CHAPER-4 CHEMICAL BONDING :- AND MOLECULAR STRUCTURE

* Why Bond form for stability

Stability $\propto$ Bond Strength

↓ Potential energy $\propto \frac{1}{\text{stability}}$ ↑

exp. Noble gas. not a single element are found in free state exept this is because of not a single element is stable in atomic form.

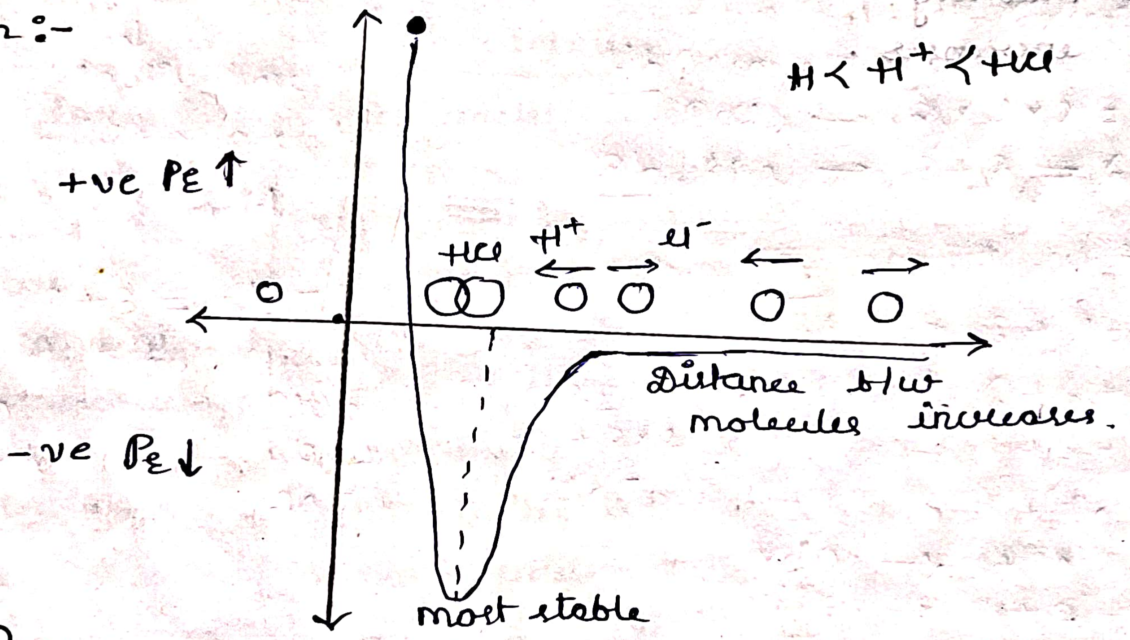
That's why all the molecules are form by any atom. $\propto$ decreases in P_E.

strength of Bond is directly $\propto$ to stability.

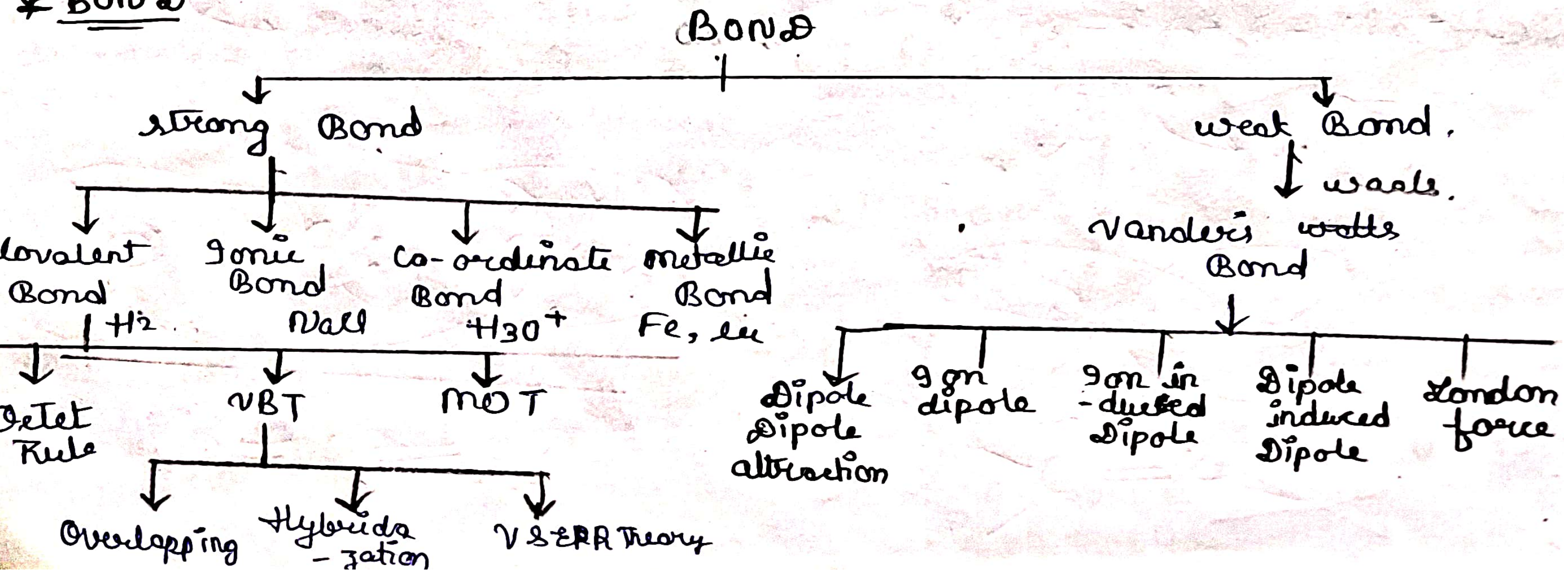
→ **Bond formation is exothermic process** so all the molecules can form bond and all of them make itself stable & release lots of potential energy.

* graph :-

$H < H^+ < HCl$



* BOND



Atom → molecular form.

1) By give & take of e^-

$_{11}Na \rightarrow 2, 8, 1 \longrightarrow Na^+$

$_{17}Cl \rightarrow 2, 8, 7 \longrightarrow Cl^-$

$\longrightarrow$ NaCl

Ionic Bond
or
Electrovalent Bond.

2) By sharing of e^-

$_6C \rightarrow 2, 4 \rightarrow$ sharing $\rightarrow$ Covalent Bond.

3) By give & take of lone pair of e^-

$\overset{\cdot\cdot}{N}H_3 \longrightarrow H^+ \longrightarrow NH_4^+ \rightarrow$ Coordinate bond
or
Dative Bond.

4) Covalent Bond

i) Octet Rule — By Lewis & Kossel.

→ Atom → molecule → reason that their outermost shell have to be filled with $8e^-$ in octet.

share

$2e^- \longrightarrow$ Single Bond → (–)

$4e^- \longrightarrow$ Double Bond → (=)

$6e^- \longrightarrow$ Triple Bond → (≡)

Lewis & Kossel

Atom 1 $\longrightarrow$ •

Atom 2 $\longrightarrow$ ×

central atom → •

Que.) What is central atom?

i) They are single.

$H_2\underline{O}$, $H_2\underline{S}$

ii) central atom same

HF , HCl , HBr.

iii) Which is larger

$H\underline{Cl}$, $H\underline{Br}$

iv) If they are in same period.

More <u>electropositive</u> is central atom.

Octet Rule :-

$\underline{C}H_4$

step - I) Identification of central atom.

step - II) central atom e^- configuration

step - III) valence shell e^- represented as dot (•)

step - IV) addition atom only valency show as (×)

valency → 1, 2, 3, 4

Valence shell e^- → more than 4 we substract it from 8.

① Li

1⑤ N

1⑥ O

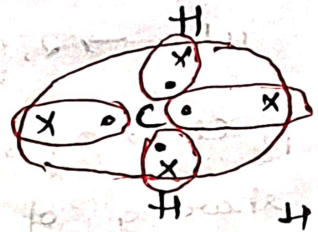
1⑦ F

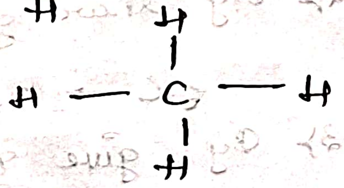
<u>Note</u> :- Always first atom ka valency^e shell e^- or second Ka valency ~~shell~~ $e^=$

CHAPER-4 CHEMICAL

CH_4
Draw a Lewis & kossel cross dot stre. & also write its molecular formula.

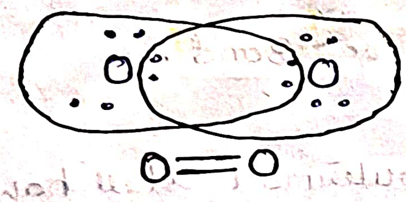
CH_4 → $_6C - 2,④$ → (•)
→ H → valency 1 (x)





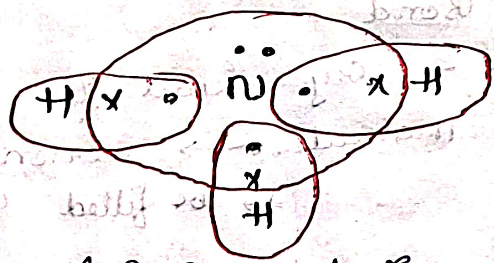
→ H & Li → Octet Rule → Duplet Rule
↓
considered with $2e^-$

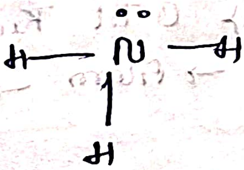
O_2
$_8O \rightarrow 2,6$ $_8O \rightarrow 2,6$



$O=O$

NH_3
$_7N - 2,5$
→ valency = 1 -





* lone pairs :- Lewis & kossel

lone pair → Donate
↓
Lewis base

lone pair ↔ accept
↓
Lewis acid

Lewis & kossel Exceptions -

1) Incomplete octet
$BeCl_2 \rightarrow 2 \times 1 \times 2 = 4e^-$

2) ($BF_3 \rightarrow 3+3 = 6e^-$

3) $AlCl_3 \rightarrow 3+3 = 6e^-$

odd electron species

NO	NO_2	ClO_2
$5+2 = 7e^-$	$5+2\times2$ $9e^-$	$7+2\times2$ $11e^-$

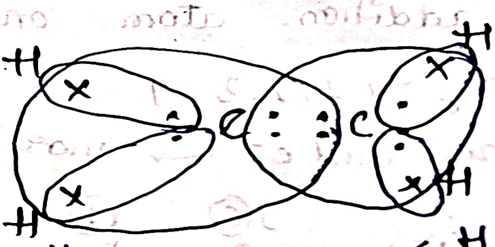
4) Extended octet $8 < e^-$

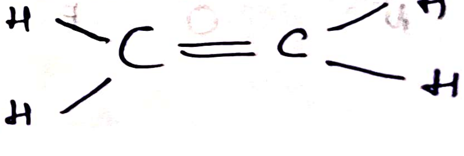
$SF_4 \rightarrow 6+4 = 10e^-$
$SF_6 \rightarrow 6+6 = 12e^-$
$ClF_5 \rightarrow 7+5 = 12e^-$
$IF_7 \rightarrow 7+7e = 14e^-$
$XeO_3 \rightarrow 8+3\times2 = 14e$
$XeF_2 \rightarrow 8+2 = 10e^-$
$XeF_6 \rightarrow 8+6 = 14e^-$

i) CO_2.
central atom 2,4
Valency = 2

$O=C=O$

C_2H_4
2,4
1

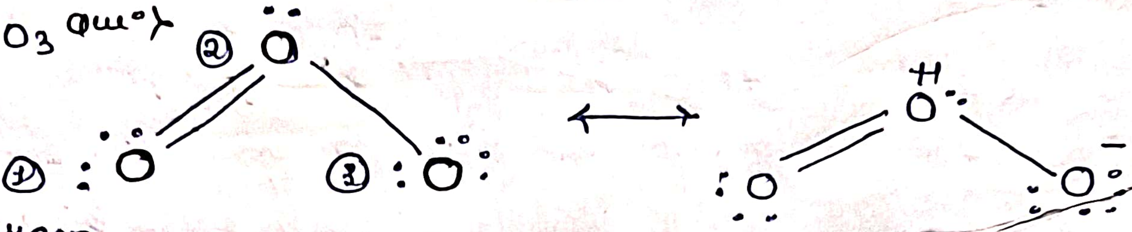




* **Formal charge** :- $\frac{\text{central atom valence shell } e^-}{}$ − no. of lone pair of e^- − $\frac{1}{2}$ Bond pair e^-

↓
available charge in atom.

eg:- O_3 ques:-



−1/3

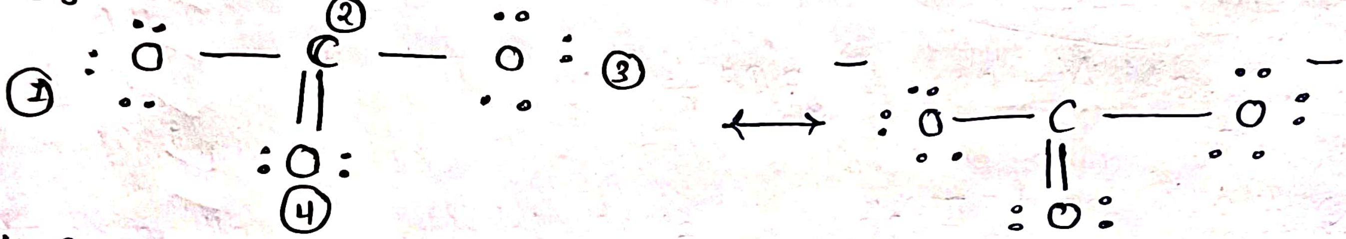
① Oxygen $= 6-4-\frac{1}{2}\times 4 = 0$

2) Oxygen $= 6-2-\frac{1}{2}\times 6 = +1$

3) Oxygen $= 6-6-\frac{1}{2}\times 2 = -1$

−2/3

CO_3^{-2}



1) Oxygen $= 6-6-\frac{1}{2}\times 2 = -1$

2) Carbon $= 4-0-\frac{1}{2}\times 8 = 0$

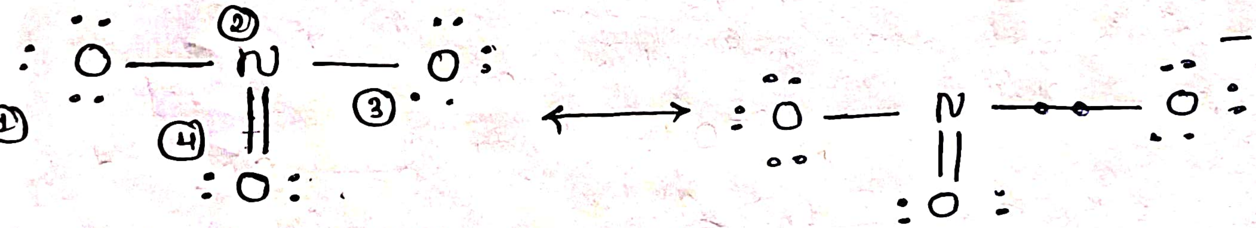
3) Oxygen $= 6-6-\frac{1}{2}\times 2 = -1$

4) Oxygen $= 6-4-\frac{1}{2}\times 4 = 0$

overall charge = 0

NO_3^-

−1/3



1) $6-6-\frac{1}{2}\times 2 = -1$

2) $5-\frac{1}{2}\times 8 = +1$

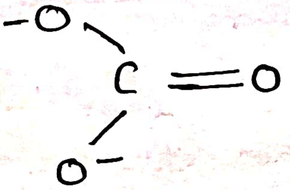
3) $6-6-\frac{1}{2}\times 2 = -1$

4) $6-4-\frac{1}{2}\times 4 = 0$

overall charge $= \frac{-1+1-1}{3} = \frac{-1}{3}$

Average charge $= \frac{-\text{ve charge (no.)}}{\text{no. of side atoms.}}$

eg:-



$\Rightarrow -\frac{2}{3}$ //

→ Ionic Bond :- 100% without any exception — octet rule.

→ Electrovalent Bond

"Complete transfer of e^- from ionic bond".

→ Electrovalency → no. of e^- complete transfer By any atom.

eg 1) NaCl

$_{11}Na + _{17}Cl \longrightarrow Na^+ + Cl^- \rightarrow NaCl$

2, 8, 1 ⟶ $1e^-$ ⟶ 2, 8, 7

Na = Electrovalency = 1

Cl = E.V = 1

eg 2) $CaCl_2$

$_{20}Ca$ $_{17}Cl \longrightarrow Ca^{+2} + 2Cl^- \rightarrow CaCl_2$.

2, 8, 8, 2 ⟶ $1e^-$ ⟶ $_{17}Cl$ 2, 8, 7

⟶ $1e^-$ ⟶ 2, 8, 7

Electrovalency of Ca = 2

Electrovalency of Cl = 1

eg 3) CaO

$_{20}Ca$ $_8O \longrightarrow Ca^{+2} + O^{-2} \rightarrow CaO$

2, 8, 8, 2 ⟶ $1e^-$, $1e^-$ ⟶ 2, 6

Electro. V of Ca = 2

E.V of O = 2.

eg) Al_2O_3

Al 2, 8, 3 O 2, 6

O 2, 6

Al 2, 8, 3 O 2, 6

$\longrightarrow 2Al^{+3} + 3O^{-2} \rightarrow Al_2O_3$

Electrovalency of Al = 3

Electrovalency of O = 2

* **Preperation of Ionic Bond.**

"**Born - habber cycle**" ⟶ Calculation of lattice energy.

