

Alkali metals

the earth metals

als

family

family

gens

gens

ens

ble Grass.

(14 elements)

Amphoteric Oxides -

Znake Aali Me Bekaar Gaya Punjabi Song Aaj Sb Bikeri Indore Ga

Zn

Al

Be

Ga

Pb

Sn

As

Sb

Bi

In

Ge

Oxides of Non-metal - Acidic

Oxides of Metals - Basic
(except CrO_5 , Mn_2O_7]
Acidic

→ The suffix um/ium is added if the element is a metal or having metallic character. (except Helium)

Nomenclature of elements of higher atomic no.

0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

e.g. At no. 123
unbitrium
Ubt

* Quantum Number.

2	He
10	Ne

1) Principle quantum number (n)

It gives information about the shell in order of which e^- is present.

Allowed values of $n = 1, 2, 3, 4, \dots$

2) Azimuthal quantum number (l)

It gives information about no. of sub-shells present in a shell.

Its allowed values are - 0 to (n-1)

Note - The no. of subshells in n^{th} shell = n .

$l =$	0	1	2	3	4
	s	p	d	f	g

* Existence and Non-existence of subshells and orbitals

In case, $l = n$ or $l > n$, those subshells don't exist.

e.g. - $2d$ don't exist

$$n=2, l=2 \quad n=l \quad X$$

$\therefore 5h$ doesn't exist

$$n=5, l=5 \quad n=l \quad X$$



3) Magnetic Quantum Number (m_l)

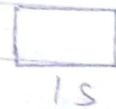
It gives the information ^{about} no. of orbitals in a subshell.

Allowed value, $-l$ to l

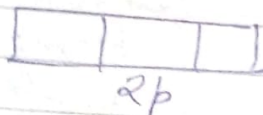
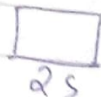
$$\text{No. of orbitals} = \underline{2l+1}$$

$\rightarrow$ No. of orbitals in n^{th} shell $= n^2$
 $\rightarrow$ No. of orbitals in l^{th} sub-shell $= 2l+1$

$n=1, l=0, m_l=0$

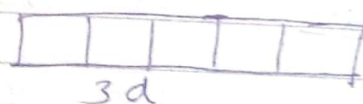
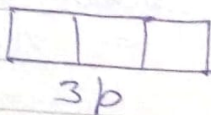
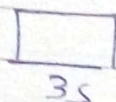


$n=2, l=0, 1, m_l=0, m_l=-1, 0, 1$



$n=3, l=0, 1, 2$

$m_l = -2, -1, 0, 1, 2$



4)

Spin Quantum Number - (s/m_s)
 It gives information about the spin of the electron.

Allowed values are - $+\frac{1}{2}$ & $-\frac{1}{2}$

*

Pauli's Exclusion Principle

No two electrons can have same value of all the four quantum numbers.

$\rightarrow$ In hypothetical questions, if the values of spin quantum number are increased, it will increase the number of orbitals e^- in orbitals.

if. $m_s/s \rightarrow +\frac{3}{2}, +\frac{1}{2}, -\frac{1}{2}, -\frac{3}{2}$

1 orbital $\rightarrow 4e^-$

* Aufbau Principle

Orbitals are filled in increasing order of their energies.

Comparison of energy of orbitals

→ (n+l) rule.

Acc. to this rule, the orbital for which, value of (n+l) is smaller, will have lower energy.

In case, value of (n+l) comes out to be same, orbital with smaller value of n will have lower energy.

e.g.

$2p$	$3s$
$n = 2$	3
$l = 1$	0
3	3

Order of Energy - $2p < 3s$

→ General Formula for the orbitals that will be filled in n^{th} period.

$ns \quad np \quad (n-1)d \quad (n-2)f \quad (n-3)g \dots$

Ques. Which orbitals will be filled in hypothetical 8th period

$8s \quad 8p \quad 7d \quad 6f \quad 5g$

The no. of elements in n^{th} period is twice the no. of orbitals that will be filled in n^{th} period.

Q. Find the no. of elements that will be present in 8^{th} period.

8s 8p 8d 6f 5g

$$1 + 3 + 5 + 7 + 9 = 25 \times 2 = \underline{50}$$

→ Formula to calculate no. of elements in n^{th} period

For $n = \text{odd}$

$$\left(\frac{n+1}{2} \right)^2 \times 2$$

For $n = \text{even}$

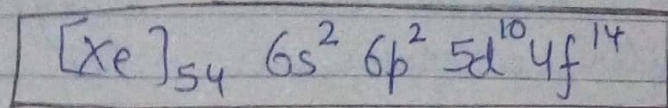
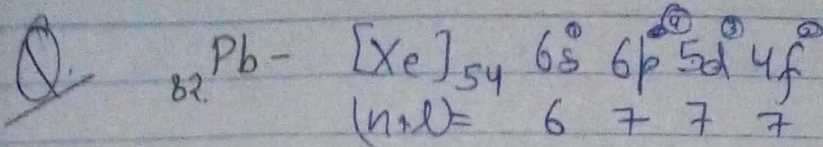
$$\left(\frac{n+2}{2} \right)^2 \times 2$$

Q. How many elements will be present in hypothetical 9^{th} period if spin quantum no. can have three values.

$$25 \times 3 = 75$$

* Condensed Electronic Configuration

- Find out the period to which the element belongs with the help of atomic no. of noble gas.
- Use the noble gas of previous period $(n-1)^{\text{th}}$.
- Write out the orbitals that will be filled in n^{th} period.
- Fill the e^- in acc. with Aufbau principle, Pauli's principle and Hund's rule.



2	H ₁
10	Ne
18	Ar
36	Kr
54	Xe
86	Rn
82	
54	
28	

→ Identification of period, block and group of an element.

When e^- configuration is given,

→ The highest value of n represents the period number

→ The orbital in which the last e^- is filled decides block of the element.

Group		Period	Block
②	$[X] = [\text{Ne}] 3s^2$	3	s
$5+1=6$	$(Y) = [\text{Ar}] 3s^2 3p^6 3d^5 4s^1$	4	d
$12+3=15$	$[Z] = [\text{Ne}] 3s^2 3p^3$	3	p

→ For s-block elements, group no. is equal to the no. of e^- in the s-orbital of valence shell.

→ For p-block, group no. is the no. of electron in p-orbital of valence shell + 12

→ For d-block elements, group no. is equal to the no. of e^- in s-orbital of valence and d-orbital of penultimate shell.

