Unit

3

Classification of Elements and Periodicity in Properties

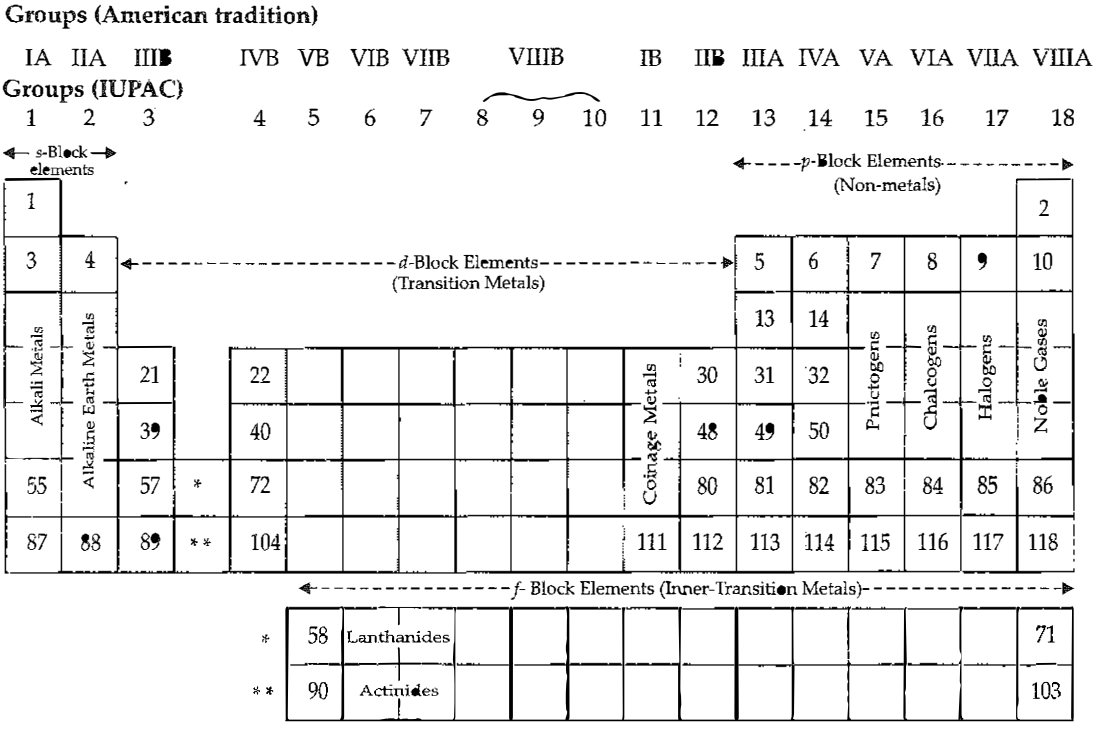
- The basic object of classification is to arrange the facts regarding elements in such a way that we may have greatest control over their characteristics with least possible effort.
- A tabular arrangement of elements in which elements with similar properties are grouped together is called a **periodic table**.

Modern Periodic Law

- Moseley suggested that basis of classification of elements should be the atomic number of the elements rather than the atomic mass of the elements.
- Modern periodic law states that "the physical and chemical properties of the elements are periodic function of their atomic numbers". Thus, when the elements were arranged in the order of their increasing atomic numbers, the elements of similar properties appear at regular intervals.

Modern Periodic Table

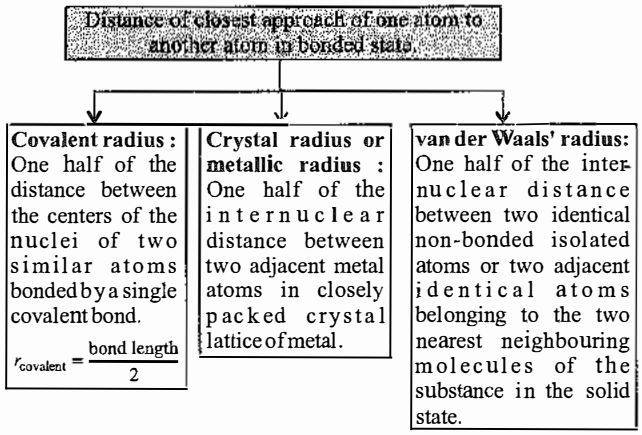
- Long form of periodic table consists of horizontal rows called as '**periods**' and vertical columns called as '**groups**'.
- **Periods :** Modern periodic table has seven horizontal rows known as periods. There is a periodicity occurring at regular intervals of 2, 8, 8, 18, 18, and 32 and so the number 2, 8, 18, and 32 are called magic numbers.
- **Groups :** The Modern periodic table consists of eighteen vertical columns called as group. There are 18 groups in the long from of the periodic table and they are numbered from 1 to 18 in the IUPAC system. In the old system of naming they are numbered as IA – VIIA, IB – VIIB, VIII and zero. Generally all the groups are named after first member of each element. There are some common names given to few groups also.
  - Elements of group-1 are called ***alkali metals.***
  - Elements of group-2 are called ***alkaline earth metals.***
  - Elements of group-11 are called ***coinage metals.***
  - Elements of group-15 are called ***pnictogens.***
  - Elements of group-16 are called ***chalcogens.***
  - Elements of group-17 are called ***halogens.***
  - Elements of group-18 are called ***noble gases or inactive gases.***



