 34111
55	3226.12	II	8379 - 39367	130	3309.14	II	7332 - 37542
55	3226.41	II	9585 - 40570	130	3309.36	I	0 - 30209
110	3227.77	II	0 - 30972	180	3310.25	II	6244 - 36445
560	3229.01	II	7332 - 38292	55	3313.07	I	10527 - 40701
110	3230.87	II	9712 - 40655	180	3313.65	I	4962 - 35131
110	3232.12	I	2869 - 33800	240	3314.83	II	8606 - 38765
40	3232.30	I	0 - 30929	55	3317.75	II	13251 - 43383
55	3235.00	I	3688 - 34591	55	3318.98	II	6691 - 36813
480	3235.84	II	6168 - 37063	280	3320.30	II	6700 - 36809
590	3238.12	II	4113 - 34987	510	3321.45	II	4113 - 34212
55	3238.93	I	2869 - 33735	55	3322.09	I	2558 - 32651
100	3239.29	II	6700 - 37562	390	3324.75	II	1860 - 31929
110	3240.48	II	6691 - 37542	840	3325.12	II	4147 - 34212
55	3240.64	I	2869 - 33718	100	3326.46	II	4490 - 34544
240	3241.11	II	7001 - 37846	130	3327.19	I	3688 - 33734
110	3244.45	I	0 - 30813	55	3328.26	II	13251 - 43288

Thorium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	3329.73	I	7795 - 37819	980	3402.70	II	6214 - 35594
250	3330.48	I	0 - 30017	200	3403.27	II	9061 - 38436
100	3332.40	II	12220 - 42220	170	3404.65	II	10189 - 39552
170	3333.13	I	2869 - 32863	200	3405.56	I	3688 - 33043
620	3334.60	II	6214 - 36194	130	3406.24	II	6691 - 36041
130	3335.06	II	8606 - 38582	70	3407.83	I	7795 - 37131
620	3337.87	II	1860 - 31811	250	d 3408.64	II	10855 - 40184
130	3338.40	II	7332 - 37277		3408.75	I	2869 - 32197
55	bl 3341.31	ThO		200	3409.27	II	10572 - 39895
55	3343.26	II	15787 - 45689	170	3411.78	II	7829 - 37130
130	3343.62	II	17272 - 47171	250	3413.01	I	2869 - 32160
130	3344.87	II	8605 - 38493	130	3414.50	II	9585 - 38864
100	bl 3345.89	ThO		70	3415.88	I	3688 - 32955
180	3346.55	II	9585 - 39458	200	3418.78	II	19880 - 49121
310	3348.77	I	0 - 29853	200	3418.95	II	8606 - 37846
130	3348.95	II	10855 - 40706	270	3419.17	II	13407 - 42645
980	3351.23	II	1522 - 31353	390	3421.21	I	4962 - 34183
130	3353.95	II	11117 - 40924	200	3422.66	I	
310	3354.18	II	10379 - 40184	130	3423.13	II	12472 - 41677
200	3354.62	II	8379 - 38180	270	3423.99	I	0 - 29197
130	3355.27	II	10572 - 40367	130	3425.18	II	9202 - 38389
100	3356.82	II	9585 - 39367	130	3425.94	II	9401 - 38582
620	3358.60	II	1860 - 31626	200	3429.00	I	2558 - 31713
130	3360.15	II	11576 - 41328	110	3429.39	II	9238 - 38389
130	3360.37	II	10189 - 39939	130	3429.90	II	4490 - 33637
310	d 3361.62	II	17727 - 47466	130	3431.81	II	20158 - 49289
	3361.73	II	9720 - 39458	980	3434.00	II	1860 - 30972
100	3362.18	II	12488 - 42222	130	3434.76	I	10414 - 39520
130	3362.52	II	9712 - 39443	770	3435.98	II	0 - 29095
70	3362.67	II	4113 - 33843	270	3436.73	I	3865 - 32954
130	3363.07	II	8379 - 38105	130	3437.02	II	8379 - 37465
130	3363.68	II	13406 - 43127	340	3437.31	I	2869 - 31953
250	3364.69	II	12488 - 42200	340	3438.95	II	13249 - 42319
130	3365.34	I	2869 - 32575	70	3439.40	I	3688 - 32755
250	3366.52	II	13249 - 42944	530	3439.71	II	10379 - 39443
390	3367.82	II	4490 - 34175	130	3441.04	II	9712 - 38765
250	3371.80	II	12571 - 42220	130	3441.36	II	6691 - 35741
130	3373.49	I	2869 - 32504	110	3442.58	I	4962 - 34001
250	3374.58	II	9238 - 38863	70	3443.11	II	9401 - 38436
250	3374.98	I	4962 - 34583	70	3443.98	I	
70	3376.84	II	10673 - 40278	200	3445.22	II	10379 - 39397
390	3378.58	II	8018 - 37608	70	3445.39	II	12472 - 41488
130	3380.86	I	2869 - 32439	200	3445.74	II	14791 - 43804
70	3381.34	II	15324 - 44890	70	3449.29	II	23187 - 52170
55	3381.37	II	9585 - 39151	170	3449.65	II	10572 - 39552
130	3383.15	II	16818 - 46368	110	3450.95	II	13251 - 42220
310	3385.53	II	4490 - 34019	130	3451.70	I	
310	3386.50	II	9061 - 38582	270	3452.68	II	6244 - 35199
110	3387.92	I	7795 - 37303	110	3453.51	I	15490 - 44438
110	3388.58	II	9238 - 38740	100	3454.21	II	9238 - 38180
130	3389.46	I	8111 - 37606	200	3461.02	I	0 - 28885
310	3389.64	II	1860 - 31353	270	3461.22	I	4962 - 33845
110	3390.37	I		340	3462.85	II	9712 - 38582
1300	3392.04	II	1522 - 30994	270	3463.72	II	13251 - 42113
70	3393.23	II	8379 - 37841	70	3465.06	I	8244 - 37095
110	3394.14	II	11116 - 40570	450	3465.76	II	6700 - 35546
130	3394.80	II	17722 - 47171	130	3465.92	II	4113 - 32957
110	3395.37	II	7001 - 36445	130	3466.54	I	4962 - 33801
130	3396.39	II	15787 - 45221	140	3466.64	I	10414 - 39252
	3396.46	II	17272 - 46706	390	3468.22	II	6700 - 35525
200	3396.73	I	3865 - 33297	170	3469.34	I	3688 - 32504
220	3397.52	I		1300	3469.92	II	4147 - 32957
250	3398.54	I	2869 - 32285	170	3471.22	I	3865 - 32666
200	3401.65	II	7001 - 36390	70	3471.96	I	7280 - 36074
200	3402.03	II	8460 - 37846	130	3473.03	II	9061 - 37846

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
100	3473.42	II	9712 - 38494	140	3551.40	I	2869 - 31019
170	3476.54	II	6700 - 35456	200	3553.11	II	12570 - 40706
70	3477.70	II	15349 - 44096	70	3553.38	II	9712 - 37846
130	3478.13	II	9202 - 37945	200	d 3555.01	I	2869 - 30991
130	3478.46	II	13407 - 42147		3555.10	II	9720 - 37841
250	3479.17	II	6691 - 35426	70	3555.70	I	10414 - 38530
70	3480.05	I	8111 - 36838	170	3557.46	II	6168 - 34270
130	3482.55	II	9585 - 38292	530	3559.45	II	6244 - 34330
130	3482.76	II	1860 - 30565	270	3559.94	II	12488 - 40570
200	3485.21	II	8379 - 37063	70	3561.78	I	6362 - 34430
390	3486.51	II	10189 - 38862	110	3563.38	I	11197 - 39252
	3486.55	I	0 - 28673	70	3564.71	II	9711 - 37756
70	3490.27	II	14484 - 43127	140	3565.40	II	9238 - 37277
70	3490.45	II	15324 - 43966	70	3567.05	II	6700 - 34727
70	3491.58	II	17272 - 45904	170	3567.26	I	0 - 28025
270	3493.52	II	7829 - 36445	70	3567.70	II	12902 - 40924
130	3495.70	I	4962 - 33560	70	3569.62	II	6168 - 34175
70	3496.81	I	0 - 28589	140	3569.82	I	3865 - 31870
70	3497.01	II	10855 - 39443	110	3571.57	II	10189 - 38180
70	3497.26	II	9202 - 37788	340	3572.39	II	8460 - 36445
200	3498.01	II	1521 - 30101	200	3573.22	II	8606 - 36584
130	3498.62	I	8244 - 36818	530	3575.32	II	6700 - 34662
130	3498.96	I	7502 - 36074	200	3576.56	I	
	3498.99	II	9720 - 38292	340	3579.33	II	8460 - 36390
200	3499.99	II	8018 - 36582	140	3580.23	II	12488 - 40412
140	3501.46	II	10189 - 38740	200	3582.01	II	10855 - 38765
70	3501.87	I	5563 - 34111	140	d 3583.04	II	16907 - 44808
200	3502.78	II	9061 - 37602		3583.10	I	4962 - 32863
140	3503.62	II	13818 - 42352	110	3584.18	I	2869 - 30762
70	3503.79	I	7280 - 35813	130	3585.05	II	16564 - 44450
140	3505.49	II	13818 - 42336	270	d 3585.77	II	9585 - 37465
70	3506.85	II	15237 - 43744		3585.88	II	12488 - 40367
70	3509.09	I	6362 - 34852	170	3588.22	II	9202 - 37063
110	3511.16	I	3688 - 32160		3588.30	II	1859 - 29720
670	d 3511.56	II	4490 - 32960	110	3589.15	II	6700 - 34553
	3511.67	II	15305 - 43733	200	3589.36	II	6691 - 34544
140	3512.74	II	9720 - 38180	170	3589.75	I	7502 - 35351
200	3514.53	II	9401 - 37846	110	3591.06	II	8606 - 36445
70	3514.96	II	9238 - 37680	140	3591.45	I	3688 - 31524
140	3516.35	II	8379 - 36809	270	3592.78	I	8800 - 36626
140	3516.82	II	8018 - 36445		3592.83	II	9238 - 37063
140	3518.40	I	2869 - 31283	140	3593.88	II	13406 - 41223
70	3518.90	II	7332 - 35741	70	3595.33	II	12472 - 40278
70	3521.06	I	3688 - 32080	70	3595.62	I	8244 - 36047
340	3521.91	II	10379 - 38765	270	3598.12	I	0 - 27784
70	3523.50	I		390	3601.03	II	17727 - 45489
70	3526.63	I	0 - 28348	340	3603.20	II	9720 - 37465
140	3528.82	II	6691 - 35021	70	3603.36	II	12472 - 40216
270	3528.95	II	10189 - 38518	70	3604.06	I	7502 - 35241
110	3530.51	I	8111 - 36427	110	3604.68	I	3865 - 31599
140	3531.45	I	4962 - 33271	70	3605.19	I	13175 - 40905
140	3531.93	II	18118 - 46423	110	3605.65	II	10855 - 38582
200	3537.16	II	9202 - 37465	170	3608.38	I	
340	3539.32	II	4490 - 32736	200	3609.22	II	10673 - 38372
670	3539.59	II	0 - 28244	980	3609.44	II	4113 - 31811
140	3541.62	II	8460 - 36688	240	d 3610.04	II	13407 - 41099
70	3542.50	I	6362 - 34583		3610.12	II	9585 - 37277
180	3544.02	I	8800 - 37009	170	3610.40	II	7332 - 35021
70	3544.99	II	9401 - 37602	200	3610.80	II	4113 - 31800
250	d 3545.18	II	13249 - 41448	200	3612.43	I	0 - 27674
	3545.28	II	1522 - 29720	70	3612.87	I	0 - 27671
70	3545.96	I	12848 - 41041	140	3613.78	II	4147 - 31811
140	3547.34	I	3688 - 31870	140	3614.01	II	14484 - 42147
170	3549.60	I	8111 - 36275	70	3614.21	I	
70	3550.29	II	12486 - 40644	70	3614.35	I	10527 - 38186

Thorium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
480	3615.13	II	4147 - 31800	40	3700.98	I	5563 - 32575
670	3617.02	II	15305 - 42944	40	3702.86	II	19912 - 46911
	3617.12	II	10855 - 38494	85	3703.78	I	4962 - 31953
110	3618.36	I	7502 - 35131	250	3703.91	II	10855 - 37846
40	3619.71	II	10673 - 38292		3703.99	II	10572 - 37562
200	3620.37	II	12571 - 40184		3704.08	II	9400 - 36390
270	3621.12	II	10572 - 38180	85	3704.86	I	2869 - 29853
140	3622.29	I	10783 - 38382		3704.97	II	15237 - 42220
140	3622.34	I	5563 - 33162	340	3706.77	I	8111 - 35081
110	3622.80	I	3688 - 31283	40	3707.00	I	
270	3624.90	II	6700 - 34279	40	3707.43	II	0 - 26965
390	3625.63	II	1522 - 29095	35	3708.75	II	16818 - 43774
200	3625.90	I	7280 - 34851	280	3711.30	II	6700 - 33637
110	3632.62	II	9061 - 36582	85	3711.62	I	6362 - 33297
140	3632.83	I	11242 - 38761	55	3712.53	II	17461 - 44389
240	3634.58	I	7795 - 35301	40	3717.83	II	14102 - 40992
140	3635.24	II	15787 - 43288	40	3718.17	II	9238 - 36125
200	3635.42	II	22028 - 49527	590	3719.44	I	0 - 26878
270	3635.94	I		450	3719.98	II	10189 - 37063
110	3637.56	II	6691 - 34175	270	3720.31	II	9712 - 36584
55	3638.32	I	4962 - 32439	770	3721.82	II	1860 - 28721
70	3638.64	I	8800 - 36275	340	3722.12	II	4113 - 30972
340	3639.45	II	6168 - 33637	50	3723.29	II	15350 - 42200
310	3642.25	I	0 - 27448	55	3723.66	II	4147 - 30994
110	3643.51	I	6362 - 33801	85	3724.73	II	17460 - 44300
70	3644.35	II	10673 - 38105	70	3725.39	I	
100	3647.30	II	12486 - 39895	220	3726.72	II	4147 - 30972
	3647.37	II	14791 - 42200	110	3727.90	I	2869 - 29686
150	3647.65	II	12488 - 39895	130	3730.37	I	6362 - 33162
110	3648.17	II	0 - 27403	170	3730.75	II	15350 - 42147
140	3648.42	II	1521 - 28923	22	3731.30	I	
310	3649.25	II	7332 - 34727	40	3731.42	II	15144 - 41936
170	3649.74	I	5563 - 32955	50	3732.98	I	10527 - 37307
170	3650.77	II	9061 - 36445	50	3733.67	I	8111 - 34887
370	3652.17	II	10189 - 37562	100	3734.60	II	4490 - 31259
140	3652.54	II	7829 - 35199	100	3737.51	I	3865 - 30614
100	3656.20	II	9720 - 37063	170	3738.85	II	8460 - 35199
420	3658.06	II	7001 - 34330	110	3740.85	II	11117 - 37841
560	3659.51	II	13407 - 40725	1300	3741.18	II	1522 - 28244
55	3661.62	I	3687 - 30990	150	3742.92	I	4962 - 31671
220	3663.20	I	2869 - 30160	40	3743.51	II	10572 - 37277
340	3663.70	II	9401 - 36688	55	3744.74	II	8460 - 35157
130	3666.98	I	8800 - 36063	50	3745.66	I	14482 - 41172
140	3668.14	I	8244 - 35498	340	3745.97	II	7332 - 34019
280	3669.97	I	8111 - 35351	310	3747.54	II	9202 - 35879
	3670.06	II	4113 - 31353	40	3751.02	I	0 - 26652
100	3671.54	I	6362 - 33591		3751.12	I	11242 - 37893
140	3673.28	II	10572 - 37787	650	3752.57	II	9238 - 35879
200	3673.79	II	7332 - 34544	35	3753.24	I	7795 - 34431
700	3675.57	II	1522 - 28721	55	3754.03	I	8244 - 34874
200	3678.02	II	8018 - 35199	130	3754.59	II	0 - 26626
200	3678.04	II	9400 - 36581	130	3755.21	I	11197 - 37819
280	3679.71	II	13407 - 40575	50	3756.29	I	8111 - 34725
85	3681.88	II	11576 - 38729	140	3757.69	I	10527 - 37131
240	3688.76	II	13468 - 40570	130	3758.47	I	2558 - 29157
210	3690.49	II	9720 - 36809	130	3759.26	I	8111 - 34704
180	3691.88	I	7795 - 34874	50	3760.27	II	0 - 26586
170	3692.57	I	3688 - 30762	70	3761.10	II	12488 - 39069
280	3693.90	II	12488 - 39552	50	3761.47	I	9805 - 36383
150	3695.97	II	11117 - 38165	510	3762.88	II	6168 - 32736
70	3696.65	II	9401 - 36445		3762.94	I	3688 - 30255
70	3697.03	II	6168 - 33209	50	3763.32	II	16818 - 43383
180	3698.11	I	9805 - 36838	110	3765.24	I	8800 - 35351
55	3698.26	II		200	3767.90	II	9061 - 35594
110	3700.77	II	15305 - 42319	180	3770.06	I	5563 - 32080

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
200	3771.37	I	0 - 26508	250	3874.86	I	4962 - 30762
100	3772.24	II	7829 - 34330	210	3875.37	I	10414 - 36211
170	3773.76	II	10572 - 37063	28	3875.65	I	7502 - 33297
50	3774.20	II	19880 - 46368	140	3879.64	I	7502 - 33271
70	3775.90	II	14349 - 40826	55	3884.52	II	9720 - 35456
85	3776.27	I	8800 - 35274	140	3884.82	II	19912 - 45646
25	3777.41	I	7502 - 33968	55	3885.77	II	1522 - 27250
50	3780.97	I	2869 - 29310	100	3886.92	I	2869 - 28589
25	3781.32	I	7280 - 33718	100	3887.02	I	10414 - 36133
170	3783.01	II	13469 - 39895	85	3891.05	II	11117 - 36809
140	3783.29	II	0 - 26425	28	3891.72	I	11197 - 36885
340	3785.60	II	6168 - 32577	50	3892.31	II	6244 - 31929
50	3785.91	II	17771 - 44177	55	3893.11	II	13407 - 39086
70	3786.88	II	7332 - 33731	28	3893.42	II	12488 - 38165
50	3788.36	II	4490 - 30880	340	3895.42	I	7795 - 33459
310	3789.12	II	1860 - 28244	50	3898.44	I	2869 - 28513
85	3790.36	I		35	3898.51	I	11242 - 36885
200	3790.79	I	7795 - 34167	28	3900.13	II	12472 - 38105
70	3791.30	II	11576 - 37945	55	3900.58	I	8800 - 34430
110	3792.37	I	10414 - 36775	340	3900.88	II	7332 - 32960
100	3794.15	II	11117 - 37465	55	3901.15	II	12220 - 37846
55	3794.70	I	13175 - 39520	50	3902.17	I	
85	3795.39	I		110	3903.10	I	7795 - 33409
55	3796.73	I	8800 - 35131	140	3904.08	II	4113 - 29720
40	3797.45	II	15787 - 42113	170	3905.19	II	13469 - 39069
55	3798.10	I	4962 - 31283	50	3908.75	I	11242 - 36818
130	3801.44	I	7502 - 33801	28	3909.14	I	12114 - 37688
28	3802.15	II	9585 - 35879	85	3911.91	I	4962 - 30517
590	3803.08	I	0 - 26287	110	3912.28	II	10572 - 36125
85	3803.98	I	8800 - 35081	100	3913.00	II	13818 - 39367
110	3805.82	II	6691 - 32960		3913.08	I	11601 - 37149
370	3807.88	II	9202 - 35456	55	3913.82	II	1860 - 27403
55	3808.61	I	10527 - 36775	50	3916.42	I	0 - 25526
55	3809.83	II	14484 - 40725	140	3916.80	II	17722 - 43246
100	3810.99	I	7502 - 33735	55	3917.27	I	10526 - 36047
28	3812.40	I	15490 - 41713	85	3918.07	I	14482 - 39997
340	3813.07	II	9238 - 35456	55	3918.50	II	
40	3815.03	II	10379 - 36584	110	3919.02	I	3688 - 29197
110	3817.48	I	8244 - 34431	55	3922.22	II	9238 - 34727
50	3818.68	I	4962 - 31141	28	3923.80	I	2869 - 28347
170	3821.43	II	11117 - 37277	140	3925.09	I	3688 - 29158
170	3822.15	II	9585 - 35741	28	3926.71	II	12486 - 37945
85	3823.58	II	13251 - 39397	110	3927.18	II	13407 - 38863
28	3826.37	I	10527 - 36654	110	3927.42	II	14484 - 39939
110	3826.95	II	14349 - 40472	590	3929.67	II	0 - 25440
450	3828.38	I	0 - 26113	55	3932.00	II	14791 - 40216
150	3829.42	II	17122 - 43228	85	3932.23	II	9238 - 34662
55	3830.06	I	10414 - 36516	200	3932.91	I	7795 - 33215
110	3830.77	I	0 - 26097	140	3935.48	I	
270	3831.74	II	14484 - 40575		3935.63	II	16818 - 42220
50	3832.97	II		140	3937.04	II	10673 - 36066
70	3836.54	I	7502 - 33560	110	3937.92	II	7828 - 33216
55	3836.58	I	4962 - 31019	110	3938.61	I	8800 - 34183
250	3837.88	I	2869 - 28918		3938.78	II	6244 - 31626
840	3839.74	II	6700 - 32736	110	3941.23	I	5563 - 30929
85	3840.80	I	4962 - 30991	50	3942.07	I	7502 - 32862
280	3841.96	II	9720 - 35741	70	3942.64	II	10189 - 35546
85	3842.90	I	11197 - 37212	150	3943.39	II	9202 - 34553
28	3846.25	II	22014 - 48006	85	3943.69	II	12472 - 37822
85	3852.14	I	3688 - 29640	220	3945.51	II	10855 - 36193
390	3854.51	II	10189 - 36125	85	3945.82	II	10189 - 35525
140	3859.84	II	8379 - 34279	220	3946.14	II	13407 - 38741
450	3863.40	II	6700 - 32577	110	3947.33	I	9805 - 35131
340	3872.72	II	10379 - 36193	50	3948.03	I	0 - 25322
370	3873.82	I	2869 - 28676	20	3948.13	I	8244 - 33565

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>		
200	h	3948.96	II	9238 - 34554	250		4030.84	I	2869 - 27671
200		3950.39	I	0 - 25306	110		4032.46	II	
28		3951.11	II	12486 - 37788	110		4032.60	I	8800 - 33591
220		3951.52	II	12488 - 37788	140		4034.25	II	6214 - 30994
50		3952.76	I	3865 - 29157	70		4034.92	II	4146 - 28923
110		3955.17	I	9805 - 35081	250		4036.05	I	0 - 24770
50		3955.89	I	2869 - 28141	240		4036.56	II	1860 - 26626
390	d	3956.59	II	10189 - 35456	110		4039.86	I	14207 - 38953
		3956.69	II	0 - 25267	240		4041.20	II	10855 - 35594
55		3957.16	II	20989 - 46253	70		4043.13	II	1859 - 26586
110		3959.30	I	5563 - 30813	110		4043.39	I	4962 - 29686
70		3960.33	II	13251 - 38494	50		4045.63	II	6168 - 30880
55		3962.42	I	3688 - 28918	55		4048.29	I	7502 - 32197
50		3963.22	II	15350 - 40575	55		4048.43	I	12114 - 36808
28		3963.47	II	10379 - 35602	85	d	4049.94	I	3688 - 28373
50	d	3964.74	II	17121 - 42336	110		4050.89	I	
		3964.86	II	10379 - 35594	140		4053.53	I	7795 - 32458
390		3967.39	I	4962 - 30160	140		4059.25	I	6362 - 30991
70		3969.00	II	0 - 25188	250		4063.41	I	11197 - 35800
200		3972.15	I	7795 - 32963	55		4064.33	I	11197 - 35794
70		3972.64	I	8244 - 33409	55		4065.69	II	9585 - 34175
150		3973.20	I	6362 - 31524	55		4067.45	I	2869 - 27448
55		3974.22	II	14546 - 39701	910		4069.20	II	6691 - 31259
210		3976.41	II	9585 - 34727	55		4071.75	I	8244 - 32796
55		3979.04	II	15243 - 40367	55		4075.50	I	2558 - 27088
150		3980.09	I		55		4080.71	I	7795 - 32294
55		3980.75	II	24381 - 49495	110		4081.37	I	8800 - 33295
200		3981.10	II	13407 - 38518	110		4082.26	II	11576 - 36066
55		3981.83	I	12848 - 37955	70		4083.47	I	865 - 28348
85		3987.22	I	7502 - 32575	700		4085.04	II	10189 - 34662
200		3988.02	II	9202 - 34270	85		4085.43	I	8800 - 33271
55		3988.60	II	1521 - 26586	700		4086.52	II	0 - 24464
70		3988.84	II	6691 - 31754	50		4087.28	I	10414 - 34873
110		3990.49	I	3865 - 28918	70		4088.73	I	6362 - 30813
110		3991.73	I	8800 - 33845	55		4089.14	I	2869 - 27317
55		3992.28	II	9238 - 34279	50		4091.35	II	9202 - 33637
530		3994.55	II	0 - 25027	85		4093.39	II	7332 - 31754
250		3996.06	II	15350 - 40367	700		4094.75	II	0 - 24415
55		3997.47	II	11117 - 36125	55		4097.32	I	6362 - 30761
150		3997.86	II	9720 - 34727	110		4097.75	I	2869 - 27266
55		4000.28	I	10414 - 35405	170		4098.93	II	8460 - 32850
110		4001.06	I	7795 - 32782	150		4100.34	I	0 - 24381
55		4001.73	II	4113 - 29095	140		4100.82	II	14484 - 38863
110		4003.10	II	10572 - 35546	55		4102.62	I	7502 - 31870
240		4003.31	II	9202 - 34175	140		4104.38	II	8379 - 32736
55		4005.09	I	3688 - 28649	270		4105.34	II	7001 - 31353
140		4005.53	II	15453 - 40411	70		4105.91	II	10673 - 35021
100		4006.38	II	10572 - 35525	55		4107.37	II	11117 - 35456
250		4007.02	II	11117 - 36066	55		4107.86	I	3688 - 28025
220		4008.21	I	7795 - 32737	840		4108.42	II	4490 - 28824
220		4009.06	I	11197 - 36134	55		4109.32	I	8111 - 32439
28		4009.72	I	8111 - 33043	110	d	4110.51	II	12488 - 36809
28		4009.82	I	13175 - 38107			4110.64	II	6244 - 30565
55		4011.59	I	6362 - 31283	85		4110.83	I	
110		4011.74	I	4962 - 29881	240		4112.75	I	0 - 24308
280		4012.50	I	2869 - 27784	280		4115.76	I	5563 - 29853
55		4014.51	II	1522 - 26425	1100		4116.71	II	6168 - 30453
55		4018.10	I	0 - 24880	50		4118.49	I	13297 - 37571
4200		4019.13	II	0 - 24874	55		4122.70	II	
110		4019.77	ThO		110		4123.53	II	8606 - 32850
210		4022.07	I	8244 - 33099	200		4127.41	I	
		4022.09	II	4490 - 29345	55		4130.33	I	15490 - 39694
210		4025.65	II	9720 - 34553	110		4131.00	I	7795 - 31996
170		4026.14	II		110		4131.42	II	8379 - 32577
140		4027.01	I	3688 - 28513	340		4132.75	II	9711 - 33902

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
140	h	4133.46	ThO	55	4218.19	II	11726 - 35426
200		4134.06	I	55	4218.54	II	10572 - 34270
		4134.11	II	55	4220.06	I	5563 - 29253
140	d	4136.29	I	55	4224.24	II	1522 - 25188
		4136.39	II	55	4227.39	I	7280 - 30929
70	h	4139.19	ThO	100	4229.45	II	12488 - 36125
220		4140.24	II	85	4230.43	I	11242 - 34873
150		4141.63	II	55	4233.29	II	15453 - 39069
170		4142.48	II	85	4235.46	I	0 - 23604
250		4142.70	II	50	4240.59	II	6213 - 29788
55		4145.84	I	85	4243.93	II	9401 - 32957
220		4148.18	II	28	4247.60	II	4490 - 28026
50		4148.72	I	140	4248.00	II	9202 - 32736
450		4149.99	II	55	4249.68	II	7829 - 31353
55	d	4152.20	I	170	4250.34	II	
		4152.34	I				
110		4155.30		110	4253.54	I	13297 - 36801
70		4155.47		70	4256.09	II	9720 - 33209
130		4156.24	II	70	4256.25	I	7502 - 30991
340		4156.51	II	100	4257.50	I	0 - 23481
				110	4260.33	I	9805 - 33271
28		4157.27	I	28	4262.61	I	16784 - 40237
28		4157.39	I	55	4263.36	II	9401 - 32850
110		4158.54	I	28	4269.94	I	8111 - 31524
85		4159.66	II	55	4270.33	II	15453 - 38864
55	d	4161.59	II	50	4271.10	II	1860 - 25267
		4161.74	I	55	4272.88	I	8800 - 32197
55		4162.51	I	280	4273.36	II	8379 - 31773
140		4162.68	II	110	4274.02	II	12488 - 35879
170		4163.64	II	100	4276.81	II	8379 - 31754
110		4164.25	II	55	4276.97	II	9202 - 32577
55		4165.07	II	480	4277.31	II	0 - 23373
140		4165.77	I	70	4278.32	I	14204 - 37571
55	h	4168.05	I	28	4280.57	I	5563 - 28918
170		4168.63	II	130	4281.07	II	1522 - 24874
220		4170.47	II	110	4281.42	II	8460 - 31811
		4170.53	I	700	4282.04	II	6168 - 29515
55		4170.78	II	110	4283.52	II	9238 - 32577
110		4171.34	II	70	4284.98	II	16565 - 39895
50	d	4176.33	II	50	4286.19	II	17722 - 41047
		4176.48	I		4286.23	I	6362 - 29686
620		4178.06	II	55	4288.05	II	14791 - 38105
250		4179.71	II	28	4288.47	I	13848 - 37160
150		4179.96	II	28	4288.67	I	7502 - 30813
55		4180.88	I	55	4291.81	I	8244 - 31537
110		4182.16	II	85	4295.04	II	17771 - 41047
55		4183.56	II	55	4297.31	I	11197 - 34461
50		4184.71	II	70	4298.83	II	12486 - 35741
50		4189.56	I	85	4299.84	I	11197 - 34447
55		4191.83	II	55	4306.37	II	19912 - 43127
28		4192.36	I	100	4307.18	I	11197 - 34408
130		4193.02	I	28	4308.12	I	11242 - 34447
50		4194.94	I	200	4309.99	II	10189 - 33384
70		4195.56	II	28	4311.58	I	11803 - 34990
85		4195.83	II	28	4311.80	I	8244 - 31429
		4195.95	II	140	4312.99	I	2869 - 26049
55		4199.02	II	55	4315.25	I	2869 - 26036
170		4201.85	II	110	4318.29	II	9585 - 32736
50		4206.66	II		4318.42	I	
620		4208.89	II	28	4319.10	II	15243 - 38389
55		4210.76	I	140	4320.13	II	4490 - 27631
130		4210.92	I	85	4320.59	II	12902 - 36041
55		4213.07	I	40	4327.09	II	4490 - 27594
28		4214.54	II	40	4327.23	II	4146 - 27249
28		4214.83	I	55	4328.69	II	17272 - 40367
55		4217.22	II	55	4329.49	II	14484 - 37575

Thorium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28	4330.84	I	8111 - 31195	140	4440.87	II	8460 - 30972
55	4331.92	II	14484 - 37562	50	4443.09	II	8378 - 30879
28	4333.93	II	22028 - 45095	28	4445.03	I	10783 - 33274
28	4335.31	II	12485 - 35545	28	4445.90	I	
170	4335.69	II	11117 - 34175	110	4447.83	II	6244 - 28721
130	4337.28	I	0 - 23049	25	4452.56	I	2869 - 25322
	4337.38	II		25	4454.51	II	11576 - 34019
50	4338.11	I	10414 - 33459	85	4458.00	I	3688 - 26113
55	d 4340.90	I	8111 - 31141	85	d 4461.06	II	13469 - 35878
	4341.03	II	23187 - 46216		4461.24	I	3688 - 26097
85	4342.26	II	12571 - 35594	40	4461.53	I	8244 - 30651
70	4342.44	I	8244 - 31266	40	4461.70	II	18816 - 41223
100	4343.95	II	1860 - 24874	220	4465.34	II	8606 - 30994
130	4344.33	II	0 - 23012	55	4469.53	I	10414 - 32782
170	4344.62	ThO		35	4472.28	II	13248 - 35602
70	4346.43	I	7280 - 30281	40	4474.07	II	13249 - 35594
25	4347.19	II	14791 - 37788	85	4480.82	II	4113 - 26425
25	4347.24	II	14546 - 37542	40	4482.17	I	4962 - 27266
55	4348.60	I	13848 - 36837	40	4485.80	II	10673 - 32960
55	4349.07	I	4962 - 27949	25	4486.63	II	18817 - 41099
140	h 4350.82	ThO		25	4486.90	I	2558 - 24839
85	4352.68	II	12488 - 35456	110	4487.50	II	4147 - 26425
85	4353.40	II	10673 - 33637	140	4488.68	II	4490 - 26762
55	4354.48	I	13175 - 36133	40	4492.24	II	12472 - 34727
110	4355.32	II	8018 - 30972	170	4493.33	I	0 - 22249
55	4357.61	II	1522 - 24464	40	4496.32	II	19912 - 42146
55	4358.32	I	10783 - 33721	24	4497.91	I	13848 - 36074
85	4359.37	I	10527 - 33459	110	4498.95	I	5563 - 27784
85	4361.31	II	15243 - 38165	70	4499.98	I	7795 - 30011
85	4365.93	I	8244 - 31142	55	4505.22	I	8800 - 30991
85	4369.32	II	8379 - 31259	24	4506.47	I	7502 - 29686
85	4373.90	II	9720 - 32577	280	4510.53	II	10572 - 32736
85	4374.12	I	0 - 22855	40	4512.48	II	11576 - 33731
130	4374.78	II	4113 - 26965	55	4513.68	I	9805 - 31953
55	4378.18	I	2869 - 25703	40	4515.12	I	0 - 22142
70	4381.40	II	4146 - 26963	40	4515.96	II	20990 - 43127
1300	4381.86	II	6700 - 29515	22	4517.04	II	16033 - 38165
28	4384.66	I		22	4518.64	II	17771 - 39895
1100	4391.11	II	4490 - 27257	22	4519.26	I	3688 - 25809
55	4392.97	I	7795 - 30553	22	4519.75	II	12902 - 35021
28	4393.76	I	7502 - 30255	70	h 4521.20	I	2869 - 24981
85	4394.89	II	8606 - 31353		4521.24	II	
70	4396.48	II	9061 - 31800	22	4522.78	II	24757 - 46861
85	4397.91	II	6700 - 29431	40	4524.84	II	7001 - 29095
50	4399.09	II	20288 - 43014	28	4525.09	II	11117 - 33209
55	4401.58	I	7795 - 30508	20	4529.48	II	12472 - 34544
55	4402.93	I	2869 - 25575	22	4530.32	I	11242 - 33309
85	4408.88	I	3688 - 26363	70	4531.71	II	13818 - 35879
28	4410.49	II	17272 - 39939	85	4532.26	II	12486 - 34544
85	4412.56	I	13175 - 35831	170	4533.30	II	9720 - 31773
210	4412.74	II	6168 - 28824	70	4534.12	II	10572 - 32621
55	4414.49	I	8244 - 30890	40	4535.26	I	8244 - 30287
85	4416.24	II	10572 - 33209	70	4537.07	II	15242 - 37277
28	4416.84	I	9805 - 32439	55	4540.40	II	14791 - 36809
28	4418.66	II	16818 - 39443	70	4544.51	II	4490 - 26489
50	4421.54	II	1522 - 24132	35	4545.82	II	12220 - 34212
50	4422.05	I	10783 - 33391		4545.92	I	
55	4427.66	II	14484 - 37063	22	4551.47	I	13848 - 35813
28	4432.25	I	6362 - 28918	35	4552.15	I	8800 - 30762
250	4432.96	II	9202 - 31754	70	4555.81	I	3865 - 25809
22	4436.05	II	10673 - 33209	70	4561.35	I	7280 - 29197
28	4436.29	II	9238 - 31773	90	4563.29	II	18817 - 40725
40	4436.55	II	14276 - 36809	40	4563.66	I	8111 - 30017
140	4439.12	II	11117 - 33637	21	4564.18	II	10673 - 32577
40	4440.57	II	0 - 22513	30	4566.65	II	7829 - 29720



Thorium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
21	4567.24	I	7795 - 29684	30	4729.13	I	7795 - 28935
65	4570.97	I	11197 - 33068	45	4729.88	II	8379 - 29515
26	4573.70	II	6168 - 28026	13	4732.67	II	22686 - 43809
21	4575.25	II	1522 - 23373	190	4740.53	II	6168 - 27257
21	4575.42	II	14276 - 36125	13	4741.31	I	6362 - 27448
21	4581.23	II	16906 - 38728	26	4742.24	II	
40	4581.58	II	15243 - 37063		4742.26	II	10673 - 31754
30	4584.37	II	12472 - 34279	45	4743.69	II	4113 - 25188
30	4588.23	II	16033 - 37822	26	4749.20	I	7795 - 28846
50	4588.43	I	10414 - 32202	21	4749.97	I	8111 - 29158
40	4589.12	II	12486 - 34270	140	4752.41	II	6214 - 27250
30	4589.67	II	12488 - 34270	45	4758.14	I	
50	4592.67	I	8244 - 30011	65	4761.11	II	16565 - 37562
19	4593.64	I	13089 - 34852	40	4764.34	II	17121 - 38105
75	4595.42	I	3688 - 25443	13	4766.60	I	3865 - 24839
45	4602.88	II	7001 - 28721	65	4774.25	II	6691 - 27631
26	4606.50	II	12472 - 34174	26	4777.19	I	14204 - 35131
50	4609.37	II	12486 - 34174	26	4778.29	I	0 - 20922
65	4611.86	II	9202 - 30880	13	4779.59	II	
26	4612.54	II	9585 - 31259	23	4782.76	II	6691 - 27594
65	4619.48	II	9238 - 30879	15	4784.04	I	15619 - 36516
40	4619.56	II	14484 - 36125	40	4789.39	I	3688 - 24562
30	4623.89	II	20288 - 41909	13	4800.17	II	6700 - 27527
26	4624.14	II	11117 - 32736	21	4803.48	II	19912 - 40725
26	4625.05	II	16565 - 38180	12	4803.95	II	13469 - 34279
140	4631.76	II	10189 - 31773	45	4808.13	I	4962 - 25754
45	4633.76	I	12114 - 33689	26	4813.72	I	
65	4639.70	II	12472 - 34019		4813.89	I	7795 - 28563
65	4640.04	II	10379 - 31924	45	4818.64	II	17771 - 38518
30	4641.24	I	11242 - 32782	18	4820.88	II	12472 - 33209
140	4651.55	II	7332 - 28824	12	4821.27	II	13818 - 34553
30	4651.99	II	1522 - 23012	26	4822.86	I	4962 - 25690
23	4663.20	I	2869 - 24308	23	4823.18	II	4147 - 24874
65	4666.00	II	6168 - 27594	30	4823.60	I	6362 - 27088
50	4666.80	I	6362 - 27784	40	4826.70	I	13088 - 33801
90	4668.17	I	7502 - 28918	45	4831.12	I	3688 - 24381
50	4669.98	I	8244 - 29651	13	4831.60	I	8244 - 28935
75	4673.66	I	2869 - 24260	65	4832.80	II	0 - 20686
65	4676.06	I	10414 - 31794	45	4840.47	II	1860 - 22513
30	4680.64	II	6168 - 27527	50	4840.84	I	2869 - 23521
15	4686.20	I	2869 - 24203	45	4844.16	II	11117 - 31754
100	4689.17	II	6691 - 28011	18	4844.56	II	9238 - 29874
15	4690.68	II	17837 - 39150	30	4848.36	I	3688 - 24308
40	4691.05	II	19912 - 41223	40	4849.04	II	22028 - 42645
15	4691.63	I	6362 - 27671	75	4850.44	II	4147 - 24758
140	4694.09	II	0 - 21297	15	4852.87	I	16218 - 36818
50	4694.92	II	4147 - 25440	12	4858.10	II	18973 - 39552
	4695.04	I	3688 - 24981	40	4858.33	II	10379 - 30956
50	4700.14	II	14276 - 35546	13	4861.22	I	8111 - 28676
15	4702.31	II	9712 - 30972	280	4863.16	II	6213 - 26770
50	4703.99	I	0 - 21253	45	4865.48	I	7795 - 28342
130	4705.76	II	9711 - 30956	12	4868.27	II	18817 - 39352
40	4706.25	II	7001 - 28244	12	4868.88	I	11242 - 31775
15	4708.10	II	11726 - 32960	40	4872.92	I	6362 - 26878
65	4712.39	II	9238 - 30453	13	4874.36	I	8800 - 29310
	4712.48	I	9804 - 31019	50	4877.00	II	16565 - 37063
26	4715.43	II	10572 - 31773	26	4878.73	I	2558 - 23049
65	4718.62	II	19912 - 41099	45	4894.96	I	0 - 20424
40	4719.98	II	14276 - 35456	30	4898.46	II	17771 - 38180
30	4722.09	I	7502 - 28673	13	4898.80	II	17272 - 37680
90	4723.44	I	0 - 21165	26	4899.24	I	
120	4723.78	II	1522 - 22686	18	4911.38	I	9805 - 30160
50	4724.77	II	9720 - 30880	40	4912.53	II	4113 - 24464
30	4726.33	II	1860 - 23012	15	4914.12	II	17122 - 37465
	4726.46	II	12486 - 33637	240	4919.82	II	6168 - 26489

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
26	4920.53	II	8605 - 28923	50	5110.86	II	16565 - 36125
65	4921.61	II	9202 - 29515	30	5115.04	I	3865 - 23410
18	4922.95	II	10572 - 30880	40	5131.07	II	15243 - 34727
26	4924.42	II	4113 - 24415	24	5140.77	I	6362 - 25809
18	4927.78	I	8244 - 28531	95	5143.27	II	1860 - 21297
18	4929.98	II	14275 - 34553	24	5143.92	I	10414 - 29849
18	4933.85	II	7332 - 27594	24	5145.04	II	7332 - 26762
40	4936.77	I	8800 - 29050	120	5148.21	II	15243 - 34662
40	4939.64	I	7795 - 28034	50	5151.61	I	3687 - 23093
17	4943.06	I	2869 - 23094	24	5151.86	II	4113 - 23518
17	4945.46	I	0 - 20215	50	5154.24	I	7795 - 27191
17	4946.66	II	19248 - 39458	85	5158.60	I	2869 - 22249
60	4947.56	II	10673 - 30879	70	5160.72	I	7280 - 26652
50	4950.62	II	9238 - 29431	24	5163.46	I	3688 - 23049
95	4954.56	II	11576 - 31754	50	5164.98	I	14204 - 33560
	4954.66	II	14484 - 34661	24	5170.22	II	11117 - 30453
19	4960.42	I		50	5176.96	I	11197 - 30508
	4960.49	II	9720 - 29874	35	5182.53	II	18816 - 38107
24	4963.18	II	11117 - 31259	35	5183.99	II	12488 - 31773
50	4964.12	II	10855 - 30994	14	5187.46	I	
24	4968.75	I	13848 - 33968	21	5189.67	II	20288 - 39552
40	4970.03	II	8605 - 28720	50	5190.87	II	4113 - 23373
35	4972.17	II	15350 - 35456	40	5193.82	II	0 - 19248
35	4973.38	II	15324 - 35426	50	5195.82	I	4962 - 24203
35	4975.95	II	12486 - 32577	50	5198.80	I	10527 - 29756
19	4976.59	II	12488 - 32577	95	5199.16	I	3865 - 23094
19	4980.95	II	6691 - 26762	24	5205.78	II	15349 - 34553
24	4985.37	I	3688 - 23741	60	5206.49	II	6213 - 25414
110	4987.15	II	18817 - 38863	50	5206.66	II	10673 - 29874
19	4989.31	I	7280 - 27317	50	5211.23	I	3865 - 23049
24	4997.80	II	15453 - 35456	24	5213.35	I	7795 - 26971
19	4999.94	II	14276 - 34270	95	5216.59	II	1522 - 20686
50	5002.10	I	2869 - 22855	50	5218.53	II	7332 - 26489
19	5008.19	II	17983 - 37945	35	5219.11	I	8111 - 27266
50	5015.89	II		110	5231.16	I	2558 - 21669
260	5017.26	II	7332 - 27257	24	5232.04	II	
40	5019.32	II	14102 - 34019	85	5233.22	II	9720 - 28824
17	5020.54	II	13818 - 33731	40	5237.91	II	17722 - 36809
130	5028.61	II	10572 - 30453	40	5240.20	II	6168 - 25246
17	5029.63	II	15145 - 35021	95	5247.65	II	0 - 19051
24	5039.23	I	2558 - 22397	19	5253.44	II	15145 - 34175
40	5040.15	ThO		35	5258.36	I	3865 - 22878
24	5040.56	II	22685 - 42518	12	5266.71	I	3688 - 22670
24	5040.68	I	3688 - 23521	70	5277.50	II	10572 - 29515
50	5044.72	I	0 - 19817	12	5280.10	II	14276 - 33209
	5044.75	I	7795 - 27612	30	5297.75	I	8800 - 27671
19	5045.25	I	7502 - 27317	35	5301.40	II	14102 - 32960
19	5047.05	I	4962 - 24770	12	5303.05	II	12902 - 31754
24	5047.43	II	15787 - 35593	12	5304.62	II	14791 - 33637
240	5049.80	II	6691 - 26489	17	5305.58	II	9401 - 28244
24	5050.78	I	3688 - 23481	30	5307.47	II	16564 - 35400
85	5055.34	II	1522 - 21297	40	5310.26	II	1860 - 20686
70	5058.56	II	14790 - 34553	35	5312.00	I	3688 - 22508
24	5059.86	I	7502 - 27260	35	5312.53	I	5563 - 24381
40	5061.22	II	14791 - 34544	60	5325.14	II	12486 - 31259
19	5064.60	I	4962 - 24701	50	5326.98	I	8111 - 26878
24	5066.78	I	18011 - 37742	24	5329.37	II	10673 - 29431
110	5067.97	I	7795 - 27522	50	5329.48	II	18816 - 37575
24	5075.47	II	15324 - 35021	60	5343.58	I	3688 - 22397
24	5090.75	II	8606 - 28244	30	5345.31	II	
21	5094.13	I	14207 - 33832	14	5347.04	II	22028 - 40724
40	5095.07	I	18432 - 38053	14	5351.13	I	15619 - 34301
50	5098.04	II	1521 - 21131	40	5375.35	II	1522 - 20120
21	5100.62	I	4962 - 24562	24	5375.77	II	15305 - 33902
24	5107.24	II	7829 - 27403	12	5378.84	I	14482 - 33068

Thorium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	5382.92	II	4113 - 22686	7	5601.60	I	0 - 17847
12	5384.03	I		50	5604.51	II	0 - 17837
35	5386.61	I	4962 - 23521	7	5605.30	I	
70	5390.46	II	6700 - 25246	12	5610.24	I	7502 - 25322
50	5392.57	II	4147 - 22686	19	5610.68	I	11601 - 29419
12	5394.76	I	3865 - 22397	12	5612.07	I	10414 - 28228
24	5398.92	I	8800 - 27318	35	5615.32	I	3865 - 21669
24	5407.65	I	11197 - 29684	24	5615.73	II	17722 - 35525
21	5410.77	I	6362 - 24839	7	5626.73	II	19912 - 37680
70	5415.46	II	14276 - 32736	7	5630.30	I	19986 - 37742
24	5417.49	I	3688 - 22142	70	5639.75	II	1522 - 19248
19	5421.84	II	7001 - 25440	50	5645.89	II	11117 - 28824
21	5424.01	I	10414 - 28845	12	5652.90	II	17771 - 35456
60	5425.68	II	9585 - 28011	12	5654.02	II	6700 - 24381
12	5431.11	I	6362 - 24770	12	5657.93	I	12848 - 30517
10	5433.70	II	11117 - 29515	17	5665.18	I	8244 - 25890
12	5435.13	II	12486 - 30880	30	5665.62	II	9711 - 27357
50	5435.89	II	12488 - 30879	14	5674.99	I	11803 - 29419
24	5437.38	II	12570 - 30956	7	5678.92	II	16033 - 33637
35	5443.11	II	4147 - 22513	24	5700.45	II	9712 - 27250
40	5449.48	II	14276 - 32621	95	5700.70	II	9720 - 27257
30	5452.22	I	9805 - 28141	50	5700.91	II	4146 - 21682
24	5461.74	II	13469 - 31773	95	5707.10	II	6214 - 23731
30	5462.61	II	14276 - 32577	19	5719.62	I	7502 - 24981
19	5474.86	II	1860 - 20120	50	5720.18	I	3688 - 21165
24	5484.14	II	11117 - 29346	30	5725.39	I	9805 - 27266
24	5488.62	II	0 - 18214	30	5732.98	II	17727 - 35165
7	5495.81	II	14546 - 32736	7	5738.31	II	17121 - 34543
10	5496.14	I	5563 - 23753	19	5741.17	II	7001 - 24415
30	5499.26	I	2558 - 20737	24	5742.08	II	13468 - 30879
12	5501.94	II	6244 - 24415	10	5745.68	II	20990 - 38389
19	5504.30	I	7280 - 25443	10	5748.74	I	6362 - 23753
35	5509.99	I	9805 - 27949	30	5749.38	II	1860 - 19248
12	5510.68	II	15243 - 33384	10	5753.03	I	4962 - 22339
19	5514.87	I	7795 - 25923	70	5760.55	I	0 - 17355
19	5518.99	I	16347 - 34461	10	5763.53	I	2869 - 20215
12	5521.75	I	19227 - 37332	10	5784.87	II	17272 - 34553
24	5524.22	II	16565 - 34662	21	5796.42	II	11576 - 28824
12	5524.58	I	13175 - 31271	35	5804.14	I	0 - 17224
12	h 5528.00	II	20081 - 38165	17	5806.28	II	12570 - 29788
12	5537.13	II	9202 - 27257	19	5815.42	II	1860 - 19051
50	5539.26	I	9805 - 27853	10	5838.94	II	0 - 17122
70	5539.91	II	9585 - 27631	7	5852.68	I	10414 - 27496
19	5542.89	I	10527 - 28563	17	5859.67	II	13818 - 30879
10	5546.12	I		17	5870.55	II	12486 - 29515
35	5548.18	I	6362 - 24381	14	5885.70	I	9805 - 26790
24	5551.37	II	9585 - 27594	8	5891.45	I	10527 - 27496
24	5557.04	I	8800 - 26790	40	5914.39	II	9585 - 26489
12	5557.31	II	16564 - 34553	17	5914.65	I	7280 - 24182
50	5558.34	I	8111 - 26097	19	5925.87	II	10379 - 27250
7	5559.89	I	3688 - 21669	17	5938.83	I	5563 - 22397
60	5564.20	II	12486 - 30453	10	5944.65	I	10527 - 27344
35	5568.00	II	13818 - 31773	30	5973.66	I	3688 - 20424
35	5571.19	I	11197 - 29142	30	5975.07	I	6362 - 23094
17	5572.47	I	7502 - 25443	85	5989.04	II	1522 - 18214
40	5573.36	I	8111 - 26049	14	5991.00	I	6362 - 23049
24	d 5576.00	I		24	5994.13	I	3865 - 20544
	5576.20	I	10414 - 28342	7	6001.21	I	8111 - 24770
35	5579.36	I	5563 - 23481	21	6007.07	I	8800 - 25443
21	5583.76	II	9061 - 26965	11	6010.16	I	2869 - 19503
60	5587.03	I	4962 - 22855	30	6015.42	II	15305 - 31924
24	5587.73	II	20288 - 38179	12	6019.00	II	15145 - 31754
24	5588.87	II	6244 - 24132	17	6021.04	I	7795 - 24399
24	5593.61	II	7001 - 24874	17	6037.70	I	3865 - 20424
24	5595.06	I	8244 - 26112	24	6044.43	II	4147 - 20686