→ For f-block elements, group no. is always 3.

Effective Nuclear Charge (Z_{eff})

The actual or reduced nuclear charge experienced by an electron after screening is called Z_{eff} (E.N.C).

Mathematically,

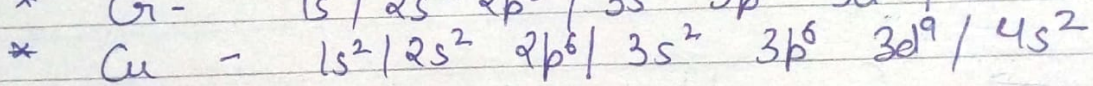
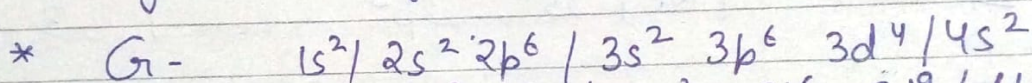
$$Z_{\text{eff}} = Z - \sigma$$

where, σ is known as screening constant.

→ For monoatomic species, $Z_{\text{eff}} = Z$

Calculation of Screening Constant (σ) according to Slater's Rule

→ Write down the ground state configuration in increasing order of shell number.



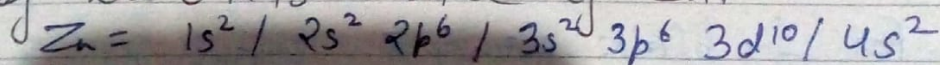
For s and p- e^- :

→ The remaining e^- s in the same shell shields by the factor of 0.35

→ The e^- s in $(n-1)^{\text{th}}$ shell will shield by the factor of 0.85.

→ The remaining inner e^- shields by a factor of 1.

Ques. What is the effective nuclear charge, experienced by the e^- in $4s$ orbital of Zn.



$$\sigma = 1 \times 0.35 + 18 \times 0.85 + 10 \times 1$$

$$= 0.35 + 15.3 + 10 = 25.65$$

$$Z_{\text{eff}} = 30 - 25.65 = \underline{\underline{4.35}}$$

for d and f e⁻

- The e⁻s which are present on the right hand side for them σ is ~~not~~ considered to be zero.
- The remaining e⁻ in the same subshell shield by the factor of 0.35
- The remaining inner e⁻s, shields by the factor of 1.

Ques- What is the effective nuclear charge experienced by the e⁻ of 3d orbital of Zn.

$$\sigma = 9 \times 0.35 + 18 \times 1 = 3.15 + 18 = 21.15$$
$$Z_{\text{eff}} = 30 - 21.15 = \underline{\underline{8.85}}$$

The effective nuclear charge experienced by 3d e⁻ is greater than the e⁻ in 4s orbital.
 $\therefore$ the e⁻ is removed first, which experience less Z_{eff} .

Ques- What is the screening constant for the e⁻ in 3p orbital of Zn.

$$\sigma = 7 \times 0.35 + 8 \times 0.85 + 2 \times 1$$
$$\sigma = 2.45 + 6.8 + 2$$
$$\sigma = \underline{\underline{11.25}}$$

Ques- What is the Z_{eff} nuclear charge experienced by the 3s e⁻ of Zinc.

$$\sigma = 1 \times 0.35 + 8 \times 0.85 + 2 \times 1$$
$$= 0.35 + 6.8 + 2 = 9.15$$
$$Z_{\text{eff}} = 30 - 9.15 = 20.85$$

Ques. Effective Nuclear Charge of 3d e⁻ in V (23)
Acc. to Slater's rule is -

$$V = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^3$$

$$V = 1s^2 \mid 2s^2, 2p^6 \mid 3s^2, 3p^6, 3d^3 \mid 4s^2$$

$$\sigma = \cancel{10 \times 0.35 + 10 \times 1}$$

$$= \cancel{3.5 + 10}$$

$$\sigma = \cancel{13.5}$$

$$Z_{\text{eff}} = \cancel{23 - 13.5 = 9.5}$$

$$\sigma = 2 \times 0.35 + 18 \times 1 = 0.70 + 18$$

$$\sigma = 18.7$$

$$Z_{\text{eff}} = 23 - 18.7 = \underline{\underline{4.3}}$$

* → For those elements, where, outer most shell = 1,
screening constant is taken as 0.30 instead of 0.35

eg- He
1s²

$$\sigma = 1 \times 0.30 = 0.30$$

$$Z_{\text{eff}} = 2 - 0.30 = \underline{\underline{1.70}}$$

* → Whenever e⁻ is added in s and p
Z_{eff} increases by 0.65,
e.g.

$$Li = 1s^2, 2s^1$$

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

$$\sigma = 1.70$$

$$Z_{\text{eff}} = 3 - 1.70$$

$$= 1.30$$

$$Be = 1s^2, 2s^2$$

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

$$\sigma = 2.05$$

$$Z_{\text{eff}} = 4 - 2.05$$

$$= 1.95$$

$$B = 1s^2, 2s^2, 2p^1$$

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

$$\sigma = 2.4$$

$$Z_{\text{eff}} = 5 - 2.4$$

$$= 2.6$$

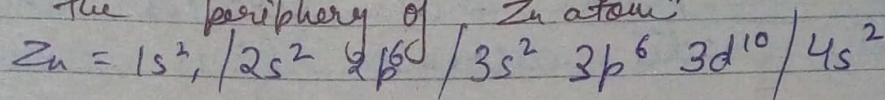
On moving along the period, Z_{eff} increases.

Limitations of Slater's Rule

- It considers, the e^- in s, p and d orbital screens equally
- It is not valid for lanthanoids and actinides.

→ If Z_{eff} is asked for periphery (surface of atom) in that case we have to include, all the e^- s.

eg. Ques What is the eff. nuclear charge on the periphery of Zn atom?



$$\sigma = 2 \times 0.35 + 18 \times 0.85 + 10 \times 1$$

$$= 0.70 + 15.3 + 10$$

$$\sigma = 26$$

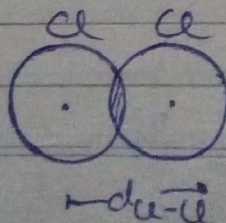
$$Z_{eff} = 30 - 26 = \underline{\underline{4}}$$

For non-transition metals,
 Z_{eff} decreases down the group and for
transition metals,
 Z_{eff} increases down the group.

