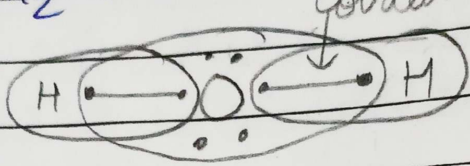
Ch-4 - Chemical Bonding And Molecular Structure

⇒ Chemical Bonding ⇒ attraction force which hold various constituent particle (atom, ions or molecules) in the different chemical reaction.

$H_2 + O \rightarrow H_2O$

covalent bond



⇒ Sharing of e^- → covalent bond
transfer of e^- → ionic bond

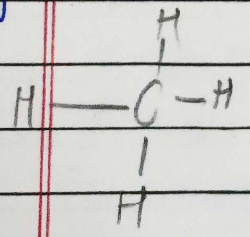
$\underset{(2,8,1)}{Na} \rightarrow 1e^- + Na^+$

$\underset{(2,8,7)}{Cl} + 1e^- \rightarrow Cl^-$

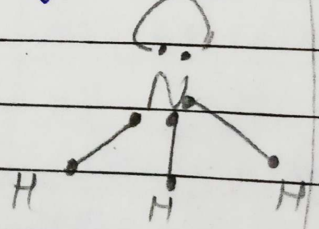
$Na^+ + Cl^- \rightarrow NaCl$

* Lewis Dot Structure :-

eg:- CH_4



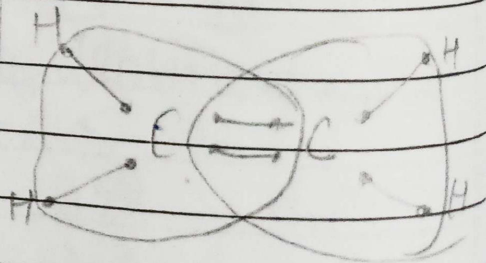
eg:- NH_3



eg :- C_2H_4 weak π bond

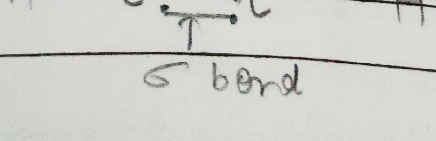
$CH_2 = CH_2$

σ bond → strong

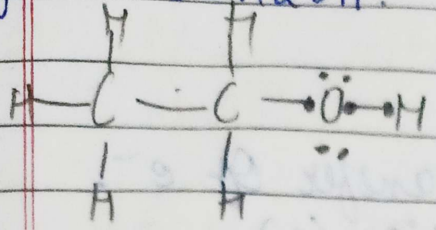


⇒ Carbon → tetravalency
↳ catenation.

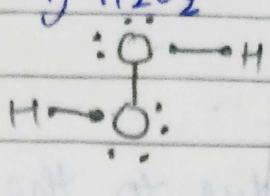
eg:- $CH \equiv CH$



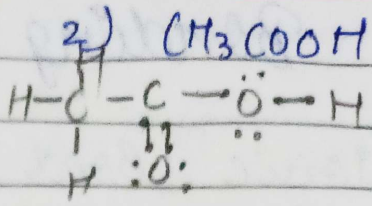
eg:- CH_3CH_2OH.



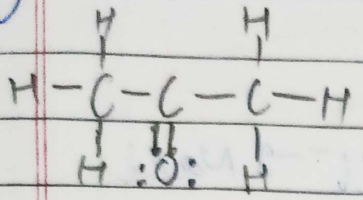
1) H_2O_2



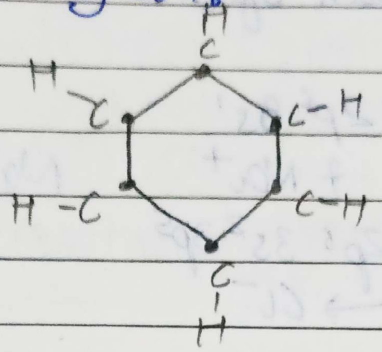
2) CH_3COOH



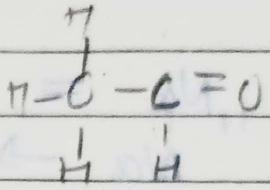
3) CH_3COCH_3



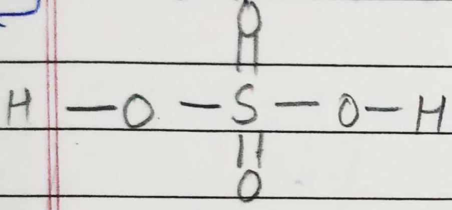
4) C_6H_6



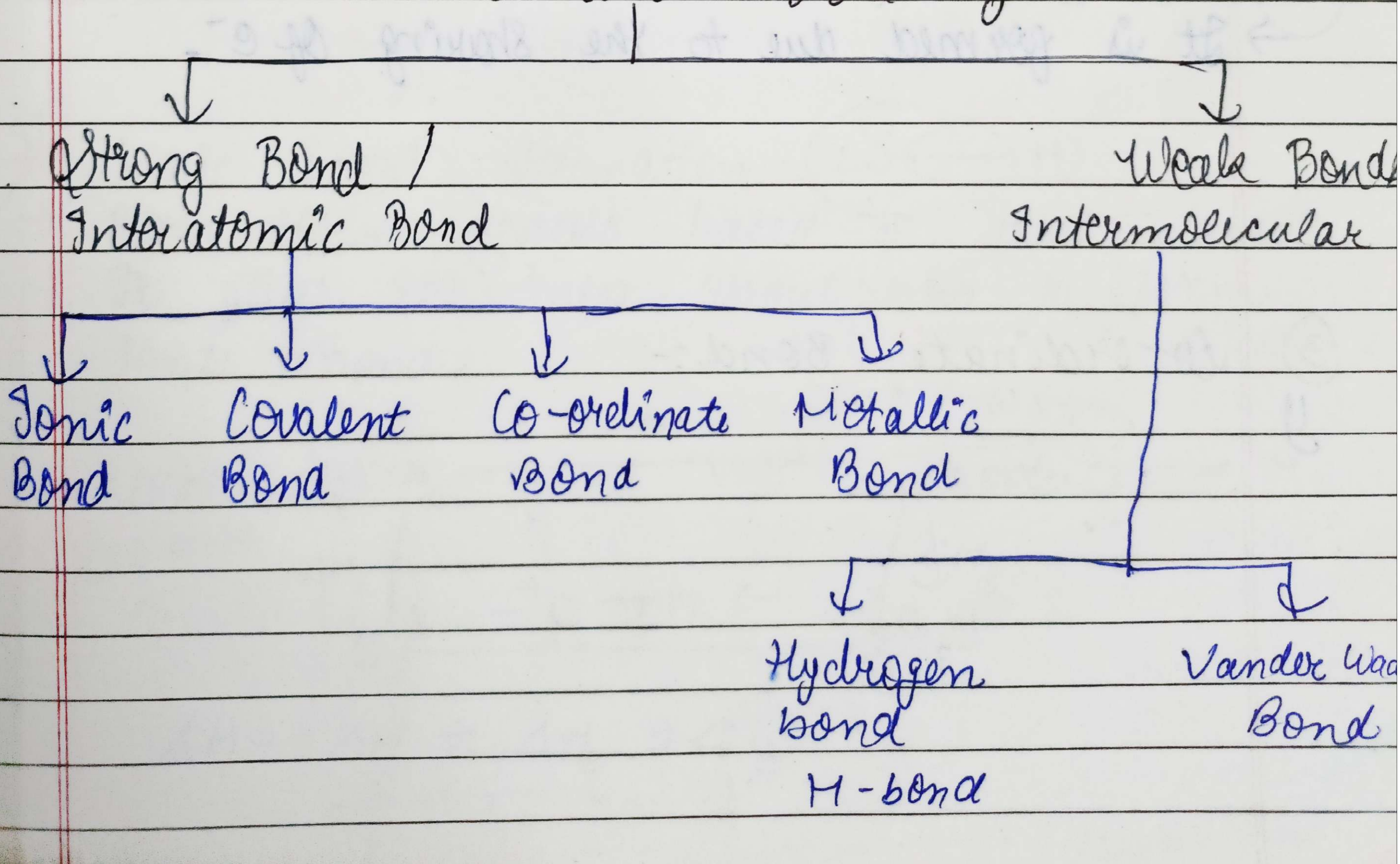
5) CH_3CHO



6) H_2SO_4



Chemical Bonding



① Ionic Bond :-

→ It is formed due to the transfer of e^-.

→ Metal → loss of e^- → cation (+)

Non-Metal → gain of e^- → anion (−)

→ $_{11}Na = 1s^2 2s^2 2p^6 3s^1$

$Na \rightarrow 1e^- + Na^+$ $\quad Na^+ + Cl^- \rightarrow NaCl$

→ $_{17}Cl = 1s^2 2s^2 2p^6 3s^2 3p^5$.

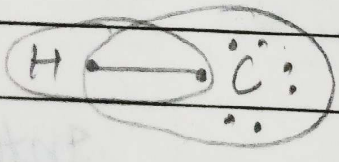
$Cl + 1e^- \rightarrow Cl^-$

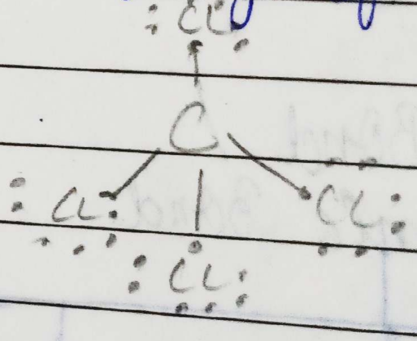
- Anion or cation in b/w electrostatic force is present.

$$= \frac{Kq_1q_2}{r^2}$$

② Covalent Bond :-

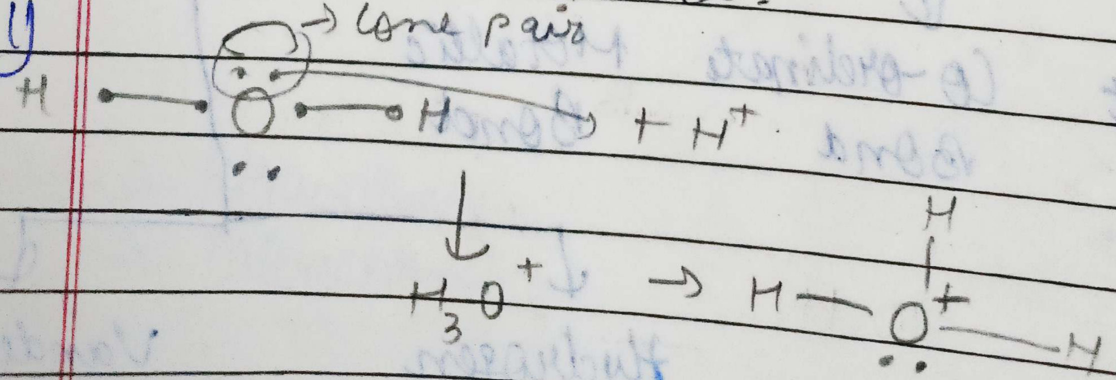
→ It is formed due to the sharing of e^-.





