Available online at www.joac.info

ISSN: 2278-1862

Journal of Applicable Chemistry

2015, 4 (6): 1574-1578

(International Peer Reviewed Journal)

Chemical Education

Secondary Analogy Based Periodic Arrangement of the Elements

Narendra S. Bhandari

Department of Chemistry, Kumaun University, Soban Singh Jeena Campus, Almora-263601 Uttaranchal, **INDIA**

Email: bhandarins1959@gmail.com

Accepted on 12th October 2015

ABSTRACT

A restructuring of the extensively used planar-block periodic table by making separate use of group modifiers and group numbers is presented. The resulting new scheme is a collection of families of elements. Each family consists of elements with the same number of "valence electrons". This electronic structure of the elements connects them with secondary inter-group or intra-family analogy. This new arrangement, therefore, will give impetus to users of the table to develop periodic trends in properties of the elements in terms of the family and can be a valuable addition to periodic teaching. In addition to this, insertion of the f-series elements with their natural order of appearance as group-C makes the new scheme a compact periodic table of all the elements.

Keywords: Graduate Education, Inorganic Chemistry, Analogies, Inner Transition Elements, Main Group Elements, Periodic Table, Transition Elements.

INTRODUCTION

The extensively used planar-block periodic tables mainly provide a primary intra-group analogy. So this feature of the table has become a base of periodic teaching right from basic to advanced inorganic courses. In addition to the primary intra-group analogy there occurs, which however is becoming a form of lost knowledge [1], definite secondary inter-group analogy [2]. This inter-group resemblance was shown by Newland [3] Mendeleev [4], Bayley [5], Thomsen [6], and Bohr [7] in early classifications of the elements. W. B. Jensen has discussed these analogies in the step-pyramid periodic table [8]. A new layout of the periodic table is presented by M. Laing [9] to show the secondary inter-group analogy. The ways of displaying secondary analogy and related periodic systems have recently been discussed by Bent [10]. Here a scheme is attempted with separate use of group modifiers and group numbers along with extension of the group concept to the f-series elements so that one can get some useful information, secondary inter-group analogy in particular, from a glance at the periodic table.

Format

The table is divided horizontally into periods. The first period is occupied by only two elements, hydrogen and helium. Each of the next two periods contains 8 elements, arranged in a single row, across the table. The 4th and 5th periods, containing 18 elements each, are arranged in the form of two rows across the table. Following these are two periods, the 6th and 7th, consisting of 32 elements each, arranged in three rows. All the periods, except the first one, start with s-elements and end with p-elements.

In the present scheme, the old concept of groups A and B is extended to the inner transition elements with the group modifier C [11], making them a part of the systematic periodic classification. A different use, i.e. not with group numbers, of the A-B-C group modifiers is made in the periodic table as two vertical columns to distinguish elements having different "valence electron" configurations in a given family (Table-1). There are in all 8 families of elements arranged in vertical columns according to the total number of "valence electron(s)" that a family has. These are numbered as group numbers I, II, III … VII, VIII and indicate the number of "valence electrons" 1, 2, 3…7, 8 respectively of the families. To identify a related group of elements in a given family, group modifiers A-B-C are inserted as columns one before family-I and another between family-II and family-III. The reason for the use of two separate columns of group modifiers can be seen from the corresponding values of A, B and C given with the periodic table. These columns separate the periodic table into two distinct blocks. The first block comprises families I and II with elements having one and two electrons respectively in their outermost *n*s (*n* = period number) orbital. The remaining families from III to VIII make the main block of the table. Each of these families consists of p, d and f elements with the "valence electron" configurations ns^2 p^{1-6}, ns^2 $(n-1)d^{1-8}$and $ns^2(n-2)f^{1-12}$ respectively. The intra-family relationship ends at family VIII due to the absence of main-group analogues in the latercolumns. So the elements of the later columns are treated as members of family VIII as their group position. This family has been called a transition family [6].

Table 1: Periodic chart exposing secondary inter- group relationships.