Atomic Radius -

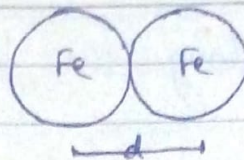
It is not possible to find, the radius of isolated atom becoz it donot have well defined boundaries therefore we find their radius in bonded state.

Covalent Radius



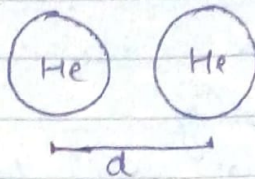
$$\frac{d_{Cl-Cl}}{2} = r_{Cl}$$

Metallic radius



$$\frac{d}{2} = r_m$$

Vanderwaal's radius



$$\frac{d}{2} = r_v$$

* For any element - $r_v > r_m > r_c$

→ Along the period Z_{eff} increases, therefore atomic radii decreases. ($\because n$ remains same)

→ Sc $\rightarrow$ Fe (radius $\downarrow$ se)

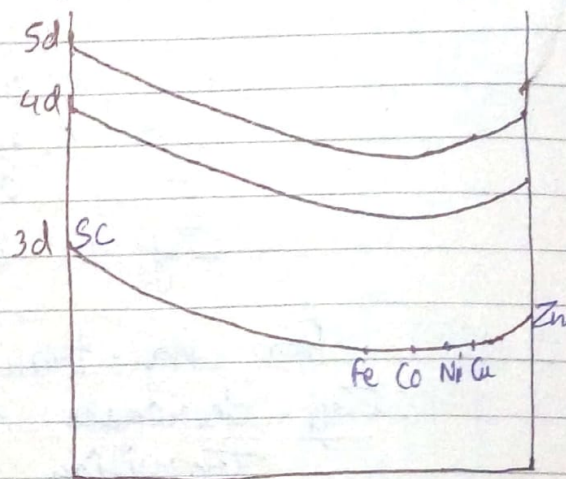
$Z_{eff} > d$ -repulsion

→ Fe $\approx$ Co $\approx$ Ni (radius constant)

$Z_{eff} = d$ -repulsion

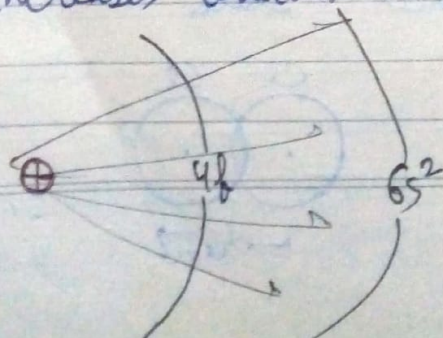
→ Ni $\rightarrow$ Cu $\rightarrow$ Zn (r $\uparrow$ se)

$d e^-$ repulsion $> Z_{eff}$



~~Lanthanoid~~ Lanthanoid Contraction -

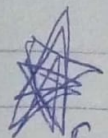
On moving along the period in lanthanoids, due to poor shielding of f-orbitals, Z_{eff} on 6s increases which results in contraction of size



Actinides Contraction -

Due to poor shielding of 5f orbitals, Z_{eff} on 7s increases, $\therefore$ Size contracts.

→ Actinide contraction is greater than lanthanoid contraction due to poor shielding of 5f than 4f.



Relativistic Effect

For heavier elements of 6th and 7th period, nucleus becomes very heavy and highly charged, which increases the electrostatic force of attraction and gravitational force also becomes dominating.

$$F_e = \frac{k q_1 q_2}{r^2}$$

$$F_g = \frac{G m_1 m_2}{r^2}$$

Due to which, e^- experience an inward pull due to and hence their velocity increases,

$$\therefore \text{Centrifugal force} = \frac{mv^2}{r}$$

which results in increase in mass of e^- acc. to eqⁿ $\uparrow$ $m_e = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$ $\left\{ \begin{array}{l} m_0 \text{ is rest mass} \end{array} \right.$
Now, when mass and velocity both increases, radius decreases significantly.
Acc. to eqⁿ,

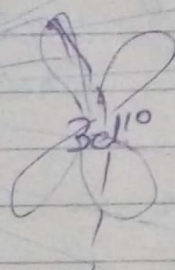
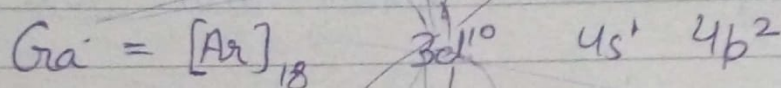
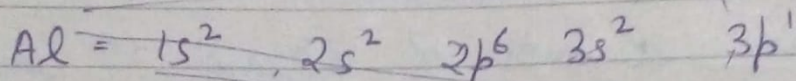
$$mvr = \frac{nh}{2\pi}$$

$$Tmvr \propto \frac{1}{r \downarrow \downarrow}$$

→ To explain the decrease in size of 6th & 7th period element, Relativistic effect is used

Q. Radius of Fr is smaller than the radius of Cs.
And radius of Ra is smaller than the radius of Ba.
Due to Relativistic Effect.

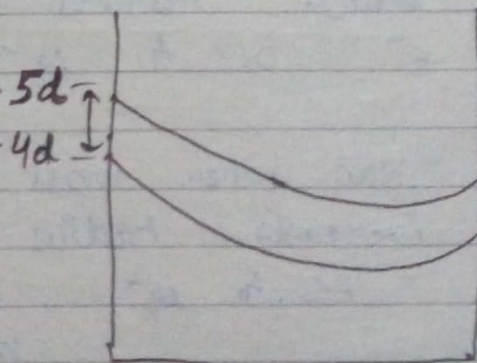
Q. The radius of Ga is less than the radius of Al.
Due to poor shielding of 3d-orbital or
Scandide contraction.



Ques.

The size of Hf is just slightly greater than
size of Zr. Why?
Due to poor shielding of 4f or Lanthanide
Contraction.

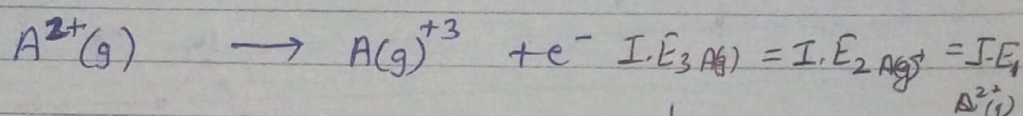
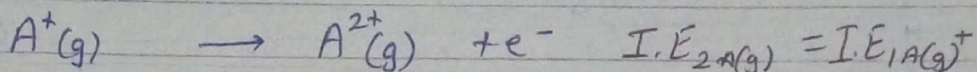
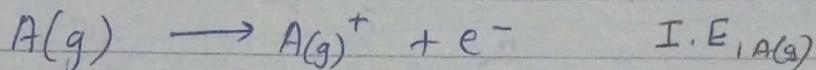
Due to Lanthanoid Contraction
and Relativistic Effect.



