LANGUAGE IN CHEMISTRY

THE EFFECT OF SOME ASPECTS OF LANGUAGE ON 'O' GRADE CHEMISTRY CANDIDATES

BY

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An Abstract

The thesis considers the function of language as a medium of communication in a very restricted area, namely multiple choice chemistry questions, and in the introduction some of the deeper issues are pointed out in order to insist that what is said later only scratches the surface of enormous problems. The literature indicating the connection between language and learning is reviewed and the comparison is made between the situation in primary schools, where there is recognition of the importance of language development and the situation in secondary schools where the subject specialist does not seem to be aware of the part language plays in learning. The factors e.g. social class, affecting language development and the problem of establishing a degree of difficulty of language are discussed in the introduction. The last part of the introduction is a review of language in science. Language is of fundamental importance to science: educational objectives assign knowledge of terminology to a position of primary importance; there is a large amount of specialised vocabulary and formalised writing is encouraged. The concern is for the lack of knowledge on language development of pupils, and the lack of structure in the presentation of language with the possible effect this may have on pupil performance.

Experience with 'O' grade chemistry candidates in secondary schools seemed to indicate that language and words in particular may be a barrier to the understanding of chemistry. Three initial exercises are described

(1) where pupils were asked to write the meaning of a word underlined in a sentence from an S.C.E. 'O' grade chemistry examination,

(2) where pupils were asked to write a sentence, using similar words from similar sources, to show that they knew the meaning of the word, and

(3) where pupils were presented with passages from chemistry texts from which every seventh word had been deleted and they were asked to put in one word in each gap which they felt helped the passage to make sense.

These initial exercises seemed to indicate that pupils had problems with words.

The two major exercises, which were an attempt to show that in multiple choice chemistry questions language influences performance, are described. The organisation and design of the two exercises are basically the same, the second one being a more refined version than the first using larger samples. One thousand seven hundred and fifty six 'O' grade candidates in twenty four schools of varying catchment area were involved in the second major exercise. An outline of the organisation and the design of these exercises is: possible questions, which were written in two forms, were scrutinised by respected chemistry teachers to check that chemical content was the same; two tests were prepared one in simplified language and one in original examination language; twenty eight multiple choice questions were used in each test - five were vocabulary questions, three were control chemistry questions identical in each test and twenty were in one of the two forms simplified or original; to try to achieve matched samples in the schools careful instructions were prepared which were in essence within each school the pupils were numbered and those who got an even number got one test while those with an odd number got the other test; and eventually the pupil answer cards were processed in appropriate batches by the computing department.

The major exercises would seem to indicate that:

(a) certain non-technical words cause pupils difficulties

(b) certain pupils particularly those from a lower social class or with a low V.R.Q. have great difficulty with words

(c) pupils' performance in multiple choice chemistry questions depends on V.R.Q., a measure of language development, and also on social class, a factor which influences language development.

In multiple choice chemistry questions certain language factors have been identified as influencing performance namely

(a) the presence of large numbers of unnecessary words

(b) the words in key positions

(c) the presence of negative expressions

(d) expressions of qualification e.g. only

(e) ambiguous expressions

(f) the way in which clauses and sentences are put together.

CHAPTER 1

INTRODUCTION

Within the content of this thesis the function of language as a medium of communication is considered in a very restricted area. It is proper, however, at least to point out the deeper issues in order to insist that what is said later, only scratches the surface of enormous problems which go far beyond the examination situation and affect not merely the teacher of chemistry, but all teachers - whatever the subject they teach at whatever level.

1.1 Language and Learning

That language is a means by which we organise our representations of the world, is a theory that finds its source in Sapir (1), Cassirer (2), and Langer (3) and its development and application in Piaget (4), Vygotsky (5), Luria (6), Bruner et al. (7) and Brown (8). Language and learning are inseparable as Vygotsky states

> Directing ones own mental processes with the aid of words or signs is an integral part of the process of learning.

Barnes (9, 10) and Holt (11, 12) in different ways emphasise the point that language is a means not only of communication but also of learning and understanding. I agree with Britton (13) that from the moment a child first speaks - first attaches a sound to an object or a person - language plays a significant and central part in his development. In primary schools there seems to be a recognition of the importance of language development and considerable material (14 - 19) is devoted to this, but in secondary schools the situation is different. The Bullock Report (20) adequately expresses the concern with the situation of the subject specialist in the secondary school.

> We must convince the teacher of history or of science, for example, that he has to understand the process by which his pupils take possession of the historical or scientific information that is offered them; and that such an understanding involves his paying particular attention to the part language plays in learning. The pupil's engagement with the subject may rely upon a linguistic process that his teaching procedures actually discourage.

We have a lot to learn regarding language development in secondary schools.

1.2 Factors affecting Language Development

Before setting up any experiment it is important to try to identify possible variables. In the case of language development, variables could be classified in two ways - personal and environmental. Personal variables may include measured intelligence and sex, while environmental factors may include social class, family size, type of school and rural/urban area. These factors are not independent. Fairly consistent social class differences in measured intelligence, almost irrespective of the instruments used, are reported (21, 22). For example Havighurst (23) in a large American study found that abilities are more highly differentiated at the age of 16 than at 10 and that children of upper socio-economic status at 16 had considerably increased their lead in verbal abilities over those of lower status as a result of increasing contact with verbal materials. Similarly in a study of sixth grade American children, Curry (24) found that correlation between social class and verbal achievement was significant with I.Q's below 116. Other findings also indicate a relationship between social class and aspects of language development e.g. mastery of certain syntactic rules (25), vocabulary (26) and achievement in reading (27).

Bernstein (28) suggests that the relative backwardness of many working class children who live in areas of high population density or in rural areas may well be a culturally induced backwardness, transmitted by the linguistic process. This is a possible explanation of why, when comparing verbal measures of intelligence with non-verbal measures of intelligence, the verbal scores of the working class pupils are depressed in relation to non-verbal measures and this is not the case with middle class pupils. This idea would be supported by evidence (29) from deaf children who are not retarded in intellectual ability but may be temporarily retarded linguistically during their development phase because of lack of sufficient general experience. The evidence (30) that more complex language constructions do not develop unless the child is exposed to them, and the fact (31) that older children showed better comprehension of material formulated in accordance with the grammatical construction used in their own speech than with less familiar construction, would also tend to support Bernstein's idea of a culturally induced backwardness transmitted by the linguistic process.

Although underachieving in rural schools compared with urban schools is well documented (32, 33, 34) and the type of school also has an influence (35) as does sex (36), these may be minor factors in comparison to social class and measured intelligence. In support of this a study (37, 38) reported that social class differentials for both boys and girls in Scotland are much larger than the influence of regional differences.

In the design and discussion of results of the major exercises in this thesis, the effect of some of these complex factors are considered.

1.3 Which Aspects Of Language?

Trying to establish possible factors for language development is easy in comparison to trying to decide on degree of difficulty of language. This quotation (39) in many ways summarises the problem

> "The same sentence of the same language may have one degree of complexity when analysed from the point of view of one grammar and a different one when analysed from the point of view of another grammar and that of two different sentences, one may have a higher degree of complexity than the other relative to one grammar, but a lower degree relative to another grammar."

The possibility of establishing some absolute measure of syntactical complexity is effectively excluded because of diverse theories (40,41) and the complexity of linguistic process (42). It is therefore necessary as a first stage to try to be selective in the aspects of language to be investigated. Factor analytic studies (43,44,45) indicate that in determining readability the factor accounting for the greatest percentage of variance is a semantic one : word difficulty. This, related to my initial feeling that the presence of certain words in chemistry questions had an adverse effect and the following interesting investigation (46) gave weight to the importance of words. By varying the frequency (47) of fifteen per cent of the words in school reading materials, gains in the comprehension of meaning of entire passages could be produced. In other words, a few less familiar words inhibited the comprehension of the total passage.

Although my investigations are in the main concerned with words, word difficulty and verbosity I take Barnes' (9) point that

> "the teacher needs to be concerned with the overall language of a lesson rather than mere vocabulary. An emphasis on vocabulary frequently detracts from understanding and can lead to the use of jargon."

but because of the complexity of linguistic process for an initial investigation some selection of aspects is necessary.

1.4 Language in Science

Language in science is of fundamental importance. Evidence for this is provided by published schemes of educational objectives (48) which agree in assigning knowledge of terminology to a position of primary importance, and although D. Evans (49) may exaggerate a little when he states that secondary school pupils may be expected to learn as many new terms in a science subject as they encounter in studying a foreign language, with the additional difficulties of an unfamiliar and detailed conceptual content, his quotation (50) from a chemistry text where 19 of the 37 words which compose the passage are technical expression, illustrates the importance of specialised vocabulary in communicating scientific information.

Does chemistry have to be so mysterious? This plea (51) from a thirteen year old girl strikes a chord with me.

> "The words in chemistry are big and I think if the words were shortened then pupils would understand better."

I agree with Sutton (52) that contrary to popular belief it is often not the processes inside the test-tubes or circuits or leaves which are mysterious, but our way of talking about them. Most of the difficulty pupils experience, when they enter science rooms, is of language: waves of it washing over them. For many it is language of a kind they have not learned to think with (53). Sutton illustrates this well by contrasting a pupil statement with a text-book statement for why acid reacts more rapidly with broken-up limestone than with a lump.

Pupil answer:	I think its coming off quicker because there's more sort of cut faces to the smaller bits.
Text book:	The rate of a chemical reaction depends upon the state of division of the reactants.

This type of formalised writing, as Smith (54) states, leads pupils to believe that their own thinking does not count and that in examinations what is required is regurgitation of someone else's thinking in someone else's language. The title of Perkes (55) article rings true when he talks about the tyranny of words and very often as Jenkins (56) states misconceptions regarding a young secondary pupil's ability in science can arise in the use of words which often give an exaggerated idea of a child's level of understanding. In addition because of the emphasis placed on formalised language, pupils can often suffer a sort of verbal diarrhoea when, in an attempt to mimic this language, words are used in incorrect situations. As Barnes (9) noted in his investigations with tape recorders in classrooms:

> "The technical term is often taken to have a value of its own and its substitution for an alternative formulation is sometimes taken to have the weight of an explanation. Side-by-side with this, some teachers are using specialist language without explicitly presenting it."

Further confusion is caused because different teachers have different opinions on what language is specialist.

Our teaching of language lacks structure - even our knowledge about pupils' competence with words is deficient. What general vocabulary should pupils at secondary school be able to cope with? What scientific vocabulary (57) should be used and how should it be introduced? These are questions without an answer as yet. There may be a little cause for optimism when one considers the worthwhile objectives of material (58) for use with teachers in training, which are

(1) Realization of the ease with which teachers can unwittingly use language unfamiliar to their pupils and so hinder communication.

(2) An ability to recognise language not likely to be understood by particular pupils.

(3) A critical attitude towards their own use of language in lessons.

To achieve this would be a start.

Certain investigations point to the importance of language in science but a great deal more remains to be done.

(a) Williams (59) described an interesting investigation into the

effect of re-writing certain scientific passages to a lower level of readability. 400 pupils, half given original passage and half the simplified passage, were given a multiple choice test on comprehension of passage. The simplified group did significantly better. Three considerations governed the rewriting of passages to make them more readable: simplification of non-technical vocabulary by substitution; amplification of technical vocabulary through the addition of phrases or complete sentences; and rephrasing and shortening sentences to make their thoughts clearer and more distinct.

(b) Gardner's (60) Australian word investigation, which is a well worked out attempt using multiple choice questions to gauge pupils familiarity with non-scientific words at various age levels.

(c) Storey (61) with reference to Fullman (62) describes an investigation with 105 pupils taught by the same teacher and when half were given a multiple choice test in a simpler language than the other half, the mean score of the simplified language group was higher than the more difficult language group.

(d) O'Donnel (63) showed that language in examinations can even affect which questions candidates choose. In 'O' grade Physics he found there was a positive relationship between the questions candidates chose most frequently to attempt and those which were least syntactically complex (41).

He suggested that vocabulary weaknesses could affect the performance of candidates on a considerable scale. One cannot help but agree with this statement and it is the purpose of my investigation to try to produce further indications of the influence of language on performance.

CHAPTER 2

EARLY EXPERIENCES

My experiences with pupils seemed to indicate that words were a barrier to the understanding of chemistry.

2.1 An Initial Exercise

An initial exercise which was conducted by myself and a colleague was based on sentences from recent Scottish Certificate of Education Examination Board '0' grade chemistry papers. Fifteen sentences were chosen and the pupils were asked to give the correct meaning of the word underlined (Appendix A) e.g. Opposite each write the corresponding piece of information.

The test was given to three hundred and twenty four fourth year chemistry pupils in eight Strathclyde schools two months before they sat their '0' grade examination, and the percentage of pupils who were able to give a correct meaning is shown.

Corresponding	54%	:	Efficiency	64%	:	Composition	50%
Observed	93%	:	Appreciable	75%	:	Dense	85%
Pungent	4%	:	Precautions	20%	:	Approximately	85%
Predominates	38%	:	Distinguish	87%	:	Justify	80%
Abundant	82%	:	Corrosion	85%	:	Products	44%

In interpretating these results two points must be borne in mind:

(a) some pupils may have had difficulty in expressing their answers in their own words.

(b) there was inevitably some subjectivity in the marking of their answers.

Nevertheless the exercise would seem to indicate a problem.

2.2 Talking and Working with Secondary pupils

Talking and working with secondary pupils, there is a realisation that they lack confidence with words. A class of fourth year '0' grade chemistry candidates were given a list of twenty words (chosen from examination papers and common pupil tests) (Appendix B) and asked to write a sentence using each to show that they knew the meaning of the word. There were a large number of what can only be described as unusual answers - few pupils did not have one.

e.g. The new shoe had been pungent me

I had to justify against the person.

The patient was not corresponding to the medicine given to him.

The attribution of the tickets was fairly sparse.

There was a dense noise at the football match.

The concept of the argument ended in a fight.

The person interviewed for the job did not have efficient 'O' grades.

The pupils were asked to indicate at the end of the test how many words they felt they had used correctly. Only one of the seventeen pupils felt that he had more than half of them correct.

This exercise would also seem to indicate a problem with words.

2.3 Another Exercise

In another exercise pupils were presented with passages from chemistry texts (64, 65, 66, 67) or examination (68), from which every seventh word had been deleted, and they were asked to put in one word in each of the gaps which they felt helped the passage to make sense. They had difficulties.

The passages were chosen randomly from the first page of each text, and sixteen third year chemistry pupils and twelve teachers not necessarily science teachers, were asked to tackle this exercise (Appendix C).

A comparison of results showed a marked contrast.

For passage	1	2	3	4	5
Scoring	0to3 : 4to6	0to3 : 4to6	0to3 : 4to6	0to3 : 4to6	0to3 : 4to6
S.3 Chemistry	12 : 4	10 : 6	12 : 4	14 : 2	12 : 4
Teachers	1 : 11	1 : 11	3 : 9	2 : 10	1 : 11

Total score distribution

Mark	0 to 5	6to10	11to15	16to20	21to25	26to30:
S.3 Chemistry	0	4	5	7	0	0
Teachers	0	0	0	2	5	5

The adults performed considerably better than the pupils who obviously found it very difficult perhaps because of uncertainty with the language. I have no reason to feel that two more recent texts (69, 70) would show any better. There may be a gulf between what authors think pupils can cope with and what pupils actually can cope with. Various investigations (71 - 80), on readability of science text books seem to indicate that the language is too difficult. Mallinson (80) has an understanding of the problem when he suggests the following reasons for text book readability difficulties

(a) Pupils encounter in science text books many technical and non-technical words the meanings of which they do not know.

(b) There is insufficient provision in science text books for repetition of scientific terms.

(c) Too large a percentage of the difficult words in such text books are non-scientific or non-technical.

(d) Too small a percentage of the scientific terms that are introduced into such text books are defined.

Hard conclusions from these three exercises would not be valid but as an indication of possible word difficulties they may be useful.

What caused me concern was that in reply to correspondence expressing my concern about language used in '0' grade chemistry papers the examination board gave the impression of complacency and a feeling that objective questions may help pupils who may be having problems with language.

This strengthened my resolve to try to show that, even in objective items, language can influence performance.

CHAPTER 3

FIRST MAJOR EXERCISE

The hypotheses were (i) that pupils have difficulty with words.

(ii) that in objective chemistry questions the language used influences performance.

and (iii) that pupils' performance depends on V.R.Q. and social class.

I. Research Design

Multiple choice chemistry questions from various sources (81 - 85) were prepared in two forms. One form was very similar to questions issued by the S.C.E.E.B. and the other form was in a simplified language either by substitution of words, removal of words or sentence reorganisation. To try to ensure that the chemical content of the questions was the same, possible questions were scrutinised by members of the inspectorate and members of the chemistry panel of the S.C.E.E.B. as well as by members of the Science Education Research Group of the University of Glasgow. Fifteen pairs of chemistry questions were eventually selected for testing.

The tests were prepared. They contained:-

(i) Three multiple choice control chemistry questions which are the same in each test.

(ii) Fifteen multiple choice chemistry questions, alternate questions in each test being in a simplified language so that each test was a mixture of examination language and simplified language questions.

(iii) Ten multiple choice vocabulary questions from an Australian Word Survey (60) which contained words that had appeared in recent Scottish '0' grade chemistry questions.

Appendix D has copies of both tests with matched questions typed opposite each other to make comparisons easier.

II. Administration

Twelve secondary schools (see Table 3.1) in Scotland varying in type, catchment area, and region offered to assist and the tests were administered in March 1975 to four hundred and forty two fourth year chemistry '0' grade candidates ranging in V.R.Q. and social class (86). Appendix E has an explanation of the social class division based on parental occupation.

Table 3.1

Campbeltown Grammar	:	Govan High School, Glasgow
Denny High	:	Kelso High
Dollar Academy	:	Kingsridge Secondary, Glasgow
Dunblane High	:	Knox Academy, Haddington
Eastbank Secondary,Glasgow	:	Madras College, St. Andrews
Glenwood Secondary,Glasgow	:	Williamwood High School,Clarkston

To try to achieve similar tested groups within each school a Teacher Information sheet (see Appendix F) was prepared and copies sent to each school. Similarly a Pupil Information sheet (see Appendix G) was also distributed to try to ensure that the candidates were confident with the procedure. Tests were printed on yellow or pink paper to match the appropriate computer answer cards and to assist with organisation. By these measures it was hoped to achieve some uniformity in the method of administering the tests in the various schools.

In essence, within each school the pupils were numbered and those who got an even number got one test while those with an odd number got the other test, and the pupil answer cards were processed in appropriate batches by the computing department of the university.

III. Results.

1. Variation between Schools

In Tables 3.2 to 3.4 all figures are percentages of pupils in each school. The schools are represented by their administration number.

(a) Social Class Table 3.2

School / Social Class	10	12	14	16	17	18	19	20	21
1 - 2	39	70	3	0	43	8	21	51	56
3	44	30	72	70	43	79	62	39	41
4 - 5	17	0	25	30	14	13	17	10	3

(b) V.R.Q. Table 3.3

School / V.R.Q.	10	12	14	16	17	18	19	20	21
120 +	5	NA	37	16	NA	29	NA	NA	3
119 - 110	19		20	31		30			40
109 - 100	33		31	34		29			32
99 -	43		11	19		10			25

(c) Pupils Rank Order Position

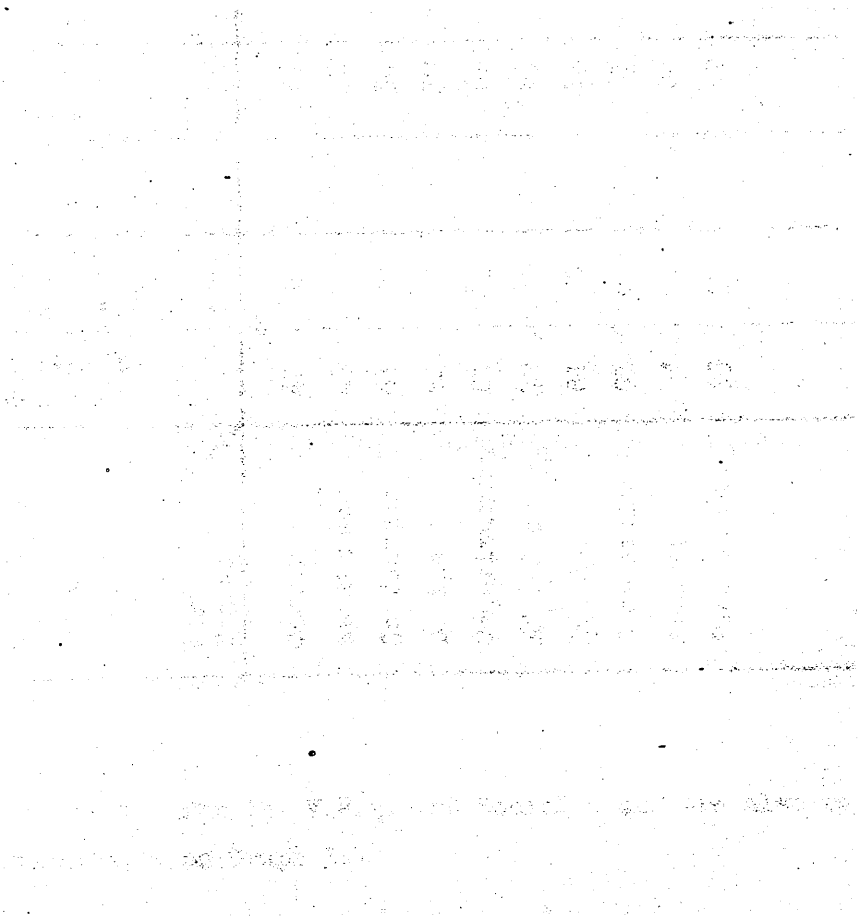
One part of the computer print out listed the pupils in order according to their overall score in the test. The percentages quoted were obtained from an examination of this order of merit.

