



Chapter - 3

Classification Of Elements And Periodicity In Properties

The first classification of elements was provided by Russian chemist D.I. Mendeleev.

1. “The physical and chemical properties of elements are periodic functions of their atomic weight.”
2. It was modified to **Modern Periodic law** : “The physical and chemical properties of elements are periodic functions of their atomic numbers.”

It is the long form of periodic table :

Horizontal rows → Periods

Vertical columns → Group

3. 1st period—2 elements
2nd and 3rd period—8 elements
4th and 5th period—18 elements
6th period—32 elements
7th period—Incomplete
4. Groups
1 and 2 — ‘s’ block elements last electron entered in ‘s’ subshell [s^1, s^2]
3 to 12 — ‘d’ block elements last electrons entered in ‘d’ subshell [d^1 to d^{10}].
13 to 18 — ‘p’ block elements last electrons enter in ‘p’ subshell [p^1 to p^6].
Group 18 — Noble gases.
5. (A) In ‘s’ and ‘p’ block elements the electrons enters outer most shell.
In ‘d’ block elements the electron enter the penultimate shell ($n - 1$).
‘f’ block elements last electron enter the subpenultimate shell ($n - 2$).
(B) ‘f’ block elements are placed in between ‘d’ block elements.
‘f’ block elements in 2 rows [4f lanthanoids 5f actinoids]
(C) Helium is placed ns^2 . But it has Noble gas configuration.
(6) General electronic configuration ‘s’ block ns^1, ns^2 [Group I]

'p' block $ns^1 np^1$ to $ns^1 np^6$ Group 13 to 18

'd' block $ns^{1,2} (n-1) d^1$ to 10 Group 3 to 12

'f' block $ns^2 (n-1) d^{0,1} (n-2) f^{1$ to 14

7. General Trends :

Atomic Radius

- (A) Left to right decreases due to effect of successive increasing nuclear charge without addition of a new shell.
- (B) From top to bottom atomic radius increases due to successive addition of shell.
- (C) Noble gases large radius than **group 17** due to complete filling of electron in outer shell electron-electron repulsion mildly increases.

8. (A) Ionization energy : The energy required to remove electron from outer most shell of an atom in its isolated gaseous state. $M_{(g)} \longrightarrow M_{(g)}^+ + e^-$

(B) From Left to right increases due to decrease in atomic radius therefore less force of attraction by protons. For 2nd group elements.

1st ionization enthalpy

$Li < B < Be < C < O < N < F < Ar$

IInd ionization enthalpy

$Be < C < B < N < F < O < Ne < Ni$

(C) From top to bottom : Due to increase in size, (due to addition of shells) the ionization enthalpy decreases from top to bottom.

(D) Metallic behaviour : Decrease from left to right due to increase in ionization enthalpy.

Non metallic behaviour : Increase from left to right due to more number of electron in outershell and added electron goes towards nucleus.

(A) Ionic radius : (A) Cation radius $<$ Atomic radius—due to more no. of protons than number of electron coulombic force increases size decreases.

$[Mg^{2+} < Mg^{+1} < Mg]$

(B) Anion radius $>$ Atomic radius—Due to more number of electron than number of protons. $[N^{3-} > O^{2-} > F^-]$

Electron-Electron repulsion increases, coulombic force of attraction decreases.

(C) For Isoelectronic species—More is the charge of cation lesser in the size.

More is the change of anion more is the size.

(D) Size— $O^{2-} > F^- > Na > Na^+ > Mg^{2+}$

(10) **Electro negativity** : (A) The tendency of an atom to attract the shared pair of electron towards itself in a bonded state.

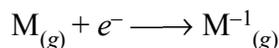
(B) Left to right size decreases shared electron nearer to nucleus—electron negativity increases.

(C) Top to bottom size increases, shared electron away from nucleus—electron negativity decreases.

(D) Four highest electronegative atoms $F > O > Cl > N$

maximum electronegative Assign to F.

(11) **Electron gain enthalpy** : The energy rescaled when an extra electron is added to neutral gaseous state.



Negative electron gain enthalpy

(A) **Trends—From left to right**—Increase due to decrease in size more attraction of added electron by nucleus.

(B) **From top to bottom**—Decreases as the added to electron is away from nucleus due to increase in size.

(C) **Cl has more electron gain enthalpy than fluorine**—Due to small size of fluorine extra added electron has more inter electronic repulsion than chlorine which has large size. Similarly **Phosphorus and Sulphur** have negative electron gain enthalpy than **nitrogen and oxygen** respectively.

(D) **Maximum electron gain enthalpy**—Chlorine (in periodic table)

(E) Electron gain enthalpy—

Halogen > Oxygen > Nitrogen > Metal of group 1 and 13 and non metal of group 14 > metal of group 2.

(F) II electron gain enthalpy in always five.

Electron affinity—The negative of the enthalpy change accompanying the addition of an electron to an isolated gaseous atom is defined as **electron affinity** (Ae).

+ **ive electron affinity**—If energy released when an isolated gaseous atom accepts an electron.