③ Co-ordinate Bond :-

y



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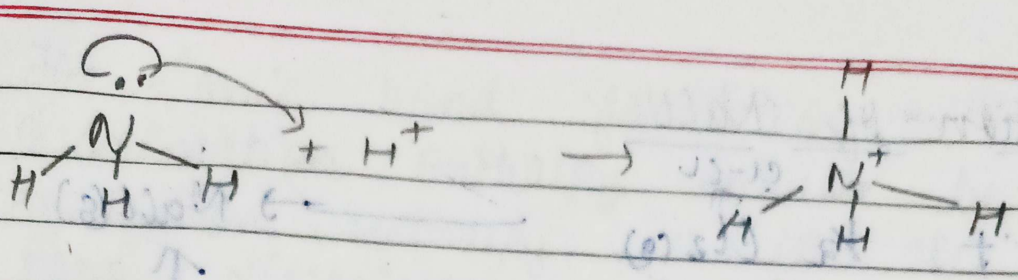
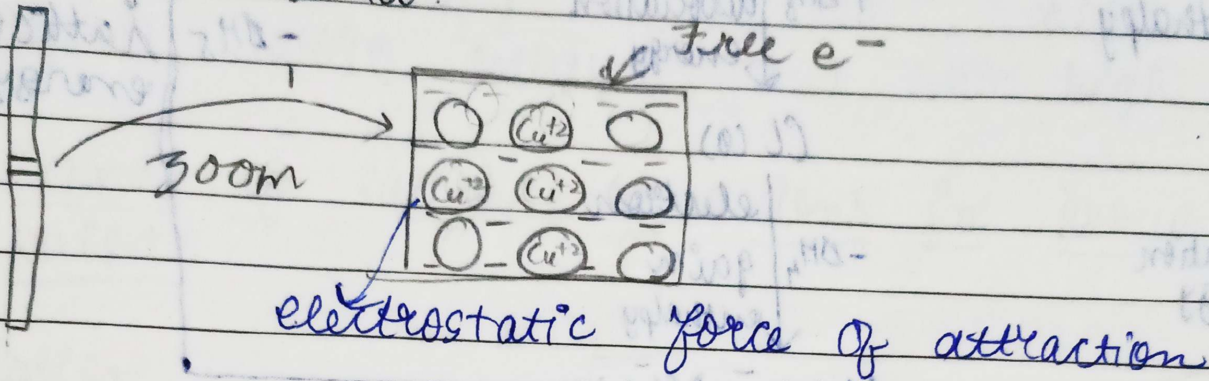
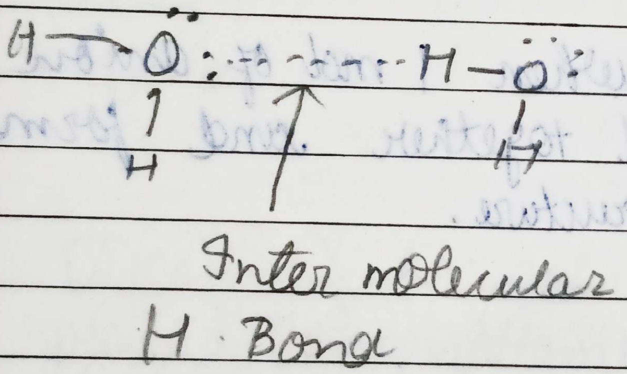


③ Metalic Bond :-



* Weak Bond.

① H- bond.



* Ionic Bond Formation :-

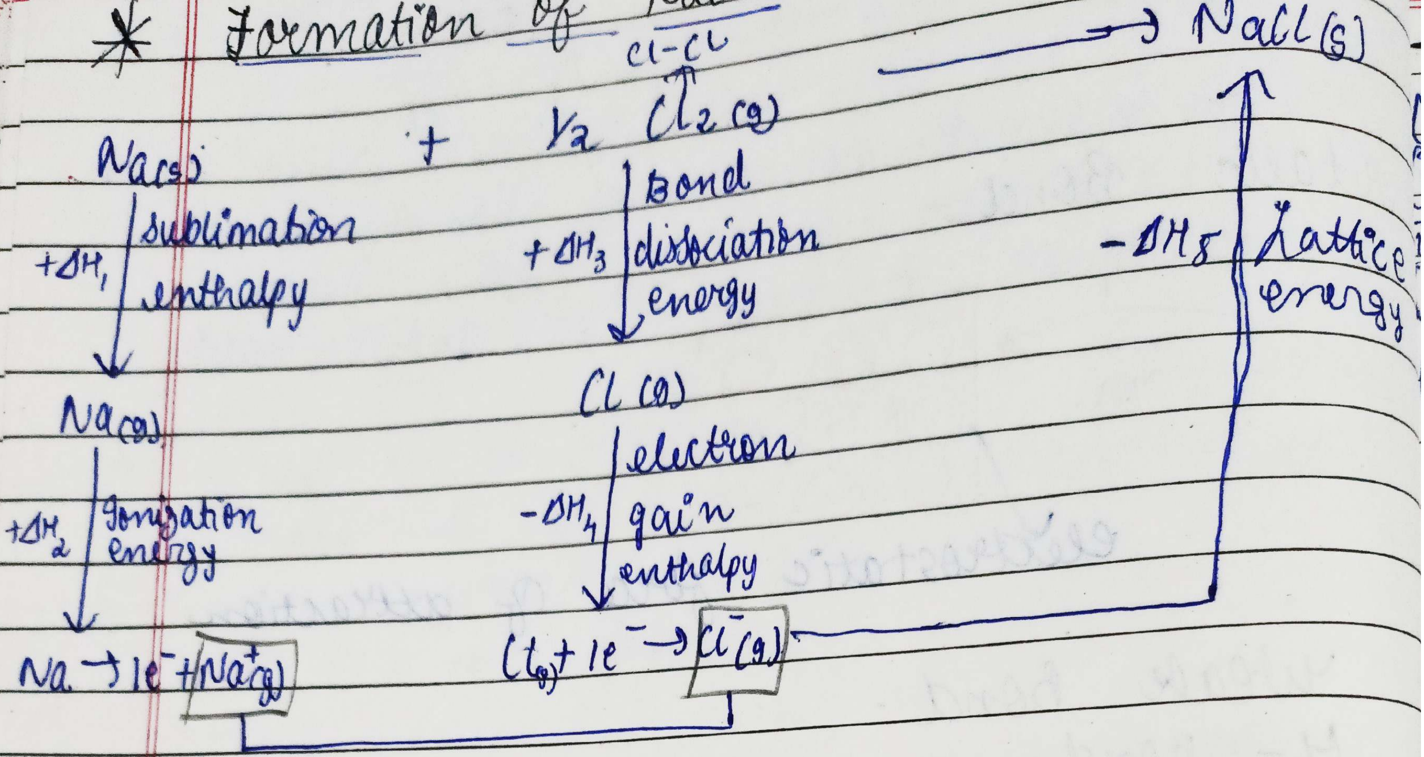
→ Born Haber process based on Hess Law.

→ It gives the info about how to form ionic Bond.

$$\begin{tikzcd}
\text{Reactant : A} \arrow[r, "\Delta H"] \arrow[d, "\Delta H_1"'] & \text{Product = D} \\
B \arrow[r, "\Delta H_2"] & C \arrow[u, "\Delta H_3"']
\end{tikzcd}$$

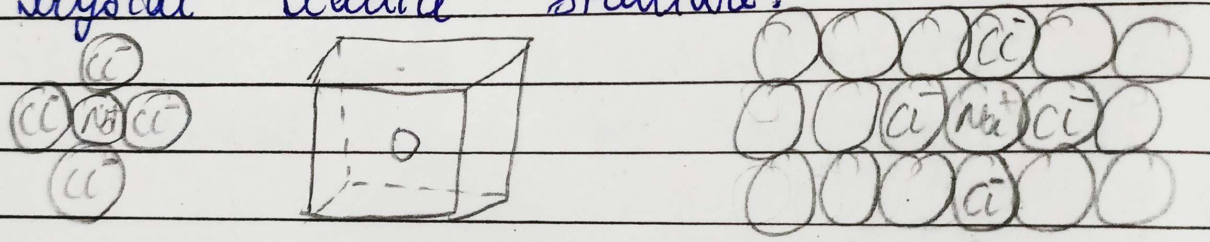
$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$.

* Formation of NaCl

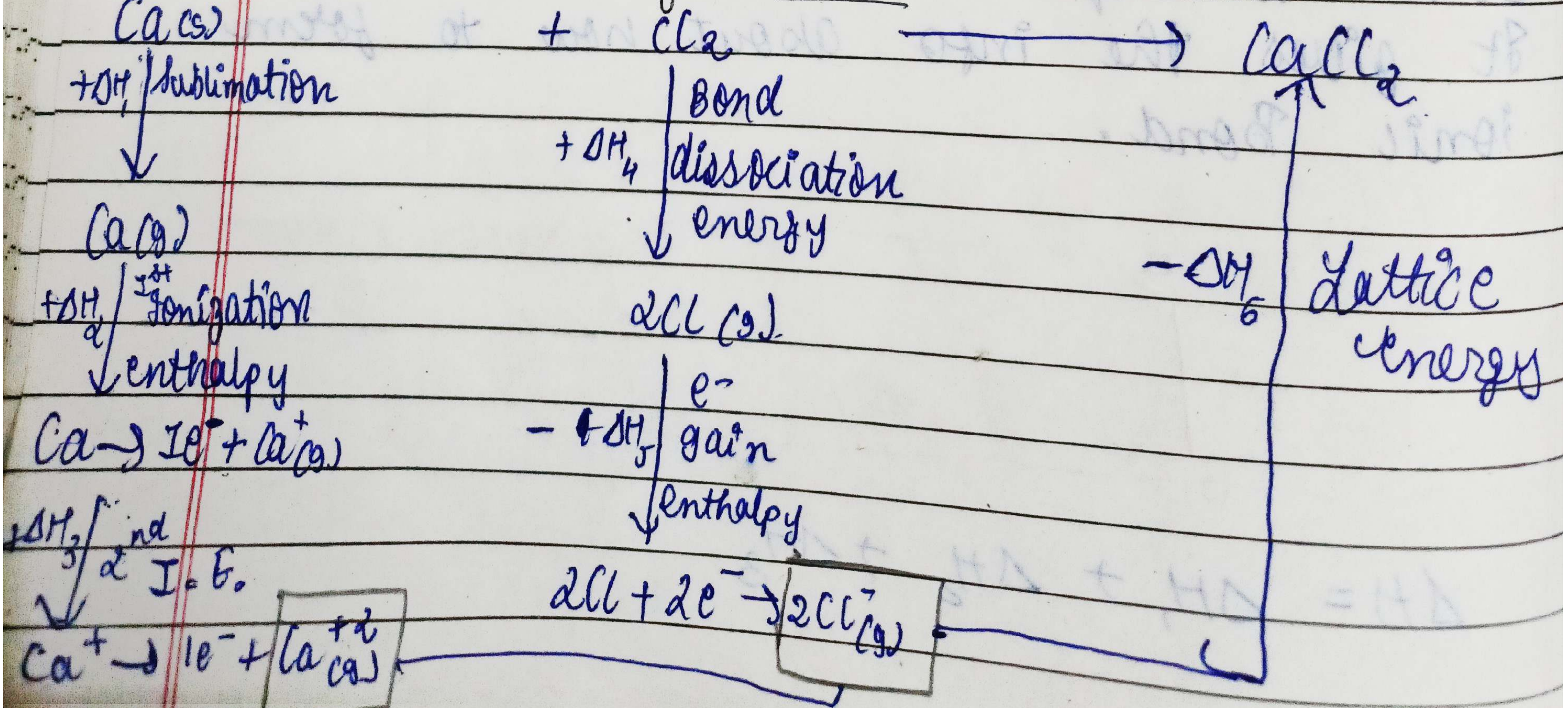


- **Lattice Energy:-**

→ energy is released when 1 mol of anion or cation are combined together and form crystal lattice structure.