Category A is the percentage of the pupils in each school who finished in the top 20% of the order of merit.

Category B is the percentage of the pupils in each school who finished in the bottom 20% of the order of merit.

Table 3.4

Category \ School	10	12	14	16	17	18	19	20	21
A	20	50	10	0	20	3	20	28	3
B	13	10	33	55	0	42	18	10	33



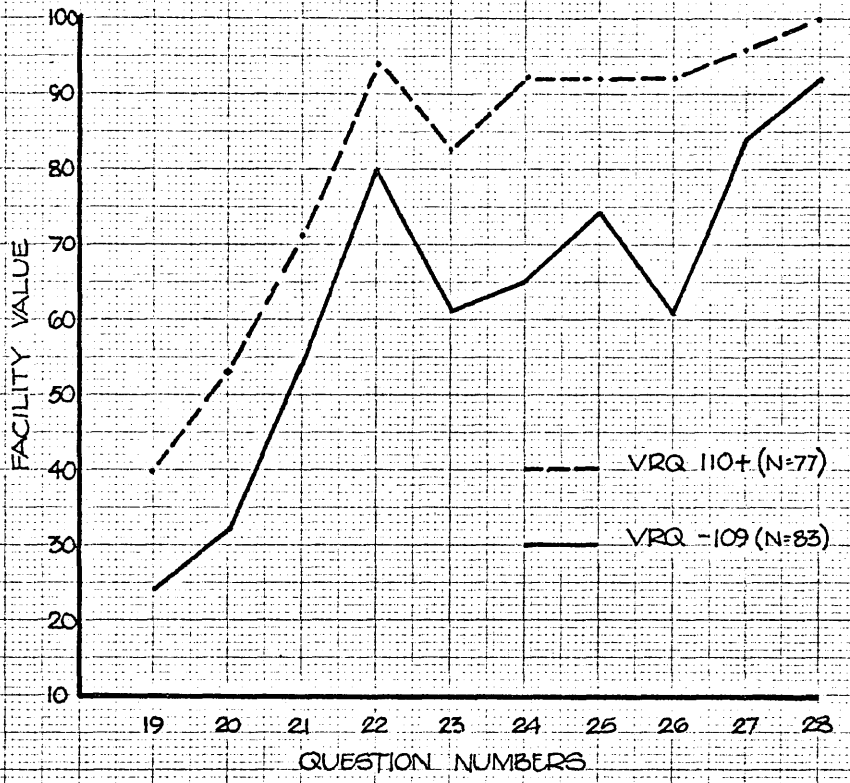
2. Vocabulary questions

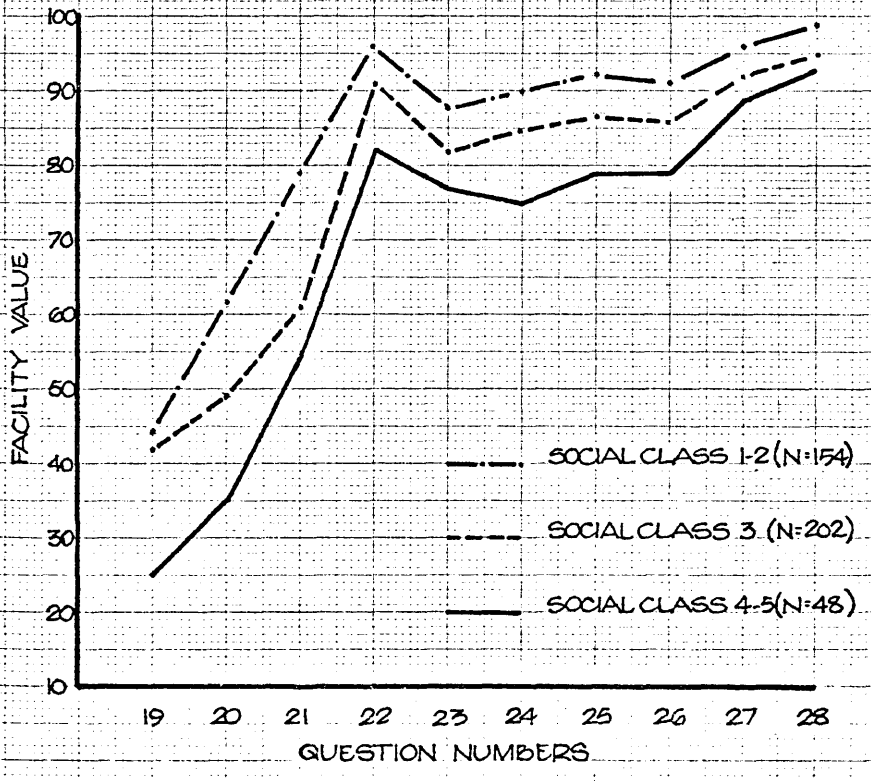
Table 3.5

% correct / Word Tested	Converse	Spontaneous	Correspond	Devise	Constituent	Efficient	Residue	Composition	Abundant	Precautions
Australian Results	41	45	61	84	81	72	81	91	94	95
Our overall Results 442	39	52	70	92	82	84	86	87	91	97
0 - 109 V.R.Q. 83	24	32	54	80	61	65	74	61	84	92
110 + V.R.Q. 77	40	53	71	94	83	92	92	92	96	100
Social Class 4 - 5 48	25	35	54	82	77	75	79	79	89	93
Social Class 3 202	42	49	71	91	82	85	87	86	92	95
Social Class 1 - 2 154	43	61	78	96	88	90	92	91	96	96
School No. 16 47	18	33	48	81	70	70	77	74	100	100
School No. 12 61	68	68	86	100	95	96	98	98	98	100

The results for the V.R.Q. and Social Class are also represented graphically on Graph 3.1

GRAPH 3.1
VOCABULARY QUESTIONS





3. Chemistry Questions

Table 3.6 shows the facility values for total samples for the questions which were the same in both tests i.e. the control questions.

Table 3.6

Control question	2	3	12	Number of Candidates
Facility Value Pink Test	5.2	6.8	6.2	219
Facility Value Yellow Test	5.5	7.1	6.2	223

There was no statistically significant difference. In all cases, social class groupings, rank order groupings, and V.R.Q. groupings the control questions confirmed the similarity of the samples.

Consequently in the following graphs the results of the test have been paired to compare simplified language facility values against original language facility values, instead of comparing yellow test facility values with pink test facility values, which would have been confusing because of the alternating original/simplified language within each test.

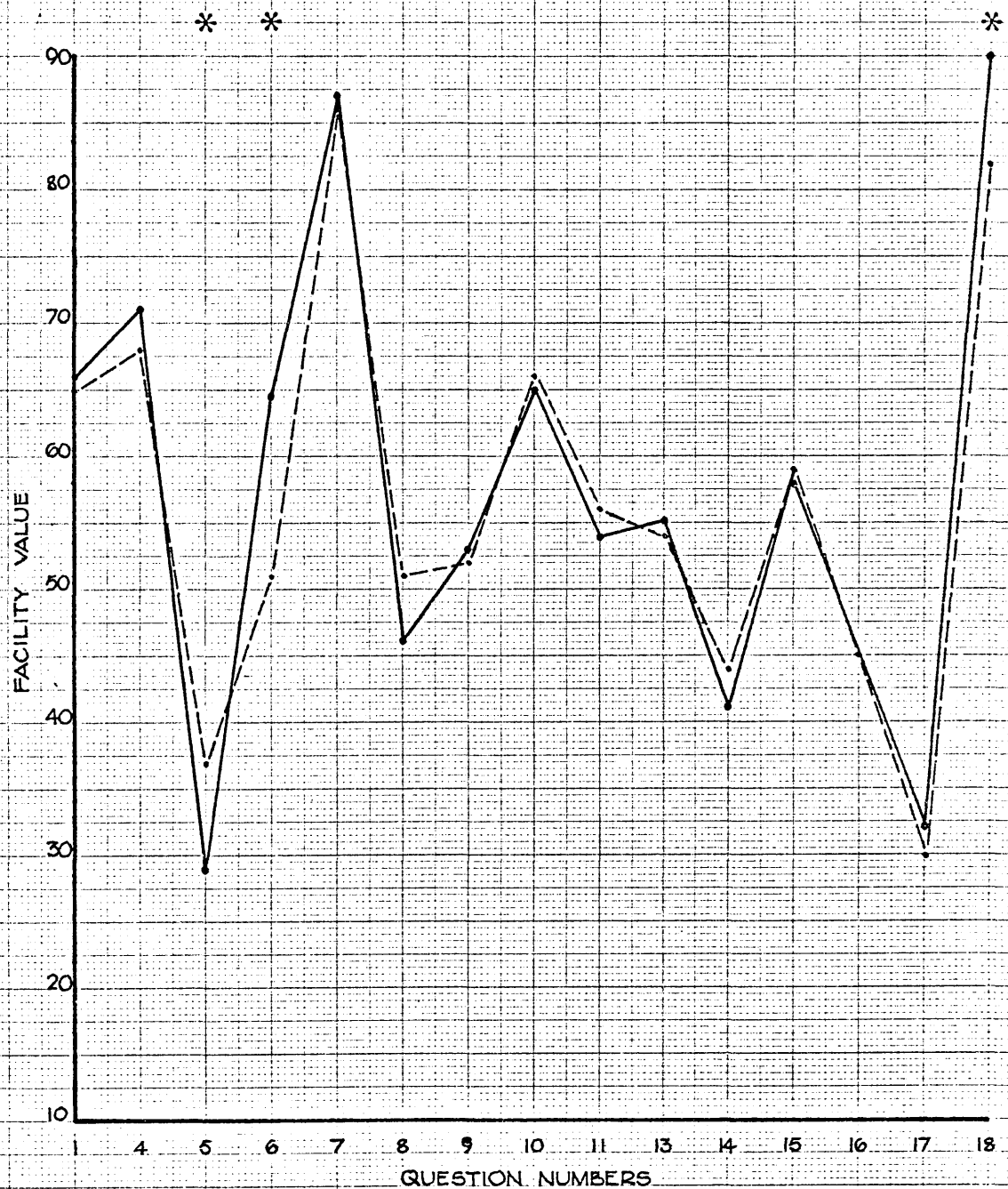
Graph 3.2 Total sample
Graph 3.3 Top third of rank order
Graph 3.4 Bottom third of rank order
Graph 3.5 Social Class 1 and 2
Graph 3.6 Social Class 4 and 5
Graph 3.7 V.R.Q. 110+
Graph 3.8 V.R.Q. 109-

The "strange" results of question five in the simplified language was due to a typing error. In the pink test $^{8}_{3}Li^{+}$ did not have the positive charge and consequently there was no correct answer.

GRAPH 3.2

CHEMISTRY QUESTIONS

TOTAL SAMPLE



KEY.

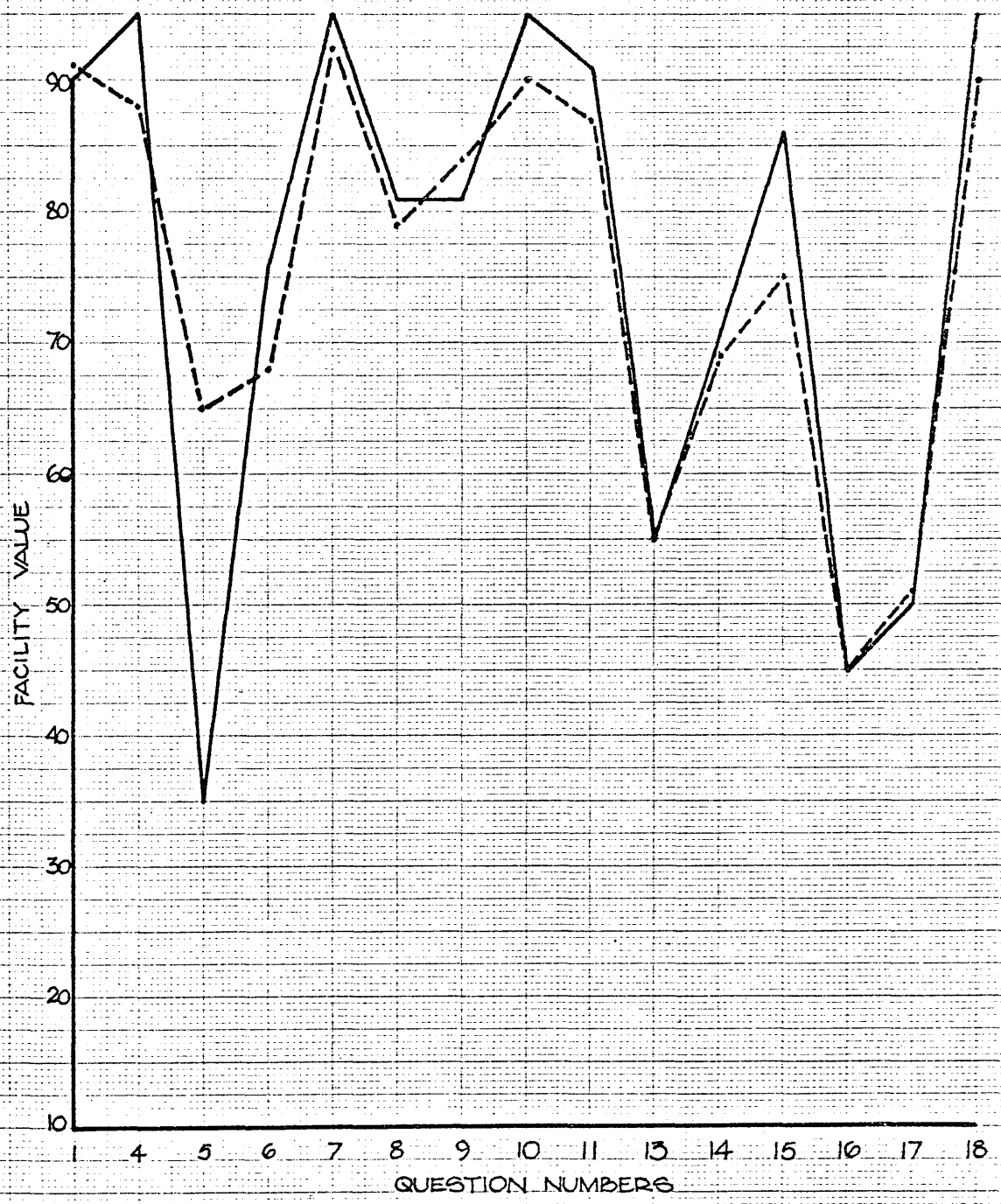
——— SIMPLIFIED LANGUAGE (N = 220)

– – – – ORIGINAL LANGUAGE (N = 220)

GRAPH 3.3

CHEMISTRY QUESTIONS

TOP THIRD OF RANK ORDER



KEY

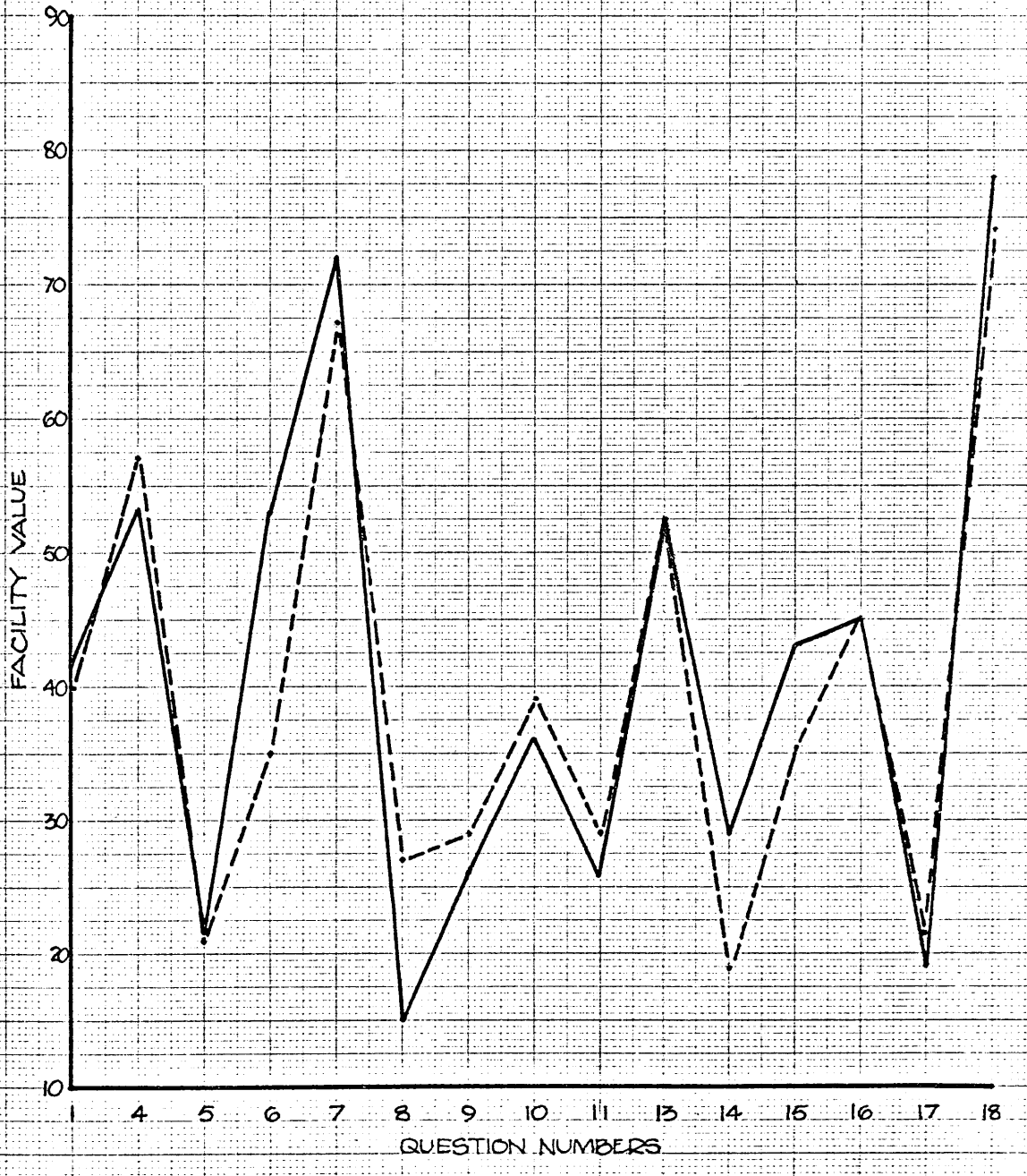
——— SIMPLIFIED LANGUAGE (N=73)

– – – – ORIGINAL LANGUAGE (N=73)

GRAPH 3.4

CHEMISTRY QUESTIONS

BOTTOM THIRD OF RANK ORDER



KEY.