Thorium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
12	6066.50	II	26647 - 43127	24	6619.94	II	4147 - 19248
30	6073.10	II	1522 - 17983	21	6644.66	II	9712 - 24758
12	6085.26	II	6214 - 22642	8	6646.54	II	12486 - 27527
30	6087.26	II	15350 - 31773	6	6648.50	II	11726 - 26762
24	6099.08	II	10379 - 26770	4	6648.96	II	10379 - 25414
11	6102.60	I	10414 - 26796	6	6658.68	I	11242 - 26256
30	6104.57	I	15619 - 31996	30	6662.27	I	7502 - 22508
40	6112.84	II	1860 - 18214	4	6678.71	I	7280 - 22249
30	6120.56	II	14546 - 30880	8	6692.72	II	4113 - 19051
14	6151.99	I	7502 - 23753	8	6704.05	II	11576 - 26489
60	6169.82	I	4962 - 21165	8	6713.97	I	6362 - 21253
50	6182.62	I	2869 - 19039	8	6719.20	I	10527 - 25405
12	6184.79	I	13089 - 29253	16	6727.46	I	5563 - 20424
19	6188.13	I	8244 - 24399	8	6733.75	I	14204 - 29051
12	6191.91	I	6362 - 22508	6	6742.88	I	12848 - 27674
24	6193.86	II	11117 - 27257	20	6756.45	I	2558 - 17355
10	6198.22	I	3688 - 19817	6	6765.68	I	18614 - 33391
12	6200.43	II	1860 - 17983	10	6770.10	II	8606 - 23373
12	6203.49	I	4962 - 21077	8	6772.18	I	15493 - 30255
19	6207.22	I	5563 - 21669	6	6778.31	I	3865 - 18614
12	6224.53	I	2869 - 18930	7	6780.13	I	8244 - 22989
12	6232.97	II	9401 - 25440	11	6780.42	I	8111 - 22855
24	h 6234.86	I	6362 - 22396	6	6787.73	I	14204 - 28933
12	h 6258.60	II	4147 - 20120	6	6788.84	I	11197 - 25923
21	6261.06	II	4113 - 20081	6	6791.23	I	8800 - 23521
21	6261.42	I	10414 - 26380	6	6804.73	II	12902 - 27594
11	6266.17	II	8460 - 24415	8	6810.54	II	12571 - 27250
50	6274.12	II	4147 - 20081	6	6812.76	II	10572 - 25246
11	6277.23	II	6214 - 22140	8	6824.68	I	11242 - 25890
30	6279.16	II	12902 - 28824	11	6829.04	I	7502 - 22142
17	6285.28	II	11726 - 27631	14	6834.92	I	4962 - 19588
11	h 6289.48	II	9711 - 25607	7	6854.11	I	13089 - 27674
11	6301.42	I		6	6868.46	I	13297 - 27853
11	h 6304.24	II	8606 - 24464	8	6874.75	I	2869 - 17411
7	6326.36	I	11242 - 27044	20	6889.30	II	1521 - 16033
21	6327.28	I	11197 - 26997	11	bl 6894.4	ThO	
35	6342.86	I	8800 - 24562	15	6909.84	II	13468 - 27937
11	h 6348.56	II	22642 - 38389	24	6911.23	I	0 - 14465
7	6358.62	II	19880 - 35602	35	6943.61	I	9805 - 24203
14	6369.14	I	17166 - 32862	6	6952.96	II	10379 - 24758
40	6376.93	I	14204 - 29881	55	6989.66	I	7795 - 22098
40	bl 6406.2	ThO		24	6993.03	II	7001 - 21297
19	6408.63	II	1522 - 17122	18	7000.81	I	9805 - 24085
30	6411.90	I	7502 - 23094	10	7018.56	I	0 - 14244
24	6413.62	I	13297 - 28885	5	7021.28	I	15970 - 30209
17	6416.10	II	9401 - 24982	7	7036.28	I	11197 - 25405
14	6424.81	II	22014 - 37575	30	7045.80	II	1522 - 15711
60	6457.28	I	7795 - 23277	15	7053.61	II	1860 - 16033
50	6462.62	I	16554 - 32024	6	7060.65	I	3688 - 17847
8	6471.20	II	12488 - 27937	6	7064.45	I	14207 - 28358
14	6490.74	I	8800 - 24203	6	7072.39	I	14207 - 28342
12	6503.51	II	11117 - 26489	24	7075.33	II	11117 - 25246
7	h 6511.36	II	9061 - 24415	30	7084.16	I	9805 - 23917
50	h 6531.34	I	6362 - 21669	24	7089.33	II	0 - 14102
6	6554.16	I	4962 - 20215	10	7100.51	II	8606 - 22686
14	6560.06	II	14276 - 29515	11	7124.56	I	0 - 14032
10	6569.63	II	12570 - 27787	4	7130.29	I	24032 - 38053
5	6572.88	II	15243 - 30453	5	7131.35	I	
19	6577.65	II	15349 - 30548	5	7140.45	II	13248 - 27249
24	6583.91	I	2869 - 18054	5	7148.56	I	10414 - 24399
24	6588.54	I	3865 - 19039	5	7150.28	I	3865 - 17847
12	6591.48	I	0 - 15167	10	hw 7154.95	I	7280 - 21253
24	6593.94	I	5563 - 20724	15	hs 7155.5	ThO	
24	6605.42	II	4113 - 19248	5	7156.94	I	4962 - 18930
10	6617.05	II	12485 - 27594	8	hs 7158.56	ThO	

Thorium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18 hs	7159.10	ThO		15	7788.93	I	11197 - 24032
5	7159.94	I	13297 - 27260	5	7798.36	I	5563 - 18383
7 hs	7164.88	ThO		21	7817.77	I	10414 - 23202
30	7168.90	I	0 - 13945	8	7834.45	II	12486 - 25246
7	7173.37	I	14204 - 28141	3	7840.29	I	13297 - 26049
5	7176.72	II	10379 - 24309	3	7840.44	I	19986 - 32737
40	7191.13	II	10855 - 24757	5	7841.78	I	11242 - 23990
7	7200.04	I	7280 - 21165	15	7847.54	I	8800 - 21540
5	7206.48	I	10527 - 24399	4	7848.44	I	15490 - 28228
35	7208.00	I	8800 - 22670	4	7849.62	II	14791 - 27527
11	7212.69	I	14482 - 28342	12	7865.95	I	14482 - 27191
10	7217.76	II	1859 - 15710	10 bl	7868.3	ThO	
11	7218.06	I	9805 - 23655	6	7886.27	I	6362 - 19039
4	7219.16	I	4962 - 18810	7	7897.9	ThO	
5	7230.87	I	17501 - 31327	11	7900.31	I	15619 - 28273
5	7244.69	I	7795 - 21594	11	7941.72	I	16347 - 28935
7	7284.90	I	3688 - 17411	7 h	7972.60	I	4962 - 17501
5 hs	7285.62	ThO		24	7978.98	I	3688 - 16218
7 hs	7287.05	ThO		5	7981.21	II	8605 - 21131
11 hs	7288.98	ThO		4	7981.67	II	16906 - 29431
11	7305.40	II	7001 - 20686	11	7987.97	I	13848 - 26363
7	7324.81	I	14204 - 27853	11	8032.43	I	7502 - 19948
7	7328.28	I	7280 - 20922	4	8054.52	II	12570 - 24982
7	7335.57	I		11	8062.64	I	19227 - 31626
8	7341.15	I	10414 - 24032	5	8075.65	I	11803 - 24182
5	7342.57	I	18011 - 31627	5	8085.23	I	8800 - 21165
5	7346.34	II	10855 - 24463	5	8093.63	I	3865 - 16218
6 h	7358.35	II	12902 - 26489	7	8122.72	I	19986 - 32294
8	7376.88	I	14482 - 28034	11	8138.47	I	5563 - 17847
7	7383.71	I	20868 - 34408	5 h	8139.90	II	9401 - 21683
18	7385.50	I	3688 - 17224	18	8143.14	I	8800 - 21077
3	7393.43	II	13249 - 26771	5	8152.39	II	10379 - 22642
5	7402.25	I	10527 - 24032	12	8159.74	I	6362 - 18614
21	7428.94	I	7280 - 20737	10	8163.12	II	7001 - 19248
10	7430.26	I	6362 - 19817	7	8166.44	II	1860 - 14102
4	7447.85	I	11242 - 24665	7	8169.79	I	7280 - 19517
10	7481.35	I	8800 - 22163	15	8186.92	I	8111 - 20322
7	7511.35	II	7001 - 20310	12	8203.19	II	12571 - 24758
50	7525.51	II	9401 - 22686	7	8217.22	II	13248 - 25414
4	7528.49	I	11601 - 24880	5	8252.40	I	0 - 12114
5	7536.41	I	12847 - 26113	4	8261.01	I	15490 - 27592
7	7549.32	I	7280 - 20523	5	8263.93	I	9805 - 21902
7	7566.53	II	17272 - 30484	18	8275.63	I	11197 - 23277
18	7567.74	I	9805 - 23015	15	8320.86	I	7502 - 19517
12	7585.69	I	16554 - 29733	30	8330.46	I	7502 - 19503
12	7585.78	I	2558 - 15737	4	8358.73	I	11242 - 23202
4	7598.20	I	11241 - 24399	4	8369.33	I	13945 - 25890
7	7625.70	I	14482 - 27592	6	8387.09	II	4113 - 16033
5	7627.18	I	4962 - 18069	18	8403.79	II	12485 - 24381
4 h	7630.31	I	8800 - 21902	15	8416.74	I	0 - 11878
30	7647.38	I	9805 - 22878	5	8418.00	I	12114 - 23990
7	7653.83	I	14204 - 27266	12	8421.23	I	3865 - 15737
4	7658.32	I	8111 - 21165	8	8445.50	I	8111 - 19948
7	7676.21	II	1522 - 14546	21	8446.52	I	
4	7678.12	I	7502 - 20523	5	8450.68	II	10855 - 22686
21	7685.30	II	4113 - 17121	18	8478.35	I	5563 - 17355
4	7693.80	I	17166 - 30160	5	8500.67	II	10379 - 22139
8 h	7701.10	II	14275 - 27257	6 h	8516.55	I	19588 - 31326
5	7709.59	II	16906 - 29873	4	8543.72	I	15490 - 27191
4	7710.26	I	8111 - 21077	4	8544.59	I	29310 - 41010
10	7731.72	II	9711 - 22642	4 h	8556.32	I	10414 - 22098
4	7742.55	I	15619 - 28531	4	8568.20	II	18816 - 30484
3	7743.93	II		11	8573.12	I	5563 - 17224
7	7782.32	I		5 h	8587.63	II	20158 - 31800
15	7787.79	II	8460 - 21297	12	8591.83	II	10379 - 22015

*Thorium—all observed lines—Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
4	8639.44	I	10526 - 22098	15	8758.25	I	8800 - 20215
4	8645.31	I	13962 - 25526	8 h	8775.58	I	8111 - 19503
10	8665.49	I	7502 - 19039	8 h	8784.55	II	1522 - 12902
4	8668.12	I	12848 - 24381	8	8816.16	II	4113 - 15453
4	8686.07	II	6213 - 17722	6	8841.17	I	7502 - 18809
5	8709.23	I	3688 - 15167	18	8842.07	II	4147 - 15453
5	8719.62	II	15305 - 26771	15	8868.82	I	9804 - 21077
5	8721.65	II	15787 - 27249	15	8957.97	II	12571 - 23731
8	8732.43	I		40	8967.64	I	8800 - 19948
18	8748.04	I	7502 - 18930	15 bl	8971.96	ThO	
6	8749.17	I					

# Thulium

$$\text{Tm, } Z = 69, M = 168.9342, \text{ Ratio } \frac{\text{Tm}}{\text{Cu}} = 2.658$$

Tm I Normal state of valence electrons  $4f^{13}6s^2 2F_{3/2}^{\circ} = 0$ . I.P. = 49880  $\text{cm}^{-1}$ .

Tm II Normal state of valence electrons  $4f^{13}6s 3F_4^{\circ} = 0$ . I.P. = 97200  $\text{cm}^{-1}$ .

Tm III Normal state of valence electrons  $4f^{13} 2F_{3/2}^{\circ} = 0$ . I.P. = 191000  $\text{cm}^{-1}$ .

## References

### Wavelengths and Spectrum Assignments:

W. F. Meggers and J. Sugar, unpublished material (1966).

### Classification:

Tm I, J. Sugar, W. F. Meggers, and P. Camus, J. Res. Nat. Bur. Stand. (U.S.), **77A** (Phys. and Chem.), No. 1, 1-43 (Jan.-Feb. 1973).

Tm II, J. Sugar, private communication (1974).

Tm III, J. Sugar, J. Opt. Soc. Am. **69**, 454 (1970).

### *Strong lines of thulium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
10000	4094.19	I	0 - 24418	4900	3453.66	II	237 - 29183
9500	4105.84	I	0 - 24349	4800	3700.26	II	237 - 27254
8900	3848.02	II	0 - 25980	4800	3761.91	II	0 - 26575
8800	4187.62	I	0 - 23873	4000	3362.61	II	237 - 29967
8500	3462.20	II	0 - 28875	3800	3701.36	II	0 - 27009
7700	3717.91	I	0 - 26889	3500	3916.48	I	8771 - 34297
7400	3131.26	II	0 - 31927	3000	4242.15	II	237 - 23803
7100	3795.75	II	237 - 26575	2700	4359.93	I	0 - 22930
6800	3883.13	I	0 - 25745	2400	3734.12	II	237 - 27009
6400	3425.08	II	237 - 29425	2300	3133.89	II	0 - 31900
6000	3761.33	II	0 - 26579	2300	3172.83	II	237 - 31745
6000	4203.73	I	0 - 23782	2300	3241.54	II	0 - 30841
5400	3887.35	I	0 - 25717	2300	3291.00	II	0 - 30377
5000	3744.06	I	0 - 26701	2100	3608.77	II	0 - 27702
4900	3441.50	II	237 - 29286	2000	3302.46	II	237 - 30509

Thulium— all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
360	2284.79	II	0 - 43754	30	2551.51	II	26256 - 65436
120	2329.77	II		120	2552.46	III	22897 - 62063
230	2331.80	III	31037 - 73909	360	2552.76	I	0 - 39161
220	2338.36	III	25920 - 68672	540	2561.65	II	0 - 39025
70	2340.92	II		150	2563.86	II	0 - 38991
310	2357.05	III	25302 - 67715	65	2565.98	II	237 - 39197
120	2361.23	III	33802 - 76140	35	2568.26	II	237 - 39162
120	2363.91	II		35	2569.34	II	16567 - 55476
	2363.97	III	31368 - 73657	45	2574.52	III	34826 - 73657
45	2365.96	II	12457 - 54710	35	2583.42	I	0 - 38696
160	2367.11	II		430	2588.27	II	12457 - 51081
150	2383.68	II	236 - 42176	35	2594.98	II	19526 - 58051
110	2388.95	II	0 - 41846	170	2596.49	I	0 - 38502
55	2408.23	II	0 - 41511	110	2601.09	I	0 - 38433
450	2409.02	II		220	2606.02	II	0 - 38361
110	2412.44	II	12457 - 53896	810	2607.06	II	237 - 38583
65	2419.37	II		60	2609.46	II	
30	2420.20	II	20619 - 61925	80	2613.59	II	
120	2421.65	II	12457 - 53738	40	2615.99	II	18291 - 56506
23	2423.28	II		80	2616.32	II	19619 - 57829
450	2426.17	II		40	2616.99	II	0 - 38200
55	2428.43	II	0 - 41166	40	2620.93	II	16567 - 54710
30	2430.77	II	20619 - 61745	80	2622.21	II	237 - 38361
55	2434.75	II		730	2624.33	II	0 - 38094
45	2436.19	II		70	2629.78	II	
65	2437.67	II	0 - 41010	40	2632.23	II	
90	2440.70	II	0 - 40959	60	2637.23	II	19619 - 57526
140	2445.47	II	12457 - 53336	70	2638.41	II	19682 - 57573
35	2445.94	II		210	2640.76	II	237 - 38094
65	2447.38	II	12457 - 53304	40	2642.83	II	
80	2451.20	II		40	2643.50	II	12457 - 50274
35	2454.91	II	237 - 40959	130	2646.45	II	0 - 37775
80	2458.58	II		70	2648.14	II	
80	2464.95	II	12457 - 53013	160	2650.27	II	237 - 37958
18	2471.37	II		35	2653.40	II	21021 - 58698
80	2476.97	II	0 - 40359	190	2658.48	II	237 - 37841
770	2480.13	II	236 - 40545	250	2660.09	II	0 - 37581
150	2481.15	II		50	2664.45	II	25219 - 62739
130	2487.52	II		140	2668.20	II	
150	2489.44	III	27557 - 67715	40	2674.98	II	23024 - 60396
35	2490.93	II	17974 - 58107	60	2677.12	II	20619 - 57961
250	2491.60	II	237 - 40359	50	2678.09	II	16567 - 53896
90	2499.20	II		310	2679.57	II	12457 - 49765
100	2499.54	II	237 - 40232	95	2682.32	III	25302 - 62572
55	2502.70	II	17974 - 57919	95	2684.07	II	236 - 37482
65	2504.71	III	27547 - 67460	35	2686.20	II	
27	2505.90	II	0 - 39894		2686.32	II	21021 - 58236
27	2506.45	II	17974 - 57859	35	2689.99	II	17974 - 55138
130	2507.15	II	12457 - 52331	35	2693.46	II	19526 - 56642
1300	2509.08	II	0 - 39843	170	2697.50	II	
45	2511.84	II	20619 - 60418	40	2698.21	III	30664 - 67715
90	2513.78	I	0 - 39768	40	2699.49	III	38055 - 75088
	2513.87	II	17974 - 57741	40	2699.80	III	0 - 37028
23	2518.48	II		50	2700.18	II	19619 - 56642
100	2519.78	III	36466 - 76140	40	2701.96	II	
200	2520.87	II	237 - 39893	80	2707.03	III	33802 - 70732
	2520.94	II		19	2708.18	II	237 - 37151
250	2522.17	II	0 - 39636	95	2709.74	III	33831 - 70724
180	2524.11	II		110	2711.50	II	0 - 36869
130	2527.02	I	0 - 39560	40	2717.56	III	39934 - 76721
110	2527.42	II		200	2719.47	III	25302 - 62063
35	2527.85	I	0 - 39547	540	2721.19	II	12457 - 49195
18	2531.45	II	17974 - 57465	29	2721.90	II	
120	2542.66	II	237 - 39554	200	2727.56	III	25920 - 62572
30	2544.03	II	19682 - 58978	150	2729.04	II	237 - 36869



Thulium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	2730.72	II	17974 - 54583	29	2842.76	II	
70	2731.38	III	34124 - 70724	310	2844.67	II	237 - 35380
50	2735.33	II	0 - 36548	60	2845.35	II	20619 - 55753
95	2742.95	II	16567 - 53013	95	2848.86	II	19619 - 54710
200	2744.08	II	20619 - 57050	29	2848.98	II	8957 - 44047
110	2750.76	II	17974 - 54317	29	2852.59	II	18291 - 53336
110	2753.18	II	237 - 36548	29	2853.25	II	237 - 35274
150	2756.69	II	8769 - 45034	90	2854.02	II	17974 - 53002
90	2758.97	II	20619 - 56853	200	2854.17	I	0 - 35026
40	2759.55	II	19526 - 55753	60	2854.89	II	23961 - 58978
70	2766.81	II	0 - 36132	200	2860.12	II	26188 - 61141
50	2767.09	II	18291 - 54419	50	2860.36	II	21021 - 55972
110	2771.04	II	8957 - 45034	70	2860.55	II	237 - 35185
90	2773.79	II	0 - 36041	200	2861.74	II	17974 - 52907
70	2774.77	II	21022 - 57050	95	2863.35	II	0 - 34914
180	2774.97	II	18291 - 54317	150	2863.75	II	
50	2776.68	II		29	2864.75	I	15271 - 50167
120	2777.04	II	22052 - 58051	160	2868.01	II	20619 - 55476
90	2777.50	II	8957 - 44950	1600	2869.23	II	12457 - 47299
50	2778.39	II	17974 - 53955	80	2873.00	II	8957 - 43754
270	2779.55	II	0 - 35966	40	2878.20	II	
110	2780.87	II	19526 - 55476	60	2878.36	II	21021 - 55753
350	2785.07	II	237 - 36132	18	2883.04	II	
95	2786.18	II	22355 - 58236	140	2886.45	II	237 - 34871
50	2787.96	II		60	2887.95	II	18291 - 52907
29	2791.43	II		95	2889.64	II	23904 - 58500
120	2791.61	II		29	2889.93	II	25014 - 59607
180	2792.16	II	237 - 36041	35	2890.74	II	23768 - 58351
680	2794.60	II	0 - 35772	630	2890.94	II	0 - 34580
95	h 2796.09	II	0 - 35754	50	2893.62	II	20619 - 55167
730	2797.27	II	12457 - 48195	170	2894.47	II	20619 - 55157
60	2797.98	II	237 - 35966	130	2903.08	II	
95	2800.39	II	17974 - 53673	29	2904.10	II	26709 - 61133
70	2803.10	II	18291 - 53955	95	2905.42	II	
40	2806.77	III	33236 - 68853	70	2907.17	II	17974 - 52361
180	2807.98	II	17974 - 53576	60	2908.69	II	19526 - 53896
170	2808.42	II	237 - 35834	29	2910.37	II	12457 - 46807
95	2812.25	II		50	2911.87	II	23904 - 58236
40	2813.02	II	19619 - 55157	130	2913.96	II	0 - 34308
29	2813.82	II	23768 - 59297	170	2914.84	I	0 - 34297
140	2814.41	II	22052 - 57573	130	2916.53	II	19619 - 53896
140	2814.50	II	17974 - 53494	210	2918.27	II	
29	2814.74	II	25696 - 61213	70	2920.98	II	21608 - 55833
40	2816.55	II	23803 - 59297	60	2921.26	II	
90	2817.31	II	21021 - 56506	70	2922.09	II	19526 - 53738
110	2818.14	II	22052 - 57526	70	2922.84	II	23904 - 58107
250	2818.47	II	12457 - 47927	270	2925.65	II	20465 - 54636
70	2819.08	II	19526 - 54988	70	2925.92	II	236 - 34404
24	2820.22	II	20619 - 56066	680	2926.74	II	0 - 34157
40	2823.54	II		29	2927.31	II	22355 - 56506
60	2824.76	II	8769 - 44160	50	2927.67	II	23904 - 58051
95	2826.43	II	19619 - 54988	110	2928.22	II	26256 - 60396
250	2827.02	II	17974 - 53336	29	2928.63	II	21021 - 55157
80	2827.76	II	20619 - 55972	50	2930.56	II	31323 - 65436
580	2827.92	II	12457 - 47808	40	2931.09	I	16456 - 50563
50	2830.16	II		70	2932.58	II	23961 - 58051
200	2831.55	II	19682 - 54988	80	2932.97	I	0 - 34085
70	2833.81	II		29	2933.78	II	
50	2836.16	II		40	2933.88	II	26188 - 60262
40	2838.63	II	22355 - 57573	29	2935.49	II	19682 - 53738
160	2838.93	II	20619 - 55833	630	2935.99	II	16567 - 50617
95	2839.10	II		29	2936.59	II	22308 - 56352
70	2839.85	II	18291 - 53494	70	2943.36	II	20619 - 54583
120	2841.38	II	19526 - 54710	95	2946.83	II	23904 - 57829
40	2842.42	II	22355 - 57526	140	2948.00	H	17974 - 51885

Thulium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
95	2948.15	II	25980 - 59889	75	3061.14	II	22052 - 54710
35	2950.07	II	27254 - 61141	75	3062.05	II	19682 - 52331
350	2951.26	II		75	3064.00	II	16567 - 49195
50	2951.80	II	23961 - 57829	55	3068.11	II	22052 - 54636
50	2952.47	II	27254 - 61114	580	3073.08	II	
60	2953.58	II	26478 - 60325	150	3073.48	II	
50	2955.05	II	23768 - 57599	75	3073.84	II	
29	2957.04	II		360	3081.12	I	0 - 32446
60	2957.54	II	22355 - 56157	150	3087.01	II	19619 - 52003
29	2957.66	II	20619 - 54419	180	3093.11	II	19682 - 52003
180	2959.64	II	19526 - 53304	120	3096.96	II	21608 - 53888
50	2961.39	II	22308 - 56066	740	3098.60	II	236 - 32500
430	2965.86	II	16567 - 50274	75	3099.60	II	23904 - 56157
120	2967.75	II	19619 - 53304	55	3101.85	II	28096 - 60325
120	2969.50	II	0 - 33666	75	3102.87	II	8769 - 40988
490	2973.22	I	0 - 33624	55	3113.31	II	22308 - 54419
160	2973.38	II	19682 - 53304	150	3122.53	I	8771 - 40787
110	2974.28	II	23961 - 57573	40	3123.29	II	22308 - 54317
29	2974.60	II	28095 - 61703	75	3124.90	II	21021 - 53013
150	2978.42	II	0 - 33565	75	3125.73	II	18291 - 50274
35	2979.44	II	26709 - 60262	150	3126.01	II	21021 - 53002
540	2981.48	II	12457 - 45987	7400	3131.26	II	0 - 31927
70	2983.12	II	8957 - 42470	2300	3133.89	II	0 - 31900
70	2985.08	II		150	3142.43	I	8771 - 40584
130	2985.37	II	19526 - 53013	230	3144.90	II	
350	2986.52	II		230	3146.16	II	8769 - 40545
630	2990.54	II	237 - 33666	75	3149.15	II	0 - 31745
35	2992.88	II	22355 - 55758	75	3150.06	II	
200	2993.26	II	0 - 33399	1900	3151.04	II	0 - 31726
120	2993.90	II	0 - 33392	1500	3157.34	II	237 - 31900
29	2994.33	II	25257 - 58644	75	3162.44	II	23024 - 54636
130	2999.60	II	237 - 33565	75	3164.87	II	8957 - 40545
35	3001.15	II	26578 - 59889	190	3168.19	II	19526 - 51081
29	3004.16	II	20619 - 53896	75	3168.82	II	30197 - 61745
60	3006.35	II	17974 - 51227	450	3172.65	I	0 - 31510
120	3008.91	II	16567 - 49792	2300	3172.83	II	237 - 31745
29	3009.20	II	25015 - 58236	380	3173.58	II	18291 - 49792
70	3013.59	II		130	3177.46	II	8770 - 40232
230	3013.71	II	19619 - 52791	75	3178.20	II	17974 - 49429
430	3014.65	II	237 - 33399	150	3180.56	I	0 - 31432
1500	3015.30	II	237 - 33392	150	3185.47	II	12457 - 43840
70	3016.09	II	23904 - 57050	230	3195.33	II	8770 - 40056
	3016.18	II	28096 - 61241	130	3196.54	II	8957 - 40232
35	3016.79	II	28974 - 62113	130	3199.99	II	16567 - 47808
270	3017.09	II	19526 - 52661	320	3210.56	II	18291 - 49429
70	3017.26	II	23024 - 56157	320	3210.82	II	0 - 31136
29	3018.26	II	25257 - 58379	320	3212.01	II	8770 - 39894
95	3018.59	II		130	3214.63	II	8957 - 40056
60	3019.79	II	22052 - 55157	75	3216.11	II	23904 - 54988
35	3022.07	II	28276 - 61356	75	3226.81	II	22355 - 53336
330	3026.07	II	0 - 33036	75	3228.90	II	22052 - 53013
55	3028.73	II		230	3231.51	II	8957 - 39894
75	3031.67	II	21608 - 54583	75	3233.74	I	0 - 30915
75	3034.08	II	23904 - 56853	470	3235.44	II	237 - 31136
85	3035.98	II	21608 - 54536	1200	3236.81	II	8957 - 39843
280	3042.35	II	237 - 33097	1600	3240.23	II	237 - 31090
340	3046.76	II	22355 - 55167	2300	3241.54	II	0 - 30841
	3046.87	I	0 - 32811	130	3245.86	II	237 - 31037
170	3048.81	II	18291 - 51081	320	3246.96	I	8771 - 39560
320	3050.73	II		420	3247.46	II	8770 - 39554
75	3053.70	II	23768 - 56506	75	3249.83	II	26837 - 57599
150	3054.04	II	12457 - 45191	75	3251.33	II	19526 - 50274
340	3056.07	II	19619 - 52331	160	3251.63	II	8770 - 39514
75	3058.35	II		1900	3258.05	II	0 - 30684
75	3058.98	II	23961 - 56642	400	3261.65	II	20465 - 51116

Thulium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
320	3264.10	II	0 - 30627	8500	3462.20	II	0 - 28875
1600	3266.64	II	237 - 30841	210	3467.51	I	15587 - 44418
1200	3267.40	II	8957 - 39554	340	3476.69	I	13119 - 41874
790	3268.99	II		340	3480.98	I	15587 - 44307
1100	3276.81	II	0 - 30509	340	3481.75	II	8769 - 37482
1200	3283.40	II	237 - 30684	170	3487.08	II	19526 - 48195
85	3284.68	II	22355 - 52791	420	3487.38	I	13119 - 41786
1200	3285.61	II	8770 - 39197	130	3489.52	I	19466 - 48115
2300	3291.00	II	0 - 30377	55	3491.72	I	18853 - 47484
2000	3302.46	II	237 - 30509	210	3492.58	II	8957 - 37581
210	3306.01	II	8957 - 39197	85	3495.19	II	24059 - 52661
210	3306.91	II	8769 - 39000	340	3499.95	I	
210	3308.01	II	31135 - 61356	130	3503.36	I	
1200	3309.80	II	8957 - 39162	250	3513.02	II	22308 - 50766
640	3310.59	II	0 - 30197	85	3514.11	I	0 - 28449
85	3316.17	II	19619 - 49765	85	3514.86	I	
400	3316.88	II	237 - 30377	250	3517.60	I	
210	3318.65	II		140	3517.72	I	19466 - 47885
160	3323.21	II	19682 - 49765	170	3522.43	II	8770 - 37151
85	3327.58	II	8957 - 39000	85	3525.03	I	18853 - 47214
85	3335.05	II	22355 - 52331	65	3525.28	I	
230	3349.99	I	13119 - 42961	250	3534.85	II	19526 - 47808
230	3354.86	II		1700	3535.52	II	0 - 28276
4000	3362.61	II	237 - 29967	490	3536.21	II	16567 - 44838
130	3368.33	II	24059 - 53738	850	3536.58	II	0 - 28268
130	3368.60	I	16957 - 46634	420	3537.91	I	
160	3369.64	II	19526 - 49195	55	3542.08	I	18990 - 47214
490	3374.50	II	8957 - 38583	140	3548.48	II	21021 - 49195
55	3380.04	II	22308 - 51885	85	3550.16	II	27598 - 55758
170	3380.53	I		85	3550.83	II	25257 - 53411
420	d 3384.99	II	23803 - 53336	85	3551.68	I	
	3385.08	I	15270 - 44803	210	3555.82	I	16456 - 44571
170	3393.19	I	13119 - 42581	85	3556.57	I	16456 - 44565
1700	3397.50	II	0 - 29425	85	3557.34	I	17454 - 45557
65	3397.87	I	13119 - 42541	420	3557.79	II	8770 - 36869
170	3398.02	II	16567 - 45987	340	3560.92	I	18693 - 46767
420	3399.95	II	8957 - 38361	420	3563.88	I	0 - 28051
850	3410.05	I	0 - 29317	490	3565.91	II	19619 - 47654
55	3411.57	II	8957 - 38261	1300	3566.47	II	237 - 28268
340	3412.59	I	15271 - 44565	420	3567.36	I	0 - 28024
340	3416.59	I	0 - 29260	130	3569.80	I	13119 - 41124
170	3421.79	I	15587 - 44803	280	3574.06	II	19682 - 47654
65	3424.50	I	18692 - 47885	85	3575.29	I	13119 - 41081
6400	3425.08	II	237 - 29425	85	3583.43	I	16957 - 44855
950	3425.63	II	0 - 29183	280	3586.07	I	16456 - 44334
170	3428.61	II	21608 - 50766	130	3590.73	I	15587 - 43429
340	3429.33	I	16456 - 45608	170	3598.62	I	15271 - 43051
850	3429.96	II	8769 - 37916	85	3599.16	II	25014 - 52791
420	3431.19	II	8957 - 38094	130	3607.35	II	22052 - 49765
55	3434.90	II	23803 - 52907	2100	3608.77	II	0 - 27702
190	3435.35	I	16456 - 45557	250	3609.53	II	18291 - 45987
85	3437.63	II	16567 - 45648	65	3611.61	II	19619 - 47299
140	3438.80	II	8769 - 37841	95	3612.39	II	17974 - 45648
4900	3441.50	II	237 - 29286	85	3613.03	II	16567 - 44237
170	3442.99	I	15270 - 44307	180	3619.97	II	34307 - 61924
85	3444.16	I		30	3623.42	II	8957 - 36548
85	3446.55	I	17454 - 46461	85	3624.20	I	15271 - 42855
170	d 3447.26	II	8957 - 37958	380	3638.41	I	13119 - 40596
	3447.35	I	13119 - 42119	35	3639.89	II	237 - 27702
170	3449.76	II	23024 - 52003	85	3642.94	I	15587 - 43030
85	h 3453.03	I	18693 - 47644	950	3643.65	II	
4900	3453.66	II	237 - 29183	180	3646.70	I	13119 - 40533
55	3456.36	I		140	3647.22	II	22355 - 49765
140	3458.55	I	18853 - 47759	240	3647.72	II	12457 - 39863
140	3461.16	II	8957 - 37841	600	3653.61	II	8770 - 36132

Thulium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	3660.88	II	20619 - 47927	10000	4094.19	I	0 - 24418
500	3665.81	II	8770 - 36041	9500	4105.84	I	0 - 24349
1100	3668.09	II	0 - 27254	70	4107.93	I	16742 - 41078
120	3673.14	II	17974 - 45191	120	4132.69	II	19526 - 43717
410	3677.98	II	12457 - 39638	1100	4138.33	I	8771 - 32928
450	d 3678.85	II	8957 - 36132	120	4149.14	I	
	3678.95	II	21021 - 48195	55	4150.10	I	17752 - 41841
140	3683.20	II	22052 - 49195	120	4158.60	I	8771 - 32811
410	3694.74	II	237 - 27294	70	4159.54	II	19682 - 43717
	3694.82	II	24059 - 51116	70	4170.45	I	18990 - 42961
85	3697.57	II		8800	4187.62	I	0 - 23873
170	3699.87	II	12457 - 39477	520	4199.92	II	0 - 23803
4800	3700.26	II	237 - 27254	6000	4203.73	I	0 - 23782
3800	3701.36	II	0 - 27009	220	4206.00	II	0 - 23768
330	3704.85	II	8769 - 35753	55	4212.79	II	8770 - 32500
7700	3717.91	I	0 - 26889	380	4222.67	I	8771 - 32446
70	3719.71	II	8957 - 35834	95	4236.94	II	24059 - 47654
890	3725.06	II	0 - 26837	3000	4242.15	II	237 - 23803
120	3730.81	II	8957 - 35753	55	4246.39	II	8957 - 32500
2400	3734.12	II	237 - 27009	70	4268.56	I	17343 - 40763
5000	3744.06	I	0 - 26701	270	4271.71	I	8771 - 32174
1700	3751.81	I	0 - 26646	150	4298.36	I	13119 - 36377
310	3756.86	II	8770 - 35380	95	4318.40	I	17613 - 40763
6000	3761.33	II	0 - 26579	70	4344.48	I	17752 - 40763
4800	3761.91	II	0 - 26575	70	4346.48	I	15587 - 38588
70	3765.85	II	18291 - 44838	55	4351.00	II	21022 - 43998
85	3781.15	I	0 - 26440	95	4351.18	II	8770 - 31745
260	3783.55	II	8957 - 35380	2700	4359.93	I	0 - 22930
50	3787.01	I	16456 - 42855	95	4363.66	II	16567 - 39477
380	3795.16	II	237 - 26579	55	4367.89	II	19682 - 42570
7100	3795.75	II	237 - 26575	1400	4386.43	I	0 - 22791
770	3798.54	I	8771 - 35089	200	4394.42	I	8771 - 31520
240	3798.75	II	8957 - 35274	120	4395.96	I	15271 - 38012
70	3802.07	I	15587 - 41881	140	4396.50	I	8771 - 31510
600	3807.72	I	8771 - 35026	55	4399.72	I	18853 - 41576
380	3810.72	II	8769 - 35003	55	4437.40	II	22308 - 44838
550	3817.39	II	0 - 26188	80	4442.74	I	16742 - 39244
60	3821.62	I	17454 - 43614	50	4447.58	I	16742 - 39220
290	3826.39	I	0 - 26127	120	4454.03	I	16742 - 39187
1300	3838.20	II	8957 - 35003	80	4459.99	I	
290	3840.87	I	15271 - 41299	50	4467.98	I	15270 - 37646
8900	3848.02	II	0 - 25980	540	4481.26	II	0 - 22309
70	3853.10	II	18291 - 44237	80	4489.70	II	8770 - 31037
140	3857.84	II	8957 - 34871	150	4519.60	I	16742 - 38861
6800	3883.13	I	0 - 25745	260	4522.57	II	
1800	3883.44	II	237 - 25980	180	4529.38	II	237 - 22309
5400	3887.35	I	0 - 25717	80	4532.15	I	15587 - 37646
440	3890.53	II	0 - 25696	110	4548.60	I	17343 - 39322
440	3896.62	I	0 - 25656	40	4556.68	II	26256 - 48195
680	3900.79	II	8769 - 34398	40	4561.86	II	8770 - 30684
3500	3916.48	I	8771 - 34297	80	4564.68	I	17343 - 39244
120	3928.66	II	8957 - 34404	40	4567.11	II	17974 - 39863
570	3929.58	II	8957 - 34398	95	4596.63	I	17613 - 39362
1500	3949.27	I	8771 - 34085	270	4599.02	I	0 - 21738
55	3957.42	II	237 - 25498	35	4601.29	II	8957 - 30684
1500	3958.10	II	0 - 25258	55	4603.43	II	
95	3976.68	I	16742 - 41881	40	4604.85	I	17752 - 39462
440	3995.58	II	237 - 25258	50	4613.97	I	17752 - 39419
1800	3996.52	II	0 - 25014	40	4614.47	II	22052 - 43717
220	4024.23	I	16456 - 41299	300	4615.94	II	16567 - 38225
80	4034.76	II	25014 - 49792	35	4619.06	II	22355 - 43998
380	4044.47	I	8771 - 33489	40	4621.72	I	17613 - 39244
80	4055.81	I	13119 - 37768	80	4626.33	II	21608 - 43217
80	4090.29	II	8957 - 33399	95	4626.56	II	0 - 21608
80	4091.49	II	8957 - 33392	40	4626.97	I	17613 - 39220

Thulium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	4634.26	II	18291 - 39863	19	5182.68	I	21799 - 41089
40	4642.96	II	22308 - 43840	40	5185.25	I	8771 - 28051
95	4643.12	I	8771 - 30302	14	5204.51	II	27598 - 46807
35	4644.58	I	17752 - 39277	80	5213.38	I	16456 - 35633
120	4655.09	I	17613 - 39089	22	5228.23	II	
35	4666.70	II	23768 - 45191	14	5260.93	II	26188 - 45191
35	4671.99	II	26256 - 47654	24	5267.34	II	25257 - 44237
35	4675.10	I		40	5291.14	I	21799 - 40693
80	4675.31	I	15270 - 36653	40	5294.32	I	24611 - 43494
40	4677.86	II	237 - 21608	35	5300.21	I	15587 - 34449
160	4681.92	I	8771 - 30124	35	5302.69	I	8771 - 27624
70	4685.11	I	13119 - 34457	55	5305.87	II	21022 - 39863
120	4691.11	I	8771 - 30082	650	5307.12	I	0 - 18837
110	4724.26	I	0 - 21161	16	5322.99	II	35535 - 54317
680	4733.34	I	0 - 21121	35	5338.90	I	16957 - 35682
35	4750.75	II			5339.03	I	17454 - 36179
70	4759.90	I	15270 - 36273	80	5346.49	II	19526 - 38225
27	4789.92	II	28276 - 49147	27	5372.98	II	19619 - 38225
27	4807.48	I	16456 - 37252	14	5391.96	II	25696 - 44237
35	4808.68	I	15587 - 36377	27	5400.46	II	24059 - 42570
35	4813.50	I	19748 - 40517	27	5402.23	I	
27	4826.99	II	28096 - 48807	14	5405.98	II	
27	4828.97	I	16456 - 37159	14	5461.95	II	34027 - 52331
80	4831.20	II	23024 - 43717	14	5464.14	I	22559 - 40855
35	4835.75	I	13119 - 33793	14	5465.54	II	0 - 18291
27	d 4851.76	I	19132 - 39737	16	5500.30	II	
	4851.90	II	27009 - 47614	14	5526.82	II	34913 - 53002
19	4872.28	II	22052 - 42570	24	5528.34	I	22419 - 40503
27	4879.19	I	18990 - 39479	14	5539.03	II	26188 - 44237
27	4891.64	I		27	5566.00	I	13119 - 31080
24	4909.74	I	15271 - 35633	22	5581.37	I	20406 - 38318
55	4923.83	I	18853 - 39157	14	5586.65	II	34766 - 52661
140	4957.18	I	18990 - 39157	14	5589.94	II	
40	4970.87	II	19526 - 39638	14	5606.64	I	20406 - 38237
27	4971.26	I	19548 - 39658	270	5631.41	I	0 - 17753
40	4975.12	II	23904 - 43998	40	5642.60	I	8771 - 26488
50	4978.90	I	19548 - 39628	27	5645.40	I	22419 - 40128
40	4980.68	II	23768 - 43840	70	5658.30	I	8771 - 26440
55	4989.32	II	23961 - 43998	520	5675.84	I	0 - 17614
27	4993.79	II	19619 - 39638	14	5683.59	I	16456 - 34046
19	4994.72	II	27598 - 47614	40	5684.76	II	22052 - 39638
35	5001.02	I	22742 - 42733	14	5696.42	II	
27	5001.59	I	19753 - 39741	35	5709.97	II	22355 - 39863
160	5009.77	II	19682 - 39638	22	5715.79	I	15271 - 32761
35	5014.56	II	23904 - 43840	14	5733.81	II	33182 - 50617
27	5017.87	II	28974 - 48898	11	d 5737.20	II	22052 - 39477
160	5034.22	II	19619 - 39477		5737.25	II	
27	h 5041.00	II	28095 - 47927	14	h 5738.92	II	40959 - 58379
22	5043.50	I	17454 - 37276	27	5758.02	I	15587 - 32950
35	5045.41	I	19748 - 39563	55	5760.20	I	8771 - 26127
27	5060.42	II	23961 - 43717	190	5764.29	I	0 - 17343
150	5060.90	I	0 - 19754	5	5778.82	II	30508 - 47808
27	5062.25	I	0 - 19748	19	5782.36	II	17624 - 34913
27	5065.88	I	19753 - 39488	22	5784.46	II	
80	5066.67	I	19748 - 39479	11	5799.97	II	34766 - 52003
27	5072.42	I	19753 - 39462	14	5811.19	II	21022 - 38225
27	5076.36	I	21799 - 41493	14	h 5816.46	I	16456 - 33644
27	5077.18	I	19753 - 39444	35	5838.76	II	22355 - 39477
35	5085.09	I	19753 - 39413	240	5895.63	I	0 - 16957
40	5107.53	I	19748 - 39322	35	5899.47	I	8771 - 25717
95	5113.97	I	0 - 19549	24	5901.57	I	18693 - 35633
50	5114.55	II	23024 - 42570	8	5912.58	I	25520 - 42429
22	5120.67	I	19753 - 39277	11	5931.70	I	15587 - 32441
22	5140.28	II	23768 - 43217	27	5935.90	I	15271 - 32112
40	5149.40	II	23803 - 43217	140	5971.26	I	0 - 16742

Thulium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	5975.02	I	20406 - 37138	10	7106.14	I	18693 - 32761
11	5984.87	I		5	7231.33	I	25717 - 39542
19	6025.44	I	17454 - 34046	5	7233.74	II	24273 - 38093
11	6067.78	II		4	7257.72	I	17613 - 31388
16	6131.53	I	16456 - 32761	17	7272.62	I	17752 - 31499
14	6175.29	I	13119 - 29308	8	7284.30	I	19132 - 32856
14	6181.41	II	22052 - 38225	11	7286.16	I	15587 - 29308
14	6299.46	II	22355 - 38225	14	7310.51	I	27314 - 40989
27	6352.66	I	16742 - 32479	11	7336.63	II	34027 - 47654
22	6401.44	I	16742 - 32359	14	7432.18	I	18990 - 32441
8	6430.94	II	35535 - 51081	5	7434.51	II	21133 - 34580
14	6440.54	I	16956 - 32479	5	7439.95	II	20228 - 33665
200	6460.26	I	16742 - 32217	75	7481.08	I	18853 - 32217
14	6490.70	I	16956 - 32359	75	7490.20	I	19132 - 32479
14	6519.78	I	25656 - 40989	10	7507.28	I	25745 - 39061
8	6575.54	I		14	7545.78	I	13119 - 26368
95	6604.96	I	17343 - 32479	140	7558.33	I	18990 - 32217
8	6627.25	I	26126 - 41211	17	7580.61	I	28024 - 41211
35	6657.72	I	17343 - 32359	20	7593.74	I	28023 - 41189
11	6658.64	I	24348 - 39362	17	7595.07	II	20228 - 33391
11	6692.93	I	19132 - 34069	5	7629.85	I	19753 - 32856
30	6721.36	I	17343 - 32217	5	7648.76	II	32917 - 45987
9	6726.34	I	26126 - 40989	17	7655.00	I	30914 - 43974
9	6727.94	II	38717 - 53576	4	7660.32	I	28340 - 41391
18	6739.22	I		7	7666.24	I	26701 - 39741
9	h 6767.48	I	26439 - 41211	8	7676.04	II	21133 - 34157
9	6777.93	I	26439 - 41189	8	h 7701.46	I	25520 - 38502
110	6779.77	I	17613 - 32359	80	7731.53	I	19548 - 32479
14	h 6782.00	I	24348 - 39089	4	h 7778.27	I	26889 - 39741
18	6788.52	I	17752 - 32479	12	h 7782.35	I	28143 - 40989
13	h 6820.27	I	17454 - 32112	8	h 7785.51	I	26701 - 39542
14	6826.95	I	24418 - 39061		7785.90	I	21120 - 33961
14	6829.12	II	21133 - 35772	17	7803.93	I	19548 - 32359
23	6831.09	I	26439 - 41074	4	7829.22	I	26701 - 39470
120	6844.26	I	17752 - 32359	40	7856.08	I	19753 - 32479
80	6845.76	I	17613 - 32217	3	7861.67	I	26646 - 39362
18	6854.12	I	26488 - 41074	5	7918.10	I	28448 - 41074
6	6898.56	I			7927.51	I	19748 - 32359
6	6915.86	I	27037 - 41493	110	7930.84	I	19753 - 32359
10	6937.37	I	16957 - 31367	6	7971.56	I	28448 - 40989
5	6949.54	I		11	h 7985.93	I	28555 - 41074
5	h 6976.69	II	30508 - 44838	14	h 8014.77	I	26889 - 39362
5	7010.79	I		95	8017.90	I	19748 - 32217
6	h 7014.31	II	21713 - 35966	3	h 8021.33	I	19753 - 32217
10	7017.90	I	26448 - 40693	14	8194.19	I	26889 - 39089
6	h 7029.40	I		5	8294.52	I	19466 - 31519
12	7034.34	I		7	8365.75	I	19548 - 31499
10	7056.43	II	25696 - 39863	7	8460.79	II	33022 - 44838
5	7060.97	I	8771 - 22930	27	8472.01	II	17624 - 29424
6	7079.78	II	17624 - 31745	7	h 8546.07	II	20228 - 31926
				11	8565.73	II	20228 - 31899

# Tin

Sn,  $Z = 50$ ,  $M = 118.7$ , Ratio  $\frac{\text{Sn}}{\text{Cu}} = 1.868$

Sn I Normal state of valence electrons  $5s^2 5p^2 \ ^3P_0 = 0$ . I.P. =  $59232 \text{ cm}^{-1}$ .