Energy → Heat
- Ultimate Exothermic −ve
- Absorb Endothermic +ve

$NaCl \longrightarrow Na^+ + Cl^-$

* DPP - 02   pg = 26

Que. 1) E.V = no. of e^- give / take
option - 4.

Que. 3) Lattice

Que. 4) low IP
EA = high
option - 4

Que. 2) 100 % follow octet Rule
option - 4

Que. 5) mp / BP high

* DPP - 03   pg = 27.

Que. 1) $LE \propto \frac{1}{\text{cation size}}$

K^+, Na^+, Cs^+, Rb^+

$Na^+ < K^+ < Rb^+ < Cs^+$

option - 2 //

Que. 3) Covalent charo. < Fajans
+ cation small
− Anion large

$LiCl < BeCl_2 < BCl_3 < CCl_4$

$Li^+ > Be^{+2} > B^{+3} > C^{+4}$

→ Anion size same
→ cation size decreases
→ $\text{cation size} \propto \frac{1}{\text{covalent chro.}}$
→ covalent property increases.

Que. 2) NaF > NaCl > NaBr > NaI

$F^- \rightarrow Cl^-$ Br^- I^-

→ size increase Anion
→ cation size same
→ $LE \propto \frac{1}{\text{size of Anion}}$
→ L.E decrease   option - 1.

Que. 4) ZnO < ZnS

$O^{-2} < S^{-2}$

→ anion size ↑
→ anion size ∝ covalent

Que. 5) All of Above.

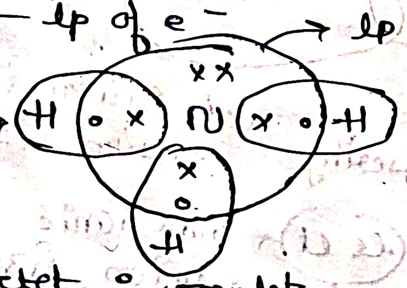
* Co-ordinate Bond. Or Dative Bond :- (दाती) ← देना

1) This type of Bond form when lp (lone pair) are transferred to one molecules to other. We can say that it is a kind of coovalent bond a giver atom called as Lewis Base & taker atom Lewis acid.

eg :- Share — lp of e^- → lp

NH_3 →

s ↲



lewis - lp given → lewis Base.

& his followers - lp take → lewis acid.

* Taker → octet incomplete
* giver → octed complete
→ lp available min 1

→ N → 1
O - 2 lp
F - 3 lp

eg 1) $NH_3 \longrightarrow BF_3$

↓ $5+3=8$ lewis base

$3+3=6e^-$ lewis acid

sign → + → Ionic

→ —— covalent

→ ——→ coordinate

eg 2) $NH_4^+ \longrightarrow NH_3 + H^+$

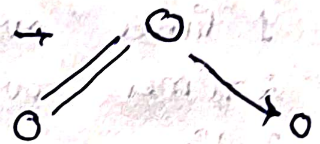
$8e^-$ 1lp $\quad 0e^-$

$NH_3 \longrightarrow H^+$

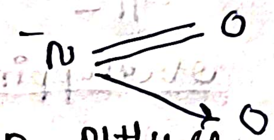
eg 3) H_3O^+ → Hydronium

$H_2O + H^+ \rightarrow H_2O \rightarrow H^+$

→ O_3 →



→



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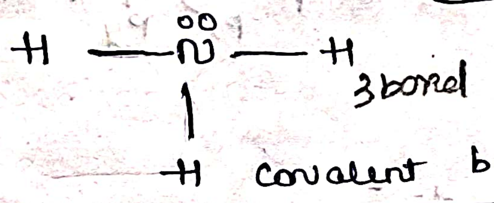
Ques) How many types of bonds are present in NH_4Cl.

Ans) $\underbrace{NH_4^+ + Cl^-}_{\text{ionic bond}}$ $\quad \underbrace{\overset{8e^-}{NH_3} \longrightarrow \overset{0e^-}{H^+}}_{\text{coordinate bond}}$

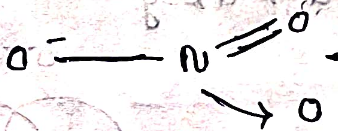


3 bond

covalent bond

eg 2) KNO_3^-

$\underbrace{K^+ \quad NO_3^-}_{\text{ionic}}$



→ covalent & coordinate

(VBT)

~~Slater~~ Slater & pauling :- VALENCE BOND THEORY :-

→ It is given by Heitler & London or extended & experimental prove by Pauling & slater.

→ To form covalent bond overlapping is necessary but only b/w valence shell of half filled orbitals not e^-

→ Two atom come near & form covalent bond.

→ Valence bond theory have three sub-division

- Overlapping
- Hybridization
- VSEPR

→ VBT → only & only for valence shell e⁻

→ 1) Shape
2) Angle
3) Magnetic behaviour
4) Dipole Moment
5) Resonance
6) Bond order, Bond length, bond energy
7) Polarity

1) overlapping :- valence shell e⁻
min 1e⁻ present in per-orbital

→ more overlapping ∝ more bond strength.

→ Overlapping ∝ $\frac{1}{\text{energy of atoms}}$

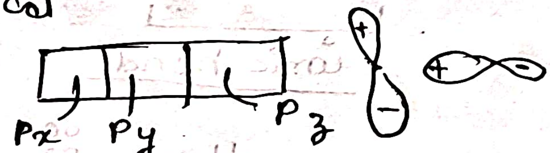
→ New orbital form

→ 1 times overlapping σ bond
2 times overlapping π bond
3 times -||- δ bond

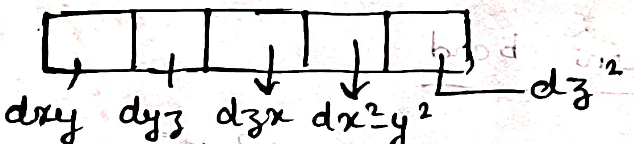
→ Types of Overlapping :-

shape of orbital

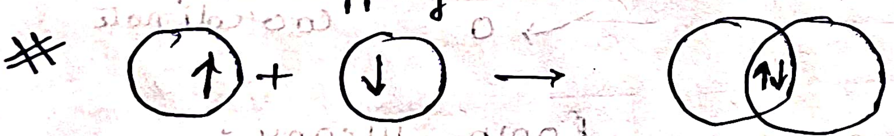
shape of s →  spherical

shape of p → dumbell shape 

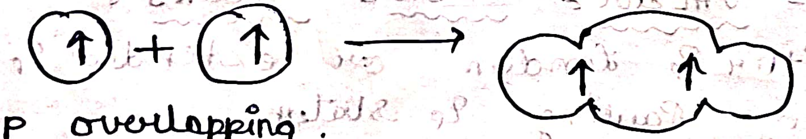
d shape → double dumbell



1) s-s over lapping —— σ bond

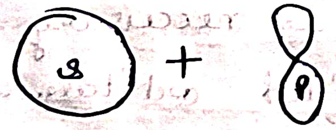


bonding (BMO)

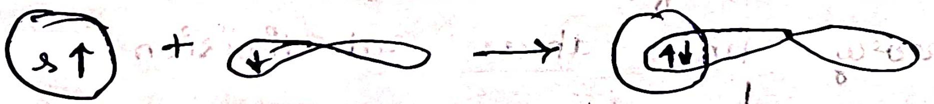


σ * bond
Anti bonding (ABMO)

2) s-p overlapping.



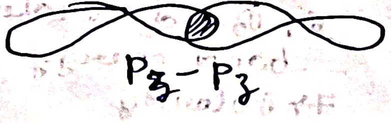
→ No overlapping
zero overlapping.



σ bond.

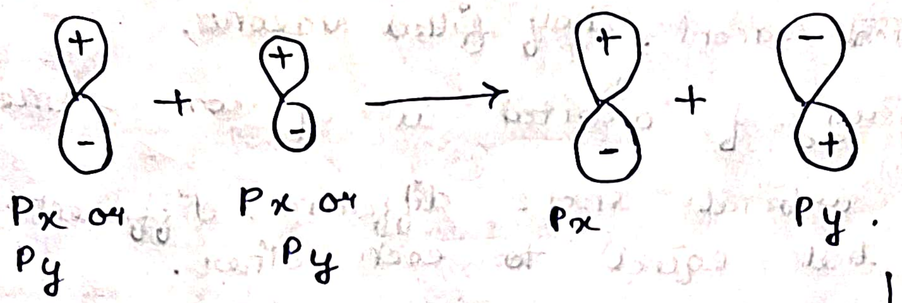
3) p-p axial overlapping

σ bond
most strength σ bond.

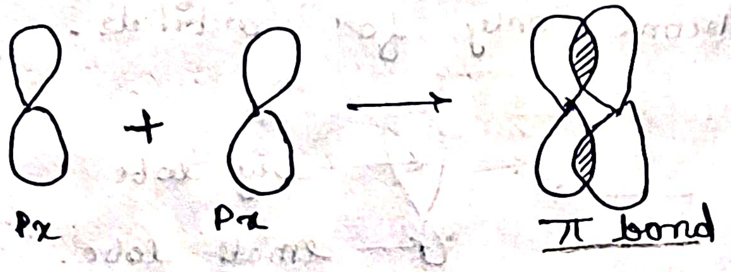


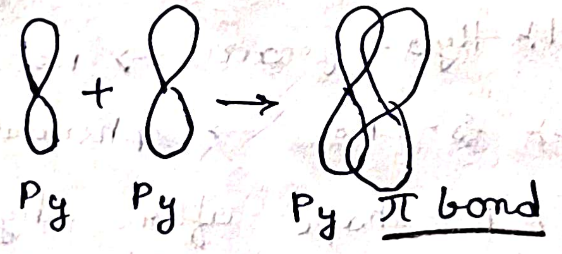
σ bond.

p - p collateral / lateral overlapping .

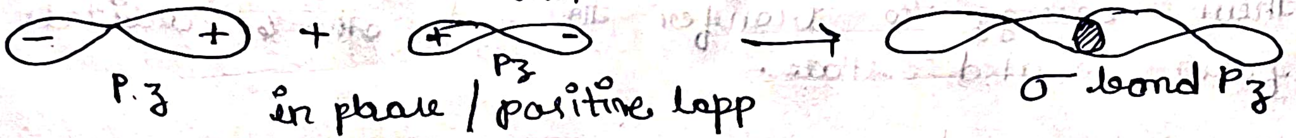


→ Zero overlapping .

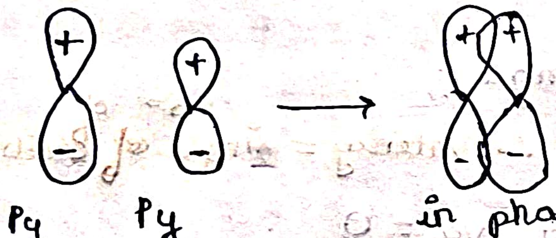




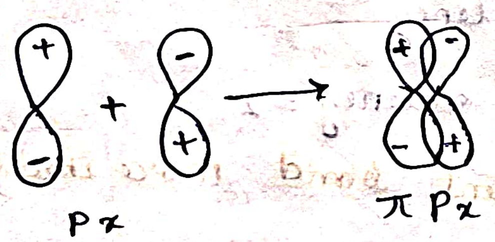
overlapping of P are of two types
↳ orbital

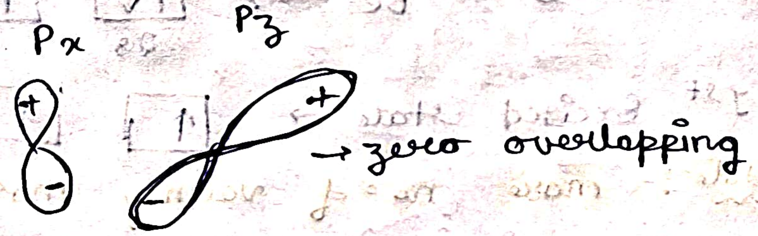


in phase / positive lapp



in phase or positive .





→ zero overlapping

* HYBRIDISATION :-

1) Formulae = No. of e⁻ in valence shell of central atom + no. of only single bond + no. of (-ve) charge − no. of (+ve) charge
/ 2 .

code = 2 → sp
3 → sp2
4 → sp3
5 → sp3d
6 → sp3d2
7 = sp3d3 .

Hybridization [illegible].

1) Valence shell → fullfilled vacant, half filled vacant.

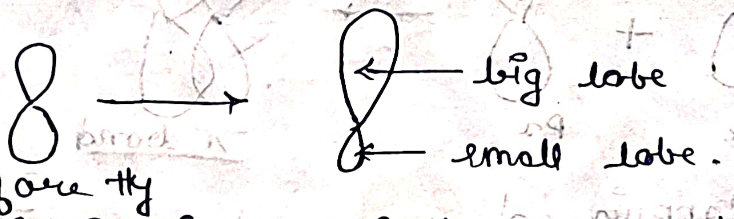
2) During Hybo → energy of orbital is approx same.

3) After Hyb. ⟶ New orbital shape different, different energy but equal to each other.

4) Hyb. process → not for electrons only for orbitals.

5) s-shape → spherical

6) p-shape after hyb.



7) Hyb. → energy equal distributions & orbitals energy share. their energy to transfer to each other & orbitals form excited state.

8) Hyb. → covalent bond

9) Hyb. → After hyb. e^- sharing single.

∴ Valency = single no. of electrons

$_4Be \rightarrow 1s^2\,2s^2\,2p^0$

Ground state Be ⟶ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\,|\;\;|\;\;}$ valency = 0
2s 2p

1st Excited state ⇒ $\boxed{\uparrow}$ $\boxed{\uparrow\,|\;\;|\;\;}$ valency = 2

Note :- more no. of valency more co-valent bond more stability

eg) $_6C \rightarrow 1s^2\,2s^2\,2p^2$

Ground state C ⟶ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow\,|\uparrow|\uparrow}$ valency = 2

1st E.S of C → $\boxed{\uparrow}$ $\boxed{\uparrow|\uparrow|\uparrow}$ valency = 4.

eg) $_{15}P \rightarrow 1s^2\,2s^2\,2p^6\,3s^2\,3p^3\,3d^0$

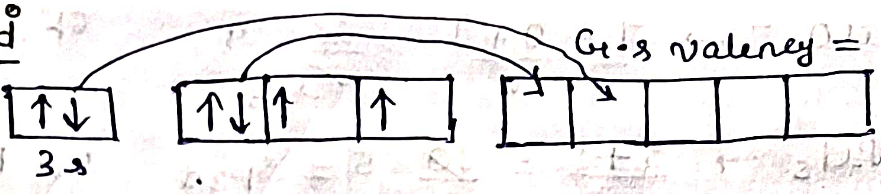
Ground state of P → $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow|\uparrow|\uparrow}$ $\boxed{\;\;|\;\;|\;\;|\;\;|\;\;}$
3s 3p valency = 3

1st E.S of P → $\boxed{\uparrow}$ $\boxed{\uparrow|\uparrow|\uparrow}$ $\boxed{\uparrow|\;\;|\;\;|\;\;|\;\;}$ valency = 5

$_{16}S \rightarrow 1s^2 2s^2 2p^6 \underline{3s^2 3p^4 3d^0}$

G.S valency = 2.

Ground state of S =



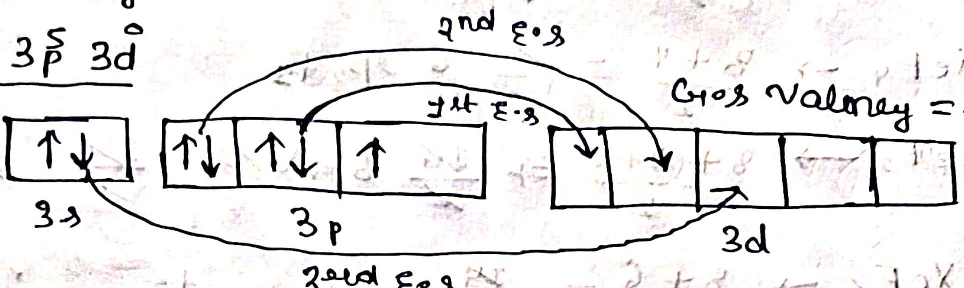
1st E.S = valency = 4

2nd E.S = valency = 6

$_{17}Cl \rightarrow 1s^2 2s^2 2p^6 \underline{3s^2 3p^5 3d^0}$

G.S valency = 1

Ground state →



Ist E.S = 3

IInd E.S = 5

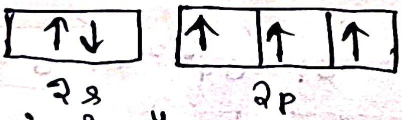
IIIrd E.S = 7

Ques: Why NCl_5 and PCl_5 ↳ It is stable?
↓
unstable

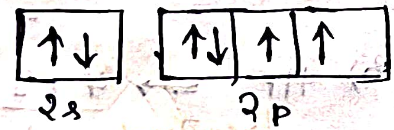
NCl_5 is not possible anyhow. N shows both valency 1 & 3. including the period it belongs to. valency = 3

→ $_7N \rightarrow 1s^2 2s^2 2p^3$

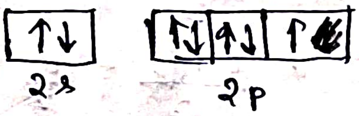
N.G.S



→ $_8O \rightarrow \underline{1s^2 2s^2 2p^4}$



→ $_9F \rightarrow 1s^2 2s^2 2p^5$



eg: CCl_4
↓ ↓
4 4

$Hy = \frac{4+4}{2} = 4 = sp^3$

Bond possible
Cl → 1 ✓
H → 1 ✓
O → 2 ✓
N → 3 ✓

eg: $BeCl_2$

$\frac{2+2}{2} = 2 = sp$

Cl only have 1 bond $1 \times 2 = Cl_2$

eg: NH_4^+

$\Rightarrow \frac{5+4-1}{\cancel{4}\,2} \Rightarrow \frac{8}{2} = 4 = sp^3$

eg: NO_3^-

$\Rightarrow \frac{5+0+1}{2} = \frac{\cancel{6}}{\cancel{2}}\ 3 = sp^2$

* **Class work :-**

1) $NO_2^- \rightarrow \frac{5+0+1}{2} = 3 = sp^2$

2) $H_2S \rightarrow \frac{2+6}{2} = \frac{8}{2} = 4 = sp^3$
↑
central atom → Valence shell e^-
H_2 → Valency.