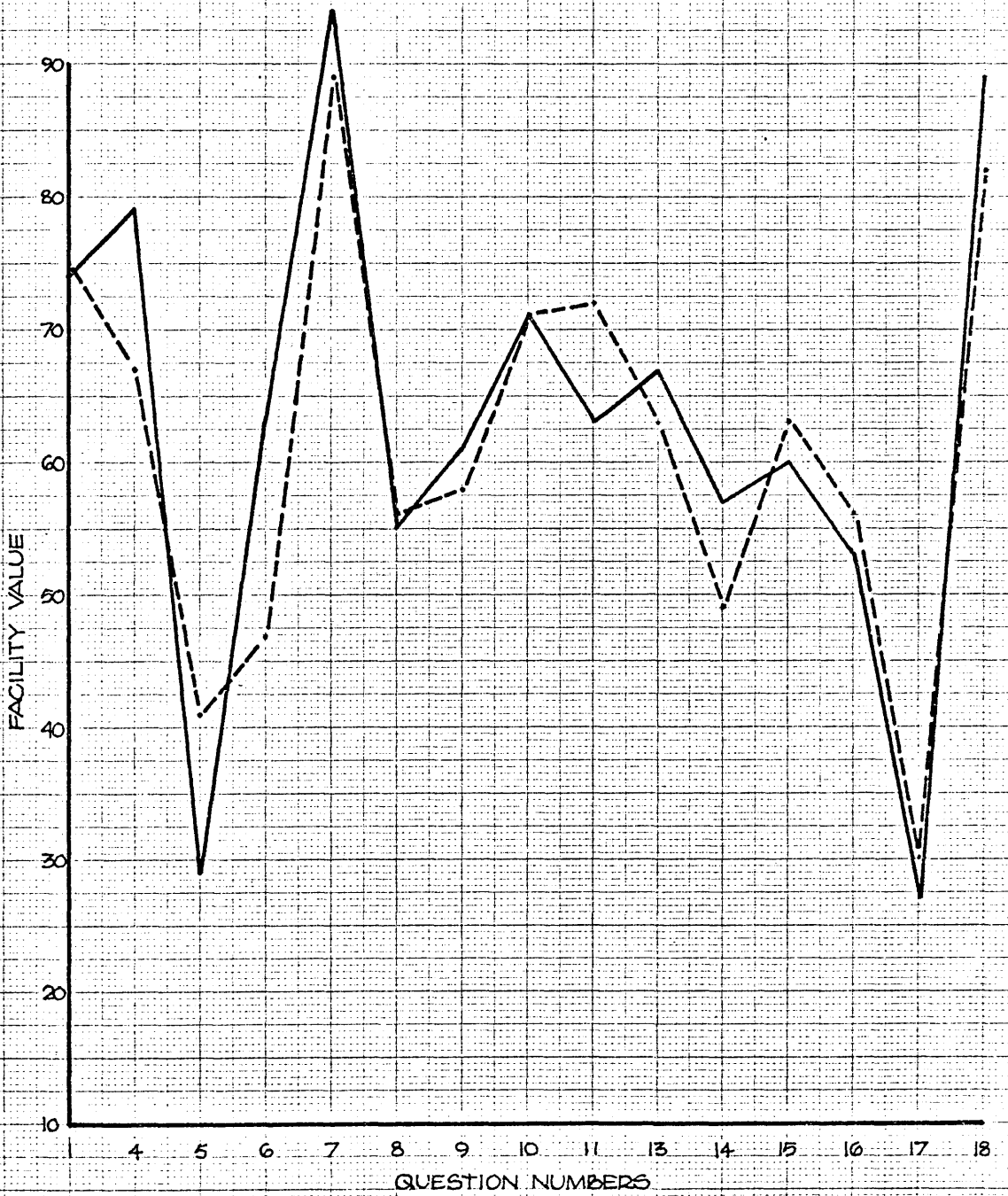
——— SIMPLIFIED LANGUAGE (N = 73)

– – – ORIGINAL LANGUAGE (N = 73)

GRAPH 3.5

CHEMISTRY QUESTIONS

SOCIAL CLASS 1-2



KEY

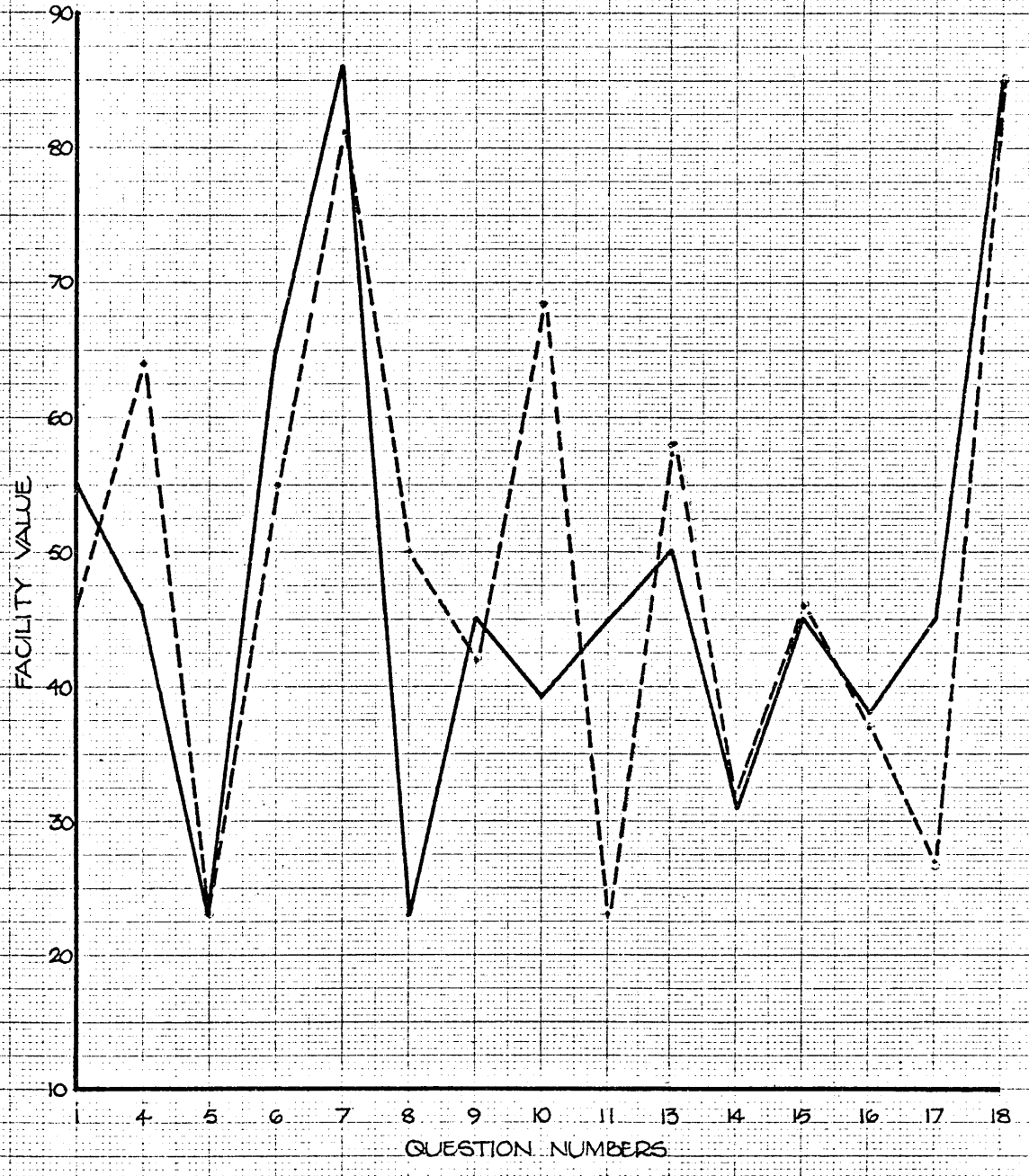
——— SIMPLIFIED LANGUAGE (N = 77)

- - - - ORIGINAL LANGUAGE (N = 77)

GRAPH 3.6

CHEMISTRY QUESTIONS

SOCIAL CLASS 4-5



KEY

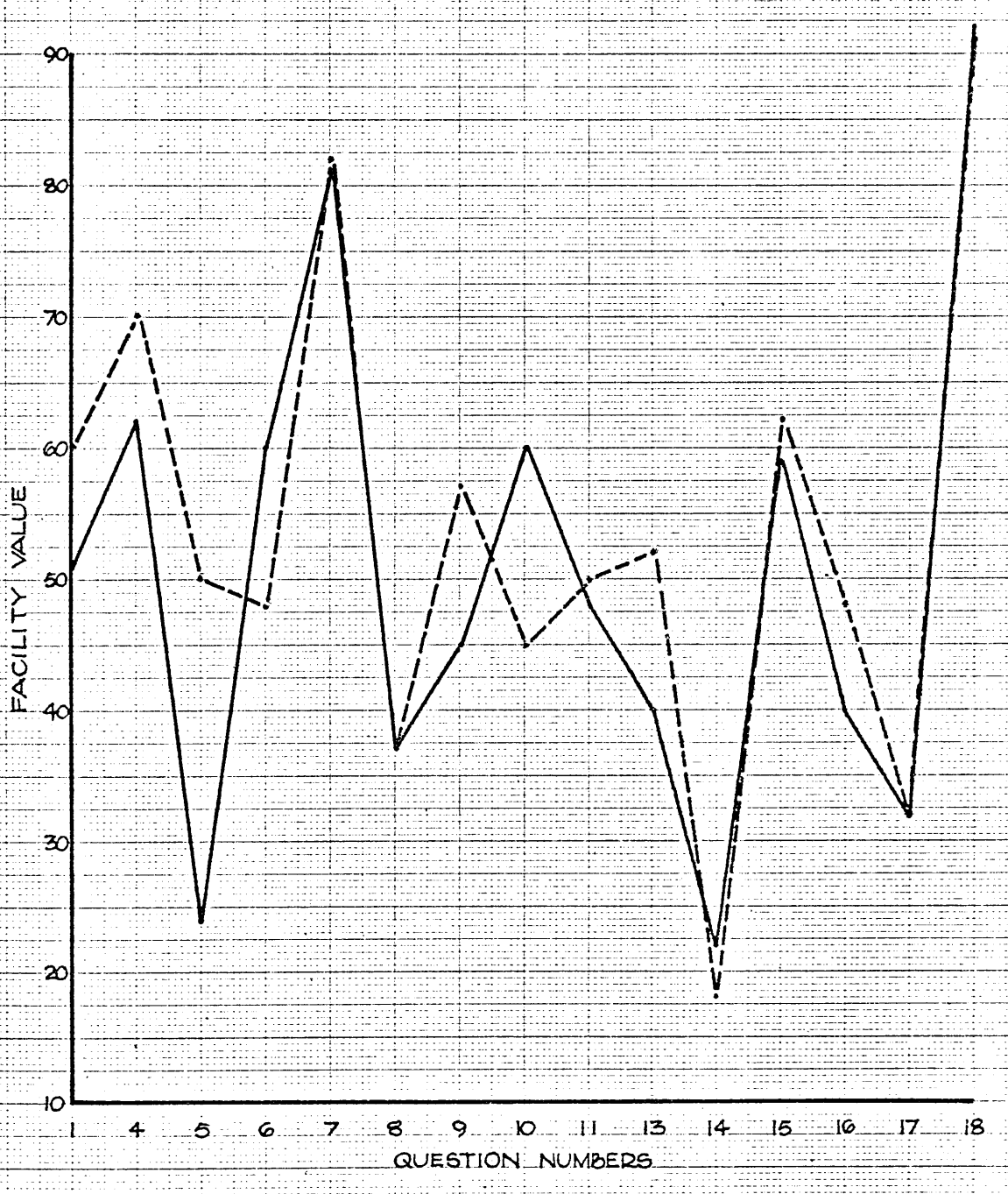
——— SIMPLIFIED LANGUAGE (N = 24)

- - - - ORIGINAL LANGUAGE (N = 24)

GRAPH 3.7

CHEMISTRY QUESTIONS

V.R.Q. 1104



KEY.

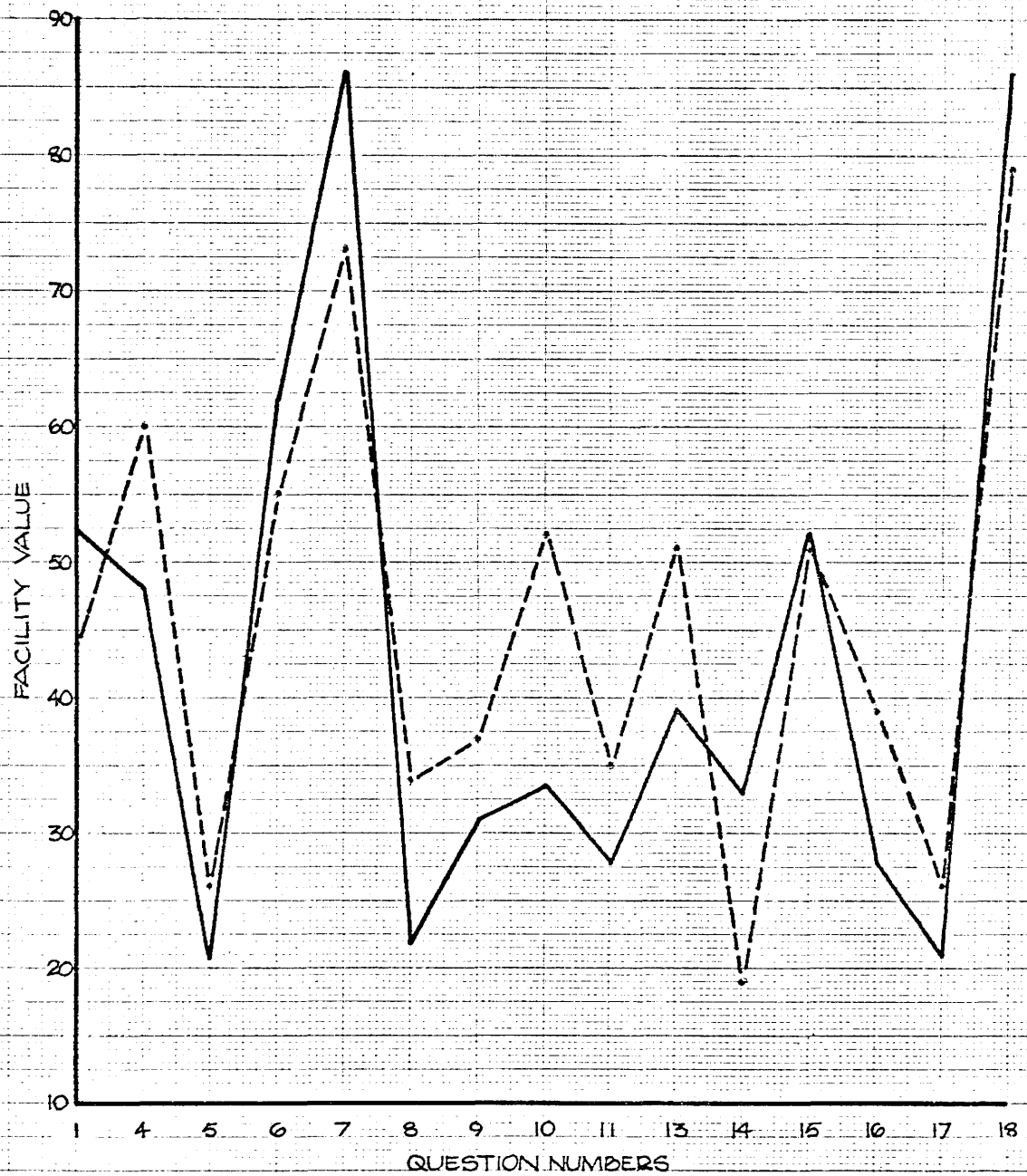
——— SIMPLIFIED LANGUAGE (N = 38)

– – – – ORIGINAL LANGUAGE (N = 38)

GRAPH 3.8.

CHEMISTRY QUESTIONS

V.R.Q. - 109



KEY.

——— SIMPLIFIED LANGUAGE (N = 41)

- - - - ORIGINAL LANGUAGE (N = 41)

4. Overall scores

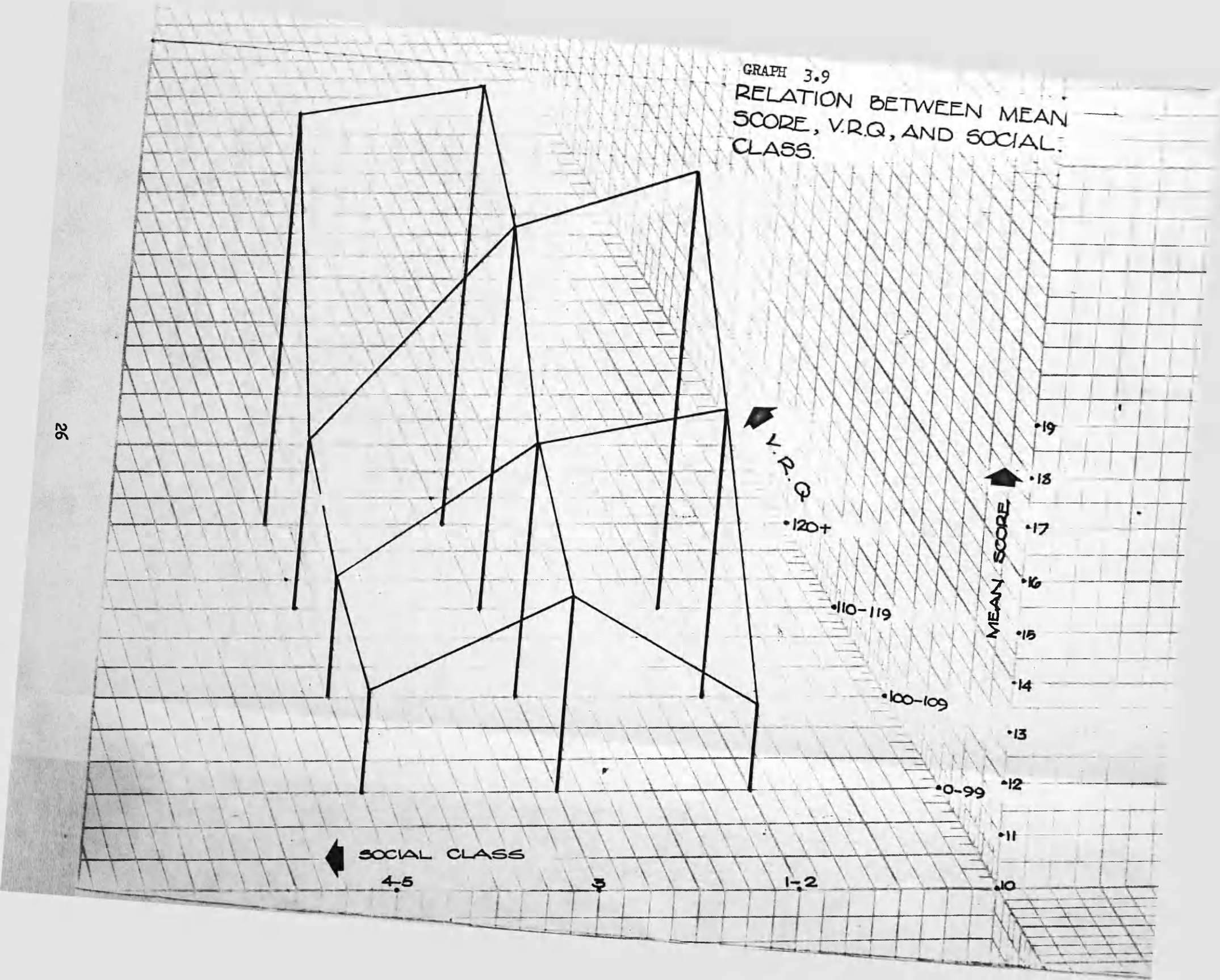
Table 3.6

V.R.Q. range	0 - 99			100 - 109			110 - 119			120+		
Social Class	5-4	3	2-1	5-4	3	2-1	5-4	3	2-1	5-4	3	2-1
Number N of candidates	7	12	9	8	26	9	3	24	12	5	22	
Mean Score $\bar{X}$	12.57	13.41	13.44	12.62	14.80	15.66	13.33	16.91	17.5	19	17.95	

These are also expressed in the three dimensional graph (See Graph 3.9)

GRAPH 3.9

RELATION BETWEEN MEAN SCORE, V.R.Q, AND SOCIAL CLASS.



IV. Discussion

1. Variation between schools

The schools had been selected to try to be typical of Scottish schools and consequently included a variety of types of schools; schools which served a whole small town community; rural schools; urban schools; schools with a predominantly council house catchment area; and selective schools. From the results Table 3.2 and 3.3 the schools were as expected different. The percentage of pupils in social class 1 - 2 varied from zero percent in one school to seventy percent in another, and although only a small number of schools released V.R.Q. information there was a variation in pupils with V.R.Q. over one hundred and twenty from three per cent in one school to thirty seven in another. Comparing Table 3.4 with Table 3.2, those schools with a small percentage of pupils in the top twenty percent of rank order i.e. schools 14, 16 and 18, seem to have a small percentage of pupils in social class 1 - 2, whereas schools with a large percentage of pupils in the top twenty percent of rank order i.e. schools 12 and 20, seem to have a large percentage of pupils in social class 1 - 2. There would seem to be a positive relationship between percentage of pupils in social class 1 - 2 and percentage of pupils in top twenty percent of rank order. School 21 does not fit this pattern perhaps because this is a junior high school where forty percent of the pupils of higher ability are creamed off at the end of their second year.

2. Vocabulary questions.

From the results (Graph 3.1) there is a relationship between pupils' performance in these questions and V.R.Q. In all questions the pupils of higher V.R.Q. performed better than the pupils of lower V.R.Q. There is also a relationship between pupils' performance and social class. Graph 3.1 indicates a separation in the performance of the three social class groups. Pupils in social class 1 - 2 do better than pupils in social class 3 who in turn do better than pupils in social class 4 - 5. Indeed schools with a different distribution of social class have very different results (Table 3.5).

What percentage correct is acceptable if the word is to be used in examinations? Even eighty percent correct means that one

pupil in five may have difficulty with that word, yet for example the results (Table 3.5) for question 19 indicate that the familiar exam word "converse", for all social class or V.R.Q. groupings, is understood by less than fifty percent of the pupils.

There is a similarity between these results with Scottish pupils and the Australian results (Table 3.5) and further investigation may show that the Australian findings (60) for the five hundred and ninety nine words they investigated are applicable, at least in part, to this country.

3. Chemistry questions.

Comparing the performance of pupils in top third of rank order with those in bottom third of rank order (Graph 3.3 and 3.4), comparing the performance of pupils in social class 1 and 2 with those in social class 4 and 5 (Graph 3.5 and 3.6) and comparing performance of pupils with V.R.Q. of over 110 with those of lower V.R.Q., the simplification of the language generally seemed to improve the performance of the better pupils more than the poorer pupils, perhaps because pupils who are confident with the chemistry are going to benefit more by a simplification of the language.

The following questions are ones where there was a statistically significant difference at the five percent level. A hypothesis is suggested as an introduction to each question(s) discussed.

(a) If a key word, i.e. a word the pupil has to understand to answer the question, is replaced by a simpler key word, the chemistry performance improves.

Which one of the following is <u>not</u> a pungent gas?	Which one of the following is <u>not</u> a choking gas?
A. Sulphur dioxide	A. Sulphur dioxide
B. Hydrogen chloride	B. Hydrogen chloride
C. Chlorine	C. Chlorine
D. Oxygen	D. Oxygen

Replacing 'pungent' with 'choking' the percentage correct for the overall population (Graph 3.2) changes from 80 to 90 which is statistically significant at the five percent level.

An atom of element X can be represented as $^{16}_{8}X$. What is the valency number of element X?	How many bonds would an atom of $^{16}_{8}X$ form?
A. 0	A. 0
B. 2	B. 2
C. 6	C. 6
D. 8	D. 8

Removing 'valency', the percentage correct for overall population (Graph 3.2) changes from 51 to 62 which is statistically significant at the five percent level.

