Module-I : Periodic Properties

CO1 : To demonstrate and realise the trend in various Periodic properties associated with different elements present in different groups and periods of modern periodic table.

Topic :- Introduction about Periodic table

→ The latest Periodic table is based on Henry-Moseley's Modern Periodic Law.

→ Henry Moseley is an English Physicist.

→ As per the Periodic Law the Properties of elements are Periodic functions of their atomic numbers, means that if the elements are arranged in increasing order of their atomic numbers, the elements with similar properties are repeated after certain regular intervals. This cause of Periodicity in properties is the repetition of similar outer electronic configuration at certain regular intervals.

→ It is made up of 118 elements in a modern Periodic table.

- Periodic Properties actually depends upon the following points given below :-

→ Most of the physical and chemical properties of the elements change periodically with the atomic number.

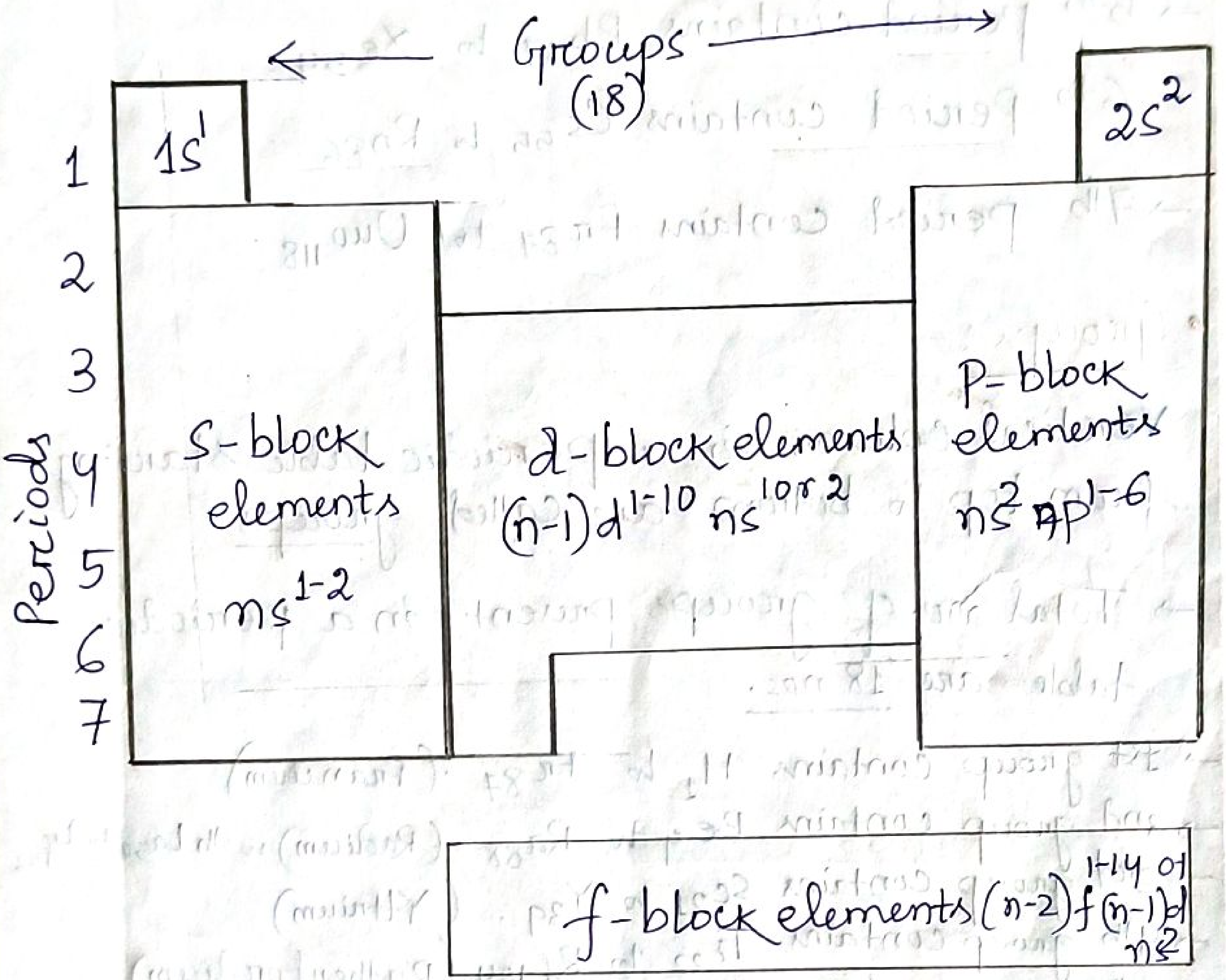
→ Some of these properties such as effective nuclear charge, atomic size, ionization energy and electron affinity are directly related to the electronic - configurations of the atoms.