* Formation of $CaCl_2$



→ For ionic bond formation :-

(i) Sublimation enthalpy should be less.
(ii) Ionization enthalpy should be less.
(iii) Bond dissociation " " less.
(iv) e^- gain enthalpy " " high.
(v) Crystal lattice energy " " high.

* Trends of cations & anions in group & period.

1) Cation :-

(i) Group	Li^+	Period.
→ size ↑	Na^+	→ Left to right.
→ radius ↑	K^+	→ size ↓
→ Ionization E. ↓	Rb^+ ↓	→ radius ↓ → I.E. ↑
	Cs^+	

2) Anion :- (e^- gain enthalpy)

(-) group. (top to bottom)	period. (left to right)
→ Radius ↑	→ size ↓
→ size ↑	→ Radius ↓
→ e^- gain enthalpy ↓	→ e^- gain enthalpy ↑.

group 17 F
↓
Cl
↓
Br
↓
I

* Conductivity of cation or Anion.

→ in the group
→ size of cation increases.
$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
→ conductivity increases

② Hydration Energy :-

→ As we go down in the group, size of the cation increases, So, Hydration enthalpy decreases.

$$\boxed{\text{Hydration energy} \propto \frac{1}{\text{size}}}$$

* Covalent Bond :-

→ It is formed due to the sharing of e^-.

Or

→ It is formed due to the overlapping of orbitals.

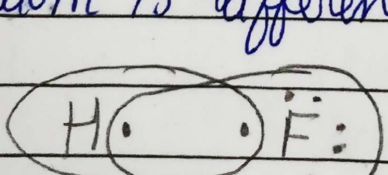
Covalent Bond

- Polar-covalent
- Non Polar covalent

→ When electronegativity of atom is different

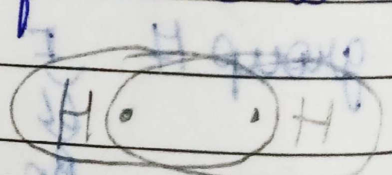
When e.negativity of atom is same

eg:-



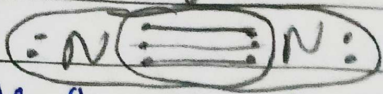
2.1 4

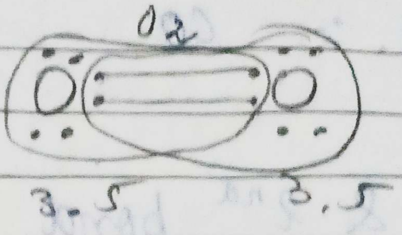
$H^{+\delta}$ —— $F^{-\delta}$



2.1 2.1

eg :- N_2





→ N_2 is inert gas at room temperature

→ Bond in N_2 is stronger.

* Electron dot structure / Lewis dot structure :-

→ Valence e⁻ present in the outermost shell represent around the atom of an element in the form of dot is called . . .

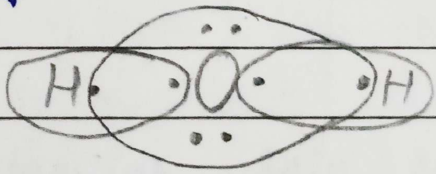
Period : I :- H• •He•

Period : 2 :- Li• •Be• •B• •C• •N• :O: :F: :Ne:

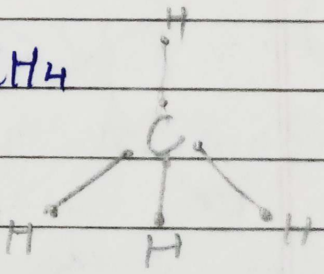
Period : 3 :- Na• •Mg• •Al• •Si• •P• :S: :Cl: :Ar:

→ **Octet Rule** :- Every atom want to complete its octet for ~~that~~ its stability ; for that, they will perform transfer of e⁻ or sharing of e⁻.

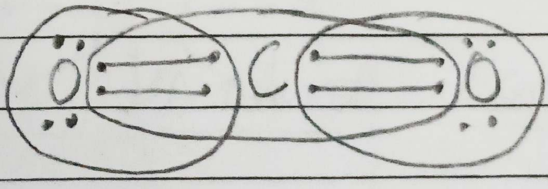
eg. :- H_2O.



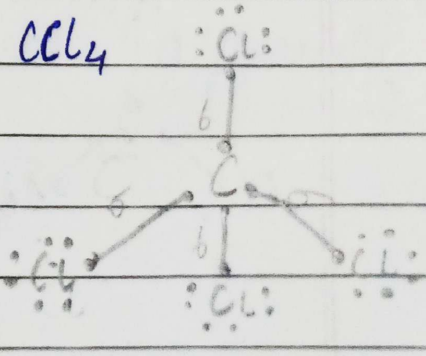
eg :- CH_4



eg. :- CO_2



eg. :- CCl_4



eg. :- CO

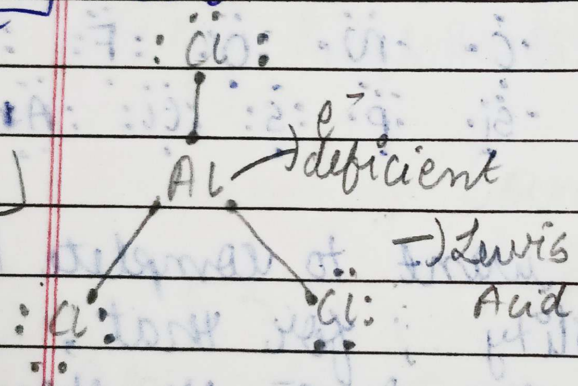
→ 1st & 2nd bond is covalent.
→ 3rd bond is co-ordinate bond.

- **Exception in Octet Rule :-**

Compound having less than 8e⁻ } Lewis Acid

1) $AlCl_3$
2) BF_3
3) BCl_3

1)



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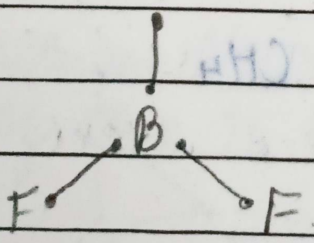
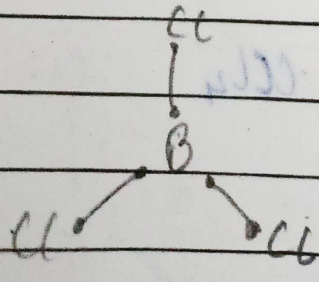


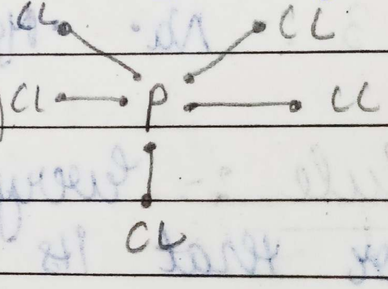
3)



Lewis Base { Compound having more than 8e⁻

① PCl_5
② SF_6
③ IF_7
④ SO_3

1)



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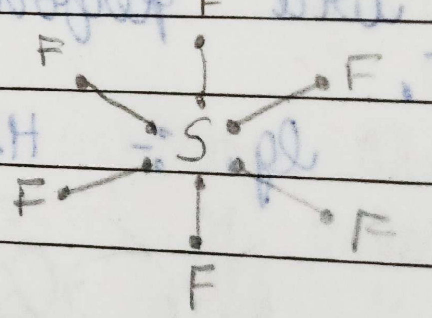
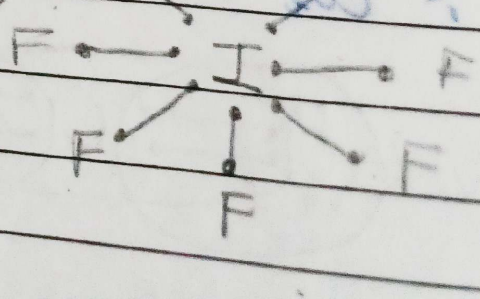
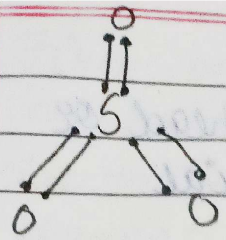
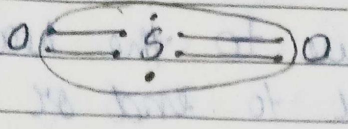


3)

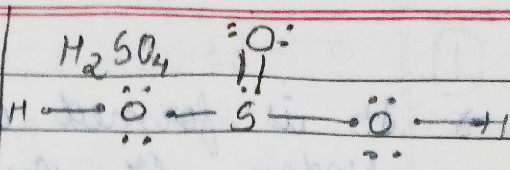


4) 

SO_2



H_2SO_4



* VBT (Valence Bond Theory) IMP

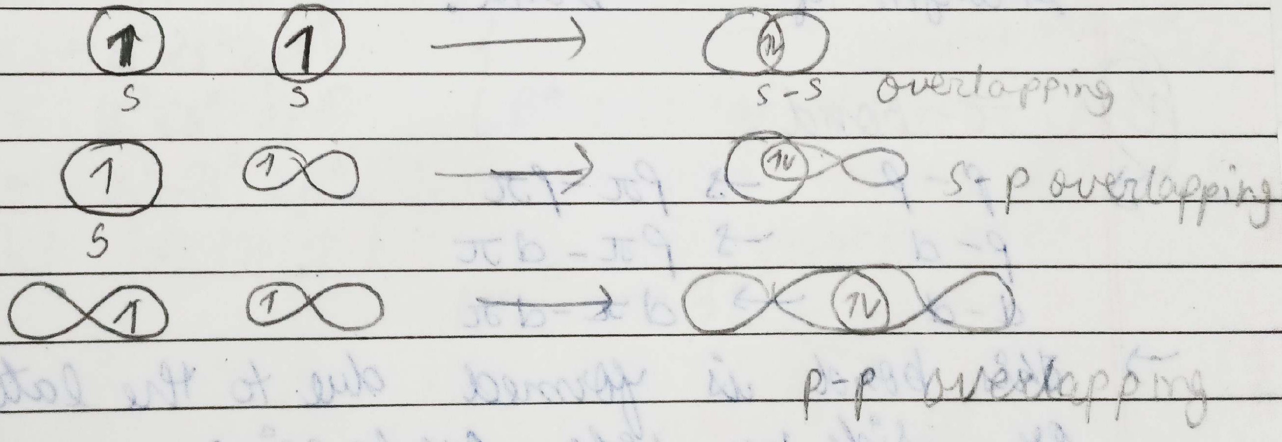
→ It gives the info. about the formation of covalent bond.

- **Postulates :-**

→ Covalent bond is formed due to overlapping of orbitals.

→ In the formation of covalent bond valence shell participate.

eg :-



→ Before overlapping spin of valence e^- is same.

→ After the overlapping spin will be different.