For isotopes more is the number of neutrons, in the
nucleus, smaller will be the size.

Ionization Energy

The minimum energy which is required to remove an e^- from the valence shell of an isolated gaseous atom.



Order of Successive I.E

Successive Ionisation energy.

$$I.E._3 > I.E._2 > I.E._1$$

→ High the charge, higher will the ionisation energy.

→ Electronic configuration

Fully filled.
- like noble gas

Fully filled
not like noble gas

Half filled.

grp-18

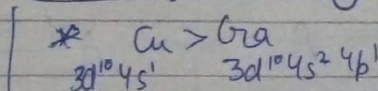
grp 2 & 12

grp-15

I.E maximum in its period

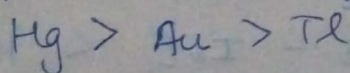
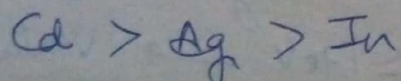
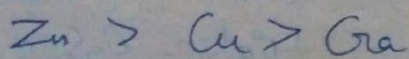
I.E. greater than its neighbour only

$$\rightarrow I.E. \propto \frac{1}{\text{Size}}$$

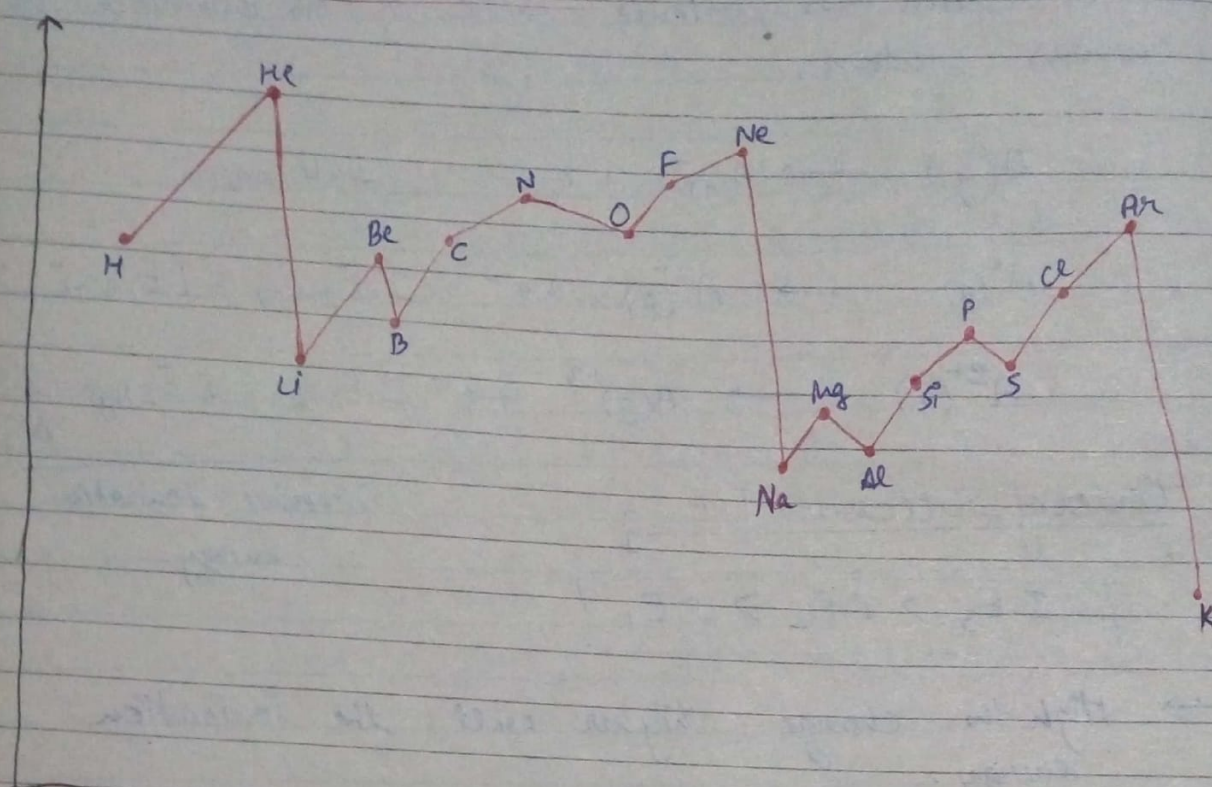


$\text{Cu} < \text{Zn} > \text{Gr}$ (fully filled config not like noble gas)

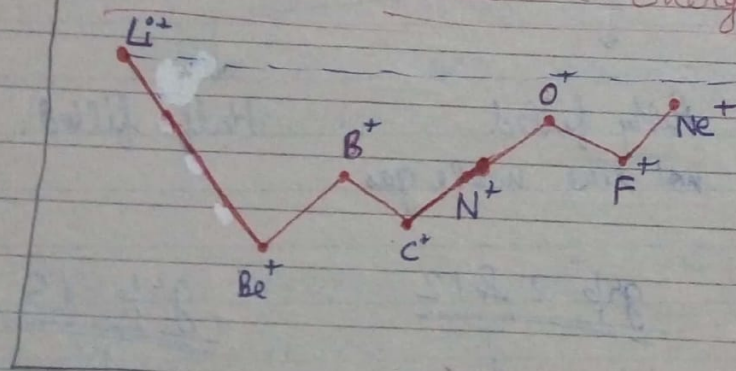
→ I.E depends on penetration effect.



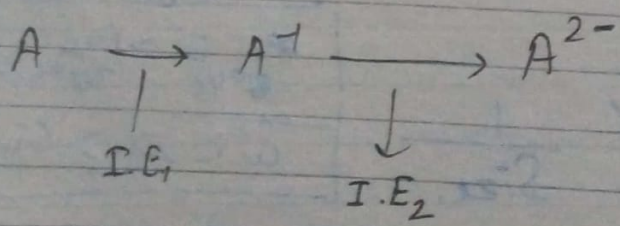
* Comparison of First I.E. from atomic no 1 to 20.