PERIODIC TRENDS IN PROPERTIES OF ELEMENTS

- Periodic trend means a property is repeated in a system at regular intervals.
- Atomic properties which depend upon electronic configuration and show a regular change on moving left to right in a period and top to bottom in a group in periodic table are called periodic properties. For example atomic size, atomic volume, etc.

Atomic Radii



- If we compare three types of atomic radii, it is seen that : van der Waals radius > Metallic radius > Covalent radius
- **Variation in a period :** On moving from left to right in a period, atomic radii decrease with increase in atomic number, because of increasing nuclear charge along a period.
- The nuclear charge increases progressively by one unit, consequently the electrons are pulled closer to the nucleus by the effective nuclear charge resulting in decrease in the size of atom.
- **Variation in a group :** The atomic radii of elements increases from top to bottom in a group. A new shell is added at each succeeding element while the number of electrons in the valence shell remains the same. So the distance of the valence electron from the nucleus increases. Thus the size of the atom goes on increasing down the group in spite of increasing nuclear charge.

Period/Group →	I	II	III	IV	V	VI	VII
↓ 1	H						
	0.37						
2	Li	Be	B	C	N	O	F
	1.23	0.89	0.80	0.77	0.75	0.73	0.72
3	Na	Mg	Al	Si	P	S	Cl
	1.54	1.36	1.20	1.17	1.10	1.04	0.99
4	K	Ca	Ga	Ge	As	Se	Br
	2.03	1.74	1.26	1.22	1.20	1.16	1.14
5	Rb	Sr	In	Sn	Sb	Te	I
	2.16	1.91	1.44	1.41	1.40	1.36	1.33
6	Cs	Ba	Tl	Pb	Bi	Po	
	2.35	1.98	1.48	1.47	1.46	1.46	

Increases ↓

→ Decreases

Ionic Radii

- Ionic radius is defined as the distance from centre of nucleus to the outermost shell of an ion or effective distance from the center of nucleus of an ion up to which it has an influence on its electron cloud.
- **Radius of the cation**
  - A cation is formed by the loss of one or more electrons from the gaseous atom.
  - Size of cation is always smaller than that of parent atom because of increase in effective nuclear charge per electron.
- **Radius of the anion**
  - An anion is formed by the gain of one or more electrons in the neutral atom. This causes an increase in the size of the ion.
  - Anion is always larger in size than its parent atom because the effective nuclear charge per electron is reduced and the electron cloud is held less tightly by the nucleus.
- **Variation of ionic radii in a group**

The ionic radii in a particular group increase on moving from top to bottom because of the increase in the number of shells.

Li^+ < Na^+ < K^+ < Rb^+ < Cs^+
0.59 Å 0.99 Å 1.33 Å 1.48 Å 1.69 Å

F^- < Cl^- < Br^- < I^-
1.36 Å 1.81 Å 1.96 Å 2.20 Å

The size of the cations of the same element decreases with the increase of positive charge.

Fe^{3+} 0.67 Å Cu^{2+} 0.72 Co^{3+} 0.64
Fe^{2+} 0.82 Å Cu^+ 0.96 Co^{2+} 0.82

This can be explained on the basis of Z/e ratio $\left(\frac{\text{Nuclear charge}}{\text{No. of electrons}}\right)$. Whenever Z/e ratio increases, the size decreases and when Z/e ratio decreases, the size increases.

- Isoelectronic species (ions or atoms) are those which have same number of electrons. For such species the size decreases with an increase of atomic number.

Atom or ion	Atomic no. (Z)	No. of electrons (e)	Z/e ratio	Size in Å
C^{4-}	6	10	0.6	2.60
N^{3-}	7	10	0.7	1.71
O^{2-}	8	10	0.8	1.40
F^-	9	10	0.9	1.36
Ne	10	10	1.0	1.12
Na^+	11	10	1.1	0.99
Mg^{2+}	12	10	1.2	0.65
Al^{3+}	13	10	1.3	0.50