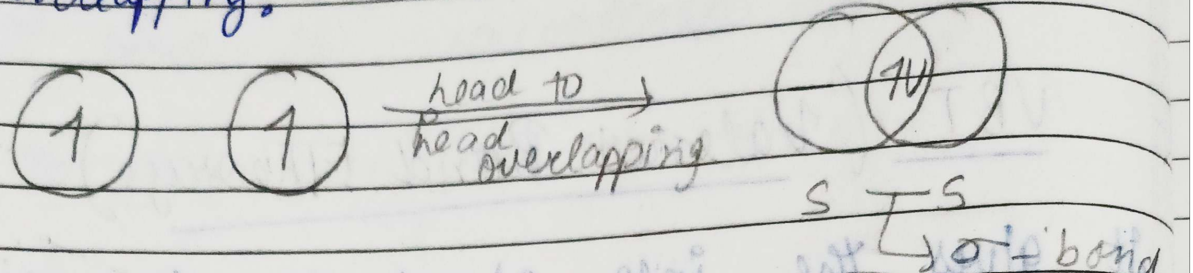
* Types of covalent bond :-

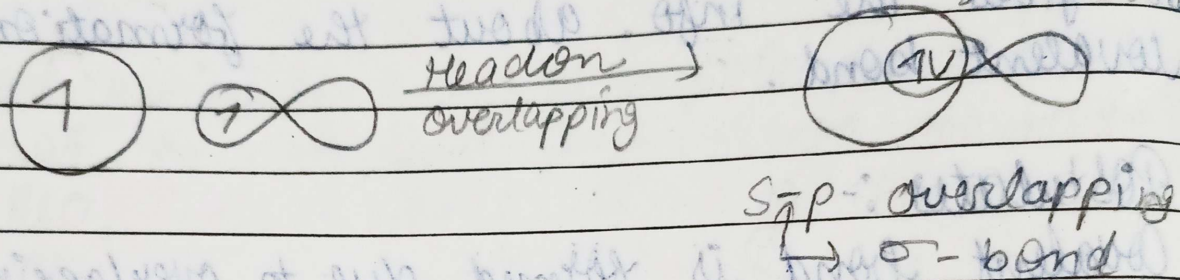
1) σ - bond
2) π - bond.

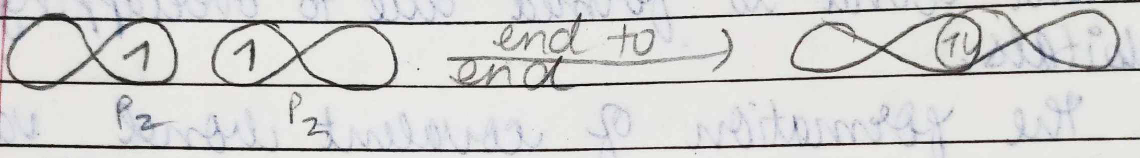
① σ - bond.

→ It is formed due to the head to head or headon or end to end or axcial overlapping.

ex.







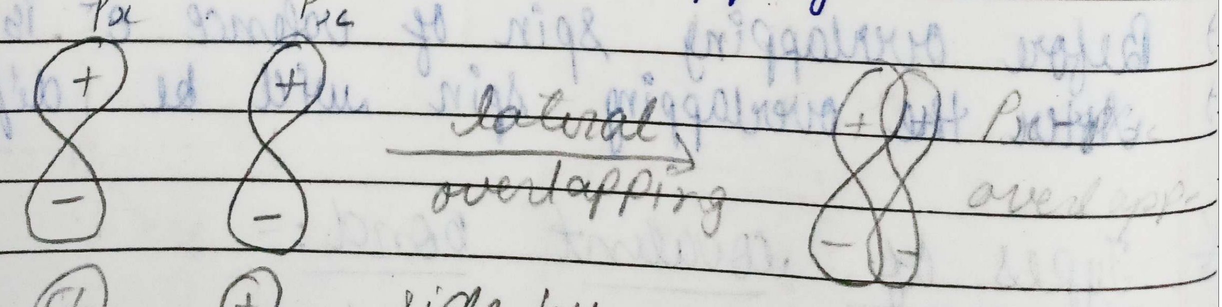
→ Higher the extent of overlapping, higher the strength of σ - bond.

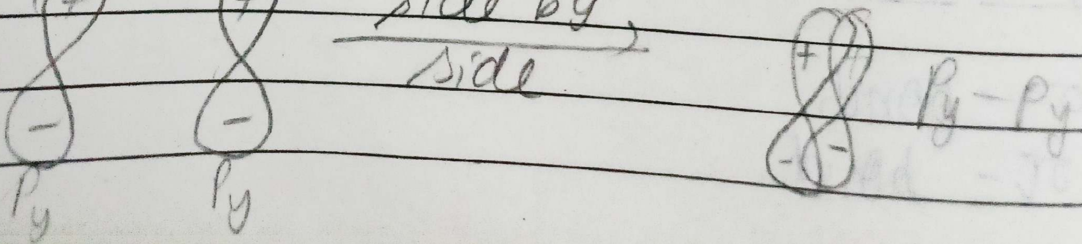
② π - bond.

→ p - p → $p\pi - p\pi$
p - d → $p\pi - d\pi$
d - d → $d\pi - d\pi$

→ This bond is formed due to the latral or side by side overlapping.

eg:-



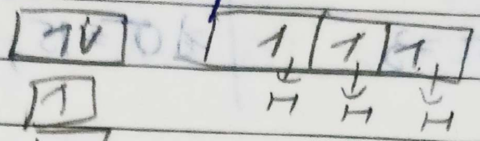


→ First bond is always σ bond.

→ σ bond is more stronger than π bond due to their greater overlapping in σ-bond formation.

eg:- 1) NH_3.

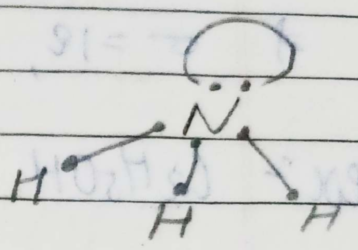
$_7N$: $1s^2 2s^2 2p^3$

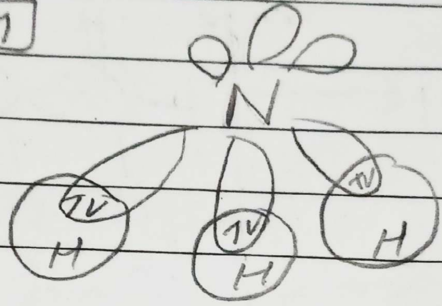


1) ,H = $1s^1$ $\boxed{\uparrow}$

2) ,H = $1s^1$ $\boxed{\uparrow}$

3) ,H = $1s^1$ $\boxed{\uparrow}$





2) BF_3

$_5B$ = $1s^2 2s^2 2p^1$ →

B : $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\ |\ \ |\ \ }$ ↳ ground state

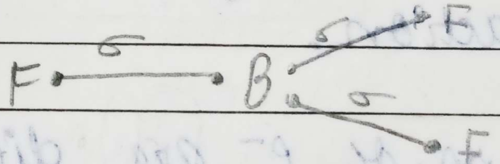
B^* : $\boxed{\uparrow}$ $\boxed{\uparrow\ |\ \uparrow\ |\ \ }$ ↳ excited state

1) $_9F$ = $1s^2 2s^2 2p^5$

2) $_9F$ = $1s^2 2s^2 2p^5$

3) $_9F$ = $1s^2 2s^2 2p^5$

$\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow\ |\ \uparrow\downarrow\ |\ \uparrow}$



3) C_2H_2.

$H\overset{\sigma}{-}C\equiv C\overset{\sigma}{-}H$

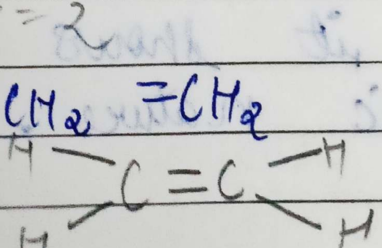
σ = 3 π = 2

4) H_2O

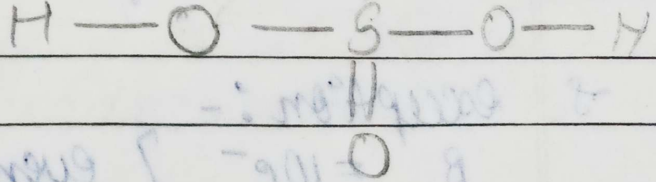
H —O— H

σ = 2

5) $CH_2=CH_2$



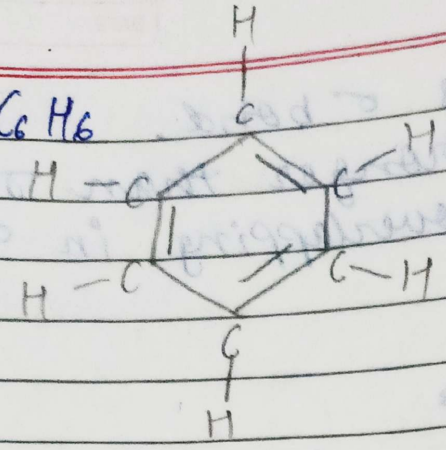
6) H_2SO_4



σ = 6

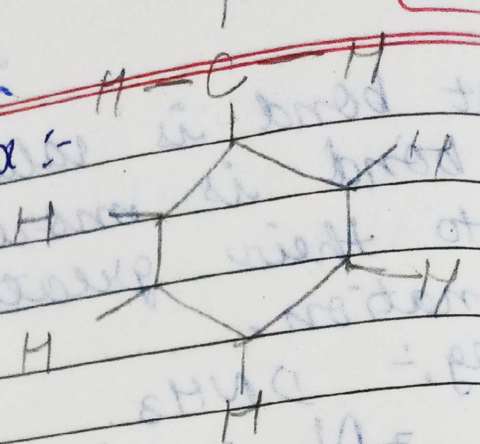
π = 2

ex :- C_6H_6



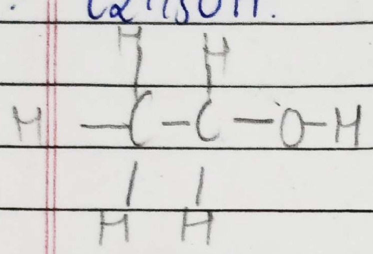
→ $\sigma = 12$, $\pi = 3$.

ex :-

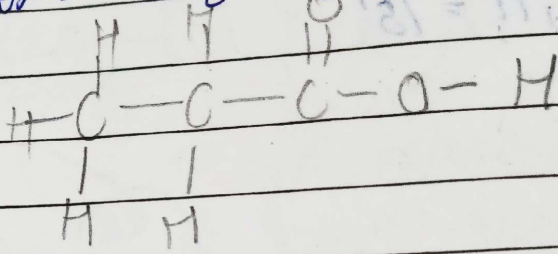


→ $\sigma = 15$, $\pi = 3$

ex :- C_2H_5OH.



ex :- CH_3CH_2COOH



- **Drawbacks of VBT :-**

[1] → ~~even~~ Odd no. of e^- are paramagnetic in nature.

→ 1, 3, 5, 7, 9 [↿ | ↿ | ↿]

→ In the magnetic field, they show attraction.

[2] → even no. of e^- are diamagnetic in nature.

→ 2, 4, 6, 8, 10 [↿⇂ | ↿⇂ | ↿⇂]

→ In the magnetic field, repulsion occurs

→ exception :-

B = $10e^-$ } even. but it shows

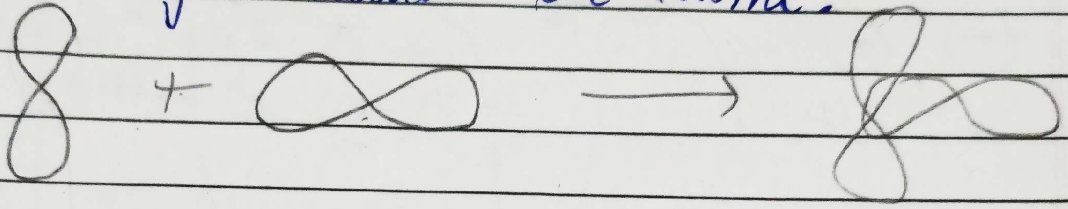
O_2 = $16e^-$ } paramagnetic nature.