* Second Ionisation Energy of 2nd period elements



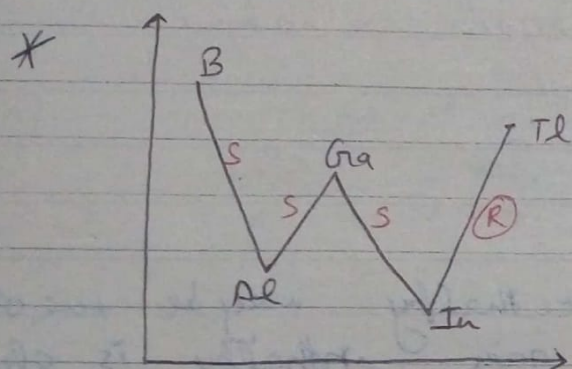
Application of Ionization Energy.



* $I.E_2 - I.E_1 > 17\text{eV}$ Lower O.S Stable
 $I.E_2 - I.E_1 < 11\text{eV}$ Higher O.S "
 $11\text{eV} \leq I.E_2 - I.E_1 \leq 17\text{eV} \rightarrow$ Variable O.S

→ Variation of I.E down the group-

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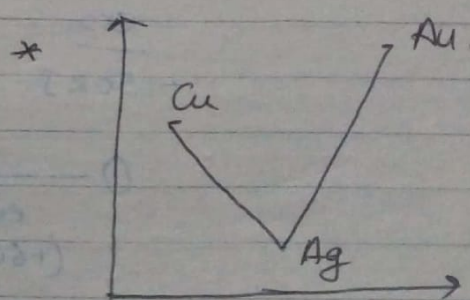
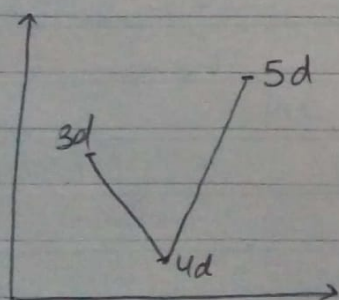


Ti V Cr Ni

↓ down the group
I.E increases.

* Ni < Pd < Pt.

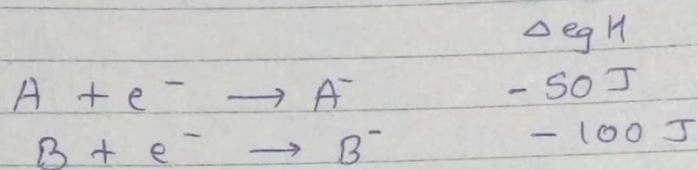
* In 7, 8, 9, 11, 12. [same trend]



Electron Gain Enthalpy ($\Delta_{eg}H$)

The energy released when an extra e^- is added in the isolated gaseous atom.

→ More is the energy released, greater is the tendency to gain the e^- .

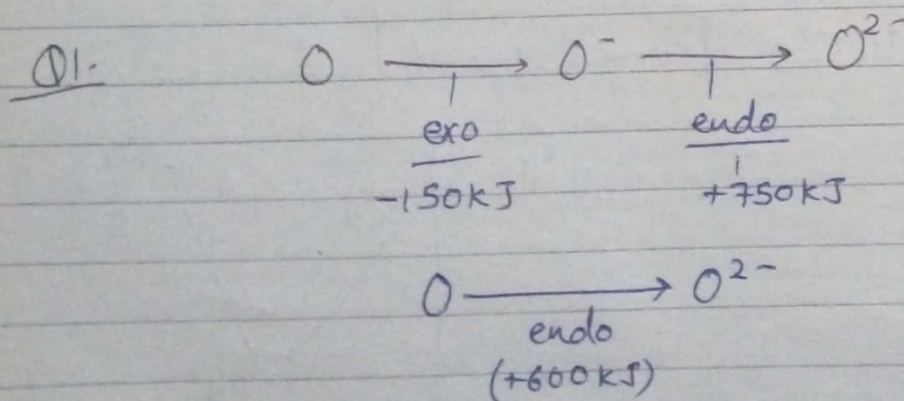


→ B has higher tendency to gain e^-

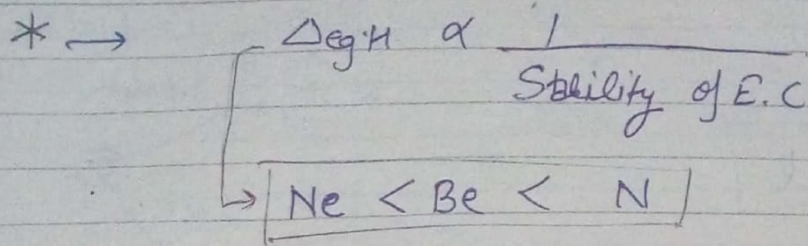
Factors affecting e^- gain enthalpy

* → $\Delta_{eg}H \propto \frac{1}{\text{Size}}$

→ ($\Delta_{eg}H_1$) 1st e^- gain enthalpy may be +ve or -ve
But ($\Delta_{eg}H_2$) 2nd e^- gain enthalpy is always +ve

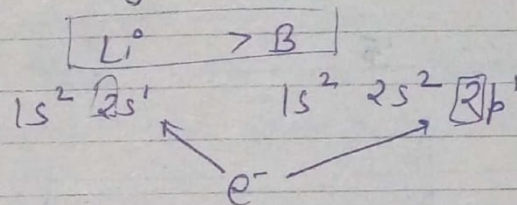


Why O^- compound not found?



* $\rightarrow$ Penetration Effect $\rightarrow$ * n - same
l $\rightarrow$ diff

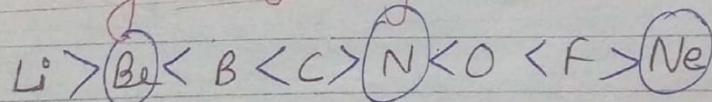
Q. The Δ_{egH} of Li is greater than B. Why?
Due to higher penetration power of 2s than 2p.



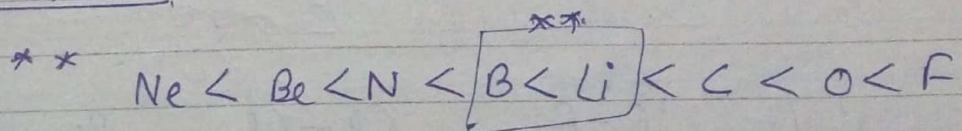
Q. Order of stability of anion (i.e. Order of Δ_{egH})
 $\text{Li}^{\ominus}, \text{B}^{\ominus}, \text{Be}^{\ominus}, \text{C}^{\ominus}$

* * $\boxed{\text{C}^{\ominus} > \text{Li}^{\ominus} > \text{B}^{\ominus} > \text{Be}^{\ominus}}$

Comparison of Δ_{egH} of 2nd period elements.