→ The properties such as melting point and density are indirectly related to the electronic configuration of the atoms.

Conclusion :-

* The properties which are directly or indirectly related to their electronic configuration and show a regular gradation when we move from left to right in a period or from top to bottom in a group are called Periodic properties.

Topic :- Discussion about Period, Group in a Periodic table



Periods :-

The horizontal rows from left to right in the periodic table are called Periods.

→ There are 7 Periods.

→ 1st period contains H_1 & He_2.

→ 2nd period contains Li_3 to Ne_{11}

→ 3rd period contains Na_{11} to Ar_{18}.

→ 4th period contains K_{19} to Kr_{36}.

→ 5th period contains Rb_{37} to Xe_{54}.

→ 6th Period contains Cs_{55} to Rn_{86}.

→ 7th period contains Fr_{87} to Uuo_{118}.

- **Groups :-**

Vertical columns in a periodic table starting from top to bottom are called groups.

→ Total no. of groups present in a periodic table are '18' nos.

→ 1st group contains H_1 to Fr_{87} (francium)
→ 2nd group contains Be_4 to Ra_{88}. (Radium) with La_{57} to Lr_{103}
→ 3rd group contains Sc_{21} to Y_{39}. (Yttrium)
→ 4th group contains Ti_{22} to Rf_{104} (Rutherfordium)
→ 5th group contains V_{23} to Db_{105} (Dubnium)
→ 6th group contains Cr_{24} to Sg_{106} (seaborgium).
→ 7th group contains Mn_{25} to Bh_{107} (Bohrium).
→ 8th group contains Fe_{26} to Hs_{108} (Hassium)
→ 9th group contains Co_{27} to Mt_{109} (Meitnerium).
→ 10th group contains Ni_{28} to Ds_{110} (Darmstadtium).
→ 11th group contains Cu_{29} to Rg_{111} (Roentgenium).
→ 12th group contains Zn_{30} to Cn_{112} (copernicium)
→ 13th group contains B_5 to Uut_{113} (Ununtrium).
→ 14th group contains C_6 to Fl_{114} (Flerovium).
→ 15th group contains N_7 to Uup_{115} (Ununpentium).
→ 16th group contains O_8 to Lv_{116} (Livermorium)
→ 17th group !! F_9 to Uus
→ 18th " !! He, to

Topic :- S-block elements details.

Group No:	Recommended Name :
1 (except H)	Alkali Metals Li , Na , K , Rb, Cs, Fr.
2	Alkali earth Metals Be , Mg , Ca , Sr, Ba , Ra . (S-block elements)

Characteristics :- (S-block)

→ Their outer electronic configuration is ns^1 & ns^2.

→ They are soft metals with low melting & boiling points , reactive also .

→ They are low ionisation enthalpies and strong reducing agents as they lose electrons to acquire stable noble gas .

→ Their common Oxidation State are +1, +2.

→ Their reactivity increases down the group and most of them form ionic compounds except Li & Be.

Topic :- Introduction for d- block elements

(i) d- block elements are the elements in which the last electron enters the d - subshell.

(ii) d- block elements are situated at the middle of the periodic table and act as a bridge between metal and non-metals in the periodic table.

(iii) These elements are also called transition elements.

(iv) These elements, Play a significant role in shaping our fundamental understanding of chemical principles.

(v) They reside in the central part of the table, spanning groups 3 to 12 and Periods 4 to 7.

(vi) All transition metals are d-block elements but not all d-block elements are transition metals.

Ex- Sc & Yttrium of group-3 are considered transition metals due to their Partially -

- filled d-subshell in the metallic state. However, Elements like Zn and Hg have filled d-subshells but are not considered transition metals.

1st transition series:-

Sc	$4s^2 3d^1$
Ti	$4s^2 3d^2$
V	$4s^2 3d^3$
Cr	$4s^1 3d^5$
Mn	$4s^2 3d^5$
Fe	$4s^2 3d^6$
Co	$4s^2 3d^7$
Ni	$4s^2 3d^8$
Cu	$4s^1 3d^{10}$
Zn	$4s^2 3d^{10}$

2nd transition series:-

Y	$5s^2 4d^1$
Zr	$5s^2 4d^2$
Nb	$5s^1 4d^4$
Mo	$5s^1 4d^5$
Tc	$5s^2 4d^5$

Ru	$5s^1 4d^7$
Rh	$5s^1 4d^8$
Pd	$5s^0 4d^{10}$
Ag	$5s^1 4d^{10}$
Cd	$5s^2 4d^{10}$

Continue...