Oxygen is central atom.

3) $F_2O \rightarrow \frac{6+2}{2} = \frac{\cancel{7}\,8}{2} = 4 = 3sp^3$

4) $MgCl_2 \rightarrow \frac{2+2}{2} = \frac{4}{2} = 2 = sp$

5) $ClO_4^- \rightarrow \frac{7+0+1}{2} = \frac{\cancel{8}}{\cancel{2}}\ 4$ sp^3

6) $ClO_3^- \rightarrow \frac{7+0+1}{2} = \frac{\cancel{8}}{\cancel{2}}\ 4$ sp^3.

7) $PCl_5 \rightarrow \frac{5+5}{2} = \frac{\cancel{10}}{\cancel{2}}\ 5 = sp^3d$

8) $PCl_3 \rightarrow \frac{5+3}{2} = \frac{\cancel{8}}{\cancel{2}}\ 4$ sp^3~~d~~

9) $XeF_2 \rightarrow \frac{8+2}{2} = \frac{10}{2} = 5$ sp^3d

10) $XeO_3 \rightarrow \frac{8+0}{2} = 4$ sp^3.

11) $XeF_4 \rightarrow \frac{8+4}{2} = \frac{\cancel{12}}{\cancel{2}}\ 6$ sp^3d^2

12) $XeOF_2 \rightarrow \frac{8+0+2}{2} \Rightarrow \frac{\cancel{16}}{\cancel{2}}\ \cancel{6} \Rightarrow \cancel{8}/8 \cdot \frac{\cancel{10}}{\cancel{2}}\ 5 \rightarrow sp^3d$

13) $XeF_6 \rightarrow \frac{8+6}{2} = \frac{\cancel{14}}{\cancel{2}}\ 7 \Rightarrow sp^3d^3$.

14) $I_3^- \rightarrow \frac{7+2+1}{2} = \frac{\cancel{10}}{\cancel{2}}\ 5 \Rightarrow sp^3d$ ← one I should be considered as central atom - $I\ I_2^-$

15) $ClO^- \rightarrow \frac{7+1}{2} = 4 = sp^3$

16) $PO_4^{-3} = \frac{\cancel{*}5+0+3}{2} \Rightarrow \frac{\cancel{8}}{\cancel{2}}\ \cancel{8}\ 4$ sp^3

* <u>Some more example</u> :-

1) $BCl_3 \rightarrow \frac{3+3}{2} = 3 = sp^2$

2) $NH_3 \rightarrow \frac{5+3}{2} = \frac{8}{2} = 4 = sp^3$

3) $SO_2 \rightarrow \frac{6+0}{2} = 3 = sp^2$

4) $SO_3 \rightarrow \frac{6+0}{2} = 3 = sp^2$

5) $NO_2^- \rightarrow \frac{5+1+0}{2} = 3 = sp^2$

6) $SO_4^{-2} \rightarrow \frac{6+0+2}{2} = 4 = sp$

7) $H_2O = \frac{6+2}{2} = 4 = sp^3$

8) $HF \rightarrow \frac{7+1}{2} = 4 = sp^3$
↳ central atom.

9) $SF_2 \rightarrow \frac{6+2}{2} = 4 = sp^3$

10) $SF_4 \rightarrow \frac{6+4}{2} = 5 = sp^3d$

eg)
$BeCl_2$:- to find Hyb., shape, Angle & character.

$BeCl_2$

$Be_4 - 1s^2 2s^2 2p^0$

ground state :- $\underset{2s}{\boxed{\uparrow\downarrow}}\ \underset{2p}{\boxed{\ }\boxed{\ }\boxed{\ }}$ valency = 0

1st E.S :- $\underset{2s}{\boxed{\uparrow}}\ \underset{2p}{\boxed{\uparrow}\boxed{\ }\boxed{\ }}$ valency = 2 Hyb = 1s & 1p = sp //

shape for → linear

$Cl \longrightarrow Be \longleftarrow Cl$ Angle = 180°

$\Rightarrow$ s character $= \frac{s \times 1}{1s + 1p} \times 100 = \frac{1}{2} \times 100 = 50\%$.

eg) BCl_3

$_5B \rightarrow 1s^2 \underline{2s^2 2p^1}$

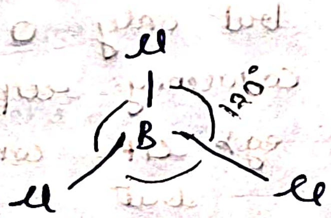
B in Ground state [↑↓] [↑| |] valency = 1

2s 2p but valency = 3.

B in 1st E.S [↑] [↑|↑|]

2s 2p 1s & 2p = sp_2.

Hyb = sp_2



→ shape → Trigonal planner

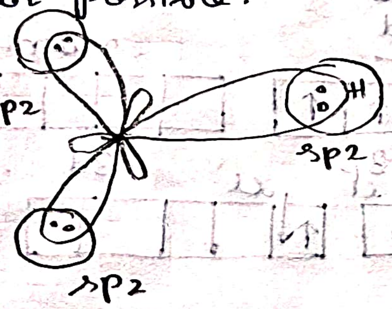
→ Angle → 120°

→ s character $= \frac{1}{3} \times 100 = 33.33\%$.

→ BCl_3 str is not possible.

eg) BH_3

$\Rightarrow \frac{3+3}{2} = \frac{6}{2}$ 3



$\underline{sp_2}$ have same energy

Geometry ↑

K=3 sp2, sp2, sp2

8 8 8

valency = 2

eg) CH_4

$1s^2 2s^2 2p^2$

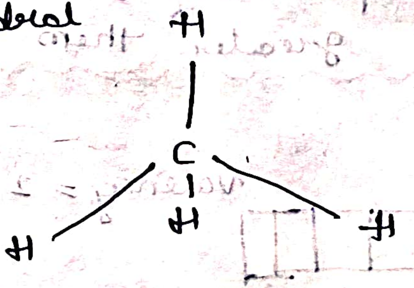
C in Ground state – [↑↓] [↑|↑|]

2s 2p H H H

C in First state – [↑↓] [↑↓|↑↓|↑↓] valency = 4

1s & 3p $\Rightarrow sp_3$ = Hyb.

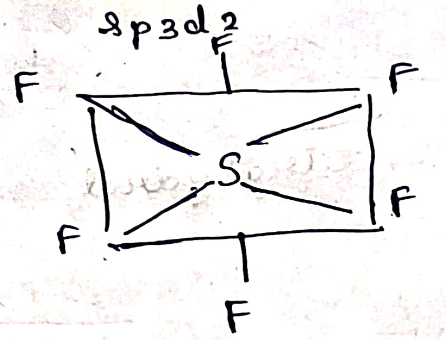
shape → Tetrahydral



Angle = 109° 28' = 109.5°

s character $\Rightarrow \frac{1}{4} \times 100 = 25\%$

sp^3d^2



→ square bi pyramidal
→ octahydral
→ Angle → 90°

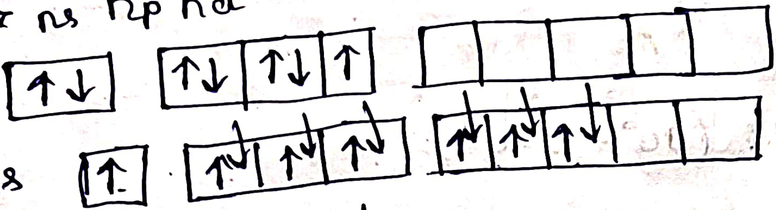
$\frac{7+7}{2} = \frac{\cancel{14}}{\cancel{2}}$ 7

eg IF_7 }
↳ $ns^2\ np^5\ nd^0$

sp^3d^3

G.S

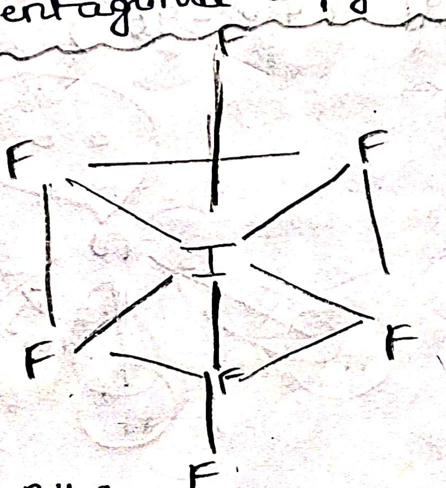
3rd E.S

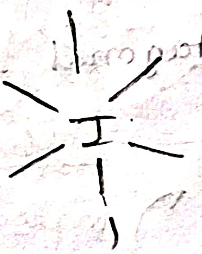


sp^3d^3.

Hyb → sp^3d^3.

shape → pentagonal bipyramidal





72° → equilateral.
90° → Axial

HW :- Book - 1
pg - 46 → Q no 1 - 42

* VSEPR THEORY :-

↓
Valence shell Electron Pair Repulsion Theory.

Given by slater, Acc^{ing} to this theory the central atom change their shape & angle acc^{or} to the presence of lone pair and bond pair of electron.

In the term of this :-

They feel repulsion in ^{p}
lp - lp > lp - bp > bp - bp's

& the bond angle $\propto \frac{1}{\text{no. of lp}}$

According to this theory, the maximum repulsion b/w lp - lp & the shape of the orbital also change.

eg ① calculation of lp. –

$NH_3 = \frac{5-3}{2} = 1lp$
$3bd$ 4 sp3 → tetrahydral

sp → linear (180°)

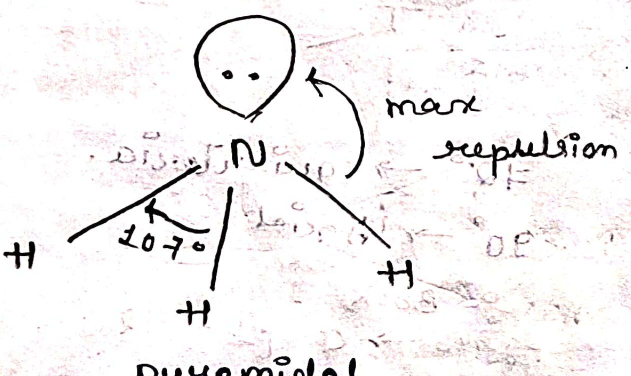
sp2 → trigonal planar (120°)

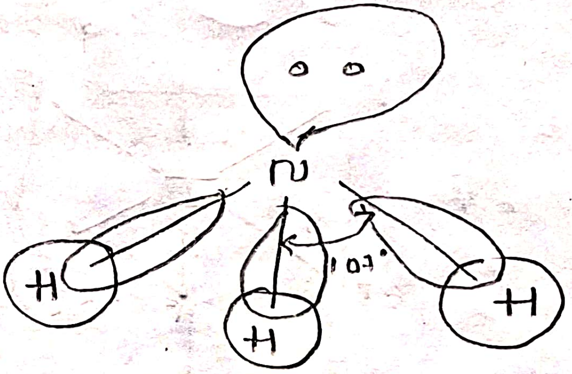
sp3 → tetrahydral (109.5)

sp3d → trigonal bipyramid (90° – 120°)

sp3d2 → octahydral (90°)

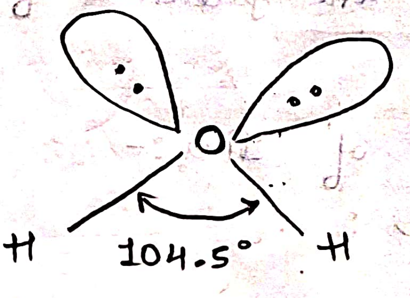
sp3d3 → ptentagonal bi-pyramid (72°–90°)

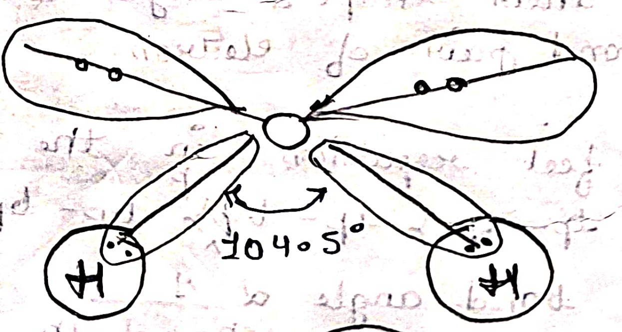




pyramidal

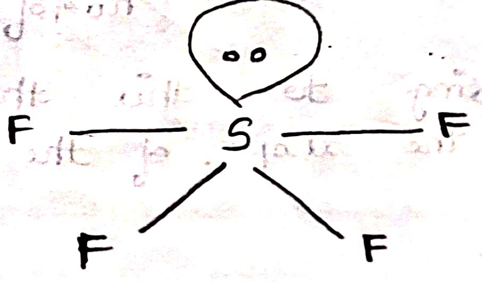
$H_2O \rightarrow \frac{6-2}{2} = 2lp$
$2bp$
$4 = sp3 = $ tetrahydral





Bend shape.

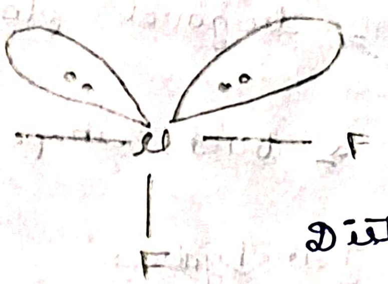
$SF_4 \rightarrow \frac{6-4}{2} = 1lp$
$4bp$
sp3d
Trigonal bipyramidal →



See saw

$\frac{\quad}{2}$ = 3 bd

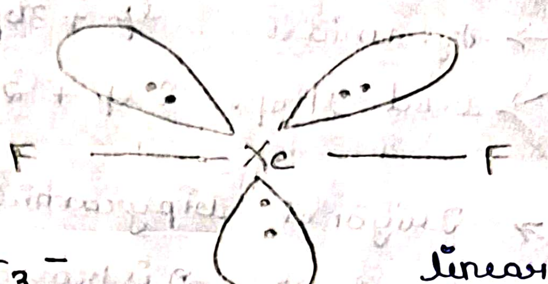
sp3d



Disturoted T shape.

$XeF_2 \rightarrow \frac{8-2}{2} = 3lp + 2bd$

sp 3d



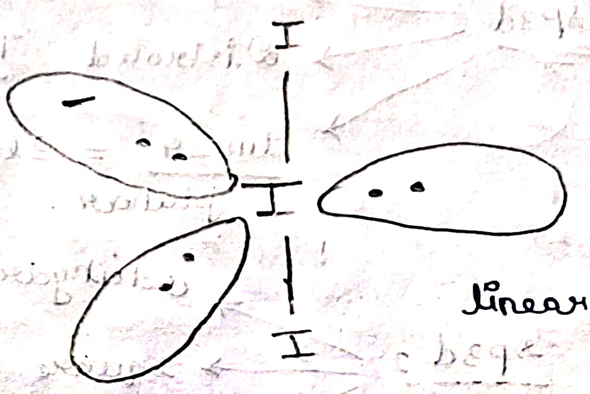
(ClF3) k type → IF_2^- / I_3^-

↓

$\frac{7-3}{2} = 3lp$ 2 bp

sp 3d

linear.

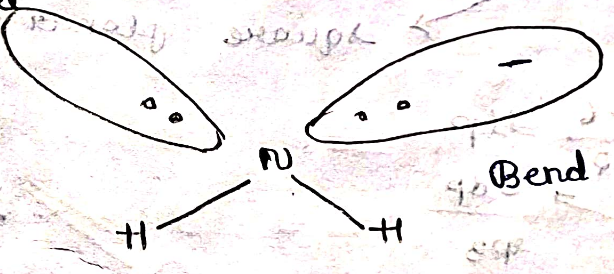


linear

$NH_2^- \longrightarrow NH_3$

sp 3. tetrahydral

$\frac{5+3}{2} = 4$



Bend shape.

$CO_2 \rightarrow \frac{4-4}{2} = 0lp$ 2 bp

sp

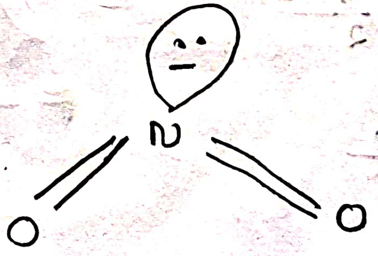
$O = C = O$

linear

180°

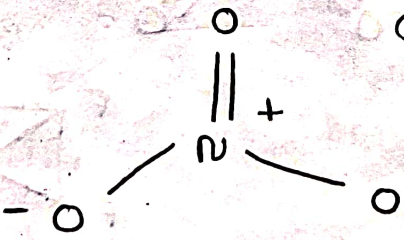
AB_2L_0

$NO_2^- \longrightarrow \frac{5+1}{2} = 3 \rightarrow sp_2$



Bend shape

NO_3^- = sp 3.