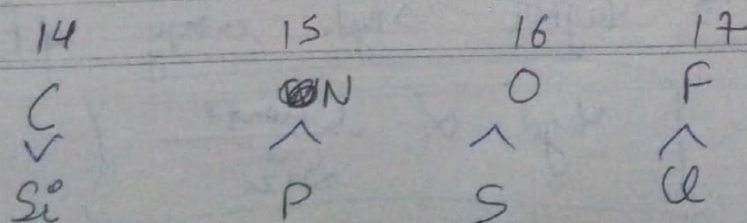


Exact Order:



Variation of Δ_{egH} down the group

The Δ_{egH} of 3rd period element is greater than the 2nd period elements except group no. 14.

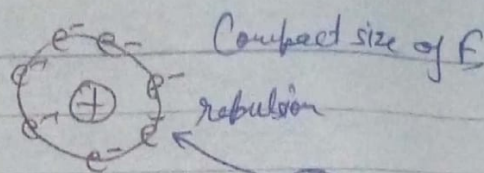


F

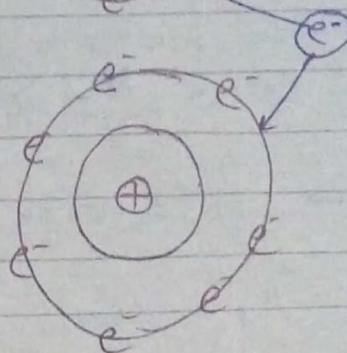
Explanation

$$\Delta_{egH} = \boxed{F < Cl}$$

F



Cl



Exact trend

Group 17

$$\boxed{Cl > F > Br > I}$$

Group 16

Group 15

Group 14

S
V
Se
V
Te
V
Po
V
O

As
V
Sb
V
Bi
V
P
V
N

C
V
Si
V
Ge
V
Sn
V
Pb

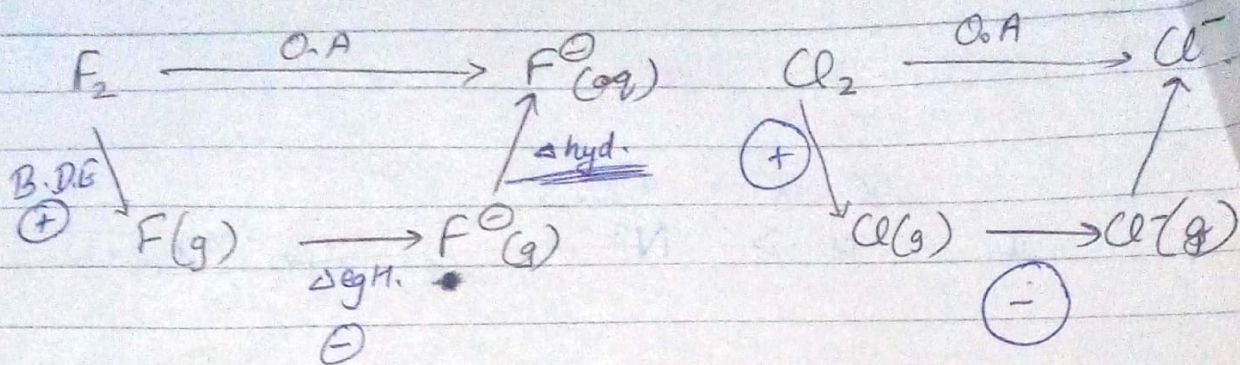
Bond Dissociation Energy.

Group 17 $\overset{+}{F} \overset{-}{F}$ Cl-Cl Br-Br I-I

Exact order - $Cl_2 > Br_2 > F_2 > I_2$

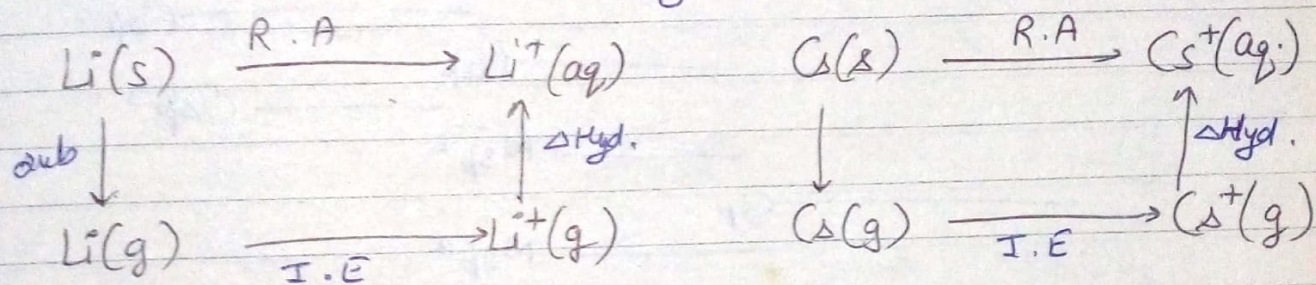
Q. Δ_{egH} of Cl is greater than F , but F_2 is better oxidising agent. (more -ve)
Due to higher $\Delta_{hyd.}$ energy of F .

$$\Delta_{hyd} \propto \frac{\text{Charge}}{\text{Size}}$$



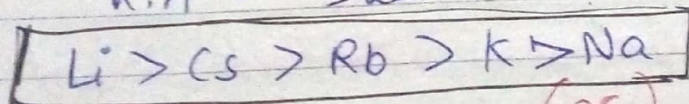
$$\text{Oxidising Agent} = \text{B.D.E.} + \Delta_{\text{egH.}} + \Delta_{\text{hyd.}}$$

Q. I.E. of Cs is lower than that of Li.
 But Li acts as better reducing agent.
 Due to high $\Delta_{\text{Hyd.}}$ energy of Li^+ .



Sublimation energy $\propto$ Metallic Bonding

$$\text{R.A.} = \text{Sub.} + \text{I.E.} + \Delta_{\text{hyd.}}$$



Electronegativity (X)

It is the tendency of a covalently bonded atom to attract the shared pair of e^- s towards itself.

