

UNIT-2 : (Periodic Properties)

Grp-1 Grp-2		Grp (13-18)					
Li	Bc	B C N O F N ₂ O					
S.block		p block (1-6)					
ns ⁽¹⁻²⁾	Sc Ti V Cr Mn Fe Co Ni Cu Zn	ns ² np					
	(n-1)d ¹⁻¹⁰ ns ⁽¹⁻²⁾ np ⁶	d block					

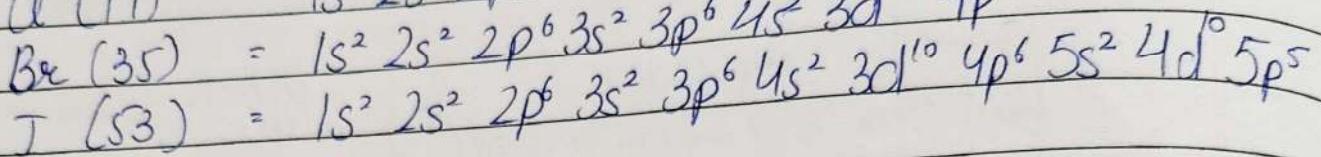
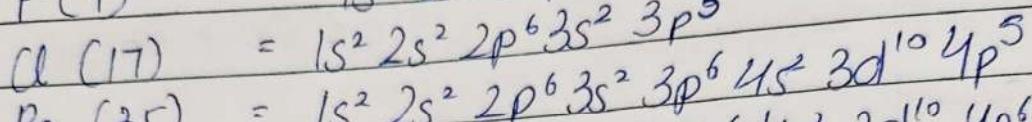
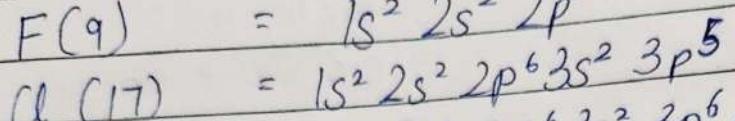
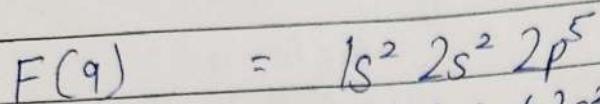
La	f block
Ac	(n-2)f ¹⁻¹⁴ (n-1)d ⁰⁻⁷ ns ² np ⁶

Seven Periods (Horizontal)
18 Groups (Vertical)

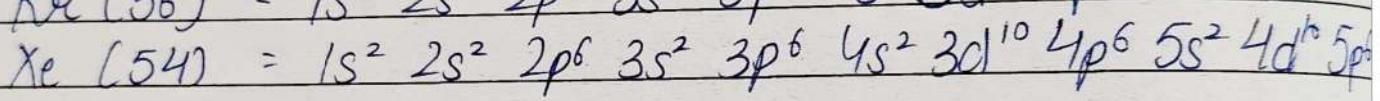
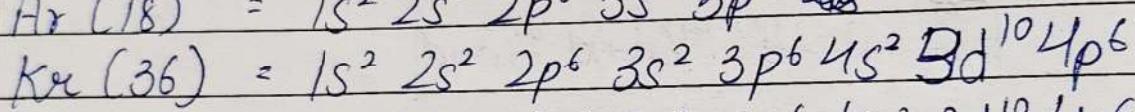
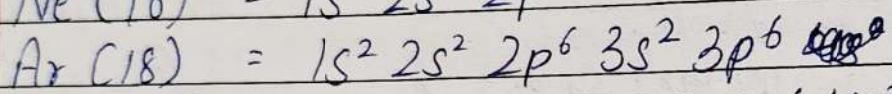
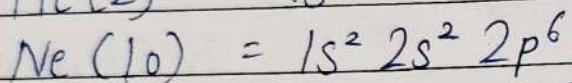
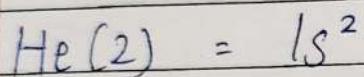
- Key terms →
 - Atomic Radii
 - Ionic Radii
 - Effective Nuclear Charge
 - Oxidation State
 - Ionic Character
 - Acidity / Basicity