Sn II Normal state of valence electrons  $5s^2 5p \ ^2P_{1/2}^o = 0$ . I.P. =  $118017 \text{ cm}^{-1}$ .

## References

Wavelengths and Classification:

Sn I, W. F. Meggers, J. Research NBS **24**, 153 (1940) RP 1275.

### *Tin—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
26000	1970.80	I	1692 - 52416	1100	2483.39	I	3428 - 43683
15000 h	1983.55	I	3428 - 53826	1100	2495.70	I	8613 - 48670
8000	2040.66	I	3428 - 52416	150	2523.92	I	8613 - 48222
4800	2073.08	I	0 - 48222	2400	2546.55	I	0 - 39257
5500	2091.58	I	1692 - 49487	1000	2571.58	I	8613 - 47488
1400 h	2096.39	I	8613 - 56299	550	2594.42	I	8613 - 47146
1500	2100.93	I	3428 - 51010	1400	2661.24	I	1692 - 39257
5500	2113.93	I	1692 - 48982	7000	2706.51	I	1692 - 38629
600	2148.73	I	1692 - 48216	110	2761.78	I	3428 - 39626
1400	2151.43	I	3428 - 49894	1000	2779.81	I	8613 - 44576
1600	2194.49	I	3428 - 48982	320	2785.03	I	8613 - 44509
2200	2199.34	I	1692 - 47146	120	2812.59	I	17163 - 52707
3200	2209.65	I	3428 - 48670	600	2813.58	I	8613 - 44145
300	2211.05	I	8613 - 53826	14000	2839.99	I	3428 - 38629
480	2231.72	I	3428 - 48222	1700	2850.62	I	8613 - 43683
4200	2246.05	I	0 - 44509	10000	2863.33	I	0 - 34914
190	2251.17	I	8613 - 53021	240 h	2913.54	I	17163 - 51475
480	2267.19	I	8613 - 52707	7000	3009.14	I	1692 - 34914
3200	2268.91	I	3428 - 47488	400	3032.80	I	17163 - 50126
650	2286.68	I	3428 - 47146	8500	3034.12	I	1692 - 34641
2200	2317.23	I	8613 - 51754	40	3141.84	I	17163 - 48982
1400	2334.80	I	1692 - 44509	5500	3175.05	I	3428 - 34914
5500	2354.84	I	1692 - 44145	5500	3262.34	I	8613 - 39257
60	2357.90	I	8613 - 51010	1100	3330.62	I	8613 - 38629
200	2380.72	I	1692 - 43683	400	3655.78	I	17163 - 44509
260	2408.15	I	8613 - 50126	2800	3801.02	I	8613 - 34914
3600	2421.70	I	8613 - 49894	400	4524.74	I	17163 - 39257
5500	2429.49	I	3428 - 44576	40	5631.71	I	17163 - 34914
35	2433.47	I	3428 - 44509	8 h	8552.60	I	34914 - 46603
50	2455.24	I	3428 - 44145				

# Titanium

$$\text{Ti, } Z = 22, M = 47.9, \text{ Ratio } \frac{\text{Ti}}{\text{Cu}} = 0.754$$

Ti I Normal state of valence electrons  $3d^24s^2 \ ^3F_2 = 0$ . I.P. = 55138  $\text{cm}^{-1}$ .

Ti II Normal state of valence electrons  $3d^24s \ ^4F_{1/2} = 0$ . I.P. = 109506  $\text{cm}^{-1}$ .

## References

### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

### Supplemented by the following:

A. S. King, *Astrophys. J.* **39**, 139 (1914).

C. C. Kiess and W. F. Meggers, *Sci. Papers BS* **16**, 51 (1920).

H. Crew, *Astrophys. J.* **60**, 108 (1924).

A. S. King, *Astrophys. J.* **59**, 155 (1924).

W. F. Meggers and C. C. Kiess, *J. Research NBS* **9**, 309 (1932) RP 473.

H. W. Banks, W. R. Bozman, and C. M. Wilson, *Georgetown Obs. Mono. No.* **20** (1966).

### Classification:

Ti I, H. N. Russell, *Astrophys. J.* **66**, 347 (1927).

W. F. Meggers and C. C. Kiess, *J. Research NBS* **9**, 309 (1932) RP 473.

Ti II, H. N. Russell, *Astrophys. J.* **66**, 283 (1927).

### Molecular Spectra:

TiO, F. Lowater, *Proc. Phys. Soc. (London)* **41**, 557 (1929).

### *Strong lines of titanium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
12000	3349.41	II	393 - 30241	5200	3236.57	II	225 - 31114
7800	3998.64	I	387 - 25388	5200	3752.86	I	387 - 27026
7200	3361.21	II	225 - 29968	5200	3958.21	I	387 - 25644
	3361.26	I	170 - 29912	4800	3635.46	I	0 - 27499
7200	3653.50	I	387 - 27750	4800	3981.76	I	0 - 25107
6600	3234.52	II	393 - 31301	4600	4991.07	I	6743 - 26773
6600	3642.68	I	170 - 27615	4500	3948.67	I	0 - 25318
6000	4305.92	I	6843 - 30060	4500	3956.34	I	170 - 25439
6000	4533.24	I	6843 - 28896	4300	3349.04	II	4898 - 34748
5800	4981.73	I	6843 - 26911	4300	3371.45	I	387 - 30039
5700	3341.88	I	0 - 29915	4100	3239.04	II	94 - 30959
		II	4629 - 34543	4100	3354.64	I	170 - 29971
5700	3372.80	II	94 - 29734	4100	4301.09	I	6743 - 29986
5700	3383.76	II	0 - 29544	4000	4999.51	I	6661 - 26657
5700	3989.76	I	170 - 25227	3800	3199.92	I	387 - 31629



Titanium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
140	2272.61	I	387 - 44376	250	2742.32	I	7255 - 43710
180	2273.28	I	0 - 43976	40	2749.06	I	8492 - 44858
130	2276.70	I	170 - 44079	65	2757.40	I	8602 - 44858
190	2279.96	I	387 - 44233	95	2758.08	I	12118 - 48365
150	2299.85	I	0 - 43468	15	2761.29	II	8710 - 44915
140	2302.73	I	170 - 43583	250	2802.50	I	7255 - 42928
190	2305.67	I	387 - 43745	55	2805.70	I	8602 - 44233
65	2380.81	I	387 - 42377	30	2806.50	II	9851 - 45473
35	2384.52	I	387 - 42311	40	2809.17	I	8492 - 44079
55	2418.36	I	0 - 41337	75	2810.30	II	29734 - 65307
75	2421.30	I	170 - 41458	30	2812.98	I	8437 - 43976
95	2424.24	I	387 - 41624	30	2817.40	I	8492 - 43976
40	2428.23	I	0 - 41170	65	2817.84	I	8602 - 44079
35	2433.22	I	170 - 41255		2817.87	II	29968 - 65446
19	2434.10	I	387 - 41458	65	2828.07	I	6557 - 41907
35	2440.21	II	12629 - 53597		2828.15	II	30241 - 65589
65	2440.98	I	387 - 41342	130	2832.16	II	4629 - 39927
24	2450.44	II	12758 - 53555	190	2841.94	II	4898 - 40075
24	2504.54	I		110	2851.10	II	9851 - 44915
75	2517.43	II	1087 - 40798	40	2853.93	II	4898 - 39927
40	2519.04	I	0 - 39686	95	2862.32	II	9976 - 44902
140	2520.54	I	0 - 39662	55	2868.74	II	4629 - 39477
75	2524.64	II	984 - 40582	180	2877.44	II	8998 - 43741
360	2525.60	II	1216 - 40798	280	2884.11	II	9118 - 43781
29	2527.98	I	170 - 39716	65	2888.93	II	4629 - 39233
210	2529.85	I	170 - 39686	55	2891.07	II	4898 - 39477
190	2531.25	II	1087 - 40582	55	2905.66	I	
190	2534.62	II	984 - 40426	30	2909.92	II	393 - 34749
130	2535.87	II	908 - 40330	450	2912.08	I	7255 - 41585
190	2541.92	I	387 - 39716	340	2928.34	I	12118 - 46258
65	2555.99	II	4629 - 43741	15	2931.03		
110	2571.03	II	4898 - 43781	180	2933.55	I	0 - 34079
50	2572.65	II		26	2935.96		
50	2580.82	I		150	2937.32	I	170 - 34205
35	2590.26	I	170 - 38765	1100	2942.00	I	0 - 33981
190	2593.64	I	0 - 38544	1300	2948.26	I	170 - 34079
65	2596.58	I	170 - 38671	30	2954.58		
270	2599.92	I	0 - 38451	1600	2956.13	I	387 - 34205
340	2605.15	I	170 - 38544	170	2956.80	I	170 - 33981
510	2611.28	I	387 - 38671	30	2958.77		
75	2611.48	I	170 - 38451	26	2959.71	I	8492 - 42270
300	2619.94	I	387 - 38544	35	2959.99	I	8602 - 42377
170	2631.54	I	170 - 38160	170	2965.71	I	8602 - 42311
170	2632.42	I	0 - 37977	190	2967.22	I	387 - 34079
640	2641.10	I	0 - 37852	26	2968.23	I	0 - 33680
800	2644.26	I	170 - 37977	75	2970.38	I	0 - 33656
950	2646.64	I	387 - 38160	30	2974.93	I	8602 - 42207
30	2649.30	I		170	2983.31	I	170 - 33680
15	2654.93	I	0 - 37655	35	3000.87	I	387 - 33701
35	2657.19	I	0 - 37623	120	3017.19	II	12775 - 45909
85	2661.97	I	0 - 37555	140	3029.73	II	12677 - 45674
95	2669.60	I	170 - 37618	110	3046.68	II	9396 - 42209
130	2679.93	I	387 - 37690	130	3056.74	II	9364 - 42069
26	2684.80	I		130	3057.40	II	0 - 32698
30	2685.14	I	387 - 37618	170	3058.09	II	9518 - 42209
65	2688.82	I		85	3059.74	II	9396 - 42069
26	2716.25	II	8744 - 45549	1300	3066.22	II	94 - 32698
85	2725.07	I	8492 - 45178		3066.35	II	0 - 32603
75	2727.42	I	8437 - 45091	70	3071.24	II	9518 - 42069
21	2731.13	I	8602 - 45206	600	3072.11	II	225 - 32767
40	2731.58	I	8492 - 45091	1100	3072.97	II	0 - 32532
170	2733.26	I	8602 - 45178	1600	3075.22	II	94 - 32603
55	2735.29	I	8492 - 45041	2300	3078.64	II	225 - 32698
40	2735.61	I	7255 - 43800	3600	3088.02	II	393 - 32767
85	2739.81	I	8602 - 45091	180	3089.40	II	15266 - 47625

Titanium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
180	3097.19	II	9931 - 42209	220	3282.33	II	9873 - 40330
180	3100.67	I	8602 - 40844	530	3287.66	II	15266 - 45674
230	3103.80	II	15258 - 47467	290	3292.08	I	7255 - 37623
230	3105.08	II	9873 - 42069	170	3299.41	I	7255 - 37555
260	3106.23	II	10025 - 42209	170	3306.88	I	17215 - 47447
70	3106.81	I	8492 - 40671	220	3308.39	I	8437 - 38654
50	3110.67	II	9931 - 42069	220	3308.81	II	1087 - 31301
50	3112.48	I	8437 - 40556	260	3309.50	I	8492 - 38700
140	3117.67	II	9931 - 41997	60	3309.73	I	17075 - 47281
720	3119.72	I	12118 - 44163	110	3312.69	I	16961 - 47140
	3119.80	II	10025 - 42069				
190	3123.07	I	7255 - 39266	840	3314.42	I	8602 - 38765
240	3130.80	II	94 - 32026		3314.52	I	8492 - 38654
140	3141.54	I	7255 - 39078	290	3315.32	II	9873 - 40027
95	3141.67	I	17215 - 49036	330	3318.02	II	984 - 31114
				550	3321.70	II	9931 - 40027
220	3143.76	II	225 - 32026	2900	3322.94	II	1216 - 31301
240	3148.04	II	0 - 31757	380	3326.76	II	908 - 30959
240	3152.25	II	984 - 32698	2100	3329.46	II	1087 - 31114
240	3154.20	II	908 - 32603	550	3332.11	II	10025 - 40027
240	3155.67	II	1087 - 32767	1800	3335.20	II	984 - 30959
500	3161.20	II	908 - 32532	1100	3340.34	II	908 - 30837
780	3161.77	II	984 - 32603	5700	3341.88	I	0 - 29915
1000	3162.57	II	1087 - 32698			II	4629 - 34543
1600	3168.52	II	1216 - 32767	120	3342.15	I	0 - 29912
2400	3186.45	I	0 - 31374	260	3343.77	II	1216 - 31114
1000	3190.87	II	8744 - 40075	330	3346.73	II	1087 - 30959
3100	3191.99	I	170 - 31489	4300	3349.04	II	4898 - 34748
50	3197.52	II	225 - 31491	12000	3349.41	II	393 - 30241
3800	3199.92	I	387 - 31629	120	3352.94	I	170 - 29986
780	3202.54	II	8710 - 39927	4100	3354.64	I	170 - 29971
50	3203.44	II	0 - 31207	290	3358.28	I	0 - 29769
240	3203.83	I	170 - 31374	290	3360.99	I	170 - 29915
50	3204.87	I	8492 - 39686	7200	3361.21	II	225 - 29968
110	3213.14	II	94 - 31207		3361.26	I	170 - 29912
260	3214.24	I	387 - 31489	120	3361.84	I	170 - 29907
190	3214.75	II	393 - 31491	1100	3370.44	I	0 - 29661
1100	3217.06	II	225 - 31301	4300	3371.45	I	387 - 30039
110	3217.94	I	15877 - 46944	140	3372.21	II	4898 - 34543
260	3218.27	II	12677 - 43741	5700	3372.80	II	94 - 29734
110	3219.21	I	15976 - 47030	60	3374.35	II	9976 - 39603
110	3221.38	I	16106 - 47140	2900	d 3377.48	I	387 - 29986
1300	3222.84	II	94 - 31114		3377.58	I	170 - 29769
220	3223.52	I	16268 - 47281	290	3379.22	I	387 - 29971
240	3224.24	II	12775 - 43781	1400	3380.28	II	393 - 29968
140	3226.13	I	16459 - 47447	170	3382.31	I	8602 - 38160
530	3228.60	II	8710 - 39675	5700	3383.76	II	0 - 29544
780	3229.19	II	0 - 30959	170	3385.66	I	387 - 29915
530	3229.42	II	9118 - 40075	1400	3385.95	I	387 - 29912
110	3231.32	II	1087 - 32026	1400	3387.84	II	225 - 29734
240	3232.28	II	8998 - 39927	60	3388.76	II	9976 - 39477
6600	3234.52	II	393 - 31301	140	3390.68	I	8492 - 37977
220	3236.12	II	8710 - 39603	140	3392.71	I	12118 - 41585
5200	3236.57	II	225 - 31114	1100	3394.58	II	94 - 29544
4100	3239.04	II	94 - 30959	60	3398.63	I	8437 - 37852
220	3239.66	II	8744 - 39603	60	3402.42	II	9851 - 39233
2600	3241.99	II	0 - 30837	60	3407.20	II	393 - 29734
1200	3248.60	II	10025 - 40798	95	3409.81	II	225 - 29544
950	3251.91	II	94 - 30837	60	3439.30	I	11777 - 40844
1200	3252.91	II	225 - 30959	890	3444.31	II	1216 - 30241
1200	3254.25	II	393 - 31114	60	3452.47	II	16516 - 45473
1200	3261.60	II	15258 - 45909	180	3456.39	II	16625 - 45549
310	3271.65	II	10025 - 40582	600	3461.50	II	1087 - 29968
310	3272.08	II	9873 - 40426	95	3467.26	I	8492 - 37325
200	3278.29	II	9931 - 40426	600	3477.18	II	984 - 29734
260	3278.92	II	8744 - 39233	60	3478.92	I	8437 - 37173

Titanium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	3480.53	I	8602 - 37325	600	3771.66	I	387 - 26893
60	3485.69	I	8492 - 37173	30	3776.06	II	12758 - 39233
60	3489.74	II	1087 - 29734	840	3786.04	I	7255 - 33661
480	3491.05	II	908 - 29544	120	3789.30	I	11777 - 38160
60	3495.75	I	8492 - 37091	70	3795.90	I	11640 - 37977
95	3499.10	I	8602 - 37173	60	3798.31	I	11532 - 37852
890	3504.89	II	15258 - 43781	70	3818.22	I	18193 - 44376
120	3506.64	I	387 - 28896	60	3822.03	I	17075 - 43232
600	3510.84	II	15266 - 43741	240	3828.19	I	17215 - 43330
60	3520.25	II	16516 - 44915	95	3833.68	I	
310	3535.41	II	16625 - 44902	95	3836.78	I	
190	3547.03	I	12118 - 40303	60	3846.45	I	
120	3573.74	II	4629 - 32603	130	3853.05	I	15877 - 41823
60	3574.24	I	18288 - 46258	130	3853.73	I	15976 - 41917
60	3587.13	II	4898 - 32767	170	3858.14	I	16106 - 42018
240	3596.05	II	4898 - 32698	240	3866.44	I	16268 - 42124
190	3598.72	I	7255 - 35035	170	3868.40	I	15976 - 41819
600	3610.16	I	7255 - 34947	120	3873.21	I	16106 - 41917
190	3624.82	II	9851 - 37431	260	3875.26	I	0 - 25798
95	3635.20	I	387 - 27888			I	16106 - 41903
4800	3635.46	I	0 - 27499	170	3882.15	I	16268 - 42019
120	3637.97	I	0 - 27480	170	3882.33	I	16268 - 42018
190	3641.33	II	9976 - 37431	500	3882.89	I	16459 - 42206
6600	3642.68	I	170 - 27615	60	3888.02	I	16106 - 41819
180	3646.20	I	0 - 27418	70	3889.95	I	0 - 25700
7200	3653.50	I	387 - 27750	200	3895.25	I	16459 - 42124
290	3654.59	I	0 - 27355	85	3898.49	I	0 - 25644
660	3658.10	I	170 - 27499	530	3900.54	II	9118 - 34748
120	3659.76	II	12758 - 40075	180	3900.96	I	170 - 25798
380	3660.63	I	170 - 27480	2600	3904.78	I	7255 - 32858
190	3662.24	II	12629 - 39927	110	3911.19	I	16459 - 42019
380	3668.97	I	170 - 27418	500	3913.46	II	8998 - 34543
600	3671.67	I	387 - 27615	500	3914.34	I	387 - 25927
3100	3685.20	II	4898 - 32026	24	3914.74	I	0 - 25537
120	3685.96	I	11532 - 38654	35	3919.82	I	12118 - 37623
95	3687.35	I	387 - 27499	290	3921.42	I	0 - 25494
600	3689.91	I	387 - 27480	1100	3924.53	I	170 - 25644
140	3694.45	I	11640 - 38700	110	3926.32	I	20796 - 46258
30	3698.18	I	18145 - 45178	890	3929.88	I	0 - 25439
60	3698.43	I	11640 - 38671	35	3932.02	II	9118 - 34543
60	3700.08	I		70	3934.24	I	387 - 25798
120	3702.29	I	8437 - 35439	1100	3947.78	I	170 - 25494
190	3704.30	I	11777 - 38765	4500	3948.67	I	0 - 25318
140	3706.23	II	12629 - 39603	4500	3956.34	I	170 - 25439
50	3707.53	I	16268 - 43232	5200	3958.21	I	387 - 25644
290	3709.96	I	8492 - 35439	950	3962.85	I	0 - 25227
30	3715.40	I		950	3964.27	I	170 - 25388
450	3717.40	I	0 - 26893	4800	3981.76	I	0 - 25107
140	3721.64	II	4629 - 31491	570	3982.48	I	0 - 25103
330	3722.57	I	170 - 27026	60	3984.33	I	16961 - 42053
600	3724.57	I	12118 - 38960	35	3985.25	I	
380	3725.16	I	8602 - 35439	60	3985.59	I	
2900	3729.82	I	0 - 26803	5700	3989.76	I	170 - 25227
50	3735.67	I		35	3994.70	I	16875 - 41901
60	3738.90	I	15157 - 41895	7800	3998.64	I	387 - 25388
3300	3741.06	I	170 - 26893	70	3999.36	I	16961 - 41959
330	3741.64	II	12758 - 39477	70	4002.49	I	17075 - 42053
160	3748.10	I	15108 - 41781	70	4003.81	I	17215 - 42185
5200	3752.86	I	387 - 27026	35	4005.97	I	16961 - 41917
600	3753.64	I	170 - 26803	70	4008.06	I	17075 - 42018
140	3757.69	II	12629 - 39233	950	4008.93	I	170 - 25107
3300	3759.30	II	4898 - 31491	190	4009.66	I	170 - 25103
2900	3761.32	II	4629 - 31207	70	4012.39	II	4629 - 29544
50	3761.89	II	20892 - 47467	180	4013.58	I	17215 - 42124
60	3766.45	I	8492 - 35035	70	4015.38	I	16817 - 41714

Titanium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
35	4016.28	I	17215 - 42107	160	4284.99	I	14028 - 37359
120	4017.77	I	16875 - 41757	890	4286.01	I	6661 - 29986
140	4021.83	I	16961 - 41819	840	4287.40	I	6743 - 30060
1200	4024.57	I	387 - 25227	30	4288.16	I	6599 - 29912
40	4025.14	II	4898 - 29734			I	8492 - 31806
190	4026.54	I	17075 - 41903	950	4289.07	I	6599 - 29907
40	4027.48	I		120	4290.23	II	9396 - 32698
40	4028.34	II	15258 - 40075	840	4290.94	I	6557 - 29855
190	4030.51	I	17215 - 42019	120	4291.14	I	
40	4033.91	I	17424 - 42207	140	4294.12	II	8744 - 32026
30	4034.91	I	17370 - 42146	840	4295.76	I	6557 - 29829
110	4035.83	I	17540 - 42311	2000	4298.66	I	6599 - 29855
35	4040.32	I	17075 - 41819	200	4299.23	I	14106 - 37359
290	4055.02	I	8437 - 33091	200	4299.64	I	6661 - 29912
85	4057.62	I	18594 - 43232	200	4300.05	II	9518 - 32767
85	4058.14	I	18695 - 43330	2900	4300.56	I	6661 - 29907
410	4060.26	I	8492 - 33114	4100	4301.09	I	6743 - 29986
200	4064.22	I	8492 - 33091	85	4301.93	II	9364 - 32603
200	4065.10	I	8492 - 33085	6000	4305.92	I	6843 - 30060
840	4078.47	I	8602 - 33114	180	4307.90	II	9396 - 32603
40	4079.72	I	17424 - 41929	35	4308.50	I	8602 - 31806
290	4082.46	I	8602 - 33091	40	4311.65	I	17370 - 40556
85	4099.17	I	17540 - 41929	85	4312.87	II	9518 - 32698
220	4112.71	I	387 - 24695	85	4314.35	I	6743 - 29915
85	4122.17	I	21470 - 45722	1200	4314.80	I	6743 - 29912
40	4123.31	I	22405 - 46650			I	6599 - 29769
85	4123.57	I	21588 - 45832	360	4318.64	I	18193 - 41342
130	4127.54	I	21740 - 45960	180	4321.66	I	18037 - 41170
40	4129.17	I		190	4325.13	I	18141 - 41255
40	4131.25	I	18525 - 42724	160	4326.36	I	6661 - 29769
140	4137.29	I	18695 - 42859	30	4334.84	I	6599 - 29661
85	4143.05	I	18594 - 42724	160	4337.92	II	8710 - 31756
170	4150.96	I	17540 - 41624	24	4344.29	II	8744 - 31756
85	4159.64	I	17424 - 41458	70	4346.11	I	18037 - 41040
70	4163.65	II	20892 - 44902	35	4354.06	I	17424 - 40385
35	4164.14	I	15108 - 39116	95	4360.49	I	17540 - 40467
40	4166.32	I	15157 - 39152	24	4368.94	I	18288 - 41170
85	4169.35	I	15220 - 39198	95	4369.68	I	20796 - 43674
120	4171.03	I	17370 - 41337	60	4372.38	I	20063 - 42928
40	4171.90	II	20952 - 44915	30	4388.08	I	18062 - 40844
35	4183.30	I	18062 - 41959	170	4393.92	I	18288 - 41040
360	4186.12	I	12118 - 36000	330	4395.04	II	8744 - 31491
40	4188.69	I	18062 - 41929	60	4399.77	II	9976 - 32698
70	4200.75	I	18145 - 41944	240	4404.28	I	18145 - 40844
85	4203.46	I	18145 - 41929	60	4404.90	I	15157 - 37852
35	4211.73	I	20063 - 43800	30	4405.68	I	8492 - 31184
40	4224.79	I	22405 - 46068	60	4416.54	I	15108 - 37744
40	4227.65	I	20063 - 43710	220	4417.28	I	15220 - 37852
130	4237.89	I	20210 - 43800	60	4417.72	II	9396 - 32026
85	4249.12	I	18525 - 42053	120	4421.76	I	18062 - 40671
130	4256.04	I	18695 - 42185	120	4422.82	I	8602 - 31206
70	4258.54	I	18483 - 41959	24	4424.39	I	18288 - 40883
70	4261.60	I	18594 - 42053	30	4425.83	I	8602 - 31191
330	4263.13	I	15220 - 38671	120	4426.06	I	15157 - 37744
35	4265.71	I	15108 - 38544	890	4427.10	I	12118 - 34700
40	4266.22	I	18525 - 41959	21	4430.02	I	19422 - 41988
70	4270.14	I	18695 - 42107	85	4430.37	I	11640 - 34205
85	4272.43	I	6661 - 30060	50	4431.28	I	17996 - 40556
240	4274.58	I	6599 - 29986	30	4432.60	I	
		I	15157 - 38544	24	4433.58	I	19323 - 41872
120	4276.43	I	13982 - 37359	170	4434.00	I	11532 - 34079
120	4278.23	I	20796 - 44163			I	15108 - 37655
30	4278.81	I	18594 - 41959	70	4436.59	I	15157 - 37690
110	4281.38	I	6557 - 29907	30	4438.23	I	18145 - 40671
220	4282.71	I	15108 - 38451	130	4440.35	I	15108 - 37623

Titanium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	4441.27	I	15108 - 37618	480	4623.09	I	14028 - 35653
230	4443.80	II	8710 - 31207	190	4629.34	I	13982 - 35577
24	4444.27	I	18062 - 40556	50	4634.87	d	
840	4449.15	I	15220 - 37690	60	4637.88	I	18912 - 40467
30	4450.49	II	8744 - 31207	240	4639.37	I	14028 - 35577
550	4450.90	I	15157 - 37618	220	4639.67	I	14106 - 35653
840	4453.32	I	11532 - 33981	190	4639.95	I	13982 - 35528
290	4453.71	I	15108 - 37555	140	4645.19	I	13982 - 35503
950	4455.33	I	11640 - 34079	120	4650.02	I	14028 - 35528
1100	4457.43	I	11777 - 34205	24	4656.04	I	14106 - 35577
21	4462.09	I	0 - 22405	720	4656.47	I	0 - 21470
70	4463.38	I	15157 - 37555	840	4667.59	I	170 - 21588
95	4463.54	I	15220 - 37618	70	4675.12	I	8602 - 29986
290	4465.81	I	14028 - 36415	950	4681.92	I	387 - 21740
240	4468.50	II	9118 - 31491	21	4686.92	I	17370 - 38700
240	4471.24	I	13982 - 36341	24	4690.80	I	8602 - 29915
95	4474.85	I	11640 - 33981	190	4691.34	I	8602 - 29912
95	4479.70	I	13982 - 36298	40	4693.68	I	170 - 21470
50	4480.59	I	14028 - 36341	24	4696.94	I	17370 - 38654
530	4481.26	I	14106 - 36415	190	4698.76	I	8492 - 29769
95	4482.69	I	11777 - 34079	120	4710.19	I	8437 - 29661
19	4488.32	II	25193 - 47467	24	4715.30	I	387 - 21588
260	4489.09	I	14028 - 36298	65	4722.62	I	8492 - 29661
24	4492.55	I	16961 - 39214	65	4723.17	I	8602 - 29769
40	4495.01	I		55	4731.17	I	17540 - 38671
240	4496.15	I	14106 - 36341	45	4733.43	I	17424 - 38544
24	4497.73	I	17075 - 39302	18	4734.68	I	18037 - 39152
200	4501.27	II	8998 - 31207	22	4742.11	I	17370 - 38451
40	4503.78	I	17215 - 39413	170	4742.79	I	18037 - 39116
21	4506.36	I		22	4747.68	I	18141 - 39198
50	4511.17	I		310	4758.12	I	18141 - 39152
780	4512.74	I	6743 - 28896	310	4759.28	I	18193 - 39198
19	4515.62	I	17075 - 39214	45	4766.33	I	18141 - 39116
1000	4518.03	I	6661 - 28788	28	4769.77	I	18193 - 39152
95	4518.70	I	11532 - 33656	65	4778.26	I	18037 - 38960
1000	4522.80	I	6599 - 28703	45	4781.72	I	6843 - 27750
780	4527.31	I	6557 - 28639	110	4792.49	I	18826 - 39686
6000	4533.24	I	6843 - 28896	45	4796.22	I	18818 - 39662
240	4533.97	II	9976 - 32026	35	4797.98	I	18826 - 39662
3600	4534.78	I	6743 - 28788	110	4799.80	I	18288 - 39116
2400	4535.58	I	6661 - 28703	28	4805.10	II	16625 - 37431
1200	4535.92	I	6599 - 28639	110	4805.43	I	18912 - 39716
1200	4536.05	I	6557 - 28596	45	4808.53	I	24695 - 45485
24	4537.23	I		22	4811.08	I	15220 - 36000
24	4539.10	I		40	4812.25	I	18912 - 39686
720	4544.69	I	6599 - 28596	200	4820.42	I	12118 - 32858
950	4548.77	I	6661 - 28639	22	4825.46	I	18695 - 39413
240	4549.63	II	12775 - 34748	40	4836.13	I	18288 - 38960
950	4552.46	I	6743 - 28703	470	4840.87	I	7255 - 27907
24	4555.08	I	19422 - 41369	65	4848.47	I	17540 - 38160
720	4555.49	I	6843 - 28788	290	4856.01	I	18193 - 38780
19	4557.86	I	19938 - 41872	35	4864.18	I	17424 - 37977
19	4558.11	I	18912 - 40844	200	4868.26	I	18037 - 38573
60	4559.92	I	11777 - 33701	250	4870.14	I	18141 - 38669
50	4562.63	I	170 - 22081	28	4880.91	I	17370 - 37852
35	4563.43	I	19574 - 41481	45	4882.35	I	18193 - 38669
110	4563.77	II	9851 - 31756	400	4885.08	I	15220 - 35685
35	4570.91	I	19323 - 41194	380	4899.91	I	15157 - 35560
240	4571.98	II	12677 - 34543	320	4913.62	I	15108 - 35454
19	4585.84			55	4915.24	I	15220 - 35560
24	4589.95	II	9976 - 31756	130	4919.87	I	17424 - 37744
60	4599.23	I		180	4921.77	I	17540 - 37852
21	4609.37	I		55	4925.41	I	15157 - 35454
950	4617.27	I	14106 - 35758	30	4926.16	I	6599 - 26893
24	4619.52	I	18826 - 40467	150	4928.34	I	17370 - 37655

Titanium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
30	4937.74	I	6557 - 26803	120	5206.08	I	20063 - 39266
95	4938.29	I	20796 - 41040	75	5207.87	I	16817 - 36014
30	4941.58	I	17424 - 37655	65	5208.42		
21	4948.19	I	17540 - 37744	1400	5210.39	I	387 - 19574
21	4958.25	I	7255 - 27418	65	5212.29	I	
55	4964.75	I	15877 - 36014	150	5219.71	I	170 - 19323
21	4966.04	I	17424 - 37555	95	5222.69	I	16817 - 35959
65	4968.58	I	15976 - 36096	85	5223.64	I	16875 - 36014
75	4973.05	I	16106 - 36209	250	5224.32	I	17215 - 36351
120	4975.35	I	20210 - 40303	95	5224.56	I	16961 - 36096
65	4977.74	I	16268 - 36351	190	5224.95	I	17075 - 36209
120	4978.20	I	15877 - 35959	65	5226.56	II	12629 - 31756
5800	4981.73	I	6843 - 26911	120	5238.58	I	6843 - 25927
150	4989.15	I	15976 - 36014	21	5246.15	I	20210 - 39266
4600	4991.07	I	6743 - 26773	55	5246.57	I	6743 - 25798
30	4995.08	I	18145 - 38160	75	5247.31	I	16961 - 36014
140	4997.10	I	0 - 20006	21	5250.95	I	6661 - 25700
4000	4999.51	I	6661 - 26657	110	5252.11	I	387 - 19422
230	5001.01	I	16106 - 36096	75	5255.83	I	17075 - 36096
3600	5007.21	I	6599 - 26564	55	5259.99	I	22081 - 41087
120	5009.65	I	170 - 20126	55	5263.50	I	17215 - 36209
230	5013.30	I	16268 - 36209	150	5265.98	I	15220 - 34205
3200	5014.19	I	0 - 19938	40	5282.39	I	8492 - 27418
	5014.24	I	6557 - 26494	140	5283.45	I	15157 - 34079
580	5016.17	I	6843 - 26773	35	5284.39	I	8437 - 27355
840	5020.03	I	6743 - 26657	26	5288.81		
840	5022.87	I	6661 - 26564	65	5295.79	I	8602 - 27480
580	5024.84	I	6599 - 26494	120	5297.26	I	15108 - 33981
300	5025.58	I	16459 - 36351	65	5298.44	I	20210 - 39078
1200	5035.91	I	11777 - 31629	26	5336.81	II	12758 - 31491
840	5036.47	I	11640 - 31489	17	5341.50	I	34947 - 53663
740	5038.40	I	11532 - 31374	75	5351.08	I	22405 - 41087
1200	5039.95	I	170 - 20006	26	5366.65	I	6599 - 25227
75	5040.62	I	6661 - 26494	55	5369.64	I	
85	5043.59	I	6743 - 26564	40	5389.18	I	6557 - 25107
35	5044.27	I	17540 - 37359	55	5389.99	I	15108 - 33656
55	5045.41	I	6843 - 26657	17	5396.60	I	170 - 18695
26	5048.21	I	17370 - 37173	85	5397.09	I	15157 - 33680
110	5052.87	I	17540 - 37325	35	5404.02	I	18826 - 37325
21	5054.08	I	21588 - 41369	110	5409.61	I	15220 - 33701
110	5062.11	I	17424 - 37173	40	5426.26	I	170 - 18594
35	5064.07	I	21740 - 41481	75	5429.15	I	18912 - 37325
1400	5064.66	I	387 - 20126	26	5436.73	I	7255 - 25644
95	5065.99	I	11640 - 31374	17	5438.32	I	11532 - 29915
35	5068.33	I	21470 - 41194	40	5446.64	I	18818 - 37173
65	5069.35	I	17370 - 37091	11	5448.34	Ti O	
130	5071.48	I	11777 - 31489	30	5448.90	I	18826 - 37173
40	5085.34	I	11532 - 31191	21	5449.16	I	11640 - 29986
130	5087.07	I	11532 - 31184	35	5453.65	I	11640 - 29971
21	5103.15	I		55	5460.51	I	387 - 18695
55	5109.44	I	11640 - 31206	75	5471.21	I	11640 - 29912
190	5113.44	I	11640 - 31191	35	5472.70	I	11640 - 29907
270	5120.42	I	20796 - 40320	40	5473.55	I	18826 - 37091
30	5129.15	II	15258 - 34748	85	5474.23	I	11777 - 30039
270	5145.47	I	11777 - 31206	30	5474.46	I	18912 - 37173
230	5147.48	I	0 - 19422	120	5477.71	I	19574 - 37825
210	5152.20	I	170 - 19574	110	5481.43	I	19422 - 37660
21	5166.86	Ti O		75	5481.87	I	11532 - 29769
1100	5173.75	I	0 - 19323	85	5488.20	I	19323 - 37539
40	5186.34	I	17075 - 36351	150	5490.15	I	11777 - 29986
85	5188.70	II	12758 - 32026	26	5490.84	I	387 - 18594
30	5189.58	I	18061 - 37325	110	5503.90	I	20796 - 38960
1300	5192.98	I	170 - 19422	40	5511.78	I	20063 - 38201
85	5194.04	I	16961 - 36209	340	5512.53	I	11777 - 29912
65	5201.10	I	16875 - 36096	270	5514.35	I	11532 - 29661

Titanium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
320	5514.54	I	11640 - 29769	30	bl	Ti O	
26	5530.49			35		I	17540 - 33701
110	5565.49	I	18037 - 36000	95	h	I	21740 - 37825
13	5579.16			75	h	I	21588 - 37660
21	h			65	h	I	21470 - 37539
30	h			380		I	11640 - 27615
65	bl	Ti O		380		I	11777 - 27750
55	bl	Ti O		300		I	11532 - 27499
17	5635.84			65		I	11640 - 27499
250	5644.14	I	18288 - 36000	55		I	11777 - 27615
75	5648.58	I	20126 - 37825	26		I	11532 - 27355
26	bl	Ti O		30		I	11640 - 27418
190	5662.16	I	18695 - 36351	35		I	11777 - 27480
75	5662.91	I	20006 - 37660	11		I	17540 - 33114
21	5673.42	I	25103 - 42724	17		I	11640 - 27026
130	5675.44	I	18594 - 36209	19		I	11532 - 26893
30	h			55		I	11532 - 26803
95	5679.94	I	19938 - 37539	65		I	11640 - 26893
75	5689.47	I	18525 - 36096	11	h		
35	5702.68	I	18483 - 36014	75		I	11777 - 27026
35	5708.23	I	18695 - 36209	19	h		
65	5711.88	I	18594 - 36096	14	h		
40	h			35		I	20796 - 36000
95	5713.92	I	18463 - 35959	18	bl	Ti O	7255 - 22405
55	5715.13	I	18193 - 35685	18	h		
55	5716.48	I	18525 - 36014	22	h		
35	5720.48	I	18483 - 35959	9			
85	5739.51	I	18141 - 35560	18		I	20063 - 35035
40	5740.02	I	18037 - 35454	22	b	Ti O	
19	5741.22	I	20210 - 37623	26		I	20063 - 34947
21	5752.84	I	18062 - 35439	16	bl	Ti O	
19	5756.86	I		80		I	7255 - 22081
40	h			22		I	18037 - 32857
55	h			18			
75	h			18			
30	5762.27	I	26494 - 43844	18			
75	5766.35	I	26564 - 43902	35		I	18288 - 32858
30	5774.05	I	26657 - 43972	9		I	21588 - 36132
75	5780.78	I	18145 - 35439	12		I	21740 - 36201
75	h			14	h	I	25107 - 39527
65	hl			14	h	I	25388 - 39786
21	bl	Ti O	26911 - 44135	23		I	18826 - 33114
40	5823.71	I	18288 - 35454	15		I	18818 - 33091
21	h			14		I	18826 - 33091
21	5841.18			14	h	I	18826 - 33085
21	5852.34			14	h	I	25318 - 39527
400	5866.46	I	8602 - 25644	40		I	18912 - 33114
65	5880.31	I	8492 - 25494	14		I	18912 - 33091
21	h			40	bl	Ti O	
230	5899.32	I	8492 - 25439	23		I	25644 - 39786
55	5903.33	I	8602 - 25537	23			
120	5918.55	I	8602 - 25494	45	bl	Ti O	
150	5922.12	I	8437 - 25318	30	b	Ti O	
75	5937.82	I	8602 - 25439	40	bl	Ti O	
120	5941.76	I	8492 - 25318	26		I	11640 - 25644
300	5953.17	I	15220 - 32014	26			
200	5965.84	I	15157 - 31914	23			
270	5978.56	I	15108 - 31830	23			
340	5999.04	I	17540 - 34205	55		I	20796 - 34700
65	5999.68	I	18037 - 34700	26	b	Ti O	
21	6012.73			60		I	11777 - 25644
110	6064.63	I	8437 - 24921	60		I	11640 - 25494
120	6085.23	I	8492 - 24921	130		I	11640 - 25439
120	6091.17	I	18288 - 34700	130		I	11532 - 25318
40	6092.81	I	15220 - 31629	19			
40	h			19		I	13982 - 27740
35	h			19	b	Ti O	
120	6121.01	I	15157 - 31489	19			
19	6126.22	I	8602 - 24921	19			
30	6138.38	I	17370 - 33656	19			
30	6146.22	I	15108 - 31374	19			
21	6149.74	I	17424 - 33680	19			

Titanium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
15	7315.56	I	17540 - 31206	75	8364.24	I	6743 - 18695
26	7318.39	I	18145 - 31806	100	8377.85	I	6661 - 18594
120	7344.72	I	11777 - 25388	100	8382.54	I	6599 - 18525
11	7352.16	I	20063 - 33661	55	8382.82	I	6557 - 18483
90	7357.74	I	11640 - 25227	75	8396.87	I	6557 - 18463
60	7364.11	I	11532 - 25107	120	8412.36	I	6599 - 18483
26	7440.60	I	18193 - 31629	19	8416.98	I	18037 - 29915
9	7474.94	I	14106 - 27480	15	8424.41	I	16961 - 28829
26	7489.61	I	18141 - 31489	170	8426.52	I	6661 - 18525
19	7496.12	I	18037 - 31374	490	8434.94	I	6843 - 18695
12	7580.55	I	17996 - 31184	240	8435.70	I	6743 - 18594
9 bl	7589.62	Ti O		40	8438.93	I	18193 - 30039
15	7614.50	I	18062 - 31191	40	8450.89	I	18141 - 29971
23	7654.44	I	18145 - 31206	9 h	8457.10	I	14106 - 25927
11 bl	7705.21	Ti O		19 h	8467.15	I	17075 - 28882
30	7949.17	I	12118 - 24695	45	8468.50	I	15220 - 27026
26 h	7961.58	I	26657 - 39214	15	8496.04	I	18145 - 29912
60	7978.88	I	15220 - 27750	19 h	8518.05	I	17215 - 28952
9	7979.07	I	26773 - 39302	40	8518.32	I	15157 - 26893
30	7996.53	I	26911 - 39413	14	8539.38	I	18062 - 29769
7 h	8003.55			40	8548.12	I	15108 - 26803
55	8024.84	I	15157 - 27615	9	8569.77	I	17996 - 29661
30	8068.24	I	15108 - 27499	9 h	8598.18	I	18288 - 29915
8	8267.62			90	8675.39	I	8602 - 20126
14 h	8306.31	I	27750 - 39786	45	8682.99	I	8492 - 20006
9 h	8307.41	I	6661 - 18695	23	8692.33	I	8437 - 19938
9 h	8311.76	I	27499 - 39527	19	8734.69	I	8492 - 19938
8 h	8312.85	I	27615 - 39641	23	8766.64	I	8602 - 20006
12	8334.37	I	6599 - 18594	15 h	8778.71	I	14106 - 25494
14	8353.15	I	6557 - 18525				



# Tungsten

$$W, Z = 74, M = 183.8, \text{Ratio } \frac{W}{Cu} = 2.893$$

W I Normal state of valence electrons  $5d^46s^2 \ ^5D_0 = 0$ . I.P. = 64400  $\text{cm}^{-1}$ .

W II Normal state of valence electrons  $5d^46s \ ^6D_{1/2} = 0$ . I.P. = 143000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

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### Classification:

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W II, D. D. Laun, J. Res. Nat. Bur. Stand. (U.S.), **68A** (Phys. and Chem.), No. 2, 207-252 (Mar.-Apr. 1964).