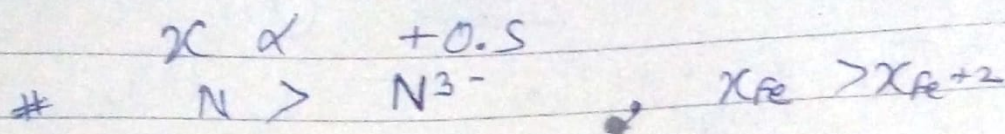
Factors affecting e^- -ivity

①

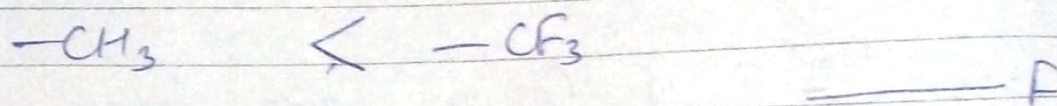
Size

$$\boxed{X \propto \frac{1}{\text{Size}}}$$

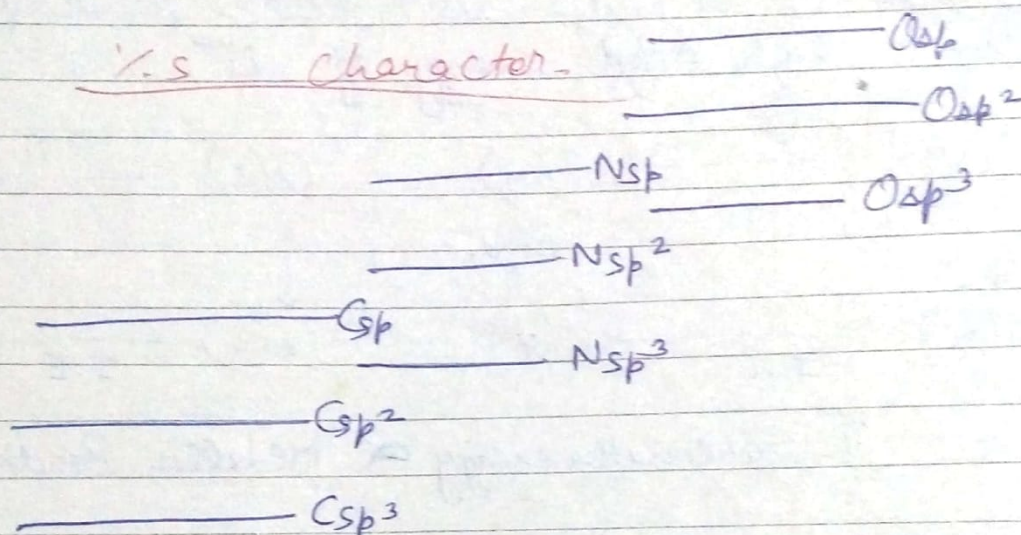
① Oxidation State



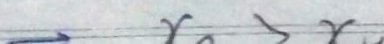
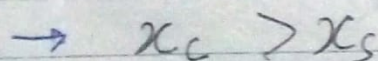
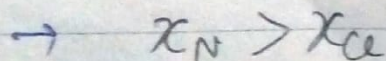
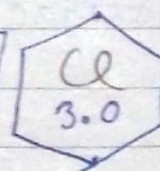
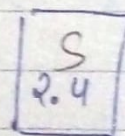
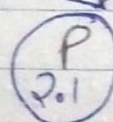
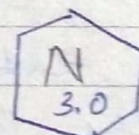
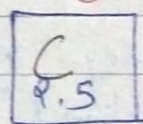
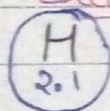
③ Chemical Environment



④ %s character



* Electronegativity of some important elements on Pauling's Scale

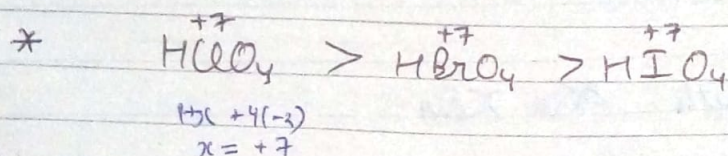
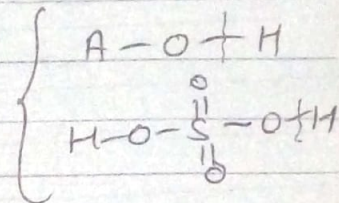


* Applications Of Electronegativity

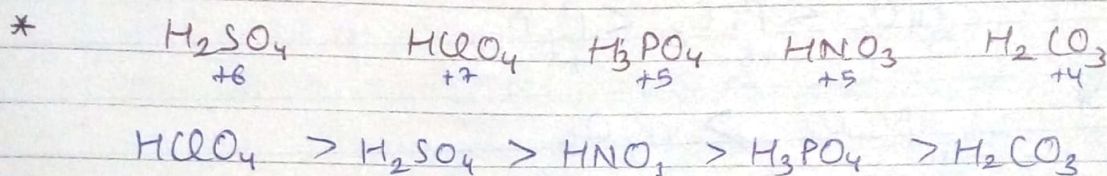
Comparison of acidic strength of oxoacids

→ Oxoacids of different element -

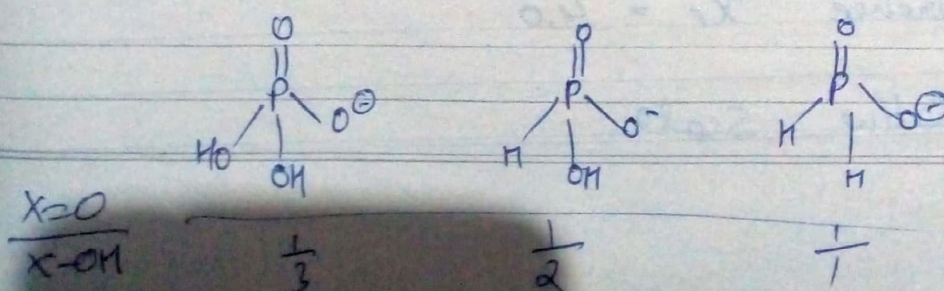
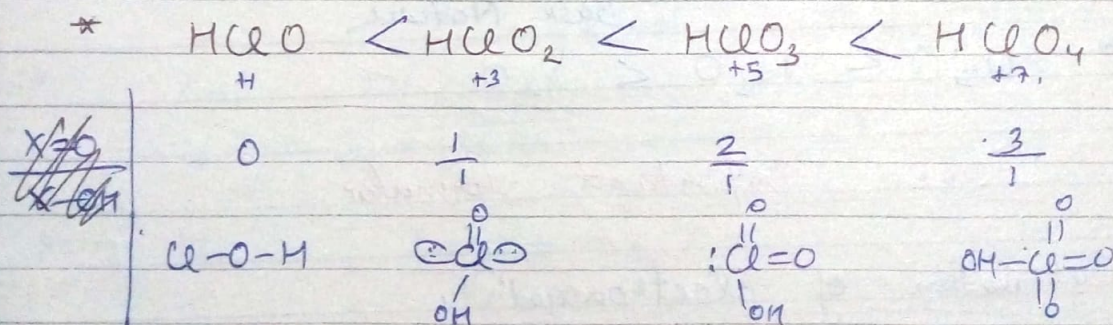
$$A.S \propto x_{CA} \propto \frac{+O.S}{Size}$$