- Scandium (Sc) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$
- Ti (22) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
- V (23) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
- Cr (24) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
- Mn (25) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
- Fe (26) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
- Co (27) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
- Ni (28) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
- Cu (29) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$
- Zn (30) $\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

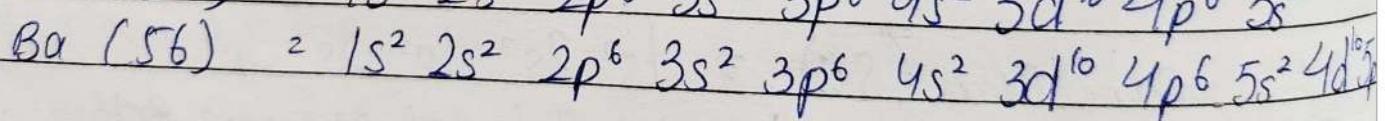
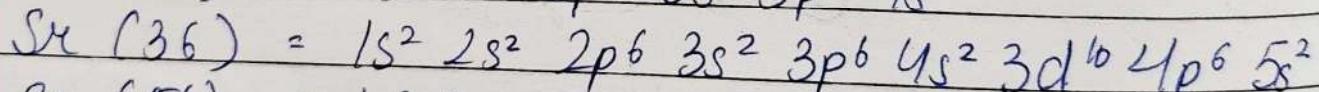
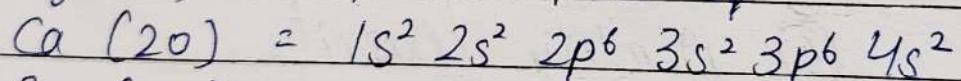
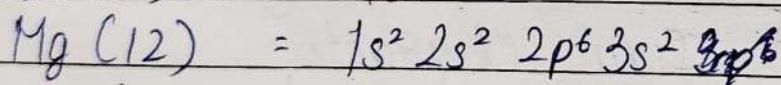
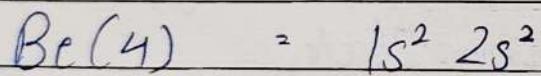
- Halogens $(ns^2 np^5)$



- Noble Gases = inert gases $(ns^2 np^6)$



- Group - 2



Effective nuclear charge (Slater rule)

- The actual nuclear charge felt by the outermost electron is called effective nuclear charge. It is denoted by Z^* . ^{effective}
- Effective nuclear charge can be calculated by following eqⁿ.

$$Z^* = Z - S$$

where, Z = Nuclear charge (at no) , Also $Z = n \times e^- / n \times \rho$
 S = Shielding / screening effect

- If screening is small then effective nuclear charge will be high and if screening is high the effective nuclear charge will be low.
- Slater rule →

Slater proposed certain rules for calculation of effective nuclear charge-

(i) Write the electronic configuration in the following order

(1s) (2s 2p) (3s 3p) (3d) (4s 4p) (4d) (4f)

(ii) Electron in any group higher in the sequence than e^- under consideration do not screen those in lower group and therefore contribute

zero to screening constant.

- (iii) Electron in the same group contribute screening constant ($S=0.35$) each, except H,.
- (iv) All electron in $(n-1)$ will contribute ($S=0.85$) each and all electrons in $(n-2)$ shell will contribute ($S=1$) each.
- (v) Foreign ^{an} electron in nd or nf shell ; all electrons in the lower group will contribute ($S=1.0$) each. Only the electrons present in the same group will contribute ($S=0.35$) each.

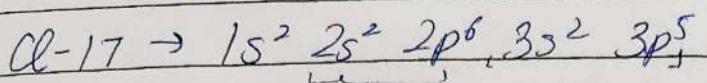
Ques- Calculate the effective nuclear charge for outermost electron of Oxygen atom?

