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Periodic Classification of Elements

Periodic Classification-

Classification of elements on the basis of their similarities in properties is called periodic classification.

Need of Periodic Classification-

To simplify and organize the study of the elements and their compounds.

History of Periodic Classification-

(1) **Classification of elements in Metals, Non-metals and Metalloids-** first the elements were classified into Metals (Na, K, Ca, Fe etc.), Non-metals (H, O, N, F etc.) and Metalloids (Ge, As, Sb, Te etc,). This system was not very useful as most of the known elements fell under metals with extremely different properties.

(2) **Dobereiner's Triads (1817)-** Dobereiner made the groups of three elements where, if the elements are arranged in increasing order of their atomic mass then the atomic mass of middle element is nearly the average of the atomic masses of rest two elements. These groups were termed as Dobereiner's Triads. For example,

(1) Elements of Triad **Li** **Na** **K**

Atomic mass **7** **23** **39**

Average of the atomic masses of first and last elements $= \frac{7 + 39}{2}$

$= 23$

(2) Elements of Triad **Ca** **Sr** **Ba**

Atomic mass **40** **87.6** **137**

Average of the atomic masses of first and last elements $= \frac{40 + 137}{2}$

$= 88.5$

(3) Elements of Triad **Cl** **Br** **I**

Atomic mass **35.5** **80** **127**

Average of the atomic masses of first and last elements $= \frac{35.5 + 127}{2}$

$= 81.2$

Some other examples of Dobereiner's Triad-

[K, Rb, Cs], [P, As, Sb], [S, Se, Te]

All the elements could not be grouped in triad. It is not applicable on d and f block elements.

(3) **Newland Octaves (1865)-** Newland arranged different elements in increasing order of their atomic mass and found that just like musical notations each eighth element is identical to first element. For example-

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca					

Here, properties of Li, Na and K are similar. In the same way properties of Be, Mg and Ca are similar.

Re-occurrence of Musical Notations-

Sa	**Re**	**Ga**	**Ma**	**Pa**	**Dha**	**Ni**
Sa						

This trend fails after Calcium. However, it gave a correlation between atomic mass and the properties of the elements.

(4) **Lother-Mayer curve-** Lother-Mayer plotted atomic volume of different elements against their atomic mass and found that the elements having similar properties occupy similar position on the curve. For example,

(a) Most electropositive alkali metals (Li, Na, K, Rb, Cs) occupy peak of the curve.

(b) Less electropositive alkaline earth metals (Be, Mg, Ca, Sr, Ba) occupy descending position of the curve.

(c) Most electronegative halogens (F, Cl, Br, I) occupy the ascending position of the curve.

(d) Metalloids (B, Si, As, Te) and transition metals occupy nitch (bottom) of the curve.