Group Modifier **Family**

Period		I	II		III	IV	V	VI	VII							
1	*A*	$_{1}$H								$_{2}$He						
2	*A*	$_{3}$Li	$_{4}$Be	*A*	$_{5}$B	$_{6}$C	$_{7}$N	$_{8}$O	$_{9}$F	$_{10}$Ne						
3	*A*	$_{11}$Na	$_{12}$Mg	*A*	$_{13}$Al	$_{14}$Si	$_{15}$P	$_{16}$S	$_{17}$Cl	$_{18}$Ar						
4	*A*	$_{19}$K	$_{20}$Ca	*B*	$_{21}$Sc	$_{22}$Ti	$_{23}$V	$_{24}$Cr	$_{25}$Mn	$_{26}$Fe	$_{27}$Co	$_{28}$Ni				
	B	$_{29}$Cu	$_{30}$Zn	*A*	$_{31}$Ga	$_{32}$Ge	$_{33}$As	$_{34}$Se	$_{35}$Br	$_{36}$Kr						
5	*A*	$_{37}$Rb	$_{38}$Sr	*B*	$_{39}$Y	$_{40}$Zr	$_{41}$Nb	$_{42}$Mo	$_{43}$Tc	$_{44}$Ru	$_{45}$Rh	$_{46}$Pd				
	B	$_{47}$Ag	$_{48}$Cd	*A*	$_{49}$In	$_{50}$Sn	$_{51}$Sb	$_{52}$Te	$_{53}$I	$_{54}$Xe						
6	*A*	$_{55}$Cs	$_{56}$Ba	*C*	$_{57}$La	$_{58}$Ce	$_{59}$Pr	$_{60}$Nd	$_{61}$Pm	$_{62}$Sm	$_{63}$Eu	$_{64}$Gd	$_{65}$Tb	$_{66}$Dy	$_{67}$Ho	$_{68}$Er
	C	$_{69}$Tm	$_{70}$Yb	*B*	$_{71}$Lu	$_{72}$Hf	$_{73}$Ta	$_{74}$W	$_{75}$Re	$_{76}$Os	$_{77}$Ir	$_{78}$Pt				
	B	$_{79}$Au	$_{80}$Hg	*A*	$_{81}$Tl	$_{82}$Pb	$_{83}$Bi	$_{84}$Po	$_{85}$At	$_{86}$Rn						
7	*A*	$_{87}$Fr	$_{88}$Ra	*C*	$_{89}$Ac	$_{90}$Th	$_{91}$Pa	$_{92}$U	$_{93}$Np	$_{94}$Pu	$_{95}$Am	$_{96}$Cm	$_{97}$Bk	$_{98}$Cf	$_{99}$Es	$_{100}$Fm
	C	$_{101}$Md	$_{102}$No	*B*	$_{103}$Lr	$_{104}$Rf	$_{105}$Db	$_{106}$Sg	$_{107}$Bh	$_{108}$Hs	$_{109}$Mt	$_{110}$Ds				
	B	111	112	*A*	113	114	115	116	117	118						

Features

The family concept of the table is self-evident so far as the secondary inter group or intra family relationship of elements is concerned. The presence of Cu, Ag and Au in Family I show that these elements exhibit similarities with alkali metals. That Zn, Cd and Hg are not transition elements is conspicuous from their family kinship with alkaline-earth metals. Similarly, one can expect some (very weak!) resemblance in the properties of Tm and Md with the alkali metals and (stronger), those of Yb and No with the alkaline-earth metals. For example No (II) in solution behaves like Ba (II); crystalline compounds of Yb(II) are usually isostructural with their Sr(II) and Ba(II) analogs;YbI_2 form 6-coordinated layers like CaI_2 .Like the alkaline earth metals, Yb dissolves in NH_3 to give an intensely blue solution.