Ans- $D = 1s^2 \underbrace{2s^2}_{\text{outermost}} 2p^4$

$$\begin{aligned} \text{Here, } S &= 5 \times 0.35 + 2 \times 0.85 \\ &= 1.75 + 1.70 \\ &\Rightarrow 3.45 \end{aligned}$$

$$\begin{aligned} Z^* &= 8 - 3.45 \\ &= 4.55 \end{aligned}$$

2. Calculate the E.N.C of 3p electron of chlorine

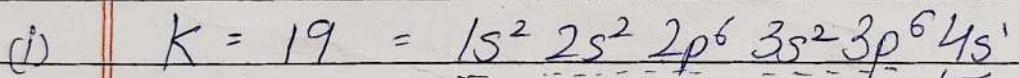


$$\begin{aligned} \text{Here, } S &= 6 \times 0.35 + 8 \times 0.85 + 2 \times 1 \\ &= 2.10 + 6.80 + 2 \\ &\Rightarrow 10.9 \end{aligned}$$

$$\begin{aligned} Z^* &= 17 - 10.9 \\ &= 6.1 \end{aligned}$$

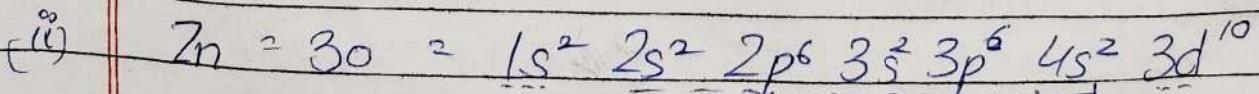
Ques → Calculate ENC for the following

- (i) 4s electron of potassium
- (ii) 4s e⁻ of zinc.
- (iii) 5s and 4d e⁻ of silver
- (iv) 3p of phosphorous



$$\begin{aligned} \text{Here, } S &= 0 \times 0.35 + 8 \times 0.85 + 1 \times 1 + 10 \\ &= 6.80 + 10 \\ &= 16.80 \end{aligned}$$

$$\begin{aligned} Z^* &= Z - S \\ &= 19 - 16.80 \\ &= 2.20 \end{aligned}$$

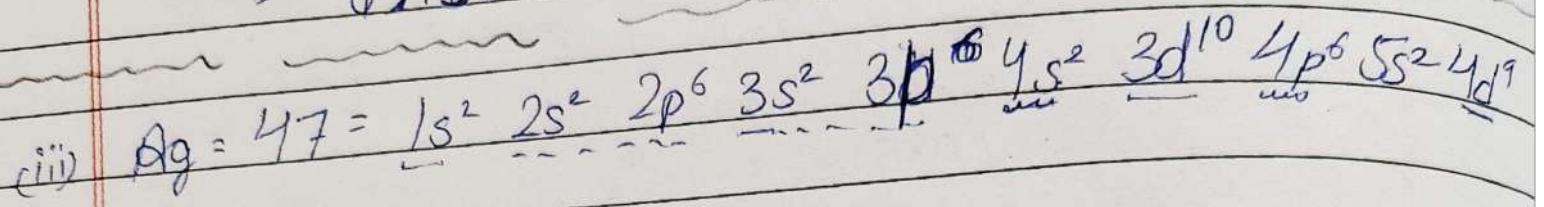


$$\begin{aligned} \text{Here, } S &= 1 \times 0.35 + 10 \times 0.85 + 1 \times 1 + 10 \\ &= 0.35 + 15.80 + 10 \\ &= 25.65 \end{aligned}$$

$$Z^* = Z - S$$

$$= 30 - 25.65$$

$$= 04.35$$



Ans. For $5d$ orbital

$$= \text{Ag} = \underbrace{1s^2}_{\text{1s}} \underbrace{2s^2}_{\text{2s}} \underbrace{2p^6}_{\text{2p}} \underbrace{3s^2}_{\text{3s}} \underbrace{3p^6}_{\text{3p}} \underbrace{4s^2}_{\text{4s}} \underbrace{3d^{10}}_{\text{3d}} \underbrace{4p^6}_{\text{4p}} \underbrace{4d^{10}}_{\text{4d}} \underbrace{5s^1}_{\text{5s}}$$