Third transition series :-

La	$6s^2 5d^1$
Hf	$6s^2 5d^2$
Ta	$6s^2 5d^3$
W	$6s^2 5d^4$
Re	$6s^2 5d^5$
Os	$6s^2 5d^6$
Ir	$6s^2 5d^7$
Pt	$6s^1 5d^9$
Au	$6s^1 5d^{10}$.
Hg	$6s^2 5d^{10}$.

Group No.	Recommended Name
3 to 12	Transition elements except (Lanthanum) La_{57} to Lu_{71} & Ac_{89} (Actinium) to Lr_{103}.

Characteristics of d-block elements:-

(i) Outer most electronic configreration is $(n-1)d^{1-10} ns^{0-2}$.

(ii) These are mostly alkali earth metals.

(iii) High melting Point.

(iv) High boiling Point.

(v) Generally they forms coloured complexes.

(vi) They exhibit variable valency (0.5).

(vii) Mn, Ni, Co, Cr, V, Pt used as catalyst.

Characteristics :-

- → It includes both metal & non-metal.
- → The non-metallic character increases as we move from left to right across the period.
- → Metallic character increases, we move top to bottom in group.
- → IE is more than S-Block elements.

Topic :- f- block elements :-

(i) The f-block elements are a group of metals in the Periodic table that are located at the bottom and are known as inner transition elements.

(ii) The f-block elements are located in the third group of the periodic table and are placed separately at the bottom.

(iii) The name comes from the fact that the last electron enters the f-block elements i.e, f- orbital of the anti-Penultima-te shell.

(iv) The f-block elements are divided into two series : the lanthanides & the actinides :-

1. Lanthanides :-
These elements are generally considered of atomic no, 58-71. including lanthanum.

2. Actinides :-
These elements are generalley considered to have atomic numbers 89- 103 including actinium to lawrencium.

Characteristics :-

(i) They are excellent conductors of both heat & electricity.

(ii) Their colour fades and their luminosity decreases quickly when exposed to air.

(iii) High melting & Boiling points.

(iv) They exhibit variable (O.S) & form coloured ions.

(v) Tendency to form Complex compounds.

(vi) Actinoids elements are radio-active.

(vii) Elements after Uranium(92) are called trans - Uranium elements.

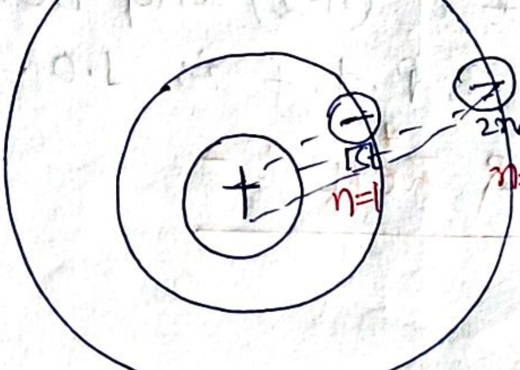
Topic :- Effective nuclear charge, Screening effect, Slater's rule :-

1. Effective nuclear charge :-

Defn :- The effective nuclear charge is the net positive charge experienced by an electron in a polyelectronic atom.

2. Screening effect :-

The decrease in force of attraction between nucleus & valence e⁻ due to inner-shell e⁻ is called screening effect or shielding effect.



→ There is a reduction in nuclear charge due to screening effect.

→ Reduced nuclear charge is called Effective nuclear charge.

$$Z^*_{eff} = Z - \sigma$$

Where, $\sigma \rightarrow$ Screening constant.
$Z \rightarrow$ Atomic no.
$Z^*_{eff} \rightarrow$ Effective nuclear charge.

3. Slater's rule :-

a) Screening effect of one e^- of the 1s is 0.30.

b) Screening effect of ns & np (outermost orbit) electron is 0.35.

c) Screening effect of (n-1) s, p, d (Penultimate orbit) electron is 0.85.

d) Screening effect of (n-2) and below all the e^- present in s, p, d, f is 1.0.