### Strong lines of tungsten

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
15000	2029.98	II	6147 - 55393	2400	2098.60	II	1519 - 49154
13000	2008.07	II	4716 - 54499	2400	2121.59	II	3173 - 50292
9700	2079.11	II	6147 - 54229	2400	2944.40	I	2951 - 36904
8600	4008.75	I	2951 - 27890	2400	2946.99	I	2951 - 36874
7300	2026.08	II	4716 - 54057	2300	2065.57	II	4716 - 53114
6100	2094.75	II	1519 - 49242	2200	2075.59	II	8711 - 56875
5800	2001.71	II	3173 - 53114	2200	2089.14	II	4716 - 52567
5300	2049.63	II	1519 - 50292	2200	2100.67	II	0 - 47589
5100	2009.98	II	1518 - 51254	2200	4302.11	I	2951 - 26189
5000	4074.36	I	2951 - 27488	2100	2118.87	II	0 - 47180
4100	2010.23	II	3173 - 52902	2100	2681.42	I	2951 - 40234
4100	2014.23	II	3173 - 52803	2100	2718.91	I	2951 - 39720
4100	4294.61	I	2951 - 26230	1900	3617.52	I	2951 - 30587
3600	2088.19	II	3173 - 51045	1800	2435.96	I	4830 - 45869
3400	2071.21	II	3173 - 51438	1800	3867.99	I	2951 - 28797
2700	2035.03	II	7420 - 56544	1700	2090.48	I	0 - 47820
2700	2551.35	I	0 - 39183	1700	2405.58	I	1670 - 43228
2600	2724.35	I	2951 - 39646	1700	2405.69	I	4830 - 46385

*Tungsten—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
5800	2001.71	II	3173 - 53114	60	2358.81	II	3173 - 45554
13000	2008.07	II	4716 - 54499	580	2360.44	I	3326 - 45678
5100	2009.98	II	1518 - 51254	850	2363.07	I	1670 - 43975
4100	2010.23	II	3173 - 52902	60	2364.22	II	14968 - 57252
4100	2014.23	II	3173 - 52803	110	2365.45	I	0 - 42262
7300	2026.08	II	4716 - 54057	110	2365.85	I	17008 - 59264
15000	2029.98	II	6147 - 55393	110	2366.18	I	4830 - 47079
2700	2035.03	II	7420 - 56544	95	2366.96	I	9528 - 51763
5300	2049.63	II	1519 - 50292	150	2367.69	I	1670 - 43893
2300	2065.57	II	4716 - 53114	95	2370.89	I	2951 - 45117
3400	2071.21	II	3173 - 51438	35	2371.39	I	17107 - 59264
2200	2075.59	II	8711 - 56875	50	2374.13	I	6219 - 48326
9700	2079.11	II	6147 - 54229	510	2374.47	I	4830 - 46932
3600	2088.19	II	3173 - 51045	85	2374.76	I	3326 - 45422
2200	2089.14	II	4716 - 52567	95	2376.06	I	15070 - 57143
1700	2090.48	I	0 - 47820	50	2376.57	I	17107 - 59172
6100	2094.75	II	1519 - 49242	50	2377.05	I	16431 - 58487
2400	2098.60	II	1519 - 49154	210	2382.99	I	6219 - 48171
2200	2100.67	II	0 - 47589	670	2384.82	I	6219 - 48138
1500	2101.54	I	3326 - 50894	85	2386.16	I	17008 - 58904
1500	2106.18	II	1519 - 48983	240	2389.08	I	1670 - 43515
1300	2110.34	II	4716 - 52087	120	2390.37	II	7421 - 49242
2100	2118.87	II	0 - 47180	120	2392.93	II	4716 - 46493
2400	2121.59	II	3173 - 50292	120	2395.48	I	9528 - 51260
850	2153.56	II	6147 - 52567	730	2397.09	II	3173 - 44877
850	2157.80	II	4716 - 51045	560	2397.73	I	3326 - 45019
1500	2166.32	II	4716 - 50863	560	2397.98	I	3326 - 45015
480	2182.90	I	6219 - 52015	60	2399.04	I	17107 - 58778
440	2194.52	II	0 - 45554	30	2401.30	I	6219 - 47851
1300	2204.48	II	6147 - 51495	95	2402.45	I	13778 - 55389
460	2248.75	II	0 - 44455	75	2404.24	II	8711 - 50292
460	2249.80	I	1670 - 46105	50	2405.26	I	13349 - 54912
180	2270.24	II	1519 - 45554	1700 d	2405.58	I	1670 - 43228
95	2271.37	I	3326 - 47338		2405.69	I	4830 - 46385
510	2277.58	I	0 - 43893	95	2409.03	I	4830 - 46328
160	2284.91	I	1670 - 45422	60	2410.62	I	6219 - 47689
320	2285.17	I	6219 - 49966	75	2411.54	II	17437 - 58892
530 d	2294.49	I	6219 - 49789	320	2414.04	I	3326 - 44737
	2294.54	II	4716 - 48285	610	2415.68	I	1670 - 43054
270	2298.33	I	4830 - 48326	50	2416.24	I	6219 - 47593
240	2303.83	II	1519 - 44912	50	2419.34	II	20040 - 61361
240	2306.59	I	2951 - 46292	60	2420.20	I	13778 - 55084
340	2309.02	I	6219 - 49514	50	2421.01	II	13412 - 54705
440	2313.17	I	0 - 43217	130	2422.29	I	3326 - 44596
220	2314.17	I	6219 - 49418	40	2422.66	I	6219 - 47484
190	2315.02	II	3173 - 46355	870	2424.21	I	4830 - 46068
110	2318.96	I	15070 - 58179	190 d	2425.98	I	13349 - 54557
460	2321.63	I	3326 - 46385		2426.08	I	19535 - 60741
290	2326.09	II	6147 - 49125	130	2427.28	I	15070 - 56256
390 d	2326.56	I	6219 - 49188	190	2427.49	II	3173 - 44355
	2326.70	I	3326 - 46292	170	2429.39	II	26929 - 68079
75	2328.31	II	1519 - 44455	170	2429.84	I	6219 - 47362
180	2331.29	I	12162 - 55043	120	2430.44	I	14976 - 56109
75	2331.91	I	15460 - 58330	580	2431.08	I	3326 - 44447
75	2332.76	I	6219 - 49073	630	2433.98	I	4830 - 45902
130	2333.77	II	1519 - 44355	60	2435.01	II	20534 - 61590
210	2341.37	I	1670 - 44367	1800	2435.96	I	4830 - 45869
60	2343.12	I	17008 - 59673	29	2436.26	I	2951 - 43985
75	2347.97	I	3326 - 45902	250	2436.62	I	3326 - 44353
75	2349.26	II	20534 - 63088	29	2437.95	I	9528 - 50534
	2349.33	I	13307 - 55859	60	2442.98	I	13348 - 54269
120 d	2350.37	II	20456 - 62990	24	2443.33	I	19826 - 60741
	2350.46	I	4830 - 47362	95	2443.61	I	17008 - 57919
320	2354.61	I	6219 - 48676	580	2444.06	I	1670 - 42573
60	2358.07	I	12162 - 54557	160	2446.39	II	7421 - 48285

Tungsten—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
270	2448.39	I	12162 - 52993	29	2518.50	I	12162 - 51856
270	2451.35	I	12162 - 52943	95	2519.87	I	13307 - 52979
780	2451.48	II	1519 - 42298	310	2520.46	I	15070 - 54733
870	2452.00	I	0 - 40771	60	2520.98	I	13348 - 53003
430	2454.72	I	15070 - 55796	780	2521.32	I	2951 - 42601
630	2454.98	I	4830 - 45551	270	2522.04	II	4716 - 44355
780	2455.51	I	6219 - 46932	780	2523.41	I	4830 - 44447
780	2456.53	I	3326 - 44020	60	2523.59	I	17701 - 57315
1100	2459.30	I	3326 - 43975	75	2524.81	I	13349 - 52943
270	2460.16	I	6219 - 46855	140	2525.68	I	2951 - 42532
190	2461.57	I	12162 - 52774	95	2526.42	I	6219 - 45790
480	2462.79	I	1670 - 42262	430	2527.76	I	17008 - 56557
270	2464.30	I	3326 - 43893	190	2529.72	I	17008 - 56527
95	2465.20	I	17008 - 57561	24	2530.99	I	2951 - 42450
230	2466.52	II	1519 - 42049	780	2533.64	I	1670 - 41127
1400	2466.85	I	3326 - 43851	29	2533.98	I	15460 - 54912
75	2470.80	II	20781 - 61241	50	2534.68	I	15460 - 54900
75	2471.21	I	17107 - 57561	50	2534.82	II	20781 - 60219
480	2472.51	I	4830 - 45263	85	2535.11	I	1670 - 41104
95	d 2473.70	I	14976 - 55389	70	2539.31	I	13434 - 52803
	2473.82	I	0 - 40411				
1200	2474.15	I	6219 - 46625	75	2541.70	I	6219 - 45551
290	2477.80	II	6147 - 46493	120	2543.44	I	13348 - 52653
870	2480.13	I	1670 - 41979	29	2544.17	I	14976 - 54269
40	2480.66	I	2951 - 43251	580	2545.34	I	3326 - 42601
390	2480.96	I	1670 - 41965	1200	2547.14	I	3326 - 42573
1500	2481.44	I	6219 - 46506	35	2548.15	I	6219 - 45452
480	d 2482.10	I	2951 - 43228	35	2548.56	I	13777 - 53003
	2482.21	I	12162 - 52436	50	2549.09	II	3173 - 42390
29	2484.40	II	20040 - 60279	40	2550.10	II	23235 - 62437
580	2484.74	I	12162 - 52395	780	2550.38	I	1670 - 40868
130	2486.30	I	17107 - 57315	140	2551.00	I	3326 - 42514
390	2487.50	I	4830 - 45019	2700	2551.35	I	0 - 39183
270	2488.77	II	7420 - 47589	29	2551.99	I	17107 - 56280
120	2488.93	I	6219 - 46385	170	2553.17	I	4830 - 43985
390	2489.23	II	4716 - 44877	450	2553.82	I	4830 - 43975
70	2489.72	I	3326 - 43479	410	2554.86	II	0 - 39129
75	2490.85	I	17008 - 57143	580	2555.09	II	3173 - 42298
75	2492.93	II	14857 - 54959		2555.21	I	3326 - 42450
70	2493.39	I	12162 - 52256	40	2556.27	I	13777 - 52885
630	2495.26	I	1670 - 41734	310	2556.75	I	1670 - 40771
230	2496.64	II	4716 - 44758	75	2557.57	I	13349 - 52436
50	2496.97	I	17107 - 57143	29	2558.48	I	19256 - 58330
95	2497.48	II	6147 - 46175	290	2560.12	I	15070 - 54119
95	2499.43	I	13349 - 53346	29	2560.76	I	23484 - 62524
140	2499.69	II	7420 - 47413	85	2561.53	I	2951 - 41979
40	2500.11	II	18000 - 57986	730	2561.97	I	4830 - 43851
160	d 2501.78	I	2951 - 42911	230	2563.16	II	17437 - 56440
	2501.90	II	13412 - 53370	110	2563.91	II	11301 - 50292
14	2503.04	I	15070 - 55009	150	2564.70	I	17008 - 55988
40	2503.96	I	14976 - 54900	140	2567.51	I	3326 - 42262
70	2504.53	I	9528 - 49444	130	2568.21	I	3326 - 42251
680	2504.70	I	1670 - 41583	95	2568.56	I	2951 - 41872
40	2505.37	I	3326 - 43228	75	2568.99	I	19648 - 58563
95	2505.65	I	12162 - 52060	190	2569.25	I	12162 - 51072
270	2506.02	I	3326 - 43217		2569.30	II	15147 - 54057
24	2508.00	II	16553 - 56413	160	2570.10	I	6219 - 45117
95	2508.44	I	12162 - 52015	530	2571.44	II	3173 - 42049
190	2508.73	I	6219 - 46068	170	d 2572.24	II	20534 - 59399
250	2510.17	I	15070 - 54896		2572.35	II	13412 - 52276
75	2510.47	II	19071 - 58892	190	2573.53	I	13307 - 52153
29	2512.94	I	17008 - 56790	75	2573.95	II	16553 - 55393
140	2513.93	I	4830 - 44596	50	2575.47	I	19828 - 58644
85	2516.55	I	17107 - 56832	140	2577.03	I	15070 - 53863
60	2518.14	II	10593 - 50292	190	2579.26	II	23955 - 62714
				190	2579.41	I	13307 - 52064
					2579.54	II	7420 - 46175

Tungsten — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
290	2580.34	I	2951 - 41694	80	2653.57	II	4716 - 42390
870	2580.49	I	1670 - 40411	130	2654.66	I	15460 - 53118
140	2581.06	I	12162 - 50894	80	d 2655.56	I	19826 - 57471
40	2581.20	II	6147 - 44877		2655.67	II	8711 - 46355
				1600	2656.54	I	2951 - 40583
75	2583.22	I	13777 - 52477	400	2657.38	I	4830 - 42450
390	2584.39	I	17008 - 55691	400	d 2658.04	II	1519 - 39129
40	2585.24	I	23484 - 62154		2658.18	I	19535 - 57143
110	2585.43	I	13349 - 52015	80	2660.53	I	19256 - 56832
40	2586.35	I	3326 - 41979	80	2661.55	I	13349 - 50909
50	2586.64	I	4830 - 43479	810	2662.84	I	3326 - 40868
120	2586.94	I	12162 - 50806	80	2663.94	I	14976 - 52503
95	2587.77	I	2951 - 41583	160	2664.32	I	6219 - 43741
390	2589.17	II	6147 - 44758		2664.34	II	17437 - 54959
170	2591.49	II	0 - 38576	260	2664.97	I	1670 - 39183
70	2593.39	I	2951 - 41499	160	2665.78	I	6219 - 43721
50	2596.35	I	19826 - 58330	75	2666.49	II	7421 - 44912
70	2596.67	I	15460 - 53959	210	2669.30	I	13349 - 50800
75	2597.73	I	17008 - 55492	40	2669.78	I	3326 - 40771
70	2598.42	I	17701 - 56175	810	2671.47	I	4830 - 42251
110	2598.74	II	8711 - 47180	80	2673.59	II	18000 - 55392
75	2600.73	I	17107 - 55546	65	2674.69	I	22852 - 60229
370	2601.96	I	4830 - 43251	40	2675.13	I	13349 - 50719
75	2602.51	II	18000 - 56413	40	2675.40	I	15070 - 52436
130	2602.80	I	3326 - 41734	130	2675.87	I	1670 - 39030
75	2603.02	II	16553 - 54959	650	d 2677.28	I	3326 - 40666
270	2603.54	I	4830 - 43228	160	2677.79	II	4716 - 42049
150	2604.38	I	17107 - 55492		2677.91	I	17701 - 55033
170	2605.51	I	3326 - 41694	40	2678.53	I	19826 - 57149
680	2606.39	I	0 - 38356	400	2678.88	I	2951 - 40269
75	2606.89	I	17107 - 55455	130	2680.05	I	17008 - 54310
	2606.98	II	8833 - 47180	2100	2681.42	I	2951 - 40234
320	2607.38	I	1670 - 40011	290	2683.35	I	12162 - 49418
370	2608.32	I	6219 - 44547	80	2687.37	I	18974 - 56175
50	2610.74	I	9528 - 47819	210	2691.09	I	4830 - 41979
180	2612.19	I	19648 - 57919	40	2692.16	I	18974 - 56108
970	2613.08	I	3326 - 41583	650	2695.67	I	3326 - 40411
480	2613.82	I	2951 - 41198	130	2697.51	I	2951 - 40011
230	2615.12	I	6219 - 44447	210	2697.71	II	1519 - 38576
70	2615.44	II	15147 - 53370	160	2698.84	I	4830 - 41872
160	2618.81	I	3326 - 41499	650	2699.59	I	6219 - 43251
210	2619.18	I	15070 - 53238	400	2700.01	I	12162 - 49188
400	2620.25	I	2951 - 41104	40	2701.48	II	14857 - 51863
400	2622.21	I	15070 - 53194	160	2702.11	II	13434 - 50431
400	2625.22	I	4830 - 42911	210	2702.52	I	19535 - 56527
80	2626.24	I	14976 - 53042	80	2706.02	I	3326 - 40269
210	2628.26	I	1670 - 39707	400	2706.58	I	13349 - 50285
160	d 2628.89	I	14976 - 53003	40	2707.03	I	23484 - 60414
	2629.00	II	13412 - 51438	65	2707.88	I	19256 - 56175
400	2632.48	I	12162 - 50137	40	2708.19	I	16431 - 53346
400	2632.70	I	2951 - 40924	400	d 2708.59	I	15070 - 51979
810	2633.13	I	1670 - 39637	400	2708.80	I	1670 - 38576
290	2636.54	I	2951 - 40868		2708.93	I	4830 - 41734
400	d 2638.62	I	19256 - 57143	80	2709.58	II	14968 - 51863
	2638.75	I	15460 - 53346	40	2710.78	II	16235 - 53114
160	2643.12	I	13778 - 51600	400	2715.50	I	6219 - 43034
80	2644.60	I	6219 - 44020	80	2716.32	II	14634 - 51438
210	2645.69	I	15070 - 52856	80	2717.53	I	14976 - 51763
650	2646.18	I	3326 - 41104		2717.61	I	15070 - 51856
400	2646.73	I	4830 - 42601	80	2718.04	II	16590 - 53370
160	2647.09	I	6219 - 43985	2100	2718.91	I	2951 - 39720
75	2647.74	II	25209 - 62966	320	2719.33	I	16431 - 53194
80	2649.98	I	17008 - 54733	210	2719.86	I	2951 - 39707
160	2652.59	I	16431 - 54119	160	d 2722.67	I	14976 - 51694
40	2653.42	II	16553 - 54229		2722.81	II	15147 - 51863

Tungsten— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
2600	2724.35	I	2951 - 39646	1600	2831.38	I	2951 - 38259
210	2724.62	I	6219 - 42911	810	2833.63	I	6219 - 41499
400	2725.03	I	3326 - 40011	210	2835.64	I	2951 - 38206
	2725.06	I	1670 - 38356	80	2836.25	I	19648 - 54896
130	2727.95	I	6219 - 42866	110	2837.34	I	1670 - 36904
80	2729.62	II	8833 - 45457	40	2837.77	I	18117 - 53345
80	2733.18	I	9528 - 46105	40	2838.89	I	15070 - 50285
40	2735.98	I	19256 - 55796	130	2839.34	I	9528 - 44737
40	2738.00	I	16431 - 52943	400	2841.57	I	4830 - 40011
75	2740.79	II	23804 - 60279	40	2842.57	I	16431 - 51600
160	2743.43	I	13349 - 49789	80	2843.78	I	
80	2744.34	I	19828 - 56256	160	2847.83	I	3326 - 38430
40	2746.21	I	15069 - 51473	810	2848.02	I	2951 - 38053
80	2746.74	I	15460 - 51856	160	2849.47	I	19828 - 54912
650	2748.84	I	4830 - 41198		2849.56	I	13307 - 48390
160	2753.05	I	19535 - 55847	130	2850.81	I	15070 - 50138
80	2754.92	I	13349 - 49637	40	2852.91	I	16431 - 51473
40	2755.27	I	17107 - 53390	80	2853.50	I	15460 - 50495
80	2755.94	I	4830 - 41104	40	2853.84	I	3326 - 38356
40	2760.04	I	15070 - 51291	80	2855.35	I	13307 - 48319
40	d 2760.74	II	19277 - 55488	650	2856.03	I	1670 - 36674
	2760.84	I	13307 - 49517	80	2857.14	I	14976 - 49966
80	2761.59	II	8711 - 44912	160	2858.04	I	6219 - 41198
400	2762.34	I	0 - 36190	130	2863.01	I	1670 - 36588
400	2764.27	II	0 - 36165	130	2863.89	I	19826 - 54733
210	2768.98	I	1670 - 37774	650	2866.06	I	3326 - 38206
400	2769.74	I	4830 - 40924	40	2866.39	I	4830 - 39707
810	2770.88	I	2951 - 39030	40	2870.91	I	13349 - 48171
210	2773.70	I	19648 - 55690	130	2871.36	I	4830 - 39646
810	2774.00	I	4830 - 40868	130	2875.21	I	12162 - 46932
810	2774.48	I	6219 - 42251	230	2878.72	I	3326 - 38053
160	2776.50	II	14857 - 50863	610	2879.11	I	2951 - 37674
40	2778.69	II	16590 - 52567	610	2879.40	I	0 - 34719
160	2779.73	I	16431 - 52395	40	2880.63	I	6219 - 40924
80	2780.28	I	19535 - 55492	90	2884.18	I	19648 - 54310
160	2783.13	I	19535 - 55455	90	2887.66	I	13349 - 47969
40	2785.90	I	18974 - 54859	40	2893.12	I	17701 - 52256
210	2787.98	I	3326 - 39183	40	2894.26	I	13778 - 48319
130	2789.07	I	19648 - 55492	440	2896.01	I	1670 - 36190
40	2789.68	I	4830 - 40666	1500	2896.44	I	2951 - 37466
340	2791.96	I	12162 - 47969	50	2900.52	I	13778 - 48244
810	2792.70	I	2951 - 38748	50	2901.79	I	17701 - 52153
80	2796.15	I	4830 - 40583	50	2907.26	I	18117 - 52503
40	2797.20	I	13778 - 49517	90	2908.27	I	16431 - 50806
80	2799.03	II	15147 - 50863		2908.40	I	18280 - 52653
400	2799.93	I	3326 - 39030	90	2909.12	I	9528 - 43893
160	d 2801.05	II	13434 - 49125	230	2910.48	I	3326 - 37674
	2801.17	I	12162 - 47851	270	2911.00	I	0 - 34342
80	2802.96	I	13778 - 49444	90	2915.12	I	14976 - 49270
80	2804.02	I	6219 - 41872	90	2915.59	I	17008 - 51296
130	2804.24	I	16431 - 52081	50	2917.67	I	18974 - 53238
80	2804.68	I	17701 - 53346	360	2918.25	I	6219 - 40476
130	2805.63	I	18117 - 53749	50	2918.63	II	11301 - 45554
130	2805.92	II	16235 - 51863	360	2923.10	I	4830 - 39030
80	2807.72	I	19254 - 54859	230	2923.54	I	2951 - 37146
65	2808.57	I	18280 - 53875	230	2925.13	I	15460 - 49637
40	2812.25	II	13434 - 48983	90	2926.99	I	17701 - 51856
40	2813.13	I	17701 - 53238	50	2927.93	I	18974 - 53118
80	2815.42	I	19535 - 55043	90	2928.19	I	3326 - 37466
810	2818.06	I	6219 - 41694	50	2928.66	I	13349 - 47484
160	2822.57	II	13412 - 48831	80	2930.15	I	15070 - 49188
130	d 2827.15	I	19648 - 55009	690	2935.00	I	1670 - 35732
	2827.29	I	15069 - 50429	50	2935.63	I	15460 - 49514
260	2829.82	I	13349 - 48676	95	2936.01	I	6219 - 40269
40	2830.29	I	12162 - 47484	50	2936.66	I	23046 - 57089

Tungsten — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
95	2937.14	I	19826 — 53863	260	3120.18	I	6219 — 38259
140	2939.05	I	6219 — 40234	160	3133.88	I	13778 — 45678
50	2941.25	I	13349 — 47338	130	3141.42	I	12162 — 43985
2400	2944.40	I	2951 — 36904	65	3149.85	II	13173 — 44912
2400	2946.99	I	2951 — 36874	65	3152.95	I	16431 — 48138
480	2947.39	I	4830 — 38748	65	3155.09	I	18280 — 49966
210	2952.29	II	14968 — 48831	95	3159.18	I	13778 — 45422
95	2954.90	I	18974 — 52806	290	3163.42	I	15070 — 46672
95	2960.15	I	13307 — 47079	130	3164.44	I	13349 — 44940
440	2964.52	I	2951 — 36674	130	3165.38	I	18117 — 49700
95	2966.58	I	17107 — 50806	65	3167.58	I	27849 — 59410
50	2967.07	I	17107 — 50800	95	3170.21	I	2951 — 34486
50	2967.55	I	15460 — 49148	320	3176.60	I	1670 — 33141
80	2969.62	I	13778 — 47443	130	3179.06	I	17701 — 49148
150	2971.68	I	1670 — 35311	65	3180.74	I	13307 — 44737
150	2972.92	I	12162 — 45790	190	3181.82	I	16431 — 47851
95	2976.80	I	13349 — 46932	130	3184.05	I	18117 — 49514
480	2977.11	I	19648 — 53228	130	3184.42	I	3326 — 34719
	2977.21	I	3326 — 36904	65	3189.24	II	15147 — 46493
730	d 2979.71	I	19256 — 52806	390	3191.57	I	0 — 31323
	2979.86	I	3326 — 36874	390	3198.84	I	4830 — 36082
150	2982.61	I	19256 — 52774	520	3207.25	I	2951 — 34122
95	2984.14	I	6219 — 39720	140	3208.28	I	3326 — 34486
150	2990.51	I	4830 — 38259	1000	3215.56	I	6219 — 37309
50	2990.71	I	6219 — 39646	140	3221.21	I	18117 — 49152
400	2993.61	I	6219 — 39614	140	3221.91	I	3326 — 34354
240	2995.26	I	4830 — 38206	190	3232.49	I	6219 — 37146
190	2997.79	I	3326 — 36674	80	3232.65	I	15460 — 46385
50	3000.24	I	19535 — 52856	140	3237.09	I	9528 — 40411
80	3001.98	I	13778 — 47079	140	3242.03	I	21449 — 52285
50	3002.83	I	19826 — 53118	140	3252.29	I	23047 — 53786
190	3009.09	I	4830 — 38053	210	3254.36	I	15070 — 45789
360	3013.79	I	4830 — 38001	140	3259.43	I	18117 — 48788
520	3016.47	I	6219 — 39361	210	3259.66	I	4830 — 35499
770	3017.44	I	2951 — 36082	210	d 3266.62	I	21453 — 52057
					3266.77	I	19535 — 50138
110	3024.50	II	11301 — 44355	150	3281.94	I	20064 — 50525
210	3024.93	I	1670 — 34719	150	3293.71	I	12162 — 42514
310	d 3026.67	I	19826 — 52856	730	3300.82	I	4830 — 35117
	3026.79	I	13778 — 46806	440	3311.38	I	2951 — 33141
160	3033.56	I	12162 — 45117	75	3316.09	I	1670 — 31818
160	3034.19	I	19826 — 52774	75	3320.36	I	9528 — 39637
160	3039.31	I		440	3326.20	I	6219 — 36275
440	d 3041.73	I	15460 — 48326	440	3331.69	I	2951 — 32958
	3041.86	I	3326 — 36190	75	3345.09	I	29460 — 59346
270	3043.80	I	4830 — 37674	75	3345.86	I	13349 — 43228
440	3046.44	I	1670 — 34486	150	3354.45	I	4830 — 34633
110	3048.66	I	18280 — 51072	75	3363.34	I	6219 — 35943
80	3049.00	I	28392 — 61180	150	3371.04	I	4830 — 34486
810	3049.69	I	2951 — 35732	80	3371.35	I	1670 — 31323
55	3054.01	I	9528 — 42262	390	3373.75	I	3326 — 32958
110	3064.93	I	3326 — 35943	80	3388.82	I	21449 — 50949
180	3073.28	I	6219 — 38748	80	3391.09	I	15460 — 44940
110	3077.52	II	23955 — 56439	80	3391.52	I	15070 — 44547
180	d 3084.83	I	17107 — 49514	80	3398.09	I	19256 — 48676
	3084.91	I	3326 — 35732	80	h 3408.38	I	23047 — 52378
95	c 3089.06	I	23484 — 55847	150	3412.96	I	4830 — 34122
	3089.18	I	14976 — 47338	150	3413.53	I	2951 — 32238
	3089.31	I	2951 — 35311	150	3422.42	I	24763 — 53974
65	3090.58	I	19254 — 51600	150	3427.71	I	13349 — 42514
370	3093.50	I	4830 — 37146	230	3429.59	I	19535 — 48685
65	3105.88	I	19828 — 52015	240	3443.00	I	12162 — 41198
240	3107.23	I	3326 — 35499	80	3448.83	I	15460 — 44447
240	3108.02	I	2951 — 35117	80	3463.25	I	2951 — 31818
65	3111.12	I	15460 — 47593	80	3468.40	I	13778 — 42601
230	3117.57	I	13307 — 45374				

Tungsten—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
80	3475.82	I	12162 - 40924	70	3767.84	I	19256 - 45790
160	3477.94	I	26676 - 55420	1000	3768.45	I	1670 - 28199
80	3481.82	I	19256 - 47969	120	3769.21	I	14976 - 41499
400	3495.24	I	19648 - 48251	120	3769.86	I	15460 - 41979
160	3508.73	I	3326 - 31818	70	3772.42	I	20983 - 47484
160	3510.02	I	2951 - 31433	340	3773.71	I	13778 - 40269
80	3521.91	I	13349 - 41734	75	3778.55	I	19648 - 46106
160	3526.85	I	13349 - 41694	75	3778.69	I	18280 - 44737
160	3535.54	I	13307 - 41583	1000	3780.77	I	2951 - 29393
160	3537.45	I	15070 - 43331	50	3783.73	I	19256 - 45678
650	3545.22	I	0 - 28199	35	3786.37	I	17008 - 43411
80	3554.21	I	4830 - 32958	170	3792.76	I	13349 - 39707
160	3568.04	I	15460 - 43479	85	3794.34	I	15070 - 41417
240	3570.65	I	3326 - 31323	35	3796.28	I	19535 - 45869
80	3572.48	II	10593 - 38576	70	3801.51	I	13349 - 39646
160	3575.22	I	17008 - 44971	85	3801.91	I	19256 - 45551
80	3575.97	I	13778 - 41734	26	3804.07	I	19826 - 46106
80	3590.82	I	15070 - 42911	290	3809.22	I	2951 - 29196
80	3592.42	II	11301 - 39129	190	3810.38	I	18117 - 44353
240	3606.06	I	1670 - 29393	260	3810.79	I	13778 - 40011
80	3607.06	I	19826 - 47541	35	3815.77	I	25983 - 52183
80	3613.79	II	14634 - 42298	70	3816.39	I	19256 - 45452
1900	3617.52	I	2951 - 30587	1400	3817.48	I	2951 - 29139
160	3622.34	I	19256 - 46855	35	3820.11	I	16431 - 42601
130	3627.24	I	13307 - 40868	35	3824.15	I	18974 - 45117
320	3631.94	I	1670 - 29196	95	3824.39	I	19648 - 45790
240	3641.41	II	8711 - 36165	95	3826.19	I	15070 - 41198
80	3646.52	II	14634 - 42049	110	3829.13	I	1670 - 27778
80	3651.00	I	17008 - 44390	35	3834.04	I	19828 - 45902
80	3657.59	II	8833 - 36165	1100	3835.06	I	3326 - 29393
95	3663.35	I	16431 - 43721	290	3838.51	I	12162 - 38206
80	3667.71	I	18117 - 45374	90	3842.31	I	6219 - 32238
80	3668.66	I	19256 - 46506	730	3846.22	I	1670 - 27662
95	3674.58	I	19648 - 46855	250	3847.49	I	0 - 25984
160	3675.55	I	12162 - 39361	27	3851.57	II	13173 - 39129
80	3679.60	I	15070 - 42239	150	3855.55	I	13778 - 39707
650	3682.08	I	6219 - 33370	150	3859.30	I	18117 - 44020
400	3683.30	I	18280 - 45422	75	3861.07	I	14976 - 40868
	3683.39	I	15460 - 42601	35	3861.24	I	12162 - 38053
160	3683.93	I	19535 - 46672	180	3864.34	I	3326 - 29196
80	3684.65	I	19254 - 46385	65	3866.06	I	13778 - 39637
570	3688.06	I	19648 - 46755	1800	3867.99	I	2951 - 28797
80	3699.41	I	19648 - 46672	250	3872.84	I	3326 - 29139
80	3702.31	I	14976 - 41979	110	3874.41	I	19648 - 45452
80	3703.38	I	29773 - 56768	75	3875.68	I	14976 - 40771
810	3707.92	I	2951 - 29913	730	3881.41	I	4830 - 30587
60	3714.23	I	17008 - 43924	35	3883.83	I	18280 - 44020
60	3714.84	I	23982 - 50894	35	3890.75	I	18280 - 43975
60	3715.03	I	20428 - 47338	110	3892.72	I	13349 - 39030
60	3716.08	II	15147 - 42049	140	3897.91	I	29773 - 55420
85	3717.08	I	17701 - 44596	35	3901.83	I	18974 - 44596
100	3719.39	I	17107 - 43985	35	3903.98	I	29773 - 55381
85	3722.24	I	19648 - 46506	75	3905.97	I	19828 - 45422
85	3730.42	I	19826 - 46625	75	3918.59	I	12162 - 37674
50	3736.22	II	18001 - 44758	35	3924.36	I	20428 - 45902
30	3739.48	I	18280 - 45015	35	3924.69	I	18974 - 44447
120	3741.71	I	14976 - 41694	35	3926.03	I	15460 - 40924
75	3742.68	I	22477 - 49188	65	3930.24	I	19826 - 45263
70	3749.66	I	22852 - 49514	80	3930.47	I	14976 - 40411
35	3751.42	I	19254 - 45902	35	3930.96	I	18083 - 43515
35	3757.08	I	6219 - 32828	150	3935.03	I	13778 - 39183
510	3757.92	I	4830 - 31433	35	3936.22	I	18117 - 43515
680	3760.13	I	3326 - 29913	120	3936.97	I	18974 - 44367
26	3761.61	I	18974 - 45551	35	3937.61	I	19535 - 44924
70	3764.31	I	19828 - 46385	35	3939.43	I	

Tungsten—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
120	3947.98	I	19648 - 44971	55	4115.58	I	15070 - 39361
120	3952.52	I	14976 - 40269	150	4118.05	I	18974 - 43251
120	3952.90	I	19256 - 44547	100	4118.19	I	13778 - 38053
160	3953.15	I	19828 - 45117	100	4120.85	I	15460 - 39720
200	3955.30	I	19648 - 44924	55	4122.01	I	18974 - 43228
75	3958.87	I	13778 - 39030	55	4123.05	I	15460 - 39707
80	3962.32	I	17008 - 42239	100	4125.16	I	16431 - 40666
80	3964.99	I	6219 - 31433	150	4126.80	I	19254 - 43479
160	3965.14	I	22477 - 47689	55	4132.20	I	19828 - 44020
130	3968.59	I	19256 - 44447	100	4133.48	I	19535 - 43721
80	3969.20	I	19828 - 45015	55	4136.35	I	18280 - 42450
150	h 3970.80	I	28797 - 53974	540	4137.46	I	3326 - 27488
80	3975.47	I	12162 - 37309	150	4138.02	I	13307 - 37466
45	3975.90	I	17107 - 42251	90	4138.30	I	19828 - 43985
130	3979.29	I	13307 - 38430	55	4139.32	I	16431 - 40583
130	3980.64	I	19826 - 44940	110	4142.25	I	18117 - 42251
35	3982.87	I	18117 - 43217	140	4145.16	I	13349 - 37466
90	3982.97	I	19254 - 44353	110	4145.95	I	12162 - 36275
250	3983.29	I	19826 - 44924	55	4149.44	I	19648 - 43741
80	3991.23	I	21449 - 46497	160	4154.66	I	19389 - 43452
75	3992.76	I	33291 - 58330	55	4160.03	I	20983 - 45015
45	3993.91	I	23047 - 48078	45	4160.34	I	22477 - 46506
45	3997.14	I	18974 - 43985	90	4168.65	I	18280 - 42262
45	3998.16	I	21454 - 46458	160	4170.53	I	18280 - 42251
75	3998.76	I	18974 - 43975	450	4171.17	I	4830 - 28797
80	h 4000.70	I	28797 - 53786	55	4180.23	I	19826 - 43741
80	4001.38	I	12162 - 37146	55	4183.66	I	18083 - 41979
75	4005.40	I	1670 - 26630	90	4183.82	I	19826 - 43721
8600	4008.75	I	2951 - 27890	45	4186.00	I	17701 - 41583
45	4010.38	I	23047 - 47975	45	4199.62	I	17107 - 40912
540	4015.22	I	19648 - 44547	55	4200.02	I	16431 - 40234
170	h 4016.52	I	27488 - 52378	90	4203.82	I	12162 - 35943
220	4019.23	I	3326 - 28199	160	4204.40	I	19256 - 43034
130	4022.12	I	19535 - 44390	220	4207.05	I	19648 - 43411
180	4028.79	I	9528 - 34342	110	4215.38	I	19535 - 43251
45	4035.36	I	15460 - 40234	55	4218.55	I	18280 - 41979
180	4036.86	I	19256 - 44020	250	4219.37	I	6219 - 29913
140	4039.85	I	18974 - 43721	110	4222.04	I	15070 - 38748
45	4040.59	I	19648 - 44390	55	4224.76	I	23930 - 47593
45	4043.89	I	19254 - 43975	45	4226.34	I	19256 - 42911
140	h 4044.28	I	26230 - 50949	55	4226.92	I	18083 - 41734
910	4045.59	I	2951 - 27662	55	4233.00	I	18117 - 41734
90	4046.70	I	13349 - 38053	150	4234.34	I	19256 - 42866
45	4047.94	I	1670 - 26367	290	4241.44	I	15460 - 39030
90	4053.93	I	14976 - 39637	55	4243.63	I	18974 - 42532
45	4060.70	I	19828 - 44447	540	4244.36	I	6219 - 29773
180	4064.79	I	19256 - 43851	55	4249.45	I	13349 - 36874
150	4069.79	I	19826 - 44390	55	4258.52	I	17107 - 40583
730	4069.95	I	4830 - 29393	290	4259.35	I	21449 - 44920
340	4070.61	I	1670 - 26230	55	4259.93	I	17008 - 40476
100	4071.93	I	15460 - 40011	200	4260.29	I	18117 - 41583
80	4073.15	I	15070 - 39614	200	4263.30	I	23047 - 46497
5000	4074.36	I	2951 - 27488	55	4266.54	I	23930 - 47362
150	4082.96	I	19256 - 43741	1400	4269.38	I	2951 - 26367
130	4088.33	I	3326 - 27778	110	4269.77	I	18280 - 41694
45	4088.77	I	19535 - 43985	55	4273.69	I	22477 - 45869
100	4095.69	I	17008 - 41417	220	4274.55	I	20064 - 43452
45	4097.66	I	18117 - 42514	160	4275.49	I	18117 - 41499
35	4099.02	I	19535 - 43924	160	4276.74	I	19535 - 42911
45	4101.84	I		110	4282.34	I	19256 - 42601
1000	4102.70	I	6219 - 30587	45	4284.96	I	19535 - 42866
55	4108.53	I	18117 - 42450	110	4286.01	I	13349 - 36674
150	4109.75	I	13349 - 37674	110	4294.10	I	13307 - 36588
55	4110.57	I	18280 - 42601	4100	4294.61	I	2951 - 26230
100	4111.82	I	1670 - 25984	2200	4302.11	I	2951 - 26189



Tungsten— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
160	4306.87	I	24763 - 47975	150	4551.82	I	13349 - 35311
110	4307.64	I	19826 - 43034	35	4556.83	I	23930 - 45869
55	4316.80	I	23455 - 46613	35	4558.94	I	18083 - 40011
55	4327.40	I	27849 - 50951	35	4559.10	I	14976 - 36904
80	4330.66	I	19826 - 42911	75	4563.57	I	19828 - 41734
80	4330.97	I	19828 - 42911	35	4565.30	I	14976 - 36874
110	4332.13	I	14976 - 38053	140	4570.64	I	23047 - 44920
45	4345.83	I	18974 - 41979	35	4578.32	I	29460 - 51296
100	4347.00	I	19254 - 42251	35	4579.69	I	32828 - 54657
45	4347.50	I	19256 - 42251	65	4586.83	I	9528 - 31323
55	4348.11	I	20983 - 43975	170	4588.73	I	26189 - 47975
150	4355.17	I	12162 - 35117	75	4592.39	I	19648 - 41417
100	4361.81	I	6219 - 29139	55	4592.57	I	13349 - 35117
150	4364.78	I	3326 - 26230	140	4599.94	I	24763 - 46497
100	d 4365.95	I	28393 - 51291	30	4600.41	I	18280 - 40011
	4366.07	I	18974 - 41872	140	4609.89	I	15460 - 37146
150	4372.52	I	3326 - 26189	160	4613.30	I	6219 - 27890
200	4378.48	I	4830 - 27662	23	4614.83	I	19535 - 41198
180	4384.85	I	15460 - 38259	30	4620.52	I	19535 - 41171
55	4389.84	I	19828 - 42601	27	4623.64	I	16431 - 38053
80	4394.07	I	18117 - 40868	60	4634.79	I	16431 - 38001
100	4403.95	I	17008 - 39709	35	4641.76	I	4830 - 26367
200	4408.28	I	26676 - 49355	100	4642.53	I	13778 - 35311
130	4412.19	I	3326 - 25984	35	4643.12	I	20983 - 42514
45	4415.08	I	18280 - 40924	35	4646.14	I	19254 - 40771
45	4418.44	I	20428 - 43054	130	4657.42	I	27890 - 49355
90	4420.46	I	19256 - 41872	640	4659.87	I	0 - 21454
80	4423.77	I	22853 - 45452	25	4661.24	I	22477 - 43924
45	4425.91	I	18280 - 40868	35	4661.98	I	15460 - 36904
160	4436.90	I	20983 - 43515	40	4668.46	I	15460 - 36874
45	4438.28	I	18974 - 41499	50	4676.62	I	19535 - 40912
75	4441.81	I	17107 - 39614	60	4677.69	I	19826 - 41198
90	4445.14	I	14976 - 37466	30	4679.04	I	18280 - 39646
90	4449.00	I	12162 - 34633	640	4680.51	I	4830 - 26189
45	4450.34	I	22477 - 44940	40	4683.54	I	19826 - 41171
35	4455.46	I	19256 - 41694	100	4693.72	I	26676 - 47975
35	4456.10	I	27849 - 50284	30	4698.62	I	19828 - 41104
45	4458.09	I	13307 - 35732	50	4700.42	I	6219 - 27488
35	4458.28	I	19828 - 42251	30	4702.47	I	18974 - 40234
140	4460.49	I	13778 - 36190	20	4706.16	I	16431 - 37674
75	4463.50	I	23930 - 46328	25	4710.32	I	27849 - 49073
140	4466.34	I	13349 - 35732	25	4711.17	I	19256 - 40476
140	4466.74	I		40	4712.49	I	14976 - 36190
45	4474.03	I	23982 - 46327	25	4716.86	I	17008 - 38203
45	4481.27	I	23982 - 46291	25	4718.62	I	23930 - 45117
640	4484.19	I	1670 - 23965	25	4720.39	I	13307 - 34486
45	4489.01	I	29912 - 52183	50	4725.12	I	19254 - 40411
45	4492.30	I	17107 - 39361	80	4729.65	I	13349 - 34486
75	4493.96	I	19254 - 41499	20	4745.59	I	18117 - 39183
80	4494.50	I	19256 - 41499	30	4752.20	I	18974 - 40011
45	4495.29	I	15070 - 37309	30	4752.58	I	13307 - 34342
30	4498.45	I	18974 - 41198	20	4753.39	I	23982 - 45014
35	4504.13	I	24610 - 46806	140	4757.54	I	2951 - 23965
160	4504.84	I	12162 - 34354	25	4757.78	I	15070 - 36082
130	4512.88	I	18117 - 40269	20	4758.20	I	23930 - 44940
120	4513.25	I	13349 - 35499	18	4767.78	I	29460 - 50429
35	4519.15	I	23982 - 46104	35	4773.89	I	13778 - 34719
35	4529.74	I	22477 - 44547	16	4780.50	I	23455 - 44367
35	4530.45	I	12162 - 34229	25	4787.92	I	13349 - 34229
65	4534.68	I	19826 - 41872	20	4788.42	I	16431 - 37309
80	4535.03	I	19828 - 41872	25	4797.55	I	19828 - 40666
65	4536.64	I	21856 - 43893	80	4799.91	I	19648 - 40476
35	4542.87	I	15460 - 37466	50	4807.38	I	12162 - 32958
150	4543.54	I	21449 - 43452	20	4816.10	I	19254 - 40011
150	4546.47	I	18280 - 40269	20	4816.84	I	28600 - 49355

Tungsten— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
25	4835.01	I	20428 - 41104	13	5368.68	I	28233 - 46855
790	4843.81	I	3326 - 23965	22	5374.14	I	20428 - 39030
40	4854.08	I	13349 - 33944	22	5388.00	I	19648 - 38203
25	4863.06	I	22477 - 43034	15	5397.95	I	19254 - 37774
25	4878.28	I	18083 - 38576	11	5419.39	I	22477 - 40924
380	4886.90	I	6219 - 26676	7	5422.88	I	22477 - 40912
16	4888.37	I	13778 - 34229	7	5423.93	I	19828 - 38259
16	4890.27	I	16431 - 36874	55	5435.03	I	1670 - 20064
16	4890.87	I	20428 - 40868	11	5435.59	I	17107 - 35499
30	4892.42	I	22477 - 42911	9	5440.05	I	19826 - 38203
30	4902.32	I	19254 - 39646	22	5456.58	I	23930 - 42251
16	4902.95	I	19256 - 39646	7	5457.92	I	29853 - 48170
25	4910.74	I	19256 - 39614	11	5475.11	I	28199 - 46458
30	4916.18	I	14976 - 35311	40	5477.78	I	9528 - 27778
40	4931.55	I	15460 - 35732	15	5486.01	I	31433 - 49656
35	4953.08	I	19828 - 40011	10	5487.77	I	4830 - 23047
40	4957.37	I	13778 - 33944	65	5492.31	I	29773 - 47975
15	4972.56	I	19256 - 39361	10	5496.23	I	22477 - 40666
55	4979.84	I	18280 - 38356	27	5500.49	I	19826 - 38001
220	4982.59	I	0 - 20064	27	5503.44	I	14976 - 33141
35	4983.53	I	19648 - 39709	10	5508.61	I	20428 - 38576
22	4984.70	I	18974 - 39030	220	5514.68	I	3326 - 21454
65	4986.92	I	15070 - 35117	9	5521.00	I	18083 - 36190
22	4989.08	I	23982 - 44021	15	5531.38	I	18117 - 36190
15	4994.08	I		15	5537.72	I	19256 - 37309
15	4995.29	I	22853 - 42866	9	5539.48	I	20983 - 39030
15	5002.79	I	20428 - 40411	13	5568.09	I	34228 - 52183
330	5006.15	I	6219 - 26189	7	5576.32	I	20428 - 38356
220	5015.30	I	4830 - 24763	13	5604.31	I	31818 - 49656
55	5040.36	I	13307 - 33141	9	5616.15	I	27213 - 45014
22	5052.23	I	20983 - 40771	9	5617.05	I	17701 - 35499
820	5053.28	I	1670 - 21454	5	5624.58	I	19535 - 37309
210	5054.60	I	1670 - 21449	9	5629.67	I	15070 - 32828
27	5055.52	I	22477 - 42251	11	5631.27	I	33370 - 51123
210	5069.12	I	3326 - 23047	27	5631.94	I	12162 - 29913
120	5071.74	I	29643 - 49354	5	5635.50	I	29853 - 47593
40	5110.36	I	15070 - 34633	8	5642.03	I	1670 - 19389
40	5124.23	I	14976 - 34486	4	5644.47	I	23982 - 41694
35	5130.11	I	23965 - 43452	65	5648.37	I	18974 - 36674
40	5138.40	I	28233 - 47689	8	5660.07	I	18280 - 35943
45	5145.77	I	20983 - 40411	35	5660.72	I	19648 - 37309
17	5153.56	I	22852 - 42251	8	5664.33	I	18083 - 35732
35	5183.97	I	18974 - 38259	8	5673.53	I	19254 - 36874
45	5192.71	I	14976 - 34229	27	5674.39	I	19256 - 36874
22	5195.63	I	25984 - 45225	7	5675.37	I	18117 - 35732
45	5203.25	I	19535 - 38748	13	5676.60	I	12162 - 29773
55	5204.52	I	20428 - 39637	15	5676.90	I	17701 - 35311
55	5206.18	I	19828 - 39030	15	5697.79	I	13778 - 31323
45	5212.81	I	28797 - 47975	7	5723.05	I	25984 - 43452
770	5224.66	I	4830 - 23965	55	5735.09	I	27488 - 44920
35	5233.52	I	19254 - 38356	5	5739.60	I	32238 - 49656
75	5242.98	I	16431 - 35499	7	5747.27	I	30683 - 48078
35	5254.54	I	15460 - 34486	13	5749.24	I	30587 - 47975
45	5255.40	I	22477 - 41499	5	5754.57	I	20983 - 38355
65	5259.34	I	27488 - 46497	11	5756.10	I	15460 - 32828
13	5263.22	I	23455 - 42449	7	5759.65	I	29139 - 46497
45	5275.53	I	19256 - 38206	13	5793.06	I	27662 - 44920
27	5318.86	I	27662 - 46458	13	5796.49	I	17107 - 34354
27	5337.35	I	26189 - 44920	4	5799.51	I	13349 - 30587
45	5348.93	I	26230 - 44920	45	5804.85	I	26230 - 43452
35	5350.43	I	29393 - 48078	13	d 5806.05	I	18280 - 35499
22	5351.89	I	27778 - 46458		5806.24	I	28233 - 45452
22	5354.45	I	9528 - 28199	7	5822.60	I	22477 - 39646
13	5355.25	I	19535 - 38203	13	5833.61	I	22477 - 39614
13	5357.09	I	15460 - 34122	13	5838.97	I	17107 - 34229

Tungsten — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
17	5845.27	I	29393 - 46497	4	6994.06	I	19828 - 34122
28	5851.58	I	26367 - 43452	8	7017.88	I	28204 - 42449
11	5856.61	I	20983 - 38053	3	7028.68	I	23982 - 38206
22	5864.63	I	19828 - 36874	3	7098.22	I	44547 - 58631
11	5874.22	I	19256 - 36275	4	7111.18	I	20428 - 34486
9	5875.69	I	17107 - 34122	15	7140.52	I	13778 - 27778
13	5880.21	I	34122 - 51123	9	7162.64	I	18280 - 32238
13	5891.61	I	18974 - 35943	5	7191.33	I	31323 - 45225
13	5901.20	I	23982 - 40923	5	7198.62	I	19254 - 33141
40	5902.64	I	19254 - 36190	11	7200.16	I	13778 - 27662
13	5928.58	I	22773 - 39636	5	7216.35	I	18974 - 32828
55	5947.57	I	13778 - 30587	4	7226.06	I	19535 - 33370
13	5953.96	I	20983 - 37774	8	7237.12	I	37309 - 51123
13	5956.19	I	17701 - 34486	5	7274.47	I	38259 - 52002
27	5960.83	I	27213 - 43985	10	7278.24	I	15460 - 29196
55	5965.86	I	18974 - 35732	15	7285.81	I	19648 - 33370
27	5972.51	I	3326 - 20064	15	7296.55	I	19256 - 32958
20	5978.86	I	28199 - 44920	3	7298.25	I	27213 - 40911
20	5983.82	I	28233 - 44940	7	7385.08	I	18280 - 31818
13	6009.01	I	18083 - 34719	4	7451.39	I	24789 - 38206
55	6012.78	I	19648 - 36275	3	7456.37	I	26861 - 40269
40	6021.52	I	18117 - 34719	8	7483.35	I	20983 - 34342
20	6028.32	I	29913 - 46497	7	7504.13	I	13307 - 26630
20	6043.31	I	31433 - 47975	10	7509.00	I	19828 - 33141
13	6049.92	I	18974 - 35499	3	7520.66	I	19535 - 32828
13	6065.08	I	20983 - 37466	9	7537.45	I	18974 - 32238
22	6081.44	I	18280 - 34719	9	7550.48	I	18083 - 31323
13	6111.66	I	15460 - 31818	17	7569.92	I	18117 - 31323
13	6115.52	I	14976 - 31323	5	7582.88	I	28233 - 41417
22	6128.25	I	28233 - 44547	3	7612.18	I	23455 - 36588
13	6143.94	I	22477 - 38748	17	7614.15	I	19828 - 32958
20	6153.72	I	19254 - 35499	3	7631.29	I	27670 - 40770
20	6154.87	I	17701 - 33944	3	7654.81	I	13307 - 26367
20	6203.51	I	19828 - 35943	13	7688.97	I	19826 - 32828
20	6254.28	I	33370 - 49355	4	7701.01	I	19256 - 32238
27	6285.88	I	19828 - 35732	5	7761.16	I	13349 - 26230
45	6292.02	I	13307 - 29196	3	7776.73	I	24610 - 37466
20	6303.21	I	19256 - 35117	11	7784.15	I	18974 - 31818
13	6386.47	I	23982 - 39636	7	7808.96	I	14976 - 27778
35	6404.21	I	14976 - 30587	2	7823.82	I	29460 - 42239
40	6445.12	I	18974 - 34486	4	7863.47	I	20428 - 33141
11	6508.05	I	13778 - 29139	2	7867.04	I	16431 - 29139
15	6532.39	I	20428 - 35732	4	7880.40	I	14976 - 27662
13	6538.11	I	19826 - 35117	5	7886.48	I	13307 - 25984
13	6563.20	I	19254 - 34486	9	7940.92	I	13778 - 26367
20	6573.93	I	20983 - 36190	3	7957.06	I	19254 - 31818
11	6607.13	I	17107 - 32238	22	8017.19	I	18117 - 30587
11	6609.05	I	15460 - 30587	7	8054.89	I	13778 - 26189
17	6611.62	I	32958 - 48078	22	8055.64	I	19828 - 32238
11	6621.74	I	19535 - 34632	5	8060.38	I	18280 - 30683
13	6678.42	I	18974 - 33944	13	8123.82	I	18280 - 30587
15	6693.08	I	14976 - 29913	5	8143.19	I	23455 - 35731
5	6746.56	I	23930 - 38748	3	8165.72	I	28233 - 40476
5	6764.45	I	27670 - 42449	5	8210.22	I	19256 - 31433
7	6805.31	I	19254 - 33944	4	8322.05	I	23930 - 35943
9	6814.92	I	22477 - 37146	10	8338.08	I	19828 - 31818
9	6820.27	I	19828 - 34486	4	8348.81	I	20983 - 32958
8	6828.43	I	31818 - 46458	7	8358.72	I	23982 - 35943
4	6853.74	I	19535 - 34122	3	8382.94	I	9528 - 21454
4	6876.01	I	35117 - 49656	4	8402.60	I	19535 - 31433
5	6908.29	I	13307 - 27778	4	8475.14	I	18117 - 29913
9	6934.23	I	14976 - 29393	27	8585.11	I	22477 - 34122
8	6964.12	I	13307 - 27662	10	8594.42	I	18280 - 29913
13	6984.27	I	13349 - 27662	8	8613.27	I	19826 - 31433
8	6993.27	I	19826 - 34122	3	8614.50	I	19828 - 31433
				13	8865.53	I	18117 - 29393

# Uranium

$$U, Z = 92, M = 238.029, \text{Ratio } \frac{U}{Cu} = 3.746$$

U I Normal state of valence electrons  $5f^3 6d 7s^2 5L_6^{\circ} = 0$ . I.P. = 48800  $\text{cm}^{-1}$ .

U II Normal state of valence electrons  $5f^3 7s^2 4I_{4,1/2}^{\circ} = 0$ . I.P. = 96000  $\text{cm}^{-1}$ .

## References

### Wavelengths:

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### Spectrum Assignments:

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### Classification:

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U II, J. C. van den Bosch, Physica **15**, 503 (1949).