$$\text{Here, } S = 9 \times 0.35 + 1 \times 36 \\ = 39.15$$

$$Z^* = Z - S$$

$$= 47 - 39.15 = 7.85$$

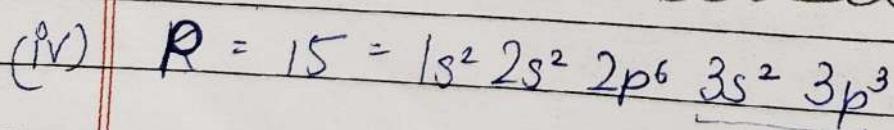
For $5s$

~~Ans.~~

$$\text{Here, } S = 0 \times 0.35 + 18 \times 0.85 + 28 \times 1 \\ = 43.3$$

$$Z^* = Z - S$$

$$= 47 - 43.3 = 3.7$$



Ans. For $3p$ orbital

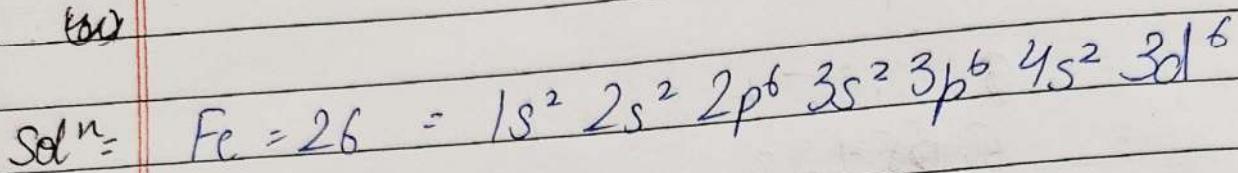
$$\text{Here, } S = 4 \times 0.35 + 8 \times 0.85 + 2 \times 1 \\ = 1.40 + 6.8 + 2 \Rightarrow 10.9$$

$$Z^* = 15 - 10.9 = 4.8$$

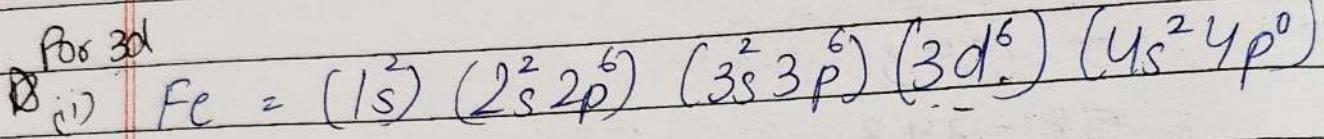
Ques) Calculate the ENC for (i) $4s^2$ & iron?

- (ii) 3d e⁻ of iron
- (iii) 2p e⁻ of Nitrogen
- (iv) 4s e⁻ of Copper

(v)



Accⁿ to Slatter rule



$$\begin{aligned} \text{Here, } S &= 5 \times 0.35 + 8 \times 0.85 + 10 \times 1 \\ &= 1.75 + 0.85 + 10 \\ &= 19.75 \end{aligned}$$

$\begin{matrix} 10.00 \\ 1.75 \\ 6.80 \\ 18.75 \end{matrix}$

$$\begin{aligned} Z^* &= Z - S \\ &= 26 - 19.75 \\ &= 6.25 \end{aligned}$$

i) For 4s,

$$\begin{aligned} \text{Here, } S &= 1 \times 0.35 + 14 \times 0.85 + 16 \times 1 \\ &= 0.35 + 11.9 + 16 \\ &= 22.25 \end{aligned}$$

$$\begin{aligned} Z^* &= Z - S \\ &= 26 - 22.25 \\ &= 3.75 \end{aligned}$$

(iii) $N = 7 = 1s^2 2s^2 2p^3$

$$\begin{aligned} \text{Here } S &= 5 \times 4 \times 0.35 + 2 \times 0.85 \\ &= 1.4 + 1.7 \\ &= 3.1 \end{aligned}$$

$$\begin{aligned} Z^* &= Z - S \\ &= 7 - 3.1 \\ &= 3.9 \end{aligned}$$

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

According to Slater rule,

$$Cu = (1s^2)(2s^2 2p^6)(3s^2 3p^6)(3d^{10})(4s^1 4p^0)$$

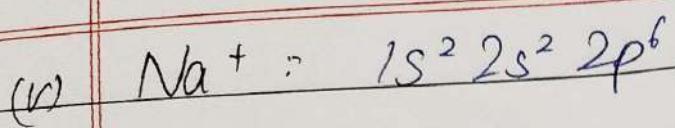
$$\begin{aligned} \text{Here } S &= 0 + 18 \times 0.85 + 10 \times 1 \\ &= 15.3 + 10 \\ &= 25.3 \end{aligned}$$