Calculation of σ & Z^*_{eff} :-

(i) $H(Z = 1) = 1s^1$

nth

$0e^-$

$\sigma = 0.30 \times 0$

$\sigma = 0$

$Z^*_{eff} = Z - \sigma$

$= 1 - 0$

$$Z^*_{eff} = 1$$

Topic :- Calculation of σ & Z^*_{eff} :-

(2) He (Z = 2) = $1s^2$

nth: 1e⁻

$\sigma = 0.30 \times 1e^-$
$= 0.30$

$Z^*_{eff} = Z - \sigma$
$= 2 - 0.30$

$Z^*_{eff} = 1.70$

(3) Li (Z = 3) = $1s^2 2s^1$

(n-1)th: 2e⁻ ; nth: 0e⁻

$\sigma = 0 \times 0.35 + 2 \times 0.85$
$= 1.70$

$Z^*_{eff} = Z - \sigma$
$= 3 - 1.70$

$Z^*_{eff} = 1.30$

(4) Be (Z = 4) = $1s^2 2s^2$

(n-1): 2e⁻ ; nth: 1e⁻

$\sigma = 0.35 \times 1 + 2 \times 0.85$
$= 0.35 + 1.70$
$= 2.05$

$Z^*_{eff} = Z - \sigma$
$= 4 - 2.05$

$Z^*_{eff} = 1.95$

(5) B (Z = 5) = $1s^2 2s^2 2p^1$

(n-1): 2e⁻ ; nth: 2e⁻

$\sigma = 2 \times 0.35 + 2 \times 0.85$
$= 0.70 + 1.70$
$= 2.40$

$Z^*_{eff} = Z - \sigma$
$= 5 - 2.40$

$Z^*_{eff} = 2.60$

$\rightarrow C\ (Z=6) = 1s^2\ 2s^2\ 2p^2$

$(n-1)$: $2e^-$; n^{th}: $3e^-$

$\sigma = 0.35 \times 3 + 0.85 \times 2$

$= 1.05 + 1.70$

$= 2.75$

$Z^*_{eff} = Z - \sigma$

$= 6 - 2.75$

$Z^*_{eff} = 3.25$

$\rightarrow N\ (Z=7) = 1s^2\ 2s^2\ 2p^3$

$(n-1)$: $2e^-$; n^{th}: $4e^-$

$\sigma = 0.35 \times 4 + 0.85 \times 2$

$= 1.4 + 1.70$

$= 3.10$

$Z^*_{eff} = Z - \sigma$

$= 7 - 3.10$

$Z^*_{eff} = 3.90$

$\rightarrow O\ (Z=8) = 1s^2\ 2s^2\ 2p^4$

$(n-1)$: $2e^-$; n^{th}: $5e^-$

$\sigma = 0.35 \times 5 + 0.85 \times 2$

$= 1.75 + 1.7$

$= 3.45$

$Z^*_{eff} = Z - \sigma = 8 - 3.45 = 4.55$

$\rightarrow F\ (Z=9) = 1s^2\ 2s^2\ 2p^5$

$(n-1)$: $2e^-$; n^{th}: $6e^-$

$\sigma = 6 \times 0.35 + 0.85 \times 2$

$= 2.10 + 1.70$

$= 3.80$

$Z^*_{eff} = Z - \sigma$

$= 9 - 3.80$

$Z^*_{eff} = 5.20$

$\rightarrow Ne\ (Z=10) \rightarrow 1s^2\ 2s^2\ 2p^6$

$(n-1)$: $2e^-$; n^{th}: $7e^-$

$\sigma = 7 \times 0.35 + 0.85 \times 2$

$= 2.45 + 1.70$

$= 4.15$

$Z^*_{eff} = Z - \sigma$

$= 10 - 4.15$

$Z^*_{eff} = 5.85$

Topic :- Calculation of σ & Z^*_{eff} Continue :-

→ Na (Z = 11) → $1s^2\ 2s^2\ 2p^6\ 3s^1$

(n−2): 2e⁻ ; (n−1): 8e⁻ ; nth: 0e⁻

$\sigma = 0 \times 0.35 + 8 \times 0.85 + 1 \times 2$
$= 0 + 6.8 + 2$
$= 8.8$

$Z^*_{eff} = Z - \sigma$
$= 11 - 8.8$

$Z^*_{eff} = 2.2$

→ Mg (Z = 12) → $1s^2\ 2s^2\ 2p^6\ 3s^2$

(n−2): 2e⁻ ; (n−1): 8e⁻ ; nth: 1e⁻

$\sigma = 1 \times 0.35 + 8 \times 0.85 + 1 \times 2$
$= 0.35 + 6.8 + 2$
$= 9.15$

$Z^*_{eff} = Z - \sigma$
$= 12 - 9.15$
$= 2.85$

→ Al (Z = 13) → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

(n−2): 2e⁻ ; (n−1): 8e⁻ ; nth: 2e⁻

$\sigma = 2 \times 0.35 + 8 \times 0.85 + 2 \times 1$
$= 0.7 + 6.8 + 2$
$= 9.5$

$Z^*_{eff} = Z - \sigma$
$= 13 - 9.5$
$Z^*_{eff} = 3.5$

→ Si (Z = 14) → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

$1s^2$: (n-1), $2e^-$; $2s^2\ 2p^6$: (n-1), $8e^-$; $3s^2\ 3p^2$: nth, $3e^-$

$\sigma = 3 \times 0.35 + 8 \times 0.85 + 2 \times 1$
$= 1.05 + 6.8 + 2$
$= 9.85$