Trigonal planar

sp 2
- → Trigonal planar 3 bp → planar
- → bend shape 2 bp + lp → planar.

sp3
- → Tetrahydral 4 bp
- → Pyramidal lp + 3bp
- → bend shape 2 lp + 2 bp → planar.

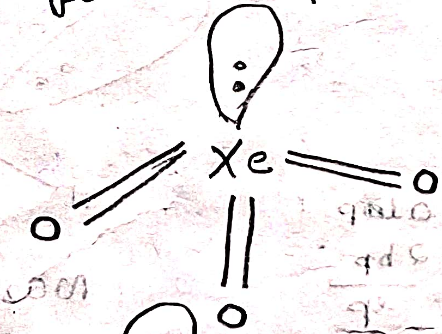
sp3d
- → Trigonal bipyramidal = 5bp
- → See saw, Distroted Tetrahydral = 1lp + 4bp
- → Distroted T shape = 2lp + 3 bd
  planar
- → linear = 3lp + 2bp
  planar.

sp3d 2
- → Octahydral = 6bp
- → square pyramidal = lp + 5bd
- → square planar = 2lp + 4bp

$XeO_3 = \frac{8-6}{2}$ = 1lp

3 dp

sp3

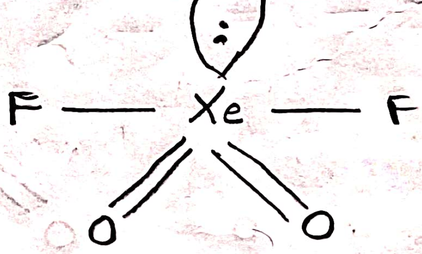


$XeF_2O_2 = \frac{8-4-2}{2}$

1 lp

4 bp

5



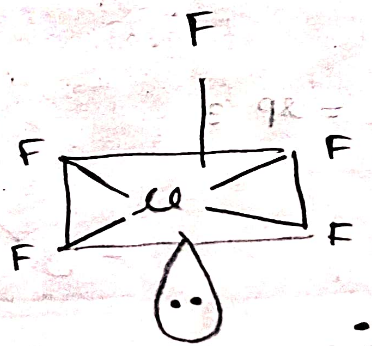
$ClF_5 = \frac{8-6}{2}$ = 1lp

3bp

6

sp 3d 2

Octahydral

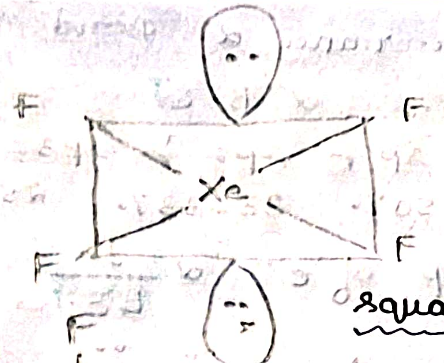


square pyramidal.

$XeF_4 = \frac{8-4}{2} = 2lp$

$4\ bp$

$6 = sp^3d^2$



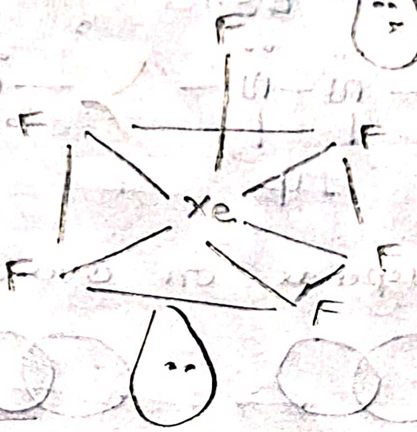
square planar

$XeF_6 = \frac{8-6}{2} = 1lp$

$6\ bp$

7

sp^3d^3



polygonal pyramidal

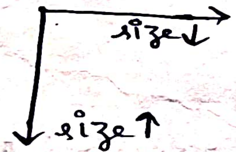
* BOND PARAMETERS :-

1) Bond length :-

Bond length

The distance b/w two nucleus in a covalent bond.

BL ∝ atomic size.



HF < HCl < HBr < HI

[HI is more acidic as बड़ा - छोटे के साथ so the bond will break H+ ion will dissosiates]

$Cl_2 < Br_2 < I_2 < \underline{F_2}$

→ Due to F_2 have Repulsion of nucleus & nucleus.

$BL \propto \frac{1}{\text{Bond energy}}$.

$BL \propto \frac{1}{\text{Bond order}}$

Bond order are the no. of bonds b/w two atoms in a molecule.

2) Bond Energy :- Energy required to break covalent bond.

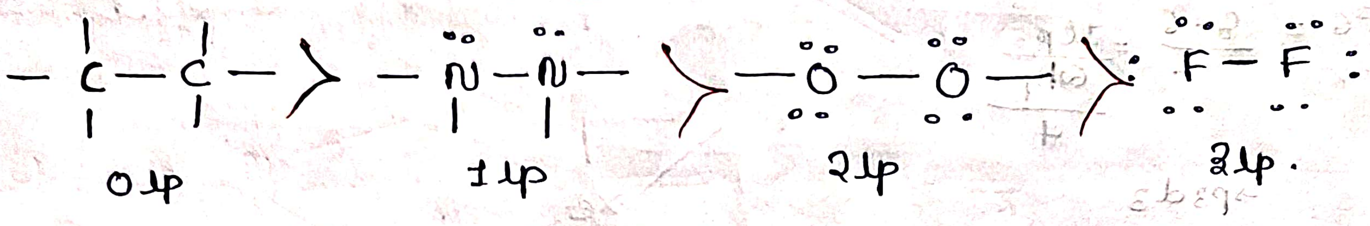
$BE \propto \frac{1}{BL}$, $BE \propto BO$ $C-C < C=C < C\equiv C$

Resonance & Bond Energy.

s character ∝ B.E

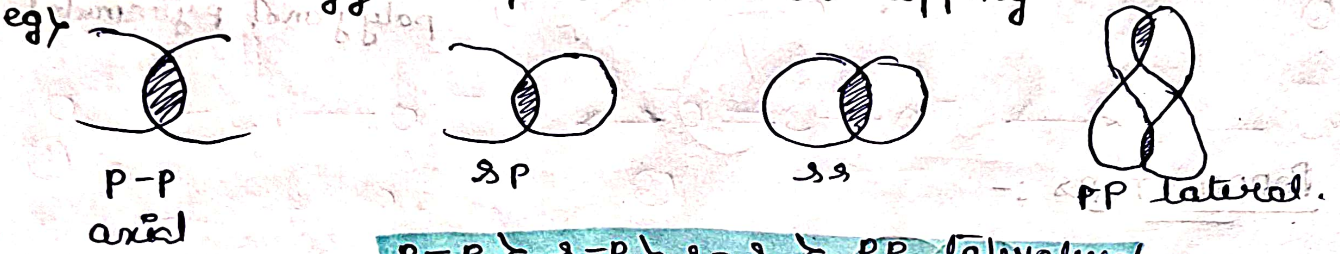
sp > sp2 > sp3
50% 33.33% 25%

lp of e^- ∝ $\frac{1}{BE}$.



Bond Energy depends on Overlapping.

eg)



p-p axial > s-p > s-s > pp lateral

more merging more energy required.

2) Bond Order :- no. of bond between the covalent bond.

C—C single bond

—C≡C—, N≡N triple bond.

$-\overset{|}{C}=\overset{|}{C}-$, O=O double bond.

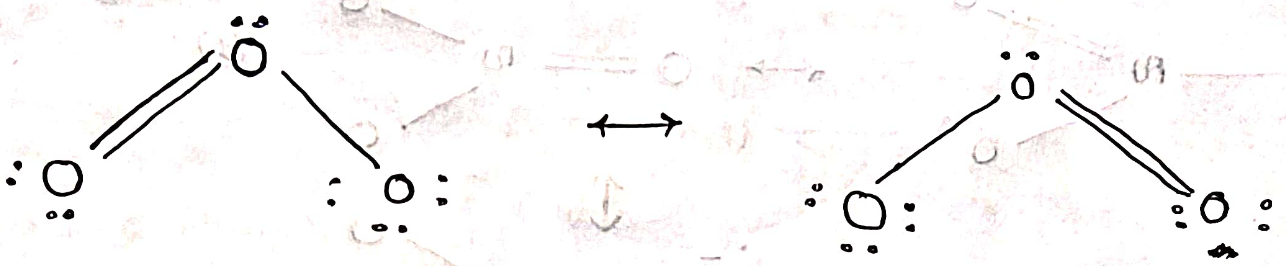
BO ∝ $\frac{1}{BL}$ & **BO ∝ B.E.**

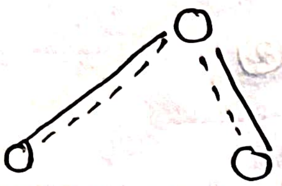
$-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}- < -\overset{|}{C}=\overset{|}{C}- < -C\equiv C-$ ⟵ Energy require to break the triple bond is more.

* RESONANCE :- It is found that in "ozone" bondlength are change due to Resonance.

" The actual structure in b/w the shifting of π e⁻ or delocalisation of πe⁻ is called Resonance & the str. are called as Resonic structure. or canonical form.

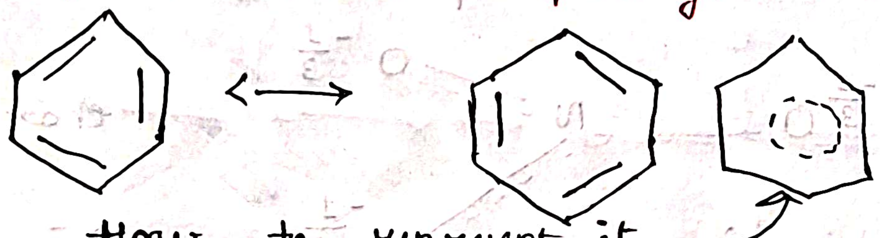
The canonical form have no real existence.





conical form.

Resonance are Temperory.



How to represent it

Conditions :-

1) =, —, = → eg) $-\overset{|}{C}=C-\overset{|}{C}=\overset{|}{C}-$

2) =, —, lp eg $\ddot{O}=O-\ddot{O}:$

3) =, —, -ve eg $-\overset{|}{C}=C-O^-$

4) =, —, +ve eg $-\overset{|}{C}=C-O^+$

5) =, —, • free radical $-\overset{|}{C}=C-\dot{C}-$

Rules :-

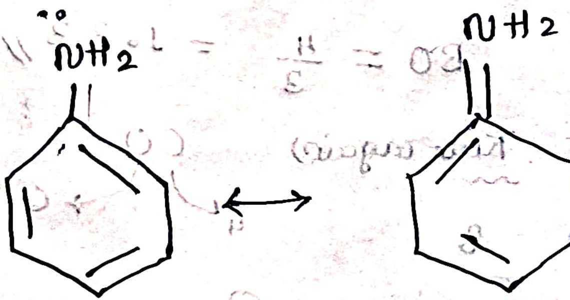
1) = → wiping

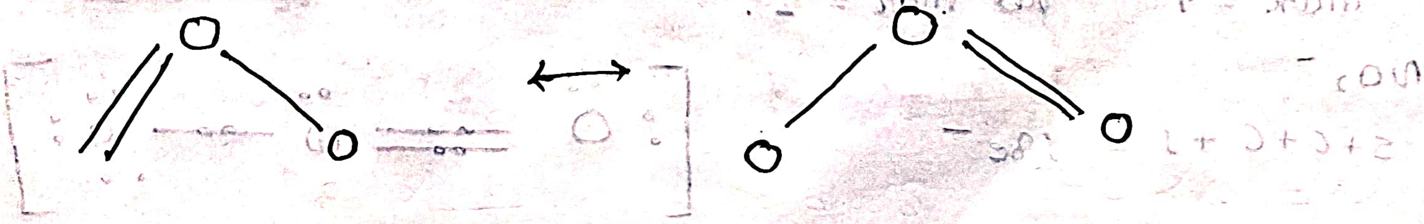
$-\overset{|}{C}=C-\overset{\ominus}{C} \rightarrow -\underset{\ominus}{\overset{|}{C}}-C=C$

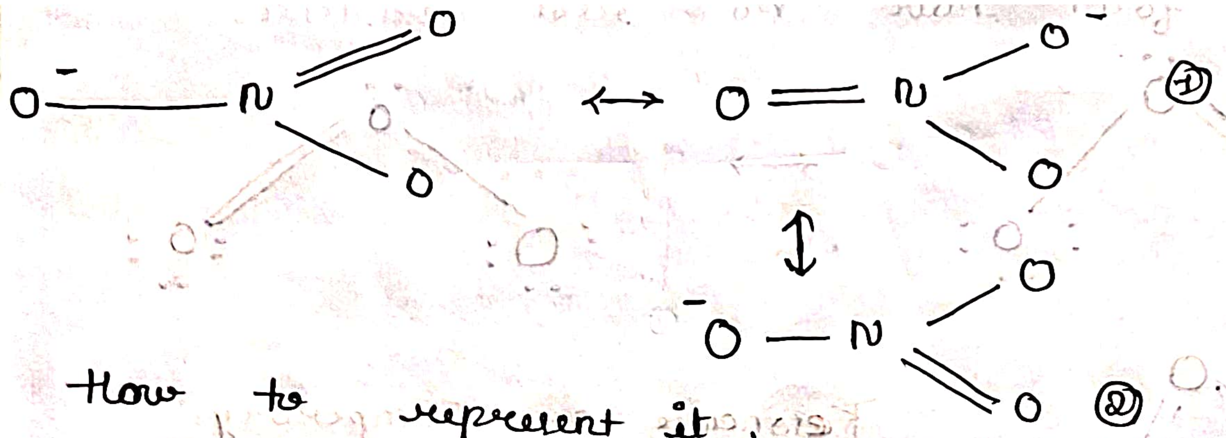
2) Charge → Alternation

3) lp → give.

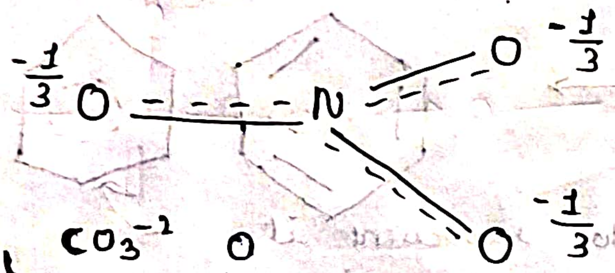
lp give → =
→ +ve
→ Alternate → -ve





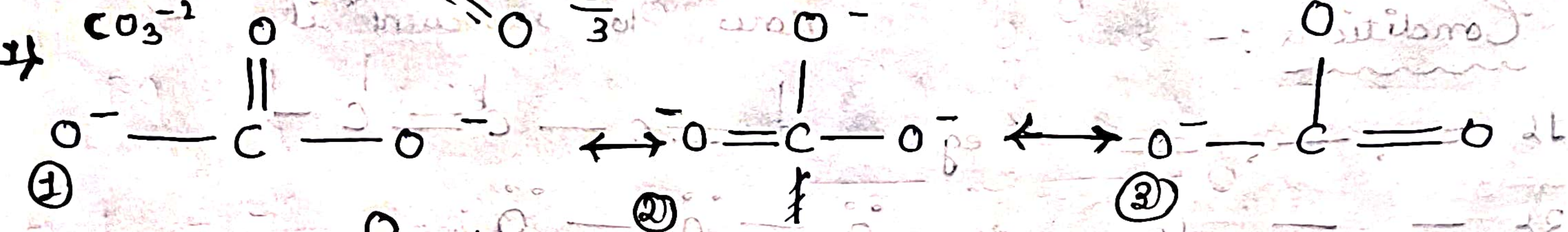


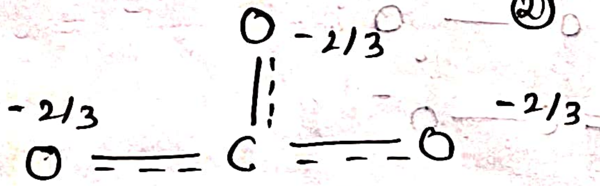
How to represent it.



charge = $-\frac{1}{3}$

CO_3^{-2}





charge (Formal) = **no. of charge** / **no. of participating atoms** = $\frac{2}{3}$ //

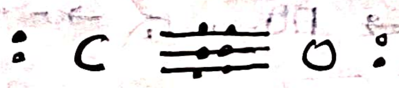
BO = To no. of ~~atom~~ bonds participating in Resonance / Resonic structure.

$BO = \frac{4}{3} = 1.33$ //

* Octet Rule (again)   CO   4   6 $4+6 = 10e^-$

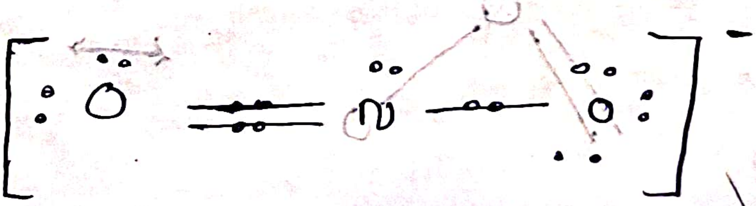
atom = 8

C → max = 4   O → val max = 2.