There are strong intra family resemblances that exist from the boron to the helium families. Given here are some common examples. The family-III comprises of IIIA, IIIB, and IIIC elements (B to Lr). All the elements have three valence electrons, so +3 oxidation states is the prominent feature of this family. Each of the elements forms aquated ions,$[M(H_2O)_6]^{3+}$, except lawrencium. They hydrolyze in water and solution becomes acidic. Hydrolysis increases with the decrease in the ionic radii of metal ions.

$$[M\,(H_2O)_6]^{3+} + H_2O = [M(OH)\,(H_2O)_5]^{2+} + H_3O^{2+}$$

The oxides of the formula, M_2O_3, are formed by all the elements. Scandium and lutetium form less basic oxides,$Sc_2\,O_3$ and Lu_2O_3 , and closely resemble Al_2O_3. Similar to later, they react with alkali and produce scandate, $[Sc(OH)_6]^{3-}$ and lutetate, $[Lu(OH)_6]^{3-}$ respectively. A hydroxide, ScO (OH) is found isostructural with AlO (OH). All the elements form oxychloride, MOX (X=Cl, Br). Lutetium trichloride has aluminum trichloride structure,$LnCl_2$ (u-Cl)$_2$$LnCl_2$. A striking feature of the chemical reactivity of this family is the formation of double salts. Double sulphates of all the elements with the type $M_2(SO_4).3Na_2SO_4.12H_2O$ are well characterized. All the elements are known to give trialkyl, R_3M and triaryl,Ar_3M, organometallics of polymeric nature. Aluminum forms $[AlF_6]^{3-}$, and similar anionic species are also formed by scandium and lutetium.

In the nitrogen family V, Nb, Ta and Pa, like P_2O_5, all are known to form acidic pentaoxides. The elements vanadium, niobium, tantalum and protactinium, all have well characterized dioxocation, $[MO_2]^+$, solution chemistry. Mixed metal oxides of the type $M^I\,M^VO_3$ and $M^IM^VO_4$ ($LiAsO_3$, NaBiO3, NaSbO3, $LiNbO_3$, LiTaO3, NaPaO3) are also reported to all the elements. Similar to oxides, elements give pentahalides (PCl_5, $SbCl_5$, VF_5, TaF_5, PaF_5).They also form isostuctural oxohalides ($POCl_3$, $AsOCl_3$, $VOCl_3$, $PaOCl_3$). Some elements of the helium family, for example Xe and Os, form compounds with the oxidation states II to VIII, and XeO_4 is isostructural with OsO_4. Moreover, to have a clear understanding of the intra-family resemblance, one can easily extract sub-groups A, B and C from each of the families from this table. On classifying the group modifiers according to their electronic structure and arranging them in order of atomic number of the elements concerned, the group chart of the family is derived. The group chart for families II, V and VIII is shown in figure 2. In the group chart, thick lines represent the primary intra-group analogy and the secondary inter- group analogy is indicated by dotted lines. In family-II (Figure 1) thick lines from beryllium to radium put them in group IA and dotted lines connecting Mg to Zn and Cd with Yb exhibit the secondary connectivity of group IA with group IB (Zn group) and IB with IC (Yb group) respectively.