D. D. Laun, unpublished material (1969).

### Strong lines of uranium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
4900	3859.58	II	289 - 26191	1100	3701.52	II	5527 - 32535
3200	3584.88	I	0 - 27887	1000	3881.46	II	4585 - 30342
2800	3670.07	II	915 - 28154	1000	4042.76	I	620 - 25349
2400	3854.66	II	4663 - 30599	1000	4241.67	II	4585 - 28154
2300	3566.60	I	620 - 28650	970	2865.68	II	0 - 34886
2200	3890.36	II	289 - 25986	970	3111.62	II	1749 - 33877
2200	4090.14	II	1749 - 26191	960	3659.16	I	620 - 27941
2000	3831.46	II	4663 - 30756	950	3748.68	II	5716 - 32384
2000	3932.03	II	289 - 25714	920	2832.06	II	
1900	3782.84	II	289 - 26717	880	4062.55	II	0 - 24608
1900	3812.00	I	0 - 26226	880	4153.97	I	0 - 24067
1900	3865.92	II	2295 - 28154	870	2802.56	II	289 - 35960
1600	3489.37	I	0 - 28650	870	2821.12	II	
1600	3514.61	I	0 - 28444	840	3638.20	I	3801 - 31279
1600	4050.04	II	0 - 24684	830	2793.94	II	
1500	3871.04	I	0 - 25826	830	2943.90	II	
1400	4171.59	II	1749 - 25714	810	4116.10	II	0 - 24288
1300	2941.92	II	5527 - 39508	780	2906.80	II	
1200	2889.63	II	289 - 34886	780	2908.28	II	
1200	3550.82	II	0 - 28154	780	3507.34	I	0 - 28504
1200	3561.80	I	0 - 28067				
1200	3839.62	I	3801 - 29838	750	3826.51	II	289 - 26415
1200	3943.82	I	0 - 25349	730	3291.34	II	
1200	3985.80	II	5260 - 30342	730	3390.39	I	620 - 30107
1100	3305.90	II	2294 - 32534	680	4341.69	II	289 - 23315

Uranium — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	
100	2419.57	II	0 - 41317	85	2623.54	II		
50	2423.70	II		130	2624.92	II		
65	2427.45	II		130	2625.26	II		
50	2432.4	II		65	2625.86	II		
65	2448.93	II		85	2628.50	II		
65	2450.44	II		200	2628.93	II		
60	2454.37	II		35	2629.15	II		
35	2455.68	II		85	2631.26	II		
50	2468.26	II		170	2632.66	II		
85	2470.64	II		240	2632.98	II		
40	2477.18	II		610	2635.53	II		
50	2484.01	II		50	2636.25	II		
20	2490.93	II		100	2637.70	II		
27	2498.83	II	5526 - 45533	27	2638.6	II		
170	2500.86	II		50	2639.01	II		
20	2503.9	II		130	2639.84	II		
85	2514.77	II	4420 - 44174	65	2639.89	II		
85	2518.97	II		65	2641.55	II	5790 - 43635	
40	2528.10	II		100	2641.93	II		
50	2533.23	II		24	2643.24	II		
50	2534.95	II		24	2643.54	II		
85	2537.30	II		130	2644.12	II		
150	2538.43	II		40	2644.48	II		
40	2538.73	II		470	2645.47	II	0 - 37789	
40	2541.37	II		35	2647.02	II	914 - 38681	
35	2544.36	II		24	2647.53	II		
85	2549.30	II	4420 - 43635	65	2648.79	II		
270	2556.19	II	0 - 39109	250	2649.07	II	289 - 38027	
50	2559.49	II		200	2652.83	II		
200	2562.94	II		100	2654.58	II		
440	2565.41	II	0 - 38968	65	d	2656.46	II	
30	2567.11	II		24	d	2657.86	II	
85	2567.96	II		24	d	2658.36	II	
85	2568.87	II		65		2659.02	II	0 - 37596
30	2568.98	II	5259 - 44174	85		2659.46	II	
340	2569.71	II	0 - 38903	130		2660.14	II	
150	2570.67	II		65		2661.17	II	
130	2577.32	II		170		2664.15	II	
85	2579.16	II		100		2665.70	II	
85	2579.44	II		100		2665.87	II	289 - 37789
85	2579.57	II		130		2666.54	II	
40	2582.11	II		50		2668.02	II	
40	2583.48	II		340		2669.17	II	
130	2584.42	II	0 - 38681	130		2670.52	II	
85	2584.90	II		50		2670.89	II	
85	2586.20	II		100		2672.21	II	
100	d	2587.07	II	50		2672.69	II	
50		2589.59	II	24		2673.58	II	
340		2591.25	II	130		2675.12	II	
130		2592.57	II	130		2675.88	II	1749 - 39109
150		2593.57	II	220		2676.41	II	6283 - 43635
240		2597.69	II	35		2676.69	II	
120		2598.86	II	24		2678.86	II	
190		2601.54	II	35	d	2681.73	II	
27		2603.55	II	470		2683.28	II	8276 - 45533
85		2604.31	II	150		2684.04	II	
130		2606.52	II	24		2684.29	II	
130		2606.73	II	65		2685.61	II	
130		2608.20	II	270		2685.98	II	1749 - 38968
65		2609.26	II	24		2689.13	II	
85		2612.46	II	130		2690.51	II	
150		2613.95	II	320		2691.04	II	
50		2615.95	II	100		2691.80	II	8394 - 45533
100		2616.07	II	200		2692.36	II	
65		2621.81	II	170		2693.77	II	

Uranium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	2694.22	II		130	2758.50	II	
200	2695.49	II		150	2758.96	II	
50	2695.91	II		130	2759.79	II	
40	2696.30	II		35	2760.33	II	
100	2697.40	II					
270	2698.06	II		27	2761.18	II	
100	2698.45	II		340	2762.85	II	
24	2699.37	II		100	2764.25	II	
65	2700.96	II		200	2765.40	II	0 - 36150
85	2701.55	II		190	2766.88	II	
35	2704.80	II		390	2770.04	II	
200	2705.19	II		95	2772.18	II	
27	2705.77	II		190	2772.59	II	
370	2706.95	II		150	2773.61	II	
27	2708.50	II		120	2774.74	II	
50	2709.03	II		120	2775.02	II	
100	2709.51	II	4420 - 41317	85	2775.22	II	
65	2711.10	II	914 - 37789	85	2775.78	II	
65	2711.76	II		85	2776.29	II	
130	2712.06	II		75	2778.45	II	9553 - 45533
65	2713.91	II		170	2779.41	II	
100	2714.58	II		190	2780.04	II	0 - 35960
100	2715.54	II	2295 - 39109	220	2780.77	II	
85	2716.39	II		220	2781.04	II	
50	2717.56	II		190	2781.62	II	
130	2719.33	II		120	2782.07	II	
200	2723.03	II		170	2783.29	II	
35	2725.07	II		410	2784.45	II	0 - 35903
100	2725.52	II		170	2784.67	II	
130	2725.94	II	2294 - 38968	75	2784.92	II	8276 - 44174
100	2727.34	II		60	2785.17	II	
120	2728.55	II		170	2787.33	II	
120	2728.7	II		150	2788.13	II	
50	2729.26	II		170	2790.66	II	
170	2730.31	II		120	2791.07	II	
100	2731.27	II		75	2791.26	II	
50	2732.95	II		830	2793.94	II	
50	2733.77	II		190	2795.23	II	
370	2733.97	II		290	2797.14	II	
120	2734.96	II		85	2797.30	II	
85	2735.58	II		85	2797.77	II	
85	2737.07	II		120	2799.12	II	
100	2738.13	II		870	2802.56	II	289 - 35960
50	2738.41	II		120	2803.83	II	
100	2738.98	II		170	2805.24	II	
170	2739.39	II	289 - 36783	630	2807.05	II	289 - 35903
65	2740.86	II		440	2808.98	II	
35	2741.06	II		220	2809.95	II	
130	2741.75	II		120	2810.35	II	
85	2742.60	II		290	2811.38	II	1749 - 37308
100	2743.22	II		170	2813.04	II	
100	2743.66	II		120	2815.76	II	
35	2744.27	II		170	2815.98	II	289 - 35790
170	2744.40	II		60	2816.74	II	
130	2746.16	II	1749 - 38152	630	2817.96	II	
60	2746.3	II		120	2818.98	II	
50	2747.15	II		220	2819.84	II	
100	2747.36	II		190	2820.27	II	
170	2748.45	II		870	2821.12	II	
100	2749.96	II		390	2824.37	II	289 - 35685
50	2750.13	II		120	2824.86	II	
470	2754.16	II		190	2825.35	II	
130	2755.13	II		220	2826.19	II	
60	2757.55	II		95	2827.00	II	
65	2757.92	II		680	2828.90	II	
	2758.18	II					

Uranium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
190	2829.37	II		490	2882.74	II	
920	2832.06	II		240	2882.93	II	
220	2833.82	II		85	2883.75	II	
95	2834.55	II		150	2884.92	II	
150	2835.80	II		95	2885.19	II	
360	2837.19	II	914 - 36150	95	2886.05	II	
220	2837.33	II		190	2886.45	II	289 - 34924
95	2837.73	II		460	2887.25	II	
75	2838.62	II	915 - 36133	150	2887.59	II	9553 - 44174
460	2839.89	II	289 - 35491	95	2887.91	II	
95	2840.47	II		410	2888.26	II	0 - 34612
190	2840.62	II		190	2888.74	II	
360	2842.09	II		1200	2889.63	II	289 - 34886
95	2842.24	II		150	2891.80	II	
95	2842.48	II		95	2893.76	II	
150	2844.99	II		320	2894.14	II	
190	2845.60	II		410	2894.51	II	
150	2845.96	II		95	2894.84	II	
95	2846.14	II	8510 - 43635	95	2894.89	II	
95	2847.34	II		190	2895.54	II	
50	2847.72	II		240	2896.68	II	
60	2848.05	II		85	2896.96	II	
360	2849.48	II		150	2898.01	II	
150	2849.7	II		150	2898.1	II	
95	2849.98	II		95	2898.37	II	
190	2850.49	II		95	2898.56	II	
95	2850.82	II		150	2898.71	II	2294 - 36782
120	2851.81	II		190	2901.22	II	
150	2852.09	II		150	2902.41	II	
190	2852.75	II		95	2902.81	II	0 - 34439
50	2852.94	II		95	2903.05	II	
190	2853.42	II		150	2903.55	II	
190	2853.57	II	1749 - 36782	120	2904.02	II	
95	2854.92	II		150	2904.41	II	
150	2855.96	I	0 - 35004	240	2904.51	II	289 - 34708
95	2857.47	II		780	2906.80	II	
290	2858.90	II		190	2906.91	II	
120	2859.74	II		780	2908.28	II	
390	2860.47	II	0 - 34949	190	2908.41	II	
170	2860.80	II		190	2909.25	II	
170	2861.13	II		170	2910.82	II	
120	2862.41	II		95	2911.55	II	
95	2862.62	II	4585 - 39508	150	2912.58	II	289 - 34612
75	2862.80	II		95	2912.75	II	
95	2863.44	II		150	2913.44	II	
95	2863.54	II		320	2914.25	II	289 - 34593
150	2864.10	II		360	2914.63	II	
150	2864.28	II		95	2914.84	II	
290	2865.14	II		220	2915.54	II	
970	2865.68	II	0 - 34886	220	2916.46	II	
150	2866.16	II		95	2918.37	II	
95	2867.80	II		95	2918.68	II	
190	2868.19	II		170	2918.97	II	5260 - 39508
190	2869.37	II		440	2921.68	II	
340	2870.97	II			2921.72	II	
95	2873.00	II		95	2922.06	II	
220	2874.08	II		95	2923.17	II	0 - 34199
220	2875.20	II	914 - 35685	270	2923.50	II	
190	2876.43	II		170	2924.58	II	
95	2877.05	II		95	2925.22	II	
50	2877.83	II		270	2925.57	II	
95	2878.87	II		170	2925.98	II	
240	2879.59	II		95	2926.13	I	0 - 34164
190	2880.59	II		95	2926.39	II	
95	2882.34	II		220	2926.59	II	

Uranium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
320	2927.38	II	289 - 34439	530	2984.61	II	2295 - 35790
490	2928.60	II		95	2985.08	II	
170	2929.12	II		170	2985.80	II	
220	2929.64	II		170	2987.80	II	289 - 33749
170	2929.78	II		95	2987.95	II	
190	2930.43	II		290	2988.42	II	
120	2930.59	II	0 - 34112	240	2988.71	II	
580	2931.41	I		290	2989.88	II	
220	2931.89	II		95	2990.21	II	
120	2932.18	II		410	2992.72	II	
440	2932.61	II		170	2993.70	II	
340	2933.86	II		120	2994.45	II	
170	2935.62	II		120	2996.10	II	
270	2936.45	II		120	2996.39	II	
95	2936.78	II	1749 - 35790	120	2998.36	I	0 - 33341
120	2937.35	II	914 - 34949	170	2999.03	II	
220	2939.04	II		170	2999.22	II	
120	2939.49	II	9626 - 43635	170	3000.09	II	
95	2940.04	II		120	3001.21	II	
530	2940.37	II		120	3002.64	II	
220	2941.34	II		240	3003.07	II	
1300	2941.92	II	5527 - 39508	290	3003.32	II	
220	2942.12	II		120	3003.85	II	
270	2942.85	II	915 - 34886	240	3004.15	II	
120	2943.18	II		220	3005.10	II	
120	2943.40	II		190	3005.52	II	
830	2943.90	II		360	3007.91	II	5667 - 38903
170	2944.19	II		290	3009.42	II	
220	2945.89	II	1749 - 35685	120	3010.37	II	
270	2947.43	II		170	3010.75	II	
340	2948.09	II	289 - 34199	120	3011.48	I	
95	2948.44	II		95	3012.45	II	289 - 33475
290	2948.94	II		170	3012.71	II	
220	2949.61	II		240	3013.37	II	4420 - 37596
95	2949.97	I		170	3013.44	II	
120	2951.93	I	620 - 34486	120	3014.88	II	
220	2954.39	II	2295 - 36133	120	3015.68	II	
390	2954.77	II		95	3016.05	II	
240	2955.65	II	289 - 34112	290	3016.96	II	1749 - 34885
580	2956.06	II		170	3017.35	II	
170	2956.78	II		150	3018.10	II	
170	2957.74	II		120	3018.59	II	
120	2958.10	II		120	3020.24	II	
240	2959.85	II		120	3020.57	II	
240	2962.78	II	1749 - 35491	120	3020.92	II	
240	2964.25	II		320	3021.22	II	
460	2965.03	II		630	3022.21	II	1749 - 34827
170	2966.12	II		170	3024.38	II	
240	2966.66	II	914 - 34612	320	3024.51	II	
580	2967.94	II	289 - 33972	190	3026.15	II	
170	2968.40	II	914 - 34593	120	3026.43	II	
120	2970.48	II		190	3026.70	II	
580	2971.06	II		240	3027.66	I	620 - 33640
240	2973.08	II		320	3028.19	II	
290	2973.26	II		220	3029.13	II	
240	2975.22	II		120	3029.42	II	
170	2975.64	II		120	3030.83	II	
290	2975.88	II		630	3031.99	II	
410	2976.35	II	289 - 33877	490	3033.19	II	1749 - 34708
290	2977.27	II		220	3035.51	II	
240	2978.14	II		120	3035.96	II	1749 - 34678
120	2980.28	II		190	3036.45	II	
120	2980.69	II		120	3036.61	II	
120	2981.04	II		190	3038.05	II	0 - 32906
320	2982.74	II		190	3039.14	II	4663 - 37558



Uranium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
240	3039.26	II	5259 - 38152	970	3111.62	II	1749 - 33877
95	3039.93	II		240	3112.25	II	289 - 32410
120	3040.46	II	914 - 33794	170	3114.54	I	0 - 32098
120	3041.25	II		150	3114.59	II	2294 - 34392
95	3041.86	II		150	3115.93	II	
95	3041.9	II		150	3119.24	II	
95	3042.73	II		530	3119.35	II	5260 - 37308
190	3043.79	II	1749 - 34593	150	3120.87	II	
490	3044.16	II		120	3121.09	II	
95	3045.46	II		150	3121.33	II	0 - 32028
190	3046.46	II	289 - 33104	190	3124.43	II	
190	3046.57	II		680	3124.90	II	914 - 32906
190	3046.84	II		150	3126.17	II	
240	3047.57	II		170	3126.70	II	4663 - 36637
290	3048.64	I	620 - 33412	190	3129.73	II	5526 - 37469
95	3049.84	II		95	3130.73	II	
580	3050.20	II	0 - 32775	190	3131.99	II	
240	3051.14	II		95	3133.42	II	2295 - 34199
240	3052.91	II		95	3133.63	II	
120	3054.73	II		150	3133.92	II	
240	3055.59	II		150	3136.89	II	6283 - 38152
190	3056.72	II		120	3138.51	II	
630	3057.91	II		120	3138.83	II	
120	3060.06	II		530	3139.60	II	5716 - 37558
460	3061.62	II	1749 - 34402	150	3141.95	II	2294 - 34112
630	3062.54	II	1749 - 34392	410	3144.96	II	
95	3063.88	II	2295 - 34924	490	3145.56	II	5527 - 37308
95	3064.18	II	5526 - 38152	190	3146.26	II	
120	3066.87	II		150	3146.75	II	
270	3068.65	II		270	3147.09	I	620 - 32386
95	3072.34	II		150	3148.56	II	0 - 31751
85	3072.45	II		680	3149.21	II	
580	3072.78	II		95	3150.36	II	
190	3073.50	II		150	3151.08	II	1749 - 33475
270	3075.04	II		150	3152.31	II	
120	3075.45	II	8510 - 41017	530	3153.12	II	
120	3077.33	II		95	3155.26	II	
270	3079.95	II		150	3155.41	II	4663 - 36346
290	3080.74	II	2294 - 34745	270	3155.86	II	2294 - 33972
170	3081.19	II		190	3156.07	II	
270	3082.02	II		150	3157.45	II	
190	3083.61	II		190	3157.86	II	
120	3084.24	II	2295 - 34708	150	3159.82	II	
190	d 3086.73	II		190	3160.77	II	
120	3087.11	II	2294 - 34678	95	3163.73	II	
240	3088.99	II	1749 - 34112	95	3165.28	II	
190	3090.36	II		220	3165.50	II	2294 - 33876
95	3090.55	II		220	3167.10	II	
120	3091.25	II		150	3170.86	II	
580	3093.01	II		150	3171.37	II	5260 - 36782
120	3094.83	II		95	3173.71	II	0 - 31499
290	3095.04	II	1749 - 34049	150	3175.36	II	
190	3095.23	II	2295 - 34593	340	3176.21	II	1749 - 33224
320	3095.75	II		340	3177.33	II	9553 - 41017
120	3096.88	II		220	3179.04	II	289 - 31736
320	3098.01	II		220	3179.83	II	914 - 32353
580	3102.39	II		220	3180.20	II	
150	3102.61	II		75	3182.55	II	
85	3102.90	II		75	3182.83	II	289 - 31698
120	3103.77	II	5259 - 37469	120	3185.14	II	
460	3104.16	II		270	3185.71	II	1749 - 33130
150	3105.10	II	2294 - 34490	220	3188.34	II	1749 - 33104
120	3105.65	II		150	3189.02	II	
95	3110.52	II		75	3189.42	II	
150	3110.83	II		150	3190.70	II	

Uranium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	3190.89	II		75	3332.42	II	5791 - 35790
75	3191.76	II	4663 - 35985	150	3336.68	II	2294 - 32255
220	3193.23	II		390	3337.79	II	289 - 30240
120	3196.74	II		150	3338.48	II	915 - 30860
240	3200.14	II		440	3341.66	II	2295 - 32211
340	3206.05	II	914 - 32096	290	3342.68	II	1749 - 31656
150	3206.23	II	2295 - 33475	150	3344.87	II	
75	3211.77	II		95	3345.56	I	0 - 29881
75	3213.09	II	8394 - 39508	150	3345.89	I	620 - 30499
75	3214.70	I	0 - 31098	270	3354.50	II	2294 - 32096
220	3218.34	II		75	3355.11	II	289 - 30086
150	3219.17	II		270	3357.93	II	289 - 30061
240	3224.26	II		150	3360.00	I	0 - 29753
240	3226.17	II	914 - 31902	150	3361.73	II	2294 - 32032
730	3229.50	II		150	3367.56	I	
680	3232.16	II	289 - 31219	120	3367.90	II	0 - 29683
150	3233.34	II		220	3368.83	II	
75	3235.23	II		75	3368.98	I	0 - 29673
75	3238.46	II	914 - 31784	120	3370.13	II	5260 - 34924
75	3240.35	II		290	3371.29	II	
220	3241.99	II	914 - 31751	220	3372.01	II	289 - 29936
440	3244.17	II		220	3375.78	II	
150	3244.79	II	2295 - 33104	120	3376.55	II	2294 - 31902
220	3246.11	II		150	3377.39	II	
220	3246.39	II	289 - 31084	75	3378.20	I	4453 - 34046
75	3247.49	II		150	3380.70	II	
95	3248.07	II		150	3381.95	II	
95	3249.14	II		75	3382.68	II	915 - 30469
150	3250.28	II		220	3384.45	II	289 - 29828
150	3253.75	II	5716 - 36441	220	3386.13	II	914 - 30438
220	3254.84	II		730	3390.39	I	620 - 30107
75	3257.26	II	0 - 30691	120	3390.97	I	3800 - 33282
290	3261.72	II	1749 - 32398	75	3392.99	II	4585 - 34049
120	3263.12	I	0 - 30637	290	3393.91	II	2294 - 31751
340	3265.81	II	914 - 31526	340	3394.78	II	5260 - 34708
75	3269.78	II	289 - 30863	290	3395.32	II	1749 - 31193
440	3270.12	II	289 - 30860	290	3395.52	I	0 - 29442
75	3271.45	II	5401 - 35960		3395.58	II	2294 - 31736
75	3279.55	I		75	3397.19	I	4275 - 33703
150	3280.00	II	914 - 31393	150	3398.26	II	5259 - 34678
150	3282.48	II	0 - 30455	75	3399.01	I	
190	3283.10	II	914 - 31364	290	3401.01	II	289 - 29683
290	3285.22	II	1749 - 32179	150	3401.21	II	
220	3287.45	II		75	3401.87	II	4585 - 33972
440	3288.21	II	289 - 30691	290	3403.55	II	
730	3291.34	II		95	3405.72	I	3800 - 33154
75	3293.56	I	0 - 30353	220	3406.28	II	915 - 30264
120	3294.44	II		150	3407.87	I	3800 - 33136
95	3297.89	II			3407.97	II	1749 - 31083
270	3299.06	II		290	3411.53	I	
220	3299.70	II		290	3412.10	II	
290	3303.60	II	289 - 30550	150	3412.36	II	
1100	3305.90	II	2294 - 32534	120	3413.81	II	5259 - 34544
75	3307.55	II		75	3414.32	I	4453 - 33733
75	3310.50	II		75	3416.12	II	
290	3311.72	II		75	3418.39	I	620 - 29866
290	3313.94	II	289 - 30455	220	3421.69	II	8379 - 37596
75	3318.79	II	4585 - 34708	75	3422.35	II	5401 - 34612
150	3319.21	I	3868 - 33987	220	3423.05	II	
150	3319.32	II		580	3424.56	II	1749 - 30942
220	3322.12	II	4585 - 34678	150	3424.81	II	
75	3322.46	II		170	3426.39	II	
150	3325.66	II	0 - 30061	50	3430.18	I	3868 - 33013
150	3327.50	II	914 - 30958	75	3430.48	II	
290	3329.92	II	2294 - 32316	150	3431.14	I	4276 - 33412

Uranium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	3431.54	II	5791 - 34924	320	3508.85	II	1749 - 30240
75	3433.71	II		390	3509.67	II	0 - 28484
150	3433.90	I	7645 - 36758	240	3511.44	I	0 - 28470
270	3434.15	II	1749 - 30860	150	3511.58	II	289 - 28758
120	3434.61	I	0 - 29107	150	3513.37	II	
150	3435.20	I	3800 - 32902	320	3513.68	I	620 - 29072
580	3435.49	I	0 - 29099	1600	3514.61	I	0 - 28444
150	3436.78	II	4706 - 33794	120	3515.24	II	4420 - 32860
75	3437.93	II		150	3516.3	II	
150	3440.98	I		150	3516.85	I	3868 - 32294
270	3442.95	I	0 - 29036	150	3517.05	II	6283 - 34708
75	3447.32	II		390	3519.96	II	914 - 29316
150	3448.78	I	0 - 28987	190	3520.79	II	6283 - 34678
150	3451.21	II		120	3521.48	II	
360	3453.57	II	8521 - 37469	150	3522.58	I	
150	3453.78	II	5667 - 34612	150	3522.67	I	3800 - 32180
320	3454.23	II		75	3523.35	II	
240	3455.74	II	1749 - 30678	240	3523.57	II	
320	3457.05	II	6445 - 35363	240	3525.14	II	
320	3457.71	II	5526 - 34439	240	3525.65	I	0 - 28355
240	3458.17	I	3800 - 32709	75	3525.73	II	9241 - 37596
75	3458.68	II		240	3526.60	II	289 - 28636
360	3459.92	I	0 - 28894	240	3528.69	II	
320	3462.21	I	0 - 28875	75	3529.77	II	0 - 28322
460	3463.54	I	620 - 29484	390	3531.11	II	1749 - 30061
630	3466.30	I	0 - 28840	240	3531.64	I	620 - 28927
150	3469.49	I	3800 - 32615	630	3533.57	II	915 - 29207
120	3469.78	I	0 - 28811	320	3534.33	I	0 - 28286
390	3472.51	II		75	3535.84	I	620 - 28894
150	3472.56	II	2295 - 31084	75	3537.06	I	
320	3473.43	I	3868 - 32650	240	3537.28	I	0 - 28262
150	3474.54	II		150	3537.44	II	8521 - 36782
150	3474.99	II	914 - 29683	120	3538.23	I	620 - 28875
150	3476.44	II		240	3539.65	I	3800 - 32044
75	3477.50	II		530	3540.46	II	5716 - 33953
270	3477.84	II		75	3541.89	II	
120	3479.16	I		320	3542.57	I	
360	3480.36	I	5762 - 34486	240	3543.16	II	4276 - 32496
680	3482.49	II	1749 - 30455	120	3543.73	I	5260 - 33475
120	3486.30	II		150	3544.21	II	7326 - 35536
150	3488.82	II		150	3544.99		6283 - 34490
1600	3489.37	I	0 - 28650	240	3545.44	I	4275 - 32472
220	3489.57	II	5791 - 34439	240	3545.67	I	4453 - 32648
290	3490.24	II	914 - 29557	240	3546.13	I	620 - 28811
120	3491.34	II		240	3546.68	II	1749 - 29936
390	3493.33	II	5259 - 33877	390	3547.19	II	1749 - 29932
340	3493.99	I	620 - 29233	150	3548.62	I	4275 - 32447
320	3494.84	II		320	3549.20	I	
75	3495.60	II		150	3550.17	I	5762 - 33921
75	3495.75	II	1749 - 30347	1200	3550.82	II	0 - 28154
530	3496.42	II	1749 - 30342	150	3551.04	II	289 - 28441
150	3497.26	I	3800 - 32386	320	3552.17	II	2294 - 30438
150	3497.62	II		150	3552.67	II	
240	3499.33	II	2295 - 30863	75	3552.95	I	4453 - 32590
630	3500.07	I	0 - 28563	150	3553.44	I	3800 - 31934
75	3500.33	II		680	3555.32	I	0 - 28119
75	3501.00	I	4453 - 33008	390	3557.84	I	0 - 28099
240	3502.24	I	3868 - 32413	150	3560.31	I	5991 - 34070
	3502.24	II	4585 - 33130	150	3560.44	II	1749 - 29828
320	3504.00	I	3800 - 32331	320	3561.41	I	3800 - 31871
150	3504.93	I	0 - 28523	1200	3561.80	I	0 - 28067
320	3505.07	II	5259 - 33781	390	3563.66	I	0 - 28053
150	3505.45	II	4585 - 33104	120	3564.18	I	620 - 28669
240	3507.05	I	620 - 29126	240	3564.59	II	
780	3507.34	I	0 - 28504	150	3564.88	II	9553 - 37596

Uranium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	3565.05	I	4276 - 32318	120	3625.98	II	
2300	3566.60	I	620 - 28650	75	3628.38	II	289 - 27841
150	3568.82	II		460	3630.73	II	
530	3569.06	II		75	3632.95	II	
75	3570.65	II		190	3633.29	II	
75	3570.93	II	4420 - 32416	120	3634.56	I	3868 - 31374
150	3571.16	I	620 - 28614	150	3635.30	I	3801 - 31301
120	3571.56	II	5790 - 33781	150	3635.40	II	0 - 27499
150	3571.69	II	4420 - 32410	120	3637.51	I	5991 - 33474
190	3574.11	I	7005 - 34976	840	3638.20	I	3801 - 31279
320	3574.76	I	0 - 27966	120	3638.65	I	8118 - 35593
240	3576.22	II		310	3640.76	II	
150	3577.08	II		240	3640.95	II	1749 - 29207
360	3577.92	I	0 - 27941	160	3642.44	I	4275 - 31722
240	3578.33	I	0 - 27938	420	3644.24	I	620 - 28053
630	3578.72	II		50	3644.85	II	
190	3580.25	I	620 - 28543	310	3645.03	II	914 - 28341
360	3581.84	II	5716 - 33627	170	3649.51	II	0 - 27393
290	3582.02	II			3649.58	I	5762 - 33154
190	3582.62	I	4275 - 32180	660	3651.53	I	3800 - 31178
3200	3584.88	I	0 - 27887	490	3652.07	I	4275 - 31649
240	3585.84	I	620 - 28499	140	3653.21	I	3801 - 31166
120	d 3587.78	I	4453 - 32318	140	3654.89	I	3868 - 31221
	3587.84	II		120	3657.32	II	
240	3589.66	I	620 - 28470	170	3659.01	II	4706 - 32028
240	3589.79	I	3800 - 31649	960	3659.16	I	620 - 27941
290	3590.32	II	5260 - 33104	170	3659.59	I	620 - 27938
320	3590.50	II	915 - 28758	160	3662.33	II	4663 - 31961
150	3591.56	II	4420 - 32255	170	d 3666.10	II	
390	3591.74	I	620 - 28454		3666.21	II	8521 - 35790
120	3592.97	I	620 - 28444	100	3667.13	I	0 - 27261
240	3593.20	I	4276 - 32098	100	3667.98	II	
460	3593.52	II		120	3669.18	I	5762 - 33008
120	3593.68	I	5762 - 33580	2800	3670.07	II	915 - 28154
290	3594.95	II	1749 - 29557	240	3670.53	I	7645 - 34881
150	d 3596.76	II		190	3672.58	II	
	3596.88	II		170	3673.06	I	
150	3599.84	II		190	3673.39	II	
150	3600.29	I	620 - 28387	190	d 3674.13	I	620 - 27829
75	3601.19	I	8118 - 35879	190	d 3674.99	II	6445 - 33648
150	3602.48	I	3801 - 31552		3675.08	II	5259 - 32462
150	3603.36	I	0 - 27744	260	3676.56	II	6283 - 33475
120	3603.74	I	4276 - 32017	260	3677.39	I	3801 - 30986
460	3605.28	I	0 - 27729	190	3677.67	II	
120	3605.48	II	1749 - 29477	380	3678.75	II	
360	3606.32	II	4663 - 32384	240	3679.38	I	620 - 27791
150	3608.96	II		280	3679.81	II	
240	3609.68	II		240	3680.88	I	4275 - 31435
150	3610.49	II	6283 - 33972	230	3682.04	II	5259 - 32410
150	3610.69	I	4453 - 32141	140	3682.46	I	0 - 27148
75	3611.24	II	2294 - 29978	180	3683.59	II	
75	3611.40	I	0 - 27682	180	3684.62	I	13567 - 40700
190	3612.67	II	915 - 28587	150	3685.78	I	620 - 27744
150	3615.54	I	0 - 27650	540	3691.92	II	4706 - 31784
320	3616.33	I	3801 - 31445	330	3693.70	II	7547 - 34612
320	3616.76	II	289 - 27930	190	3697.13	I	3800 - 30841
75	3616.89	I		220	3697.93	II	8755 - 35790
75	3617.49	I	7103 - 34739	540	3700.58	II	915 - 27930
75	3617.62	I	3800 - 31435	1100	3701.52	II	5527 - 32535
150	3618.49	II		230	3702.62	I	4276 - 31276
75	3619.13	II		230	3703.27	I	620 - 27616
320	3620.08	I	0 - 27616	230	3704.09	I	7326 - 34315
75	3622.04	I	0 - 27600	180	3705.04	II	
320	3622.70	I	4275 - 31871	110	3705.98	II	
390	3623.06	II	915 - 28508	230	d 3707.29	I	3800 - 30767
					3707.39	I	

Uranium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
110	3707.65	II		190	3787.23	II	5259 - 31656
110	3707.95	I	3868 - 30829	190	3788.16	I	5991 - 32381
110	3709.87	I	5762 - 32709	120	3790.22	II	5790 - 32166
350	3713.56	I	0 - 26921	120	3790.33	II	914 - 27290
	3713.65	II	5259 - 32179	120	3792.41	I	4275 - 30636
230	3714.76	II	2295 - 29207	570	3793.10	II	4585 - 30942
230	3715.47	I	4275 - 31182	380	3793.28	I	6249 - 32604
110	3716.14	I	3800 - 30702	380	3793.57	II	914 - 27267
300	3717.42	II		220	3795.13	II	2294 - 28636
350	3718.11	II	1749 - 28636	240	3796.20	I	3868 - 32023
160	3718.61	II	5526 - 32410	240	3796.54	II	4663 - 30996
110	3719.29	I	620 - 27499	240	3796.84	II	6445 - 32775
230	3720.39	I	3800 - 30672	190	3797.77	I	11308 - 37631
230	3722.68	I	7191 - 34046	240	3798.84	I	11308 - 37624
				240	3799.20	II	8394 - 34708
110	3724.23	I		240	3799.55	II	
350	3724.99	II	1749 - 28587	240	3801.15	I	620 - 26921
	3725.07	II		240	3802.27	II	2294 - 28587
120	3725.65	II		120	3803.35	II	0 - 26285
350	3729.82	II	5526 - 32330	380	3808.93	I	6249 - 32496
120	3730.13	II		380	3809.22	II	5716 - 31961
95	3731.45	I	0 - 26792	95	3810.10	I	3868 - 30107
230	3731.58	II		1900	3812.00	I	0 - 26226
	3731.77	I	7645 - 34434	120	3812.58	I	
230	3732.26	I	3801 - 30587	380	3813.79	II	2295 - 28508
350	3732.62	II	914 - 27697	380	3814.07	II	915 - 27126
350	3733.07	II		120	3816.61	II	
230	3733.58	I	6249 - 33025	120	3817.16	II	2294 - 28484
230	3737.25	II		160	3818.06	I	5762 - 31945
600	3738.05	II	5791 - 32535	120	3818.48	II	1749 - 27930
190	3742.35	I	7005 - 33719	120	3818.76	II	
300	3744.24	II		120	3819.25	I	4276 - 30451
680	3746.41	II	5527 - 32211	120	3821.22	II	
350	3747.12	II	8521 - 35201	240	3821.95	I	3801 - 29958
950	3748.68	II	5716 - 32384	120	3822.35	I	10347 - 36501
600	3751.18	I	5762 - 32412	120	3822.56	II	4706 - 30859
240	3751.72	I	620 - 27267	750	3826.51	II	289 - 26415
350	3752.66	II	5526 - 32166	240	3829.03	II	915 - 27023
190	3754.31	II	0 - 26628	190	3829.39	II	4585 - 30691
350	3755.48	II	5790 - 32410	120	3829.79	I	0 - 26104
240	3756.66	II		2000	3831.46	II	4663 - 30756
240	3756.92	II	4706 - 31316	240	3831.86	I	4275 - 30365
490	3758.36	I	4276 - 30876	200	3833.02	II	
350	3759.23	II		240	3835.14	II	
120	3759.88	II		120	3835.22	I	0 - 26066
240	3760.88	II	0 - 26581	200	3835.92	II	7598 - 33660
160	3761.96	II		120	3837.26	I	
160	3762.11	II	1749 - 28322	200	3838.15	II	2294 - 28341
330	3763.27	I	7006 - 33571	1200	3839.62	I	3801 - 29838
490	3764.57	II		120	3842.99	II	
270	3765.35	I	0 - 26550	120	3844.00	II	
430	3766.89	I	4453 - 30993	120	3844.23	II	
240	3768.80	II	5790 - 32316	120	3845.12	II	5526 - 31526
330	3769.54	II		380	3845.32	II	
190	3772.82	II	8347 - 34845	120	3846.24	I	7005 - 32997
540	3773.44	I	6249 - 32742	240	3846.55	I	3801 - 29791
240	3775.99	II		200	3847.84	I	7021 - 33002
300	3776.48	I	4275 - 30747	490	3848.62	II	5259 - 31235
120	3779.05	II			3848.72	II	
380	3780.72	II	915 - 27357	120	3849.71	II	8522 - 34490
120	3781.75	I	7645 - 34080	200	3849.85	II	0 - 25968
1900	3782.84	II	289 - 26717	120	3851.72	I	7021 - 32976
430	3783.84	II	5791 - 32211	620	3854.22	I	0 - 25938
120	3786.57	II	8521 - 34923	2400	3854.66	II	4663 - 30599
240	3786.84	I	6249 - 32648	4900	3859.58	II	289 - 26191

Uranium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
490	3861.16	I		2000	3932.03	II	289 - 25714
120	3863.09	I	3868 - 29747	120	3933.03	II	5259 - 30678
240	3864.30	II	4585 - 30455	490	3935.38	II	2294 - 27697
240	3864.48	II	4663 - 30533	330	3940.49	II	914 - 26285
1900	3865.92	II	2295 - 28154	190	3942.55	II	8755 - 34112
380	3866.80	II		240	3942.84	I	5762 - 31117
240	3867.17	I	7021 - 32872	1200	3943.82	I	0 - 25349
120	3868.42	II	4421 - 30264	240	3944.13	II	4585 - 29932
240	3870.02	II	5667 - 31499	300	3948.45	I	0 - 25319
1500	3871.04	I	0 - 25826	95	3951.48	I	4453 - 29753
95	3871.88	II	8347 - 34167	95	3951.55	II	
620	3874.04	II	289 - 26094	300	3953.58	II	2294 - 27581
240	3876.13	I	0 - 25792	540	3954.62	II	5716 - 30996
120	3876.59	II	8755 - 34544		3954.67	II	8347 - 33627
620	3878.09	II		240	3955.38	I	7103 - 32378
240	3879.53	I	4453 - 30222	120	3959.20	I	7005 - 32255
240	3879.71	I	7021 - 32788	190	3962.79	II	4706 - 29934
1000	3881.46	II	4585 - 30342	350	3964.22	I	6249 - 31467
490	3882.56	II	1749 - 27499	240	3964.67	II	7166 - 32382
240	3883.13	II		160	3964.96	II	0 - 25213
380	3883.33	II		240	3966.40	II	2295 - 27499
240	3884.68	II	8755 - 34490	600	3966.52	II	289 - 25492
180	3887.45	I	7021 - 32737	120	3967.47	I	620 - 25818
180	3887.70	II		120	3969.02	II	
2200	3890.36	II	289 - 25986	120	3974.90	I	7645 - 32796
120	3891.68	II	8510 - 34199		3974.98	II	
240	3891.80	I	7021 - 32708	190	3978.80	II	
240	3892.41	II	8755 - 34439	120	3980.80	I	5762 - 30876
620	3892.68	II	5260 - 30942	230	3983.91	II	
490	3894.12	I	0 - 25672	95	3984.18	I	
200	3895.27	II	4421 - 30086	1200	3985.80	II	5260 - 30342
490	3896.78	II	4585 - 30240	80	3988.64	II	
240	3897.06	II	6283 - 31936	190	3988.89	II	2295 - 27357
190	3897.26	I	7021 - 32672	460	3990.42	II	915 - 25968
120	3897.71	II	5667 - 31316	380	3992.54	II	5716 - 30756
190	3899.10	II	4421 - 30061	120	3994.29	II	289 - 25317
240	3899.27	I	4275 - 29914	230	3994.98	II	
240	3899.48	II	4663 - 30301	190	3995.97	II	
620	3899.78	II	2295 - 27930	120	3997.09	I	3800 - 28811
410	3902.56	II	289 - 25906	350	3998.24	II	
460	3904.30	II	8347 - 33953	120	3999.18	I	3801 - 28799
240	3904.56	II	5260 - 30863	120	4001.28	I	7021 - 32005
120	3904.85	II	1749 - 27351	120	4002.34	II	4706 - 29684
380	3906.46	I	3868 - 29459	120	4003.20	II	2294 - 27267
120	3908.32	I	4453 - 30032	350	4004.06	II	1749 - 26717
120	3908.47	II	8394 - 33972	430	4005.21	I	620 - 25580
120	3909.06	II	5790 - 31364	190	4005.70	I	620 - 25577
240	3910.89	I	7021 - 32583	120	4009.17	II	6283 - 31219
330	3911.67	II	4420 - 29978	110	4011.45	II	5401 - 30323
190	3914.20	II		80	4014.16	II	8755 - 33660
190	3914.27	II		570	4017.72	II	5716 - 30599
380	3915.88	II		300	4018.99	II	289 - 25164
120	3916.53	I	7021 - 32546	80	4026.02	II	2295 - 27126
240	3917.25	I	8119 - 33640	160	4031.31	II	914 - 25713
120	3917.82	II		160	4033.43	II	4421 - 29207
80	3918.06	II	4421 - 29936	190	4033.73	II	7598 - 32382
190	3921.55	II	0 - 25492	220	4034.50	I	4453 - 29233
120	3923.05	II	8394 - 33877	70	4039.75	I	7645 - 32392
190	3924.27	II	4585 - 30061	150	4039.80	I	
330	3926.22	I	0 - 25463	1000	4042.76	I	620 - 25349
330	3926.73	I	7021 - 32480	520	4044.42	II	5259 - 29978
240	3927.76	II	6283 - 31736	410	4047.62	I	620 - 25319
120	3928.83	I	0 - 25445	1600	4050.04	II	0 - 24684
160	3930.43	II		540	4051.91	II	5260 - 29932
430	3930.98	II	289 - 25720	180	4053.03	II	1749 - 26415

Uranium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
300	4054.31	II	6283 - 30942	180	4197.52	II	8394 - 32211
430	4058.19	II	289 - 24923	140	4198.22	I	620 - 24433
80	4060.10	II		55	4200.10	II	6283 - 30086
80	4061.35	I	620 - 25235	95	4201.13	I	7645 - 31442
110	4061.74	II	7598 - 32211	180	4204.37	II	0 - 23778
880	4062.55	II	0 - 24608	80	4210.45	II	1749 - 25492
110	4064.16	I	5991 - 30589	240	4211.66	II	4585 - 28322
110	4066.80	II	8521 - 33104	140	4212.26	II	4421 - 28154
520	4067.76	II	6283 - 30860	140	4213.87	I	11308 - 35032
410	4071.11	II		80	4214.28	I	7645 - 31367
300	4074.49	II	1749 - 26285	80	4214.42	II	289 - 24010
330	4076.69	II	914 - 25437	70	4219.97	I	4275 - 27965
220	4077.79	I	7021 - 31537	350	4222.36	I	3801 - 27478
330	4080.61	II		70	4227.33	II	6283 - 29932
190	h 4084.93	II	5791 - 30264	80	4228.76	II	4706 - 28347
270	4088.25	II	0 - 24453	220	4231.67	I	7646 - 31270
2200	4090.14	II	1749 - 26191	70	4232.04	II	289 - 23912
220	4091.52	II		160	4236.04	I	620 - 24220
110	4091.64	I	0 - 24433	55	4240.59	II	
80	4094.62	II	11544 - 35960	1000	4241.67	II	4585 - 28154
80	4094.89	II	8276 - 32690	520	4244.37	II	0 - 23554
220	4095.75	II	6283 - 30691	260	4246.26	I	0 - 23544
220	4096.35	I	7021 - 31426	160	4252.43	II	4420 - 27930
460	4098.03	II	289 - 24684	55	4266.32	I	0 - 23433
200	4101.91	I	8118 - 32490	140	4267.30	II	915 - 24342
190	4103.12	I	7326 - 31690	55	4267.94	I	6249 - 29672
380	4106.28	I		80	4268.85	II	2294 - 25713
200	4106.93	II	0 - 24342	160	4269.61	II	1749 - 25164
70	4108.36	I	0 - 24334	80	4273.98	II	915 - 24306
110	4113.11	II	0 - 24306	80	4276.47	II	5259 - 28636
810	4116.10	II	0 - 24288	200	4282.03	II	289 - 23636
55	4116.88	I	3868 - 28151	160	4282.45	II	4585 - 27930
410	4124.73	II	1749 - 25986	200	4287.87	II	0 - 23315
410	4128.34	II	4420 - 28636	200	4288.84	I	6249 - 29559
140	4132.02	I	4275 - 28470	150	4297.11	II	289 - 23554
140	4133.20	II	5790 - 29978	120	4301.47	II	0 - 23241
200	4133.50	I	0 - 24186	35	4306.73	I	
95	4135.76	II	6283 - 30455	27	4306.82	I	0 - 23212
140	4136.81	II	4421 - 28587	55	4310.39	II	6283 - 29477
95	4138.66	II	9626 - 33781	150	4313.13	I	3801 - 26979
190	4139.14	II	0 - 24153	120	4313.88	II	1749 - 24923
460	4141.23	II	8394 - 32535	40	4319.78	II	2294 - 25437
70	4141.86	I	620 - 24757	70	4325.90	II	5526 - 28636
150	4144.70	II	2295 - 26415	120	4335.73	I	0 - 23058
55	4145.39	II		680	4341.69	II	289 - 23315
55	4146.61	I	7326 - 31435	150	4347.19	II	915 - 23912
880	4153.97	I	0 - 24067	140	4354.55	I	3800 - 26758
270	4155.41	II	6283 - 30342	430	h 4355.75	I	620 - 23572
380	4156.66	I	620 - 24671	430	4362.05	I	0 - 22919
70	4160.95	I	0 - 24026	190	4362.26	II	0 - 22917
240	4162.43	I	3801 - 27818	70	4362.93	II	4585 - 27499
350	4163.68	II	0 - 24010	95	4371.76	I	8119 - 30986
70	4164.79	II	289 - 24293	160	4372.57	II	915 - 23778
270	4165.68	II	289 - 24288	70	4372.76	I	0 - 22862
70	4166.64	I	620 - 24613	110	4373.41	II	1749 - 24608
160	4169.06	I	8119 - 32098	55	4383.27	I	3801 - 26608
1400	4171.59	II	1749 - 25714	330	4393.60	I	0 - 22754
140	4172.97	II	6283 - 30240	70	d 4402.30	II	9075 - 31784
220	4174.19	II	5527 - 29477		4402.44	II	8510 - 31219
140	4179.00	II	4585 - 28508	140	4415.24	II	0 - 22642
80	h 4184.89	II	8521 - 32410	70	4426.68	II	4706 - 27290
190	4186.96	I	4276 - 28153	70	4426.94	I	0 - 22583
190	4188.07	II	289 - 24160	110	4427.65	II	289 - 22868
300	4189.28	II	289 - 24153	70	4433.89	II	8394 - 30942
55	4191.94	I	0 - 23849	110	4434.53	II	1749 - 24293

Uranium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	4440.74	I	3801 - 26313	28	4886.33	II	5527 - 25986
150	4462.97	II	915 - 23315	90	4899.29	II	915 - 21320
70	4465.13	II	2295 - 24684	45	4910.35	I	6249 - 26608
55	4469.32	I	0 - 22368	70	4913.16	II	2295 - 22642
600	4472.34	II	289 - 22642	40	4924.64	II	5667 - 25968
70	4477.71	II	915 - 23241	40	4928.44	I	4276 - 24560
110	4490.84	II	1749 - 24010	23	4933.06	I	3801 - 24067
70	4510.32	II	0 - 22165	28	4933.66	II	4421 - 24684
240	4515.28	II	289 - 22430	28	4950.17	II	5791 - 25986
70	4516.73	I	620 - 22754	40	4955.78	I	7646 - 27818
190	4538.19	II	1749 - 23778	40	4967.33	I	3801 - 23927
620	4543.63	II	915 - 22917	40	4972.10	II	915 - 21021
150	4545.58	II	2295 - 24288	40	4986.90	II	915 - 20962
45	4551.98	I	620 - 22583	110	5008.22	II	1749 - 21711
40	4553.86	II	915 - 22868	23	5011.42	I	620 - 20569
80	4555.10	II	8394 - 30342	170	5027.38	I	0 - 19885
55	4563.95	I	13127 - 35032	23	5047.41	II	2295 - 22101
95	4567.69	II	1749 - 23636	35	5063.77	I	3801 - 23544
140	4569.91	II	289 - 22165	23	5077.82	II	289 - 19977
40	4570.99	II	6283 - 28154	35	5085.86	II	915 - 20572
160	4573.69	II	2295 - 24153	21	5088.29	I	0 - 19648
55	4576.64	I	620 - 22464	70	5117.25	II	2294 - 21831
55	4584.85	II	1749 - 23554	18	5137.05	II	6445 - 25906
55	4601.13	II	915 - 22642	23	5145.08	II	6283 - 25714
140	4603.66	II	2295 - 24010	28	5154.04	II	2294 - 21691
55	4605.15	II	5791 - 27499	80	5160.33	II	5791 - 25164
40	4609.86	II	289 - 21975	55	5164.14	I	8119 - 27478
40	4611.44	II	8276 - 29955	55	5184.59	II	5402 - 24684
300	4620.23	I	6249 - 27887	45	5204.32	II	6283 - 25492
40	4622.43	II	5260 - 26887	23	5225.12	II	5790 - 24923
240	4627.08	II	4585 - 26191	18	5238.61	II	9553 - 28636
210	4631.62	I	0 - 21585	18	5247.35	II	5402 - 24453
60	4641.66	II	8394 - 29931	45	5247.75	II	4585 - 23636
220	4646.60	II	915 - 22430	45	5257.04	II	5667 - 24684
50	4663.75	I	620 - 22056	16	5272.00	I	7646 - 26608
140	4666.86	II	289 - 21711	23	5278.18	II	5402 - 24342
100	4671.41	II	4585 - 25986	70	5280.38	I	0 - 18933
170	4689.07	II	0 - 21320	18	5288.40	II	5402 - 24306
45	4700.98	II	289 - 21555	40	5308.54	I	3801 - 22633
50	4702.05	II	4706 - 25968	21	5310.04	II	0 - 18827
100	4702.52	II	2295 - 23554	40	5311.88	II	4421 - 23241
45	4715.68	I	10208 - 31408	16	5312.73	II	5791 - 24608
160	4722.73	II	1749 - 22917	18	5315.27	II	7646 - 26454
120	4731.60	II	4585 - 25714	21	5319.38	I	10081 - 28874
35	4743.53	I	6249 - 27324	16	5321.60	II	5667 - 24453
100	4755.73	II	0 - 21021	35	5327.76	II	6283 - 25047
150	4756.80	I	620 - 21637	40	5329.26	I	0 - 18759
35	4768.66	I	620 - 21585	21	5349.92	II	4420 - 23107
75	4769.26	II	0 - 20962	18	5362.40	II	
100	4772.70	II	2295 - 23241	18	5363.82	II	5667 - 24306
35	4778.10	I	10347 - 31270	28	5368.43	II	9075 - 27697
50	4779.63	II	914 - 21831	11	5373.45	II	1749 - 20353
35	4780.19	I	10081 - 30994	11	5382.94	I	620 - 19192
35	4785.91	I	3868 - 24757	11	5385.54	I	13127 - 31690
45	4790.06	I	7645 - 28516	55	5386.19	II	15392 - 33953
35	4810.90	I	3801 - 24581	18	5389.83	I	10347 - 28895
50	4819.54	II	4421 - 25164	35	5400.90	I	10288 - 28798
50	4842.48	I	620 - 21265		5400.94	II	5402 - 23912
75	4847.65	II	2295 - 22917	23	5403.20	II	5790 - 24293
85	4858.08	II	4585 - 25164	23	5405.98	II	8394 - 26887
75	4859.68	II	0 - 20572	14	5410.24	I	4276 - 22754
100	4861.02	II	5402 - 25968	11	5423.35	I	5762 - 24195
35	4868.86	I	3801 - 24334	35	5444.48	II	5791 - 24153
45	4883.78	II	2294 - 22764	18	5449.86	II	4420 - 22764
45	4885.15	I	0 - 20464		5449.93	II	