NO_2^-

$5+6+6+1 = 18e^-$

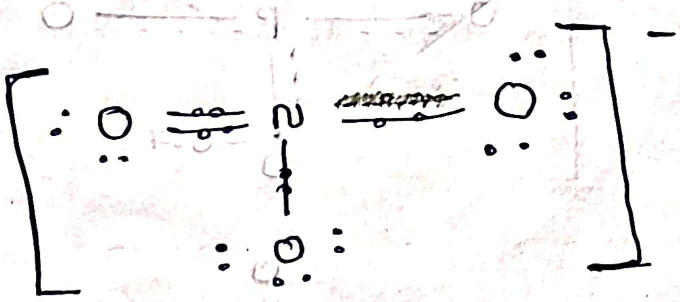


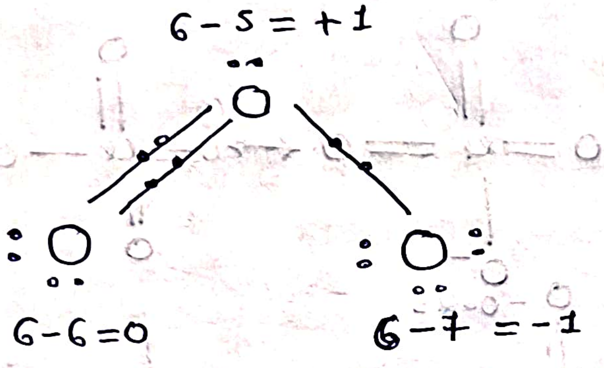
CO_2

$4 + 6 \times 2 = 16e^-$

NO_3^-

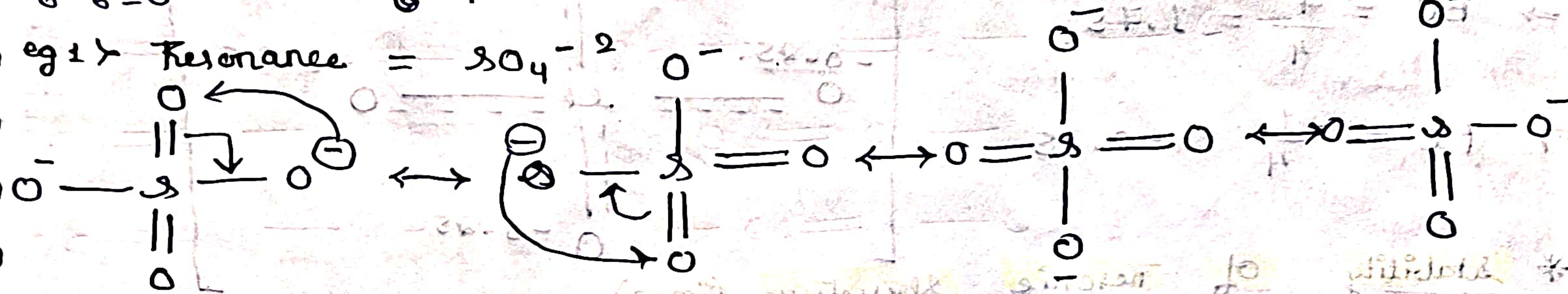
$5 + 6 \times 3 + 1 = 24e^-$





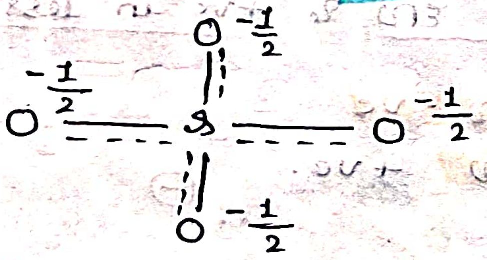
जितना होना चाहिए − जितना है

eg 1) Resonance = SO_4^{-2}



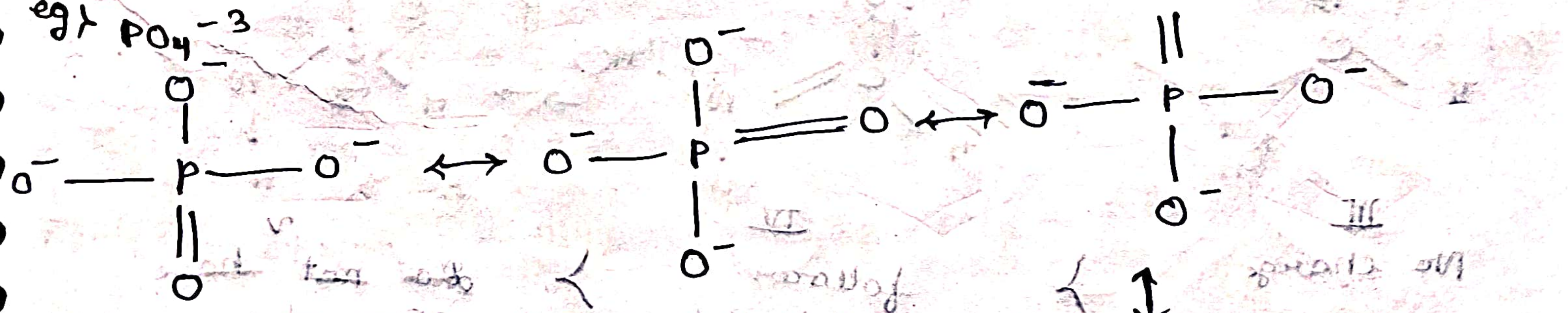
$$BO = \frac{\text{Total no. of bonds}}{\text{Total no. of resonic}} = \frac{6}{4} = 1.5$$

str.



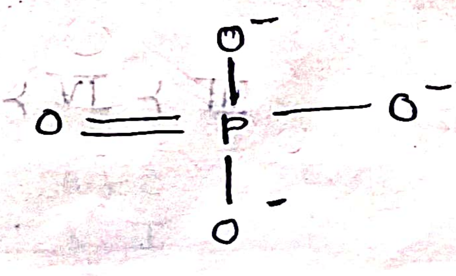
$$\text{Formal charge} = \frac{\text{Total no. of charge}}{\text{Total no. of } e^-} = \frac{-2}{4} = \frac{-1}{2}$$

eg) PO_4^{-3}

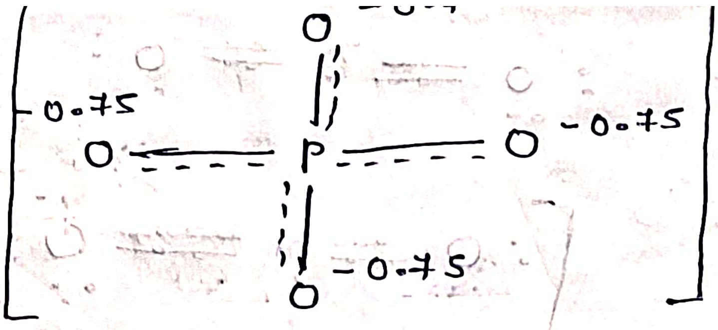


$$BO = \frac{5}{4} = 1.25$$

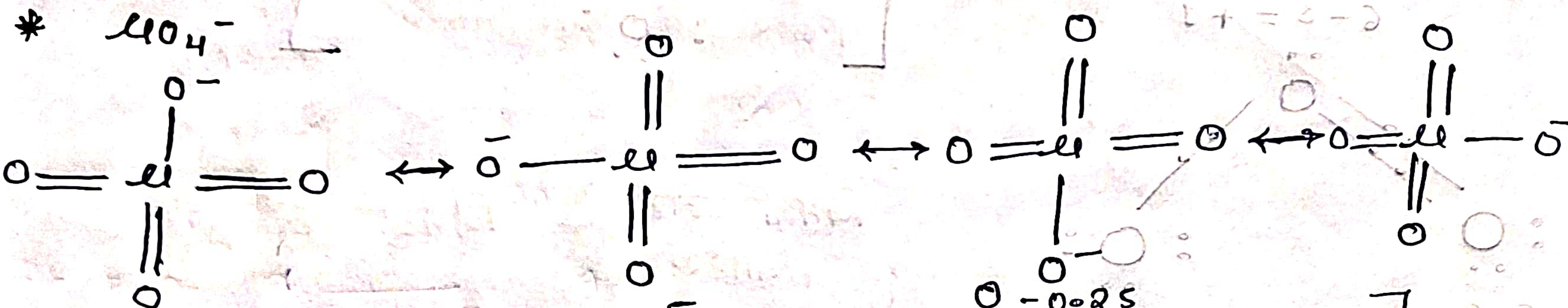
$$FC = -\frac{3}{4} = -0.75$$



~~Reson~~

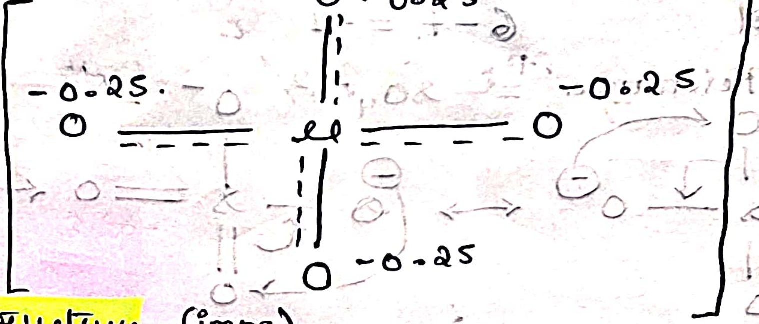


* ClO_4^-



→ $BO = \frac{7}{4} = 1.75$

→ $FC = \frac{-1}{4} = -0.25$



* Stability of Resonic Structure (impo)

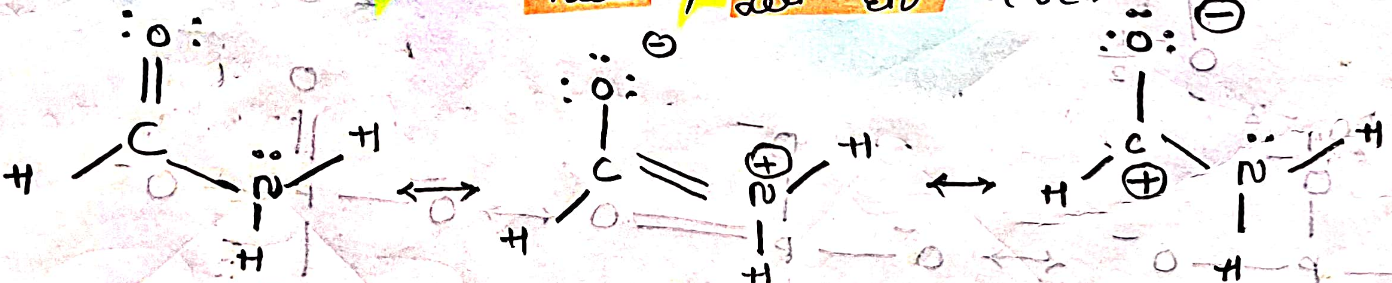
5:35

1) No charge are very very stable

2) structure which have complete their octet are more stable.

3) structure which have -ve in more EN & +ve in less EN.

No charge > Octet Rule > more EN -ve Less EN +ve.

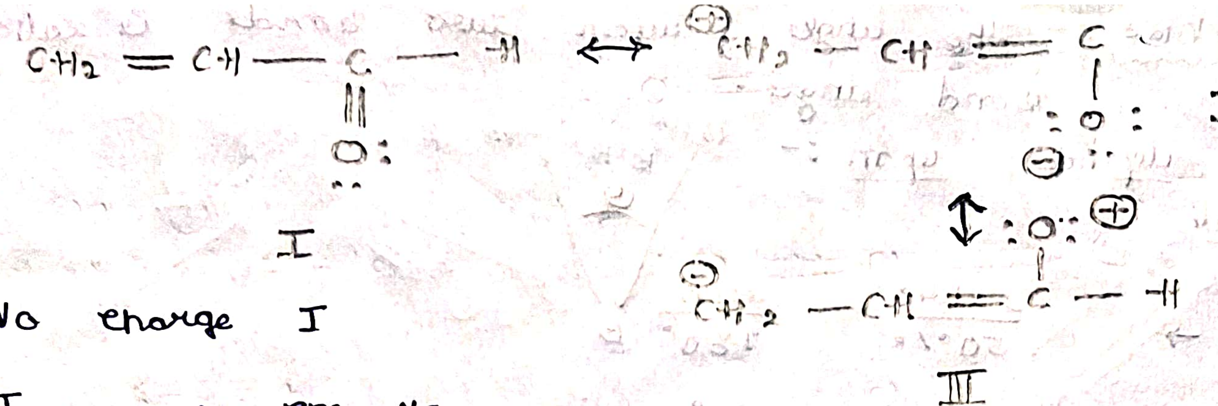


III
No charge

> IV
follows octet Rule

> V
Do not have any charge octet incomplete

III > IV > V

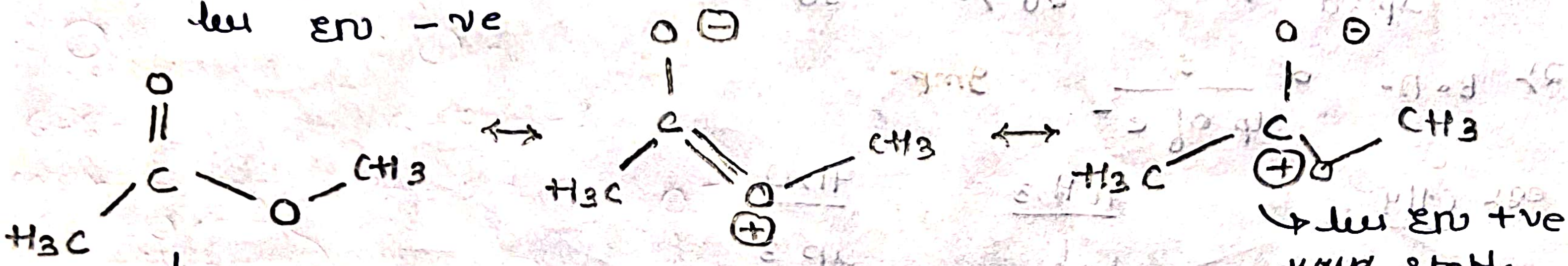


No charge I

II → more EN −ve
less EN +ve

III → More EN +ve
less EN −ve

I > II > III



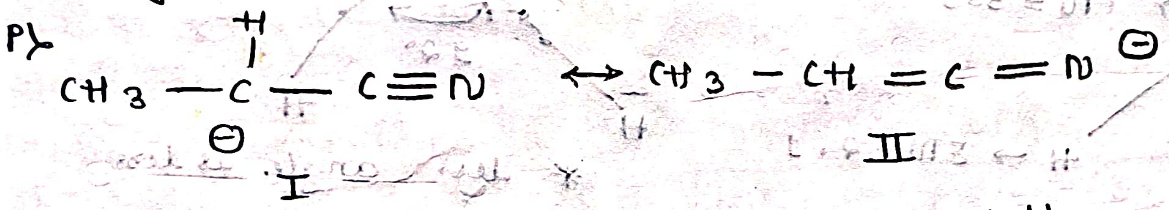
No charge

more EN +ve unstable

→ less EN +ve
stable

I > III > II

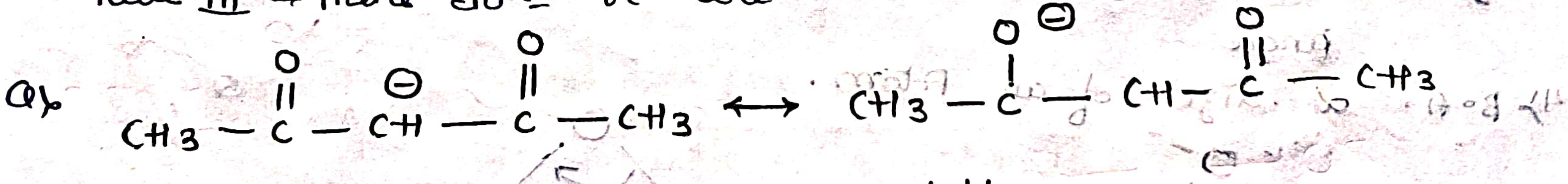
Ques) In the following set of resonic structure which are major contribution in Resonic Hybrid.

P) 

$CH_3-\overset{H}{\underset{\ominus}{C}}-C\equiv N \longleftrightarrow CH_3-CH=C=N^{\ominus}$

I II

Rule III → more EN = −ve are more stable   II > I

Q) 

$CH_3-\overset{O}{\overset{\|}{C}}-\overset{\ominus}{CH}-\overset{O}{\overset{\|}{C}}-CH_3 \longleftrightarrow CH_3-\overset{O^{\ominus}}{\overset{|}{C}}=CH-\overset{O}{\overset{\|}{C}}-CH_3$

Rule III) more EN −ve & more stable.

R) $CH_3-CH_2-\overset{\oplus}{CH}-NH_2 \longleftrightarrow CH_3-CH_2-C=\overset{\oplus}{N}H_2$

I II

EN C < N.

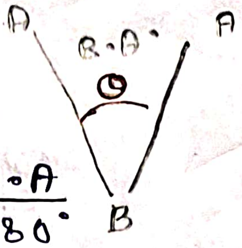
Rule III → less EN → +ve   I > II

S) $CH_3-\overset{\ominus}{CH}-CH=CH-NO_2 \longleftrightarrow CH_3-CH=CH-CH=\overset{\ominus}{N}O_2$

Rule III → more EN −ve   EN) N > C

II > I

* **BOND ANGLE** :- The angle between two bonds is called Bond angle.