$Z^*_{eff} = Z - \sigma$
$= 14 - 9.85$
$Z^*_{eff} = 4.15$

→ P (Z = 15) → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

$1s^2$: (n-2), $2e^-$; $2s^2\ 2p^6$: (n-1), $8e^-$; $3s^2\ 3p^3$: (nth), $4e^-$

$\sigma = 4 \times 0.35 + 8 \times 0.85 + 2 \times 1$
$= 1.4 + 6.8 + 2$
$= 10.2$

$Z^*_{eff} = Z - \sigma$
$= 15 - 10.2$
$Z^*_{eff} = 4.8$

Topic :- Continue... Calculation σ & Z^*_{eff} :-

→ $S(Z=16) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

(n-2): 2e⁻ ; (n-1): 8e⁻ ; nth: 5e⁻

$\sigma = 0.35 \times 5 + 0.85 \times 8 + 1 \times 2$

$= 1.75 + 6.8 + 2$

$= 10.56$

$Z^*_{eff} = Z - \sigma$

$= 16 - 10.55$

$Z^*_{eff} = 5.45$

→ $Cl(Z=17) \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

(n-2): 2e⁻ ; (n-1): 8e⁻ ; nth: 6e⁻

$\sigma = 0.35 \times 6 + 0.85 \times 8 + 1 \times 2$

$= 2.1 + 6.8 + 2$

$= 10.9$

$Z^*_{eff} = Z - \sigma$

$= 17 - 10.9 = 6.1$

$Z^*_{eff} = 6.1$

→ $Ar(Z=18) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

(n-2): 2e⁻ ; (n-1)th: 8e⁻ ; nth: 7e⁻

$\sigma = 0.35 \times 7 + 0.85 \times 8 + 1 \times 2$

$= 2.45 + 6.8 + 2$

$= 11.25$

$Z^*_{eff} = Z - \sigma$

$= 18 - 11.25$

$Z^*_{eff} = 6.75$

→ $K(Z=19) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

(n-3): 2e⁻ ; (n-2): 8e⁻ ; (n-1): 8e⁻ ; nth: 0e⁻

$\sigma = 0.35 \times 0 + 0.85 \times 8 + 1 \times 8 + 1 \times 2$

$= 0 + 6.8 + 8 + 2$

$= 16.8$

$Z^*_{eff} = Z - \sigma$

$= 19 - 16.8$

$Z^*_{eff} = 2.2$

→ $Ca(Z=20) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(n-3): 2e⁻ ; (n-2): 8e⁻ ; (n-1): 8e⁻ ; nth: 1e⁻

$\sigma = 1 \times 0.35 + 0.85 \times 8 + 1 \times 8 + 1 \times 2$

$= 0.35 + 6.8 + 8 + 2$

$= 17.15$

$Z^*_{eff} = 20 - 17.15$

$Z^*_{eff} = 2.85$

→ $Sc(Z=21) = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$

2e⁻ ; 8e⁻ ; 9e⁻ ; 1e

$\sigma = 1 \times 0.35 + 0.85 \times 9 + 1 \times 8 + 1 \times 2$

$= 0.35 + 7.65 + 8 + 2$

$= 18$

$Z^*_{eff} = Z - \sigma$

$= 21 - 18$

$= 3$

→ Ti (Z=22) → $1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^2 \; 4s^2$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	10e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 10 + 1 \times 8 + 1 \times 2$
$= 0.35 + 8.5 + 8 + 2$
$= 18.85$

$Z^*_{eff} = Z - \sigma$
$= 22 - 18.85$

$Z^*_{eff} = 3.15$

→ V (Z=23) → $1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^3 \; 4s^2$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	11e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 11 + 1 \times 8 + 1 \times 2$
$= 0.35 + 9.35 + 8 + 2$
$= 19.7$

$Z^*_{eff} = Z - \sigma$
$= 23 - 19.7$

$Z^*_{eff} = 3.3$

→ Cr (Z=24) → $1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^5 \; 4s^1$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	13e⁻	0e⁻

$\sigma = 0 \times 0.35 + 13 \times 0.85 + 10 \times 1$
$= 21.05$

$Z^*_{eff} = Z - \sigma$
$= 24 - 21.05$

$Z^*_{eff} = 2.95$

→ Mn (Z=25) →
$1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^5 \; 4s^2$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	13e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 13 + 1 \times 10$
$= 0.35 + 11.05 + 10$
$= 21.4$

$Z^*_{eff} = Z - \sigma$
$= 25 - 21.4$
$= 3.60$

→ Fe (Z=26) →
$1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^6 \; 4s^2$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	14e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 14 + 1 \times 10$
$= 0.35 + 11.9 + 10$
$= 22.25$