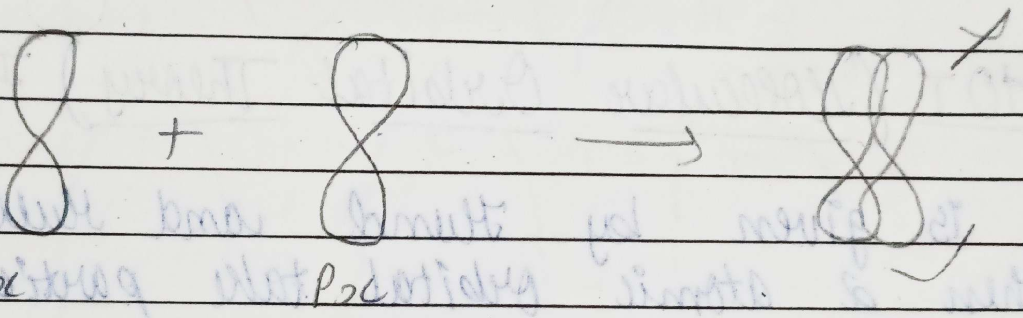
→ It does not explain unielectron overlapping.

* Condition for overlapping of orbital

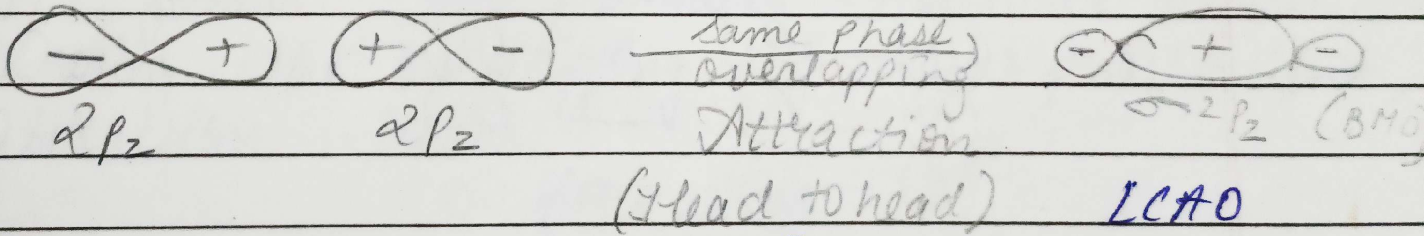
1) It must be on same energy orbital.
ex :- 1s – 1s , 2s – 2s , 3s – 3s
→ energy of orbital = n+l

2) Symmetry should be same.

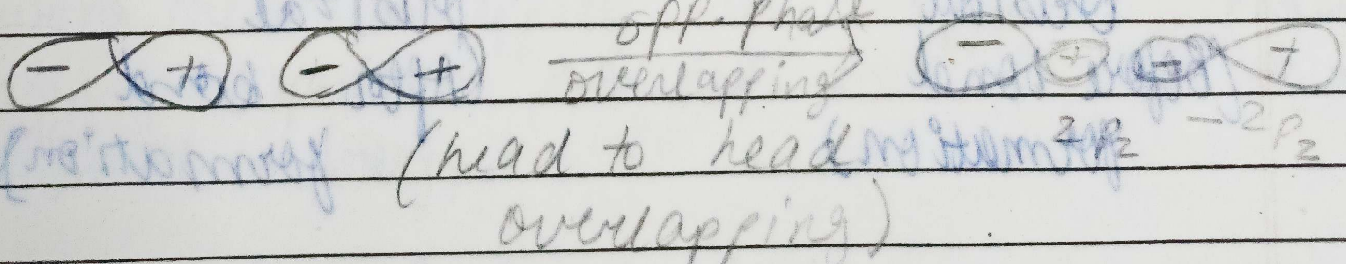




* Head to Head Overlapping :-

1) 

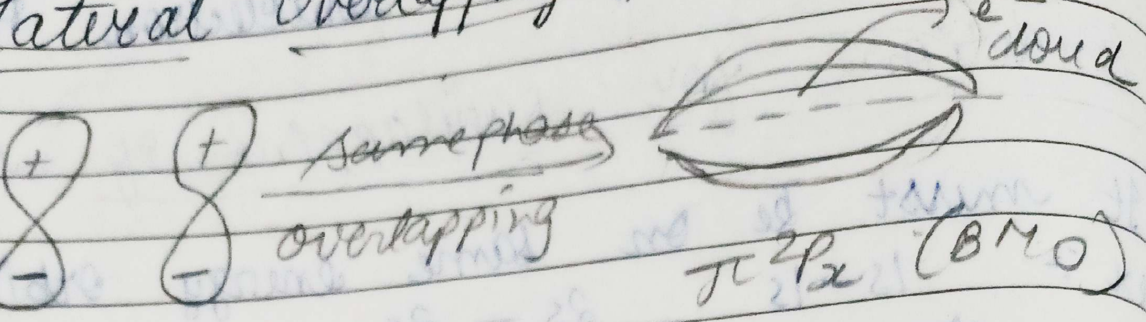
LCAO
[Linear combination of atomic orbital]

2) 

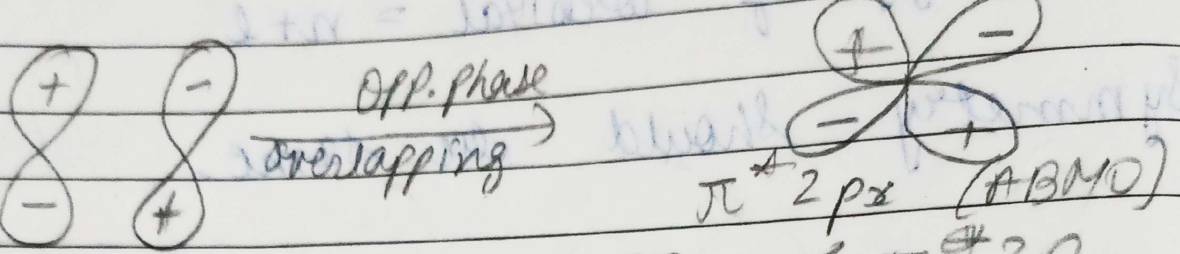
σ^*2p (ABMO)

* Lateral Overlapping / Side by side.

1)



2)



$\pi 2p_x < \pi^* 2p_x$

* MOT (Molecular Orbital Theory) IMP

→ It is given by Hund and Mulliken

→ When 2 atomic orbital take participate in formation of covalent bond, 2 molecular orbitals are formed.

H — H ⟶ H_2

N — N ⟶ N_2

C — O ⟶ CO

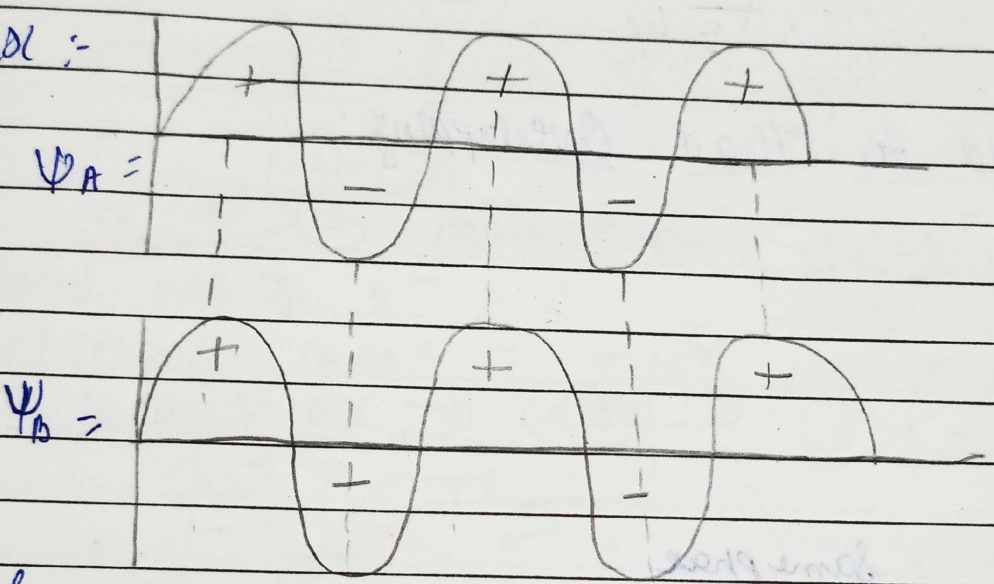
→ No. of atomic orbital (Before bond formation) = No. of molecular orbital (After bond formation)

→ When 2 atomic orbital overlap to form 2 molecular orbital in which 1^{st} molecular orbital is BMO (Bonding molecular orbital) and second molecular orbital is ABMO (Antibonding molecular orbital)

→ e^- are found in waves form.

→ It is found in x, y, z direction.

ex :-



→ Same phase-sign overlapping

→ It forms BMO (Bonding Molecular Orbital)

→ During the overlapping of same phase-sign, attraction occurs.

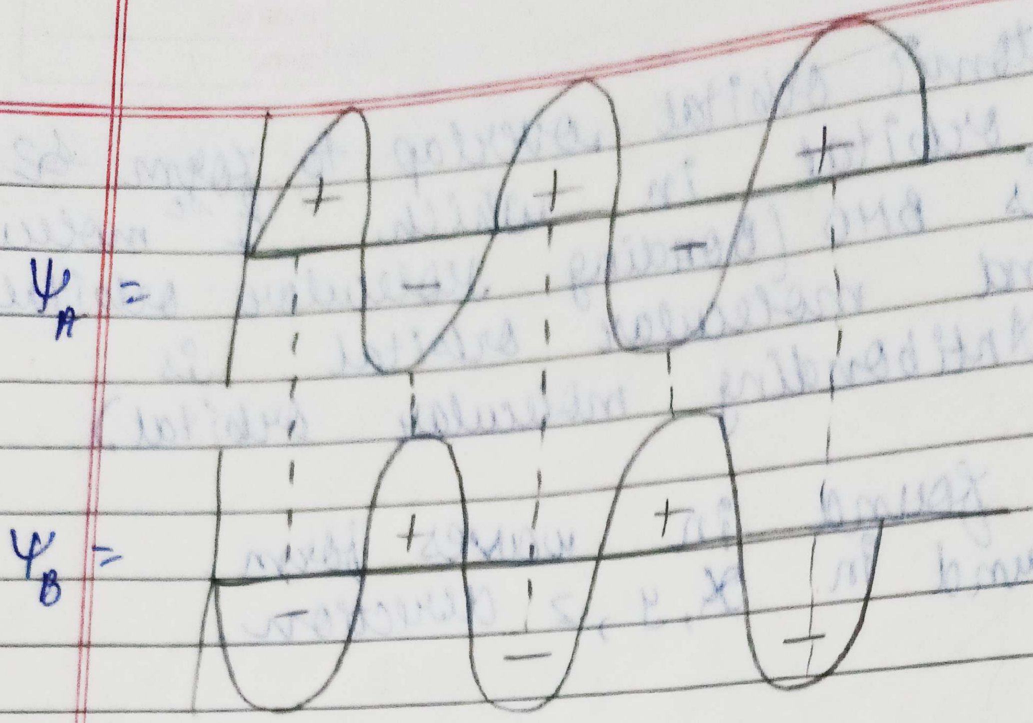
→ Opposite phase-sign overlapping

→ It forms ABMO (Antibonding molecular orbital).

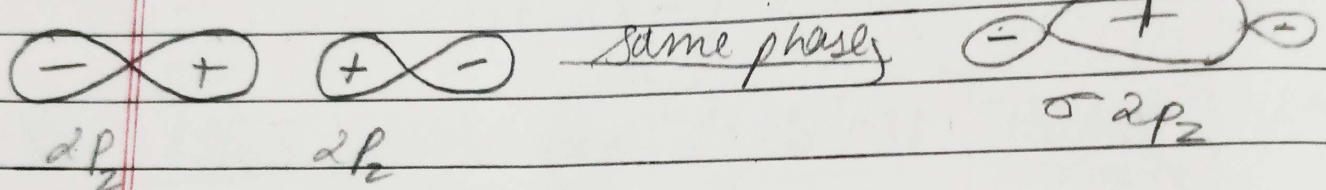
→ During the overlapping in opposite phase-sign, repulsion occurs. So, it requires more energy.