*Bond angle depends upon :-

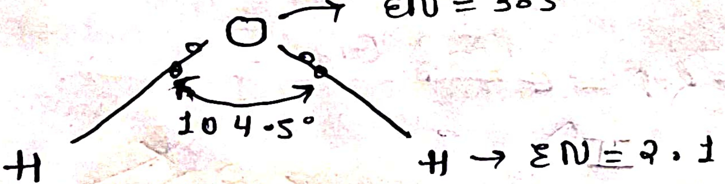
1) s character

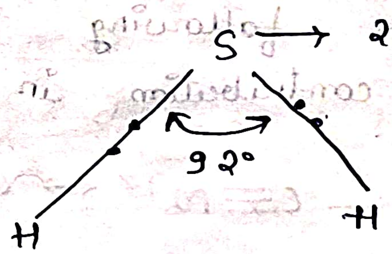
	s chr.	B.A
sp →	50%	180°
sp2 →	33.33%	120°
sp3 →	25%	109.5°
sp3d →	20%	90 - 120°

2) B.A. ∝ $\frac{1}{lp \text{ of } e^-}$ Imp.

eg)	CH_4	NH_3	H_2O
Hy)	sp3	sp3	sp3.
lp)	0 lp	1 lp	2 lp.
B.A)	109.5°	107°	104.5°

3) B.A. ∝ EN.

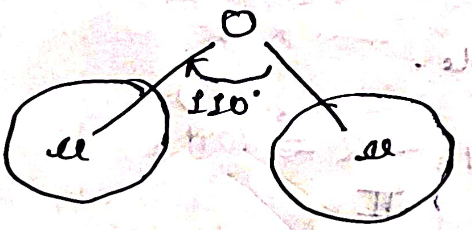


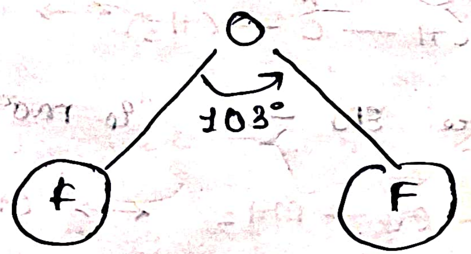


* more e⁻ attraction more angle

* less angle as less EN.

4) B.A. ∝ size of an Atom.





* BOND POLARITY :-

HCl, HBr etc.

Covalent Bond → Polar → $\Delta EN \geq 1.5$ more

→ Non-polar → H_2, O_2 etc.

* Dipole moment :- used to define the % ionic char. in covalent bond.

$\mu = Q \times d$

= Cm (columbs meter)

↑

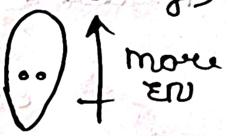
1 Debye = 3.3×10^{-30} Cm

* Bond Polar
* Molecular polar

$+\!\!\longrightarrow$ pole.

less EN. more EN

(very)



$\boxed{HCl}$

$+\delta$ $-\delta$

less EN H —— Cl more EN

$+\!\!\longrightarrow$

1) H —— H no pole formaⁿ

non-polar

2) H $+\!\!\rightarrow$ F

less EN more EN ~~no~~ Bond polar.

CO_2

↓

sp → linear

O == C == O

$\longleftarrow\!\!+ \; +\!\!\longrightarrow$ $\theta = 180°$

Bond = polar

molecule = not polar

(μ) $\boxed{\mu = 0}$

μ is vector quantity.

$$\mu = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2 2\cos\theta}$$

$\cos\theta = 0° = 1$

$\cos\theta = 180° = -1$

$\mu_1 = \mu_2 = \mu$

$$\mu = \sqrt{\mu^2 + \mu^2 + 2\mu^2 \times -1}$$

$BeCl_2$ = sp

$+\!\!\longrightarrow$

Cl —— Be —— Cl

$\longleftarrow\!\!+$

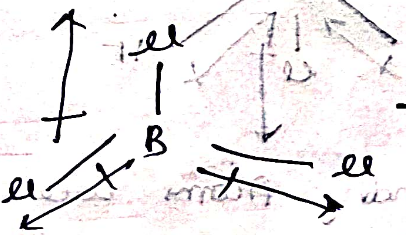
$\mu = 0$

Bond polar

Molecule Non-polar

$\mu = 0$ → non-polar.

BCl_3 = sp^2

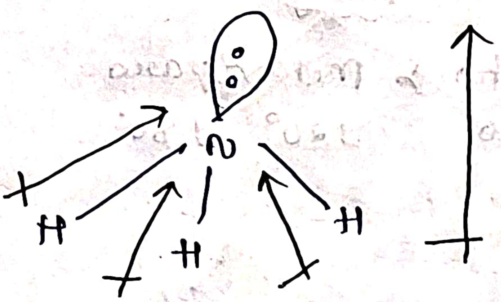


$\mu = 0$

Bond polar

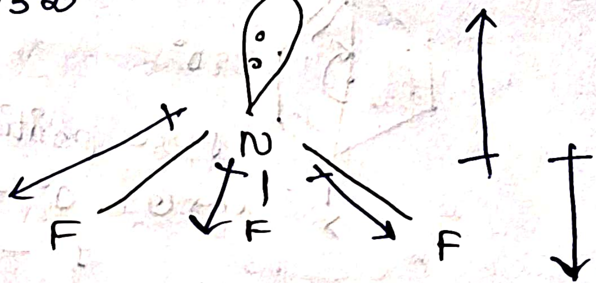
Molecule Non-polar.

NH_3 → sp^3



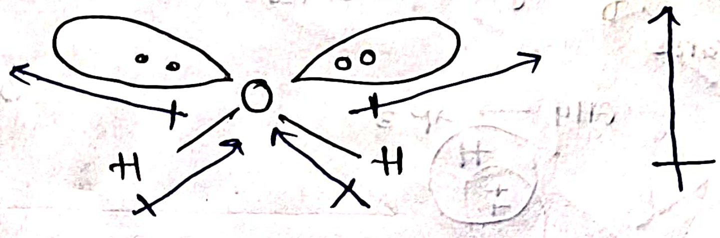
1.47 D 0.23 D

NF_3

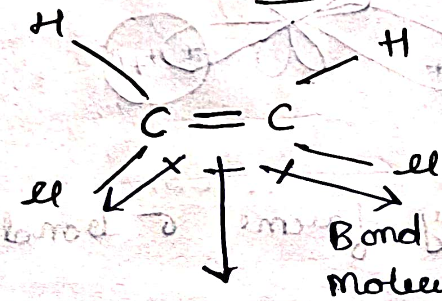


lp > polar.

H_2O → sp^3
2lp
2b

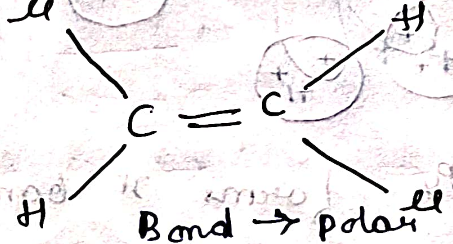


Cis



Bond → Polar
Molecule → polar

Trans



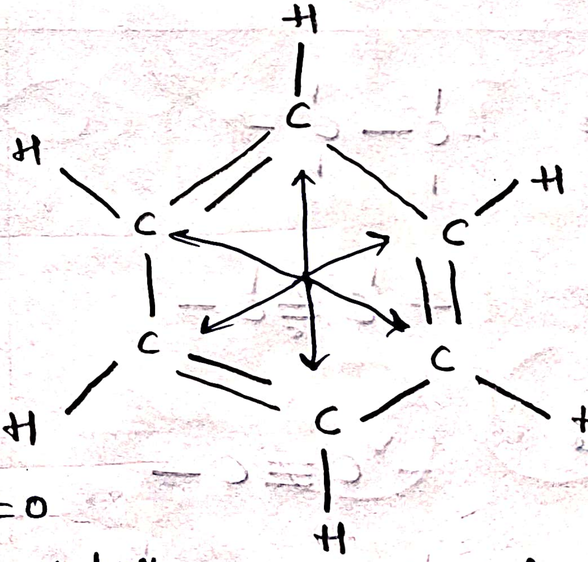
μ=0

Bond → polar
Molecule → Non-polar.

Cis > Trans. (Not Always)

* Benzene

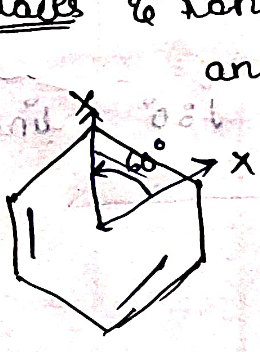
EN	s character & EN		
2.5	$-\overset{\vert}{\underset{\vert}{C}}-$	→ sp_3	25%
3.0	$-\overset{\vert}{C}=\overset{\vert}{C}-$	→ sp_2	33.33%
3.5	$-C\equiv C$	sp	50%



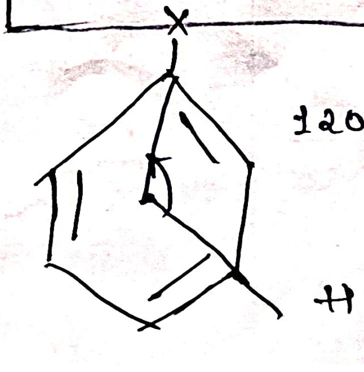
μ=0

Bond = polar
Molecule = Non-polar (as μ=0)

* Places & Ranges of angle in them.

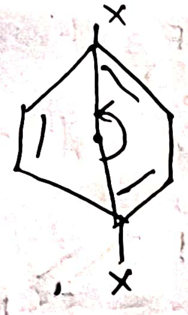


ortho position



120°

meta position



180°

para position

$\cos\theta = 0° \rightarrow 180°$

$1 \longrightarrow -1$

Range

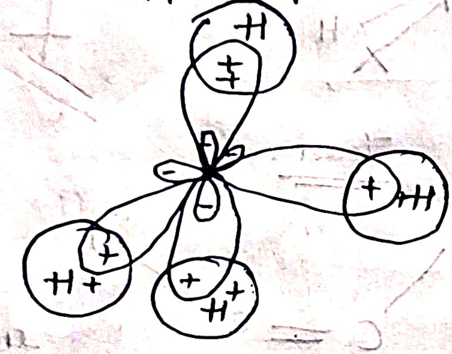
ortho > Meta > para

60° 120° 180°

* Shapes of Hydrocarbons.

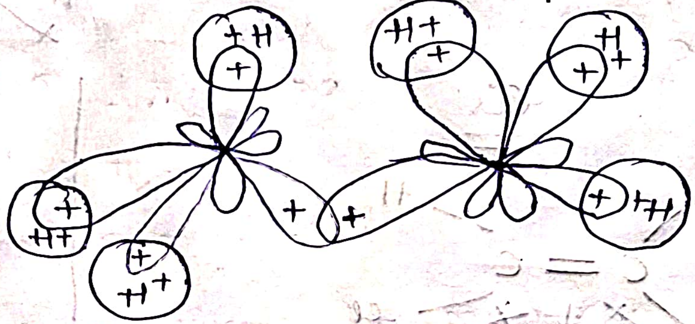
1) Methane

$CH_4 \rightarrow sp^3$



2) Ethane

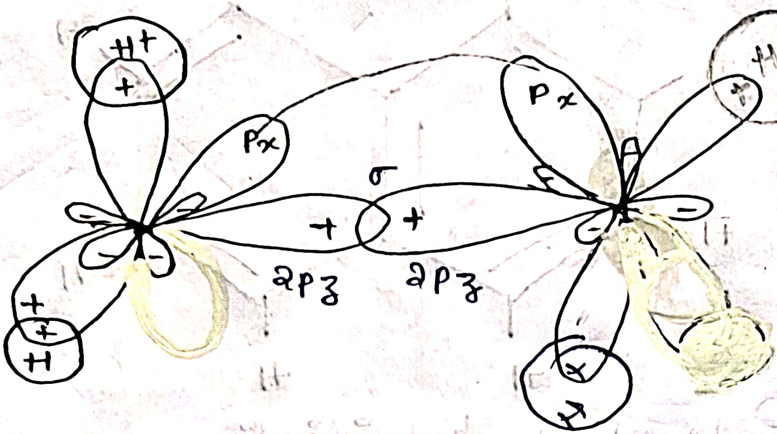
$C_2H_6 = sp^3$



* Px & Py forms π bond & Pz only forms σ bond.

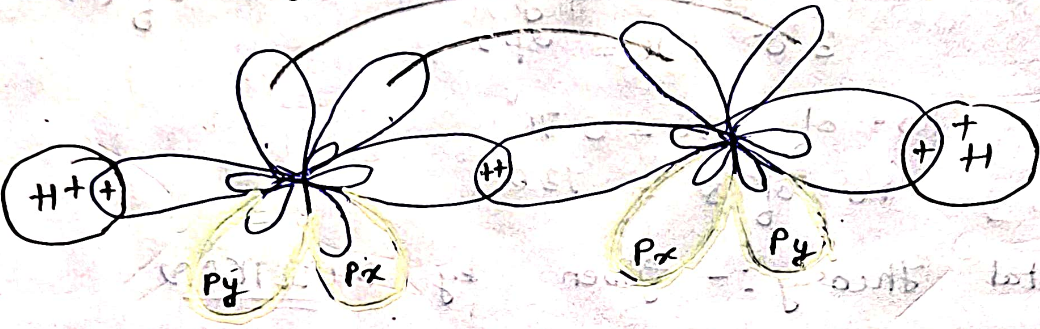
Name	str.	σ bond	π bond	Hybr.	Angle	shape.
Alkane	$-\overset{\mid}{\underset{\mid}{C}}-\overset{\mid}{\underset{\mid}{C}}-$	4σ	0	sp^3	109°28'	Tetrahedral
Alkene	$-\overset{\mid}{C}\overset{\pi}{\underset{\sigma}{=}}\overset{\mid}{C}-$	3σ	1 π	sp^2	120°	Trigonal
Alkyne	$-C\equiv C-$	2σ	2π	sp	180°	linear.
Alkadene	$-\overset{\mid}{C}=C=\overset{\mid}{C}-$	2σ	2π	sp	180°	linear

Structure of Alkenes :-

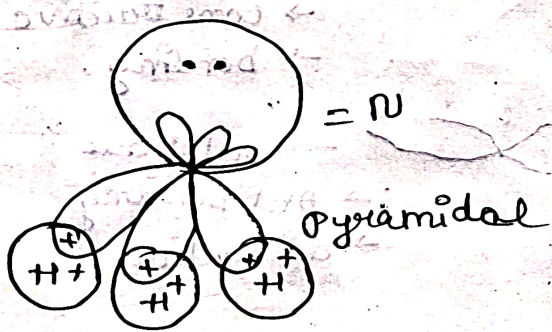


$\underline{C_2H_4}$

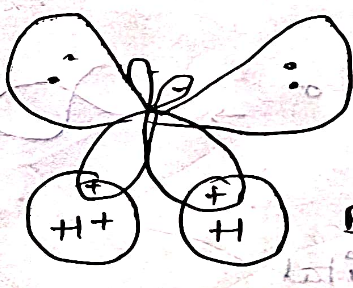
Structure of Alkynes - C_2H_2



NH_3)



H_2O)



Bend shape.

1) no. of σ and π bond.

2) Hyb. shape, Angle etc each carbon.

eg) $CH_2 = CH — CH = CH — C \equiv CH$

CH_2	CH	CH	CH	C	CH
3σ	3σ	3σ	3σ	2σ	2σ
1π	1π	1π	1π	2π	2π
sp_2	sp_2	sp_2	sp_2	sp	sp

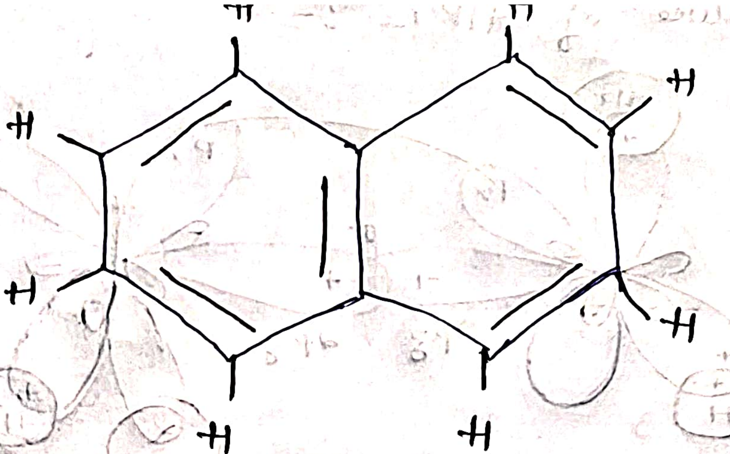
1) no. of σ = 11

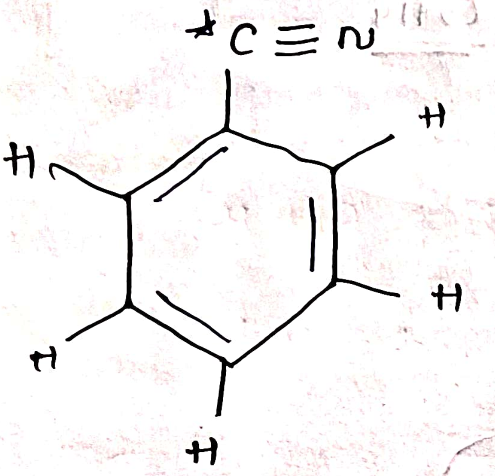
2) no. of π = 4π //

cg 26 25.* very impo

no. of π bond = 5π

σ = 19σ





to find hybridization
take any one atom of c*

3σ 1π = sp2

no. of $\pi = 5\pi$

no. of σ = 13σ

* Molecular Orbital Theory :- given by <u>MULLICAN</u>

$\psi_A + \psi_B = \sigma \rightarrow$

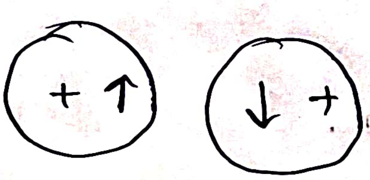
overlapping

inphase
→ constructive
→ bonding.