Uranium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
18	5459.27	I	620 - 18933	11	5705.66	I	10819 - 28341
35	5465.68	II	9626 - 27917	21	5706.99	II	9626 - 27143
80	5475.72	II	9241 - 27499	11	5709.49	I	7103 - 24613
70	5480.27	II	12513 - 30756	21	5716.87	I	4453 - 21941
70	5481.21	II	6445 - 24684	11	5722.23	I	13535 - 31005
45	5482.54	II	15392 - 33627	40	5723.63	II	5401 - 22868
11	5484.55	II	1749 - 19977	23	5733.21	II	8276 - 25714
35	5487.00	II	5791 - 24010	23	5736.38	I	7006 - 24433
28	5488.91	I		23	5737.27	I	
35	5491.22	II	8510 - 26716	21	5748.10	II	0 - 17392
160	5492.97	II	0 - 18200	11	5748.44	II	
28	5494.66	II	4420 - 22615	21	5750.54	I	8856 - 26241
35	5496.43	I	4276 - 22464	23	5758.14	I	0 - 17362
16	5500.69	I	620 - 18794	11	5758.35	I	4276 - 21637
16	5501.49	II	9553 - 27725	9	5761.88	I	16244 - 33595
40	5504.13	II	6445 - 24608	11	5763.63	I	7326 - 24671
35	5510.41	I	13127 - 31270		5763.63	I	7103 - 24449
45	5511.49	I	620 - 18759	11	5765.41	I	8118 - 25458
16	5513.39	I	7326 - 25458	11	5767.43	I	5991 - 23325
70	5527.83	II	12513 - 30599	11	5771.05	I	6249 - 23572
16	5531.26	I	7864 - 25938	11	5776.87	II	
16	5535.78	II	2294 - 20353	11	5777.77	I	12362 - 29665
23	5538.53	II	9075 - 27126	70	5780.59	I	6249 - 23544
28	5544.81	II	4585 - 22615	23	5788.59	II	6283 - 23554
16	5548.05	II	12513 - 30533		5788.59	II	4420 - 21691
28	5551.42	II	6445 - 24453	23	5791.74	II	9626 - 26887
18	5552.60	II	6283 - 24288	11	5796.51	I	17091 - 34338
16	5555.77	II		70	5798.54	II	5401 - 22642
23	5557.87	I	620 - 18607	40	5802.11	I	8119 - 25349
70	5564.17	I	3801 - 21768	11	5805.20	I	5991 - 23212
40	5570.66	II	9553 - 27499	21	5811.27	II	8510 - 25714
14	5573.07	I	10347 - 28286	11	5813.83	I	5991 - 23187
11	5573.59	I	6249 - 24186	9	5814.41	I	3868 - 21062
21	5580.81	II	5402 - 23315	11	5816.79	I	10288 - 27475
28	5581.23	II	914 - 18827	9	5819.01	I	7006 - 24186
45	5581.61	II	289 - 18200	18	5827.99	II	4706 - 21860
11	5587.17	II	8521 - 26415	18	5832.37	II	9882 - 27023
28	5597.37	II	6445 - 24306	45	5836.03	I	10347 - 27478
23	5602.90	II	6445 - 24288	55	5837.70	II	4585 - 21711
14	5603.97	II	5401 - 23241	11	5839.04	II	7166 - 24287
14	5608.86	I	15720 - 33544	18	5841.82	II	8379 - 25492
55	5610.89	I	6249 - 24067	23	5843.29	II	6445 - 23554
14	5616.58	I	8119 - 25918	11	5843.82	II	
55	5620.78	I	620 - 18406	35	5845.25	II	289 - 17392
28	5621.51	I	3801 - 21585	11	5852.01	I	4453 - 21536
14	5628.02	II	5791 - 23554	28	5853.91	II	1749 - 18827
14	5629.46	I		11	5859.16	II	
14	5632.47	I	10069 - 27818	7	5863.41	I	
28	5634.38	I	7646 - 25389	35	5870.93	II	5402 - 22430
9	5636.78	I	7005 - 24741	11	5886.93	II	8510 - 25492
14	5638.00	II		23	5895.32	II	6283 - 23241
14	5640.30	I	5762 - 23486	21	5898.78	I	6249 - 23197
9	5644.21	II	12629 - 30341	23	5902.50	I	3868 - 20805
9	5648.38	I	10557 - 28256	230	5915.40	I	0 - 16900
23	5653.77	II	2294 - 19977	23	5925.47	I	7646 - 24517
23	5654.39	II	4421 - 22101	21	5929.33	I	3801 - 20662
18	5658.26	I	3868 - 21536	16	5932.44	II	5791 - 22642
14	5664.86	II	5667 - 23315	16	5933.82	I	620 - 17468
28	5669.42	I	620 - 18254	10	5934.46	II	8510 - 25356
9	5674.88	II	9882 - 27499	10	5942.77	I	5762 - 22584
14	5680.37	I	6249 - 23849	14	5948.57	I	7646 - 24452
18	5683.33	II	9553 - 27143	21	5952.05	II	6445 - 23241
14	5685.19	I	4453 - 22038	21	5956.86	I	3868 - 20651
40	5691.40	II	6445 - 24010	55	5971.50	I	620 - 17362
23	5704.07	II	8379 - 25906	100	5976.32	I	3801 - 20529

Uranium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
28	5986.10	I	3868 - 20569	28	6392.74	I	0 - 15638
45	5997.31	I	6249 - 22919	90	6395.42	I	0 - 15632
16	5997.96	I	4276 - 20943	18	6397.14	I	7006 - 22633
23	5999.41	I	3801 - 20464	8	6400.36	II	5402 - 21021
21	6000.19	I	11308 - 27969	9	6411.59	I	7326 - 22919
21	6004.83	II		11	6424.89	II	5402 - 20962
21	6008.87	I	10254 - 26892	8	6430.93	I	5991 - 21536
21	6010.86	I	10347 - 26979	5	6448.04	II	
21	6014.07	I	14845 - 31468	110	6449.17	I	620 - 16122
10	6016.73	I	5762 - 22378	35	6465.00	I	7326 - 22790
28	6017.39	II	4706 - 21320	5	6470.55	II	10740 - 26191
21	6017.57	I	6249 - 22862	5	6481.72	I	5762 - 21185
16	6019.19	I	4453 - 21062	5	6485.38	II	6445 - 21860
23	6028.13	I	3868 - 20452	9	6488.35	I	13535 - 28943
7	6035.54	I	7191 - 23755	5	6495.23	II	4585 - 19977
21	6039.60	I	8119 - 24671	16	6503.62	I	4276 - 19648
9	6050.48	I	3868 - 20392	5	6506.32	II	
9	6050.67	I	7326 - 23849	16	6518.94	I	6249 - 21585
55	6051.74	II	914 - 17434	5	6520.98	I	8133 - 23464
16	6056.80	I	0 - 16506	7	6526.08	I	7645 - 22964
16	6057.07	I	6249 - 22754	5	6527.04	I	5762 - 21079
18	6059.73	II	5667 - 22165	5	6534.60	II	18654 - 33953
18	6062.30	I	4276 - 20766	11	6535.46	II	914 - 16211
45	6067.23	II	914 - 17392	7	6536.58	II	5667 - 20962
90	6077.29	I	620 - 17070	9	6542.98	I	10347 - 25626
28	6087.34	II	6445 - 22868	7	6549.88	II	7166 - 22429
16	6089.19	I	3801 - 20219	3	6552.75	I	7326 - 22583
18	6101.77	I	6249 - 22633	14	6555.01	I	3868 - 19119
9	6110.91	II	2294 - 18654	7	6557.58	II	10740 - 25986
16	6127.77	I	8119 - 24433	3	6582.78	I	7864 - 23051
28	6129.72	I	620 - 16930	7	6587.83	II	5526 - 20702
21	6132.61	I	11308 - 27609	6	6590.05	II	5402 - 20572
9	6138.54	I	10685 - 26971	3	6601.39	I	7646 - 22790
9	6152.25	I	4275 - 20525	1	6602.68	I	
8	6164.50	I	7326 - 23544	3	6603.34	II	2294 - 17434
16	6164.77	II		6	6603.98	I	7326 - 22464
40	6171.85	I	7646 - 23844	16	6620.52	I	620 - 15721
35	6175.38	I	4276 - 20464	16	6621.77	II	2294 - 17392
8	6181.37	II	8510 - 24684	7	6622.82	II	7547 - 22642
16	6215.37	I	3801 - 19885	7	6625.29	I	5762 - 20852
16	6234.30	I	4276 - 20312	4	6628.65	I	11677 - 26758
16	6246.53	I	5762 - 21766	3	6640.50	II	9553 - 24608
16	6254.22	II	6445 - 22430	5	6647.79	I	3800 - 18839
14	6268.66	I	8119 - 24067	5	6656.81	I	620 - 15638
11	6279.64	II	5791 - 21711	3	6671.21	II	
28	6280.20	II	5402 - 21320	9	6676.92	II	18654 - 33627
7	6291.48	II		3	6681.15	II	
14	6292.03	I	8133 - 24022	12	6683.38	I	3801 - 18759
21	6293.32	I	620 - 16506	3	6691.21	I	10686 - 25627
18	6298.53	I	4275 - 20148	3	6700.83	I	
14	6322.37	II	0 - 15812	4	6701.68	II	9690 - 24608
9	6330.77	II	914 - 16706	5	6707.59	II	5667 - 20571
7	6336.55	II	8510 - 24287	5	6710.57	II	914 - 15812
7	6346.27	II	5401 - 21154	8	6717.45	II	7547 - 22429
28	6359.28	I	0 - 15721	5	6720.76	II	6445 - 21320
55	6372.43	I	3801 - 19489	5	6726.89	II	8379 - 23241
6	6372.97	I	5762 - 21448	3	6727.96	I	5762 - 20621
11	6374.78	II	10285 - 25967	9	6736.80	I	0 - 14839
6	6375.98	II	0 - 15679	3	6742.47	II	5526 - 20353
28	6378.52	II	289 - 15962	4	6754.93	I	8119 - 22919
23	6379.64	II		3	6768.64	I	7864 - 22634
8	6383.59	I	4453 - 20114	4	6771.03	II	914 - 15679
11	6386.84	II	5667 - 21320	5	6776.89	II	10740 - 25492
23	6389.77	I	5991 - 21637	3	6780.62	I	8118 - 22862
6	6391.32	II	8510 - 24152	3	6782.70	I	3868 - 18607

Uranium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
3	6782.85	I	4453 - 19192	4	7653.62	I	8878 - 21940
13	6790.30	I	7646 - 22368	4	7668.73	II	5790 - 18827
3	6796.43	II	6445 - 21154	4	7669.69	II	9882 - 22917
3	6808.76	II		7	7748.19	I	16040 - 28943
1	6812.98	I	4453 - 19127	7	7754.18	I	7326 - 20219
3	6813.75	I	11677 - 26349	7	7759.87	I	7646 - 20529
	6813.81	I	11633 - 26305	11	7761.84	I	7006 - 19885
7	6818.29	I	3868 - 18531	14	7784.13	I	620 - 13463
23	6820.76	I	4276 - 18933	7	7802.40	II	10740 - 23553
8	6824.45	I	7103 - 21753	7	7816.32	I	13128 - 25918
90	6826.93	I	0 - 14644	3	7832.02	I	14845 - 27609
4	6832.71	I	7006 - 21637	2	7835.71	I	5991 - 18749
7	6846.25	I	6249 - 20852	9	7837.71	II	9075 - 21831
16	6869.07	I	19761 - 34315	9	7844.71	I	16040 - 28784
35	6876.75	II	8379 - 22917	14	7868.75	I	3801 - 16506
8	6887.74	I	8119 - 22633	14	7875.36	I	11308 - 24002
5	6902.55	I	4276 - 18759	50	7881.94	I	6249 - 18933
5	6915.31	I	5762 - 20219	9	7900.43	I	4276 - 16930
11	6917.05	I	3801 - 18254	6	7904.28	I	8119 - 20766
11	6948.58	II	16211 - 30599	6	7907.96	I	7006 - 19648
5	6987.72	II	10740 - 25047	9	7918.80	I	4276 - 16900
5	7015.70	I	8119 - 22368	6	7959.96	I	7326 - 19885
14	7020.71	II	10444 - 24684	14	7963.96	I	10081 - 22634
5	7030.69	I	620 - 14839	18	7970.46	I	8119 - 20662
11	7033.84	I	10347 - 24560	3	7974.66	I	7103 - 19640
5	7073.61	II	4663 - 18796	9	7975.08	I	11308 - 23843
23	7074.78	I	4276 - 18406	3	7975.47	I	18933 - 31468
11	7082.11	II	5401 - 19517	9	7976.88	II	5667 - 18200
27	7101.61	I	4453 - 18531	6	7991.30	I	6249 - 18759
30	7128.89	I	620 - 14644	9	7998.60	I	13128 - 25627
5	7130.05	I	5762 - 19783	3	8012.96	I	4453 - 16930
16	7147.87	I	10347 - 24334	5	8019.38	I	7006 - 19472
9	7164.87	I	4453 - 18406	9	8034.79	I	10347 - 22790
5	7172.10	I	14845 - 28784	3	8040.10	II	
9	7183.47	II	2294 - 16211	6	8055.61	I	8119 - 20529
9	7194.63	I	10685 - 24581	9	8065.47	I	10069 - 22464
5	7196.66	I	10081 - 23972	3	8065.84	I	3800 - 16195
5	7205.42	I	10686 - 24560	9	8074.03	II	6445 - 18827
7	7210.28	I	6249 - 20114	9	8097.62	I	8118 - 20464
7	7218.04	II	5667 - 19517	5	8126.23	I	10081 - 22383
16	7254.44	I	7645 - 21426	6	8137.21	I	10347 - 22633
5	7371.95	I	5991 - 19552	6	8153.71	I	13128 - 25389
14	7379.63	II	10740 - 24287	16	8174.30	I	4276 - 16506
5	7390.99	I	10208 - 23734	6	8175.84	I	16040 - 28268
5	7392.11	I	13127 - 26652	9	8188.20	II	6445 - 18654
14	7396.98	I	4453 - 17969	6	8210.27	II	10740 - 22917
5	7416.57	I	10081 - 23560	6	8230.83	I	5762 - 17908
23	7425.50	I	0 - 13463	3	8240.51	I	5762 - 17894
11	7454.03	II	10740 - 24152	18	8262.05	I	8119 - 20219
5	7510.08	II	8379 - 21691	4	8307.56	II	1749 - 13783
5	7517.39	I	16040 - 29339	7	8310.69	I	11457 - 23486
9	7528.70	I	19103 - 32381	16	8318.34	I	4275 - 16294
45	7533.91	I	3801 - 17070	6	8329.74	I	7645 - 19647
11	7550.23	I	10685 - 23926	16	8337.50	II	5401 - 17392
7	7580.91	II	7166 - 20353	11	8346.74	I	5991 - 17969
3	7587.55	II		6	8357.07	I	3868 - 15831
5	7590.52	I	5762 - 18933	18	8381.86	I	7006 - 18933
5	7595.04	I	10686 - 23849	7	8387.19	I	4275 - 16195
4	7600.27	I	16040 - 29194	11	8389.16	I	5991 - 17908
9	7609.16	I	7326 - 20464	7	8396.76	I	
16	7619.34	I	7646 - 20766	4	8402.58	I	
7	7621.95	I		16	8441.20	I	7646 - 19489
11	7631.72	I	3801 - 16900	35	8445.35	I	3801 - 15638
7	7634.74	I	7326 - 20420	18	8450.02	I	3801 - 15632
14	7639.54	I	4276 - 17362	7	8496.09	I	8119 - 19885

*Uranium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
7	8504.53	I	11457 - 23212	9	8641.12	I	16040 - 27609
11	8540.19	I	5762 - 17468	7	8659.57	I	10208 - 21753
4	8542.32	I	10254 - 21958	23	8691.28	I	0 - 11502
7	8557.32	I	10686 - 22368	5	8702.08	II	2294 - 13783
7	8567.71	I	4453 - 16122	18	8710.77	I	5991 - 17468
16	8570.51	I	8119 - 19783	18	8753.68	I	10347 - 21768
7	8574.59	I	6249 - 17908	30	8757.77	I	620 - 12035
75	8607.96	I	0 - 11614	8	8787.37	II	4585 - 15962
4	8618.96	II	914 - 12513	9	8816.56	I	7191 - 18530

# Vanadium

$$V, Z = 23, M = 50.941, \text{Ratio } \frac{V}{Cu} = 0.8016$$

V I Normal state of valence electrons  $3d^3 4s^2 \ ^4F_{1/2} = 0$ . I.P. = 54361  $\text{cm}^{-1}$ .

V II Normal state of valence electrons  $3d^4 \ ^5D_0 = 0$ . I.P. = 118200  $\text{cm}^{-1}$ .

## References

Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

Supplemented above 6700 Å by the following:

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W. F. Meggers and H. N. Russell, J. Research NBS **17**, 125 (1936) RP 906.

Classification:

V I, W. F. Meggers and H. N. Russell, J. Research NBS **17**, 125 (1936) RP 906.

C. E. Moore, Phys. Rev. **55**, 710 (1939).

V II, W. F. Meggers and C. E. Moore, J. Research NBS **25**, 83 (1940) RP 1317.

### Strong lines of vanadium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
12000	4379.24	I	2425 - 25254	3000	3855.84	I	553 - 26480
8900	4111.78	I	2425 - 26738	2800	4099.80	I	2220 - 26605
7000	4384.72	I	2311 - 25112				
5300	3183.98	I	323 - 31722	2800	4105.17	I	2153 - 26506
		I	0 - 31398	2800	4407.64	I	2311 - 24993
4800	4389.97	I	2220 - 24993	2600	3110.71	II	2809 - 34947
4600	4408.51	I	2153 - 24830	2600	3840.75	I	323 - 26353
		I	2112 - 24789	2400	2908.82	II	3163 - 37531
4300	4115.18	I	2311 - 26605	2400	2924.02	II	3163 - 37352
3800	3093.11	II	3163 - 35483	2400	3066.38	I	553 - 33155
3800	3185.40	I	553 - 31937	2400	3902.25	I	553 - 26172
3800	3703.58	I	2425 - 29418	2300	4109.79	I	2112 - 26438
3600	4395.23	I	2153 - 24899	2300	4134.49	I	2425 - 26605
3600	4408.20	I	2220 - 24899				
3200	3183.41	I	137 - 31541	2300	4406.64	I	2425 - 25112
3100	4128.07	I	2220 - 26438	2100	2092.44	I	553 - 48329
3100	4132.02	I	2311 - 26506	2000	3118.38	II	2687 - 34746
3000	3102.30	II	2968 - 35193	2000	4123.57	I	2153 - 26397
				2000	4460.29	I	2425 - 24839

Vanadium — all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
2100	2092.44	I	553 - 48329	130	2642.21	II	14556 - 52392
40	2384.00	II	8842 - 50775	45	2643.16	I	137 - 37960
40	2384.28	I	0 - 41928	45	2644.36	II	34746 - 72551
60	2386.96	I	10892 - 52774	150	2645.26	I	323 - 38116
60	2388.92	I	11101 - 52948	85	2645.84	II	14462 - 52246
75	2390.87	I	137 - 41950	90	2647.71	I	0 - 37757
75	2391.26	I	2220 - 44026	140	2651.90	I	137 - 37835
85	2392.90	I	2425 - 44203	45	2652.92	I	15265 - 52948
70	2397.78	I	553 - 42246	45	2653.83	I	15104 - 52774
70	2398.27	I	553 - 42237	55	2655.68	II	35193 - 72837
70	2399.96	I	0 - 41655	150	2656.22	I	323 - 37960
120	2406.75	I	323 - 41861	30	2658.98	II	14656 - 52253
110	2407.90	I	137 - 41655	30	2659.61	II	17911 - 55499
90	2412.69	I	323 - 41758	180	2661.42	I	553 - 38116
70	2413.03	I	0 - 41429	30	2665.96	I	0 - 37499
120	2415.33	I	0 - 41389	30	2671.67	I	137 - 37556
120	2416.75	I	553 - 41918	290	2672.00	II	107 - 37521
90	2417.35	I	137 - 41492	40	2673.23	II	
100	2420.12	I	553 - 41861	380	2677.80	II	36 - 37369
100	2421.06	I	137 - 41429	270	2678.57	II	209 - 37531
100	2421.98	I	323 - 41599	380	2679.32	II	209 - 37521
40	2423.38	I	137 - 41389	180	2682.87	II	107 - 37369
110	2428.28	I	323 - 41492	180	2683.09	II	0 - 37259
75	2432.02	I	323 - 41429	45	2685.14	I	9637 - 46868
110	2435.52	I	553 - 41599	70	2685.69	II	36 - 37259
55	2439.10	I	553 - 41539	45	2686.36	I	9637 - 46851
30	2441.89	I	553 - 41492		2686.51	I	553 - 37765
70	2479.05	II	13543 - 53869	1100	2687.96	II	339 - 37531
45	2479.52	II	13609 - 53927	170	2688.72	II	339 - 37521
45	2482.31	II	11908 - 52181	150	2689.88	II	36 - 37201
140	2501.61	I	0 - 39962	230	2690.24	II	209 - 37369
60	2503.02	II	8640 - 48580	240	2690.79	II	107 - 37259
75	2503.30	I	0 - 39935	120	2696.99	I	10893 - 47960
70	2506.22	II	8842 - 48731	120	2697.74	I	11101 - 48158
150	2506.90	I	0 - 39878	45	2698.73	I	9825 - 46868
240	2507.78	I	137 - 40001	30	2699.11	I	9825 - 46863
180	2511.65	I	323 - 40126	680	2700.94	II	339 - 37352
180	2511.95	I	137 - 39935	380	2702.19	II	209 - 37205
75	2514.64	II	9098 - 48853	45	2705.22	II	0 - 36955
70	2515.15	I	137 - 39884	530	2706.17	II	209 - 37151
180	2517.14	I	323 - 40039	150	2706.70	II	107 - 37041
240	2519.62	I	323 - 40000	110	2707.86	II	36 - 36955
410	2526.22	I	553 - 40126	170	2711.74	II	339 - 37205
210	2527.90	II	12706 - 52253	60	2713.05	II	107 - 36955
120	2528.47	II	12545 - 52083	120	2714.20	II	209 - 37041
150	2528.84	II	12622 - 52154	640	2715.69	II	107 - 36919
240	2530.18	I	553 - 40064	150	2722.56	I	10893 - 47612
30	2534.52	II	11296 - 50739	30	2723.22	II	209 - 36919
60	2545.98	I	0 - 39267	240	2728.64	II	36 - 36674
60	2548.69	II	11515 - 50739	180	2731.35	I	11101 - 47702
110	2549.28	II	11908 - 51123	40	2733.90	II	107 - 36674
120	2552.65	I	137 - 39300	100	2739.71	II	0 - 36489
90	2552.96	II	13609 - 52767	90	2742.41	II	36 - 36489
40	2553.67	II	11515 - 50662	30	2742.67	II	3163 - 39613
55	2554.86	I	137 - 39267	60	2747.48	II	19113 - 55499
40	2558.90	I	323 - 39391	140	2753.40	II	19192 - 55499
210	2562.13	I	323 - 39342	60	2760.12	II	13512 - 49731
75	2564.23	I	15265 - 54251	90	2760.70	II	19192 - 55403
110	2564.82	I	323 - 39300	140	2765.67	II	12706 - 48853
40	2568.39	I		60	2766.46	II	13595 - 49731
230	2574.02	I	553 - 39391	85	2768.56	II	12622 - 48731
45	2577.29	I	553 - 39342	45	2773.68	I	11101 - 47143
90	2620.29	I	8716 - 46868	90	2774.28	II	12545 - 48580
140	2630.67	II	14656 - 52658	45	2774.72	II	19113 - 55142
40	2640.69	I	9825 - 47683	45	2775.76	II	19192 - 55207

Vanadium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
140	2777.73	II	13742 - 49731	380	2914.93	I	323 - 34620
55	2783.78	I	13811 - 49723			I	16729 - 51026
26	2785.54	I	14515 - 50404	60	2915.33	I	137 - 34429
55	2785.69	I	13802 - 49689	45	2916.02	I	10893 - 45176
70	2797.02	II	16341 - 52083	120	2917.37	II	2687 - 36955
75	2797.80	II	16422 - 52154	60	2917.93	I	11101 - 45361
85	2798.76	II	16533 - 52253	210	2919.99	II	2968 - 37205
90	2799.45	II	13491 - 49202	380	2920.38	II	2687 - 36919
90	2802.80	II	13543 - 49211	710	2923.62	I	553 - 34747
120	2803.47	II	13609 - 49269	2400	2924.02	II	3163 - 37352
30	2805.54	II	18294 - 53927	1700	2924.64	II	2968 - 37151
90	2810.16	II	18294 - 53869	60	2926.26	I	323 - 34487
90	2810.27	II	18354 - 53927	55	2930.13	II	14462 - 48580
60	2817.50	II	18269 - 53751	710	2930.81	II	2809 - 36919
60	2836.52	II	13609 - 48853	70	2932.32	II	20623 - 54716
30	2838.06	I	0 - 35225	210	2934.40	II	2605 - 36674
60	2841.04	II	13543 - 48731	110	2935.87	I	323 - 34375
30	2844.93	I	14549 - 49689	90	2937.69	I	137 - 34168
45	2845.24	II	20363 - 55499	30	2938.25	II	14556 - 48580
120	2846.57	I		900	2941.37	II	3163 - 37151
110	2847.57	II	20242 - 55350	450	2941.49	II	2687 - 36674
70	2848.77	I	0 - 35092	230	2942.33	I	553 - 34530
30	2849.05	II	13491 - 48580		2942.35	I	0 - 33976
70	2849.18	I	137 - 35225	230	2943.20	I	0 - 33967
75	2850.69	II	22274 - 57343	1100	2944.57	II	2968 - 36919
	2850.77	II	14656 - 49724	110	2946.53	I	137 - 34066
140	2852.87	I	13802 - 48845	60	2949.17	II	22274 - 56171
140	2854.34	II	20280 - 55304	230	2949.63	I	137 - 34030
200	2855.22	I	0 - 35013	300	2950.35	II	2605 - 36489
60	2857.94	I	9637 - 44617	640	2952.08	II	2809 - 36674
180	2859.97	I	137 - 35092	120	2954.33	I	137 - 33976
240	2864.36	I	323 - 35225	90	2955.80	I	553 - 34375
75	2866.42	I	9825 - 44701	85	2957.33	I	323 - 34128
170	2866.59	I	15104 - 49978	260	2957.52	II	2687 - 36489
210	2868.10	I	15265 - 50121	410	2962.77	I	323 - 34066
140	2869.13	II	20363 - 55207	600	2968.38	II	13742 - 47420
30	2869.96	II	2687 - 37521	120	2972.25	II	19133 - 52767
210	2870.55	I	553 - 35379	45	2974.22	I	9637 - 43249
110	2877.69	II	14462 - 49202	90	2975.65	II	13512 - 47108
110	2879.16	II	2809 - 37531	120	2976.20	II	13512 - 47102
350	2880.03	II	2809 - 37521	380	2976.52	II	13595 - 47181
380	2882.50	II	2687 - 37369	240	2977.54	I	553 - 34128
380	2884.78	II	2605 - 37259	60	2981.20	II	19166 - 52700
140	2888.25	II	14656 - 49269	90	2988.02	II	13595 - 47052
380	2889.62	II	2605 - 37201	45	2989.60	II	13742 - 47181
900	2891.64	II	2687 - 37259	75	2994.54	II	30673 - 64057
530	2892.44	II	2968 - 37531	75	2996.00	II	13512 - 46880
900	2892.66	II	2809 - 37369	45	2999.24	I	9637 - 42969
1400	2893.32	II	2968 - 37521	260	3001.20	II	13742 - 47052
60	2894.58	I	0 - 34537	90	3003.46	II	13595 - 46880
360	2896.21	II	2687 - 37205	45	3008.61	II	13512 - 46740
90	2899.20	I	137 - 34620	90	3013.10	II	13512 - 46690
110	2899.60	I	0 - 34477	140	3014.82	II	13595 - 46755
360	2903.08	II	2605 - 37041	75	3016.16	I	9825 - 42969
60	2903.70	I	0 - 34429	180	3016.78	II	13742 - 46880
85	2904.13	I	323 - 34747	70	3031.01	I	10893 - 43875
150	2906.13	I	137 - 34537	270	3033.45	II	20363 - 53320
900	2906.46	II	2809 - 37205	290	3033.82	II	14656 - 47608
490	2907.47	II	2968 - 37352	45	3041.42	II	16341 - 49211
45	2908.44	II	20343 - 54716	90	3042.26	II	16341 - 49202
2400	2908.82	II	3163 - 37531	230	3043.12	I	137 - 32989
710	2910.02	II	2687 - 37041	230	3043.56	I	0 - 32847
530	2910.39	II	2605 - 36955	230	3044.94	I	323 - 33155
560	2911.06	II	2809 - 37151	230	3048.22	II	20280 - 53077
55	2914.30	I	16573 - 50876	90	3048.89	II	16422 - 49211

Vanadium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	3050.40	I	11101 - 43874	55	3250.78	II	23391 - 54144
170	3050.89	I	0 - 32768	40	3251.87	II	20343 - 51086
70	3052.19	I	137 - 32891	140	3254.77	II	16340 - 47056
180	3053.39	II	14556 - 47297	40	3255.65	I	8716 - 39423
450	3053.65	I	0 - 32738	140	3263.24	I	0 - 30636
70	3053.89	II	16533 - 49269	1100	3267.70	II	8640 - 39234
1200	3056.33	I	137 - 32847	900	3271.12	II	8842 - 39404
1400	3060.46	I	323 - 32989	90	3271.64	I	137 - 30694
140	3063.25	II	20242 - 52878	75	3273.03	I	10893 - 41437
2400	3066.38	I	553 - 33155	750	3276.12	II	9098 - 39613
200	3067.12	II	14462 - 47056	110	3279.84	II	19113 - 49593
140	3069.64	I	323 - 32891	55	3282.53	II	19113 - 49568
170	3073.82	I	323 - 32847	90	3283.31	I	323 - 30771
100	3075.27	I	15104 - 47612	55	3284.36	I	11101 - 41539
150	3082.11	I	553 - 32989	90	3289.39	II	8842 - 39234
45	3087.06	I	9545 - 41928	140	3298.14	I	553 - 30864
90	3088.11	I	9637 - 42010	90	3298.74	II	9098 - 39404
45	3089.13	I	9637 - 41999	55	3309.18	I	9637 - 39847
3800	3093.11	II	3163 - 35483	55	3321.54	II	19113 - 49211
200	3094.20	II	16422 - 48731		3321.68	I	15265 - 45361
55	3094.69	I	9545 - 41848	110	3329.86	I	9825 - 39847
180	3100.94	II	16341 - 48580	90	3356.35	I	9637 - 39423
3000	3102.30	II	2968 - 35193	110	3365.55	I	9545 - 39249
2600	3110.71	II	2809 - 34947	55	3376.06	I	9637 - 39249
90	3113.57	II	23391 - 55499	55	3377.39	I	9637 - 39237
2000	3118.38	II	2687 - 34746	110	3377.62	I	9825 - 39423
75	3120.73	II	20623 - 52658	170	3400.40	I	8716 - 38116
380	3121.14	II	3163 - 35193	55	3402.57	I	8579 - 37960
150	3122.90	II	23391 - 55403	55	3417.06	I	8579 - 37835
1500	3125.28	II	2605 - 34593	45	3418.52	I	8716 - 37960
260	3126.22	II	2968 - 34947	110	3425.07	I	
530	3130.27	II	2809 - 34746	110	3485.92	II	8842 - 37521
410	3133.33	II	2687 - 34593	45	3489.47	I	17242 - 45892
210	3134.93	II	20363 - 52253	55	3493.17	II	8640 - 37259
150	3136.51	II	20280 - 52154	90	3497.03	II	20981 - 49568
150	3139.74	II	20242 - 52083	40	3500.82	I	19145 - 47702
200	3142.48	II	17911 - 49724	210	3504.44	II	8842 - 37369
150	3145.34	II	3163 - 34947	55	3505.69	I	13802 - 42318
55	3145.97	II	2968 - 34746	560	3517.30	II	9098 - 37521
45	3146.23	II	20617 - 52392	150	3520.02	II	8640 - 37041
40	3151.32	II	20522 - 52246	110	3524.72	II	8842 - 37205
40	3164.83	II	8842 - 40430	230	3529.74	I	9637 - 37960
55	3168.14	II	8640 - 40196	230	3530.77	II	8640 - 36955
3200	3183.41	I	137 - 31541	560	3533.68	I	9825 - 38116
5300	3183.98	I	323 - 31722	110	3543.50	I	9545 - 37757
		I	0 - 31398	560	3545.20	II	8842 - 37041
3800	3185.40	I	553 - 31937	110	3553.27	I	9825 - 37960
410	3187.71	II	8640 - 40002	55	3556.25	I	17242 - 45354
530	3188.51	II	8842 - 40196	560	3556.80	II	9098 - 37205
750	3190.68	II	9098 - 40430	55	3560.60	II	8842 - 36919
55	3193.92	I	15063 - 46363	110	3566.18	I	8579 - 36612
530	3198.01	I	137 - 31398			II	8640 - 36674
55	3199.82	I	15001 - 46244	55	3568.94	I	17055 - 45067
750	3202.38	I	323 - 31541	55	3571.04	I	17242 - 45237
450	3205.58	I	10893 - 42079	90	3571.65	I	17117 - 45107
450	3207.41	I	553 - 31722	90	3573.52	I	17182 - 45158
75	3208.35	II	8842 - 40002	55	3577.87	I	17117 - 45059
410	3212.43	I	11101 - 42221	55	3582.81	I	17242 - 45145
75	3214.75	II	9098 - 40196	560	3589.76	II	8640 - 36489
210	3217.11	II	16533 - 47608	490	3592.02	II	8842 - 36674
		I	323 - 31398	560	3592.53	I	
40	3218.87	I	10893 - 41950	270	3593.33	II	9098 - 36919
55	3233.19	I	11101 - 42021	45	3605.59	I	
150	3237.87	II	16422 - 47297	110	3606.69	I	10893 - 38611
55	3249.57	I	553 - 31318	55	3616.72	I	



Vanadium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
45	3637.76	I		570	3799.91	I	2153 - 28462
110	3639.02	I	14549 - 42021	570	3803.47	I	2311 - 28596
55	3643.86	I	14515 - 41950	85	d 3803.78	I	10893 - 37175
110	3644.71	I	11101 - 38530		3803.90	I	323 - 26605
90	3648.97	I	16450 - 43847	190	I 3806.80	I	11101 - 37362
90	3656.71	I	16573 - 43912	300	I 3807.50	I	2112 - 28369
250	3663.59	I	16361 - 43649	520	I 3808.52	I	0 - 26249
75	3665.14	I	16729 - 44005	230	I 3809.60	I	2220 - 28462
250	3667.74	I	16450 - 43707	1000	I 3813.49	I	137 - 26353
110	3669.41	II	20363 - 47608	95	I 3815.51	I	2112 - 28314
170	3671.20	I	10893 - 38124	140	d 3817.84	I	553 - 26738
95	3672.40	I	16917 - 44140		3817.98	I	11101 - 37285
280	3673.40	I	16573 - 43788	1300	I 3818.24	I	0 - 26183
280	3675.70	I	2220 - 29418	230	I 3819.96	I	2425 - 28596
170	3676.68	I	17136 - 44327	230	I 3821.49	I	2153 - 28314
300	3680.11	I	16729 - 43894	570	I 3822.01	I	323 - 26480
570	3683.13	I	2153 - 29296	450	I 3822.89	I	2311 - 28462
190	3686.26	I	11101 - 38221	300	I 3823.21	I	2220 - 28369
470	3687.47	I	16917 - 44028	65	I 3823.99	I	8476 - 34620
1300	3688.07	I	2311 - 29418	45	I 3826.77	I	8413 - 34537
1000	3690.28	I	2112 - 29203	1700	I 3828.56	I	137 - 26249
1500	3692.22	I	2220 - 29296	45	I 3830.27	I	
450	3695.34	I	17136 - 44190	28	I 3832.84	I	13802 - 39884
1000	3695.86	I	2153 - 29203	280	I 3834.22	I	13811 - 39884
3800	3703.58	I	2425 - 29418	75	I 3835.56	I	8413 - 34477
1800	3704.70	I	2311 - 29296	75	I 3836.05	I	8476 - 34537
570	3705.04	I	2220 - 29203	160	I 3839.00	I	8579 - 34620
95	3706.04	I	15104 - 42079	110	I 3839.38	I	14549 - 40587
130	3708.72	I	15265 - 42221	75	I 3840.14	I	10893 - 36926
40	3713.96	I	553 - 27471	570	I 3840.44	I	8716 - 34747
320	3715.47	II	12706 - 39613	2600	I 3840.75	I	323 - 26353
45	3718.91	I		110	I 3841.89	I	323 - 26345
45	3722.00	I	15001 - 41861	380	I 3844.44	I	0 - 26004
45	3722.20	I	18198 - 45057	320	I 3847.33	I	137 - 26122
250	3727.34	II	13609 - 40430	110	I 3849.32	I	
45	3728.34	II	20242 - 47056	75	I 3851.17	I	8579 - 34537
55	3729.04	I	14949 - 41758	40	I 3852.10	I	8476 - 34429
280	3732.76	II	12622 - 39404	1200	I 3855.37	I	0 - 25931
150	3734.43	I	15078 - 41848	3000	I 3855.84	I	553 - 26480
45	3737.99	I	14910 - 41655	65	I 3858.68	I	8579 - 34487
85	3738.76	I	15270 - 42010	75	I 3859.34	I	8716 - 34620
40	3740.24	I	15270 - 41999	150	I 3862.22	I	137 - 26022
95	3741.50	I	18438 - 45158	130	I 3863.87	I	10893 - 36766
230	3745.80	II	12545 - 39234	1300	I 3864.86	I	137 - 26004
40	3747.98	I	15572 - 42246	230	I 3867.60	I	323 - 26172
210	3750.87	II	13543 - 40196	40	I 3870.58	I	15771 - 41599
40	3751.78	I	8579 - 35225	170	I 3871.08	I	11101 - 36926
40	3753.27	I	13802 - 40437	65	I 3873.64	I	10893 - 36701
40	3755.70	I	18302 - 44921	1500	I 3875.08	I	323 - 26122
40	3759.32	I	20830 - 47423	420	I 3875.90	I	137 - 25931
45	3761.44	I	15270 - 41848	570	I 3876.09	I	553 - 26345
85	3763.14	I	15572 - 42138	130	I 3878.71	II	14656 - 40430
40	3769.07	I	13802 - 40326	40	I 3883.89	I	15689 - 41429
210	3770.97	II	13491 - 40002	90	I 3886.59	I	11101 - 36823
40	3774.11	I	13811 - 40300	700	I 3890.18	I	323 - 26022
40	3775.19	I	15270 - 41752	90	h 3891.12	I	
40	3775.72	I	18680 - 45158	460	I 3892.86	I	323 - 26004
40	3776.16	I	15771 - 42246	90	I 3894.04	I	18174 - 43847
270	3778.68	I	2311 - 28768	90	I 3896.16	I	8716 - 34375
45	3779.65	I	10893 - 37343	90	I 3897.08	I	18259 - 43912
40	3781.39	I	15572 - 42010	280	h 3898.02	I	18680 - 44327
65	3787.14	I	15104 - 41501	140	I 3899.13	II	14556 - 40196
520	3790.32	I	2220 - 28596	140	h 3900.18	I	18372 - 44005
95	3793.61	I	0 - 26353	140	h 3901.15	I	18513 - 44140
1100	3794.96	I	2425 - 28768	2400	I 3902.25	I	553 - 26172

Vanadium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
50	3903.26	II	11908 - 37521	230	4104.40	I	17242 - 41599
50	3904.47	I	14515 - 40119	260	4104.78	I	15771 - 40126
100	3906.75	I	8579 - 34168	2800	4105.17	I	2153 - 26506
700	3909.89	I	553 - 26122	65	4107.49	I	9637 - 33976
100	3910.79	I	8413 - 33976	120	4108.22	I	17055 - 41389
220	3912.21	I	8413 - 33967	2300	4109.79	I	2112 - 26438
50	3912.89	I	8579 - 34128	8900	4111.78	I	2425 - 26738
140	3914.33	II	14462 - 40002	120	4112.33	I	17182 - 41492
100	3916.41	II	11515 - 37041	230	4113.52	I	9825 - 34128
100	3920.49	I	8476 - 33976	65	4114.53	I	15665 - 39962
100	3921.90	I	8476 - 33967	4300	4115.18	I	2311 - 26605
230	3922.43	I	8579 - 34066	1800	4116.47	I	2220 - 26506
240	3924.66	I	15063 - 40536	180	4118.18	I	15724 - 40000
150	3925.24	I	19026 - 44495	180	4118.64	I	8716 - 32989
200	3927.93	I	15001 - 40452	230	4119.46	I	8579 - 32847
260	3930.02	I	11101 - 36539	180	4120.54	I	8476 - 32738
150	3931.34	I	14949 - 40379	180	4123.19	I	15689 - 39935
260	3934.01	I	8716 - 34128	2000	4123.57	I	2153 - 26397
150	3935.14	I	14910 - 40315	120	4124.07	I	9825 - 34066
100	3936.28	I	8579 - 33976	3100	4128.07	I	2220 - 26438
50	3937.53	I	15063 - 40452	120	4128.86	I	15665 - 39878
50	3938.20	I	19078 - 44463	3100	4132.02	I	2311 - 26506
50	3939.33	I	15001 - 40379	2300	4134.49	I	2425 - 26605
40	3941.25	I	14949 - 40315	65	4136.11	I	15078 - 39249
90	3942.01	I	11101 - 36461	65	4139.26	I	15270 - 39423
150	3943.66	I	8716 - 34066	45	4150.67	I	
100	3950.23	I		45	4152.66	I	
140	3951.97	II	11908 - 37205	150	4159.69	I	2311 - 26345
90	3963.63	I		65	4171.30	I	15270 - 39237
50	3968.09	II	11296 - 36489	100	4174.01	I	13802 - 37753
100	3973.64	II	11515 - 36674	230	4179.42	I	2425 - 26345
50	3979.14	I	20768 - 45892	150	4182.59	I	2220 - 26122
50	3979.42	I	19023 - 44146	180	4189.84	I	2311 - 26172
50	3980.52	I		180	4191.56	I	2153 - 26004
50	3984.34	I	14910 - 40001	65	4197.60	I	15265 - 39081
90	3984.60	I	14949 - 40039	65	4198.61	I	2311 - 26122
90	3988.83	I	15001 - 40064	50	4200.19	I	2220 - 26022
540	3990.57	I	14949 - 40001	230	4209.86	I	2425 - 26172
260	3992.80	I	15001 - 40038	65	4218.71	I	2425 - 26122
50	3997.12	II	11908 - 36919	65	4224.14	I	15724 - 39391
430	3998.73	I	15063 - 40064	120	4226.62	I	15689 - 39342
170	4005.71	II	14656 - 39613	50	4227.74	I	13811 - 37458
50	4023.17	I	15270 - 40119	50	4229.69	I	15665 - 39300
120	4023.39	II	14556 - 39404	360	4232.46	I	15771 - 39391
120	4031.83	I	19078 - 43874	180	4232.95	I	15724 - 39342
150	4035.63	II	14462 - 39234	180	4234.00	I	15689 - 39300
120	4042.64	I	15270 - 40000	50	4234.52	I	0 - 23609
50	4048.62	I	137 - 24830	120	4235.76	I	15665 - 39267
360	4050.96	I	17182 - 41861	50	4240.36	I	15724 - 39300
360	4051.35	I	17242 - 41918	100	4257.37	I	15001 - 38483
50	4053.26	I	15270 - 39935	120	4259.31	I	137 - 23609
280	4057.07	I	17117 - 41758	120	4262.16	I	14949 - 38405
130	4057.82	I	15689 - 40326	50	4265.17	I	
230	4063.93	I	17055 - 41655	560	4268.64	I	15063 - 38483
230	4071.54	I	15572 - 40126	50	4269.76	I	14910 - 38324
65	4082.93	I	9545 - 34030	50	4270.32	I	14549 - 37960
1100	4090.58	I	8716 - 33155	460	4271.55	I	15001 - 38405
50	4091.94	I	9545 - 33976	460	4276.96	I	14949 - 38324
180	4092.41	I	9637 - 34066	45	4282.91	I	15063 - 38405
1800	4092.69	I	2311 - 26738	430	4284.06	I	14910 - 38246
120	4093.50	I	9545 - 33967	50	4286.42	I	15001 - 38324
65	4094.28	I	17242 - 41660	45	4287.81	I	
890	4095.49	I	8579 - 32989	40	4291.30	I	14949 - 38246
2800	4099.80	I	2220 - 26605	330	4291.82	I	17242 - 40536
590	4102.16	I	8476 - 32847	220	4296.11	I	17182 - 40452

*Vanadium— all observed lines— Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
170	4297.68	I	17117 - 40379	2000	4460.29	I	2425 - 24839
170	4298.03	I	17055 - 40315	75	4460.99	I	19026 - 41437
170	4306.21	I	137 - 23353	610	4462.36	I	15001 - 37404
140	4307.18	I	0 - 23211	40	4464.27	I	19145 - 41539
170	4309.80	I	323 - 23520	40	4464.75	I	15724 - 38116
40	4313.89	I	14949 - 38124	40	4465.50	I	15572 - 37960
460	4330.02	I	0 - 23088	120	4468.01	I	14910 - 37285
510	4332.82	I	137 - 23211	40	4468.76	I	15104 - 37475
40	4334.09	I	9825 - 32891	380	4469.71	I	14949 - 37316
760	4341.01	I	323 - 23353	120	4474.04	I	15771 - 38116
50	4342.83	I	15104 - 38124	200	4474.71	I	15265 - 37606
1000	4352.87	I	553 - 23520	25	4475.89	I	14949 - 37285
130	4354.98	I	15265 - 38221	75	4480.04	I	15001 - 37316
150	4355.94	I	137 - 23088	380	4488.89	I	14910 - 37181
50	4363.52	I	2220 - 25131	75	4490.80	I	14949 - 37211
50	4364.22	I	17055 - 39962	100	4496.06	I	15724 - 37960
150	4368.04	I	323 - 23211	65	4496.85	I	14949 - 37181
50	4368.60	I	17117 - 40001	40	4497.40	I	21646 - 43875
140	d 4373.23	I	21603 - 44463	120	4501.95	I	11101 - 33307
75	4373.83	I	17182 - 40039	75	4514.19	I	15689 - 37835
100	4375.30	I	21646 - 44495	140	4524.22	I	15265 - 37362
12000	4379.24	I	2425 - 25254	40	4525.16	I	15665 - 37757
100	4380.55	I	17242 - 40064	40	4527.99	I	
7000	4384.72	I	2311 - 25112	40	4529.30	I	15270 - 37343
4800	4389.97	I	2220 - 24993	75	4529.59	I	15104 - 37175
90	4392.07	I	2153 - 24915	40	4530.79	I	
45	4393.09	I	15078 - 37835	40	4533.92	I	
45	4393.84	I	8476 - 31229	40	4537.66	I	14549 - 36580
3600	4395.23	I	2153 - 24899	40	4540.01	I	15265 - 37285
1400	4400.58	I	2112 - 24830	360	4545.39	I	15771 - 37765
75	4403.67	I	15063 - 37765	100	4549.65	I	
90	h 4406.15	I	8579 - 31268	25	4551.84	I	14515 - 36478
2300	4406.64	I	2425 - 25112	90	4553.05	I	19023 - 40981
2800	4407.64	I	2311 - 24993	280	4560.71	I	15724 - 37644
3600	4408.20	I	2220 - 24899	65	4570.42	I	15771 - 37644
4600	4408.51	I	2153 - 24830	200	4571.78	I	15689 - 37556
		I	2112 - 24789	510	4577.17	I	0 - 21841
140	4412.14	I	2112 - 24771	140	4578.73	I	15665 - 37499
45	4415.06	I	15001 - 37644	30	4579.19	I	15724 - 37556
640	4416.47	I	2153 - 24789	640	4580.40	I	137 - 21964
120	4419.94	I	2220 - 24839	50	4583.78	I	15689 - 37499
640	4421.57	I	2220 - 24830	830	4586.36	I	323 - 22121
90	4423.21	I	8716 - 31318	170	4591.22	I	19145 - 40920
30	4423.91	I	20813 - 43411	1300	4594.11	I	553 - 22314
45	4424.56	I	11101 - 33695	100	4606.15	I	137 - 21841
90	4425.71	I	14910 - 37499	30	4609.65	I	11101 - 32788
460	4426.00	I	2311 - 24899	25	4611.74	I	15665 - 37343
120	4427.31	I	21603 - 44184	230	4619.77	I	323 - 21964
310	4428.52	I	2153 - 24728	65	4624.41	I	8476 - 30095
230	4429.80	I	2425 - 24993	50	4626.48	I	8413 - 30022
30	4430.50	I	15270 - 37835	100	4635.18	I	553 - 22121
90	4434.60	I	15572 - 38116	65	4640.07	I	8476 - 30022
430	4436.14	I	2112 - 24648	65	4640.74	I	8579 - 30121
640	4437.84	I	2311 - 24839	130	4646.40	I	8579 - 30095
830	4441.68	I	2220 - 24728	30	4648.89	I	19189 - 40694
90	4443.34	I	21646 - 44146	30	4666.14	I	15270 - 36695
640	4444.21	I	2153 - 24648	160	4670.49	I	8716 - 30121
65	4449.57	I	10893 - 33360	24	4684.45	I	15270 - 36612
65	4450.90	I	19078 - 41539	35	4686.92	I	15078 - 36408
610	4452.01	I	15063 - 37518	55	4706.16	I	15572 - 36815
25	4452.70	I	14910 - 37362	80	4706.57	I	17242 - 38483
40	h 4456.50	I		80	4710.56	I	17182 - 38405
410	4457.48	I	2220 - 24648	65	4714.12	I	17117 - 38324
120	4457.76	I	15104 - 37530	35	4715.89	I	19026 - 40225
1000	4459.76	I	2311 - 24728	55	4717.69	I	17055 - 38246

