New Proposal of Subgroup Classification in Long Form of the Periodic Table

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1 Abstract

In the paper "Confusion in the Periodic Table of the Elements" published in Journal of Chemical Education[1] in the U. S., the American Chemical Society (ACS) has asked for an alternative suggestion to the traditional designations to avoid the present confusion caused by the use of some designations of A and B Groups III−VIII in a manner opposite to each in the subgroups of long, or expanded form of the Periodic Table.

It is common knowledge that the same confusion prevails in Japan also. The author proposes to designate typical elements as Subgroup A, transition elements as Subghoup B and inner transition elements as Subgroup C. The private views that the elements Zn, Cd and Hg ought to be classified as the transition element and how to designate the inner transition element series will be stated hereafter.

2 Outline of the paper[1] published in U. S.

Since the paper has shown considerable interest in learning about the change of the periodic table which will also be very instructive for studying chemistry, the outline of the paper[1] will be described hereafter.

Although various types of the periodic table had been used, a plea for the adoption of the long form of the periodic table was made in a symposium on modernizing textbooks sponsored by the ACS Division of Chemical Education in 1939 and the following type (b) had been mainly used till 1970. In the long form of the periodic table of type (b), the typical elements are classified as A subgroups and the transition elements are classified as B subgroups.

(a)	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA	IB	IIB	IIIB	IVB	VB	VIB	VIIB	VIIIB(0)
(b)	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII(B)	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA(0)

In the latter half of 1970, however, it was recommended according to IUPAC Inorganic Nomenclature Rules to use the long form of the periodic table of type (a), in which the classification of A and B was arbitrary construed. As a result, the type (a) has been gradually used instead of the type (b) and the confusion has increasingly prevailed.

Various suggestions has been proposed to get rid of the confusion. For instance, one proposed was to use the letter M with the group number for the typical elements and to use the letter T with that for the transition elements, but to designate as M2 for the elements Zn, Cd and Hg belonging to Group IIB, because they are not so much transition and typical elements as the other type elements; or to give consecutive number to the head of the long form of the periodic table to avoid confusion, these were all rejected however due to the recommended A & B classification of the IUPAC Inorganic Nomenclature Rules in 1970.

The ACS Committee on Nomenclature has made efforts to the solution of the confused situation, since the choice between (a) and (b) is not imposed by rule and remains obscure. The Committee proposed at the meeting held in November, 1981, to investigate such an alternative to the classification of A and B subgroups as making the classification simple and clear, deciding whether or not the typical and transition elements must be classified by the designation and determining whether or not the conventional arbitrary designation of A and B is satisfactory. Comments and suggestions from groups and indivisuals, especially from those active in education, are earnestly solicited.

3 New proposal to improve the periodic table

(1) *Subgroup classification*

In Japan too the confusion prevailed due to the use of the classification of (a) and (b). The author was frequently asked which was correct[2]. The periodic table in all the textbooks of chemistry for the Japanese senior high schools was standardized to the type (a) in 1982. Since the practical confusion seems more or less to have raveled out, there is no scientific justification for the standardization to the type (a). Moreover considering the fact that ACS actually asked for an alternative proposal for a new classification because the choise between the types (a) and (b) was not imposed by rule and remains obscure, it is considered too early to standardize the classification in the textbooks for senior high schools to the type (a).

Since the periodic table is arranged according to the electron configuration, the element classification by s, p, d and f expressing electron configuration is considered most suitable. It is said this idea was rejected because of its non-correlation with classification by A and B. If they are classified according to the following table, this

Table-1 New Subgroup Classification

Group	Elements	Configuration of Electrons	Block
A	Typical	$ns^{1\sim2}np^{0\sim6}$	sp-block
B	Transition	$(n-1)d^{1\sim10}ns^2$	d-block
C	Inner Transition	$(n-2)f^{1\sim14}(n-1)s^2p^6ns^2$	f-block

classification follows the A−B system recommended by IUPAC, where the subgroups A and B represent the typical element [$ns^{1\sim2}np^{0\sim6}$] and the transition element [$(n-1)d^{1\sim10}ns^2$], respectively, the subgroup C represents the inner transition element [$(n-2)f^{1\sim14}(n-1)s^2p^6ns^2$] in addition. Table-2 shows the long form of the periodic table derived from the new proposal. Table-3 shows the configuration of electrons.

(2) *Classification of Zn, Cd and Hg*

According to IUPAC Inorganic Nomenclature Rules, Zn, Cd and Hg are not classified as transition elements because they have complete d shell of electrons. The reason is not very clear but probably the objection arises mainly from putting these into the same group with d^{10} electrons such as, $_{31}Ga$ or elements with larger atomic numbers which all do not belong to the transition group of elements. However, in the electron configuration $(n-1)d^{1\sim10}ns^2$ of Zn, Cd and Hg, the ns shell is filled up with electrons and the $(n-1)d$ shell is successively filled up, while in the electron configuration $(n-1)d^{10}ns^2np^{1\sim6}(n+1)s^{0\sim2}$ of the typical elements such as $_{31}Ga-_{38}Sr$, the $(n-1)d$ shell is first filled up with electrons and ns, np and $(n+1)s$ shells are successively filled up. The latter electron configuration is completely different from the former. Considering the electron configuration of Zn, Cd and Hg, it is clear that these elements are the transition elements belonging to the subgroup B.