$Z^*_{eff} = Z - \sigma$
$= 26 - 22.25$
$= 3.75$

→ Co (Z=27) →
$1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^7 \; 4s^2$

(n−3)	(n−2)	(n−1)th	nth
2e⁻	8e⁻	15e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 15 + 1 \times 10$
$= 0.35 + 12.75 + 10$
$= 23.10$

$Z^*_{eff} = Z - \sigma$
$= 27 - 23.10$
$= 3.90$

→ Ni (Z=28) →
$1s^2 \; 2s^2 2p^6 \; 3s^2 3p^6 3d^8 \; 4s^2$

(n−3)	(n−2)	(n−1)	nth
2e⁻	8e⁻	16e⁻	1e⁻

$\sigma = 0.35 \times 1 + 0.85 \times 16 + 1 \times 10$
$= 0.35 + 13.6 + 10$
$= 23.95$

$Z^*_{eff} = 28 - 23.95 =$ **4.05**

→ Cu(29) → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

$(n-3)$	$(n-2)$	$(n-1)$	n^{th}
$2e^-$	$8e^-$	$18e^-$	$0e^-$

$$\sigma = 0.35 \times 0 + 18 \times 0.85 + 10 \times 1$$
$$= 0 + 15.3 + 10$$
$$= 25.3$$

$$Z^*_{eff} = Z - \sigma$$
$$= 29 - 25.3$$
$$= 3.7.$$

→ Zn (Z = 30) → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

$(n-3)$	$(n-2)$	$(n-1)$	n^{th}
$2e^-$	$8e^-$	$18e^-$	$1e^-$

$$\sigma = 1 \times 0.35 + 18 \times 0.85 + 10 \times 1$$
$$= 0.35 + 15.3 + 10$$
$$= 15.65 + 10$$
$$= 25.65$$

$$Z^*_{eff} = Z - \sigma$$
$$= 30 - 25.65$$
$$= 4.35.$$

Periodic variation :-

① From left to right in a period Z^*_{eff} increases. i.e, Atomic size decreases.

② from top to bottom in a group, Z^*_{eff} remain constant. (not defined)

Topic :- Penetration of Orbitals :-

Defn :- It is the ability of an orbital to attract an electron.

- → This process is achieved together with release of energy.
- → The high extent of Penetration is a feature of orbitals.
- → The penetration effect of s orbital is the maximum because of the closeness to the nucleus that are the p, d & f orbitals.
- → It describes the proximity to which an e⁻ can approach to the nucleus.
- → In a multielectron system electron penetration is defined by an electron's relative electron density near the nucleus of an atom.
- → Electrons in different electron densities around the nucleus.

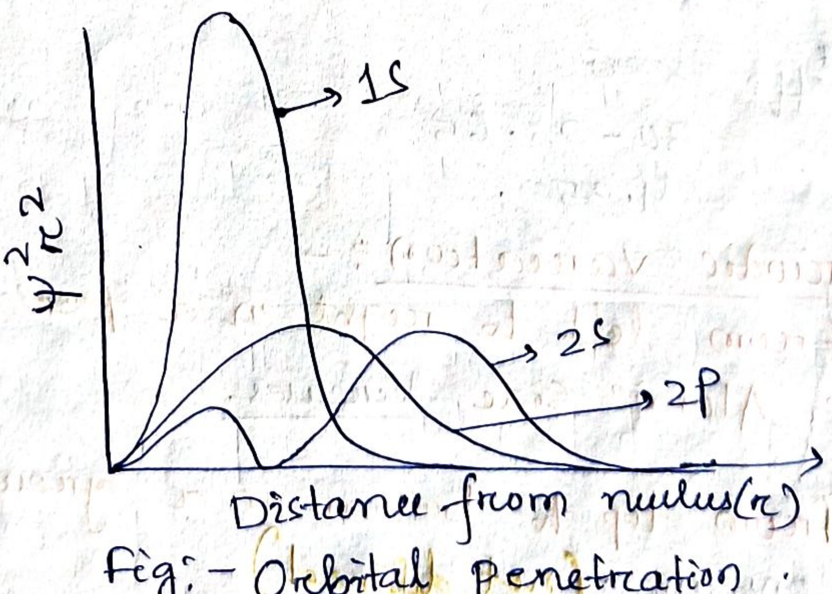


Fig:- Orbital Penetration.

s > p > d > f

→ 1s > 2s > 2p > 3s > 3p > 4s > 3d > 4p > 5s > 4d > 5p > 6s > 4f.

Topic :- Variation of s, p, d & f orbitals energy of an atom in a periodic table :-

→ There are many physical and chemical properties elements which show periodic variation with atomic no.

→ Some of these properties such as valency, atomic size, Ionization energy and electron affinity are directly related to the electronic configuration.