$$\begin{aligned} Z^* &= Z - S \\ &= 29 - 25.3 \\ &= 3.7 \end{aligned}$$

(v) $Na = 11 = 1s^2 2s^2 2p^6 3s^1 \quad 11e^-$

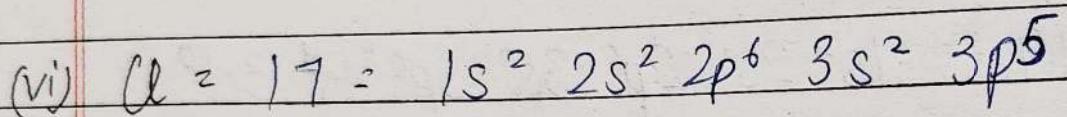
$$\begin{aligned} \text{Here } S &= 0 + 8 \times 0.85 + 2 \times 1 \\ &= 6.8 + 2 \\ &= 8.8 \end{aligned}$$

$$Z^* = Z - S = 11 - 8.8 = 2.2$$



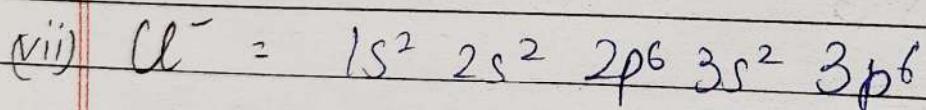
$$\text{Here } S_g = 7 \times 0.35 + 2 \times 0.85 \\ = 2.45 + 1.7 \\ = 4.15$$

$$Z^* = Z - S \\ = 11 - 4.15 \\ = 6.85$$



$$\text{Here } S = 6 \times 0.35 + 8 \times 0.85 + 2 \times 1 \\ = 2.1 + 6.8 + 2 \\ = 10.9$$

$$Z^* = 17 - 10.9 \\ = 6.1$$



$$\text{Here } S = 7 \times 0.35 + 8 \times 0.85 + 2 \times 1 \\ = 2.45 + 6.8 + 2 \\ = 11.25$$

$$Z^* = 17 - 11.25 \\ = 5.75$$

PROPERTIES

① Atomic radii

The distance from the centre of the nuclei to the outermost shell of the nuclei since, it is difficult to isolate an atom and to measure its radius.

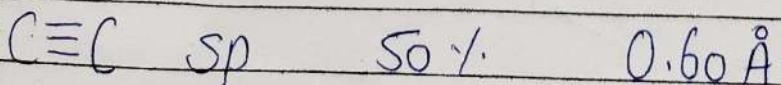
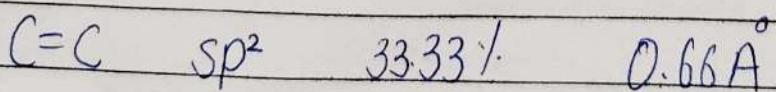
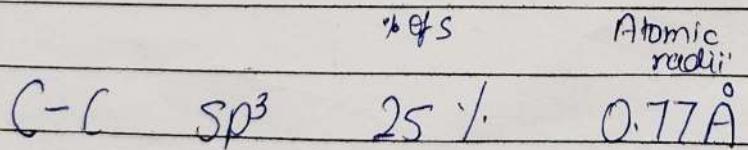
Therefore, atomic radius is measured as effective atomic size which means the distance of closest approach of one atom to another in a given bonding situation.

In other words, atomic radius may be called as covalent radius, metallic radius and Vanderwall radii.

(i) Covalent Radius → It is defined as one half of the distance b/w the centre of nuclei of two similar atom bonding together in a molecule.

It depends on 2 factors →

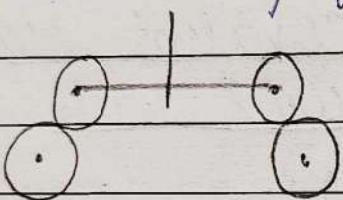
- (i) Multiplicity of the bonds
- (ii) Hybridisation



More the % of s character of Carbon more will be the Electronegativity.

(ii) Metallic Radii \rightarrow It is defined as one half of distance b/w the nuclei of 2 adjacent atoms of a metal in a metallic lattice.

(iii) Vanderwall Radii \rightarrow It is defined as one half of the internuclear distance b/w the adjacent atoms belonging to 2 nearest neighbouring molecule of the same substance in a solid state/gaseous state.