In which one of the following compounds does covalency predominate?	Which one of the following compounds is covalent?
A. Calcium fluoride	A. Calcium fluoride
B. Sulphur chloride	B. Sulphur chloride
C. Sodium bromide	C. Sodium bromide
D. Potassium iodide	D. Potassium iodide

The removal of 'predominates' does not influence the percentage correct, perhaps because of its position in the question - the last word - and it is not a key word. It may be possible still to answer the question with a nonsense word in place of predominate.

(b) If a word appears in the stem that certain pupils associate with one of the responses, then this response distracts them more markedly.

Which of the following compounds would readily conduct an electric current in the liquid state?	Which of these would conduct when melted?
A. Lithium chloride	A. Lithium chloride
B. Sulphur dichloride	B. Sulphur dichloride
C. Phosphorus trichloride	C. Phosphorus trichloride
D. Carbon tetrachloride	D. Carbon tetrachloride

For pupils in social class 1 - 2 (Graph 3.5) there was no difference between the questions. 68% got the left one correct and 72% the right. For pupils in social class 4 - 5, (Graph 3.6) the percentage correct for the left was 23% which improved to 45% on the right, which is statistically significant at the five percent level. Response D was chosen by 55% of these pupils in the left question, perhaps because of an association between the word liquid in the stem and carbon tetrachloride in response D, since it is the only one liquid at room temperature.

(c) There may be a complex relationship between language and presentation of information. A simplification of language may not necessarily be a better way of presenting information. The first sentence in a question may be important in predisposing candidates to an answer.

Two elements X and Y each form a compound with chlorine. The chloride of X is a solid which when molten has an appreciable conductivity. The chloride of Y is a liquid with no appreciable conductivity. The atomic numbers of the two elements could be -	X and Y are elements. The melted chloride of X conducts electricity. The chloride of Y is a liquid that does not conduct. The atomic numbers of the two elements would be -
A. 11 for X and 6 for Y	A. 11 for X and 6 for Y
B. 6 for X and 19 for Y	B. 6 for X and 19 for Y
C. 10 for X and 6 for Y	C. 10 for X and 6 for Y
D. 15 for X and 11 for Y	D. 15 for X and 11 for Y

The second version has shorter sentences and fewer long words than the first. For social class 1 - 2 (Graph 3.5) there was no difference but for social class 4 - 5 (Graph 3.6) 50% got the first version correct and 23% got the second version correct, which is in simpler language. Perhaps the first sentence in the second version does not predispose the candidate since it contains less information.

(d) Confidence in chemistry and its effect on performance was demonstrated by an unintentional error.

Fused nickel iodide conducts electricity. This suggests the bonding in nickel iodide is:-	Melted nickel chloride conducts electricity. This suggests the bonding in nickel iodide is:-
A. covalent	A. covalent
B. polar covalent	B. polar covalent
C. metallic	C. metallic
D. ionic	D. ionic

The percentage correct for pupils with a V.R.Q. over 110 (Graph 3.7) was 45% for the first version, improving to 60% for the second version, attributable to fused being replaced by melted.
The percentage correct for pupils with a V.R.Q. less than 110 (Graph 3.8) was 50% for the first version deteriorating to 33% for the second version. Perhaps this group, being less confident with their chemistry, were confused by the mention of nickel chloride as well as nickel iodide in the right hand question.

An isotope of aluminium has an atomic number of 13 and a mass number of 27. $^{27}_{13}Al$ an atom of this isotope will contain -	The atom $^{27}_{13}Al$ has -
A. 14 protons and 13 neutrons	A. 14 protons and 13 neutrons
B. 13 protons and 14 neutrons	B. 13 protons and 14 neutrons
C. 14 protons and 13 electrons	C. 14 protons and 13 electrons
D. 13 protons and 14 electrons	D. 13 protons and 14 electrons

		1st Version % correct	2nd Version % correct
Graph 3.5	Social Class 1 - 2	67	79
Graph 3.6	Social Class 4 - 5	64	46
Graph 3.7	V.R.Q. 110+	62	70
Graph 3.8	V.R.Q. 109-	60	48

These questions may also demonstrate the improvement to the better pupils by simplifying the language, as well as demonstrating again that there may be a complex relationship between language and presentation of information, and in this instance, for the poorer pupils a simplification of language may not necessarily be a better way of presenting information.

4. Overall Scores

From Table 3.7 and the Graph 3.9, overall scores are influenced by V.R.Q. and social class and the effect of social class seems more marked in V.R.Q. range 100 - 119 where the performance of pupils in social class 4 - 5 is apparently depressed. This compares with Curry's (24) findings. The use of larger samples may lead to more confident statements.

V. Conclusions

From the original hypothesis this exercise would seem to indicate

(i) that certain pupils, particularly those from a lower social class or with a low V.R.Q. had difficulties with words.

(ii) in a limited number of the questions in the test the language used definitely influenced performance.

(iii) pupils' performance seemed to depend on V.R.Q. and social class.

As a first exercise it had failings: certain typing errors got through the checking procedure and distorted performance; and when dividing the sample into different categories the size of divided samples became very small.

There was an obvious need to try another major exercise more tightly organised with a larger sample of pupils to try to check some of the suggestions emerging from the discussion of the results of this exercise.

CHAPTER 4

SECOND MAJOR EXERCISE

The hypotheses were

(i) that pupils have difficulty with non-technical words.

(ii) that pupils' chemistry performance depends on V.R.Q., a measure of language development, and also on social class, a factor which influences language development.

(iii) that in multiple choice chemistry questions the following language considerations influence performance:
the words in key positions in the stem:
the number of words used:
the presence of negatives:
the presence of ambiguous expressions:
and sentence construction.

I. Research Design

Multiple choice chemistry questions from various sources (81 - 85) were prepared in two forms. One form was very similar to questions issued by the S.C.E.E.B. and the other form was in a 'simplified' language either by substitution of words, removal of words or sentence reorganisation. To try to ensure that the chemical content of the questions was the same, possible questions were scrutinised by some members of the Science Education Research Group of the University of Glasgow.

To try to identify language difficulties further conversations were held with small groups of two or three 'O' grade chemistry candidates. The pupils were given questions to tackle and then they were asked to explain how they chose their answer. They were then given another version of the same question and asked to comment on its comparative difficulty. From these discussions various points arose:

(a) There was particular difficulty with non-scientific vocabulary e.g. converse, as well as with words which some teachers may consider to be scientific but were not explicitly presented as such e.g. pungent, diatomic, fused.

(b) Where there was possible ambiguity in the question, confusion reigned.

(c) When negatives appeared in the question, problems arose.

(d) In some cases a more wordy version of a question was thought to be easier because "it filled it out a bit" and in other cases a less wordy version of a question was thought to be easier because "it was more straightforward".

In addition, in an attempt to clarify points of language difficulty and possible effect on performance pairs of questions were discussed with Mr. Simpson of the Department of Linguistics and Phonetics at the University of Glasgow.

In the light of pupil and linguist comments and the experience gained from the first major exercise two tests were prepared. Appendix H has copies of both tests with matched questions typed opposite each other to make comparisons easier.

In the first major exercise alternate chemistry questions in each test were in a simplified language so that each test was a mixture of 'examination' and 'simplified' language questions. In this exercise to make one paper more like an examination paper and to facilitate comparison of overall scores it was decided to put all the examination language chemistry questions in one test and the simplified language chemistry questions in the other test.

The two tests contained:

(i) Five multiple choice vocabulary questions from an Australian word survey (60) which contained words that had appeared in recent Scottish 'O' grade chemistry papers. Questions 2, 3 and 4 had been used in the first major exercise which would enable comparison between the two major exercises.

(ii) Five simple multiple choice chemistry questions with a possible difficult word, e.g. pungent, diatomic, in a key position in the more difficult language version.

(iii) Three multiple choice control chemistry questions which were the same in each test to test similarity of the groups tested.

(iv) Fifteen multiple choice chemistry questions in two versions.

Questions 14 - 18 were designed to check the effect of certain words in key positions namely - valency, fused, crystalline and liquid.

Questions 19 - 20 in the simplified versions had a reduction in the number of words. The verbosity or noise may act as a distractor.

Questions 21 - 22 in the simplified versions had negatives removed. Negatives may cause confusion.

Question 23 in the examination version seemed to have an ambiguous response B "The copper and sulphur have combined to form a compound." A compound could mean some unspecified compound or one and only one compound. The indefinite article can mean some or one. Response B in the simplified version was "the copper and sulphur had combined to form only one compound". The ambiguity had been removed.

Questions 24 - 28 were alternative formulations of the same questions where the number of sentences had been reduced or a more complex sentence had been replaced by simpler sentences.

II. Administration

In the first major exercise twelve schools in Scotland had offered to help. To increase the sample size more schools were approached and twenty four schools offered to assist. (see Table 4.1). The schools were again chosen to give a representative cross-section of schools varying in type, catchment area and region.

The test was administered in March 1976 to 1,752 chemistry 'O' grade candidates ranging in V.R.Q. and social class (86). Appendix E has an explanation of the social class division based on parental occupation.

Table 4.1

Campbeltown Grammar	:	All Saints, Glasgow
Denny High	:	Craigbank Secondary, Glasgow
Dollar Academy	:	Eastwood High, Newton Mearns
Dunblane High	:	Grange Secondary, Glasgow
Eastbank Secondary, Glasgow	:	Greenock High School
Glenwood Secondary, Glasgow	:	Kilmarnock Academy
Govan High School, Glasgow	:	Lochend Secondary, Glasgow
Kelso High	:	Nicolson Institute, Stornoway
Kingsridge Secondary, Glasgow	:	Portobello High
Knox Academy, Haddington	:	St. Mungo's Academy, Glasgow
Madras College, St. Andrews	:	Rothesay Academy
Williamwood High, Clarkston	:	Victoria Drive Secondary, Glasgow

As in the first major exercise, to try to achieve similar tested groups within each school a Teacher Information sheet (see Appendix F) was prepared and copies sent to each school. Similarly a Pupil Information sheet (see Appendix G) was also distributed to try to ensure that the candidates were confident with the procedure. Tests were printed on yellow and pink paper to match the appropriate computer answer card and to assist with organisation. By these measures it was hoped to achieve some uniformity in the method of administering the tests in the various schools.

In essence within each school the pupils were numbered and those who got an even number got one test while those with an odd number

got the other test and the pupil answer cards were processed in appropriate batches by the computing department of the University of Glasgow.

III. Results

1. Vocabulary Questions

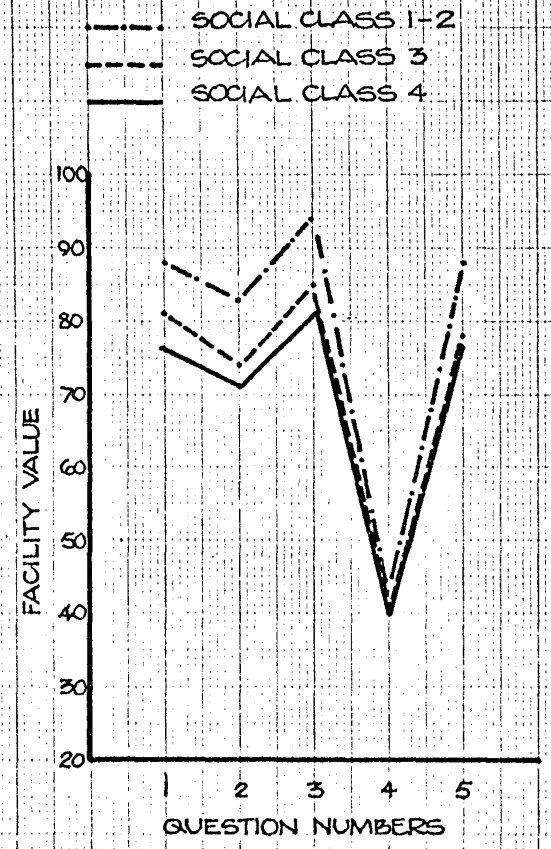
Table 4.2

% Correct / Word Tested	Australian Results	1975 Overall Results	1976 Overall Results		Soc. Class 4 - 5	Soc. Class 3	Soc. Class 1 - 2		V.R.Q. 105 -	V.R.Q. 106 - 119	V.R.Q. 120 +
No.in sample		442	1752		202	559	736		200	260	183
Negative	77	-	82		76	81	88		65	83	91
Correspond	61	70	76		71	74	83		57	79	84
Efficient	72	84	88		81	85	94		69	89	97
Converse	41	39	41		40	41	43		35	38	43
Valid	79	-	82		77	78	88		64	88	92

Not all schools released V.R.Q. information and consequently the numbers in the last three columns are smaller than would be anticipated from the total sample size.

GRAPH 4.1.

VOCABULARY QUESTIONS



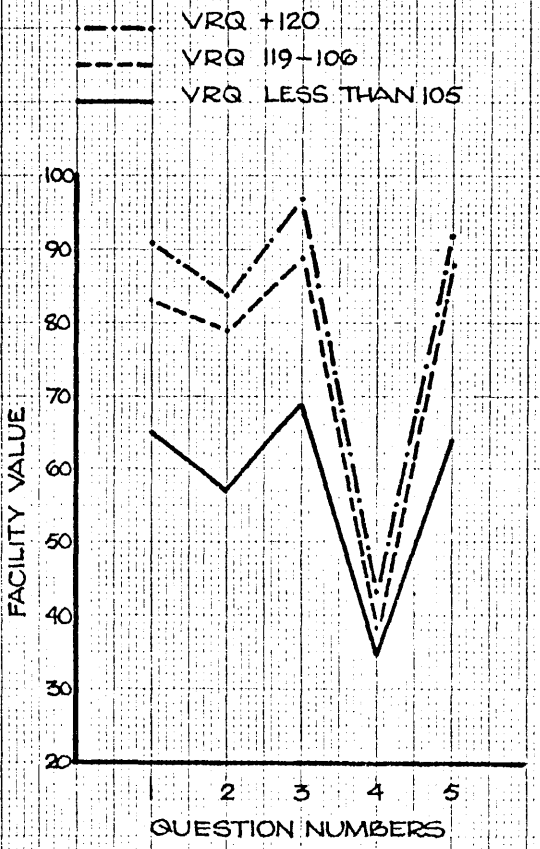


Table 4.3 Control Questions

Sample % correct / Question No.	Total Sample		Social Class un-classified		Social Class 4-5		Social Class 3		Social Class 1-2		V.R.Q. 105 -		V.R.Q. 106-119		V.R.Q. 120 +	
	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.
No. in Sample	876	876	118	137	104	98	279	280	375	361	114	86	127	132	92	91
Difference which is significant at 5% level	5		12		13		8		7		13		12		13	
11	66	65	64	63	57	66	64	58	71	71	43	42	75	75	84	82
12	64	67	58	64	53	63	64	66	69	70	47	50	67	61	79	82
13	56	57	55	51	42	47	54	57	62	60	44	37	64	60	73	71

Simp. Simplified language test
Ori. Original language test
} the control questions in both tests were the same

Table 4.4 Chemistry Questions

Sample % correct / Question No.	Total Sample		Social Class un-classified		Social Class 4-5		Social Class 3		Social Class 1-2		V.R.Q. 105-		V.R.Q. 106-119		V.R.Q. 120+	
	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.
No. in Sample	876	876	118	137	104	98	279	280	375	361	114	86	127	132	92	91
6. Pungent replaced	95 **	80	94 *	77	96 *	80	95 *	79	95 **	82	89 *	71	94 *	83	97	88
7. Group replaced	78	76	71	76	65	70	78	75	83	78	59	52	70	75	83	88
8. Diatomic replaced	62 **	42	55 *	32	45	35	58 *	40	73 **	51	49 *	21	53	48	67 *	52
9. Product replaced	75	72	67	60	67	63	69	70	83	80	45	43	74	72	80	81
10. Abundant replaced	58	57	62 *	50	50	54	51	56	64	61	44	40	53	57	60	62

* Difference which is significant at 5% level

** Difference which is significant at 1% level

Table 4.5a More Complex Chemistry Questions

Sample % correct / Question No.	Total Sample			Social Class unclassified			Social Class 4-5			Social Class 3			Social Class 1-2			V.R.Q. 105-			V.R.Q. 106-119			V.R.Q. 120+		
	Simp.	Ori.		Simp.	Ori.		Simp.	Ori.		Simp.	Ori.		Simp.	Ori.		Simp.	Ori.		Simp.	Ori.		Simp.	Ori.	
No. in sample	876	876		118	137		104	98		279	280		375	361		114	86		127	132		92	91	
14 Valency replaced	57	**	46	56	*	42	49	*	31	55	*	47	61	*	52	55	*	38	58	*	42	64	*	47
15 Valency replaced	39	**	46	38		36	30		36	34	*	44	45	*	53	32		35	44		39	49		48
16 Fused replaced	62	**	51	53		47	67		56	60	*	48	66	**	54	56	*	35	61	*	47	71	*	54
17 Crystalline replaced	70		71	68		66	60		66	68		69	75		76	51		55	62		70	85		80
18 Influence of "liquid"	42		39	37		31	30		20	37		39	51		46	26		21	39		42	50		46
19 Verbosity reduced	30		28	26		24	20		21	27		26	37		32	24		20	28		25	43	?	31
20 Verbosity reduced	61		60	57		52	55		55	57		54	68		70	46		49	61		63	78	?	66
21 Negative removed	58	**	50	53		45	51		42	49		48	68	**	55	29		31	53		52	83	*	64

* Difference which is significant at 5% level

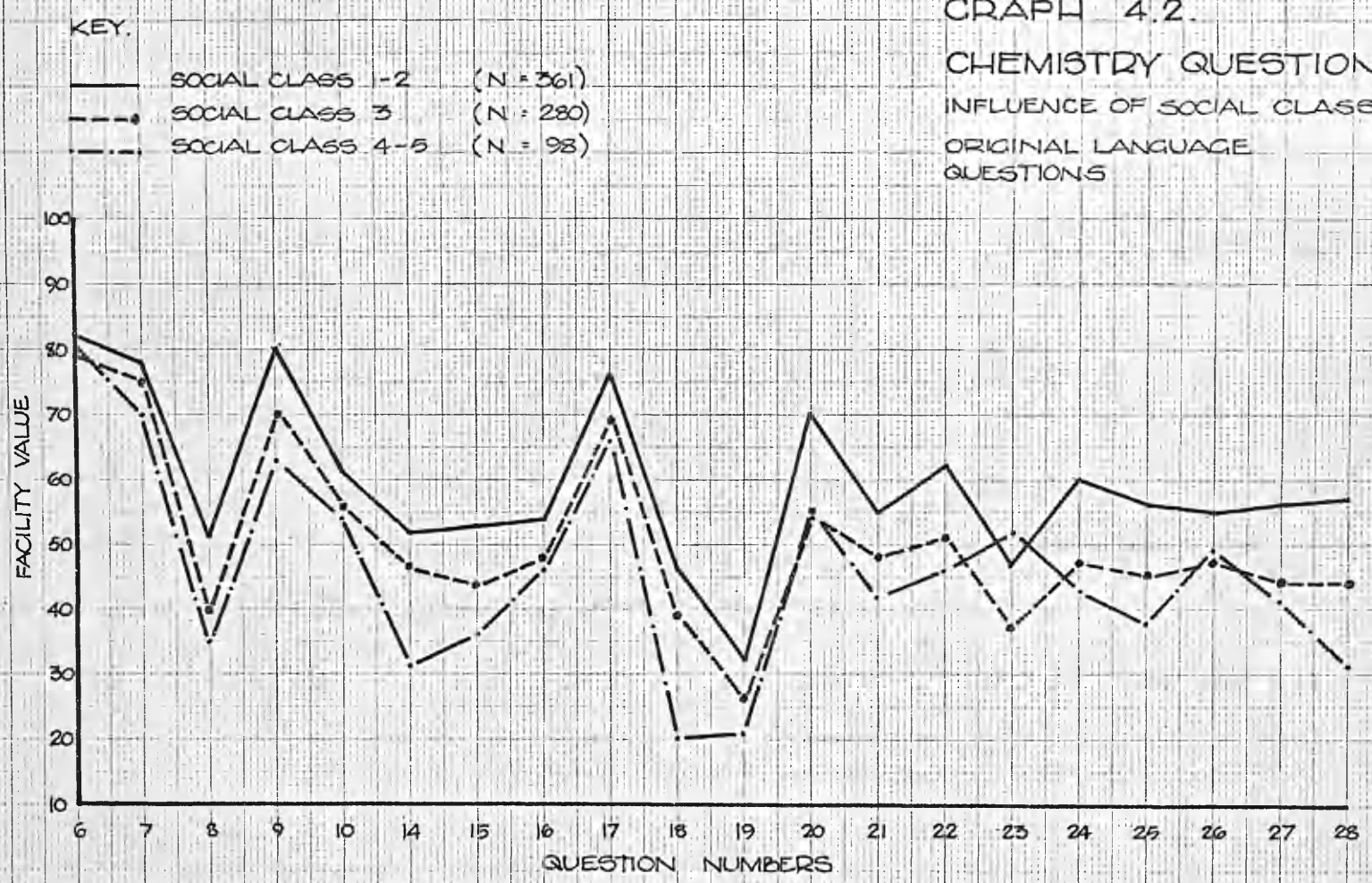
** Difference which is significant at 1% level