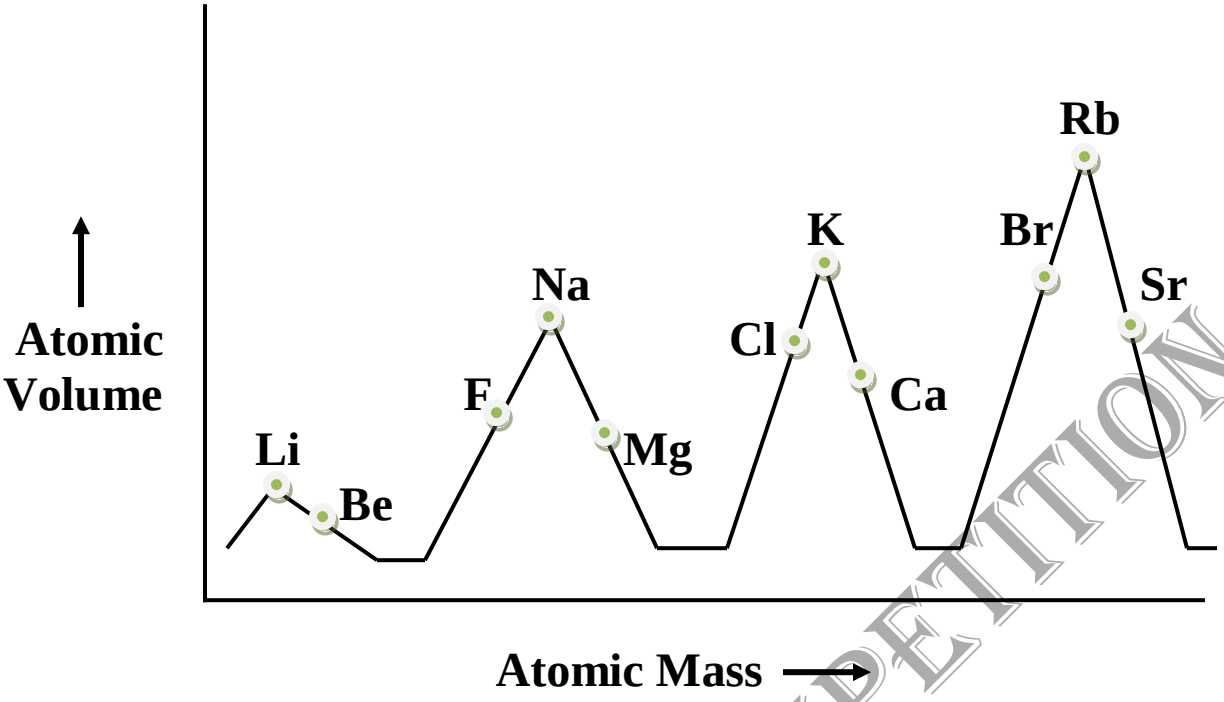

Fig.- Plot of Atomic volume against Atomic mass

(5) Mendeleev's Periodic table (1869)

Mendeleev studied different elements and their compounds comparatively and found following two observations--

1. Atomic mass is the fundamental property of the elements.
2. If different elements are arranged in increasing order of their atomic mass, then after certain regular intervals the elements having similar property are repeated. This is called periodicity of properties.

On this basis, Mendeleev gave his old or original periodic law.

Mendeleev's Old Periodic Law-

According to this law, "The physical and chemical properties of the elements are the periodic function of their atomic masses."

i.e. if different elements are arranged in increasing order of their atomic masses, after certain regular intervals the elements having similar properties are repeated. Based on his original periodic law Mendeleev prepared his periodic table called Mendeleev's original periodic table.

PERIODS		GROUPS I	II	III	IV	V	VI	VII	VIII
I	1	H						H	
II	2	Li	Be	B	C	N	O	F	
III	3	Na	Mg	Al	Si	P	S	Cl	
IV	4	K	Ca		Ti	V	Cr	Mn	Fe Co Ni
	5	Cu	Zn			As	Se	Br	
V	6	Rb	Sr	Y	Zr	Nb	Mo		Ru Rh Pd
	7	Ag	Cd	In	Sn	Sb	Te	I	
VI	8	Cs	Ba	La		Ta	W		Os Ir Pt
	9	Au	Hg	Tl	Pb	Bi			
VII	10				Th		U		

Fig. Mendeleev's Old Periodic Table

Important Features-

(i) It consisted of in all 10 rows of elements called series.

(ii) These series were divided into 7 periods (I to VII).

(iii) I, II, III and VII periods contained only one series while, IV, V and VI period were provided with two series namely even and odd series containing even and odd number of elements respectively.

(iv) Mendeleev provided preferences to the properties and tried to place elements with similar properties in same column called groups.

(v) For doing so he placed hydrogen at two places i.e. in group I along with alkali metals (Li, Na, K etc.) and in group VII along with halogens (F, Cl, Br, I) as it shows similarity in properties with both alkali metals and halogens.

(vi) He also reversed the order of elements at some places. For example, he placed Cobalt (At. Mass = 58.9) before Ni (At. Mass = 58.7) though atomic mass of Ni is lesser than that of Cobalt. Similarly, he placed

Tellurium (at. Mass = 128) before iodine (at. Mass = 127) though the atomic mass of tellurium is more than that of iodine. Such pairs of elements in periodic table where the order of atomic mass has been reversed are called inverted pairs of elements.

(vii) Mendeleev left some blank spaces for undiscovered elements in his periodic table and forecasted the properties of these undiscovered elements. Later on these elements were discovered and their properties were found to be same as forecasted by Mendeleev. For example, Mendeleev left the place of Gallium and named it eka aluminium. When it discovered, its properties were almost same as stated by Mendeleev. Similarity, he the place of Germanium and named it eka silicon. When it discovered, its properties were almost same as stated by Mendeleev.

Merits and Demerits of Mendeleev's periodic table-

(a) Merits-

(1) It simplified and organised the study of elements and their compounds.

(2) It became helpful in discovery of new elements like sc, Ga, Ge etc.

(3) It became helpful in correction of valencies and atomic masses of a number of elements. For example, previously Be was considered to be trivalent with atomic mass 13.5. Mendeleev placed it in group II along with divalent Mg, Ca, Sr etc. So, it was expected to be divalent. Later on it also found to be divalent and its atomic mass corrected to be 9.0. Similarly, atomic mass of In, Au, Pt and U also corrected.

(4) It became helpful in research and synthesis of new elements.

(b) Demerits

(1) Position of Hydrogen- In Mendeleev's periodic table hydrogen was placed at two places i.e. in group I along with alkali metals (Li, Na, K etc.) and in group VII along with halogens (F, Cl, Br, I) which was erroneous.