→ The properties such as melting point, density are indirectly related to electronic configuration.

1. Valency :-

→ The valency of an element is directly related to the electronic configuration of its atom and usually determined by the no. of electrons in the outermost shell. This is became the outer-most electrons are the ones which are largely responsible for the chemical behaviour, as the electrons in these orbital usually participate in chemical bonding.

→ The outermost shell electrons are referred as valence shell electron or valence electron.

Variation of Valency in a Period :-

→ Left to right, no. of valence electron increases for the 2nd period there are some exception to this rule.

Element	Li	Be	B	C	N	O	F
Valency	1	2	3	4	3	2	1

Increase ⟶ ⟵ Decrease

In a group :-

On moving down in a group no. of valence electron for all element for group-1 is constant.

Element	H	Li	Na	K	Rb	Cs	Fr
Valency	1	1	1	1	1	1	1

i,e, (1)

Element	Be	Mg	Ca	Sr	Ba	Ra
Valency	2	2	2	2	2	2

i,e, (2)

Transition Element :-

→ It have generally 1 to 2 electrons in their outermost orbital. So, they exhibit variable valency but most common valency is 2.

2. Atomic Radius variation :- Atomic size :-

The distance from the centre of the nucleus to the outermost shell containing the electrons.

Difficulties to determine atomic size :-

(i) The exact size of the electron cloud can't be determined as the probability of finding an electron never be easy.

(ii) It is not possible to isolate a single atom for the purpose.

(iii) Different bonded state changes the radius.

Covalent radii :-

(i) It is defined as one-half of the distance between the nuclei of two covalently bonded atoms of the same element in a molecule.

(ii) The inter-nuclear distance between two bonded atoms is called **Bond length**.

$$r_{covalent} = \frac{1}{2}(\text{Bond length})$$

Ex – (H_2)

Q.1 The internuclear distance between two H-H atom in 'H' molecule is 74 pm or 0.74 Å.

Ans :- $r_{covalent} = \frac{1}{2} \times 74 \text{ pm}$

$= 37 \text{ pm}$ or 0.37 Å

Q.2. The internuclear distance between Cl-Cl atom in Cl_2 molecule is 198 pm or 1.98 Å.

Ans :- $r_{covalent} = \frac{1}{2} \times 198 \text{ pm}$

$= 99 \text{ pm}$

Q.3. The internuclear distance between Cu-Cu atom in Cu_2 molecule is 256 pm.

Ans :- $r_{covalent} = \frac{1}{2} \times 256 \text{ pm}$

$= 128 \text{ pm}$

Periodic Trends in atomic radii :-

Atomic number ↑ , Atomic radii ↓

In a period :-

→ As we move from left to right in a period nuclear charge increases by one unit in each succeeding element while the number of shells remains same. Due to this enhanced nuclear charge, the e's of all the shells are pulled little closer to the nucleus there by making individual shell smaller & smaller. This results in a decrease of atomic radius.

Ex :- N — O — F
↓ ↓ ↓
155 pm 152 pm 147 pm

Atomic Number ↑ Atomic radii ↑

→ Top to bottom in Group :-

→ Increase in atomic number, the nuclear charge also increases.

→ The effect of the increased charge is reduced due to the screening effect on the valence electron by the e^- present in the inner shells. Thus, the effects of adding a new energy shell is so large that it over weighs -

- The contractive effect increased of nuclear change. Hence the increase in atomic radii as we move from top to bottom.

Ex - Li to Cs along with F to I due to increase new energy shell.

Ex-2 - Cl → 175 pm, Br → 185 pm, I → 198 pm

Ionisation Energy :-

→ It is the amount of energy required to remove an e^- from an isolated neutral gaseous atom.

$M(g) + I.E \longrightarrow M^+(g) + e^-(g)$

→ It is also called ionisation potential, because it measured as the amount of potential needed to remove the most loosely held e^- from the gaseous atom.

→ It is expressed in Kcal/mol or KJ/mole or eV.

→ The smaller value of I.E, the easier it is to remove the e^- from the atom.

Factor's on which Ionisation Energy depends

1. Size of the atom :-

(i) It depends upon the distance between the e^- and nucleus i.e, size of atom.

(ii) The size of the atom increases, the outermost e^- are less strongly attracted by the nucleus because the force of attraction inversely proportional to the square of the distance between the charged particles. As a result, it becomes easier to remove electron.

Size ↑ , I.E ↓

(2) Charge on the nucleus :-

The attractive force betn the nucleus and e^- increases with increase in nuclear charge. This is because the force of attraction is directly proportional to the product of charges on the nucleus and that on the e^-.

Nuclear charge ↑ , I.E. ↑

(3) Screening effect of the inner e^- :-

No. of e^-s increases, e^- force decreases and I.E also decreases.