– **ive electron affinity**—If energy is to be supplied to add an extra electron

to the isolated gaseous atom.

(12) Screening effect—(A) The decrease in force of attraction exerted by nucleus on valency electrons due to presence of electrons in inner shells is known as screening or shielding effect.

(B) Effective nuclear charge (Z^*) = Nuclear charge—Shielding effect

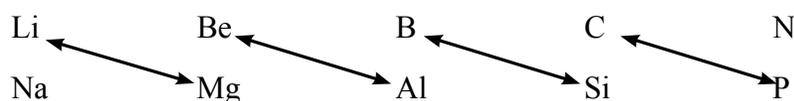
(C) Trend—Left to Right— Z^* Increases.

Top to Bottom— Z^* Decreases.

(13) Second period element—Show different behaviour that I group element—Due to (a) small size (b) High electron negativity (C) High polarising power (d) absence of 'd' orbital in I member.

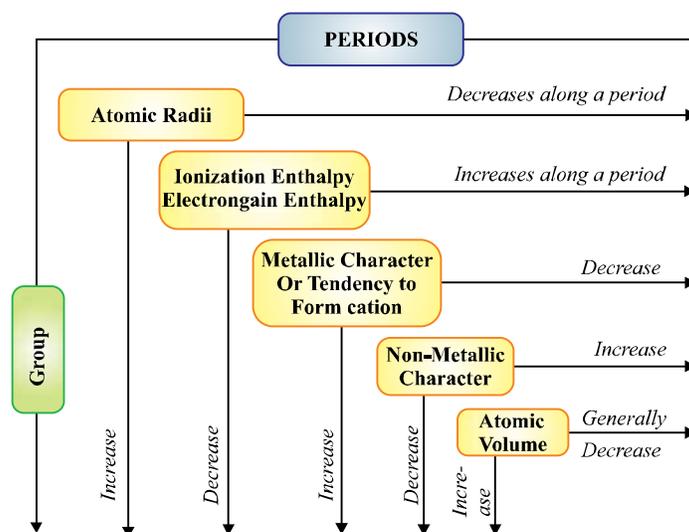
$\text{Na}_3[\text{Al}(\text{OH})_6]$ exists but $\text{Na}[\text{B}(\text{OH})_4]$ not exists.

(14) The similarities in properties of I member of a group to II member of just next higher group due to comparable atomic radius, nearly same polarising power of ions is known as **Diagonal relationship.**



Elements with outer shell

- | | |
|--------------------|------------|
| (a) 1, 2, 3, e^- | metals |
| (b) $4e^-$ | metalloids |
| (c) 5, 6, 7, e^- | non-metals |
| (d) $8e^-$ | noble gas |



Arrangement of Elements

1-Mark Questions

1. Metals are placed on which side of modern periodic table ?
2. Which pair of elements has similar properties ? $\begin{bmatrix} 13, & 31 \\ 11, & 21 \end{bmatrix}$ [Ans. 13, 31]
3. Which atomic number refers to a non-metal elements ? [Ans. 17, 35]
4. Eka Aluminium & Eka silicon are known as and
5. (a) Be shows diagonal relationship with which element. (Gr 16) (Al)
(b) Which group elements are known as chalcogens.
6. Which pair of elements are 'S' block elements ? $\begin{bmatrix} 37, & 38 \\ 55, & 37 \end{bmatrix}$ [Ans. Both]
7. The element with ns^2, np^5 configuration is non-metal or metal ?
8. Define Vanderwall radius. [The half of the distance b/w two nearly place atoms in gaseous state].
9. Write the outer shell configuration of atomic number 31. [Ans. $4s^2 4p^1$]
10. Find the group no. and period no. atomic number 52. [Ans. 5th Row, 16 gr]
11. Arrange O^{2-} O^{-1} O in decreasing radius (size). [Ans. $O^{2-} > O^{-1} > O$]
12. Which element is isoelectronic with Na^+ (Na atomic number 10)
[Ans. Ne]
13. Why noble gas have more size than halogens (Gr 1 elements).
14. An element is placed in 5th row and 3 group has what atomic no. ?
[Ans. 39]
15. How electron gain enthalpy and sulphur is more than O^- ?
16. If 'f' block elements 4f elements have what electronic configuration ?
[Ans. $6s^2, 5f^{0,1} 4f^{1 to 14}$]
17. Write the IUPAC name of element with atomic number 115, 107.
18. Write two isoelectronic species with Br (35). [Ans. Kr^+ Se^{-1}]
19. What is covalency of Al in $[AlCl_4]^{1-}$? [Ans. 4]
20. Modern periodic table which groups have less no. of elements in modern period table. [Ans. 3 to 12]
21. Show that 4th period can have maximum 18 elements.