(2) Position of isotopes- Mendeleev's original periodic table was based on atomic mass. Isotopes have different atomic masses and therefore, they were required to be placed at different places in Mendeleev's original periodic table, but they were placed at same place. It was not logical.

(3) Position of isobars- Isobars have same atomic mass and therefore, they required to be places at same place in Mendeleev's original periodic table, but they were placed at different places. It was erroneous.

(4)Placement of elements with similar properties in different groups- Au and Pt have similar properties but they were placed in different groups.

Au (Group I) Pt (Group VIII)

(5) Placement of elements with similar properties in different groups- Coinage metals (Cu, Ag and Au) were places along with alkalies metals (Li, Na, K etc.) though they have totally dissimilar properties.

(6) Presence of inverted pairs- Mendeleev reversed the order of atomic mass at some places. For example, he placed Cobalt (At. Mass = 58.9) before Ni (At. Mass = 58.7) though atomic mass of Ni is lesser than that of Cobalt. Similarly, he placed Tellurium (at. Mass = 128) before iodine (at. Mass = 127). The presence such inverted pairs of elements was not logical.

(7) Presence of even and odd series
(8) Placement of a group of three elements in group VIII.
(9) No place for inert gases
(10) No place for lanthanides and actinides.

Mendeleev's Modern Periodic Law

Moseley bombarded high speed energetic electrons over the surface of different metals to produce X-rays and found that the square root of the frequency of X-ray produced is proportional to the atomic number (Z) of the respective elements.

$$\sqrt{\upsilon} \quad \alpha \quad Z$$

Thus, on experimental basis, Moseley found that atomic number is the fundamental property of the elements but not atomic mass. Based on this fact, he modified Mendeleev's Old Periodic Law and gave Mendeleev's Modern Periodic Law. According to this law,

"The physical and chemical properties of the elements are the periodic function of their atomic numbers."

Thus, if different elements are arranged in increasing order of their atomic numbers, after certain regular intervals (2,8,18,32,-----) the elements having similar properties are repeated. This is called periodicity of properties.

Mendeleev's Modern Periodic Table

Important Features-

(i) It was based upon atomic number of the elements i.e. in this periodic table different elements were arranged in increasing order of their atomic number.

(ii) It consisted of in all 10 rows of elements called series.

(iii) These series were divided into 7 periods (I to VII).

(iv) I, II, III and VII periods contained only one series while, IV, V and VI period were provided with two series namely even and odd series containing even and odd number of elements respectively.

(v) To separate elements of dissimilar properties Group I to VII were divided into sub-groups A and B respectively.

(vi) A new group called zero group added to extreme right for inert gases (He, Ne, Ar, Kr, Xe, Rn). Thus, there were in all 9 vertical columns (groups) in this periodic table,

(vii) Here also hydrogen was placed at two places i.e. in group IA along with alkali metals (Li, Na, K etc.) and in group VIIA along with halogens (F, Cl, Br, I).

GROUPS

PERIODS	I	II	III	IV	V	VI	VII	VIII	0
	A B	A B	A B	A B	A B	A B	A B		
I	H						H		He
II	Li	Be	B	C	N	O	F		Ne
III	Na	Mg	Al	Si	P	S	Cl		Ar
IV	K Cu	Ca Zn	Sc Ga	Ti Ge	V As	Cr Se	Mn Br	Fe Co Ni	Kr
V	Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	Tc I	Ru Rh Pd	Xe
VI	Cs Au	Ba Hg	La Tl	Hf Pb	Ta Bi	W Po	At	Os Ir Pt	Rn
VII				Th		U			

Fig.- Mendeleev's Modern Periodic Table

Taking atomic number as the basis of Mendeleev's periodic table, following demerits got removed-

(1) Position of Isotopes
(2) Position of Isobars
(3) Presence of inverted pairs of elements

Following demerits still persisted in Mendeleev's modern periodic table-

(1) Position of Hydrogen
(2) Presence of even and odd series in IV, V and VI periods
(3) Presence of three elements together in group VIII
(4) No place for lanthanides and actinides

Long Form of Periodic Table

It has been found that, the properties of elements depend upon their electronic configuration and especially upon their outer shell electronic configuration. The elements having similar outer shell electronic configuration have similar properties while those having different outer shell electronic configuration have different properties.

Long form of periodic table, gives a correlation between the electronic configuration of element and its position in periodic table. It was for the first time prepared by Rang, Werner and Bury. It is based upon Bohr's scheme of electronic configuration. Hence, it is also called Bohr's Periodic Table.

The important characteristics of Long form of periodic table are as under-

(1) It is based upon electronic configuration of elements and gives a correlation between the electronic configuration of element and its position in periodic table.

(2) In this periodic table, there are in all seven horizontal rows of elements called Periods (I to VII) and in all eighteen vertical columns called Groups (1 to 18).