(3) *Nomenclature of inner transition element series*

The electron configuration of inner transition element is expressed as $(n-2)f^{1\sim14}$

(a)	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA			IB	IIB	IIIB	IVB	VB	VIB	VIIB	VIIIB
(b)	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIA	0

A Typical (sp-block elements)
B Transition (d-block elements)
C Inner Transition (f-block elements)

1 H																	2 He
3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn		31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd		49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	58 * 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 ** 103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

* Cerium series	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
* * Thorium series	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Table-2 New Periodic Table

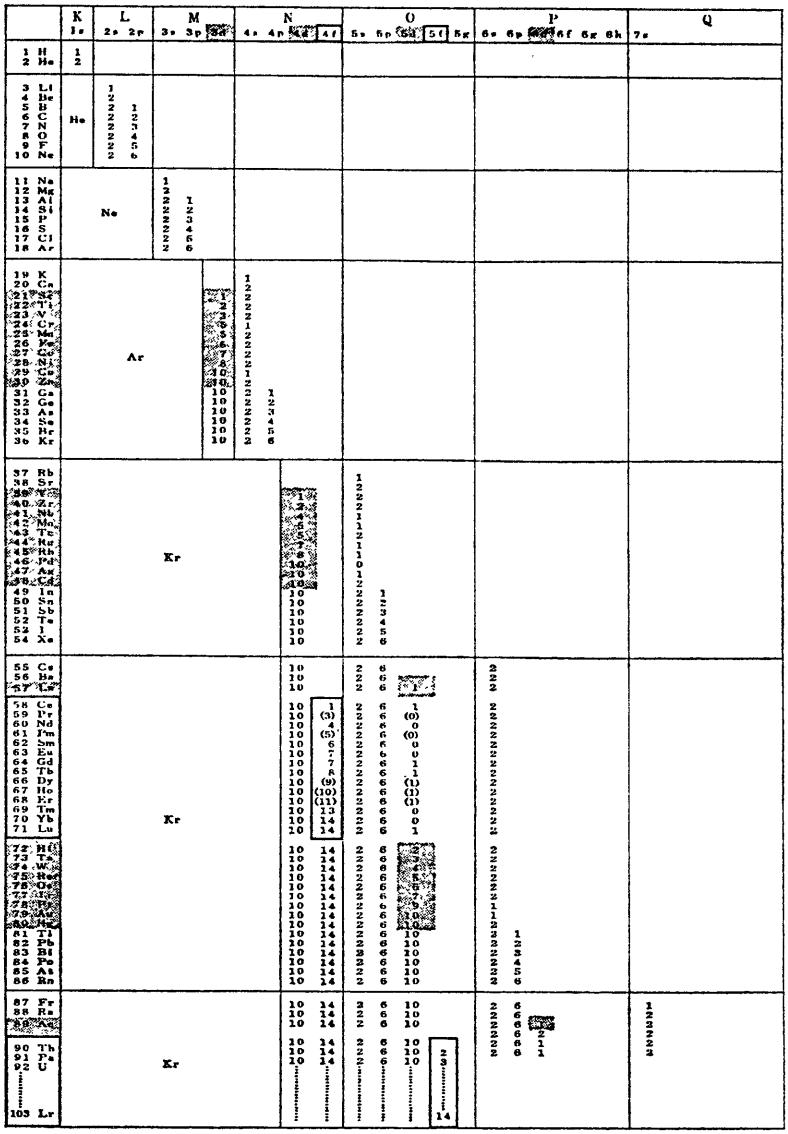

Table-3 Configuration of Electrons

$(n-1)s^2p^6ns^2$ which is characteristic of the electron in the f orbit. Since the f orbit is possible to be filled up with fourteen electrons, each inner transition element series ought to comprise fourteen elements, namely $_{58}Ce-_{71}Lu$ (14 elements) of the sixth period and $_{90}Th-_{103}Lr$ (14 elements) of the seventh period. However, judging from the electron configurations, $_{57}La$ in the sixth period and $_{89}Ac$ in the seventh period are clearly not inner transition elements, but transition elements. The inner transition element series, lanthanoid series and actinoid series are respectively named after La

and Ac which are not the inner transition elements. Since the head elements of the inner transition element series are Ce and Th, it is considered suitable to name them cerium series and thorium series respectively.

4 Conclusions

However the subgroup is classified, or however the inner transition elements are named, or whether Zn, Cd and Hg belong to the transition element or not, will not inconvenience the study of chemistry. However many people have doubts[2] about the rule recommended by IUPAC, by which Zn, Cd and Hg with d^{10} electrons do not belong to the transition element, while Cu, Ag and Au with the same d^{10} electrons belong to the transition element as the d shells of the ions of Cu, Ag, Cu are imperfectly filled up with electrons, and even the respective head elements of the fourth, fifth, sixth and seventh periods, La, Ac, Sc and Y, are classified as inner transition elements. Actually ACS is actively trying to get rid of the confusion caused by the subgroup classification recommended by IUPAC. Existence of confusion and errors in the foundamental system of chemistry will not allow chemistry to be understood properly.

However, widely it may be accepted, if a wrong interpretation is left as it is, how much confused chemical students become and how much interest they lose in chemistry, it is beyound conception.

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1) Fernelius, W. C., Powell, W. H., *J. Chem. Educ.* **59**, 504−508 (1982)

2) K. Hamada "Problems [I] and [II] in Textbook of Chemistry" published by Research Association of Textbook of Chemistry, Nagasaki, [I] : 1981 and [II] : 1983
This paper reports the problems on chemistry presented mainly by the teachers of senior high schools and of universities and the responding opinions from various group.