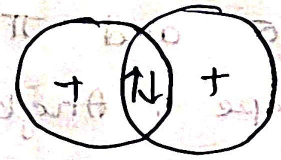
$\psi_A - \psi_B = \sigma^* \rightarrow$

– outphase
→ Antibonding
→ destructive

for s orbital



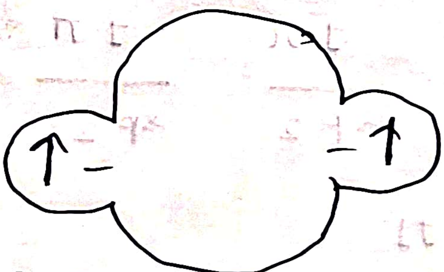
→ in phase



$\psi_A + \psi_B$

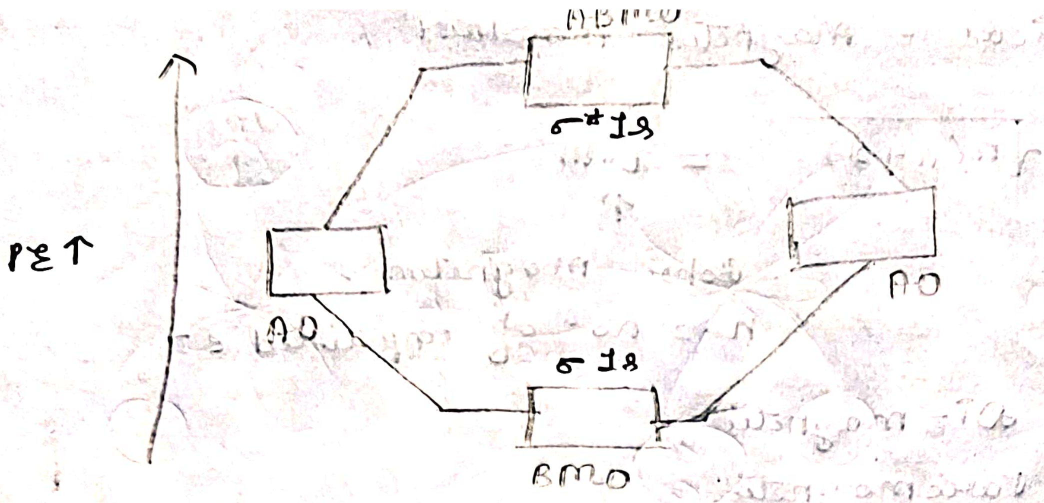
BMO = Bonding molecular orbital.

AO = Atomic orbital



ABMO

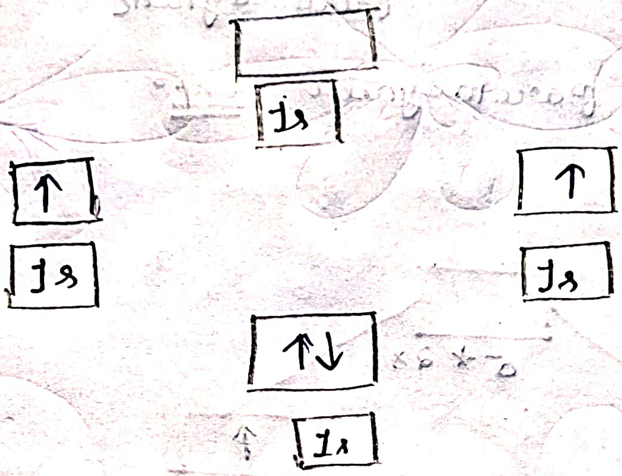
Antibonding Mole. orbital.



eg:- $H = 1s^1$ & $H = 1s^1$ of H_2.

LCAO = Linear Combination of Atomic orbital

LCAO of H_2



* Bond Order, Bond strength, Magnetic behaviour:-

$$B.O = \frac{N_b - N_A}{2}$$

N_b = No. of e^- in Bonding M.O.

N_A = No. of e^- in ABMO.

BO = 1 = S.B

BO = 2 = D.B

BO = 3 = T.B

BO = 0 = Molecules doesn't exist.

B.O ∝ Bond strength.

Stability ∝ BO ∝ B.S

$N_b > N_A$ more stable

$N_A > N_B$ (Energy)

* Magnetic Behaviour - Magnetic movement .

$\mu - \sqrt{n(n+2)} = B.M$

↑

Bohr magneton .

n = no. of unpaired e-

$\mu = 0$ → Di-magnetic

$\mu \neq 0$ → Paramagnetic .

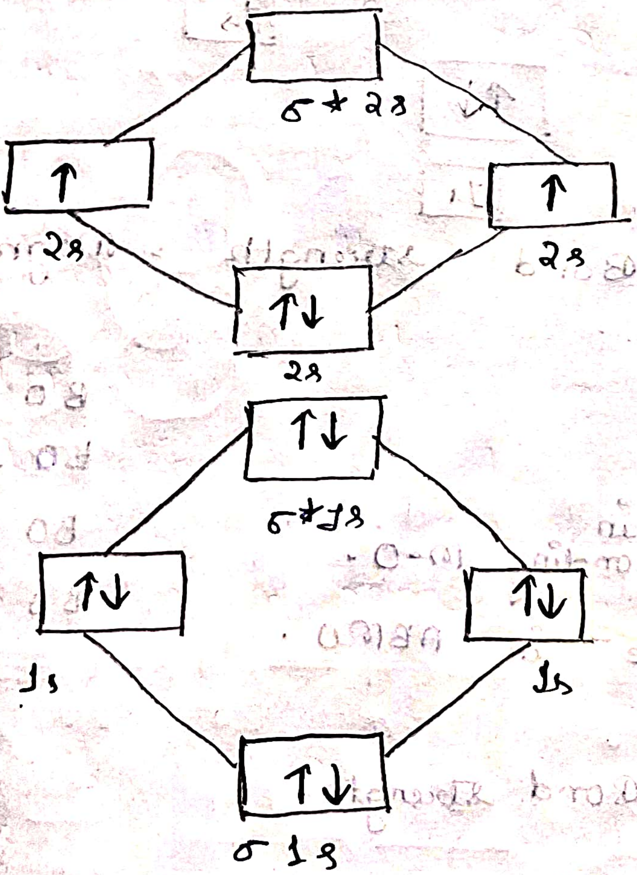
BO = 1.5, 0.5, 2.5 (Decimal)

↓

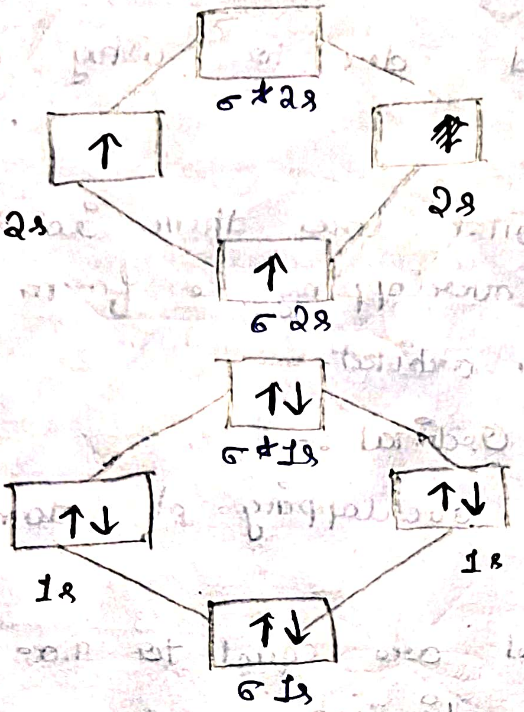
Paramagnetic

$\left[BO = \underset{16}{O_2} = \underset{10}{B_2} \right]$ paramagnetic exp°

Li . $1s^2 2s^1$

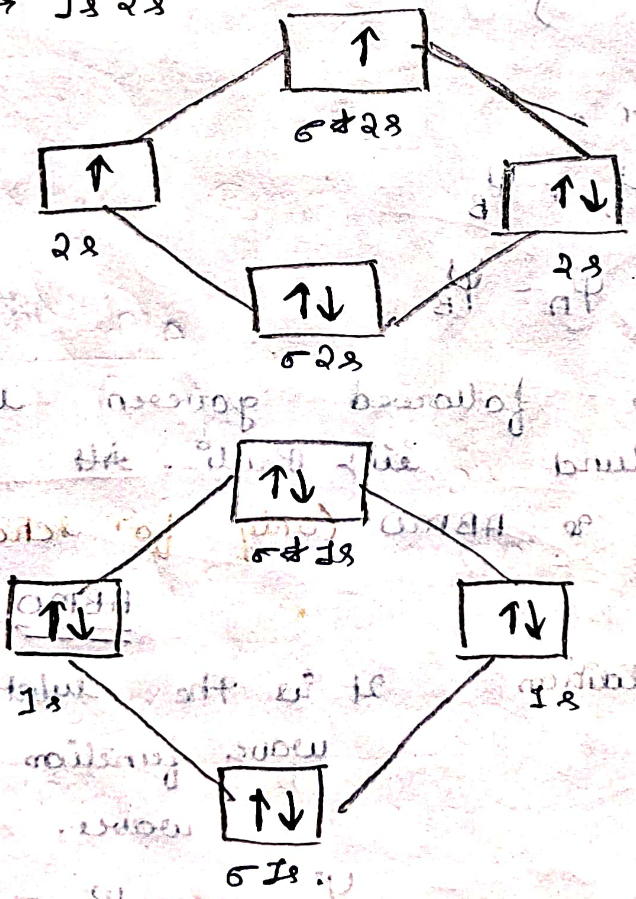


Li_2^+ − ~~1~~ $1s^2\ 2s^1$ $Li\ 1s^2\ 2s^0$



comparing Li_2^+ with Li only.

$Li_2^- \rightarrow 1s^2\ 2s^2$



MOT :-

- MOT was given by Hund & Mullican.
- This was only proposed due to why oxygen (O_2) are paramagnetic in nature.

Definition - The atomic orbital loses their identity during molecule formation overlapping & form new orbital termed as molecular orbital.

Characteristics of Molecular Orbital :-

i) Mole. O. formed by overlapping of atomic orbital of same energies.

ii) No. of molecular orbital are equal to no. of atomic orbital involve in combination.

iii) Half of the molecules have lower energy called BMO (Bonding molecular Orbital) & half of higher energies ABMO (Anti Bonding -II-)

iv) Acc^n to schrodinger,

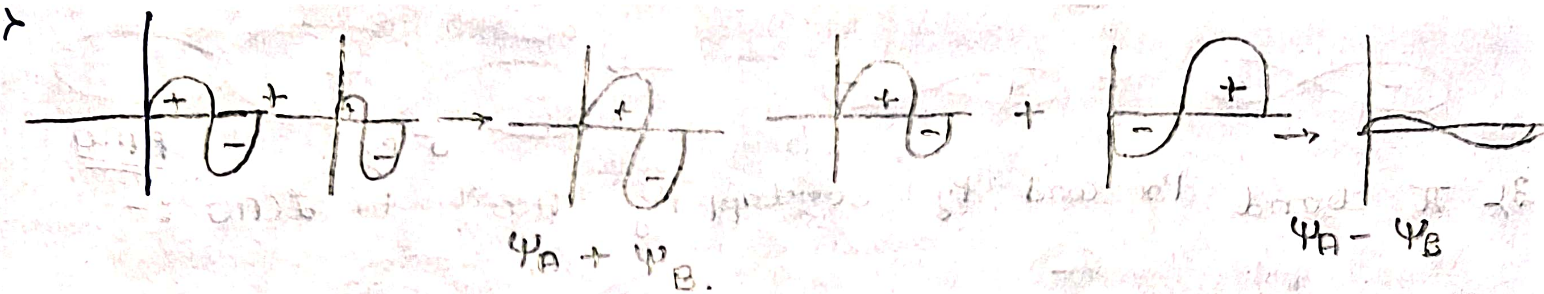
$$\psi_{BMO} = \psi_A + \psi_B$$

$$\psi_{ABMO} = \psi_A - \psi_B$$

v) Electronic configuration followed govern by three rule i) Aufbau ii) Hund iii) Pauli. ~~All~~

*Comparison b/w BMO & ABMO (only for school)

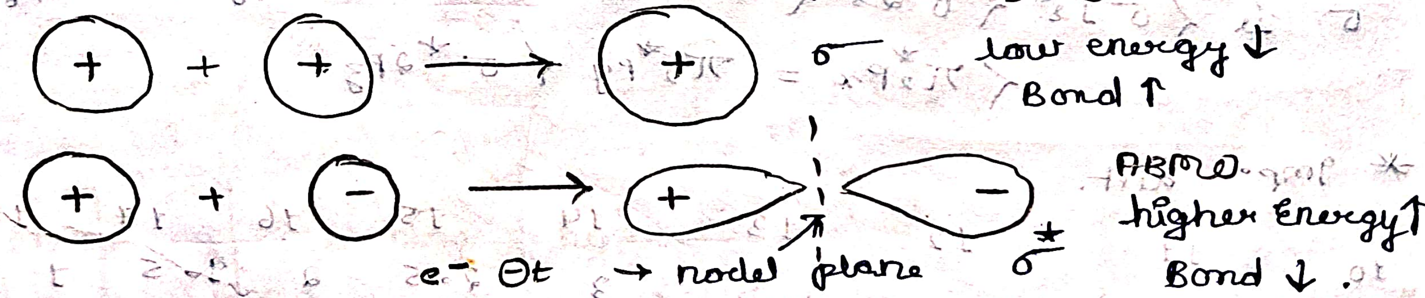
BMO	ABMO
i) It is the result of addition of two waves. $\psi_{Bmo} = \psi_A + \psi_B$.	It is the substraction of wave function of two waves. $\psi_{ABmo} = \psi_A - \psi_B$.



2)	This is constructive interference ↑ (merging of 2 waves)	This is the distructive interference
3)	Generally, does not have nodel plane.	It has always a nodel plane b/w two nucleus.
4)	e^- density increases.	e^- density decreases.
5)	It causes attraction	It causes repulsion.
6)	They have less energy & more stability.	They have ↑ energy & ↓ stability.
7)	They are denoted by σ & π	They are denoted by σ^* & π^*

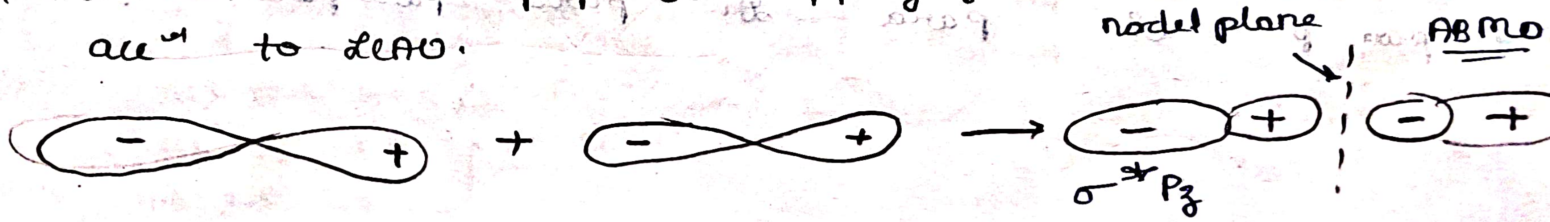
* Acc^n to LCAO types of overlapping :-

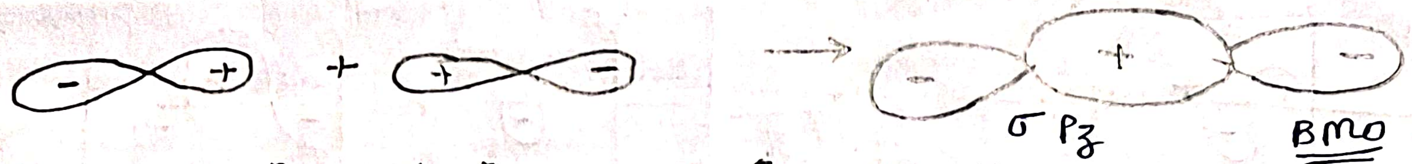
1) s-s overlapping :-



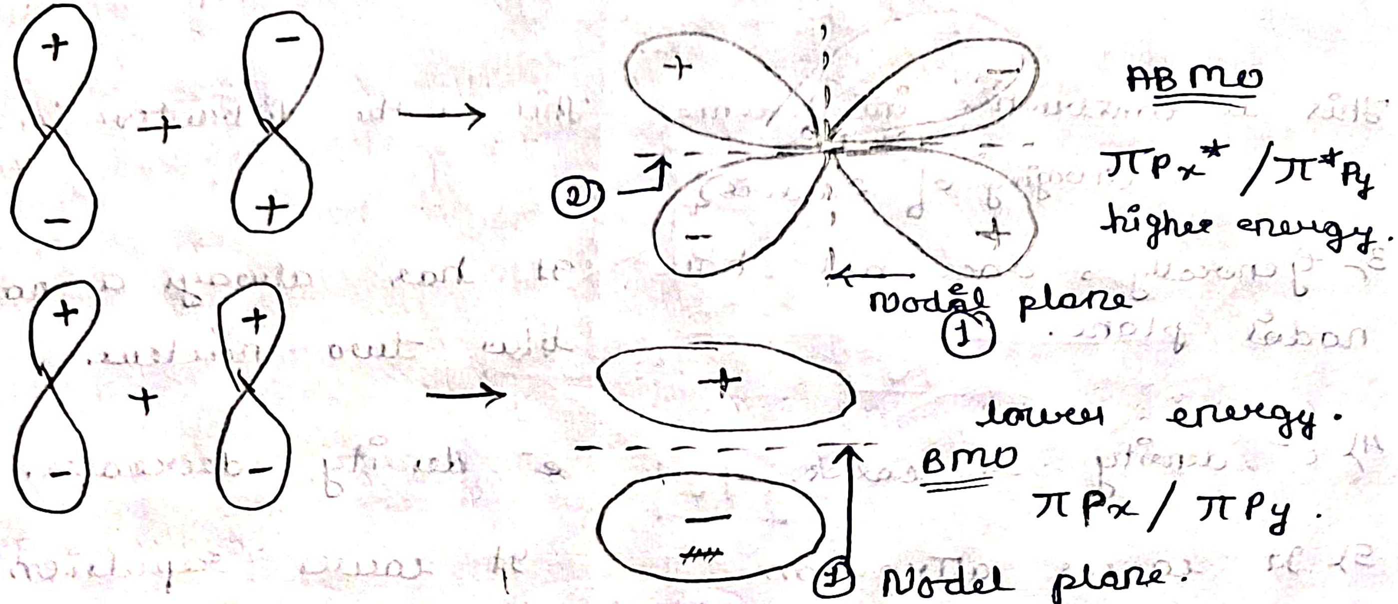
e σ^* s have 1 nodel plane.