$Vanderwall R > Metallic R > Covalent R$

Atomic Radii of I

Nuclear charge (no of P^+ present)

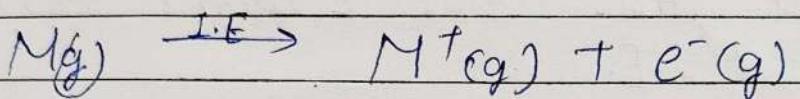
Anionic

Anionic Radii $>$ Atomic $>$ Cation

2

(2.) Ionization Energy (I) \rightarrow (kJ/mol) or (kcal/mol)

It is defined as the amount of energy required to remove the most loosely bound electron from the gaseous state & called Ionization Energy



- The various factors affecting the I.E.

(i) Nuclear charge \propto Ionisation Energy

(ii) Atomic size \propto $\frac{1}{\text{I.E.}}$

◦ With the increase in Atomic size, I.E. decreases

→ (iii) Nuclear charge \rightarrow With the increase in nuclear charge, I.E. increases

(iv) Screening / Shielding Effect \propto $\frac{1}{\text{I.E.}}$

(v) Penetration Effect \rightarrow Higher the penetration effect, higher will be the I.E.

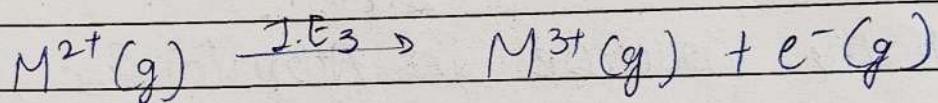
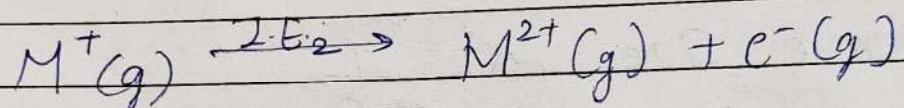
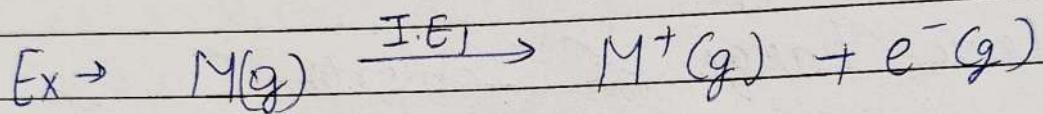
◦ P.E \propto I.E

◦ The penetration effect of orbital is \rightarrow
 $s > p > d > f$

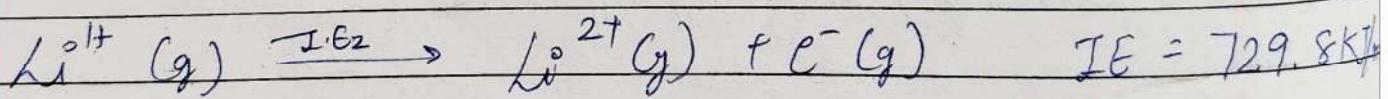
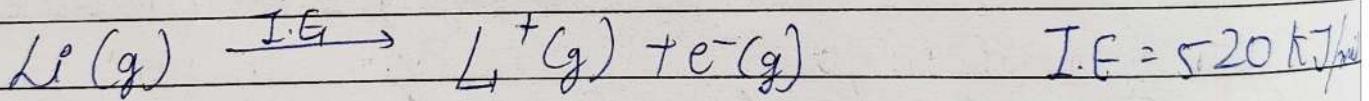
(v) Electronic Arrangement / Config. →

The half filled & fully filled orbitals are extra stable due to symmetry & exchange energy. Therefore, it has higher I.G. Ex → Noble gases whose e⁻ conf. is $\rightarrow ns^2 np^6$ have highest I.E.