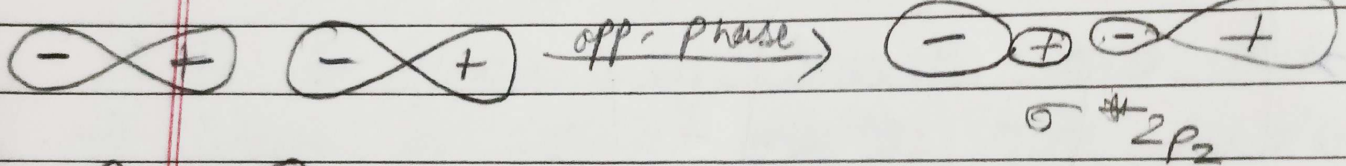
BMO < ABMO

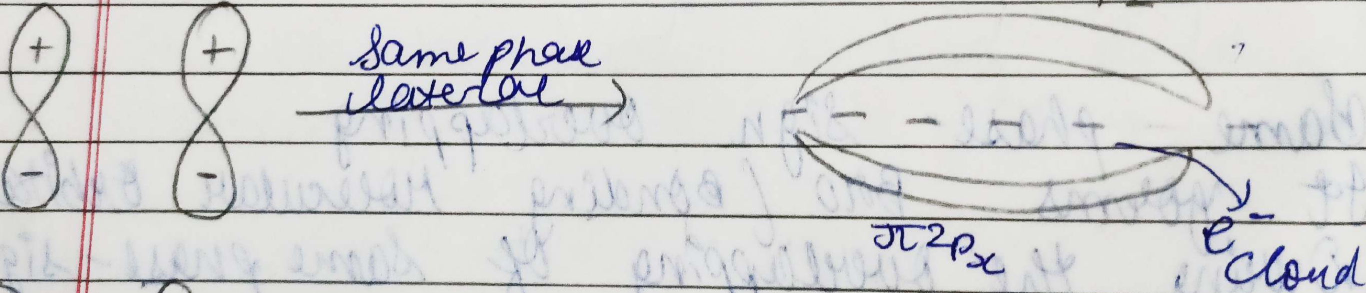
→ σ, π → σ^* & π^*

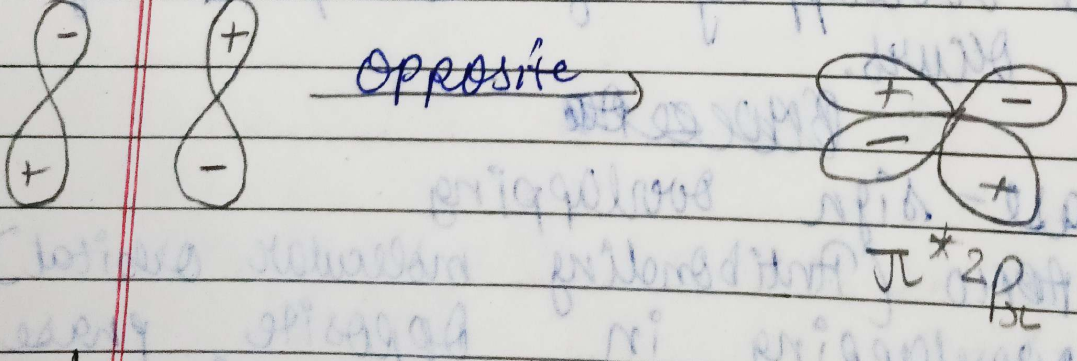


* Head to Head Overlapping :-









* Electronic configuration of molecular orbital / molecular species.

① $Z \le 7$ (H_2, Li_2, Be_2, B_2, C_2, N_2)

→ $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \pi 2p_x = \pi 2p_y < \sigma 2p_z < \pi^* 2p_x = \pi^* 2p_y < \sigma^* 2p_z$

degenerated orbital

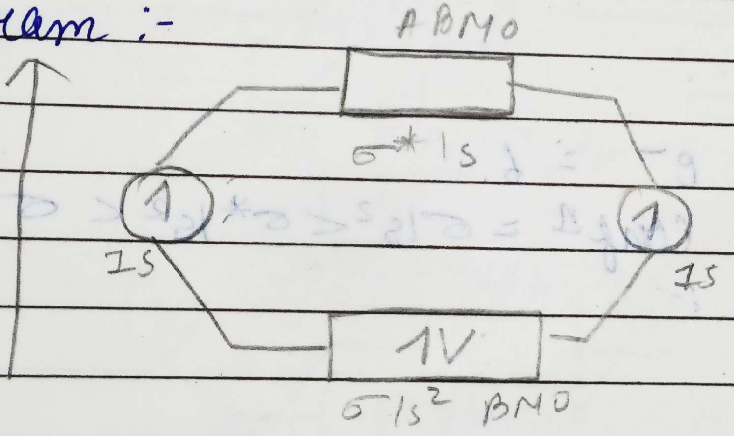
② O_2, F_2 . . . $Z \ge 8$.

→ $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < \pi 2p_x = \pi 2p_y < \pi^* 2p_x = \pi^* 2p_y < \sigma^* 2p_z$

* Energy level diagram :- M-IMP

* H_2 Molecule

1) Total no. of e^- = 2.
2) Electronic conf^n = $\sigma 1s^2$
3) Diagram :-



4) Bond Order = $\frac{\text{No. of } e^- \text{ in BMO} - \text{No. of } e^- \text{ in ABMO}}{2}$.

Or.

$$B.O = \frac{N_b - N_a}{2} = \frac{2-0}{2} = \boxed{1}$$

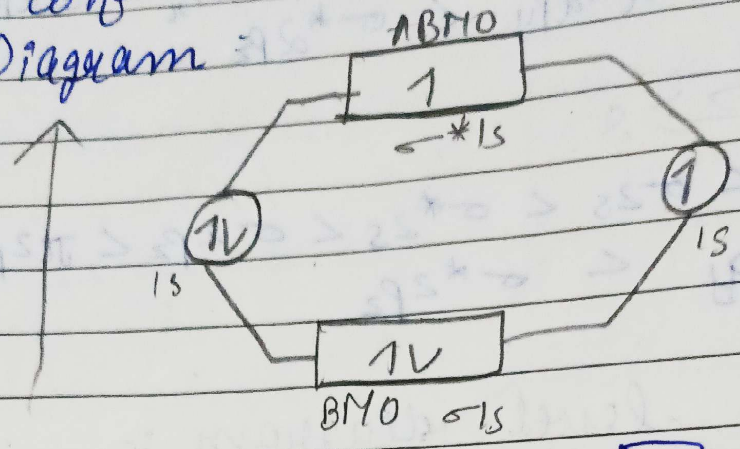
5) Magnetic properties :-

Dimagnetic ~~prop~~ in nature

Repulsion.

② H_2^-

1) No. of $e^- = 3$
2) e^- $conf^n = \sigma 1s^2 < \sigma^* 1s^1$
3) Diagram :-

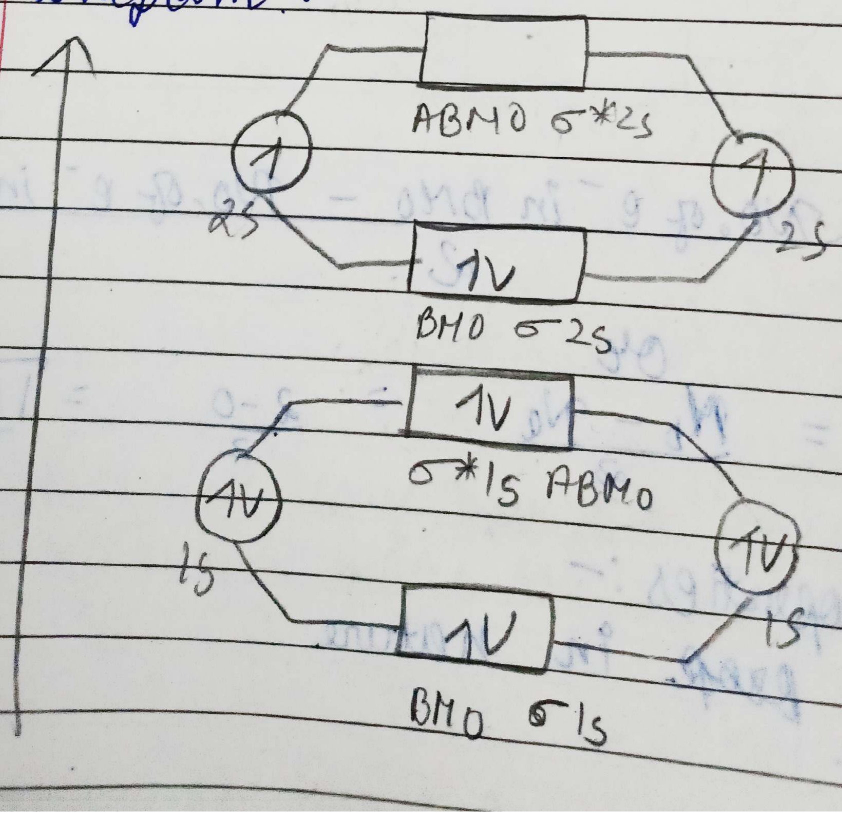


4) $B.O = \frac{N_b - N_a}{2} = \frac{2-1}{2} = \boxed{\frac{1}{2}}$

5) Magnetic properties -
→ paramagnetic.
→ Attraction

③ Li_2

1) No. of $e^- = 6$.
2) electronic $conf^n = \sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2$
3) Diagram :-