(3) I^{st} period contains only 2 elements and is called very short period. II^{nd} and III^{rd} periods contain 8 elements each and are called Short periods. IV^{th} and V^{th} periods contain 18 elements each and are called Long periods. VI^{th} period containing 32 elements is Longest period of periodic table. VII^{th} period is incomplete period of periodic table.

(4) In elements of group 1 and 2 only outer most shell is incompletely filled and last electron enters in s-orbital of outer most shell. These elements are called s-block elements. The general outer shell electronic configuration of these elements is ns^{1-2}.

(5) In elements of group 13 to 18, only outer most shell is incompletely filled and last electron enters in p-orbitals of outer most shell. These elements are called p-block elements. The general outer shell electronic configuration of these elements is ns^2np^{1-6}.

(6) In elements of group 3 and 12 outer two shells are incompletely filled and last electron enters in d-orbital of penultimate shell i.e. (n-1)d-orbitals . These elements are called d-block elements. The general outer shell electronic configuration of these elements is ns^2,$(n-1)d^{1-10}$.

(7) There are two series of 14 elements each (4f and 5f series) below the periodic table. In these elements outer three shells are incompletely filled and last electron enters in f-orbitals of anti-penultimate shell i.e. (n-2)f-orbitals . These elements are called f-block elements. The general outer shell electronic configuration of these elements is ns^2, $(n-1)d^{0-1}$, $(n-2)f^{1-14}$.

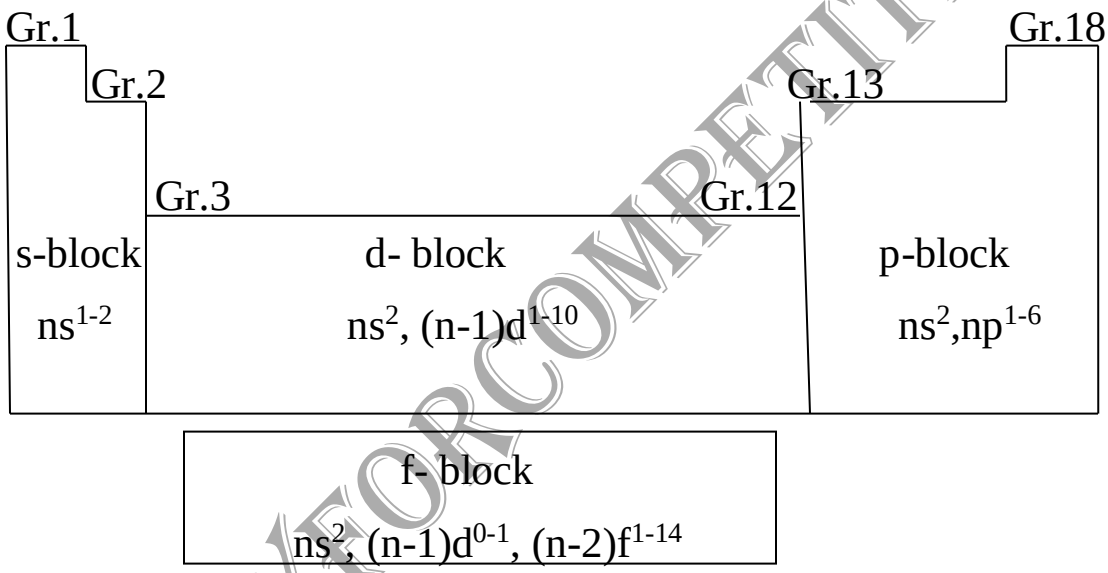

Fig.- Long Form of Periodic Table

s and p-block elements where only outer most shell is incompletely filled are collectively called **Representative Elements**.

d-block elements where outer two shells are incompletely filled show transition in properties between highly electropositive s-block elements and highly electronegative p-block elements. Hence, these elements are collectively called **Transition Elements**.

f-block elements where outer three shells are incompletely filled lie between transition elements. Hence, these elements are collectively called **Inner Transition Elements**.

If a diagonal is drawn from Boron to Astatine then it roughly devides metals and non-metals. All the elements (except H) lying left hand side of this diagonal are metals while those lying right hand side are non-metals. The elements lying near this diagonal (Ge, As, Sb & Te) are Metalloids. The elements lying on this diagonal (B, Si & At) are also non-metals.

Cause of periodicity of properties

It has been found that, the properties of the elements depend upon their electronic configuration and especially upon their outer shell electronic configuration. The elements having similar outer shell electronic configuration have similar properties while those having different outer shell electronic configuration have different properties. When different elements are arranged in increasing order of their atomic numbers, after certain regular intervals (2,8,18,32,-----) the elements having similar outer shell electronic configuration are repeated and therefore, the properties are repeated. Thus, **the repetition of similar outer shell electronic configuration after certain regular intervals is the principal cause of the periodicity of properties in periodic table.**