Vanadium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	4721.51	I	15724 - 36898	40	5385.14	I	21033 - 39597
40	4722.86	I	15771 - 36938	14	5388.30	I	20688 - 39241
40	4729.53	I	15270 - 36408	11	5397.87	I	20606 - 39127
27	4730.38	I	15689 - 36823	100	5401.93	I	19023 - 37530
27	4742.63	I	18805 - 39884	140	5415.26	I	19145 - 37606
24	4746.63	I	16361 - 37423	28	5418.09	I	19023 - 37475
40	4748.52	I	16450 - 37503	50	5424.08	I	19026 - 37458
45	4750.98	I	16573 - 37615	40	5434.18	I	19078 - 37475
35	4751.56	I	15572 - 36612	11	5437.66	I	19145 - 37530
40	4753.93	I	16729 - 37758	17	5458.12	I	19026 - 37343
65	4757.48	I	16361 - 37375	13	5471.33		
55	4766.63	I	16450 - 37423	25	5487.22	I	14549 - 32768
130	4776.36	I	16573 - 37503	85	5487.92	I	19145 - 37362
	4776.52	I	19189 - 40119	25	5489.94	I	14515 - 32725
110	4786.51	I	16729 - 37615	28	5504.87	I	13802 - 31962
130	4796.92	I	16917 - 37758	70	5507.75	I	19023 - 37175
19	4799.77	I	0 - 20828	14	5511.18	I	19145 - 37285
130	4807.53	I	17136 - 37931	23	5545.93	I	8579 - 26605
130	4827.45	I	323 - 21033	70	5547.07	I	8716 - 26738
150	4831.64	I	137 - 20828	35	5558.75	I	13802 - 31786
120	4832.43	I	0 - 20688	28	5561.66	I	13811 - 31786
19	4833.02	I	13802 - 34487	140	5584.50	I	8579 - 26480
19	4848.81	I	21603 - 42221	23	5586.00	I	15001 - 32898
320	4851.48	I	0 - 20606	100	5592.42	I	8476 - 26353
35	4862.61	I	20830 - 41389	28	5601.38	I	19078 - 36926
480	4864.74	I	137 - 20688	70	5604.94	I	8413 - 26249
21	4871.26	I	17242 - 37765	13	5624.20	I	18805 - 36580
620	4875.48	I	323 - 20828	200	5624.60	I	8579 - 26353
55	4880.56	I	9637 - 30121	70	5624.89	I	8476 - 26249
740	4881.56	I	553 - 21033	55	5626.01	I	8413 - 26183
27	4891.60	I		400	5627.64	I	8716 - 26480
21	4894.21	I	17055 - 37481	13	5632.46	I	553 - 18302
55	4900.62	I	17117 - 37517	10	5633.90	I	19078 - 36823
95	d 4904.29	I	9637 - 30022	13	5635.51	I	19026 - 36766
	4904.34	I	17242 - 37626	85	5646.11	I	8476 - 26183
85	4925.65	I	9825 - 30121	110	5657.44	I	8579 - 26249
35	4932.03	I	9825 - 30095	110	5668.36	I	8716 - 26353
23	4966.12	I	23935 - 44066	310	5670.85	I	8716 - 26345
70	5002.33	I	19023 - 39009	20	5683.22	I	
85	5014.62	I	19145 - 39081	1200	5698.52	I	8579 - 26122
28	5051.63	I	21646 - 41437	920	5703.56	I	8476 - 26004
35	5064.12	I		570	5706.98	I	8413 - 25931
35	5105.14	I		11	5708.95	I	19189 - 36701
110	5128.53	I	18438 - 37931	11	5716.21	I	
110	5138.42	I	18302 - 37758	70	5725.64	I	19078 - 36539
25	5139.53	I	19078 - 38530	850	5727.03	I	8716 - 26172
70	5148.72	I	18198 - 37615	170	5727.66	I	8476 - 25931
40	5159.35	I	18126 - 37503	230	5731.25	I	8579 - 26022
23	5169.94	I	18086 - 37423	40	5734.01	I	19026 - 36461
70	5176.77	I		230	5737.06	I	8579 - 26004
20	5192.01	I	18120 - 37375	110	5743.45	I	8716 - 26122
110	5192.99	I	18680 - 37931	17	5747.70	I	19145 - 36539
23	5193.62	I	18174 - 37423	40	5748.87	I	15270 - 32660
110	5194.83	I	18259 - 37503	17	5752.74	I	15078 - 32456
55	5195.36	I	18372 - 37615	17	5761.41	I	8579 - 25931
20	5206.61	I	18174 - 37375	70	5772.42	I	15572 - 32891
40	5216.59	I	18259 - 37423	35	5776.64	I	8716 - 26022
35	5225.77	I	18372 - 37503	11	5782.61	I	8716 - 26004
35	5233.75	I	18513 - 37615	11	5783.50	I	21841 - 39127
110	5234.07	I	19023 - 38124	40	h 5784.38	I	22314 - 39597
20	5240.20	I	18680 - 37758	55	h 5786.16	I	21964 - 39241
110	5240.87	I	19145 - 38221	23	5788.56	I	15078 - 32349
17	5260.98	I	18438 - 37441	35	h 5807.14	I	24899 - 42114
40	5353.41	I	19078 - 37753	23	5817.06	I	15270 - 32456
35	5383.43	I	20828 - 39399	35	h 5817.53	I	24993 - 42177

Vanadium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55 h	5830.72	I	25112 - 42257	11	6565.88	I	9545 - 24771
85 h	5846.30	I	25254 - 42353	50	6605.97	I	9637 - 24771
11	5850.32	I	15572 - 32660	15	6607.83	I	10892 - 26022
40	5924.57	I	15063 - 31937	10	6623.54	I	15771 - 30864
28	5978.91	I	15001 - 31722	50	6624.85	I	9825 - 24915
20	5980.78	I	9637 - 26353	13	6633.26	I	11101 - 26172
28	6002.31	I	9825 - 26480	13	6643.79	I	15724 - 30771
55	6002.63	I	8476 - 25131	8	6693.66	I	21603 - 36539
28	6016.12	I	21603 - 38221	8	6708.07	I	9825 - 24728
20	6025.41	I	14949 - 31541	65 c	6753.00	I	8716 - 23520
450	6039.73	I	8579 - 25131	10	6760.12	I	
100	6058.14	I	8413 - 24915	50 c	6766.49	I	8579 - 23353
20	6067.26	I	21646 - 38124	40	6784.98	I	8476 - 23211
480	6081.44	I	8476 - 24915	15	6786.32	I	
1300	6090.22	I	8716 - 25131	26	6812.40	I	8413 - 23088
28	6106.98	I	11101 - 27471	9 c	6829.94	I	8716 - 23353
280	6111.67	I	8413 - 24771	15	6832.44	I	8579 - 23211
600	6119.52	I	8579 - 24915	12	6839.58	I	19023 - 33640
20	6128.34	I	8476 - 24789	12	6841.90	I	8476 - 23088
280	6135.38	I	8476 - 24771	10 c	6870.88	I	19145 - 33695
180	6150.15	I	2425 - 18680	8	6871.56	I	15572 - 30121
85	6170.36	I	2311 - 18513	7	6894.00	I	19026 - 33528
23	6189.35	I	2220 - 18372	12	6974.50	I	19026 - 33360
450	6199.19	I	2311 - 18438	21	7026.07	I	19078 - 33307
130	6213.87	I	2425 - 18513	7	7063.69	I	11101 - 25254
450	6216.37	I	2220 - 18302	11 h	7092.08	I	
28 h	6218.31	I	23520 - 39597	6	7102.58	I	17242 - 31318
130	6224.50	I	2311 - 18372	24	7148.15	I	
430	6230.74	I	2153 - 18198	7	7151.36	I	20768 - 34747
100	6233.20	I	2220 - 18259	7	7182.08	I	18805 - 32725
55	6240.13	I	2153 - 18174	14	7264.29	I	20768 - 34530
170	6242.81	I	2112 - 18126	8	7321.44	I	17117 - 30771
710	6243.10	I	2425 - 18438	40	7338.92	I	17242 - 30864
280	6251.82	I	2311 - 18302	35	7356.54	I	17182 - 30771
85	6256.90	I	2220 - 18198	11	7358.66	I	20789 - 34375
85	6258.57	I	2112 - 18086	24	7361.39	I	17054 - 30636
55	6261.22	I	2153 - 18120	12	7362.49	I	19189 - 32768
85	6266.32	I	2220 - 18174	24	7363.16	I	17117 - 30694
130	6268.82	I	2425 - 18372	9	7385.95	I	19189 - 32725
170	6274.65	I	2153 - 18086	6 h	7393.49		
17	6282.33	I	17242 - 33155	12 h	7485.90	I	20813 - 34168
200	6285.16	I	2220 - 18126	12 h	7488.08	I	15270 - 28621
200	6292.83	I	2311 - 18198	12 h	7492.44		
170	6296.49	I	2425 - 18302	12 h	7578.75	I	24915 - 38106
28 h	6311.50	I	26738 - 42578	9 h	7591.24	I	24771 - 37940
14	6324.66	I	17182 - 32989	14 h	7596.92	I	19189 - 32349
70	6326.84	I	15063 - 30864	12 h	7598.28	I	18805 - 31962
55	6339.09	I	15001 - 30771	24	7624.81	I	25131 - 38242
50	6349.48	I	14949 - 30694	5	7701.37	I	18805 - 31786
14	6355.58	I	17117 - 32847	8	7704.81	I	25131 - 38106
50	6357.30	I	14910 - 30636	8 h	7851.18		
25	6358.82	I	17242 - 32964	14 bl	7865.51	VO	
35	6361.27	I	17182 - 32898	12	7896.40		
23	6379.36	I	17117 - 32788	14 h	7898.81		
14	6393.28	I	17055 - 32692	24	7937.92	I	24728 - 37322
35	6430.47	I	15771 - 31318	29 c	8027.39	I	8579 - 21033
23	6431.63	I	15724 - 31268	14	8028.13	I	
14	6433.18	I	15689 - 31229	14 h	8035.38		
11	6435.16	I	15665 - 31200	14 h	8045.71		
70	6452.34	I	9637 - 25131	12	8051.89		
11	6488.05	I	19078 - 34487	14	8093.48	I	8476 - 20828
55	6504.17	I	9545 - 24915	8	8102.44	I	
110	6531.43	I	9825 - 25131	12	8108.59	I	25112 - 37441
28	6543.51	I	9637 - 24915	9 h	8109.07	I	24899 - 37227
17	6558.02	I	11101 - 26345	120 cw	8116.80	I	8716 - 21033

*Vanadium – all observed lines – Continued*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
11 h	8136.79	I	24830 – 37117	5 h	8280.39	I	25931 – 38004
29	8144.59	I	8413 – 20688	19	8282.37	I	26172 – 38242
9	8154.55	I	24899 – 37158	8	8324.42	I	25931 – 37940
70 c	8161.07	I	8579 – 20828	14 h	8331.23	I	26004 – 38004
14	8171.35	I	24993 – 37227	14	8342.03	I	26122 – 38106
7	8180.21	I	20768 – 32989	7	8402.81	I	
35	8186.71	I	8476 – 20688	12	8499.52	I	26480 – 38242
24	8187.33	I	25112 – 37322	6	8534.49	I	21646 – 33360
29	8198.87	I	8413 – 20606	6 bl	8624.86	VO	
35	8203.07	I	25254 – 37441	60 c	8919.85	I	9824 – 21033
24	8241.61	I	8476 – 20606	29 c	8932.93	I	9637 – 20828
29 c	8253.51	I	8716 – 20828	12	8971.62	I	9545 – 20688
29	8255.88	I	8579 – 20688				

# Ytterbium

$$\text{Yb, } Z = 70, M = 173.0, \text{ Ratio } \frac{\text{Yb}}{\text{Cu}} = 2.723$$

- Yb I Normal state of valence electrons  $6s^2 \ ^1S_0 = 0$ . I.P. = 50441  $\text{cm}^{-1}$ .  
 Yb II Normal state of valence electrons  $6s^2 \ ^2S_{1/2} = 0$ . I.P. = 98150  $\text{cm}^{-1}$ .  
 Yb III Normal state of valence electrons  $4f^{14} \ ^1S_0 = 0$ . I.P. = 201900  $\text{cm}^{-1}$ .

## References

### Wavelengths:

W. F. Meggers and C. H. Corliss, J. Res. Nat. Bur. Stand. (U.S.), **70A** (Phys. and Chem.), No. 1, 63-106 (Jan.-Feb. 1966).

### Classification and Spectrum Assignments:

Yb I, W. F. Meggers, unpublished material (1965).

Yb II, W. F. Meggers, J. Res. Nat. Bur. Stand. (U.S.), **71A** (Phys. and Chem.), No. 6, 396-544 (Nov.-Dec. 1967).

Yb III, B. W. Bryant, J. Opt. Soc. Am. **55**, 771 (1965).

### Strong lines of ytterbium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
32000	3694.19	II	0 - 27062	990	2653.75	II	21418 - 59090
32000	3987.99	I	0 - 25068	930	3990.88	I	19710 - 44760
18000	3289.37	II	0 - 30392	920	3031.11	II	0 - 32982
3600	2891.38	II	0 - 34575	850	2185.71	II	0 - 45737
3000	2126.74	II	0 - 47006	750	7699.48	I	19710 - 32695
2500	2116.67	II	0 - 47229	710	4935.50	I	19710 - 39966
2400	3464.37	I	0 - 28857	690	6799.60	I	17992 - 32695
2400	5556.47	I	0 - 17992	640	4576.21	I	17992 - 39838
2000	2970.56	II	0 - 33654	640	2224.46	II	0 - 44941
1300	2750.48	II	21418 - 57765				

Ytterbium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
2500	2116.67	II	0 - 47229	21	2734.09	II	34390 - 70954
3000	2126.74	II	0 - 47006	55	2741.71	II	33494 - 69957
370	2161.60	II		55	2747.58	II	32371 - 68756
850	2185.71	II	0 - 45737	18	2748.04	II	34575 - 70954
640	2224.46	II	0 - 44941	230	2748.66	II	31568 - 67939
140	2320.81	II	0 - 43075	1300	2750.48	II	21418 - 57765
50	2362.89	II	21418 - 63727	85	2751.45	II	30224 - 66558
170	2390.74	II	21418 - 63234	21	2759.00	II	37516 - 73751
18	2398.02	II	0 - 41688	65	2760.78	II	35059 - 71270
28	2421.35	II	32371 - 73658	65	2761.37	II	35019 - 71222
25	2447.26	II	28758 - 69608	35	2764.41	II	35059 - 71222
28	2460.25	II	30224 - 70858	85	2771.32	II	34785 - 70858
460	2464.50	I	0 - 40564	170	2776.28	II	34785 - 70794
14	2484.89	II	30563 - 70794	100	2784.66	II	33494 - 69395
70	2502.02	II	21418 - 61374	18	2787.96	II	30224 - 66082
28	2505.48	II	31568 - 71469	45	2793.28	II	33654 - 69444
11	2508.07	II	24332 - 64191	25	2794.44	II	35019 - 70794
140	2512.06	II	21418 - 61215	21	2795.07	II	37516 - 73283
18	2516.35	II	33052 - 72780	18	2795.29	II	32371 - 68135
50	2522.44	II	21418 - 61051	35	2797.80	II	40917 - 76649
65	2537.65	II	30563 - 69957	100	2798.21	II	30224 - 65951
270	2538.67	II	0 - 39379	45	2799.38	II	22960 - 58672
14	2550.06	II	22960 - 62163	50	2800.00	II	33052 - 68756
70	2552.15	II	30224 - 69395	35	2800.06	II	28758 - 64461
55	2552.70	II	31632 - 70794	14	2810.72	II	32371 - 67939
21	2565.57	II	34785 - 73751	65	2814.53	II	30563 - 66082
28	2571.36	II	31980 - 70858	28	2816.32	II	33052 - 68549
13	2573.15	II	32371 - 71222	140	2821.15	II	31980 - 67416
18	2596.16	II	34784 - 73291	100	2824.97	II	30563 - 65951
28	2596.32	II	31632 - 70136	190	2830.99	II	30563 - 65876
21	2615.26	II	30224 - 68450	18	2832.20	II	28758 - 64056
100	2617.01	II	21418 - 59619	28	2834.97	II	37516 - 72780
55	2634.31	II	22960 - 60910	14	2842.59	II	32982 - 68150
45	2639.45	II	31568 - 69444	230	2847.18	II	27062 - 62174
85	2641.89	II	21418 - 59259	100	2848.44	II	33052 - 68149
80	2642.56	III	34656 - 72487	21	2849.34	II	44498 - 79583
110	2644.31	II	33052 - 70858	360	2851.13	II	26759 - 61822
28	2646.44	II	33494 - 71270	55	2851.86	II	33494 - 68549
28	2647.46	II	35019 - 72780	21	2853.41	II	46170 - 81205
28	2648.80	II	33052 - 70794	18	2853.68	II	34575 - 69608
50	2649.79	II	33494 - 71222	55	2854.14	II	35832 - 70858
28	2650.73	II	30224 - 67939	45	2854.49	II	40036 - 75058
990	2653.75	II	21418 - 59090	45	2858.33	II	30224 - 65200
35	2656.12	II	28758 - 66396	45	2858.46	II	32982 - 67955
21	2659.27	II	28758 - 66351	100	2859.39	II	35832 - 70794
200	2665.04	II	31568 - 69080	430	2859.80	II	21418 - 56376
85	2666.13	III	34991 - 72486	55	2860.39	II	38342 - 73291
85	2666.99	III	34656 - 72140	140	2861.21	II	31632 - 66571
55	2668.75	II	33494 - 70954	100	2861.34	II	35019 - 69957
390	2671.96	I	0 - 37415	200	2867.06	II	30224 - 65093
390	2672.66	II	21418 - 58823	25	2870.06	II	42915 - 77747
21	2680.40	II	26759 - 64056	45	2873.49	I	
14	2683.42	II	44438 - 81693	28	2885.97	II	33494 - 68135
70	2684.75	II	32371 - 69608	70	2886.26	II	30563 - 65200
25	2687.98	II	30224 - 67416	200	2888.04	II	26759 - 61374
28	2695.43	II	31632 - 68720	3600	2891.38	II	0 - 34575
14	2696.62	II	32371 - 69444	45	2893.62	II	35059 - 69608
18	2700.80	II	44497 - 81512	28	2896.90	II	46170 - 80679
21	2708.84	II	33052 - 69957	85	2899.70	II	28758 - 63234
65	2710.54	II	31568 - 68450	18	2902.41	II	33494 - 67939
25	2711.78	II	21418 - 58284	21	2902.92	II	38342 - 72780
55	2712.66	II	30563 - 67416	21	2906.88	II	37078 - 71469
170	2718.35	II	31980 - 68756	28	2908.33	II	30224 - 64598
21	2722.20	II	34390 - 71114	35	2909.19	II	33052 - 67416
110	2732.74	II	31568 - 68150	55	2909.48	II	30563 - 64923



Ytterbium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
85	2911.52	II	35059 - 69395	55	3116.70	II	31980 - 64056
18	2912.86	II	31568 - 65888	190	3117.81	II	26759 - 58823
170	2914.21	II	35832 - 70136	50	3136.76	II	33052 - 64923
140	2915.28	II	26759 - 61051	230	3140.94	II	28758 - 60586
18	2916.43	II	39379 - 73658	80	3141.73	II	34575 - 66396
280	2919.35	II	31632 - 65876	80	3145.06	II	34785 - 66571
55	2921.12	II	32982 - 67205	28	3145.54	II	30392 - 62174
45	2924.24	II	32371 - 66558	28	3153.18	II	33494 - 65200
25	2927.85	II	37078 - 71222	90	3153.88	II	40917 - 72615
35	2934.36	I	27315 - 61384	50	3155.18	II	32371 - 64056
55	2935.11	II	34390 - 68450	28	3162.29	I	
21	2937.19	II	37078 - 71114	70	3163.80	II	33494 - 65093
45	2939.53	II	31568 - 65577	50	3165.21	II	35832 - 67416
45	2940.52	II		120	3169.06	II	33052 - 64598
28	2942.04	II	32371 - 66351	120	3180.92	II	33494 - 64923
140	2945.91	II	34785 - 68720	390	3192.88	II	30563 - 61874
45	2946.30	II	40036 - 73967	70	3198.65	II	31980 - 63234
18	2946.76	II	43956 - 77882	240	3201.16	II	31632 - 62861
28	2950.33	II	35059 - 68944	80	3217.18	II	32982 - 64056
45	2955.32	II	26759 - 60586	50	3218.32	II	35019 - 66082
18	2957.63	II	28757 - 62559	50	3225.88	II	30224 - 61215
65	2962.52	II	34390 - 68135	45	3239.20	II	32371 - 63234
21	2963.26	II	35019 - 68756	35	3239.58	I	30524 - 61384
45	2963.46	II		35	3246.06	II	
130	2964.76	II	30224 - 63944	130	3261.51	II	30563 - 61215
2000	2970.56	II	0 - 33654	18000	3289.37	II	0 - 30392
45	2982.49	II	33052 - 66571	130	3305.25	I	
21	2982.66	II	32371 - 65888	140	3305.73	II	31632 - 61874
28	2983.70	II	33052 - 66558	50	3315.10	II	
200	2983.99	II	30224 - 63727	80	3319.41	I	
90	2985.08	II	35059 - 68549	50	3333.06	II	33654 - 63648
35	2985.88	II	32982 - 66463	240	3337.17	II	
45	2990.37	II	35019 - 68450	280	3342.93	II	
65	2991.87	II	32982 - 66396	80	3343.07	II	35019 - 64923
28	2993.94	II	35059 - 68450		3346.50		
170	2994.80	II	30563 - 63944	50	3347.54	II	35059 - 64923
28	2995.86	II	32982 - 66351	35	3351.09	II	44438 - 74270
70	3000.46	II	42915 - 76233	50	3351.26		
25	3002.61	II	41679 - 74973	100	3352.49	II	
310	3005.77	II	31632 - 64891	100	3362.44	II	
100	3009.39	II	31980 - 65200	50	3363.64	II	
65	3010.62	II	32371 - 65577	240	3375.48	II	26759 - 56376
55	3014.43	II	30563 - 63727	50	3376.62	II	
160	3017.56	II	35019 - 68149	28	3382.54		
160	3026.67	II	33052 - 66082	140	3387.50	I	
920	3031.11	II	0 - 32982	50	3390.25	II	
55	3034.64	II	31980 - 64923	28	3390.42	II	
25	3037.99	II	32982 - 65888	50	3391.10	II	37078 - 66558
55	3039.67	II	35832 - 68720	50	3394.44	II	32371 - 61822
80	3042.65	II	33494 - 66351	50	3401.01	II	30224 - 59619
21	3044.00	II	30392 - 63234	35	3404.10	II	35832 - 65200
45	3046.48	II	34390 - 67205	50	3412.45	I	
35	3047.05	II	33654 - 66463	140	3418.39	I	28184 - 57429
45	3063.12	II	30224 - 62861	360	3426.04	I	
21	3063.67	II	34785 - 67416	80	3428.46	II	34785 - 63944
110	3065.04	II	28758 - 61374	240	3431.11	I	
18	3076.01	II	26759 - 59259	45	3434.61	II	22960 - 52067
100	3089.10	II	28758 - 61120	50	3438.71	II	34575 - 63648
70	3093.87	II	31632 - 63944	100	3438.85	II	31980 - 61051
28	3100.74	I		35	3443.59		
45	3101.36	II	33654 - 65888	35	3446.89	II	32371 - 61374
28	3102.07	II	32371 - 64598	85	3452.40	I	29774 - 58732
55	3107.76	II	34390 - 66558	500	3454.08	II	26759 - 55702
170	3107.90	II	40036 - 72202	190	3458.29	II	40036 - 68944
85	3115.34	II	32371 - 64461		3458.39	I	

Ytterbium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	
360	3460.27	I	17992 - 46883	60	h	4393.69	I	25068 - 47822
35	3462.34	II		60	h	4430.21	I	24489 - 47055
2400	3464.37	I	0 - 28857	440		4439.19	I	17288 - 39809
500	3476.30	II	0 - 28758	85	h	4482.42	I	24752 - 47055
500	3478.84	II	30224 - 58961	85		4515.16	II	26759 - 48900
50	3482.56	II		35		4553.58	II	30563 - 52517
85	3485.76	II	32371 - 61051	85	h	4563.95	I	19710 - 41615
85	3488.43	II		640		4576.21	I	17992 - 39838
100	hw	II	64598 - 93194	200		4582.36	I	17992 - 39809
85	3495.90	II	37078 - 65577	70		4589.21	I	25271 - 47055
50	3517.00	I	19710 - 48136	140		4590.83	I	25859 - 47636
230	3520.29	II	30563 - 58961	40		4598.36	II	31980 - 53721
50	3545.72	II	43075 - 71270	35		4683.81	II	32371 - 53715
100	3549.82	II	33052 - 61215	40		4684.27	I	27446 - 48788
35	3559.03	I	17992 - 46082	190		4726.08	II	26759 - 47912
200	3560.33	II	21418 - 49498	170	h	4781.87	I	
170	3560.70	II	34785 - 62861	170		4786.61	II	31632 - 52517
50	h	II	31568 - 59619	35		4816.43	I	
85	3570.57	II	33052 - 61051	40		4820.24	II	28758 - 49498
50	3572.50	II	34575 - 62559	35		4836.96	II	33052 - 53721
50	3574.58	II		40		4837.46	I	24489 - 45155
360	3585.47	II	21418 - 49301	17		4851.15	II	24333 - 44941
130	3606.48	II	33494 - 61215	40	h	4894.60	I	
50	3610.23	II	31568 - 59259	27		4912.36	I	19710 - 40062
70	3611.30	II	37516 - 65200	710		4935.50	I	19710 - 39966
200	3619.80	II	28758 - 56376	24		4937.22	II	37516 - 57765
110	3634.52			140		4966.90	I	19710 - 39838
240	3637.76	II	21418 - 48900	24		5009.52	II	32982 - 52938
70	3648.15	I	27314 - 54718	17		5067.30	II	34575 - 54304
90	3655.73	I	17992 - 45339	30		5067.80	I	28184 - 47911
240	3669.69	II	27062 - 54304	70		5069.14	I	27314 - 47036
50	3670.69	II	38342 - 65577	220		5074.34	I	24752 - 44453
140	3675.08	II	30563 - 57765	50		5076.74	I	25068 - 44760
50	3690.56	II	34785 - 61874	20		5135.98	II	33052 - 52517
32000	3694.19	II	0 - 27062	14		5147.02	II	38342 - 57765
70	3698.60	II	35832 - 62861	20		5184.15	II	33654 - 52938
70	3700.58	I	25859 - 52874	60		5196.08	I	27314 - 46554
50	3710.34	II	28758 - 55702	85		5211.60	I	25271 - 44453
60	3724.21	II	31980 - 58823	35		5240.51	II	30224 - 49301
180	3734.69	I	17992 - 44760	100		5244.11	I	24752 - 43816
550	3770.10	I	17288 - 43805	40		5257.49	II	34390 - 53405
80	3774.32	I		150	h	5277.04	I	24489 - 43434
60	h	I	17992 - 44357	35		5279.53	II	34785 - 53721
170	3839.91	I	23188 - 49223	17		5300.94	II	37516 - 56376
340	3872.85	I	17992 - 43805	170		5335.15	II	30563 - 49301
340	3900.85	I	19710 - 45339	30	d	5345.66	II	35019 - 53721
50	3904.81	II	38342 - 63944			5345.83	II	40918 - 59619
140	3911.27	I	27314 - 52874	60		5347.22	II	35019 - 53715
32000	3987.99	I	0 - 25068	30	h	5351.29	I	24752 - 43434
930	3990.88	I	19710 - 44760	150		5352.95	II	30224 - 48900
50	4007.36	I	23188 - 48135	30		5358.64	II	35059 - 53715
70	4052.28	I	19710 - 44380	30		5363.66	I	23188 - 41827
85	4077.28	II	38342 - 62861	17		5389.84	II	34390 - 52938
440	4089.68	I	17992 - 42436	14		5432.71	II	47680 - 66082
120	h	II		40		5449.27	II	35059 - 53405
70	4135.09	II	34785 - 58961	14		5478.50	II	40036 - 58284
470	4149.07	I	19710 - 43805	60		5481.92	I	24489 - 42726
120	4174.56	I	17992 - 41939	40		5505.49	I	24489 - 42648
340	4180.81	II	30392 - 54304	17		5524.54	I	27314 - 45410
150	d	II	37516 - 61215	85	h	5539.05	I	
		I	24752 - 48449	2400		5556.47	I	0 - 17992
120	4231.97	I	17992 - 41615	35		5562.09	I	24752 - 42726
70	4277.74	I	24489 - 47859	20		5568.11	I	25859 - 43814
120	4305.97	I	25270 - 48487	20		5586.36	I	24752 - 42648
70	4316.95	II	30563 - 53721	40		5588.45	II	35832 - 53721

Ytterbium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	
60	5651.98	II	30224 - 47912	35	h	6417.91	I	27678 - 43255
7	5686.53	II	41678 - 59259	20		6432.73	II	32371 - 47912
220	5719.99	I	27678 - 45155	17	h	6463.15	II	46354 - 61822
10	5749.91	II	49009 - 66396	340		6489.06	I	17288 - 32695
10	h	I	25068 - 42436	20		6643.55	I	27678 - 42726
27	5771.66	II	31980 - 49301	180		6667.82	I	25068 - 40062
10	5803.44	I	28184 - 45410	15		6678.17	I	27678 - 42648
10	5819.41	II	46548 - 63727	25		6727.61	II	33052 - 47912
35	5833.99	II		25		6768.70	I	25068 - 39838
35	5837.14	II	32371 - 49498	690		6799.60	I	17992 - 32695
27	5854.51	I	25859 - 42935	18		6934.05	II	33494 - 47912
8	5897.21	II	48923 - 65876	20		6999.88	II	35019 - 49301
20	5908.36	II	31980 - 48900	10		7043.78	II	47680 - 61873
17	5989.33	I	23188 - 39880	9	h	7244.41	I	24752 - 38552
40	5991.51	II	35832 - 52517	8	h	7305.22	I	24489 - 38174
10	6052.88	II	32982 - 49498	10	h	7313.05	I	24752 - 38422
10	6054.57	I	30524 - 47036	16	h	7350.04	I	24489 - 38091
60	6152.57	II	33052 - 49301	25		7448.28	I	24752 - 38174
30	6246.97	II	33494 - 49498	30	h	7527.46	I	25271 - 38552
60	6274.78	II	31980 - 47912	750		7699.48	I	19710 - 32695
14	6308.15	II	33052 - 48900	7		7895.08	I	24752 - 37415
35	h	I	27678 - 43298	70	h	8922.56	II	44498 - 55702

## Yttrium

$$Y, Z = 39, M = 88.9059, \text{Ratio } \frac{Y}{Cu} = 1.399$$

Y I Normal state of valence electrons  $5s^2 4d^2 D_{1/2} = 0$ . I.P. = 52000  $\text{cm}^{-1}$ .

Y II Normal state of valence electrons  $5s^2 ^1S_0 = 0$ . I.P. = 99000  $\text{cm}^{-1}$ .

Y III Normal state of valence electrons  $4d ^2D_{1/2} = 0$ . I.P. = 165000  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

- A. Gatterer and J. Junkes, *Spektren der Seltenen Erden* (Specola Vaticana, Vatican, 1945), below 7350 Å.  
 G. R. Harrison, *Massachusetts Institute of Technology Wavelength Tables* (John Wiley & Sons, New York, 1939), above 7350 Å.

#### Classification:

Y I, Y II, and Y III, W. F. Meggers and H. N. Russell, *J. Research NBS* **2**, 733 (1929) RP 55.

#### Molecular Spectra:

YO, W. F. Meggers and J. A. Wheeler, *J. Research NBS* **6**, 239 (1931) RP 273.

### *Strong lines of yttrium*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
13000	3710.30	II	1450 - 28394	6200	3601.92	II	840 - 28595
12000	4374.94	II	3296 - 26147	4700	3327.89	II	3296 - 33337
10000	3600.73	II	1450 - 29214	4400	3950.36	II	840 - 26147
10000	3774.33	II	1045 - 27532	4300	3620.94	I	530 - 28140
9900	4102.38	I	530 - 24900	4000	3832.88	II	1450 - 27532
9400	4077.38	I	0 - 24519	3900	3216.69	II	1045 - 32124
8900	4128.31	I	530 - 24747	3900	3549.01	II	1045 - 29214
8000	4177.54	II	3296 - 27227	3600	3982.60	II	1045 - 26147
7800	3611.05	II	1045 - 28730	3300	3584.52	II	840 - 28730
7800	3633.12	II	0 - 27517	3000	3664.61	II	1450 - 28730
7500	4142.85	I	0 - 24131	2800	3592.92	I	0 - 27824
7400	3788.70	II	840 - 27227	2800	4309.63	II	1450 - 24647
6200	3242.28	II	1450 - 32284				

Yttrium—all observed lines

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
350	2243.06	II	0 - 44568	60	3128.77	II	27227 - 59179
50	2354.20	I	530 - 42995	80	3129.93	II	27532 - 59472
200	2367.25	III	725 - 42955	95	3135.17	II	1450 - 33337
30	2373.83			110	3173.06	II	28394 - 59900
50	2385.24			220	3179.41	II	840 - 32284
25	2413.93	II	23776 - 65189	70	3191.31	I	11360 - 42686
240	2414.68	III	0 - 41401	2300	3195.62	II	840 - 32124
560	2422.20	II	3296 - 44568	2200	3200.27	II	1045 - 32284
60	2460.61	II	24647 - 65275	2200	3203.32	II	840 - 32049
25	2490.42	I	530 - 40672	3900	3216.69	II	1045 - 32124
12	2540.28			6200	3242.28	II	1450 - 32284
14	2547.57			310	3280.91	II	14098 - 44568
10	2550.17			19	3308.47	II	28730 - 58947
20	2681.65	I	0 - 37279	4700	3327.89	II	3296 - 33337
60	2694.21			55	3340.38	I	16066 - 45994
26	2695.39	I	530 - 37620	160	3362.00	II	14833 - 44568
95	2723.00	I	530 - 37244	85	3388.59	I	15246 - 44748
22	2730.08	I	0 - 36618	45	3397.04	I	16234 - 45664
22	2734.85	II	24647 - 61200	85	3412.47	I	15712 - 45008
70	2742.53	I	0 - 36452	200	3448.82	II	3296 - 32284
140	2760.10	I	530 - 36751	70	3450.95	I	16234 - 45204
30	2785.21	II	23776 - 59670	110	3467.88	II	3296 - 32124
12	2785.59	II	24647 - 60535	170	3485.73	I	17116 - 45796
12	2791.20	I	0 - 35817	1700	3496.09	II	0 - 28595
30	2800.11	II	23445 - 59147	80	3521.53	I	14949 - 43338
26	2813.64	I	530 - 36061	45	3546.01	II	
390	2817.01	III	7466 - 42955	3900	3549.01	II	1045 - 29214
18	2818.86	I	10529 - 45994	130	3551.80	I	14949 - 43096
45	2822.56	I	10529 - 45948	540	3552.69	I	0 - 28140
22	2825.37	II	29214 - 64597	170	3558.76	I	15246 - 43338
45	2826.38	II	23776 - 59147	190	3571.43	I	15712 - 43704
70	2854.43	II	24647 - 59670	260	3576.05	I	16234 - 44190
26	2856.30	II	23776 - 58776	3300	3584.52	II	840 - 28730
11	2857.87			300	3587.75	I	
95	2886.48	I	11360 - 45994	100	3589.69	I	15246 - 43096
18	2897.69	II	24647 - 59147	2800	3592.92	I	0 - 27824
14	2898.82	II	23776 - 58262	10000	3600.73	II	1450 - 29214
160	2919.05	I	0 - 34248	6200	3601.92	II	840 - 28595
18	h 2930.03	II	27532 - 61650	7800	3611.05	II	1045 - 28730
280	h 2945.94	III	7466 - 41401	4300	3620.94	I	530 - 28140
390	2948.40	I	0 - 33907	1900	3628.71	II	1045 - 28595
350	2964.96	I	530 - 34248	7800	3633.12	II	0 - 27517
18	2973.91	II	24647 - 58262	3000	3664.61	II	1450 - 28730
480	2974.59	I	0 - 33608	45	3668.49	II	28394 - 55645
30	2980.55	II	28394 - 61934	170	3692.53	I	17116 - 44190
750	2984.26	I	530 - 34030	13000	3710.30	II	1450 - 28394
70	2995.26	I	530 - 33907	60	3718.12	I	16817 - 43704
140	2996.94	I	0 - 33358	60	3738.61	I	16597 - 43338
70	3005.26	I	0 - 33265	1200	3747.55	II	840 - 27517
55	3018.95	I	10529 - 43644	50	3749.89	I	16436 - 43096
130	3021.73	I	530 - 33614	10000	3774.33	II	1045 - 27532
90	3022.28	I	530 - 33608	1400	3776.56	II	1045 - 27517
26	3026.49	II	26147 - 59179	50	3782.30	II	29214 - 55645
30	3036.59	II	28730 - 61650	7400	3788.70	II	840 - 27227
45	3044.84	I		1300	3818.35	II	1045 - 27227
190	3045.37	I	530 - 33358	4000	3832.88	II	1450 - 27532
22	3047.11	I		70	3847.87	II	
60	3055.22	II	29214 - 61934	80	3876.82		
60	3086.85	II	26147 - 58533	480	3878.28	II	1450 - 27227
55	h 3091.70	I		30	3887.77	I	11360 - 37074
22	3093.76	II	32284 - 64597	60	h 3904.59	I	
95	3095.88	II	1045 - 33337	50	h 3918.25	I	10937 - 36452
45	3111.81	I	10529 - 42656	60	h 3930.11	I	
55	3112.04	II	0 - 32124	240	3930.66	II	3296 - 28730
22	3114.28	I		4400	3950.36	II	840 - 26147

Yttrium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	3951.60	II	3296 - 28595	40	4522.05	I	16436 - 38544
60	3955.09	I		890	4527.25	I	11532 - 33614
3600	3982.60	II	1045 - 26147	440	4527.80	I	11278 - 33358
40	3987.50	I	11360 - 36431	100	4544.32	I	15477 - 37476
940	4039.83	I	0 - 24747	100	4559.37	I	15222 - 37148
2400	4047.64	I	0 - 24699	30	4564.39	I	
9400	4077.38	I	0 - 24519	60	4573.56	I	16817 - 38675
90	4081.22	I	18499 - 42995	35	4581.32	I	15327 - 37148
2000	4083.71	I	0 - 24481	30	4581.77	I	15329 - 37148
9900	4102.38	I	530 - 24900	130	4596.55	I	17116 - 38866
60	4106.39	I	18512 - 42858	95	4604.80	I	15329 - 37040
80	4110.81	I	15246 - 39565	40	4613.00	I	15477 - 37148
320	4124.92	II	3296 - 27532	2000	4643.70	I	0 - 21529
8900	4128.31	I	530 - 24747	200	4658.32	I	16159 - 37620
7500	4142.85	I	0 - 24131	70	4658.89	I	
100	4157.63	I	15712 - 39758	85	4667.47	I	15994 - 37413
2400	4167.52	I	530 - 24519	60	4670.82	I	
2000	4174.14	I	530 - 24481	2000	4674.84	I	530 - 21915
8000	4177.54	II	3296 - 27227	60	4678.35	I	19148 - 40517
120	4199.28	II	840 - 24647	260	4682.32	II	3296 - 24647
380	4204.70	II	0 - 23776	85	4689.77	I	16159 - 37476
80	4213.02	I	16234 - 39964	180	4696.81	I	15994 - 37279
40	4213.54	I	14949 - 38675	35	4708.85	I	15222 - 36452
160	4217.80	I	10529 - 34231	60	4725.85	I	15994 - 37148
280	4220.63	I	14949 - 38636	170	4728.53	I	10529 - 31672
80	4224.25	I		60	4732.37	I	15327 - 36452
600	4235.73	II	1045 - 24647	85	4741.40	I	16159 - 37244
2200	4235.94	I	530 - 24131	160	4752.79	I	15327 - 36361
300	4251.20	I	15246 - 38762	410	4760.98	I	530 - 21529
360	4302.30	I	15712 - 38949	17	4780.18	I	15222 - 36136
2800	4309.63	II	1450 - 24647	120	4781.04	I	11278 - 32188
50	4316.30	I	11360 - 34521	160	4786.58	II	8328 - 29214
110	4330.78	I	10529 - 33613	170	4786.89	I	15477 - 36361
30	4337.29	I	15712 - 38762	180	4799.30	I	11079 - 31909
60	4344.65	I	16436 - 39446	50	4804.31	I	15327 - 36136
440	4348.79	I	16234 - 39223	70	4804.81	I	15329 - 36136
60	4352.33	I	11278 - 34248	85	4817.38	YO	
60	4352.70	I	16597 - 39565	140	4818.20	YO	
120	4357.73	I	16817 - 39758	140	4819.64	I	10937 - 31680
800	4358.73	II	840 - 23776	120	4822.13	I	15329 - 36061
120	4366.03	I	11360 - 34257	190	4823.31	II	8003 - 28730
12000	4374.94	II	3296 - 26147	60	4839.15	I	15477 - 36136
150	4375.61	I	17116 - 39964	770	4839.87	I	11532 - 32188
80	4379.33	I	11079 - 33907	550	4845.68	I	11278 - 31909
30	4385.48	I	11360 - 34156	410	4852.69	I	11079 - 31680
100	4387.74	I		120	4854.25	I	15222 - 35817
30	4394.01	I	11278 - 34030	890	4854.87	II	8003 - 28595
30	4394.67	I	16817 - 39565	50	4856.70	I	15477 - 36061
1800	4398.02	II	1045 - 23776	330	4859.84	I	10937 - 31508
890	4422.59	II	840 - 23445	50	4879.65	I	15329 - 35817
80	4437.34	I	11079 - 33608	1900	4883.69	II	8743 - 29214
100	4443.66	I	11532 - 34030	50	4886.28	I	16159 - 36618
130	4446.63	I	11360 - 33842	40	4886.65	I	15994 - 36452
20	4465.27	I		95	4893.44	I	11079 - 31508
40	4473.89	I		1100	4900.12	II	8328 - 28730
170	4475.72	I	11278 - 33614	100	4906.11	I	11532 - 31909
180	4476.96	I	11278 - 33608	45	4909.00	I	16066 - 36431
160	4477.45	I	10937 - 33265	150	4921.87	I	11360 - 31672
110	4487.28	I	11079 - 33358	35	4930.93	I	16146 - 36420
300	4487.47	I	10937 - 33215	45	4950.66	I	
30	4491.75	I	11532 - 33789	120	4974.30	I	18499 - 38597
25	4492.42	I	11360 - 33613	120	4982.13	II	8328 - 28394
500	4505.95	I	11079 - 33265	100	5006.97	I	18512 - 38479
50	4513.58	I	15327 - 37476	75	5070.21	I	19148 - 38866
80	4514.01	I	15329 - 37476	75	5072.19	I	

Yttrium— all observed lines— Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
1100	5087.42	II	8743 - 28394	21	5832.27	I	17116 - 34257
30	5088.18	I	19028 - 38675	9 b	5838.07	YO	
210	5119.11	II	8003 - 27532	15	5858.83	YO	
450	5123.21	II	8003 - 27517	15	5871.83	I	16817 - 33842
180	5135.20	I	18499 - 37967	24	5876.14	YO	
120	5196.43	II	14098 - 33337	24	5879.96	I	16146 - 33148
960	5200.41	II	8003 - 27227	24 b	5893.94	YO	
1500	5205.72	II	8328 - 27532	35	5902.96	I	16817 - 33753
180	5240.81	I	18512 - 37588	24 b	5912.19	YO	
60	5289.82	II	8328 - 27227	24 b	5931.10	YO	
45	5320.78	II	8743 - 27532	90 bl	5939.08	YO	
75	5380.62	I	15327 - 33907	45	5945.72	I	16597 - 33412
220	5402.78	II	14833 - 33337	24	5950.02	I	16436 - 33238
24	5417.03	I	16066 - 34521	75 b	5956.41	YO	
90	5424.37	I	15477 - 33907	1300 bl	5972.04	YO	
190	5438.24	I	15864 - 34248	50	5981.86	I	16436 - 33148
710	5466.46	I	11532 - 29820	1000 bl	5987.64	YO	
100	5468.47	I	15327 - 33608	740 bl	6003.60	YO	
90	5473.39	II	14018 - 32284	120	6004.65		
90	5480.74	II	13883 - 32124	120	6009.19	I	17116 - 33753
60	5493.17	I	14949 - 33148	620 bl	6019.87	YO	
35	5495.59	I	16066 - 34257	120	6023.41	I	0 - 16597
240	5497.41	II	14098 - 32284	500 bl	6036.60	YO	
300	5503.45	I	15864 - 34030	420 bl	6053.81	YO	
250	5509.90	II	8003 - 26147	130 bl	6072.78	YO	
60	5513.64	I	15477 - 33608	50	6088.00	I	16817 - 33238
120	5521.63	I	15327 - 33432	210 bl	6089.35	YO	
	5521.70	II	14018 - 32124	160 bl	6096.78	YO	
24	5526.76	I	16159 - 34248	130 bl	6107.82	YO	
740	5527.54	I	11278 - 29364	130 bl	6114.73	YO	
35	5541.63	I	15712 - 33753	75 bl	6127.38	YO	
120	5544.61	I	15327 - 33358	1400 bl	6132.06	YO	
		II	14018 - 32049	120	6135.04	I	17116 - 33412
90	5546.02	II	14098 - 32124	150	6138.43	I	530 - 16817
75	5556.43	I	15246 - 33238	1100 bl	6148.36	YO	
60	5567.75	I	15477 - 33432	120	6151.72	YO	
180	5577.42	I	15864 - 33789	820 bl	6165.08	YO	
24	5581.08	I	15994 - 33907	560 bl	6182.23	YO	
620	5581.87	I	11079 - 28989	1200	6191.73	I	0 - 16146
21	5590.96	I	15477 - 33358	590 bl	6199.82	YO	
21	5594.12	I	16159 - 34030	450 bl	6217.96	YO	
120	5606.33	I	11532 - 29364	300	6222.59	I	0 - 16066
15	5623.91	I	16066 - 33842	270 bl	6236.72	YO	
560	5630.13	I	10937 - 28694	45	6251.05	I	
24	5632.25	I	15864 - 33614	120 bl	6275.01	YO	
21	5632.89	I	16159 - 33907	60 b	6295.46	YO	
120	5644.69	I	11278 - 28989	24 b	6316.20	YO	
120	5648.47	I	15712 - 33412	24 b	6338.10	YO	
740	5662.94	II	15683 - 33337	15 b	6359.48	YO	
90	5675.27	I	11079 - 28694	15	6369.87	YO	
18	5693.63	I	16597 - 34156	75	6402.01	I	530 - 16146
160	5706.73	I	16234 - 33753	1000	6435.00	I	530 - 16066
24	5720.61	I	16436 - 33912	24	6437.18	I	18499 - 34030
75	5728.89	II	14833 - 32284	18 h	6501.23	YO	
150 bl	5730.12	YO		18 h	6518.33	YO	
21	5732.09	I	16817 - 34257	18 h	6535.84	YO	
90	5743.85	I	17116 - 34521	90	6538.60	I	18499 - 33789
18 bl	5746.93	YO		12 h	6553.84	YO	
24 bl	5764.22	YO		70	6557.39	I	0 - 15246
75	5765.64	I	16817 - 34156	12 h	6572.58		
35	5773.95	I	16597 - 33912	35	6576.85	I	19238 - 34438
100	5781.69	II	14833 - 32124	23	6584.87	I	530 - 15712
15 bl	5800.00	YO		95	6613.75	II	14098 - 29214
15 bl	5818.58	YO		14	6622.49	I	18512 - 33608
30	5821.87	I	16066 - 33238	19 h	6636.49	I	28989 - 44053

Yttrium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	6650.61	I	19406 - 34438	10 h	7195.93	I	36361 - 50254
21	6664.40	I	29364 - 44366	35	7264.17	II	14833 - 28595
150	6687.58	I	0 - 14949	9 h	7293.08	I	15712 - 29420
14 h	6691.83	I	29820 - 44760	9 h	7330.62		
7	6694.75	I	18499 - 33432	5	7332.96	II	13883 - 27517
16 h	6699.26	I		50	7346.46	I	16234 - 29843
70	6700.71	I	18512 - 33432	11 h	7398.77	I	15477 - 28989
35	6713.20	I	21529 - 36420	29	7450.30	II	14098 - 27517
40	6735.99	I	19406 - 34248	17	7494.88	I	19028 - 32366
190	6793.71	I	530 - 15246	7 h	7536.71	I	
70 h	6795.41	II	14018 - 28730	35	7563.13	I	19148 - 32366
12 h	6803.15	I	19148 - 33842	8 h	7617.72	I	
21	6815.16	I	19238 - 33907	19 h	7622.94	I	18976 - 32091
14	6832.49	II	14098 - 28730	7	7652.89	I	19028 - 32091
45	6845.24	I	19148 - 33753	5	7689.49	I	18976 - 31978
14	6858.24	II	14018 - 28595	8 h	7698.00	I	
29	6887.22	I	21915 - 36431	19	7719.89	I	19028 - 31978
21	6896.00	II	14098 - 28595	19	7724.08	I	19148 - 32091
9	6908.26	I	14949 - 29420	13	7788.42	I	16436 - 29272
14	6933.52	I	530 - 14949	13	7796.32	I	16597 - 29420
24 h	6950.31	I	19028 - 33412	6	7802.52	I	15327 - 28140
10	6951.68	II	14833 - 29214	17	7812.16	I	16817 - 29614
10	6958.04	I	15246 - 29614	29	7855.52	I	17116 - 29843
24	6979.88	I	14949 - 29272	110	7881.90	II	14833 - 27517
13 h	7008.97	I	19148 - 33412	10 h	7999.33	I	17116 - 29614
10	7009.93	I	18976 - 33238	9	8329.61	I	32188 - 44190
19 h	7035.18	I	19028 - 33238	24	8344.43	I	16159 - 28140
29	7052.94	I	15246 - 29420	8 h	8365.64	I	24481 - 36431
13 h	7054.28	I	18976 - 33148	17	8450.36	I	15994 - 27824
9	7075.13	I	15712 - 29843	8 h	8528.94	I	24699 - 36420
11	7127.92	I	15246 - 29272	95	8800.62	I	0 - 11360
35	7191.66	I	15712 - 29614	19 h	8835.85	II	14833 - 26147



## Zinc

$$\text{Zn, } Z = 30, M = 65.4, \text{ Ratio } \frac{Z_n}{\text{Cu}} = 1.029$$

Zn I Normal state of valence electrons  $3d^{10}4s^2\ ^1S_0 = 0$ . I.P. = 75768  $\text{cm}^{-1}$ .