2) head on head p-p overlapping :-
acc^n to LCAO.





3) π bond Px and Py overlapping Acc^n to LCAO :-



Sequence of filling of e⁻.

At more than 7 or Total e⁻ more than 14.

LCAO :- $\sigma 1s < \sigma^{*}1s < \sigma 2s < \sigma^{*}2s < \sigma 2P_z < [\pi 2P_x = \pi 2$ P_y

$< [\pi^{*}2P_x = \pi^{*}_{2}P_y] < \sigma^{*}2P_z$. for O_2, F_2, Ne_2 etc

for atomic no. less than 7 ie total no. of electron is also or equal or less than 14. or e⁻ are equal to 7. for C_2, B_2, N_2 etc

$\sigma 1s < \sigma 1s^{*} < \sigma 2s < \sigma^{*}2s < \pi 2P_x = \pi 2P_y < \sigma 2P_z$

$< \pi^{*}_{2}P_x = \pi_{2}^{*}P_y < \sigma^{*}2P_z$.

Imp. List.

0	11	12	13	14	15	16	17	18	19	20
1	1.5	2	2.5	3	2.5	2	1.5	1	0.5	0
	para p	Dia	para	Di	para	para	para	Di	para	Di

⇒ DPP – 13

~~Que-1~~

HYDROGEN BONDING :-

- Weak Bond
  - Hydrogen bond
    - Intermolecular H- bond
    - Intramolecular weal
  - Vander waals Bond
    - Ion Dipole attraction
    - Dipole Dipole attrac.
    - Ion Induced dipole attraction
    - Dipole Induced Dipole attra.
    - London force Dispert-Ion force.

*** Hydrogen Bond :-**

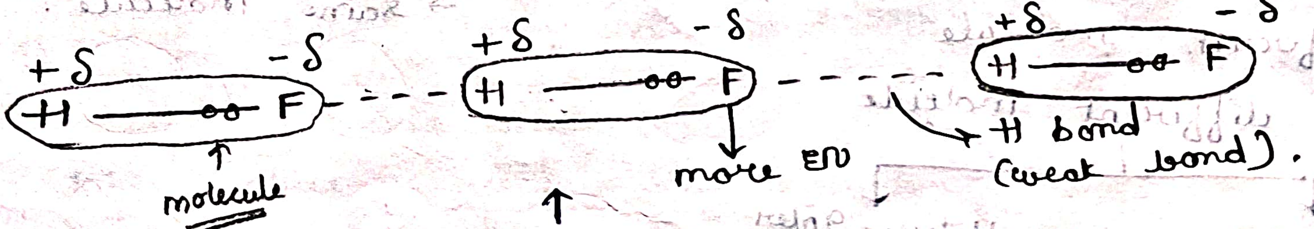
It is an Electrostatic attraction force between covalently bonded hydrogen atom of one molecule and electronegative atom. (F, O, N & sp hybridised Carbon).

i It is not found in Ionic Bond.

ii) Hydrogen bond only form in polar covalent compound. It is very weak bond but stronger than Vander waal Bond.

iii) It is a type of Dipole-Dipole attraction.

iv)



*** Condition of forming hydrogen Bond :-**

i) Must have hydrogen which is attached high electronegative compound. Size of atom should be small

ii) Electronegativity should be high. (size ↓ then H-bond ↑)

iii) N > O > F } atomic size.
F > O > N } EN.
4.0 3.5 3.0

* iv) strength of H- bond ∝ EN of atom ∝ $\frac{1}{\text{size of atom}}$.

v) $H-C\equiv C-H > CH_2=CH_2 > CH_3-CH_3$

→ carbon also forms H- bond.

→ strength of H- bond ∝ s- character

$H-C\equiv C-H > CH_2=CH_2 > CH_3-CH_3$

	sp	sp2	sp3
s chr.	50%.	33.33%.	25%.

→ only alkynes can form H- bond. (Also Alkane & Alkene)

→ Hydrogen cynide also form H- bond due to the presence of s-p carbon.

$(H-C\equiv N)\text{----}(H-C\equiv N)\text{----}(H-C\equiv N)$

sp sp sp

* **TYPE OF HYDROGEN BOND.**

Inter-molecular H - bond

→ Different molecule

→ Two different molecule

Homo intermole.

Hetero Inter mole.

Intra molecular H- bond

→ same molecule.

* Intermolecular H- Bond :-

→ H- bond formed b/w two or more molecules either it is same or different.

→ Intermolecular H- bond give more strength.

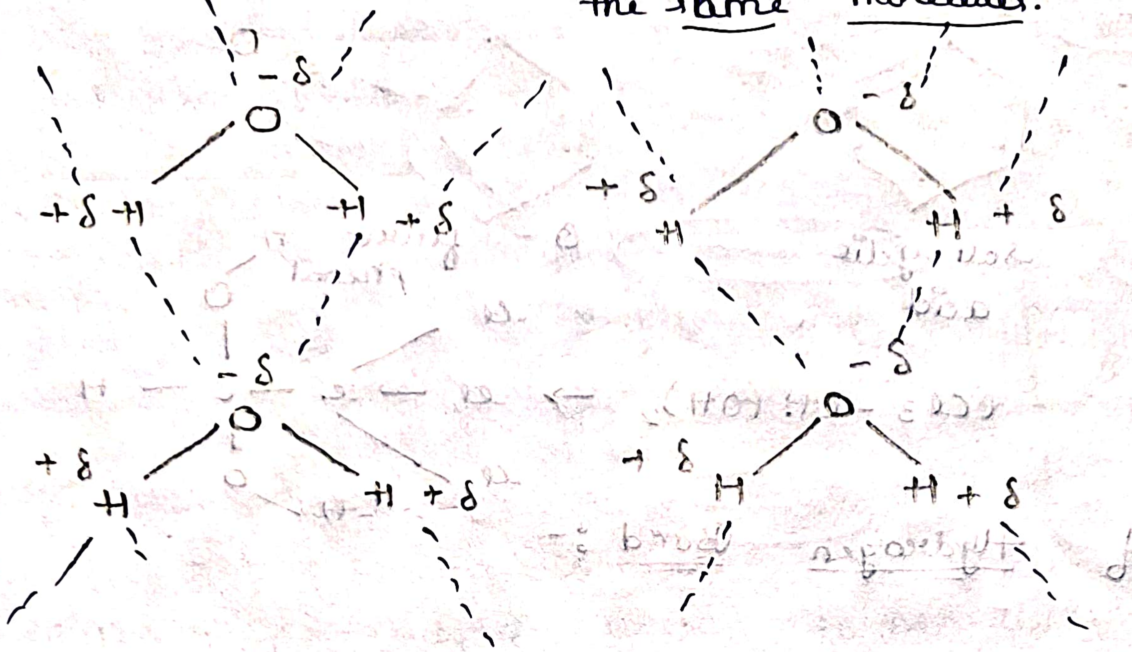
→ more boiling point but less volatile.

↳ (udd skne wala)

50. *

* Homo Inter molecular H bond.

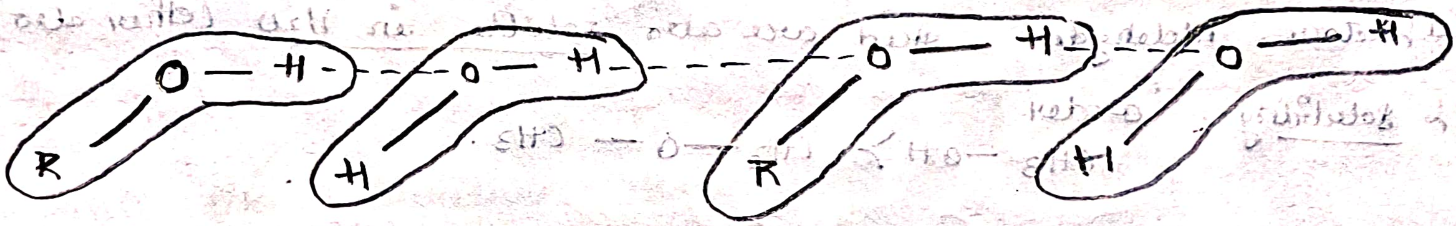
when Homo intermolecular - when H-bond formed b/w the same molecules.



attraction b/w the molecules as they are influenced by them.

* Hetero Intero molecular ~~Ho~~ H-bond

when H-bond present in two different type of molecule.



eg) Alcohol + H_2O

Que) Why H_2O & Alcohol can be mixed.

→ As they form Hydrogen atom, they're able to mixed.

Intramolecular Bond's points :-

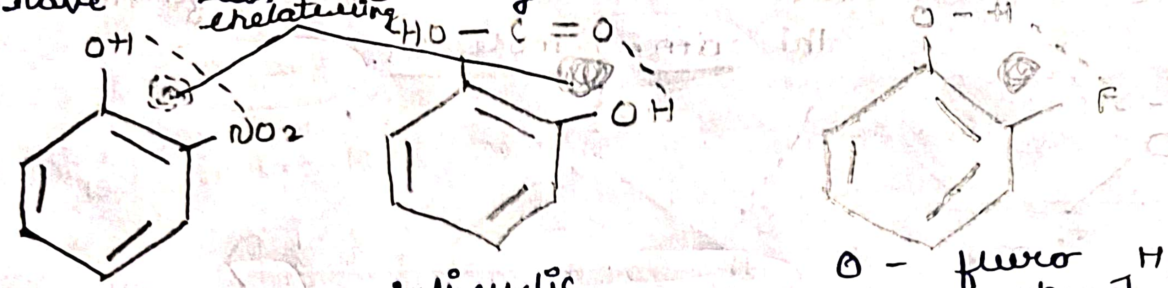
i) It take place within the molecule.

ii) Hydrogen bond with highy electronegative element of a functional group with another hydrogen atom in the nearest position.

iii) This type of H-bond mostly occurs in organic compound In the result this form chelation ↓ ring form.

iv) Intra molecular H-bond

have less boiling point & is more volatile.
50.★

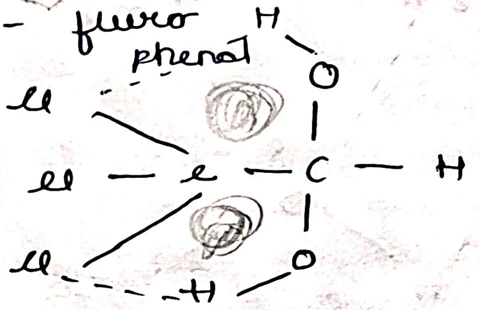


O - Nitrophyl

salicyclic acid

O - fluro phenol

chlorol hydrate $CCl_3 - CH(OH)_2 \rightarrow$



* Application of Hydrogen Bond :-

i) Solubility :-

i) Alcohol + H_2O are soluble.

ii) sugar, Glucose, fructose all are soluble in H_2O

iii) Ketone, Aldehyde, Acid are also soluble in H_2O (ether also)

iv) Solubility order
$CH_3-OH > CH_3-O-CH_3$.

v) Viscosity. ∝ no. of OH

CH_3-OH < CH_2-OH / | / CH_2-OH < CH_2-OH / | / $CH-OH$ / | / CH_2-OH

Alcohol

Glycol

Glycerene

vi) Boiling point increases ↑ & no. of OH or H ↑

① $H_2O > CH_3-OH > CH_3-O-CH_3$

② a) 15th group
$SbH_3 > NH_3 > AsH_3 > PH_3$

b) 16th group
$H_2O > TeH_2 > SeH_2 > H_2S$.

c) 17th group.
HF > HI > HBr > HCl.

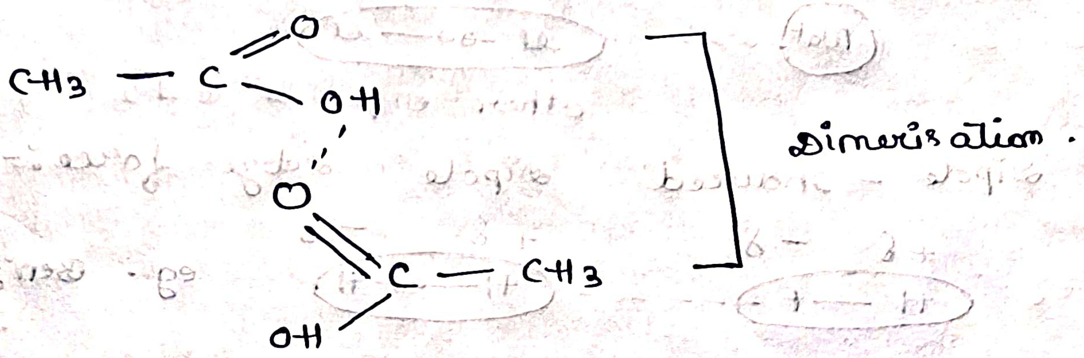
③ o nitrophenol < p nitro phenol.

$$BP \propto \frac{1}{\text{volatile}}$$

so,

O nitrophenol > P nitrophenol.
more volatile   less volatile.

④ Molar mass.



* colligative property ↑ when forms dimer in vapour phase also

⑤ * physical state property.

H_2O is liquid > H_2S is gas.

→ Ice formed six hydrogen bond with each other cage like structure, that's why its density decreases then H_2O, rather than H_2O for 4H-bond with eachother.

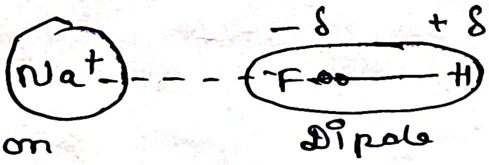
* VANDER WAAL'S BOND. :-

1) Ion Dipole attraction force :- This is weak non-directional only attraction type of force.

vander waal ∝ molare mass / weight

Strength of the Bonds.

keesom > Debye > London

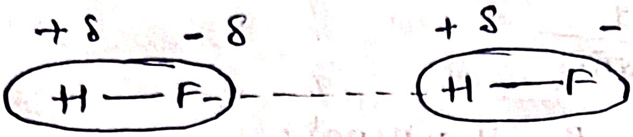


eg :- Hydration energy

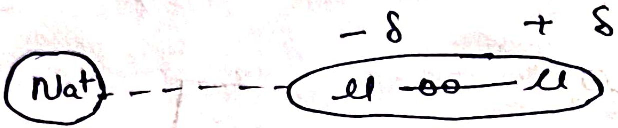
other eg.

ion + H_2O.

2) Dipole - Dipole attraction force. -
Keesom force.

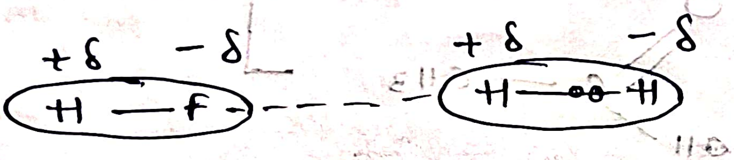


3) Ion induced Dipole attr. force :-



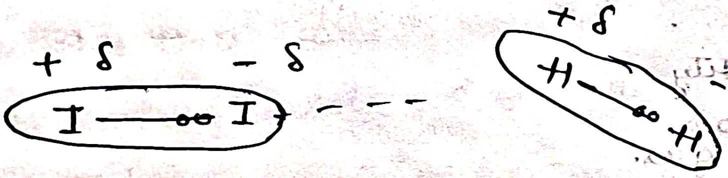
other exp : I & I_2

4) Dipole - Induced Dipole Debye force :-



eg. Benzene in NH_3 etc.

5) London force :-



other exp.
all gas & Noble gas.

This is weak, non-directional only attraction type bond.

$VB \propto$ at. w.

Keesom > Debye > London

↑

"strength of bond."