(4) Penetration effect of e^-s :-

Penetration power of e^-s increases and I.E. increases.

→ I.E. is high with high penetrating subshell.

(5) Electronic configuration :-

→ It is difficult to remove e^- from a stable configuration & I.E. is high.

→ Ex :- Noble gases have high I.E.
Be, Mg have completely filled orbitals with high I.E.

→ Thus, the more stable the electronic configuration the greater will be I.E.

→ Stable electronic configuration increases, I.E increases.

→ **Variation of I.E. in Periodic Table :-**

(i) **Variation along a Period :-**

Atomic number increases I.E. increases.

(ii) **In a group :-**

I.E decreases.

* **Electron affinity :-**

The amount of energy released when an e^- is added to an isolated gaseous atom is called Electron affinity.

→ It expressed in $KJmol^{-1}$.

* **Factors on which Electron-Affinity depends:-**

(i) **Nuclear charge :-**

E.A increases as the nuclear charge increases. Due to greater attraction for the incoming e^- if nuclear charge is high.

(ii) Size of the atom :-

→ Increase in size of the atom the distance bet^n the nucleus and the incoming e^- increases and this result lesser attraction.

→ So EA decreases with increase in size of the atom.

Size increases ; E.A decreases

(iii) Electronic configuration :-

Element having stable electronic configuration of half and completely filled valence subshell, show very small tendency to accept additional e^-.

→ Thus EA is less.

Variation :- (E.A)

Group :-

→ Moving from top to bottom the atomic size and nuclear charge increases, thus the additional e^- feels less attraction by the large atom. So, EA decreases.

Top to bottom :-

Atomic size increases. Nuclear charge increases. Electron affinity decreases.

Electron affinity :- Variation

Period :-

→ Moving from left to right, the size of the atom decreases and nuclear charge increases, so, EA increases.

Left to Right :-

Size of atom decreases Nuclear charge increases, EA increases.

* Electro-negativity :-

Defn :- The tendency of an atom to attract the shared e^- pair in a molecule, towards itself is called Electronegativity.

→ Greater the ability of an atom to attract e^- in a bond, the larger is the value of its electronegativity.

→ There is no direct methods of measuring Electronegativity.

Factors affecting the Electronegativity

1. **Oxidation state :-**
The electronegativity increases, as the (+ve) (O.S) of the atom increases.

- Because with the +ve (O.S), the tendency to attract the e^- will increase. Electronegativity increases, +ve O.S increases, attract e^- increases.

→ For anions, the electronegativity decreases with the increasing (-ve) charge of the ion. Due to more (-ve) charge ion will attract e^- less than a less (+ve) charge ion.

(2) Nature of the substituents :-

Electronegativity of group varies with the nature of the substituents. Due to inductive effect of substituent group

Ex → $-CH_3 = 2.30$

$-CCl_3 = 3.30$

$-CF_3 = 3.35$

(3) Size of the atom :-

→ Atoms with smaller size have higher value of electronegativity.

Size decreases, Electronegativity increases.

→ This is due to small atoms have higher Z^*_{eff}.

→ Therefore, the shared pair of e^- is pulled more strongly by the nucleus and the electronegativity is high.

Electronegativity depends factors Continue :-

4) Nature of the substituent attached to the atom :-

→ Electronegativity of the atom varies as the substituent attached to its are changed.

Ex - The electronegativity of Cl in ClF and HCl is different.

5) Bond Order :-

As the bond order increases the electro-negativity increases.

Bond order increases ↑, E.N ↑ increase.

Application :-

It helps in determining

a) Bond type & Bond order.

b) Qualitative thermal stabilities.

c) Logic behind similarities and difference observed in chemical behaviour of molecules.

Trends in Electronegativity :-

In a Period :-

E.N ↑ increases, Z^*_{eff} increases ↑.

In a group :-

E.N decreases ↓, Z^*_{eff} decreases ↓

Polarizability :-

→ The ease of this distoration is defined as the polarizability of the atom or molecule.

→ Here the word "Ease" means, how easily an e^- cloud can be distorted by an electric field.

Example :-

→ Large (−ve) ion such as I^- and Br^- are highly Polarizable.

→ Small (+ve) charged ions such as Mg^{2+} & Al^{3+} are Low Polarizable.

* Oxidation State :-

Ex :- $Cr_2O_7^{2-}$

Soln :- $2x + (-2)7 = -2$

$\Rightarrow 2x - 14 = -2$

$\Rightarrow 2x = 12$

$\Rightarrow \boxed{x = +6}$

Ex-2 Na_3PO_4.

Soln :- $3 \times 1 + x + (-2)4 = 0$

$\Rightarrow \boxed{x = +5}$