Zn II Normal state of valence electrons  $3d^{10}4s\ ^2S_{1/2} = 0$ . I.P. = 144893  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

#### Classification:

Zn I, C. W. Hetzler, R. W. Boreman, and K. Burns, Phys. Rev. **48**, 656 (1935).

Zn II, W. C. Martin and V. Kaufman, J. Res. Nat. Bur. Stand. (U.S.), **74A** (Phys. and Chem.), No. 1, 11-22 (Jan.-Feb. 1970).

#### *Zinc—all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
3000	2025.48	II	0 - 49355	200	3282.33	I	32311 - 62769
10000	2062.00	II	0 - 48481	900	3302.59	I	32501 - 62772
10000	2138.56	I	0 - 46745	280	3302.94	I	32501 - 62769
35 h	2756.45	I	32311 - 68579	1400	3345.02	I	32890 - 62777
60 d	2770.86	I	32501 - 68581	300	3345.57	I	32890 - 62772
	2770.98	I	32501 - 68579	60	3345.93	I	32890 - 62769
90 d	2800.87	I	32890 - 68583	400	4680.14	I	32311 - 53672
	2801.06	I	32890 - 68581	1000	4722.16	I	32501 - 53672
100 h	3072.06	I	32890 - 65432	1400	4810.53	I	32890 - 53672
260	3075.90	I	0 - 32502	120 hl	6362.35	I	46745 - 62458

## Zirconium

$$\text{Zr, } Z = 40, M = 91.22, \text{ Ratio } \frac{\text{Zr}}{\text{Cu}} = 1.435$$

Zr I, Normal state of valence electrons  $4d^25s^2\ ^3F_2=0$ . I.P. = 56077  $\text{cm}^{-1}$ .

Zr II, Normal state of valence electrons  $4d^25s\ ^4F_{1/2}=0$ . I.P. = 113175  $\text{cm}^{-1}$ .

### References

#### Wavelengths:

G. R. Harrison, Massachusetts Institute of Technology Wavelength Tables (John Wiley & Sons, New York, 1939).

#### Classification:

Zr I, C. C. Kiess and H. K. Kiess, J. Research NBS **6**, 621 (1931) RP 296.

Zr II, C. C. Kiess and H. K. Kiess, J. Research NBS **5**, 1205 (1930) RP 255.

#### Molecular Spectra:

ZrO, C. C. Kiess, Sci. Papers BS **22**, 47 (1927).

### Strong lines of zirconium

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in $\text{cm}^{-1}$
5700	3391.98	II	1323 - 30796	1800	2678.63	II	1323 - 38644
4700	3438.23	II	763 - 29840	1800	3547.68	I	570 - 28750
4100	3496.21	II	315 - 28909	1800	3551.95	II	763 - 28909
3500	3601.19	I	1241 - 29002	1600	2568.87	II	1323 - 40239
2900	3863.87	I	570 - 26444	1500	3885.42	I	0 - 25730
2900	3890.32	I	1241 - 26938	1500	4064.16	I	5249 - 29847
2300	4687.80	I	5889 - 27215	1400	2734.86	II	315 - 36869
2200	3835.96	I	0 - 26062	1400	4739.48	I	5249 - 26343
2100	2571.39	II	763 - 39640	1300	2722.61	II	1323 - 38041
2100	3556.60	II	3758 - 31866	1300	3279.26	II	763 - 31249
2100	3572.47	II	0 - 27984	1300	3481.15	II	6468 - 35186
2000	3519.60	I	0 - 28404	1300	3576.85	II	3300 - 31249
2000	3891.38	I	1241 - 26931	1300	3836.76	II	4506 - 30562
2000	4072.70	I	5541 - 30087	1200	3479.39	II	5753 - 34485
2000	4081.22	I	5889 - 30385	1200	3929.53	I	570 - 26012
2000	4227.76	I	5889 - 29535	1200	4149.20	II	6468 - 30562
2000	4239.31	I	5541 - 29123	1200	4241.69	I	5249 - 28818
1900	4710.08	I	5541 - 26766				

*Zirconium — all observed lines*

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
60	2374.42	I	0 - 42103	12	2759.48	I	1241 - 37469
60	2384.17	I		70	2761.91	II	0 - 36197
50	2388.01	I	570 - 42434	90	2763.03	I	4376 - 40558
50	2389.21	I		200	2768.73	II	1323 - 37430
45	2405.52	I	1241 - 42799		2768.85	II	763 - 36869
60	2419.41	II	4248 - 45568	170	2774.04	I	570 - 36608
150	2449.85	II	4248 - 45055		2774.16	II	6468 - 42504
21	2457.44	II	4506 - 45186	80	2786.86	I	5102 - 40974
75	2487.29	II	8153 - 48345	200	2790.14	I	5102 - 40932
45	2496.48	II	7838 - 47882	120	2792.04	I	0 - 35806
180	2532.46	II	763 - 40239	90	2793.39	I	
90	2539.65	I	570 - 39934	30	2795.13	I	570 - 36336
220	2542.10	II	315 - 39640	160	2796.90	II	5724 - 41468
45	2550.51	I	570 - 39766	110	2799.15	II	5753 - 41468
220	2550.74	II	0 - 39192	90	2806.78	I	4186 - 39804
45	2556.43	I	1241 - 40346	35	2808.16	II	315 - 35915
60	2567.45	I	1241 - 40178	180	2810.91	II	6112 - 41677
570	2567.64	II	0 - 38934	620	2814.90	I	0 - 35515
1600	2568.87	II	1323 - 40239	390	2818.74	II	7736 - 43202
2100	2571.39	II	763 - 39640	70	2819.56	I	5102 - 40558
75	2583.40	II	4506 - 43202	55	2821.56	I	570 - 36001
130	2589.07	II	4248 - 42861	530	2825.56	II	7513 - 42894
22	2589.65	I	570 - 39174	90	2827.50	II	6112 - 41468
45	2609.43	I	570 - 38882		2827.54	I	1241 - 36597
150	2630.91	II	4506 - 42504	60	2829.81	I	4376 - 39704
80	2635.42	I	1241 - 39174	110	2833.91	II	7513 - 42789
210	2639.09	II	763 - 38644	80	2834.40	II	6468 - 41738
70	2643.40	II	315 - 38134	35	2836.49	I	5102 - 40346
55	2647.78	I	570 - 38327	710	2837.23	I	570 - 35806
110	2650.38	II	763 - 38483	55	2838.02	II	6112 - 41337
70	2658.69	I	4186 - 41788	120	2839.34	II	6468 - 41677
180	2667.80	II	315 - 37788	130	2843.52	II	7736 - 42894
55	2669.49	II	5753 - 43202	660	2844.58	II	8058 - 43202
		II	7736 - 45186	210	2848.19	II	5753 - 40853
120	2670.96	II	4248 - 41677	350	2848.52	I	1241 - 36336
1800	2678.63	II	1323 - 38644	350	2851.97	II	7736 - 42789
35	2681.76	II	763 - 38041	70	2854.43	II	7838 - 42861
90	2687.75	I	1241 - 38436	27	2856.06	II	5724 - 40727
90	2692.60	II	8058 - 45186	95	2860.85	I	570 - 35515
22	2692.92	I	0 - 37123	55	2865.10	II	2895 - 37788
160	2693.53	II	315 - 37430	90	2865.60	II	3758 - 38644
180	2694.06	II	5753 - 42861	340	2869.81	II	8058 - 42894
70	2695.43	II	4248 - 41337	35	2872.53	II	8058 - 42861
95	2699.60	II	315 - 37346	490	2875.98	I	1241 - 36001
750	2700.13	II	763 - 37788	90	2877.55	II	3300 - 38041
90	2706.17	I	0 - 36942	35	2880.83	I	5102 - 39804
70	2709.33	I	570 - 37469	35	2882.09	II	4248 - 38934
280	2711.51	II	0 - 36869	55	2883.80	II	7838 - 42504
140	2712.42	II	315 - 37171	90	2888.04	II	6112 - 40727
140	2714.26	II	4506 - 41337	45	2889.43	II	2572 - 37171
12	2717.48	I	4186 - 40974	120	2892.26	I	1241 - 35806
1300	2722.61	II	1323 - 38041	90	2898.71	II	3300 - 37788
140	2725.47	I	1241 - 37921	60	2901.62	II	13428 - 47882
800	2726.49	II	763 - 37430	55	2901.82	II	2895 - 37346
60	2727.02	I	570 - 37230	160	2905.23	II	6468 - 40878
490	2732.72	II	763 - 37346	70	2907.38	II	6468 - 40853
1400	2734.86	II	315 - 36869	90	2910.25	II	8153 - 42504
35	2737.89	I		300	2915.99	II	3758 - 38041
70	2740.35	II	3758 - 40239	27	2916.25	I	570 - 34851
110	2740.51	II	4248 - 40727	110	2916.64	II	2895 - 37171
140	2741.55	II	1323 - 37788	270	2918.24	II	8153 - 42410
1100	2742.56	II	0 - 36452	70	2923.85	I	570 - 34762
660	2745.86	II	763 - 37171	45	2924.64	II	14163 - 48345
660	2752.21	II	315 - 36639	320	2926.99	II	14190 - 48345
530	2758.81	II	0 - 36237	160	2934.61	II	2572 - 36639

Zirconium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
160	2936.31	II	3300 - 37346	320	3157.82	I	4376 - 36035
90	2945.46	II	7736 - 41677			I	5102 - 36760
320	2948.94	II	7838 - 41738	540	3164.31	II	5753 - 37346
210	2951.48	II	3300 - 37171	150	3165.45	II	8058 - 39640
95	2952.24	II	1323 - 35186	880	3165.97	II	1323 - 32899
320	2955.78	II	14060 - 47882	150	3166.26	II	6468 - 38041
320	2960.87	I	0 - 33764	190	3178.09	II	7736 - 39192
320	2962.68	II	2895 - 36639	190	3181.58	II	7513 - 38934
320	2968.96	II	3758 - 37430	150	3181.92	II	5753 - 37171
120	2969.19	I	570 - 34240	880	3182.86	II	4506 - 35915
230	2969.63	II	2572 - 36237	540	3191.21	I	0 - 31327
130	2976.61	II	8153 - 41738	210	3191.90	II	6468 - 37788
320	2978.05	II	3300 - 36869	75	3197.04	I	4186 - 35456
230	2979.18	II	2895 - 36452	25	3204.35	II	7736 - 38934
160	2981.02	II	4506 - 38041	95	3204.90	I	5102 - 36295
820	2985.39	I	0 - 33487	540	3212.01	I	570 - 31695
25	2987.80	II	9743 - 43202	45	3212.58	I	5102 - 36220
50	2991.41	II	0 - 33419	75	3212.85	II	5753 - 36869
320	3003.74	II	4506 - 37788	760	3214.19	II	763 - 31866
100	3005.37	I	4186 - 37450	110	3222.47	II	14163 - 45186
160	3005.50	I	8057 - 41320	200	3228.81	II	6468 - 37430
820	3011.75	I	570 - 33764	630	3231.69	II	315 - 31249
100	3013.32	II	4506 - 37682	630	3234.12	I	1241 - 32152
65	3014.44	I	0 - 33164	110	3236.58	II	14299 - 45186
160	3019.84	II	315 - 33419	760	3241.05	II	315 - 31160
350	3020.47	II	4248 - 37346	320	3250.39	I	570 - 31327
500	3028.04	II	7838 - 40853		3250.46	II	14299 - 45055
880	3029.52	I	1241 - 34240	200	3254.28	I	16978 - 47698
180	3030.92	II	0 - 32984	200	3260.11	I	4186 - 34851
350	d 3036.39	II	4506 - 37430	40	3264.81	II	7513 - 38134
	3036.50	II	4248 - 37171	190	3269.66	I	4186 - 34762
30	3043.25	I	570 - 33420	150	3271.13	II	4248 - 34810
100	3045.83	I	4186 - 37008	540	3272.22	II	0 - 30551
70	3049.33	I	4186 - 36971	1000	3273.05	II	1323 - 31866
690	3054.84	II	8153 - 40878	1300	3279.26	II	763 - 31249
70	3057.22	II	8153 - 40853	320	d 3282.73	I	1241 - 31695
100	3060.11	II	315 - 32984		3282.83	II	14733 - 45186
90	3061.35	II	763 - 33419	880	3284.71	II	0 - 30435
70	3063.57	I	4376 - 37008	140	3285.88	II	8058 - 38483
100	3064.63	II	4248 - 36869	150	3288.80	II	763 - 31160
50	3065.21	II	0 - 32615			II	7736 - 38134
110	3085.34	I	570 - 32972	75	3296.40	II	7736 - 38063
55	3090.44	I	5102 - 37450	75	3302.67	II	9969 - 40239
110	3094.80	I	4186 - 36489			II	17614 - 47882
250	3095.07	II	315 - 32615	540	3305.15	II	315 - 30562
110	3095.82	I	4197 - 36489	880	3306.28	II	315 - 30551
280	3099.23	II	0 - 32257	40	3309.89	II	7838 - 38041
690	3106.58	II	8058 - 40239	40	3311.34	II	5724 - 35915
110	3108.37	I	4376 - 36538	150	3313.70	II	7513 - 37682
210	3110.88	II	763 - 32899	210	3314.50	II	5753 - 35915
350	3120.74	I	4186 - 36220	75	3318.51	II	6112 - 36237
70	3125.19	II	4248 - 36237	150	3319.02	II	315 - 30435
320	3125.92	II	0 - 31981	380	3322.99	II	6112 - 36197
500	3129.18	II	4248 - 36197	40	3326.41	I	4186 - 34240
500	3129.76	II	315 - 32257	380	3326.80	II	12360 - 42410
140	3131.11	I	4197 - 36125	380	3334.25	II	8058 - 38041
350	3132.07	I	4376 - 36295	210	3334.62	II	4506 - 34485
110	3133.23	I	5102 - 37008	190	3338.41	II	7736 - 37682
350	3133.48	II	7736 - 39640	760	3340.56	II	1323 - 31249
180	3136.96	I	5102 - 36971	380	3344.79	II	8153 - 38041
690	3138.68	II	763 - 32615	130	3353.66	I	1241 - 31050
140	3139.80	I	5102 - 36942	180	3354.39	II	6112 - 35915
180	3148.82	I	4376 - 36125	760	3356.09	II	763 - 30551
290	3155.67	II	7513 - 39192	540	3357.26	II	0 - 29778
150	3157.00	II	4248 - 35915	180	3359.96	II	11984 - 41738

Zirconium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
150	3360.46	I	5102 - 34851	130	3485.32	II	7513 - 36197
95	3362.68	II	8058 - 37788	45	3495.37	I	11956 - 40558
150	3363.82	II	2895 - 32615	4100	3496.21	II	315 - 28909
150	3367.82	II	2572 - 32257	190	3499.58	II	3300 - 31866
25	3368.64	I	0 - 29677	130	3501.35	I	570 - 29123
40	3369.26	II	9969 - 39640	80	3501.49	I	8057 - 36608
150	3370.59	I	5102 - 34762	350	3505.48	II	12360 - 40878
180	3373.42	II	8153 - 37788	820	3505.67	II	1323 - 29840
380	3374.73	II	8058 - 37682	80	3506.05	II	9969 - 38483
110	3376.27	II	7736 - 37346	45	3507.67	II	7736 - 36237
150	3377.46	II	3300 - 32899	1000	3509.32	I	570 - 29058
55	3378.30	II	7838 - 37430	200	3510.46	II	4506 - 32984
55	3379.92	I	17556 - 47135	2000	3519.60	I	0 - 28404
570	3387.87	II	7838 - 37346	130	3520.87	II	4506 - 32899
760	3388.30	II	0 - 29505	440	3525.81	II	2895 - 31249
5700	3391.98	II	1323 - 30796	90	3530.22	I	5102 - 33420
570	3393.12	II	315 - 29778	70	3530.85	II	14190 - 42504
160	3396.33	II	7736 - 37171	440	3533.22	I	1241 - 29535
40	3396.66	II	13429 - 42861	210	3535.16	I	8057 - 36336
40	3397.92	I	18277 - 47698	110	3536.94	II	2895 - 31160
380	3399.35	II	2572 - 31981	45	3539.01	II	13429 - 41677
150	3402.87	II	12360 - 41738	630	3542.62	II	14190 - 42410
190	3403.68	II	8058 - 37430	1800	3547.68	I	570 - 28750
570	3404.83	II	2895 - 32257	130	3549.51	II	9969 - 38134
190	3408.08	II	7838 - 37171	210	3549.74	I	8057 - 36220
40	3408.78			630	3550.46	I	0 - 28157
760	3410.25	II	3300 - 32615	1800	3551.95	II	763 - 28909
40	3411.79	I	17833 - 47135	130	3554.07	II	9553 - 37682
380	3414.66	I	570 - 29847	2100	3556.60	II	3758 - 31866
		II	8153 - 37430	150	3558.96	I	5102 - 33192
75	3419.11	II	1323 - 30562	1100	3566.10	I	1241 - 29275
110	3419.66	I	4186 - 33420	90	3568.14	II	6468 - 34485
160	3424.82	II	315 - 29505	210	3568.88	I	5102 - 33114
25	3426.93	I	8057 - 37230	2100	3572.47	II	0 - 27984
65	3430.29	I	1241 - 30385	210	3573.08	II	2572 - 30551
1000	3430.53	II	3758 - 32899	1100	3575.79	I	570 - 28528
110	3431.57	II	7736 - 36869	1300	3576.85	II	3300 - 31249
140	3432.41	II	7513 - 36639	180	3577.55	I	8057 - 36001
110	3433.91	II	8058 - 37171	150	3578.23	II	9743 - 37682
380	3437.14	II	5724 - 34810	880	3586.29	I	0 - 27876
4700	3438.23	II	763 - 29840	440	3587.98	II	2572 - 30435
180	3440.45	I	0 - 29058	180	3588.32	II	3300 - 31160
120	3443.57	II	7838 - 36869	70	3591.72	I	570 - 28404
190	3446.61	I	4186 - 33192	45	3593.13	I	17060 - 44882
600	3447.36	I	0 - 28999	90	3599.90	II	14733 - 42504
200	3455.91	I	4186 - 33114	3500	3601.19	I	1241 - 29002
110	3457.18	I	4197 - 33114	160	3607.38	II	9969 - 37682
410	3457.56	II	4506 - 33419	690	3611.89	II	14060 - 41738
200	3458.93	II	7736 - 36639	1100	3613.10	II	315 - 27984
160	3461.09	I	8057 - 36942	140	3613.70	I	4186 - 31851
820	3463.02	II	11984 - 40853	1100	3614.77	II	2895 - 30551
95	3465.63	I	1241 - 30087	1100	3623.86	I	570 - 28157
40	3469.94	II	8058 - 36869	180	3630.02	II	2895 - 30435
600	3471.19	I	0 - 28801	140	3633.49	II	14163 - 41677
25	3472.90	I	4186 - 32972	320	3634.15	I	1241 - 28750
130	3478.30	II	763 - 29505	180	3636.45	II	3758 - 31249
65	3478.50	II	9743 - 38483	30	3638.72	I	4376 - 31851
200	3478.79	I	4376 - 33114	30	3655.56	II	7838 - 35186
180	3479.02	II	4248 - 32984	260	3661.20	I	570 - 27876
1200	3479.39	II	5753 - 34485	95	3662.14	II	13429 - 40727
150	3480.41	II	7513 - 36237	1100	3663.65	I	1241 - 28528
1300	3481.15	II	6468 - 35186	160	3668.45	II	3300 - 30551
190	3482.81	I	570 - 29275	390	3671.27	II	5753 - 32984
190	3483.01	I	8057 - 36760	800	3674.72	II	2572 - 29778
760	3483.54	II	6112 - 34810	140	3678.90	II	14163 - 41337

## Zirconium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	3680.37	I	1241 - 28404	490	3966.66	I	1241 - 26444
390	3697.46	II	3758 - 30796	990	3968.26	I	1241 - 26434
960	3698.17	II	8153 - 35186	40	3972.30	I	15720 - 40888
90	3706.63	I	1241 - 28212	110	3973.39	I	12761 - 37921
720	3709.26	II	6468 - 33419	660	3973.50	I	570 - 25730
190	3714.13	I	1241 - 28157	200	3975.29	I	12773 - 37921
190	3714.78	II	4248 - 31160	65	3977.34	I	5249 - 30385
65	3718.84	II	2895 - 29778	160	3977.48	I	8057 - 33192
270	3731.26	II	14060 - 40853	40	3978.25	I	
50	3737.39	I	5102 - 31851	100	3978.74	I	12342 - 37469
50	3738.11	II	4506 - 31249	200	h 3981.60	I	11017 - 36125
560	3745.98	II	14190 - 40878			I	16978 - 42087
80	3750.64	II	4506 - 31160	100	3982.16	I	10885 - 35990
880	3751.60	II	7838 - 34485	160	3984.75	I	4186 - 29275
50	3754.79	I	14349 - 40974	65	3986.80	I	570 - 25646
95	3757.79	II	14733 - 41337	100	3988.68	I	5023 - 30087
480	3764.39	I	0 - 26557	75	3989.29	I	570 - 25630
480	3766.72	I	12342 - 38882	160	3989.50	I	15120 - 40178
340	3766.82	II	3300 - 29840	770	3991.13	II	6112 - 31160
24	3767.88	II	5724 - 32257	770	3998.97	II	4506 - 29505
720	3780.54	I	0 - 26444	40	4001.09	I	1241 - 26227
50	3782.22	II	6468 - 32899	75	4002.55	I	4871 - 29847
95	3786.61			140	4003.10	I	11017 - 35990
560	3791.40	I	570 - 26938	75	4004.40	I	12503 - 37469
90	3792.40	I	570 - 26931	75	h 4004.87	I	16978 - 41941
130	3796.48	II	8153 - 34485	200	4007.60	I	14989 - 39934
95	3808.20			200	4012.25	I	15720 - 40637
210	3817.58	II	4248 - 30435	160	4016.98	I	12342 - 37230
560	3822.41	I	0 - 26154	120	4018.38	II	7736 - 32615
		I	5541 - 31695	400	4023.98	I	5541 - 30385
55	3827.27	II		120	4024.44	II	8058 - 32899
2200	3835.96	I	0 - 26062	770	4024.92	I	5249 - 30087
1300	3836.76	II	4506 - 30562	990	4027.20	I	5023 - 29847
160	3838.28	II	4506 - 30551	240	4028.95	I	4186 - 28999
550	3843.02	II	2895 - 28909	400	4029.68	II	5753 - 30562
550	3847.01	I	570 - 26557	490	4030.04	I	4871 - 29677
550	3849.25	I	0 - 25972	40	4034.09	II	6468 - 31249
110	3855.43	II	4506 - 30435	400	4035.89	I	1241 - 26012
2900	3863.87	I	570 - 26444	40	4040.24	II	7513 - 32257
770	3864.34	I	1241 - 27111	100	4041.64	I	15201 - 39937
990	3877.60	I	8057 - 33839	240	4042.22	I	11258 - 35990
200	3879.05	I	570 - 26343	610	4043.58	I	4186 - 28910
1500	3885.42	I	0 - 25730	490	4044.56	I	4871 - 29588
2900	3890.32	I	1241 - 26938	400	4045.61	II	5724 - 30435
2000	3891.38	I	1241 - 26931	610	4048.67	II	6468 - 31160
100	h 3892.03	I	15201 - 40888	200	4050.33	II	5753 - 30435
75	h 3893.84	I	12761 - 38436	200	4050.48	I	4376 - 29058
160	3896.53	I	570 - 26227	120	4054.43	I	1241 - 25898
		I	17143 - 42799	770	4055.03	I	5023 - 29677
75	3897.66	I	14697 - 40346	600	4055.71	I	12773 - 37422
400	3900.52	I	0 - 25630	330	4061.53	I	4186 - 28801
40	3914.34	II	19515 - 45055	1500	4064.16	I	5249 - 29847
310	3915.94	II	4248 - 29778	75	4068.72	I	10885 - 35456
160	3916.64	I	1241 - 26766	2000	4072.70	I	5541 - 30087
610	3921.79	I	570 - 26062	310	4074.93	I	4376 - 28910
75	h 3926.78	I	15720 - 41179	200	4076.53	I	4186 - 28710
1200	3929.53	I	570 - 26012	240	4078.31	I	4197 - 28710
200	3934.12	II	2572 - 27984	2000	4081.22	I	5889 - 30385
200	3934.79	II	5753 - 31160	65	4082.30	I	1241 - 25730
65	3936.06	II	6468 - 31866	120	4083.08	I	11641 - 36125
100	3941.62	I	8057 - 33420	160	4084.30	I	14697 - 39174
40	3951.33	I	11641 - 36942	160	4085.66	I	12761 - 37230
40	3956.79			75	4087.69	I	12773 - 37230
940	3958.22	II	4248 - 29505	160	4090.51	II	6112 - 30551
75	h 3963.80	I	16317 - 41538	160	4090.79	I	12503 - 36942

Zirconium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
55	4093.16	I	4376 - 28801	110	4291.35	I	4186 - 27482
120	4094.27	I	12342 - 36760	550	4294.79	I	5541 - 28818
65	4096.63	II	4506 - 28909	40	4296.74	II	14163 - 37430
110	4099.31	I	0 - 24388	310	4302.89	I	5889 - 29123
160	4107.50	I	11956 - 36295	190	4304.68	I	14697 - 37921
200	4108.40	I	4376 - 28710	40	4309.82	I	4376 - 27573
110	4119.83	I	12342 - 36608	75	4317.31	II	5753 - 28909
400	4121.46	I	4376 - 28633	75	4319.05	I	1241 - 24388
75	h 4127.96	I	4186 - 28404	75	4321.17	I	1241 - 24376
		I	4376 - 28595	110	4324.03	I	14349 - 37469
75	4134.31	I	12761 - 36942	180	4325.44	I	5889 - 29002
160	4135.68	I	5102 - 29275	40	4329.56	I	570 - 23661
40	4140.01	I	14123 - 38271	40	4333.26	II	19433 - 42504
65	4147.37	I	12503 - 36608	550	4341.13	I	11258 - 34287
1200	4149.20	II	6468 - 30562	40	4343.04	I	0 - 23019
160	4150.97	II	6468 - 30551	65	4346.52	I	14123 - 37123
200	4152.64	I	11017 - 35091	35	4347.22	I	570 - 23567
75	4153.75	I	12773 - 36841	1000	4347.89	I	8057 - 31050
290	4156.24	II	5724 - 29778	35	4348.93	I	5541 - 28528
400	4161.21	II	5753 - 29778	65	4358.74	I	4186 - 27122
400	4166.36	I	5541 - 29535	290	4359.74	II	9969 - 32899
75	4169.36	I	14349 - 38327	310	4360.81	I	4186 - 27111
120	4171.48	I	10885 - 34851	350	4366.45	I	11017 - 33912
75	4179.81	II	13429 - 37346	130	4370.95	II	9743 - 32615
200	4183.32	I	5102 - 28999	35	4373.07	I	5889 - 28750
100	4186.69	II	14163 - 38041	240	4379.78	II	12360 - 35186
660	4187.56	I	11641 - 35515	35	4394.50	I	570 - 23320
120	4191.79	I	11956 - 35806	130	4394.94	I	10885 - 33632
40	4192.10	I	12761 - 36608	100	4395.21	I	4376 - 27122
40	4194.01	I	12761 - 36597	90	4400.24	I	5889 - 28609
400	4194.76	I	11258 - 35091	65	4402.95	I	4197 - 26902
75	4196.13	I	12773 - 36597	65	4403.34	II	9553 - 32257
610	4199.09	I	5102 - 28910	190	4413.04	I	11258 - 33912
610	4201.46	I	5023 - 28818	35	4414.14	I	1241 - 23889
610	4208.98	II	5753 - 29505	65	4414.54	II	9969 - 32615
75	4211.34	I	14697 - 38436	240	4420.46	I	11017 - 33632
200	4211.88	II	4248 - 27984	120	4427.24	I	18739 - 41320
75	4212.62	I	10885 - 34617	55	4429.11	I	5102 - 27673
400	4213.86	I	4871 - 28595	160	4431.49	I	10885 - 33445
120	4218.45	I	5102 - 28801	90	4438.05	I	4376 - 26902
40	4220.65	I	5023 - 28710	75	4440.46	II	9743 - 32257
65	4225.46	I	12342 - 36001	140	4443.00	II	11984 - 34485
2000	4227.76	I	5889 - 29535	28	4444.33	I	11956 - 34451
40	4231.63	II	14163 - 37788	28	4448.95	I	5102 - 27573
160	4234.63	I	5102 - 28710	90	4450.28	I	10885 - 33350
200	4236.06	I	11017 - 34617	55	4455.43	I	14791 - 37230
65	4236.55	I	0 - 23597	55	4456.30	I	14989 - 37422
100	4237.43	I	11258 - 34851	110	4457.43	I	11017 - 33445
2000	4239.31	I	5541 - 29123			II	9553 - 31981
770	4240.34	I	4871 - 28447	28	4460.34	I	5102 - 27515
770	4241.20	I	5023 - 28595	90	4461.22	II	8153 - 30562
1200	4241.69	I	5249 - 28818	110	4466.91	I	5102 - 27482
75	4253.57	I	11258 - 34762	28	4468.22	I	11258 - 33632
75	4256.44	I	4186 - 27673	45	4468.79	I	4186 - 26557
180	4258.04	II	4506 - 27984	110	4470.31	I	12342 - 34706
75	4261.21	I	5541 - 29002	190	4470.56	I	12773 - 35135
75	4261.42	I	12761 - 36220	35	4480.77	I	14697 - 37008
310	4268.02	I	5023 - 28447	45	4482.50	I	15120 - 37422
75	4273.52	II	6112 - 29506	28	4491.56	I	4186 - 26444
90	4274.77	I	4186 - 27573	55	4494.42	II	19433 - 41677
120	4276.72	I	4197 - 27573	28	4494.94	I	14989 - 37230
75	4282.03	I	17833 - 41179	200	4496.97	II	5753 - 27984
550	4282.20	I	5249 - 28595	550	4507.12	I	4376 - 26557
40	4286.51	II	7838 - 31160	28	4523.13	I	17753 - 39855
110	4291.20	I	4376 - 27673	610	4535.75	I	4186 - 26227

## Zirconium—all observed lines—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
75	4539.98	I	5102 - 27122	35	4793.28	I	14349 - 35206
490	4542.22	I	5102 - 27111	29	4794.96	I	12342 - 33192
200	4553.01	I	4197 - 26154	260	4805.87	I	5541 - 26343
45	4553.97	II	19515 - 41468	35	4806.68	I	12761 - 33559
200	4555.13	I	12503 - 34451	140	4809.47	I	12773 - 33559
140	4555.52	I	12760 - 34706	190	4815.04	I	5249 - 26012
45	4558.04	I	11258 - 33192	700	4815.63	I	4871 - 25630
		I	12773 - 34706	280	4824.29	I	5249 - 25972
22	4562.12	I		190	4828.04	I	5023 - 25730
45	4565.47	I	12342 - 34240	110	4838.78	I	12503 - 33164
20	4574.50	II	19614 - 41468	60	4838.98	I	12761 - 33420
490	4575.52	I	0 - 21849	19	4841.45	I	5249 - 25898
40	4576.20	I	11641 - 33487	19	4846.35	I	5102 - 25730
100	4582.29	I	14791 - 36608	210	4851.36	I	5023 - 25630
75	4584.24	I	11956 - 33764	160	4866.06	I	5889 - 26434
20	4590.16	I	11641 - 33420			I	17556 - 38101
140	4590.55	I	4376 - 26154	110	4881.24	I	5249 - 25730
350	4602.57	I	15120 - 36841	110	4883.60	I	5541 - 26012
140	4604.42	I	4186 - 25898	45	4893.12	I	12761 - 33192
22	4609.15	I	12761 - 34451	20	4905.08	I	5249 - 25630
22	4609.29	I	5249 - 26938	30	4930.87	I	15201 - 35476
22	4609.83	I	4871 - 26557	75	4933.64	I	14784 - 35047
22	4610.11	I	4376 - 26062	50	4948.76	I	4186 - 24388
22	bl 4619.85	Zr O		30	4962.30	I	14989 - 35135
210	4626.41	I	14989 - 36597	35	4963.72	I	15720 - 35861
22	4627.72	I	11956 - 33559	22	4987.82	I	16317 - 36360
40	4629.07	II	20080 - 41677	100	4994.76	I	15120 - 35135
700	4633.98	I	570 - 22144	85	4996.33	I	15201 - 35210
23	4634.64	I	5541 - 27111	30	5011.46	I	17060 - 37008
23	bl 4637.78	Zr O		250	5046.58	I	12342 - 32152
70	4640.13	I	14791 - 36336	85	5060.39	I	15720 - 35476
210	4644.83	I	14697 - 36220	360	5064.91	I	11956 - 31695
		I	11641 - 33164	110	5065.22	I	18739 - 38476
35	4654.38	I	12761 - 34240	100	5070.26	I	14989 - 34706
95	4657.64	I	11956 - 33420	75	5073.98	I	4186 - 23889
35	4659.49	I	5102 - 26557	470	5078.25	I	11641 - 31327
70	4667.14	I	5023 - 26444	85	5085.26	I	14791 - 34451
260	4683.42	I	12342 - 33688	50	5112.27	II	13428 - 32984
70	4684.25	I	5102 - 26444	140	5115.24	I	16317 - 35861
23	4685.19	II	19515 - 40853	50	5120.42	I	15932 - 35456
23	4686.57	I	11641 - 32972	85	5133.40	I	4186 - 23661
2300	4687.80	I	5889 - 27215	300	5155.45	I	12761 - 32152
510	4688.45	I	1241 - 22564	200	5158.00	I	16978 - 36360
23	4691.73	I	5249 - 26557	35	5158.67	I	12773 - 32152
23	4695.04	I	17143 - 38436	75	5160.99	I	11956 - 31327
45	h 4700.11	I		85	5165.96	I	12342 - 31695
	4700.18	I	4376 - 25646	17	5178.99	I	4186 - 23489
110	4707.79	I	11956 - 33192	100	5183.70	I	5102 - 24388
1900	4710.08	I	5541 - 26766	30	5187.03	I	15932 - 35206
160	4711.92	I	12342 - 33559	100	5191.60	II	14163 - 33419
70	4713.43	I	14791 - 36001	100	5201.15	I	4376 - 23597
120	4717.62	I	4871 - 26062	85	5209.30	I	12503 - 31695
210	4719.12	I	14989 - 36173	85	5224.93	I	4186 - 23320
23	4731.14	I	5023 - 26154	30	5243.47	I	17060 - 36125
300	4732.33	I	5102 - 26227	120	5277.41	I	4376 - 23320
35	4734.36	I	18739 - 39855	75	5280.05	I	12761 - 31695
1400	4739.48	I	5249 - 26343	60	5294.82	I	8057 - 26938
35	4742.94	I	12342 - 33420	120	5296.79	I	8057 - 26931
40	4751.91	I	5023 - 26062	60	5301.97	I	17753 - 36608
60	4753.05	I	15120 - 36153	110	5311.40	I	4197 - 23019
190	4762.78	I	14791 - 35782	25	5321.26	I	5102 - 23889
870	4772.31	I	5023 - 25972	22	5330.84	I	570 - 19324
210	4784.92	I	5541 - 26434	12	5338.43	I	4871 - 23597
160	4788.67	I	5889 - 26766	30	5350.09	II	14299 - 32984
40	4789.11	I	5023 - 25898	30	5350.35	II	14733 - 33419



Zirconium—*all observed lines*—Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
25	5350.90	I	18739 - 37422	85	6032.61	I	11956 - 28528
25	5351.92	I		170	6045.85	I	14791 - 31327
75	5362.56	I	4376 - 23019	100	6049.24	I	19834 - 36360
12	5363.35	I	5249 - 23889	140	6062.84	I	570 - 17060
17	5369.39	I	4871 - 23489	50	6120.83	I	4186 - 20519
20	5382.37	I	5023 - 23597	170	6121.91	I	8057 - 24388
270	5385.14	I	4186 - 22751	85	6124.84	I	4197 - 20519
30	5386.65	I	5102 - 23661	680	6127.44	I	1241 - 17556
17	5391.18	I	5023 - 23567	340	6134.55	I	0 - 16297
17	5395.88	I	17833 - 36360	100	6140.46	I	4186 - 20467
25	5405.13	I	5102 - 23597	440	6143.20	I	570 - 16844
85	5407.62	I	5889 - 24376	30	6155.61	I	12761 - 29002
17	5413.93	I	5541 - 24006	75	6157.71	I	19626 - 35861
20	5421.86	I	17422 - 35861	25	6160.20	I	12773 - 29002
15	5426.36	I	16787 - 35210	35	6189.40	I	19324 - 35476
25	5428.42	I	17060 - 35476	60	6192.96	I	4376 - 20519
25	5437.76	I	1241 - 19626	85	6213.05	I	4376 - 20467
15	5440.41	I	4871 - 23246	100	6214.69	I	17753 - 33839
35	5448.57	I	5541 - 23889	170	6226.51	Zr O	
10	5474.92	I	16787 - 35047	100	6257.26	I	12773 - 28750
10	5477.40	I	4871 - 23122	50	6261.05	Zr O	
35	5478.33	I	17753 - 36001	35	6267.06	I	11956 - 27908
35	5480.83	I	5249 - 23489	45	6292.84	Zr O	
10	5481.16	I		120	6299.66	I	12342 - 28212
30	5486.09	I	5023 - 23246	15	6304.34	I	4376 - 20234
140	5502.12	I	8057 - 26227	300	6313.02	I	12773 - 28609
25	5507.87	I	17060 - 35210	30	6314.71	I	8057 - 23889
30	5517.11	I	5541 - 23661	50	6321.35	I	12342 - 28157
10	5518.05	I	5889 - 24006	22	6340.36	I	12761 - 28528
75	5528.41	I	18277 - 36360	50	6345.10	Zr O	
20	5532.30	I	5249 - 23320	75	6345.22	I	12773 - 28528
45	5537.46	I	17422 - 35476	75	6378.56	Zr O	
50	5545.32	I	17833 - 35861	35	6407.00	I	1241 - 16844
22	bl	Zr O		50	6412.39	Zr O	
25	bl	Zr O		12	6426.17	I	22144 - 37701
12	5612.11	I	0 - 17814	35	6434.33	I	22564 - 38101
120	5620.14	I	4186 - 21974	60	6445.74	I	8057 - 23567
35	5623.53	I	4197 - 21974	20	6451.62	I	5023 - 20519
25	bl	Zr O		20	6457.63	I	11641 - 27122
25	bl	Zr O		110	6470.21	I	12761 - 28212
160	5664.51	I	5102 - 22751	60	6473.79	Zr O	
20	5666.28	I	17833 - 35476	11	6484.35	I	5102 - 20519
120	5680.90	I	4376 - 21974	110	6489.64	I	12503 - 27908
15	5685.42	I	18277 - 35861	22	6493.10	I	12761 - 28157
30	5708.89	I	0 - 17512	50	6503.26	I	12503 - 27876
75	bl	Zr O		50	6506.36	I	5102 - 20467
120	5735.70	I	0 - 17430	50	6508.15	Zr O	
35	bl	Zr O		30	6542.90	Zr O	
17	bl	Zr O		35	6550.54	I	11641 - 26902
160	5797.74	I	570 - 17814	30	6569.43	I	5249 - 20467
30	5847.32	I	17143 - 34240	20	6576.56	I	0 - 15201
50	5868.27	I	1241 - 18277	30	6578.06	Zr O	
110	5869.50	I	15120 - 32152	50	6591.99	I	11956 - 27122
340	5879.80	I	1241 - 18244	10	6596.71	I	11956 - 27111
85	5885.62	I	570 - 17556	10	6598.84	I	570 - 15720
50	5901.09	I	570 - 17512	50	6603.27	I	12342 - 27482
30	bl	Zr O		15	6620.56	I	18739 - 33839
140	5925.13	I	5102 - 21974	11	6678.01	II	19515 - 34485
100	5935.20	I	0 - 16844	22	6688.18	I	4376 - 19324
110	5955.35	I	0 - 16787	11	6702.12	I	11641 - 26557
30	bl	Zr O		17	6709.61	I	4197 - 19097
100	5984.23	I	14989 - 31695	27	6717.88	I	11017 - 25898
17	5995.37	I	5889 - 22564	40	6752.73	I	8057 - 22862
50	6001.05	I	12342 - 29002	75	6762.38	I	0 - 14784
30	6025.36	I	1241 - 17833	85	6769.16	I	12342 - 27111

Zirconium — all observed lines — Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
27	6772.89	I	10885 - 25646	8 h	7417.89	I	14123 - 27600
15	6787.15	II	20080 - 34810	10	7422.75	I	12503 - 25972
35	6790.85	I	12761 - 27482	10	7433.10	I	14123 - 27573
8	6796.68	I	14349 - 29058	110	7439.86	I	4376 - 17814
45	6828.78	I	11258 - 25898	18	7467.57	I	12342 - 25730
45	6832.89	I	570 - 15201	16	7479.58	I	14791 - 28157
7	6833.67	I	11017 - 25646	9	7502.92	I	14349 - 27673
13	6845.33	I	10885 - 25490	9	7506.51	I	
17	6846.34	I	5023 - 19626	14 h	7515.70	I	15700 - 29002
100	6846.97	I	11956 - 26557	12	7517.95	I	17753 - 31050
27	6849.26	I	12342 - 26938	9 h	7521.03	I	15457 - 28750
13	6852.56	I	12342 - 26931	20 h	7540.62	I	15146 - 28404
9	6854.63	I	5249 - 19834	20	7544.59	I	12761 - 26012
4	6857.90	I	14697 - 29275	29	7551.46	I	12773 - 26012
6	6883.23	I	5102 - 19626	7 h	7553.00	I	4186 - 17422
120	6888.29	I	11641 - 26154	40	7554.70	I	4197 - 17430
29	6900.59	I	11956 - 26444	25	7558.45	I	12503 - 25730
20	6904.36	I	1241 - 15720	12	7560.09	I	14349 - 27573
29	6907.37	I	11017 - 25490	7	7560.31	I	14989 - 28212
20	6916.87	I	4871 - 19324	12	7562.12	I	5023 - 18244
6	6922.23	I	12773 - 27215	80	7607.15	I	5102 - 18244
16	6932.38	I	11641 - 26062	8	7610.83	I	4376 - 17512
29	6948.46	I	11258 - 25646	14	7612.08	I	14349 - 27482
150	6953.84	I	5249 - 19626	20	7621.17	I	11258 - 24376
60	6966.44	I	12761 - 27111	5	7621.61	I	14791 - 27908
10	6975.91	I	11641 - 25972	29	7658.60	I	4376 - 17430
150	6990.84	I	5023 - 19324	18	7690.83	I	14123 - 27122
80	6994.32	I	5541 - 19834	14	7704.27	I	14697 - 27673
10	7005.46	I	11956 - 26227	10	7708.42	I	12761 - 25730
100	7027.40	I	4871 - 19097	6	7722.48	I	22145 - 35091
25	7057.36	I	12773 - 26938	9	7723.95	I	4871 - 17814
14	7057.96	I		8	7765.70	I	4186 - 17060
140	7087.30	I	4871 - 18976	10	7766.55	I	11017 - 23889
25	7089.43	I	12342 - 26444	6	7800.74	I	21801 - 34617
35	7094.46	I	12342 - 26434	12	7816.32	I	5023 - 17814
50	7095.59	I	11641 - 25730	110	7819.35	I	14697 - 27482
540	7097.70	I	5541 - 19626	35	7822.94	I	14123 - 26902
280	7102.91	I	5249 - 19324	40	7826.72	I	14349 - 27122
170	7103.72	I	5023 - 19097	90	7849.35	I	5541 - 18277
140	7111.68	I	4186 - 18244	35	7869.99	I	5541 - 18244
40	7112.82	I	11956 - 26012	14	7876.25	I	22398 - 35091
18	7113.52	I	12503 - 26557	16	7882.18	I	4376 - 17060
12	7132.95	I	11956 - 25972	10	7897.98	I	4186 - 16844
8	7138.28	I	12761 - 26766	16	7908.46	I	4871 - 17512
16	7140.74	I	12342 - 26343	6	7924.20	I	22145 - 34762
12	7144.47	I	12773 - 26766	20	7940.47	I	4197 - 16787
590	7169.09	I	5889 - 19834	160	7944.61	I	5249 - 17833
50	7201.62	I	15120 - 29002	80	7956.66	I	5249 - 17814
12	7258.17	I	11956 - 25730	80	7959.98	I	4871 - 17430
35	7264.76	I	14989 - 28750	20	7963.63	I	14349 - 26902
8	7284.69	I	12503 - 26227	160	8005.27	I	5023 - 17512
20	7306.21	I	12761 - 26444	7	8015.26	I	11017 - 23489
6 h	7307.32	I		4 h	8040.10	I	14123 - 26557
25	7311.62	I	12761 - 26434	25	8046.05	I	14697 - 27122
35	7313.72	I	12342 - 26012	16	8053.06	I	14697 - 27111
90	7318.08	I	12773 - 26434	20	8055.29	I	4376 - 16787
10	7327.82	I		20	8055.76	I	5102 - 17512
50	7335.97	I	4186 - 17814	60	8058.08	I	5023 - 17430
50	7343.96	I	14791 - 28404	150	8063.09	I	5023 - 17422
20	7373.50	I	12503 - 26062	790	8070.08	I	5889 - 18277
8	7374.80	I	12342 - 25898	10	8114.28	I	5102 - 17422
25	7383.63	I	14989 - 28528	20	8120.17	I	18739 - 31050
8 h	7399.30	I		390	8132.99	I	5541 - 17833
14	7400.90	I	12503 - 26012	20	8152.58	I	5249 - 17512
10	7411.39	I	15120 - 28609	12	8188.77	I	14349 - 26557

Zirconium – all observed lines – Continued

Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>	Intensity and Character	Wavelength in Å	Spectrum	Energy levels in cm <sup>-1</sup>
40	8194.73	I	10885 – 23085	40	8498.44	I	5023 – 16787
60	8201.73	I	4871 – 17060	5	8513.78	I	5102 – 16844
280	8212.53	I	5249 – 17422	5	8515.06	I	17060 – 28801
20	8240.37	I	17143 – 29275	8	8568.54	I	5889 – 17556
40	8283.81	I	11017 – 23085	7	8571.05	I	12342 – 24006
7	8299.81	I	12342 – 24388	18	8584.21	I	15120 – 26766
140	8305.90	I	5023 – 17060	7	8587.84	I	11956 – 23597
7	8309.50	I	14123 – 26154	5	8610.24	I	11956 – 23567
7	8320.16	I	5541 – 17556	5	8641.01	I	
14	8332.44	I	17060 – 29058	10	8734.86	I	14989 – 26434
50	8370.23	I	5889 – 17833	12	8749.48	I	4871 – 16297
120	8389.41	I	4871 – 16787	6	8762.93	I	
70	8414.00	I	5541 – 17422	10	8786.23	I	11641 – 23019
50	8453.17	I	11258 – 23085	16	8804.98	I	14989 – 26343
6	8457.48	I	5023 – 16844	70	8836.09	I	15120 – 26434
50	8464.65	I	5249 – 17060	60	8899.52	I	12773 – 24006
9	8495.98	I	17143 – 28910				



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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)  The relative intensities, or radiant powers, of 39 000 spectral lines with wavelengths between 2000 and 9000 Angstroms have been determined on a uniform energy scale for seventy chemical elements. This was done by mixing 0.1 atomic percent of each element in powdered copper, pressing the powder-mixture to form solid electrodes which were burned in a 10 ampere, 220 volt direct-current arc, and photographing the spectra with a stigmatic concave grating while a step sector was rotating in front of the slit. The sectored spectrograms facilitated the estimation of intensities of all element lines relative to copper lines which were then calibrated on an energy scale provided by standardized lamps, and all estimated line intensities were finally adjusted to fit this calibration. Comparisons with other intensity measurements in individual spectra indicate that the National Bureau of Standards spectral-line intensities may have average errors of 20 percent, but first of all they provide uniform quantitative values for the seventy chemical elements commonly determined by spectrochemists. These data are presented by element in part I, and all 39 000 observed lines are given in order of wavelength in part II.			
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)  Classification of spectral lines; intensities of spectral lines; spectral-line intensities; tables of spectral-line intensities; wavelengths of spectral lines.			
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