4] $B.O. = \frac{N_b - N_a}{2} = \frac{4-2}{2} = \boxed{2}$

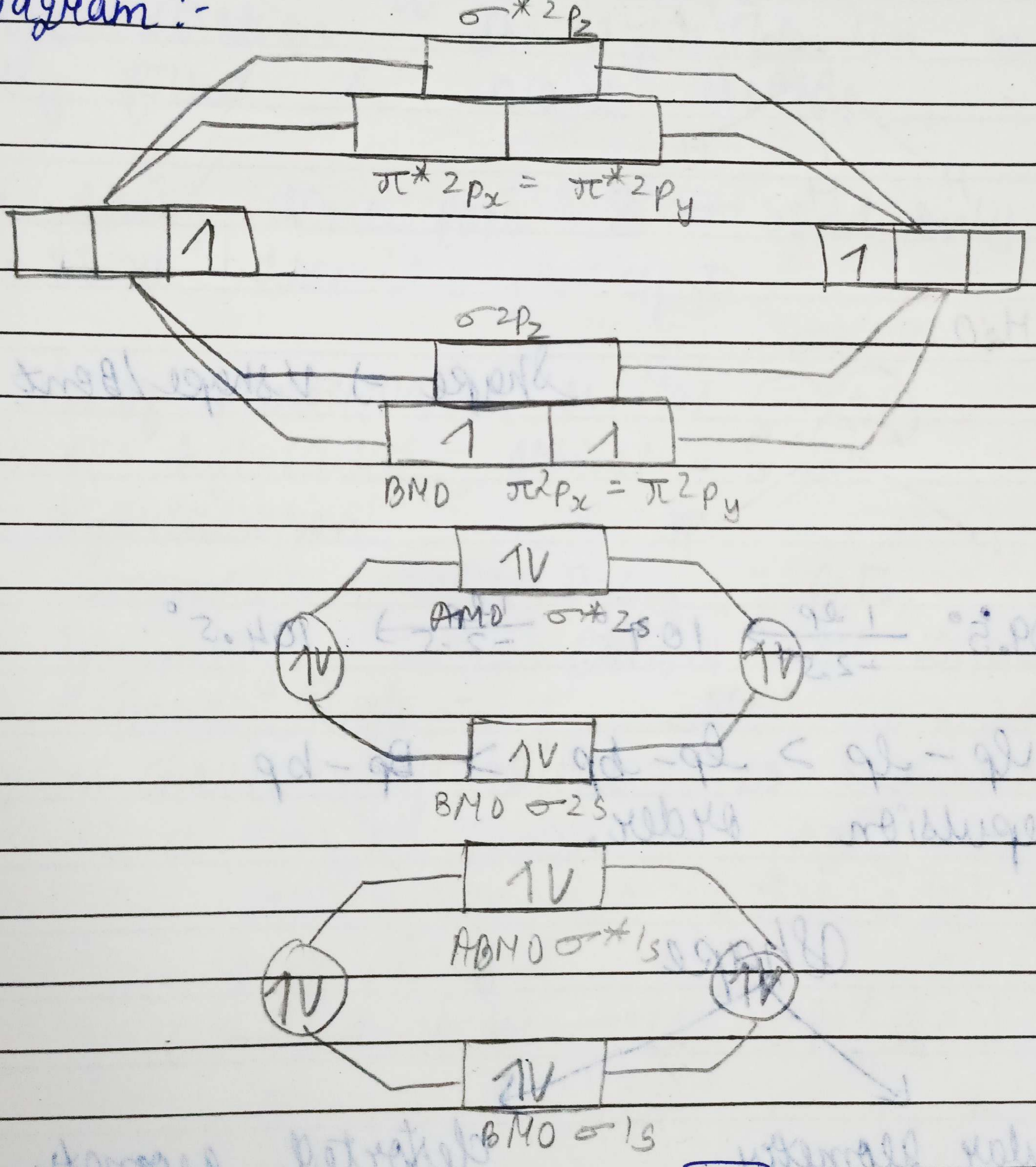
5] Magnetic Properties :-
→ Diamagnetic

④ B_2

1] No. of $e^- = 10e^-$

2] elec. conf^n = $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi 2p_x^1 = \pi 2p_y^1$

3] Diagram :-

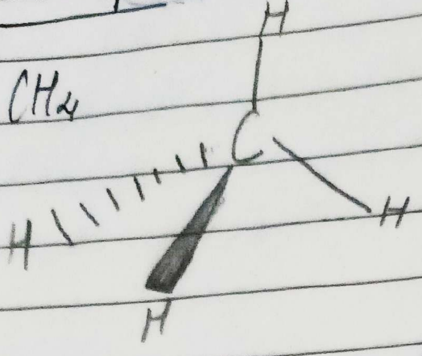


4] $B.O. = \frac{N_b - N_a}{2} = \frac{6-4}{2} = \boxed{1}$

5] Magnetic Properties → Paramagnetic

* Shape of Molecules

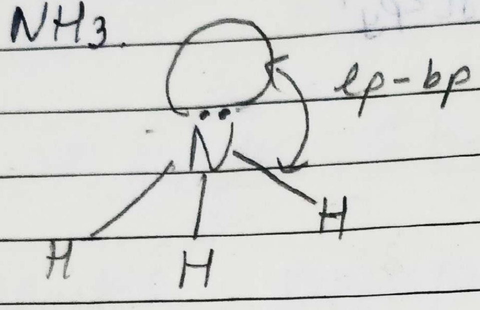
1) CH_4



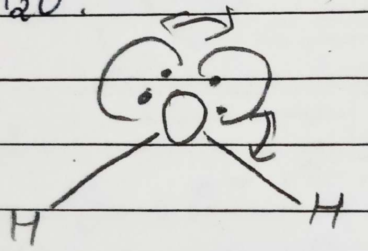
→ tetrahedral

→ Bond angle :-
109.5°. or
109-28°

2) NH_3.



3) H_2O.



Shape → V shape / Bent.

$109.5° \xrightarrow[-2.5°]{1\ lp} 107° \xrightarrow[-2.5]{1\ lp} 104.5°$.

→ lp - lp > lp - bp > Bp - bp.

→ Repulsion order.

→ Shape

Regular geometry
→ When central atom does not have any lone pair

destorted geometry
When central atom having lone pair.

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* Hybridisation

→ It is mixing of orbital of central atom which is bounded with polyatomic molecules.

→ No. of atomic orbital = No. of hybridized orbital.

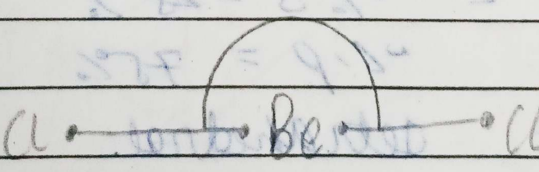
→ Combining orbital is having nearby same energy & different shape.

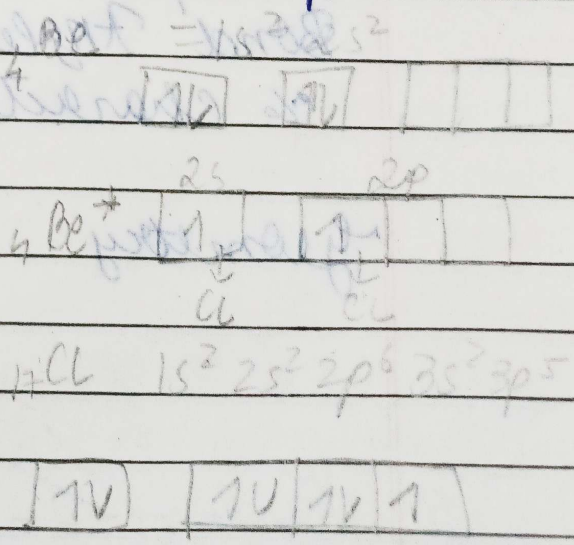
→ Hybridisation is possible in half filled, fully filled & vacant orbital.

→ In this, lone pair & σ bond only participates

→ π-bond doesn't participate.

1 (i) No. of participating orbital = s+p
(ii) No. of hybridised orbital = 2
(iii) Hybridisation = sp
(iv) example = $BeCl_2$, BeF_2
(v) Geometry = Linear
(vi) Bond Angle = 180°
(vii) % character of orbital = %s = 50% | %p = 50%

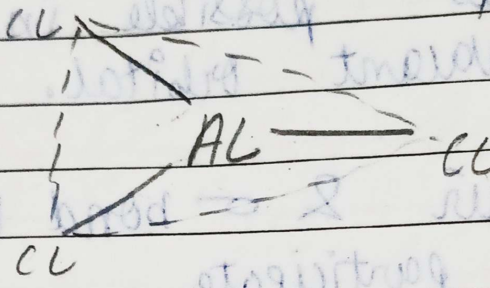


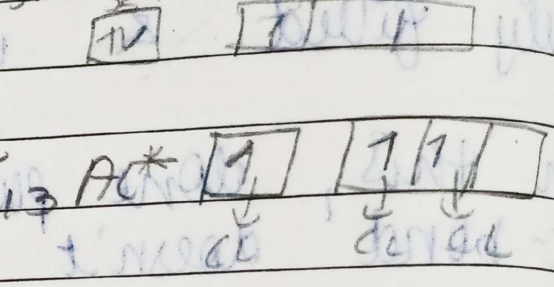


2) No. of participating orbital = s + 2p
No. of hybridised orbital = 3
Hybridisation = sp^2
example = BF_3 or $AlCl_3$
Bond Angle = 120° (3)
% character = % s = 33.3%
% = 66.6%

Geometry = trigonal planar or trigonal coplanar

$_{13}Al = 1s^2 2s^2 2p^6 3s^2 3p^1$

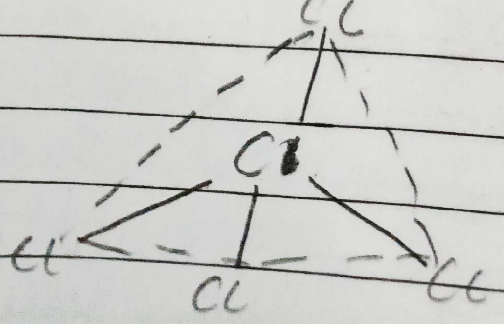




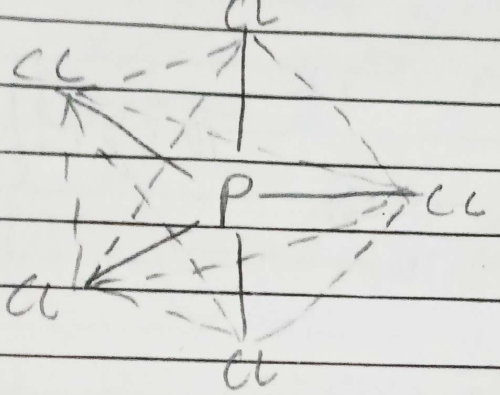
Cl :- $1s^2 2s^2 2p^6 3s^2 3p^5$
$_{17}Cl$:- " "
$_{17}Cl$:- " "
17

3) No. of participating orbital = s + 3p
No. of hybridised orbital = 4
Hybridisation = sp^3
example = CH_4 or CCl_4
Bond Angle = 109.5° or 109.28°
% Character = % S = 25%
% P = 75%

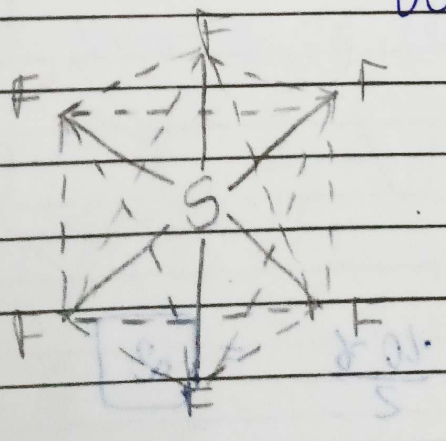
Geometry :- Tetrahedral.



4) No. of participating orbital = s + 3p + d
No. of hybridised orbital = 5
Hybridisation = sp^3d
eg. :- PCl_5
Bond angle :- 90°(6), 120°(3), 180°(1)
% character :- %s = 20% d = 20%
%p = 60%
Geometry :- Trigonal bipyramidal.



5) No. of participating orbital = s + 3p + 2d
No. of hybridised orbital = 6
Hybridisation = sp^3d^2.
example = SF_6
Bond Angle = 90°(12), 180°(3)
% character = %s = 16.6% %p = 50% %d =
Geometry = Square bipyramidal or Octahedral.