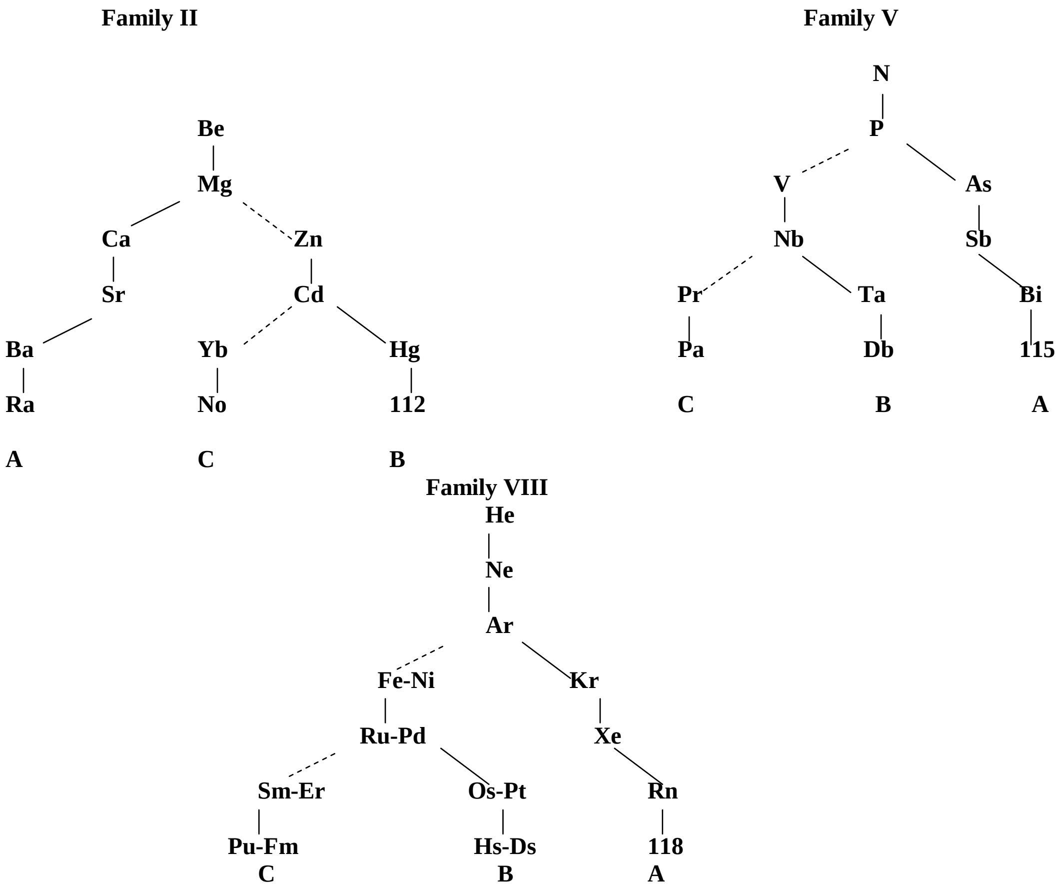

Figure 1 Group Chart of Families II, V & VIII

CONCLUSIONS

This periodic system makes it possible to study the secondary inter-group analogy among elements and would help students and their teachers to develop a comparative account of the similarities of elements in terms of family. In addition to this, it follows the natural order of appearance of elements and does not segregate any element from the main body of the table.

REFERENCES

[1] W.C. Fernelius, W.H. Powell, Confusion in the periodic table of the elements, *J. Chem. Educ.*, **1982**, 59, 504-508.

[2] N.S. Bhandari, Secondary Analogy between Chemical Elements, *Khimiya / Chemistry*, **2008**, 17, 261-269.

[3] J.A.R. Newland, On the Law of Octaves, *Chem, News,* **1865**, 12, 83.

[4] D. Mendeleev, Die periodische Gesetzmassigkeit der chemischen Elemente, *Ann.Chem*, **1872**, 8, 133-229.

[5] T. Bayley, On the connection between atomic weight and the chemical and physical properties of the elements, *Phil.Mag.* **1882**, 13, 26-37.

[6] J. Thomsen, Systematische Grruppiierung der chemischen Elemente, *Z. Anorg. Chem*, **1895**, 9,190-193.

[7] N. Bohr, The structure of the atom, *Nature*, **1923**,112, 29-44.
[8] W.B. Jensen, Classification, symmetry and the periodic table, *Comp. & Maths. with Appls*, **1986**, 12B, 487-510.
[9] M. Laing, The periodic table a new arrangement, *J. Chem. Educ*, **1989**, 66,746.
[10] H. Bent, New Ideas in Chemistry from Fresh Energy for the Periodic Law, Author House, United States, **2006**, 69-72
[11] E. G. Mazurs, Graphic Representations of the Periodic Table during One Hundred Years, University of Alabama, Alabama, **1974**.

AUTHORS' ADDRESS

1. **Narendra S. Bhandari**
Department of Chemistry,
Kumaun University,
Soban Singh Jeena Campus, Almora-263601,
Uttaranchal, INDIA.
Email – bhandarins1959@gmail.com