Table 4.5b More Complex Chemistry Questions

Sample % correct / Question No.	Total Sample		Social Class un-classified		Social Class 4-5		Social Class 3		Social Class 1-2		V.R.Q. 105-		V.R.Q. 106-119		V.R.Q. 120+	
	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.	Simp.	Ori.
No. in sample	876	876	118	137	104	98	279	280	375	361	114	86	127	132	92	91
22 Negative removed	46 **	54	42	45	41	46	39 *	51	53 *	62	32	31	44 *	56	55 *	68
23 An ambiguity removed	55 **	43	45	42	43	52	51 *	37	65 **	47	50 *	36	48 *	35	58 *	45
24 Alternative sentence construction for the same question 28	47	51	41	45	40	43	42	47	55	60	32	30	46	55	66	57
25	53 *	48	39	46	45	38	49	45	63 *	56	31	34	54	48	67	62
26	37 **	49	31	36	29 *	49	38 *	47	39 **	55	37	43	35 *	47	42 *	64
27	43	47	25 *	38	39	41	36 *	44	55	56	23	35	43	45	55	57
28	42 **	48	34	42	30	31	36 *	44	52	57	29	31	39	44	59	49

* Difference which is significant at 5% level

** Difference which is significant at 1% level

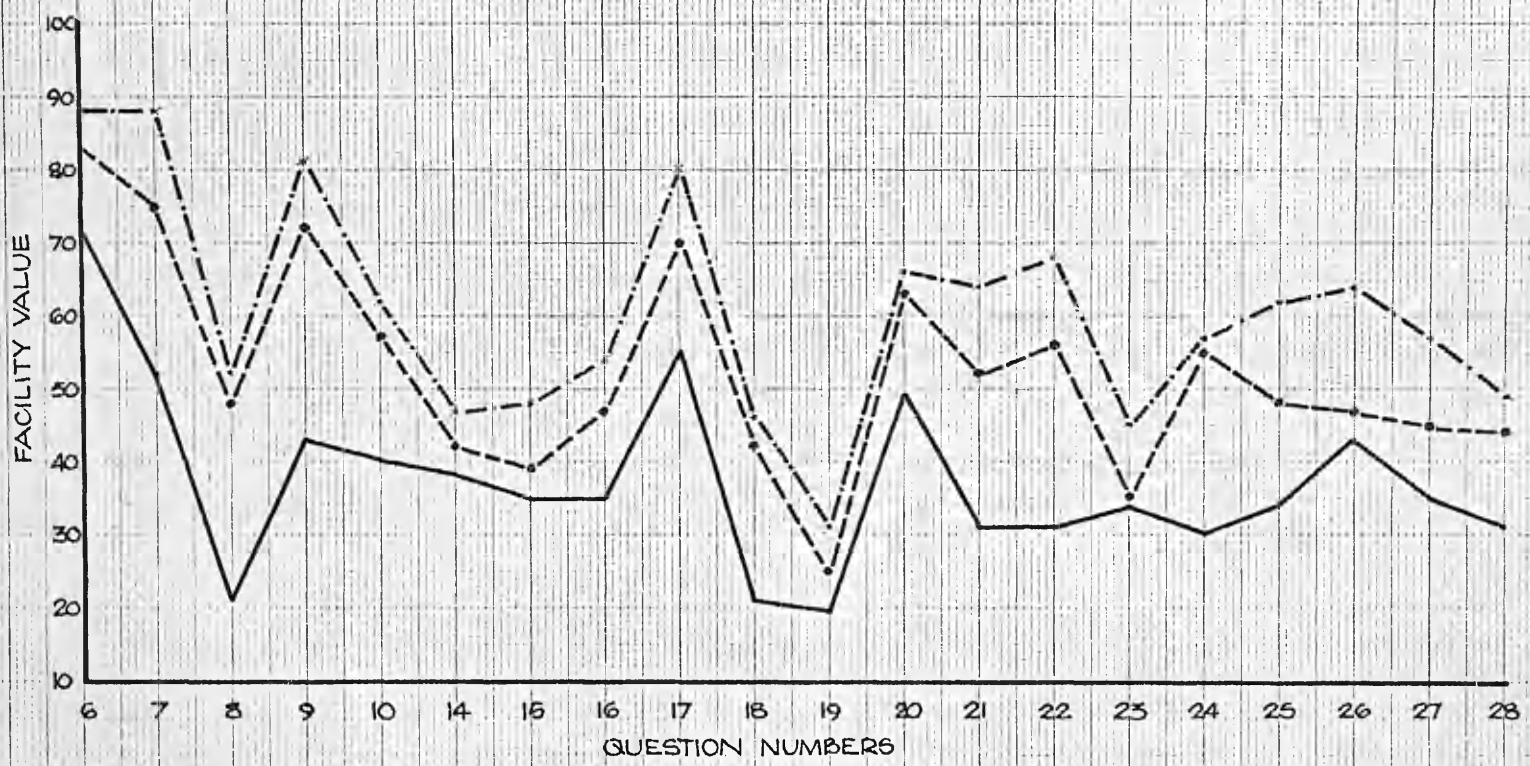

KEY.
SOCIAL CLASS 1-2 (N = 361)
SOCIAL CLASS 3 (N = 280)
SOCIAL CLASS 4-5 (N = 98)
GRAPH 4.2.
CHEMISTRY QUESTIONS
INFLUENCE OF SOCIAL CLASS
ORIGINAL LANGUAGE QUESTIONS
FACILITY VALUE
100
90
80
70
60
50
40
30
20
10
6 7 8 9 10 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
QUESTION NUMBERS

GRAPH 4.3.

CHEMISTRY QUESTIONS

INFLUENCE OF V.R.Q.

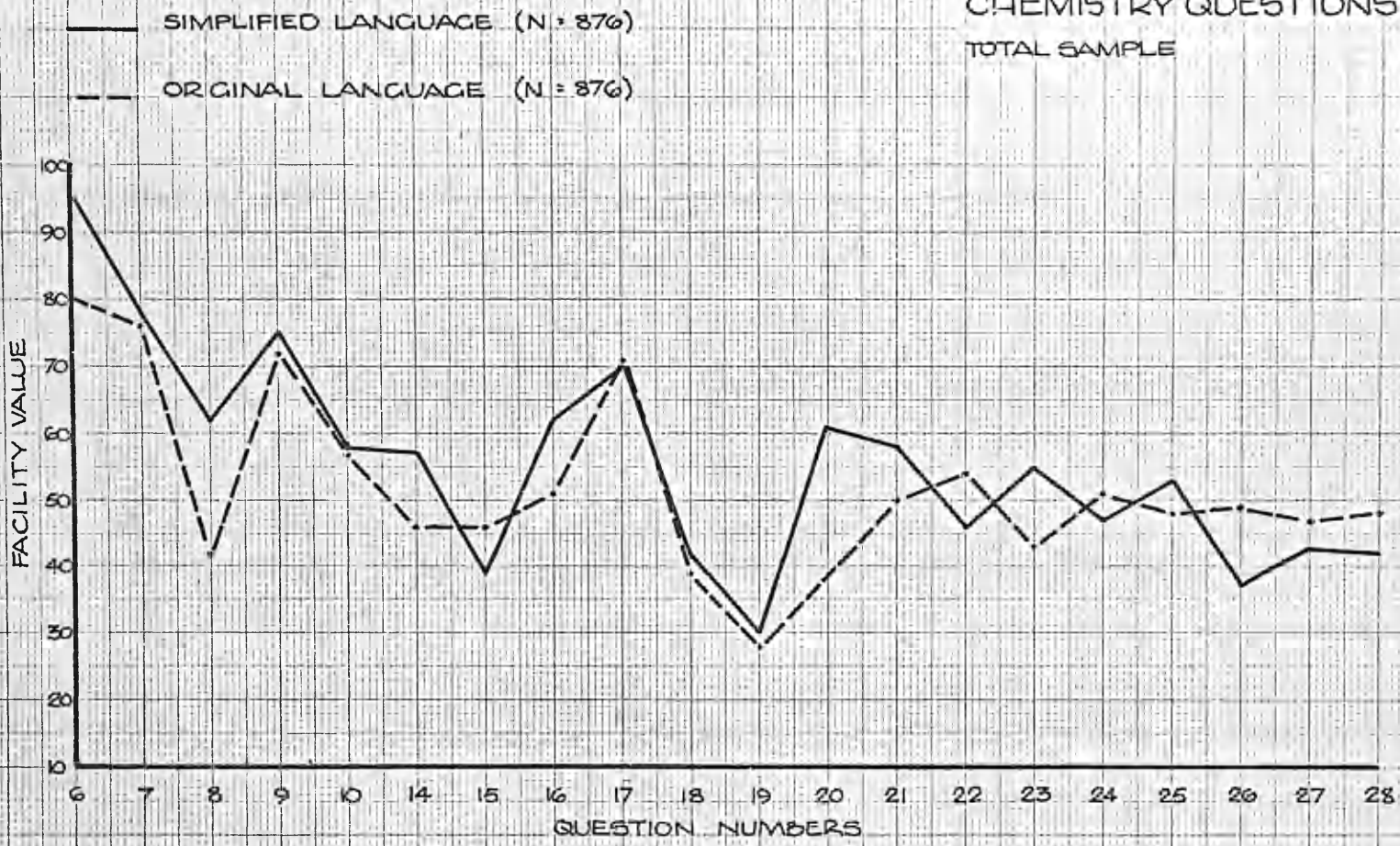
ORIGINAL LANGUAGE QUESTIONS



GRAPH 4.4.

CHEMISTRY QUESTIONS

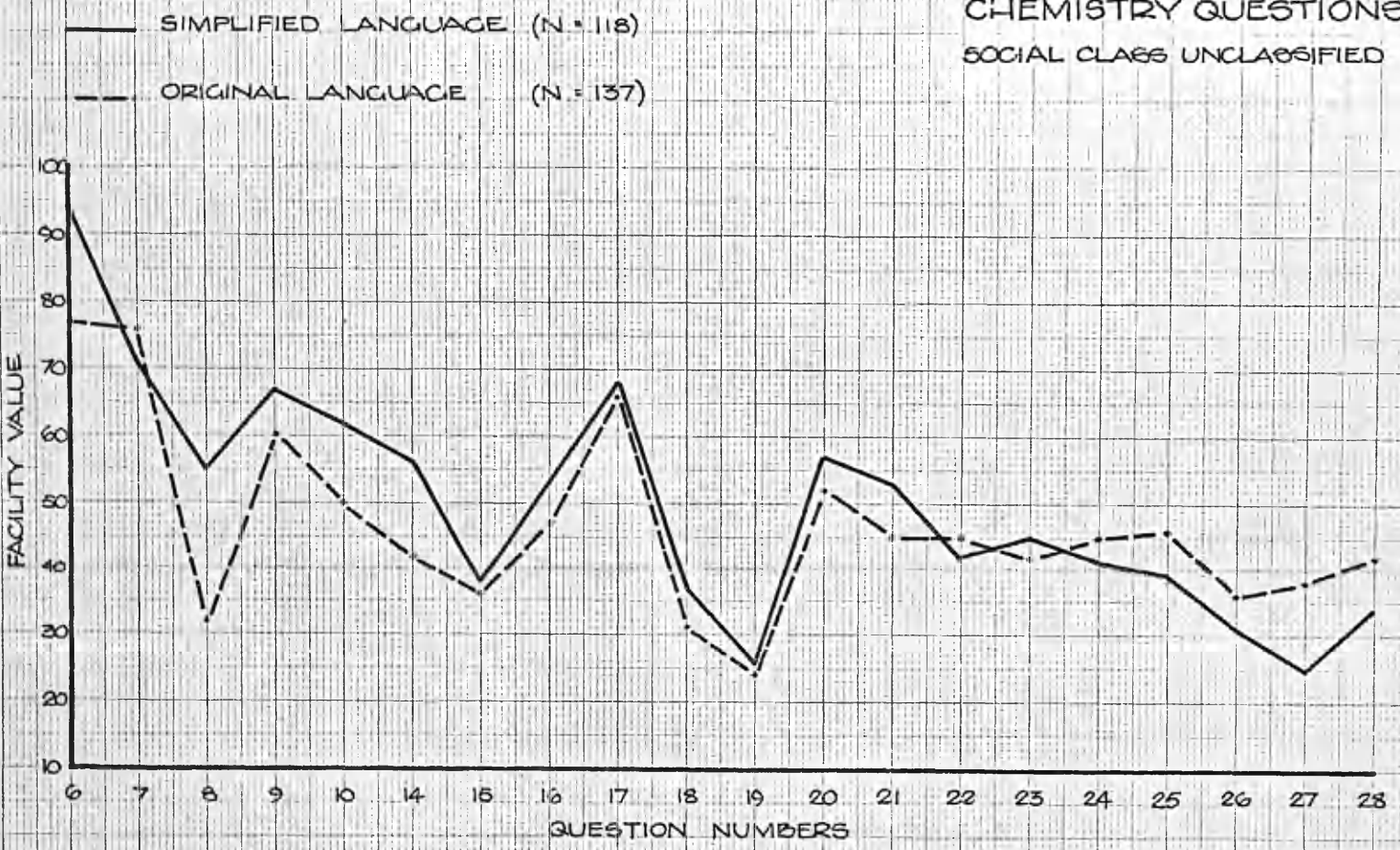
TOTAL SAMPLE



GRAPH 4.5.

CHEMISTRY QUESTIONS

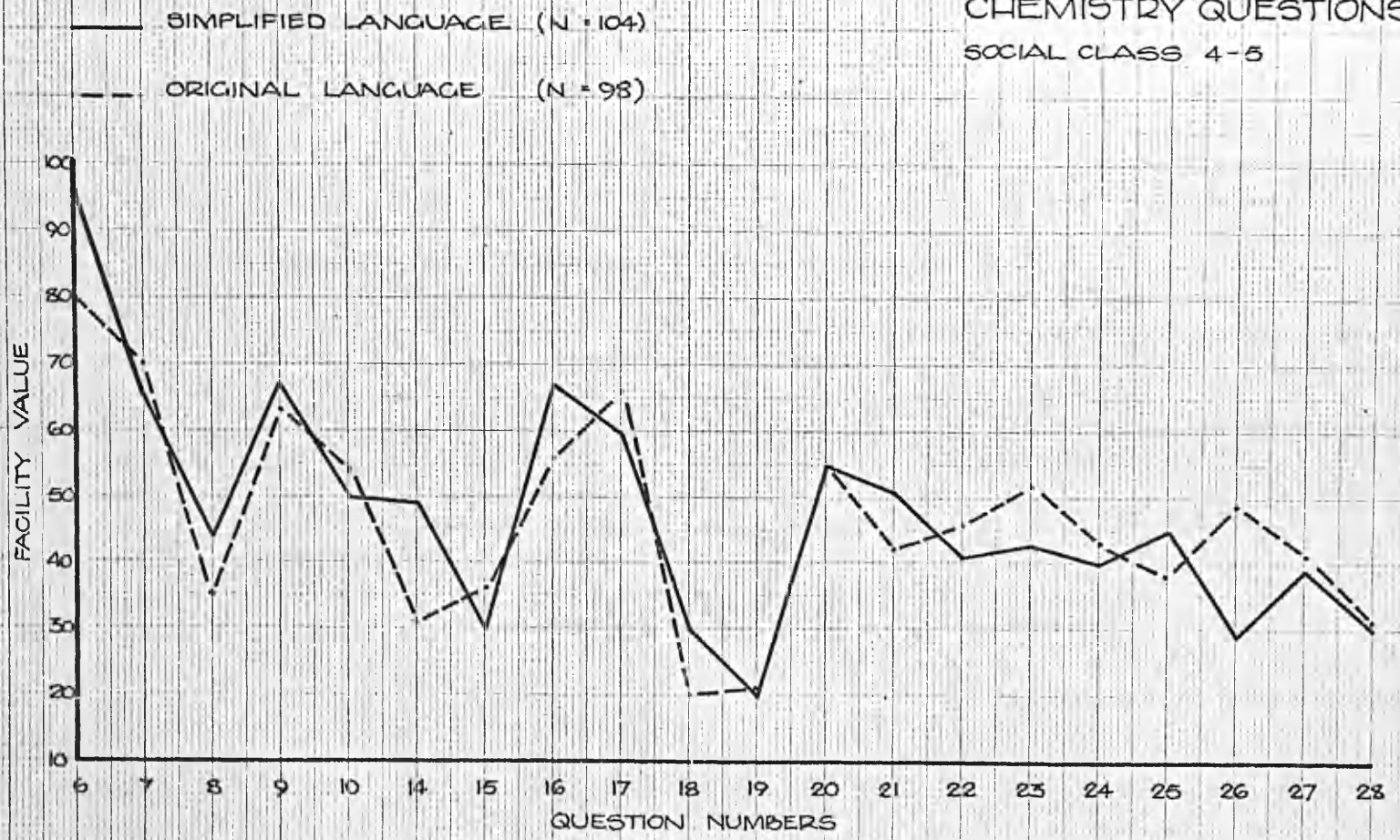
SOCIAL CLASS UNCLASSIFIED



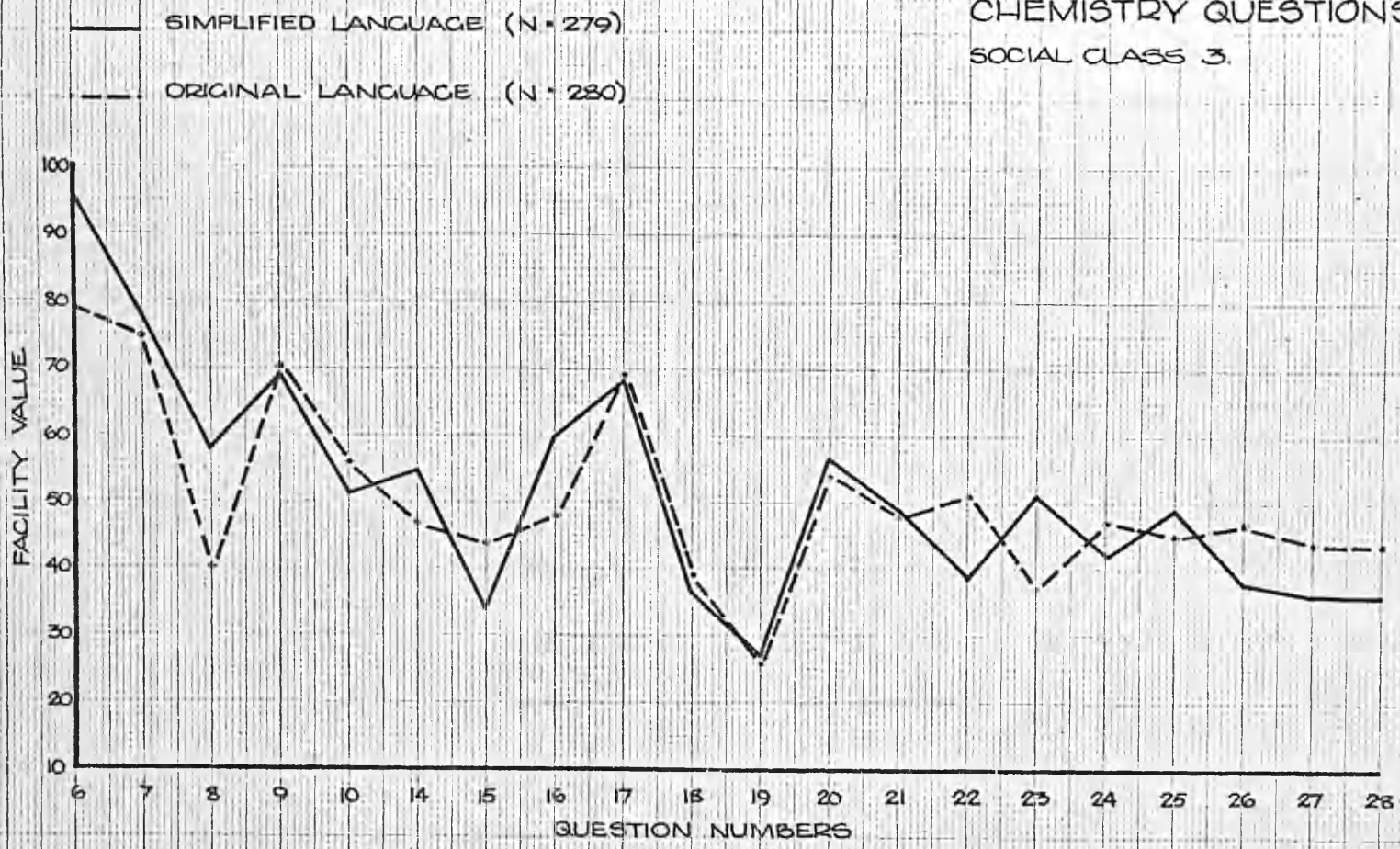
GRAPH 4.6.