(vi) Successive I.E. →



$$\textcircled{1} \quad \text{Lithium (Li)} = 1s^2 2s^1$$



$$\textcircled{2} \quad \text{Nitrogen (N)} = 1s^2 2s^2 2p^3$$

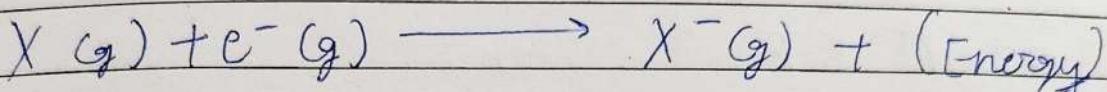
I.E₁ is higher bcz of symmetry & Exchange energy

$$\textcircled{3} \quad \text{Oxygen (O)} = 1s^2 2s^2 2p^4$$

I.E₁ is lower & I.E₂ is higher

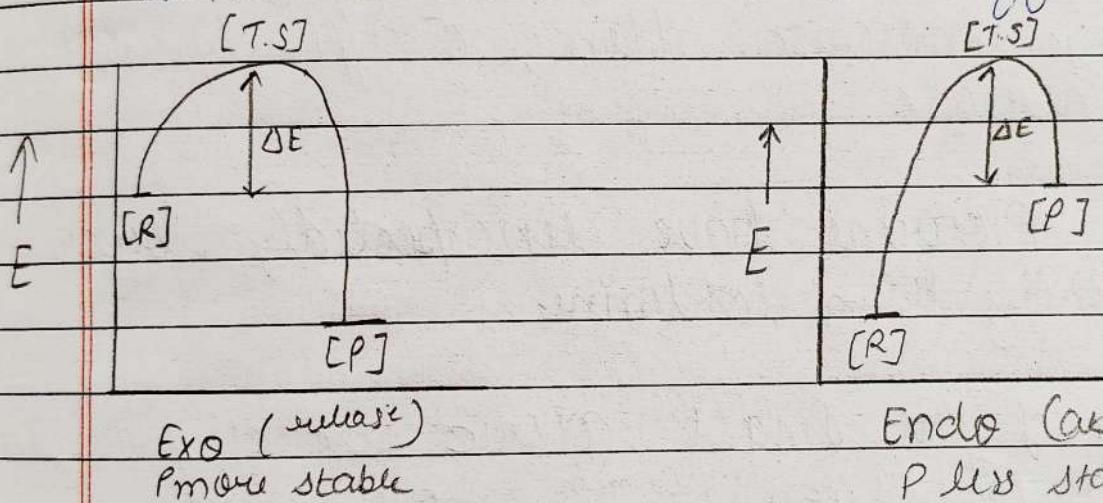
(B) Electron Affinity \rightarrow

- The amount of energy released when an electron is added to an isolated gaseous atom.



Electron Affinity can be +ve or -ve

- Factors on which electron affinity depends.



- Progress of Reaction

- Progress of rxnⁿ

- Half filled & fully filled configurations has very small tendency to accept to addⁿ e^- . Therefore, Their e^- affinity is low or almost zero.

For ex- E^- affinity of Noble gases are zero while for Be, Mg, N, P. ($E.A \rightarrow$ cannot zero)

(ii) With the increase in nuclear charge, e⁻ affinity will also increase.

For ex → Halogens have higher e⁻ affinity along its period.
 $ns^2 np^5 \rightarrow F, Cl, Br, I$

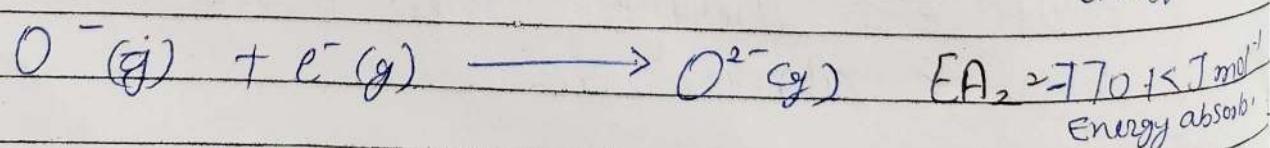
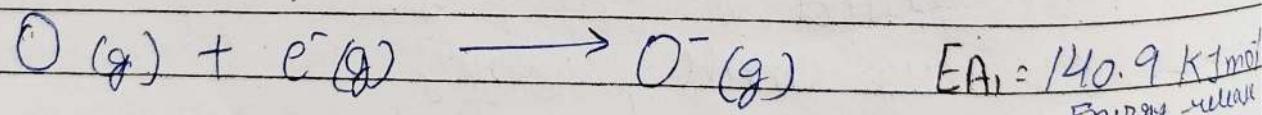
(iii) Size -

With the decrease in atomic size, nuclear charge increases. Hence, e⁻ affinity will also increase.