Order of A.S. $HClO_4 > HBrO_4 > HIO_4$



→ Oxoacids of same element -



* Comparison of Acidic Strength of Non-metals oxides

Four types of oxides.

→ Amphoteric

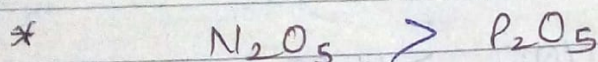
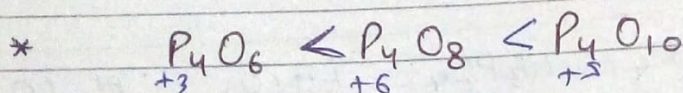
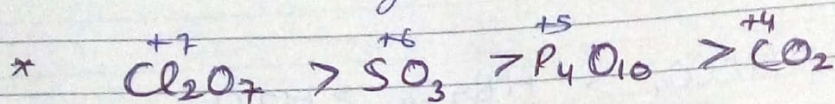
→ Neutral → $\text{CO}, \text{NO}, \text{N}_2\text{O}$

→ Acidic Oxides → Non-metal

→ Basic oxides → Metal [except $\text{CrO}_5, \text{Mn}_2\text{O}_7$]
Acidic.

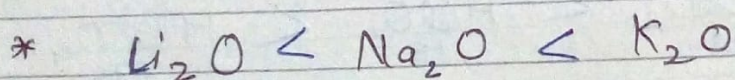
Acidic Oxides.

Acidic strength $\propto$ X.C.A



Basic Oxides.

I. E $\propto \frac{1}{\text{Basic Nature}}$



* Some important formulae

Calculation of electronegativity

a) Pauling's Scale

→ Reference, $X_F = 4.0$

→ Relative Scale.

$$* \quad |\chi_A - \chi_B| = \sqrt{E_{AB}} - \sqrt{E_{AA} \cdot E_{BB}} \quad \left[E = \text{ev/atom} \right]$$

$$* \quad |\chi_A - \chi_B| = 0.708 \sqrt{E_{AB}} - \sqrt{E_{AA} \cdot E_{BB}} \quad \left[E = \text{kJmol}^{-1} \right]$$

$$* \quad |\chi_A - \chi_B| = 0.102 \sqrt{E_{AB}} - \sqrt{E_{AA} \cdot E_{BB}} \quad \left[E = \text{kcalmol}^{-1} \right]$$

$$1 \text{ ev/atom} = 96.45 \text{ kJmol}^{-1} = 23.06 \text{ kcalmol}^{-1}$$

$$\left\{ E_{AB} = B \cdot D \cdot E (A-B) \right\}$$

$$\chi_M = 2.8 \chi_P$$

b) Mulliken's Scale -

→ Absolute Scale

→ Acc. to Mulliken, electronegativity of an element is the average of Ionization Energy of the element and its Electron affinity

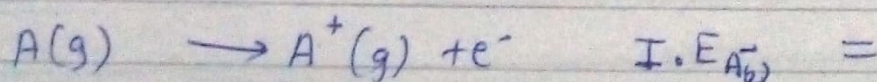
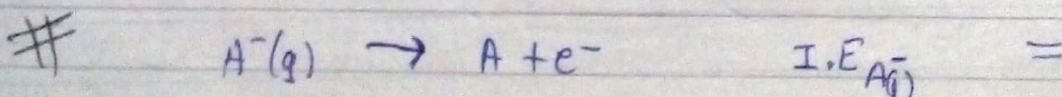
$$* \quad \chi_M = \frac{I \cdot E_A(g) + E_A}{2} \quad \text{ev/atom}$$

At Room temperature

$$\Delta_{eg}H = -E_A$$

$$* \quad \chi_M = \frac{I \cdot E_A + E_A}{2 \times 96.45} \quad \text{kJmol}^{-1}$$

$$* \quad \chi_M = \frac{I \cdot E_A + E_A}{2 \times 23.06} \quad \text{kcalmol}^{-1}$$



c) Allred - Roschow Scale -

$$r_{AR} = \frac{0.359 \times Z^*}{n^2} + 0.744$$

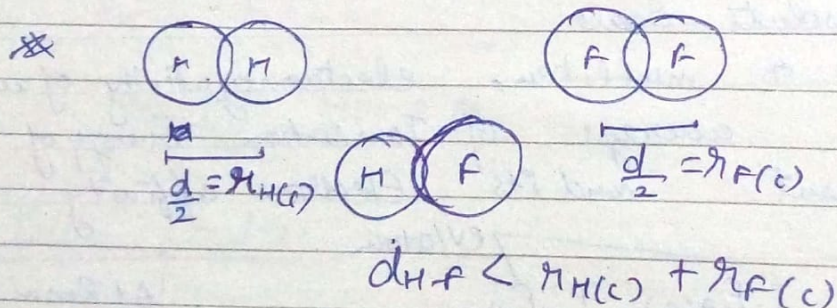
where, $n^2 = \text{covalent radius / } \text{\AA}^2$

$Z^* = Z_{\text{eff}}$ on periphery.

* Stervenson and Shoemaker's Eqⁿ

$$* \left[d_{A-B} = r_A + r_B - 0.09 | \chi_A - \chi_B | \right]$$

where, $r_A \text{ \& } r_B \rightarrow \text{\AA}^0$



Hannay & Smith Eqⁿ

$$\% \text{ ionic character} = 16 | \chi_A - \chi_B | + 3.5 | \chi_A - \chi_B |^2$$