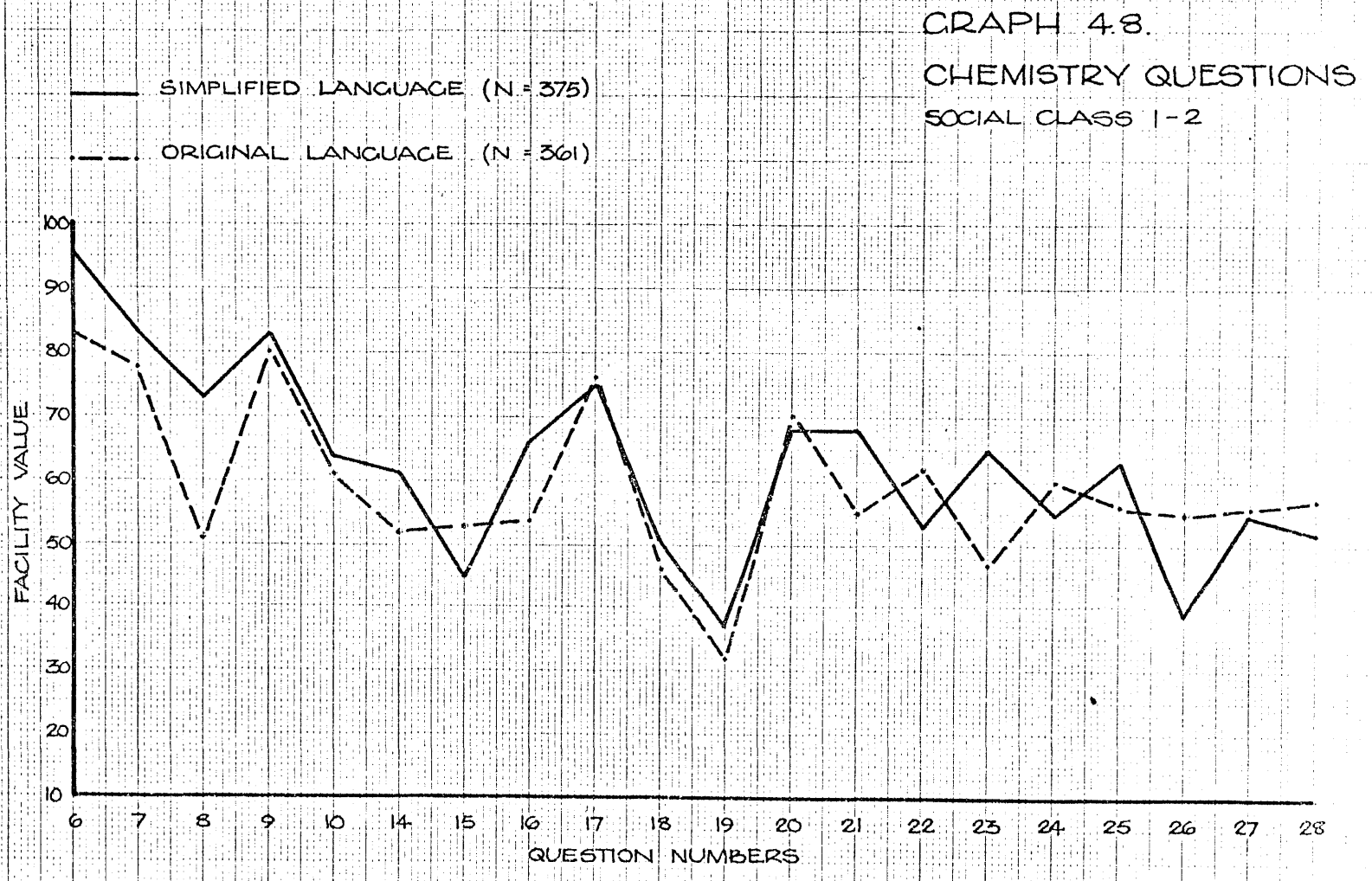
CHEMISTRY QUESTIONS

SOCIAL CLASS 4-5



GRAPH 4.7.
CHEMISTRY QUESTIONS
SOCIAL CLASS 3.

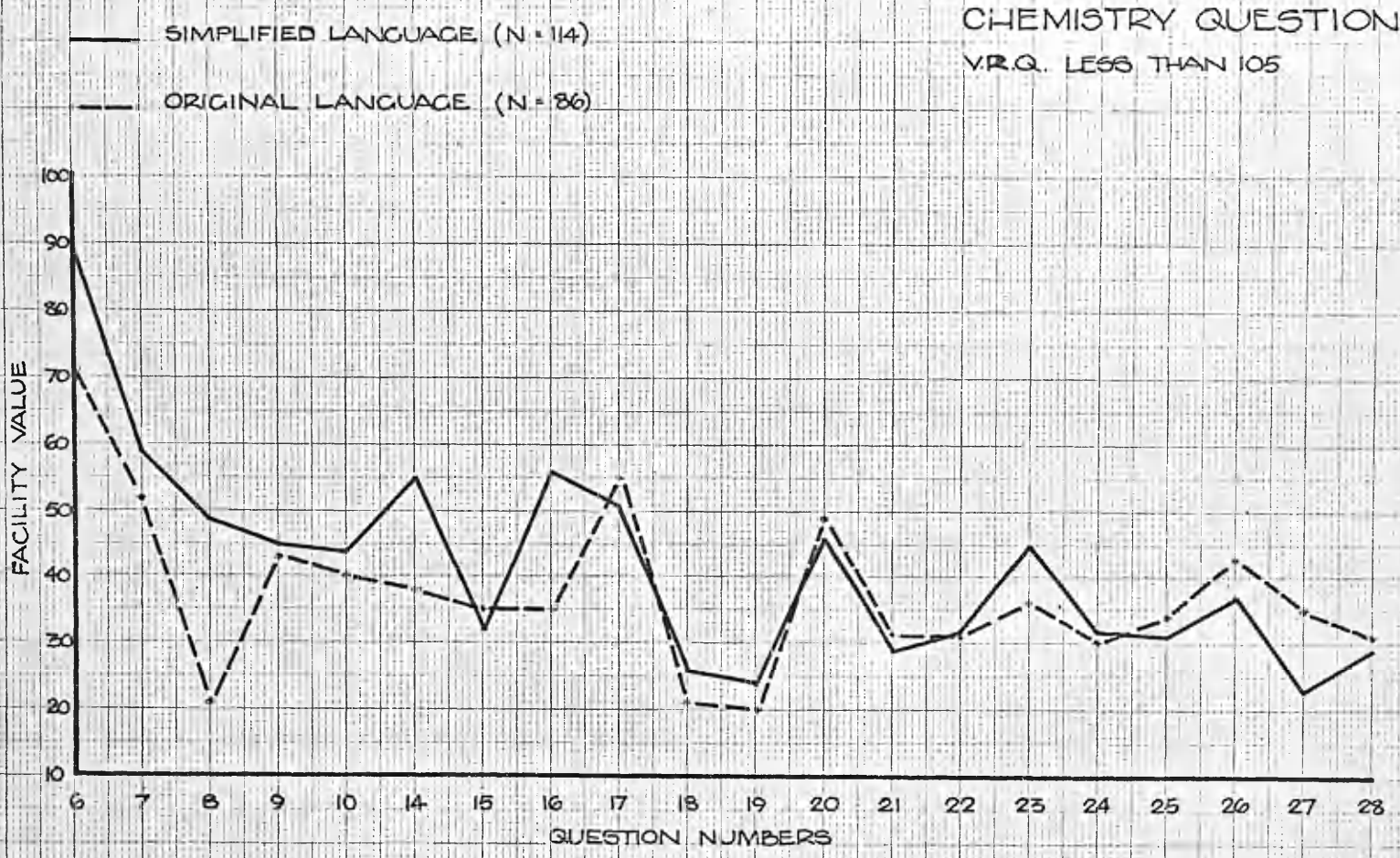



GRAPH 4.8.
CHEMISTRY QUESTIONS
SOCIAL CLASS 1-2
SIMPLIFIED LANGUAGE (N = 375)
ORIGINAL LANGUAGE (N = 361)
FACILITY VALUE
100
90
80
70
60
50
40
30
20
10
6 7 8 9 10 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
QUESTION NUMBERS

GRAPH 4.9.

CHEMISTRY QUESTIONS

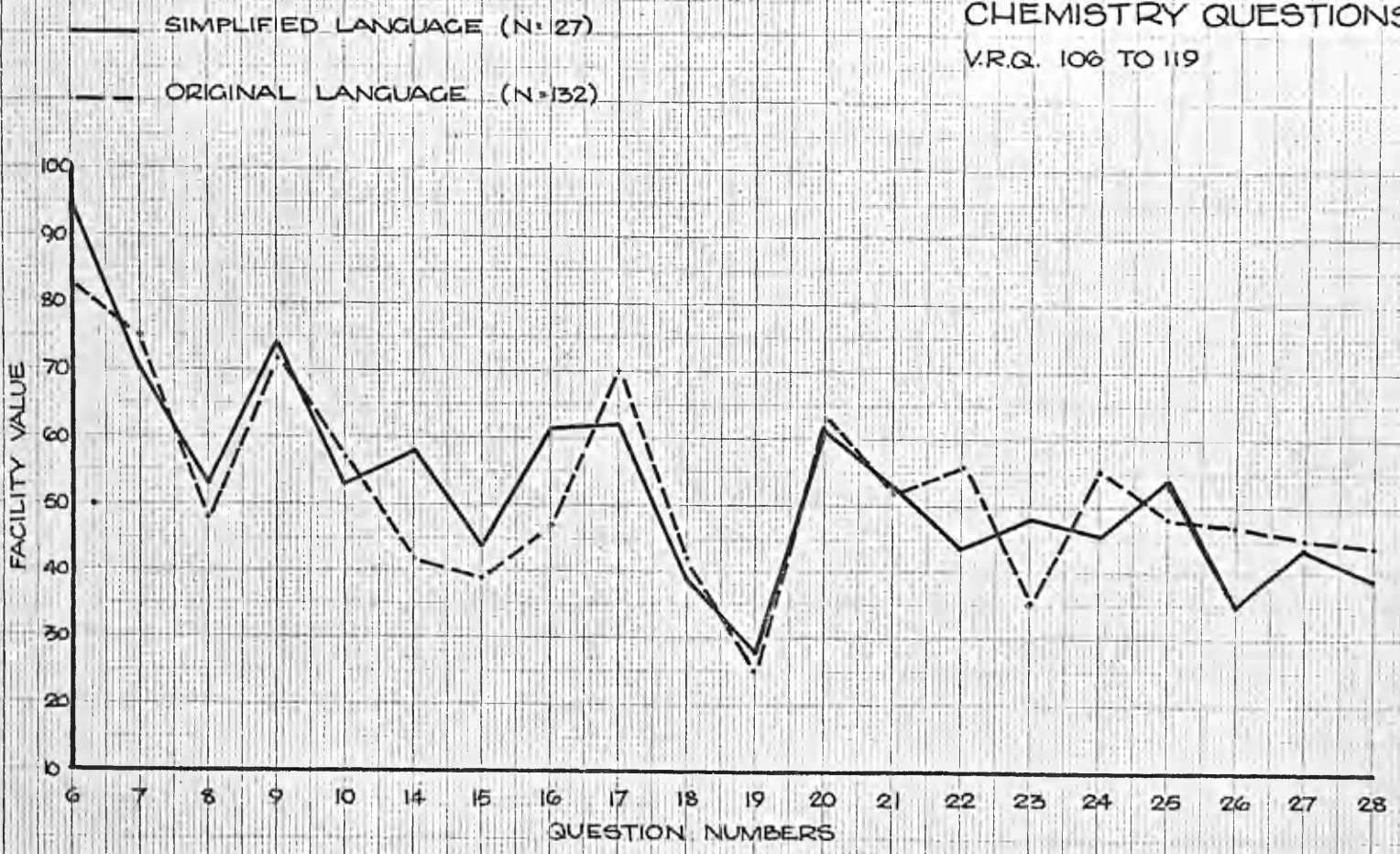
V.R.Q. LESS THAN 105



GRAPH 4.10.

CHEMISTRY QUESTIONS

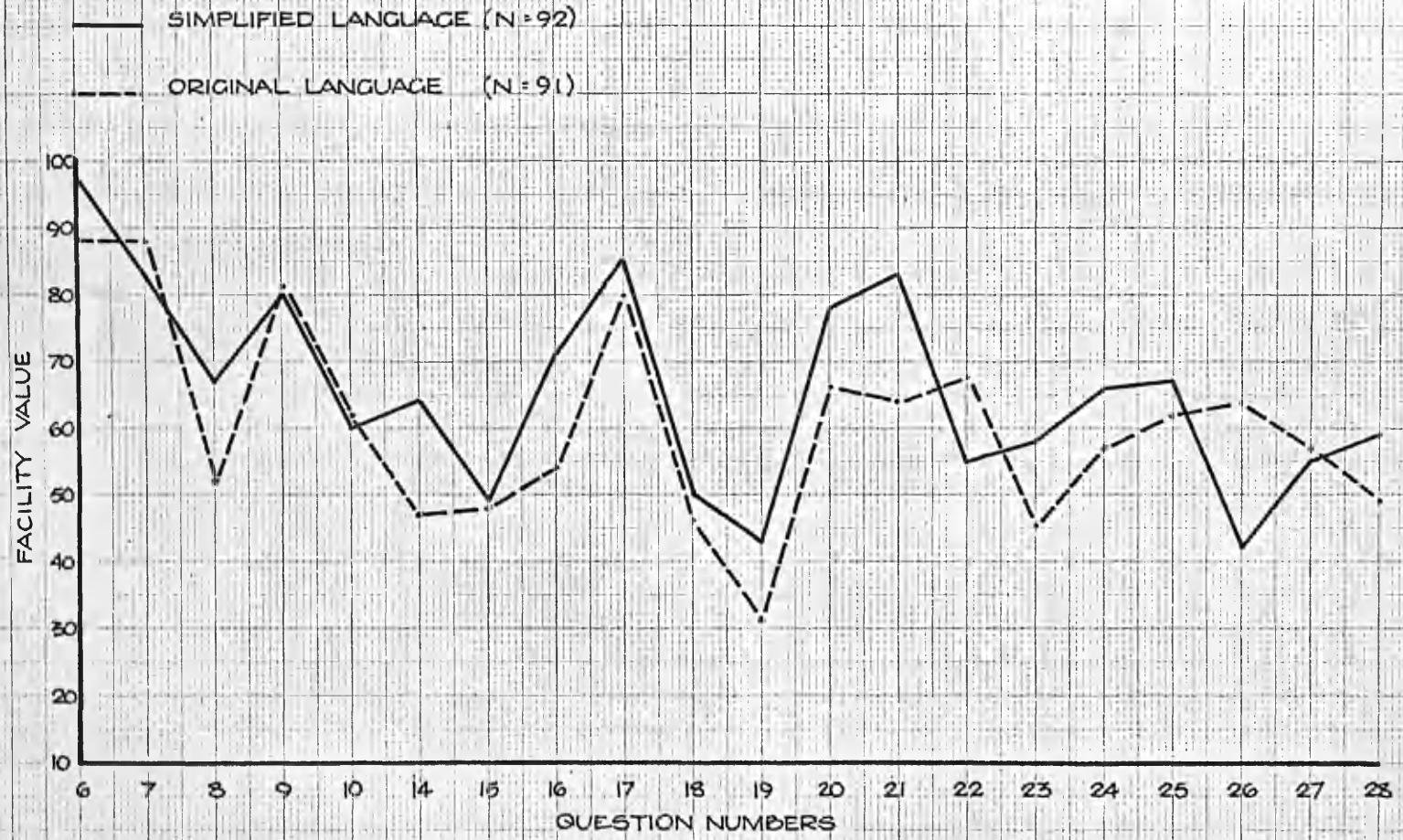
V.R.Q. 106 TO 119



GRAPH 4.11

CHEMISTRY QUESTIONS

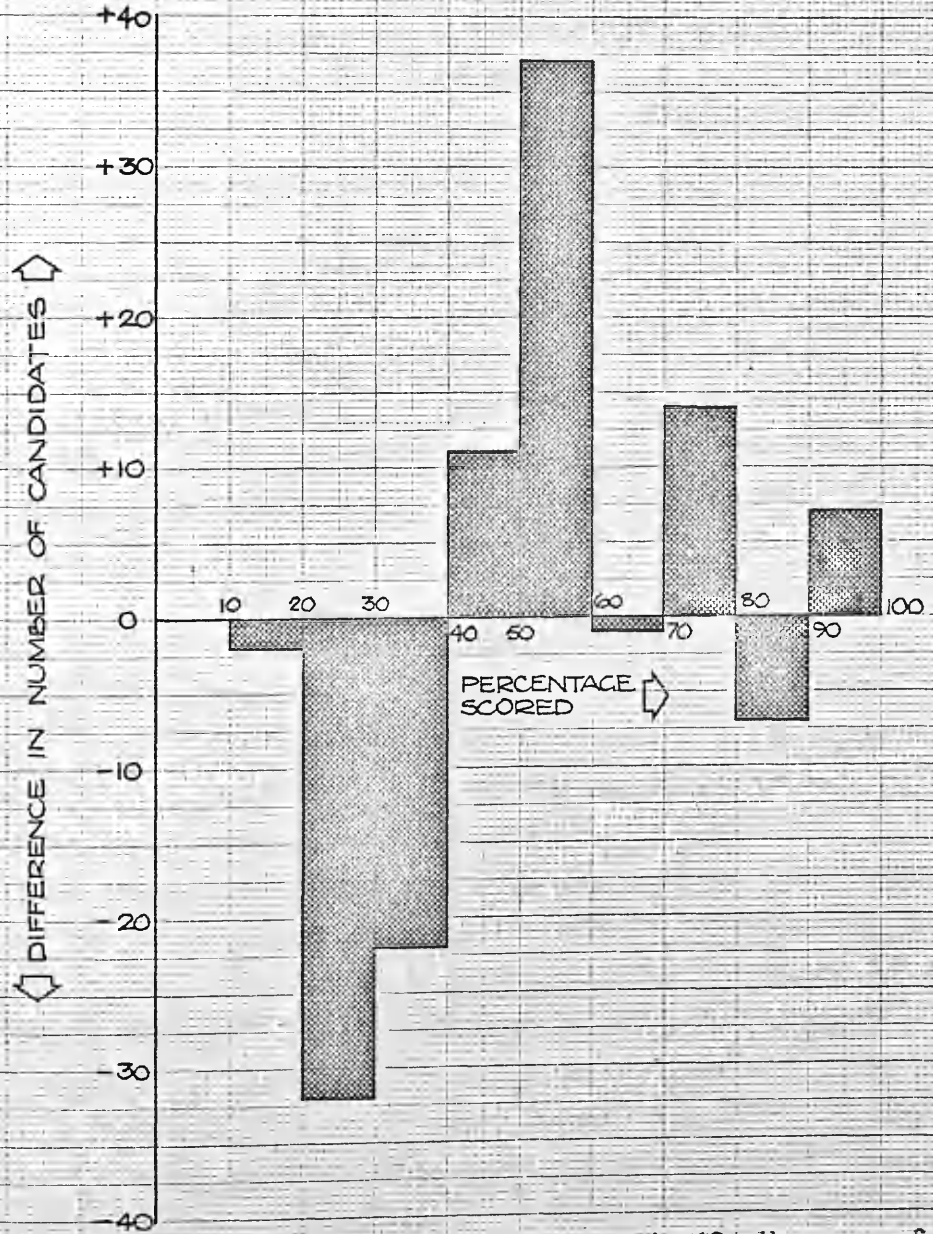
V.R.Q. OVER 120



GRAPH 4.12.

OVERALL SCORES FOR TOTAL SAMPLE

COMPARING SIMPLIFIED LANGUAGE CANDIDATES WITH ORIGINAL LANGUAGE CANDIDATES



In the lower mark ranges, up to 40, there are fewer "simplified" candidates than "original" candidates whereas in the higher mark ranges there are in the main more "simplified" candidates than "original" candidates.

IV. Discussion

1. Vocabulary Questions

From the results Table 4.2 and Graph 4.1 there is a relationship between pupils performance in these questions and V.R.Q. In all questions the pupils of higher V.R.Q. performed better than the pupils of lower V.R.Q. There is also a relationship between pupils performance and social class. Pupils in social class 1 - 2 do better than pupils in social class 4 - 5. These findings would confirm the findings of the first major exercise.

There is again a similarity between these results with Scottish pupils and the Australian results (60). Table 4.6 gives a complete list of those words from the 599 words tested which Gardner (60) found less than eighty per cent of form 4 in Australian schools could cope with.

Table 4.6

disintegrate	descendant	audible	illustrate
*converse	incident	column	invest
grain	incline	concept	logic
*spontaneous	initial	conception	*negative
latitude	partial	continent	negligible
percentage	sense	crest	probability
rate	symmetrical	diversity	propagate
revise	tabulate	effect	recoil
average	topic	emit	relative
contrast	action	factor	simultaneous
*correspond	adjust	fundamental	standard
stimulate	theory	*valid	

These words used in Gardner's work were selected by a panel of science teachers as being important for science pupils without being technical words. Although there is probably emphasis placed on the teaching of meanings of relevant technical terms e.g. isotope, it is probable that these non-technical terms tend to be neglected. The words used in either the first or second major exercises are marked (*) and the findings would substantiate the Australian results. The words in Table 4.6 are in the main fairly frequently used in classroom situations, text books and exams yet one pupil in five may be having difficulty with them and the results for "converse" would suggest that for all social classes or V.R.Q. groupings more than

one person in two may be having difficulties. One would suggest that words of this type are a barrier to learning.

2. Control Questions

Table 4.3 would seem to indicate that the procedures which had been adopted to try to ensure that the pupils who sat either test were similar, were satisfactory. For all of the groupings, all of the common questions had similar percentages correct.

3. Chemistry Questions

(a) General Observations

In chemistry multiple choice questions graph 4.2 would seem to indicate that candidates in social class 1 - 2 do better than candidates in social class 3 who in turn do better than candidates in social class 4 - 5. Similarly graph 4.3 would seem to indicate that in chemistry multiple choice questions candidates with a V.R.Q. of over 120 do better than candidates with V.R.Q. between 119 and 106 who in turn do better than candidates with a V.R.Q. of less than 105. Both social class and V.R.Q. influence performance in chemistry multiple choice questions.

A simplification in the language would seem to have more effect on candidates from a higher social class than from a lower social class. By comparing graph 4.6 for social class 4 - 5 with graph 4.8 for social class 1 - 2, more questions in the latter have positively improved by simplification.

The better pupils may be benefitting relatively more than the poorer by language simplification because the possibility of reading difficulties into the question, which may be present in the more complex form, has been reduced. Candidates, who are confident with the chemistry, are benefitting most by language simplification

An examination of graph 4.4 would seem to indicate that language does influence performance in multiple choice chemistry questions even when the total sample is considered. Ten of the questions show a significant difference at the five percent level and nine of those are significant at the one percent level.