Ionization energy electronegativity Electron Gain Enthalpy

22. 2nd IE is always more than first why ?
23. Electronegativity of $F < Cl < Br < I$ why ?
24. Arrange F, Cl in terms of increasing chemical reactivity.
25. 2nd IE of Na is more than 2nd IE of Mg. Why ?
26. $\Delta_{eg}H^{\ominus}_1$ is exothermic while $\Delta_{eg}H^{\ominus}_2$ is endothermic justify.
27. IE for cation is more than for neutral atom. Why ?
28. Arrange in decreasing order of first electron gain enthalpy exothermic .
[Ans. N, O]
29. O^{1-} O which has exothermic and which has endothermic electron gain enthalpy.

Trends, IE, Electronegativity and Electron gain enthalpy Metallic behaviour valency

2-Mark Questions

1. Cations are smaller than neutral atom why anions are larger in size than neutral atom ?
2. Ionization energy of nitrogen is more than 'O' and 'C' both why ?
3. First ionization energy of boron is less than Be but size of Be is less than Boron. Why ?
4. Electron gain enthalpy of Mg is positive why ?
5. The covalency of Si is 4 but of halogens is one why ?
6. The reactivity of halogens decrease down the group but of alkali metals (Gr 1) inc. down the group.
7. Name one halogen, one metal one gr 13 element which are liquid at 30°C.
[Ans. Br, Hg, Ga]
8. The reducing power of elements increases down the group but reverse is true for oxidising power along a period. Why ?
9. What is formula of binary compound formed b/w combination of :
(a) 1st element of 1st group and iodine.
(b) 2nd element of 2nd group and 1st element of 17 groups.
10. Arrange in increasing order of :
Size (a) I, F, Cl, Br

Oxidising power (b) I, F, Br, Cl

11. Oxygen is more metallic than nitrogen but less than fluorine why ?
12. LiCl, LiBr, LiI are covalent as well as ionic why ?
13. PbCl_2 is more stable than PbCl_4 . Why ? [Ans. Inert pair effect]
14. [Magnesium and nitrogen] and [Lithium and nitrogen] both form nitrides why ?
15. Which has least IE [$3p^3$, $3p^6$, $2p^3$, $2p^6$]
16. (a) IE of sulphur is lower than chlorine.
(b) Arrange in decreasing electronegativity F, O, N, Cl, C, H.
17. Element 'A' in Gr 17 2nd row
'B' in Gr 16 2nd row
'C' in Gr 15 2nd row
Arrange 'A', 'B' and 'C' in decreasing EN, IE and 1st EGE.
18. Element 'A' 13 group forms ionic compounds. Write the :
(a) Formula of its oxide.
(b) Arrange of decreasing electro + ve character Ga, Li, Pb, Cs.
19. Write the atomic no. of element placed diagonally to element of :
(a) Group 14 row 4 (b) Group 2 Row 5
(c) Group 17 row 4
20. An element has outer shell configuration $4s^2 4p^3$.
(a) Find the atomic number of element placed below it.
(b) Next noble gas no.

3-Mark Questions

1. What is metallic radius, Covalent radius, Vanderwall radius. Give one example for each.
2. Oxygen has first electron gain enthalpy exothermic second endothermic still a large no. of ionic oxides are formed. Why ?
3. Boron and Al give two similarities and two behaviour shown differently by each.
4. Element Gr 17; Gr 18; Gr 1 in the sequence placed in modern periodic table.
(a) Which has – ve electron gain enthalpy ?

- (b) Which has more metallic behaviour ?
 (c) Which has zero electronic behaviour ?
- What are (a) representative elements, (b) Transition elements, (c) Lanthanoid and actinoids. Give their positions in modern periodic table.
 - Why LiF NaF KF RbF CsF are ionic ? But LiF is less ionic than CsF.
 - (a) Why Ca has atomic radius than Al ?
 (b) Why $2s^2 e^-$ is difficult to remove than $2p$ electron ?
 - (a) The non-metallic behaviour is shown by halogen (Gr 17) but their compounds with (Gr 13) elements are more ionic and stable than with (group 1) elements. (b) Al_2O_3 is more ionic than MgO than Na_2O .
 - Explain the following data :
 Ionization energy $Cl < H < O < N < F$.
 - IE₂ of 3rd period elements is as follows. Why ?
 $Mg < Si < Al < P < S < Cl < Ar < Na$.

5-Mark Questions

- (A) Which of the following have same chemical properties :
 (a) Atomic no. 17, 53 (b) Atomic no. 8, 52
 (c) Both (d) None
 (B) Which of the following more (IE)
 (a) B, Al, Ga arrange in decreasing order.
 (C) C, S, N first electron gain enthalpy (decreasing order)
 (D) Al forms amphoteric oxide. Why ?
 (E) Si is a semiconductor 'C' is a non-metal why ?
- | Element | $\Delta_f H^\ominus_1$ | $\Delta_f H^\ominus_2$ | $\Delta_{eg} H^\ominus_1$ |
|---------|------------------------|------------------------|---------------------------|
| I | 1681 | 3374 | - 328 |
| II | 1008 | 1846 | - 295 |
| III | 2372 | 5251 | + 48 |

(a) The most reactive non-metal.
 (b) The least reactive non-metal.
 (c) The least reactive element give reason also. [Ans. (a) I (b) II (c) III]