Qn → Why fluorine have unexpectedly lower e⁻ affinity than chlorine

Ans → Because of the small atomic size of fluorine, the ^{attraction} ^{interpolation} is more which results in the lower e⁻ affinity of fluorine.

(iv) Successive Electron Affinity →



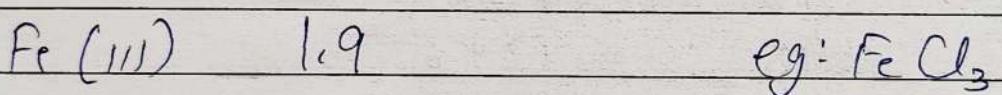
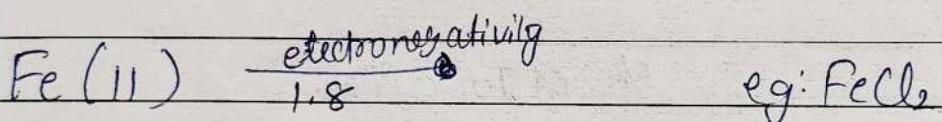
The addition of the second electron in a very charged ion leads to the ^{attraction} repulsion (Inter-electronic repulsion). Therefore, certain amount of energy is required for the addition of 2nd electron.

(4) Electronegativity →

The tendency of an atom to attract the shared pair of e⁻ toward itself is called electron negativity.

Factors affecting the Electronegativity:-

- (i) Oxidation state → With the increase in oxidation state, electronegativity will also increase. For example →



- (ii) Type of Hybridisation →

	Hybrid.	% s charac.	Electronegativity
CH_3	sp^3	25%	2.4
$\text{O}=\text{H}_2 = \text{C}=\text{H}_2$	sp^2	33.33%	2.7
$\text{CH} \equiv \text{CH}$	sp	50%	3.29

With the inc. in the % of s character of carbon, electronegativity will also inc.

- (iii) Nature of substituent

Electronegativity

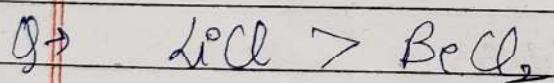
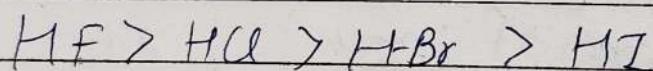
CH_3	{	2.3	}
CCl_2	{	3.30	}
CF_3	{	3.35	}

5. Ionic Character \rightarrow

It depends upon the difference in electronegativity. The greater is the diff of electronegativity in the bonded atom, the higher will be the ionic character of the

% of Ionic Char.

For ex \rightarrow	HF	45%
	HCl	19%
	HBr	11%
	H-I	4%



o Polarizability - The distortion of e^- cloud is called polarizability.

It depends upon the atomic size and electronegativity. It decide about the ionic and covalent character of the bond.

Q. Nitrogen family shows two types of oxidation state -3 and +5

The stability of higher oxidation state increases down the group due to inert pair effect.

	Oxi. state	
C	+2	+4
Si	+2	+4
Ge	+2	+4
Sn	+2	
Pb	+2	

$ns^2 np^2$

- Inert pair effect \Rightarrow It is defined as the reluctance in the participation of s-electron in bond formation due to higher penetration effect ~~or~~ called inert pair effect.

HSA B Principle-

HARD Acid

SOFT Acid

Hard Base

Soft Base

- Small size, high charge, small tve charge, not easily distorted, several valence e⁻, polarized.
- Small ionic radius, low electronegativity, high energy LUMO.
- Valence electrons or tve charge, brightley held.
- High electronegativity, intermediate electrons, low energy LUMO.
- Small radius.
- High polarizability.
- High energy HOMO.
- Valence e⁻ easily distorted.
- Small radius.
- High polarizability.
- Low energy LUMO.

e.g. H⁺, Mg²⁺

e.g. Ag⁺, Pd²⁺

e.g. F⁻ and CO₃²⁻

S²⁻, CO