(b) Specific Comments

The results in Table 4.4 and 4.5, which are also expressed in graphs 4.4 to 4.11 are discussed under various headings depending on the type of alteration which has been made.

(i) Simple chemistry questions with a key word replaced

In the tests these were questions 6 to 10. The replacement of the word "pungent" with "choking" in question six gave an improvement for all groupings. Comparing the overall samples the percentage correct improved from 80 to 95 which is significant at the one percent level. In real terms 133 more candidates out of 876 got it correct. The replacement of the word "diatomic" with "two atoms" in question eight gave an improvement for all groupings. Comparing the overall samples the percentage correct improved from 42 to 62 which is again significant at the one percent level. In real terms 173 more candidates out of 876 got it correct. The replacement of the words "group" and "product" in questions seven and nine does not seem to promote an improvement which is significant at the five percent level. Even what would be considered a simple word like "abundant" can cause problems. Question 10 for unclassified social class group illustrates an improvement. This unclassified category had in addition to candidates who gave insufficient information on father's occupation, candidates whose father was unemployed, or in the armed forces or who had no father. In this category 50 percent got question ten correct when the word "abundant" was used and this improved to 62 percent when this word was replaced. Words in key positions in simple multiple choice chemistry questions can influence performance.

(ii) The influence of words in key positions in chemistry multiple choice questions

In the tests these were questions 14 - 18. The replacement of the word "valency" (in question 14) by "number of bonds" gave an improvement for all groupings. Comparing the overall samples the percentage correct improved from 46 percent to 57 percent which is significant at the one percent level. The replacement of the word "fused" by "melted"(in question 16) gave an improvement for all groupings. Comparing the overall samples the percentage correct improved from 51 percent to 62 percent which is significant at the one percent level. In question 17 the replacement of the word "crystalline" with "solid" does not seem to influence performance. Virtually all candidates would seem to know that crystals are solids. In question 18 there is no apparent difference in performance between the two forms of the question but a consideration of number of candidates choosing each response is interesting.

Table 4.7

No. of candidates / Response	Total Sample			Soc.Class 4-5	
	Simp.	Ori.		Simp.	Ori.
A carbon tetrachloride	250	325		38	52
B sulphur dichloride	130	112		21	12
C phosphorus trichloride	105	82		13	14
D* strontium chloride	371	338		31	20
No. in sample	876	876		103	98

More candidates would seem to be choosing response A in the original form than in the simplified form. A possible explanation is that the word "liquid" in the stem of the original version is associated with response A carbon tetrachloride which consequently is a big distracter. Although it is still a big distracter in the simplified version, the removal of "liquid" from the stem reduces its distracting power. In question 15 the word "valency" has been replaced as in 14 but there is no improvement. In fact there is a statistically significant improvement at the five percent level in the opposite direction for the total sample and the higher social class groupings. In the original version of question 14 and 15 in each grouping the number who got it correct are about the same, whereas in the simplified version of question 14 and 15 this is not the case. The simplified 14 is apparently easier than the original and the simplified 15 is apparently harder than the original. Question 15 requires more processes of thought than 14 and it may be that the candidates in the original test, who know the word valency can cope with the extra processes by rote whereas in the simplified version the extra processes take their toll of the candidates.

Words in key positions in chemistry multiple choice questions can influence performance.

(iii) The effect of verbosity

In the tests these were questions 19 and 20. In both cases in the simplified versions a great deal of the verbosity or noise had been removed by reducing the number of words in both stem and responses. For the overall grouping and the majority of groupings there seems to be little improvement. For the most able candidates

with a V.R.Q. over 120 there is an improvement in both questions of the same margin. To be statistically significant at the five percent level the improvement would have to be thirteen percent and both questions have an improvement of twelve percent. This must be significant at better than the ten percent significant level.

The effect of a large number of unnecessary words in a chemistry multiple choice question could be to impede the most able candidates.

(iv) The presence of negatives

In the tests these were questions 21 and 22. The removal of the negative "not" in question 21 gave an improvement for all groupings which was statistically significant at the one percent level for the overall grouping and the social class 1 - 2 grouping and was statistically significant at the five percent level for the V.R.Q. over 120 grouping. The removal of the negative "incorrect" in question 22 did not have the same effect. In fact there is a statistically significant improvement in the opposite direction at the one percent level for the overall grouping and at the five percent level for the higher social class and V.R.Q. groupings. A consideration of the number of candidates choosing each response is interesting.

Table 4.8

No. of candidates / Response	Total Sample		Social Class 3	
	Simp.	Ori.	Simp.	Ori.
A *	401	476	110	144
B	85	140	37	54
C	107	124	43	37
D	261	122	85	39
No.in sample	876	876	279	280

Response D in the simplified version seems to be a bigger distracter than response D in the original. In the original version the response starts "it can form ... " and in the simplified version the response starts "it only forms ...". Candidates with whom this word does not register are choosing wrongly, or it is possible that the position of the only is important and if the response had been altered to "it forms ionic compounds only" a different result would

have been achieved. Whatever the explanation the presence of that little word "only" has a marked effect.

As well as the presence of a negative influencing performance in chemistry multiple choice questions, the presence of words of qualification e.g. "only" also influences performance.

(v) The influence of an ambiguity

Question 23 in the original version appeared in the 1975 'O' grade chemistry paper prepared by S.C.E.E.B. Response B is possibly ambiguous. "The copper and sulphur have combined to form a compound". The indefinite article "a" as in "a compound" can mean at least one or one only. Response B in the simplified version removes the ambiguity. The simplification gives an improvement in performance, which is statistically significant at the one percent level for the overall grouping and social class 1 - 2 grouping and is statistically significant at the five percent level for social class 3 grouping, V.R.Q. 106 - 119 grouping and V.R.Q. over 120 grouping. A consideration of the number of candidates choosing each response would seem to verify the possible ambiguity in response B which is a much poorer distracter in the simplified version.

Table 4.9

No. of candidates / Response	Total Sample		Social Class 1-2	
	Simp.	Ori.	Simp.	Ori.
A	155	120	39	29
B	138	252	53	108
C	86	104	37	47
D *	482	381	242	169
No.in sample	876	876	375	361

Any formulation of words which is open to more than one interpretation would seem to influence performance in multiple choice chemistry questions.

(vi) Influence of alternative sentence constructions

In the tests these were questions 24, 25, 26, 27 and 28. In question 26 the simplified version had three sentences (in the stem) reduced to one. There was a statistically significant difference at the one percent level for the overall grouping and for social class

1 - 2 grouping but in the opposite direction i.e. the original form was easier. The omission of information, the names Tritium and Helium, from the simplified version probably made this version more abstract and consequently more difficult. In question 25 the simplified version had two sentences in the stem reduced to one and there was a statistically significant difference at the five percent level for the overall grouping and for social class 1 - 2. In question 27 there was a similar reduction in the number of sentences but there the statistically significant difference at the five percent level for the unclassified social class grouping and social class 3 grouping was in the opposite direction. Similar alterations in question 24 brought about no significant change.

If the number of simple sentences can be reduced without removing any of the information, the question may become more straightforward. The complex relationship between language sentence structure and presentation of information is illustrated in these questions. There is little doubt from the results of these questions that in the way in which the clauses or sentences are put together in multiple choice chemistry questions influences the performance. What is difficult to do at the moment is to predict the effect of altering sentence construction.

4. Overall Scores Graph

Graph 4.12, the histogram showing the distribution of marks for both the original language and simplified language tests for the overall samples, would seem to indicate that in the simplified language test fewer people have lower marks and more people have higher marks. An indication of language influencing performance.

V. Conclusions

From the original hypothesis this exercise would seem to indicate

(i) that non-technical words cause pupil difficulties and that certain pupils, particularly those from a lower social class or with a low V.R.Q. have great difficulties with words.

(ii) that pupils' chemistry performance in multiple choice chemistry questions depends on V.R.Q. a measure of language development and social class a factor which influences language development.

(iii) that words in key positions in simple multiple choice chemistry questions influence performance.

(iv) that in more complex multiple choice chemistry questions words in key positions can influence performance.

(v) that the effect of a large number of unnecessary words in a chemistry multiple choice question could be to impede the most able candidates.

(vi) that the presence of negatives and words of qualification e.g. only, in chemistry multiple choice questions influences performance.

(vii) that an expression which is ambiguous influences performance in chemistry multiple choice questions.

(viii) that the way in which clauses or sentences are put together in multiple choice questions influences performance.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The initial concern which was felt about the influence of language on chemistry performance would seem to have been justified. The major exercises would seem to indicate that: non technical words cause pupil difficulties and that certain pupils particularly those from a lower social class or with a low V.R.Q. have great difficulty with words: pupils' chemistry performance in multiple choice chemistry questions depends on V.R.Q., a measure of language development and social class a factor which influences language development: and in multiple choice chemistry questions words in key positions, large numbers of unnecessary words, the presence of negative expressions or expressions of qualification e.g. only, ambiguous expressions, or the way in which clauses or sentences are put together, these language factors all influence performance. (To take the exercise a stage further and to be able to predict the effect of various sentence construction on performance would be useful in designing multiple choice chemistry questions). It is probable that this influence of language is not restricted to multiple choice questions. O'Donnel (63) showed that the more linguistically complex a question was, the number of candidates who tackled it got smaller. In the 1976 High grade chemistry paper set by the S.C.E.E.B. an essay question mentioned the "anomalous behaviour of water" and for a candidate who does not know the meaning of the word anomalous the question was virtually impossible.

The influence of language goes beyond the examination situation, to the teaching and learning situation - the teacher's words, the text book, the pupil's ability to communicate. Perhaps the objectives from material (58) recommended for teachers in training are worth trying to achieve. These objectives are the realization of the ease with which teachers can unwittingly use language unfamiliar to their pupils and so hinder communication, and a critical attitude of teachers towards their own use of language in lessons. To achieve this more structure is required in our presentation of language. Even in matters of vocabulary it would be useful to know: what specialist language do pupils need at each stage; what pseudo specialist language is being used without being explicitly presented to the pupil: what words can pupils cope with and how does one develop this

basic vocabulary. Language is more complex than vocabulary but this would be a start which would improve the examination and teaching situation.

The influence of language is not restricted to chemistry. Most secondary school subjects have their specialist and pseudo-specialist language. As was stated in the introduction this exercise only scratches the surface of enormous problems which go far beyond the examination situation and affect all teachers - whatever the subject they teach at whatever level.

The quote from the Bullock report (20) makes an admirable starting point:

> "We must convince the teacher of history or of science for example that he has to understand the process by which his pupils take possession of the historical or scientific information that is offered them; and that such an understanding involves his paying particular attention to the part language plays in learning."

APPENDIX A

A WORD TEST

NAME.....

DATE OF BIRTH..... AGE ON 18/2/74.....

SCHOOL.....

Try to explain the meaning of each word underlined in these sentences.

(1) Opposite each write the CORRESPONDING piece of information.

(2) What changes would be OBSERVED?

(3) A PUNGENT smelling gas was given off.

(4) The EFFICIENCY of soap is reduced.

(5) There was no APPRECIABLE difference.

(6) Explain why the above PRECAUTIONS should be taken..

(7) How does the COMPOSITION of the gas mixture differ?

(8) DEVISE an experiment.

(9) The atmosphere is known to be composed of APPROXIMATELY equal proportions of oxygen and argon.

(10) Which type of bonding PREDOMINATES?

(11) Explain how you might DISTINGUISH between the two.

(12) Use the graph to JUSTIFY the answer.

(13) There is an ABUNDANT supply.

(14) The equation represents the CONVERSION of sulphur dioxide to sulphur trioxide.

(15) What PRODUCTS would you expect?

APPENDIX B

A WORD LIST

PUNGENT	EFFICIENT	CORRESPONDING	CONSTITUENT
JUSTIFY	RESIDUE	CONVERSE	COMPONENTS
ATTRIBUTED	ABUNDANT	SPONTANEOUS	DEVISED
DENSE	PRECAUTIONS	PRODUCT	CONFIGURATION
CONCEPT	DISTINGUISH	ACCUMULATING	CULMINATING

APPENDIX C

A GAP TEST

Put one word in each of the gaps which you think helps the passage to make sense.

Example. British Leyland yesterday announced new price_____ for their cars, the second rise _____three months. Cars, lorries and buses_____cost an average 7½% more from to-morrow.

G.H. page 1.14/12/74

1. In case you should mistrust the _____theory, let us remind ourselves of_____a chemical theory comes to be _____. A number of experiments are done_____ observations are made. A theory is_____forward to explain these observations. The _____is then tested by using it to predict results.

G.T.S.Book 3. Page 1

2. Matter is made up of tiny_____. As your knowledge and experience of _____ increases, the weight of evidence in _____ of the particulate theory of matter _____ grow, and you will accept the _____as a practical concept and use _____as a good working hypothesis.

I.C. Page 2

3. Facts from a whole series of _____in a given field can be _____together as a generalisation and then_____ as a Law. An explanation can_____be suggested for all these co-ordinated _____ and this could then be called _____theory.

A.M.A.T.C. Page 1

4. Dalton imagined that atoms were the _____particles into which matter could be _____down and that particles smaller than _____atom did not exist. He also _____ the atoms of each element to_____ exactly alike and to differ from _____of all other elements.

N.C.B.B. I.T.A. Page 1

5. A concentrated solution of potassium chloride_____ water is electrolysed using carbon electrodes.

(i) _____is the pH of the original_____?

(ii) Which element is liberated at the _____electrode?

(iii) Why does the pH at_____negative electrode become greater during the _____?

'O' grade chemistry '74 question 1

APPENDIX D

YELLOW AND PINK TESTS

YELLOW O TEST

(1) In which one of the following compounds does covalency predominate?

A. Calcium fluoride.
B. Sulphur chloride.
C. Sodium bromide.
D. Potassium iodide.

(2) Three atoms have these respective nuclear compositions:-

X 8 protons and 9 neutrons.
Y 9 protons and 8 neutrons.
Z 8 protons and 8 neutrons.

Which of the following are isotopes?

A. X and Y.
B. Y and Z.
C. Z and X
D. All three.

(3) A sample of element X contains the following types of atom:-

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is:-

A. 2, 4.
B. 2, 5.
C. 2, 6.
D. 2, 7.

(4) The atom $^{27}_{13}Al$ has:

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

PINK E TEST

(1) Which one of the following compounds is covalent?

A. Calcium fluoride.
B. Sulphur chloride.
C. Sodium bromide.
D. Potassium iodide.

(2) Three atoms have these respective nuclear compositions:-

X 8 protons and 9 neutrons.
Y 9 protons and 8 neutrons.
Z 8 protons and 8 neutrons.

Which of the following are isotopes?

A. X and Y.
B. Y and Z.
C. Z and X.
D. All three.

(3) A sample of element X contains the following types of atom:-

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is:-

A. 2, 4.
B. 2, 5.
C. 2, 6.
D. 2, 7.

(4) An isotope of aluminium has an atomic number of 13 and a mass number of 27.

$^{27}_{13}Al$ an atom of this isotope will contain:-

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

(5) Which statement is true about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$?

A. They contain the same number of neutrons.
B. Their nuclei contain the same number of protons.
C. Their ions carry the same number of positive charges.
D. They contain the same number of electrons.

(6) How many bonds would an atom of $^{16}_{8}X$ form?

A. 0.
B. 2.
C. 6.
D. 8.

(7) When atoms react with each other, which particles are most likely to be involved?

A. protons.
B. neutrons.
C. nuclei
D. electrons.

(8) X and Y are elements. The melted chloride of X conducts electricity. The chloride of Y is a liquid that does not conduct. The atomic numbers of the two elements would be:-

A. 11 for X and 6 for Y.
B. 6 for X and 19 for Y.
C. 10 for X and 6 for Y.
D. 15 for X and 11 for Y.

(9) If 56g of iron displace 216g of silver from an aqueous solution of silver nitrate, how many moles of iron will displace one mole of silver? (Atomic Weight Fe 56, Ag 108)

A. 0.5.
B. 1.0.
C. 1.5.
D. 2.0.

(5) $^{8}_{3}Li$ and $^{8}_{4}Be^{2+}$ have the same number of -

A. neutrons.
B. protons.
C. charges.
D. electrons.

(6) An atom of element X can be represented as $^{16}_{8}X$. What is the valency number of element X?

A. 0.
B. 2.
C. 6.
D. 8.

(7) Which of the following take part in bonding?

A. protons.
B. neutrons.
C. nuclei.
D. electrons.

(8) Two elements X and Y each form a compound with chlorine. The chloride of X is a solid which when molten has an appreciable conductivity. The atomic numbers of the two elements could be:-

A. 11 for X and 6 for Y.
B. 6 for X and 19 for Y.
C. 10 for X and 6 for Y.
D. 15 for X and 11 for Y.

(9) If 56g of iron displace 216g of silver from a silver compound, how many moles of iron will displace one mole of silver? (Atomic Weight Fe 56, Ag 108)

A. 0.5.
B. 1.0.
C. 1.5.
D. 2.0.

(10) Melted nickel chloride conducts electricity. This suggests the bonding in nickel iodide is:-

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

(11) Which of the following compounds would readily conduct an electric current in the liquid state?

A. Lithium chloride.
B. Sulphur dichloride.
C. Phosphorus trichloride.
D. Carbon tetrachloride.

(12) Sodium chloride solution conducts electricity because it contains:-

A. charged molecules.
B. mobile electrons.
C. mobile ions.
D. ionic lattices.

(13) When concentrated aqueous solution of potassium iodide is electrolysed the product at the anode is:-

A. iodine.
B. hydrogen.
C. oxygen.
D. potassium.

(14) When electricity is passed through a solution of magnesium sulphate, what happens?

A. Magnesium is formed at the cathode.
B. Oxidation takes place at the anode.
C. Sulphate ion is released at the anode.
D. Electrons flow through the solution.

(10) Fused nickel iodide conducts electricity. This suggests the bonding in nickel iodide is:-

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

(11) Which of these would conduct when melted?

A. Lithium chloride.
B. Sulphur dichloride.
C. Phosphorus trichloride.
D. Carbon tetrachloride.

(12) Sodium chloride solution conducts electricity because it contains:-

A. charged molecules.
B. mobile electrons.
C. mobile ions.
D. ionic lattices.

(13) When concentrated aqueous solution of potassium iodide is electrolysed the product at the positive electrode is:-

A. iodine.
B. hydrogen.
C. oxygen.
D. potassium.

(14) When aqueous magnesium sulphate solution is electrolysed using carbon electrodes, which of the following occurs?

A. Magnesium is deposited on the cathode.
B. Oxidation takes place at the anode.
C. Sulphate ion is discharged at the anode.
D. Electrons flow through the solution.

(15) In the electrolysis of a concentrated copper (II) chloride solution using platinum electrodes, what would be the products formed at the electrodes?

	Anode	Cathode
A.	oxygen.	hydrogen.
B.	oxygen.	copper.
C.	chlorine.	hydrogen.
D.	chlorine.	copper.

(16) When electricity is passed through a solution of sodium bromide, what is given off at the negative electrode?

A. bromine.
B. hydrogen.
C. oxygen.
D. sodium.

(17) A saturated solution of sodium chloride in water is electrolysed using platinum electrodes. The temperature is assumed to remain constant. Which one of the following statements is false?

A. Chloride ions are oxidised.
B. Hydrogen gas is produced.
C. The pH of the solution becomes greater than 7.
D. The solution remains saturated with sodium chloride.

(18) Which one of the following is <u>not</u> a choking gas?

A. Sulphur dioxide.
B. Hydrogen chloride.
C. Chlorine.
D. Oxygen.

(15) When concentrated copper (II)chloride is electrolysed using platinum electrodes, what is formed?

	Anode	Cathode
A.	oxygen.	hydrogen.
B.	oxygen.	copper.
C.	chlorine.	hydrogen.
D.	chlorine.	copper.

(16) When concentrated aqueous solution of sodium bromide is electrolysed the product at the negative electrode is:-

A. bromine.
B. hydrogen.
C. oxygen.
D. sodium.

(17) Electricity is passed through a saturated solution of sodium chloride. The temperature stays the same. Which one of the following does <u>not</u> happen?

A. Chloride ions are oxidised.
B. Hydrogen gas is produced.
C. The pH of the solution becomes greater than 7.
D. The solution remains saturated with sodium chloride.

(18) Which one of the following is <u>not</u> a pungent gas?

A. Sulphur dioxide.
B. Hydrogen chloride.
C. Chlorine.
D. Oxygen.

The remaining questions were common to both Tests.

In the following please indicate which answer refers to the word underlined.

(19) "If it is an acid, then it will turn litmus red." The <u>converse</u> of this statement is:-

A. If it is not an acid, then it will not turn litmus red.
B. If it is an alkali, then it will turn litmus blue.
C. If it turns litmus red, then it is an acid.
D. It will only turn litmus red if it dissolves in water.

(20) When freshly cut grass is put in a pile, there can be spontaneous burning.

A. Burning will be very slow because the grass is green.
B. The sun can heat up the grass so much that it burns.
C. Burning can only take place when the grass has dried out.
D. A fire can start without someone setting the grass alight.

(21) Which sentence uses the word correspond correctly?

A. The fingers on the hand correspond to the toes on the feet.
B. The head corresponds to the neck.
C. The stomach corresponds to the mouth and intestines.
D. The feet correspond to the head.

(22) A man devising an experiment is:-

A. Writing about the results of the experiment.
B. Taking pictures with a camera.
C. Thinking about how he will do the experiment.
D. Making measurements during the experiment.

(23) A constituent of a cake is:-

A. A piece cut out of the cake.
B. One of the things from which it was made.
C. The oven in which the cake was cooked.
D. The person who eats it.

(24) Which sentence uses the word efficient correctly?

A. Children need to eat efficient food to grow strong and healthy.
B. Large brooms are more efficient than small brushes for sweeping the school yard.
C. The sick boy did not eat enough green vegetables and was efficient in vitamins as a result.
D. The girl did not stay at the school for an efficient time to learn English properly.

(25) Jack took some salt water. He boiled it in a jar and steam came off. The steam cooled and changed into pure water. In the jar, there was some salt. The residue here was:-

A. The salt water that he used.
B. The steam that came off.
C. The pure water made from the steam.
D. The salt left at the end.

(26) The children talked about the composition of the brick.

A. Its length, width and height.
B. Its shape.
C. What it was made of.
D. What it could be used for.

(27) There was an abundant supply of pears last year.

A. There were more than enough pears.
B. There were just enough pears.
C. The pears were not very good.
D. There were very few pears.

(28) Before starting the experiment, the children were given a list of precautions by the teacher.

A. Chemicals they would need.
B. Equipment they would need.
C. Things they would have to be very careful about.
D. Results that the teacher expected them to get.

APPENDIX E.

SOCIAL CLASS

As an aid to certain kinds of statistical analysis the General Register Office (86) arranges large numbers of unit groups of the Occupational Classification into a small number of broad categories called Social Classes, as follows:-

I. Professional occupations
II. Intermediate occupations
III. Skilled occupations
IV. Partly skilled occupations
V. Unskilled occupations.

> "The unit groups included in each of these categories have been selected so as to secure that, so far as is possible, each category is homogeneous in relation to the basic criterion of the general standing within the community of the occupations concerned. This criterion is naturally correlated with (and the application of the criterion conditioned by) other factors such as education and economic environment, but it has no direct relationship to the average level of remuneration of particular occupations."

The following are examples of occupations in each Social Class.

I	II	III
University Teacher	Teacher	Typist
Doctor	Nurse	Policeman
Surveyor	Radiographer	Draughtsman
Architect	Journalist	Electrician
Judge	Insurance Broker	Plumber
Solicitor	Personnel Manager	Bus Driver

IV	V
Postman	Railway Porter
Gardener	Labourer
Storeman	Kitchen hand
Waiter	Window cleaner
Paint sprayer	Stevedore
Bus conductor	Lorry driver's mate

For the purpose of this investigation the candidates, who had given sufficient information, were placed in one of three groupings based on the occupation of the parent: namely Social class I and II, or Social Class III or Social Class IV and V. This gave larger sample sizes than a five fold division would have allowed and was easier to do than a five fold division because the need to distinguish between I and II or IV and V had been removed.

APPENDIX F.

TEACHER INFORMATION

These two tests have two parts; a chemistry part and a vocabulary part. In the chemistry part, the chemical content is the same but, with the exception of 3 control questions, the questions have been written in two forms to see how this affects performance.

It is important to try to get the groups sitting the test as similar as possible. Do not give all one section one test and all another section the other test. The easiest way to get two similar groups is to give alternate pupils in each section a different test.

1. Pupils should be given:-
   - (i) The school number which is _____
   - (ii) The section number. If the sections are streamed, give the first section the number 1, the second section 2, and so on. If they are not streamed, give all sections the number 0.
   - (iii) Their own number. By prior arrangement with other sections, one section could take pupil numbers from 001 to 030, the next section could take pupil numbers from 031 to 060 and so on, avoiding overlap. By then going round the pupils in a section giving numbers, e.g. 031, 032, 033, alternative pupils will all have an odd number. Keep a note of the number given to each pupil - important for VRQ's.
2. If pupil gets an odd number, he/she should get a yellow answer card and the yellow O test.

   If pupil gets an even number, he/she should get a pink answer card and the pink E test.
3. Check that pupils have understood how to fill in answer card.

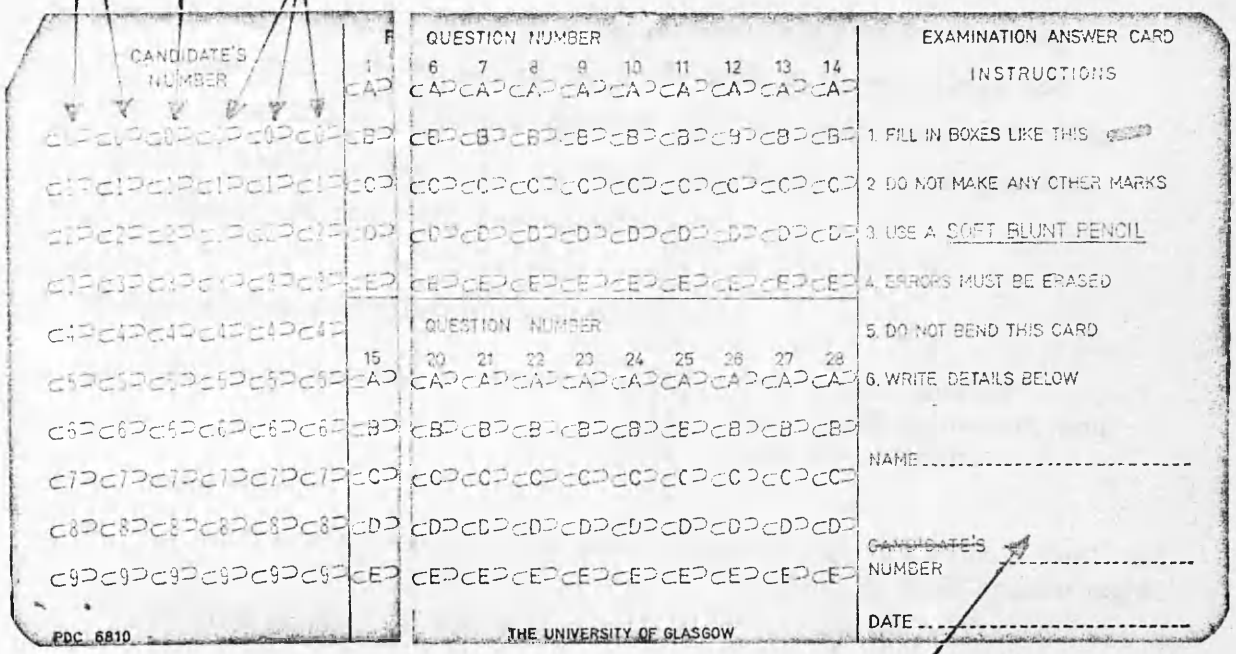
   Emphasize -
   - (i) To be done in soft pencil (preferable 2B).
   - (ii) All the area is shaded in, in heavy black - the heavier the better.
   - (iii) That Father or Guardian's occupation should be as precise as space permits.

Column for school number

Section Number

Pupil's Number

Instructions



Space for pupil's Father or Guardian's occupation

4. Thirty minutes should be ample time for the test.

Thank you for your co-operation

All comments would be welcomed

J.R.T. Cassels

APPENDIX G

PUPIL INFORMATION

The following test is one of several to try to find out how the language used in Chemistry may affect pupil understanding. Your name will not be needed and your mark will certainly not affect your future although answers from you and pupils in other parts of Scotland may help to shine some light on this problem.

Thank you for your co-operation.

Please follow instructions carefully:-

1. Your teacher will give you - (i) your school number
   (ii) your section number, and
   (iii) your own number.

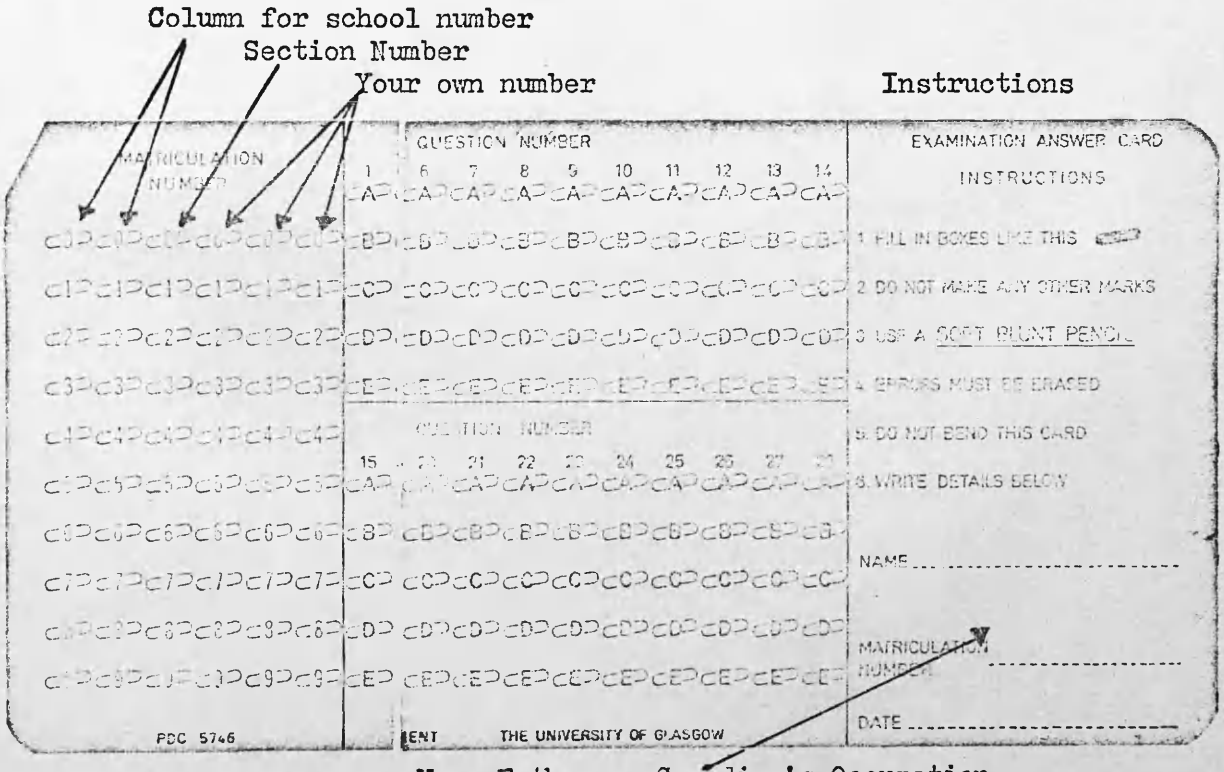
   Note them.

2. If your number is even you should have - (i) the Pink E Test and
   (ii) a pink answer card.

   If your number is odd you should have - (i) the Yellow O Test and
   (ii) a yellow answer card.

   Check this.

3. Fill in the answer card in pencil as instructed.



4. Only one oval should be shaded in any one column. If you want to change your answer rub out the shading with an ordinary rubber and shade another oval instead.

5. Tackle all the questions in the test and mark your answers with heavy shading on the answer card.

APPENDIX H

YELLOW AND PINK TESTS - 2nd VERSION

YELLOW O TEST

PINK E TEST

The first five questions were common to both Tests.

(1) The temperature of the acid was 0°C. The temperature of the powder was 25°C. The metal had a negative temperature.

A. The temperature of the metal was between the acid and the powder.
B. The metal was colder than 0°C.
C. The metal was warmer than the acid and the powder.
D. The temperature of the metal had not been measured.

(2) Which sentence uses the word correspond correctly?

A. The fingers on the hand correspond to the toes on the feet.
B. The head corresponds to the neck.
C. The stomach corresponds to the mouth and intestines.
D. The feet correspond to the head.

(3) Which sentence uses the word efficient correctly?

A. Children need to eat efficient food to grow strong and healthy.
B. Large brooms are more efficient than small brushes for sweeping the school yard.
C. The sick boy did not eat enough green vegetables and was efficient in vitamins as a result.
D. The girl did not stay at the school for an efficient time to learn English properly.

(4) "If it is an acid, then it will turn litmus red."
The converse of this statement is:-

A. If it is not an acid, then it will not turn litmus red.
B. If it is an alkali, then it will turn litmus blue.
C. If it turns litmus red, then it is an acid.
D. It will only turn litmus red if it dissolves in water.

(5) Jim said something which was valid. He was

A. correct.
B. funny.
C. hard to understand.
D. telling a lie.
E. saying something new.

YELLOW O TEST

(6) Which one of the following is <u>not</u> a choking gas?

A. Sulphur dioxide.
B. Hydrogen chloride.
C. Chlorine.
D. Oxygen.

(7) Which element is in column one of the Periodic Table?

A. Helium.
B. Beryllium.
C. Chlorine.
D. Rubidium.

(8) Which gas has two atoms in every molecule?

A. Carbon dioxide.
B. Oxygen.
C. Argon.
D. Hydrogen sulphide.

(9) A chemical reaction could be $P + Q \xrightarrow[\text{catalyst}]{\text{heat}} R + S$.
What is formed in this reaction?

A. Heat.
B. P and R.
C. Q and P.
D. R and S.

(10)

Elements in Earth's <u>Crust</u>.	Percentage by weight <u>approximately</u>.
Hydrogen	1
Magnesium	2
Potassium	3
Sodium	3
Calcium	4
Iron	5
Aluminium	8
Silicon	27
Oxygen	46

From this table which metal is there most of in the Earth's Crust?

A. Magnesium.
B. Aluminium.
C. Hydrogen.
D. Oxygen.

PINK E TEST

(6) Which one of the following is <u>not</u> a pungent gas?

A. Sulphur dioxide.
B. Hydrogen chloride.
C. Chlorine.
D. Oxygen.

(7) Which element is in group one of the Periodic Table?

A. Helium.
B. Beryllium.
C. Chlorine.
D. Rubidium.

(8) Which gas has diatomic molecules?

A. Carbon dioxide.
B. Oxygen.
C. Argon.
D. Hydrogen sulphide.

(9) A chemical reaction could be $P + Q \xrightarrow[\text{catalyst}]{\text{heat}} R + S$.
What are the products of this reaction?

A. Heat.
B. P and R.
C. Q and P.
D. R and S.

(10)

Elements in Earth's <u>Crust</u>.	Percentage by weight <u>approximately</u>.
Hydrogen	1
Magnesium	2
Potassium	3
Sodium	3
Calcium	4
Iron	5
Aluminium	8
Silicon	27
Oxygen	46

From this table what is the most abundant metal in the Earth's Crust?

A. Magnesium.
B. Aluminium.
C. Hydrogen.
D. Oxygen.

(11) A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A. 2,4.
B. 2,5.
C. 2,6.
D. 2,7.

(12) An isotope of aluminium has an atomic number of 13 and a mass number of 27.
An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

(13) Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

(14) An atom of element Y can be represented as $^{16}_{8}Y$.

How many bonds would element Y form?

A. 0.
B. 2.
C. 6.
D. 8.

(11) A sample of element X contains the following types of atom:

$^{13}_{7}X$ $^{15}_{7}X$ $^{16}_{7}X$

The electronic configuration of the element is

A. 2,4.
B. 2,5.
C. 2,6.
D. 2,7.

(12) An isotope of aluminium has an atomic number of 13 and a mass number of 27.
An atom of this isotope will contain

A. 14 protons and 13 neutrons.
B. 13 protons and 14 neutrons.
C. 14 protons and 13 electrons.
D. 13 protons and 14 electrons.

(13) Some atoms of an element are heavier than other atoms of the same element. This is because they have different numbers of

A. neutrons.
B. nuclei.
C. protons.
D. electrons.

(14) An atom of element Y can be represented as $^{16}_{8}Y$.

What is the valency number of element Y?

A. 0.
B. 2.
C. 6.
D. 8.

(15) In the compound A_2B_3,

B forms 2 bonds.
A always forms the same number of bonds.
What is the formula for a compound between A and C, if C can form 1 bond?

A. AC.

B. AC_3.

C. AC_2.

D. A_3C.

(16) A melted compound conducts electricity. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

(17) Solid potassium chloride does not conduct electricity because

A. its ions are not free to move.
B. it is a covalent compound.
C. it contains insufficient ions to carry the current.
D. it contains no electrons.

(18) Which compound conducts electricity when melted?

A. Carbon tetrachloride.
B. Sulphur dichloride.
C. Phosphorus trichloride.
D. Strontium chloride.

(15) In the compound A_2B_3,

B has valency number 2.
A always has the same valency number.
What is the formula for a compound A and C, if C has valency number 1?

A. AC.

B. AC_3.

C. AC_2.

D. A_3C.

(16) A fused compound conducts electricity. This suggests the bonding in the compound is

A. covalent.
B. polar covalent.
C. metallic.
D. ionic.

(17) Crystalline potassium chloride does not conduct electricity because

A. its ions are not free to move.
B. it is a covalent compound.
C. it contains insufficient ions to carry the current.
D. it contains no electrons.

(18) Which of the following compounds would readily conduct an electric current in the liquid state?

A. Carbon tetrachloride.
B. Sulphur dichloride.
C. Phosphorus trichloride.
D. Strontium chloride.

(19) $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$ have the same number of

A. neutrons.
B. protons.
C. charges.
D. electrons.

(19) Which statement is true about the ions $^{8}_{3}Li^{+}$ and $^{8}_{4}Be^{2+}$?

A. They contain the same number of neutrons.
B. Their atoms contain the same number of protons.
C. They will combine with the same number of F ions.
D. They contain the same number of electrons.

(20) The atomic weight of chlorine is 35.5. Why is it <u>not</u> a whole number?

Because

A. ions are present.
B. impurities are present.
C. unequal numbers of protons and neutrons are present.
D. isotopes are present.

(20) The atomic weight of chlorine is usually quoted as 35.5. It is not a whole number in spite of the fact that protons and neutrons have very closely integral atomic weights because

A. ions are present.
B. impurities are present.
C. unequal numbers of protons and neutrons are present.
D. isotopes are present.

(21) An element has only three isotopes of mass numbers 14, 16 and 17. Which one of the following could be the atomic weight of the element?

A. 13.9.
B. 11.7.
C. 17.2.
D. 15.1.

(21) An element has <u>only</u> three isotopes of mass numbers 14, 16 and 17. Which one of the following could <u>not</u> be the atomic weight of the element?

A. 14.2.
B. 15.4.
C. 16.3.
D. 17.1.

(22) Which of the following statements about element atomic number 17 is correct?

A. It is reactive.
B. It is a metal.
C. It is in group 2 of Periodic Table.
D. It only forms ionic compounds.

(22) Which of the following statements about element atomic number 17 is incorrect?

A. It is unreactive.
B. It is non-metal.
C. It is in group 7 of Periodic Table.
D. It can form covalent compounds.

(23) When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be correctly drawn from these observations alone?

A. The copper and sulphur have combined to form copper (II) sulphide.

B. The copper and sulphur have combined to form only one compound.

C. A mixture of copper and sulphur remains.

D. The copper has reacted with the sulphur.

(23) When powdered copper and sulphur are heated gently together, the mass glows red hot and the product is black. Which of the following conclusions can be correctly drawn from these observations alone?

A. The copper and sulphur have combined to form copper (II) sulphide.

B. The copper and sulphur have combined to form a compound.

C. A mixture of copper and sulphur remains.

D. The copper has reacted with the sulphur.

(24) Element X has an atomic number of 12.
Element Y has five electrons in the outer shell.
What would be the formula of a compound between X and Y?

A. XY.

B. X_2Y_5

C. X_3Y_2

D. X_2Y_3

(24) Element X has an atomic number of 12 while element Y has five electrons in the outer shell. What would be the formula of a compound between X and Y?

A. XY.

B. X_2Y_5

C. X_3Y_2

D. X_2Y_3

(25) Why are the atomic weights of naturally occurring elements not whole numbers?

A. The number of protons and neutrons in each element varies.

B. It is difficult to isolate the elements in the pure state.

C. Chemical methods of atomic weight determination are inaccurate.

D. Naturally occurring elements are mixtures of isotopes.

(25) The atomic weights of most of the naturally occurring elements are not whole numbers. Which of the following is the best explanation of this fact?

A. The number of protons and neutrons in each element varies.

B. It is difficult to isolate the elements in the pure state.

C. Chemical methods of atomic weight determination are inaccurate.

D. Naturally occurring elements are mixtures of isotopes.

(26) Why are atoms with the same mass number not necessarily atoms of the same element?

A. They could be isotopes.
B. They need to have the same number of neutrons.
C. The weight of electrons could be the same.
D. They could have different numbers of protons.

(26) Tritium has mass number 3. Helium can also have a mass number of 3. Why are these two not considered to be atoms of the same substance?

A. Because they are isotopes.
B. Because they have the same number of neutrons.
C. Because the weight of the electrons makes an appreciable difference here.
D. Because they have different numbers of protons.

(27) The melted chloride of element X conducts electricity. The chloride of element Y is a liquid that does not conduct. The atomic numbers of the two elements could be

A. 11 for X and 6 for Y.
B. 6 for X and 19 for Y.
C. 10 for X and 6 for Y.
D. 15 for X and 11 for Y.

(27) Two elements X and Y each form a compound with chlorine. The chloride of X is a solid whose solution in water has an appreciable electrical conductivity. The chloride of Y is a liquid with no appreciable conductivity. The atomic numbers of the two elements could be

A. 11 for X and 6 for Y.
B. 6 for X and 19 for Y.
C. 10 for X and 6 for Y.
D. 15 for X and 11 for Y.

(28) Element X has two electrons in the outer shell. Element Y has seven electrons in the outer shell. Which of the following statements about a compound of X and Y is true?

A. The formula is XY_2.
B. X^+ ions are present.
C. Y^{2-} ions are present.
D. The compound is covalent.

(28) Atoms of Element X, having two electrons in the outer shell come into contact with atoms of element Y with seven electrons in the outer shell. Which of the following statements is probably <u>not</u> true?

A. The compound formed has the formula X_2Y.
B. X^{2+} ions are formed.
C. Y^- ions are formed.
D. The compound formed is ionic.

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