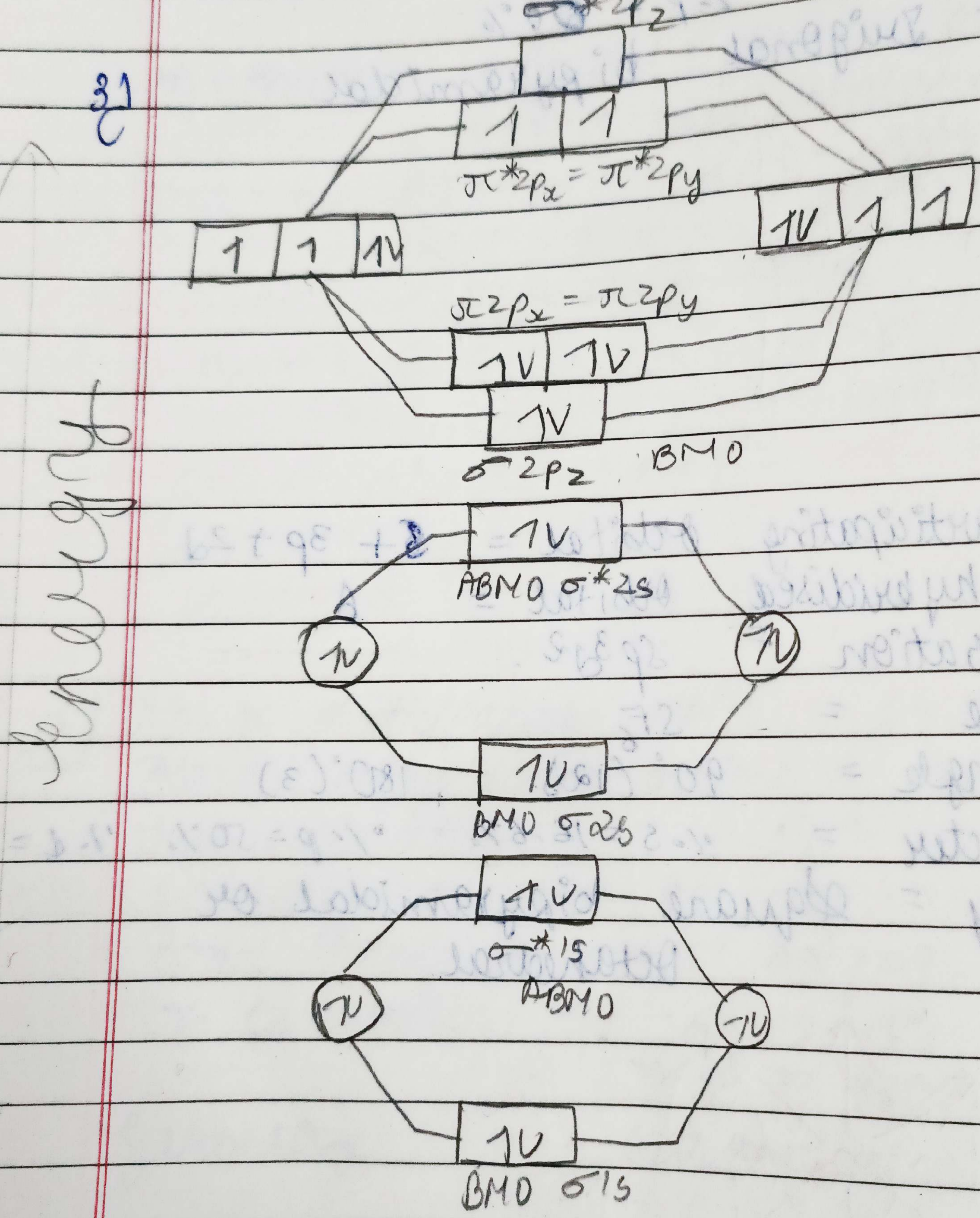
* Electronic configuration

1] O_2

1] No. of e^- = $16e^-$

2] e^- conf^n = $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_z^2 < \pi 2p_x^2 = \pi 2p_y^2 < \pi^* 2p_x^1 = \pi^* 2p_y^1$

3]



4] $B.O. = \frac{N_b - N_a}{2} = \frac{10-6}{2} = \boxed{2}$

5] Magnetic Properties = Paramagnetic

* Bond Order

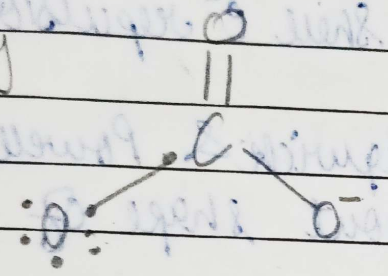
$O_2^{+2} = 14e^- \Rightarrow 3$
$O_2^{+} = 2.5$
$O_2 = 2$
$O_2^{-} = 1.5$
$O_2^{-2} = 1$

* ⇒ Bond order of species having more than 20 e^-.

1) CO_3^{-2}.

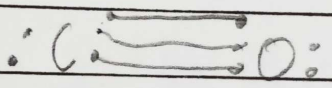
Method 1 :- $1 + \frac{\text{No. of } \pi \text{ bond}}{\text{No. of } \sigma \text{ bond}}$

⇒



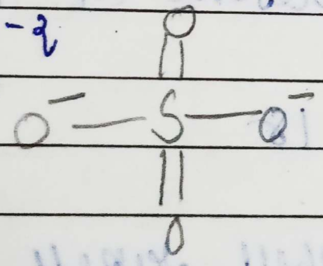
$B.O. = 1 + \frac{1}{3} = 1 + 0.333 = \boxed{1.33}$

2) CO



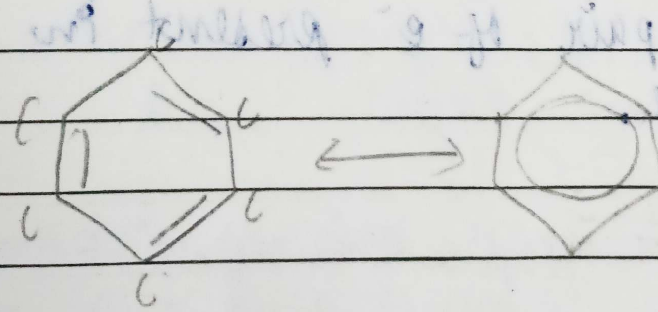
$\Rightarrow \frac{1+2}{1} = \boxed{3}$

3) SO_4^{-2}



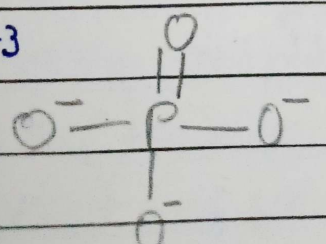
$B.O. = 1 + \frac{2}{4} = \boxed{1.5}$

4) C_6H_6



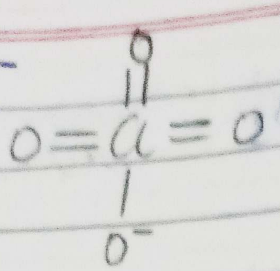
$B.O. = 1 + \frac{3}{6} = \boxed{1.5}$

5) PO_4^{-3}



$\Rightarrow B.O. = 1 + \frac{1}{4} = \boxed{1.25}$

6) ClO_4^-



$O=Cl(=O)(=O)-O^-$

→ $B.O. = 1 + \frac{3}{4} = \boxed{1.75}$

7) CO_2 $O=C=O$ → $B.O. = 1 + \frac{2}{2} = \boxed{2}$

- Method 2 :-

$$B.O. = \frac{\text{No. of resonating bond}}{\text{No. of resonating structure}}$$

* VSEPR Theory :- (Valence Shell e^- repulsion)

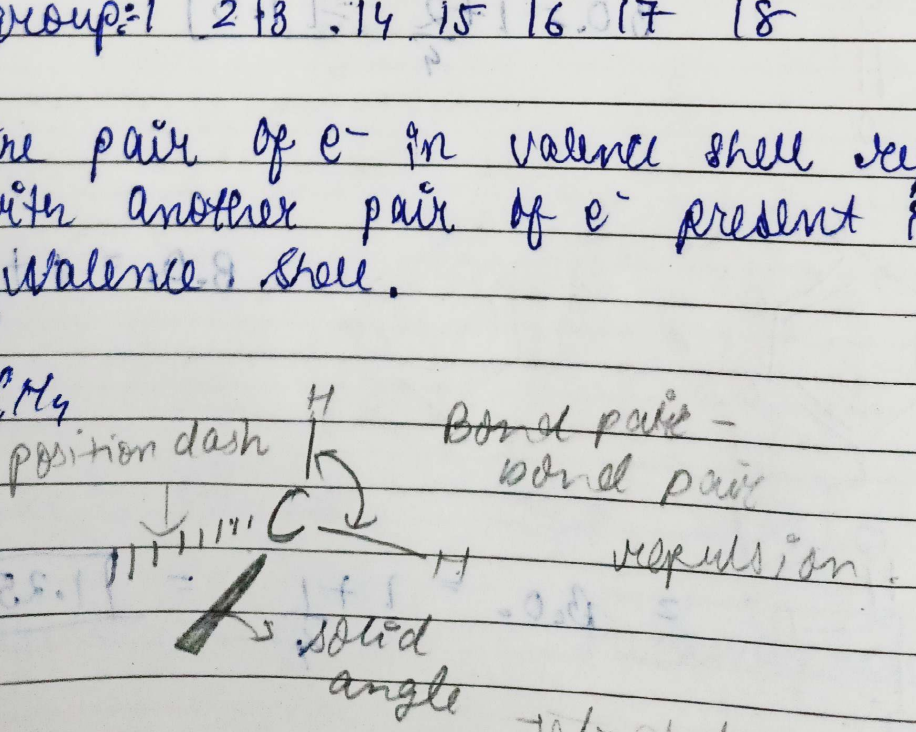
→ This theory is given by Sidgwick & Powell.
→ This theory gives info. about shape of molecules.

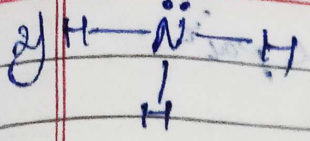
- Postulates :-

1) It depends on valence e^- present in the orbital.
group:- 1 2 13 14 15 16 17 18

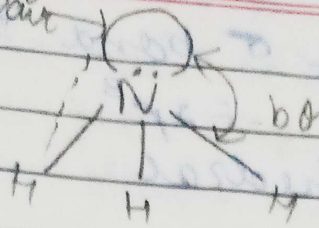
2) One pair of e^- in valence shell repell with another pair of e^- present in valence shell.

eg :- CH_4



2) 

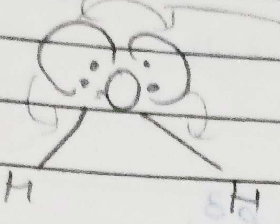
Lone pair



lone pair-bond pair repulsion

Pyramid

3) H_2O.



→ lone pair - lone pair repulsion

→ Order of repulsion.

lp-lp > lp-bp > bp-bp.

$$109.5° \xrightarrow[-2.5°]{lp} 107° \xrightarrow[-2.5°]{lp} 104.5°$$

✗ How to calculate Hybridisation :-

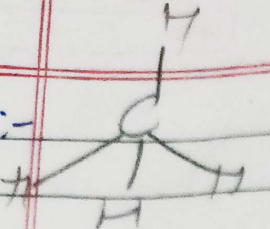
1) Hybridisation = No. of σ bond + lone pair

2) Hybridisation = $\frac{1}{2}[M+V-C+A]$

M = No. of monovalent atom
eg :- F, Cl, Br, I, H, ...
V = Valence e^- on central atom.
C = charge of cation
A = charge on anion.

→ $1\sigma + 1\,lp \rightarrow$ Hyb^n = 2 = sp.
$1\sigma + 2\,lp \rightarrow$ 3 = sp^2
$2\sigma + 2\,lp \rightarrow$ 4 = sp^3
$3\sigma + 2\,lp \rightarrow$ 5 = sp^3d^1
$3\sigma + 3\,lp \rightarrow$ 6 = sp^3d^2
7 = sp^3d^3

eg:-



= No. of σ bond + lone pair

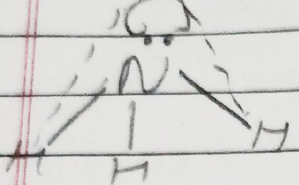
= 4 = sp^3

→ tetrahedral

or

Hyb^n = $\frac{1}{2}(4+4) = 4 = sp^3$

2) NH_3



= $3+1$

= $4 = sp^3$.

→ pyramidal.

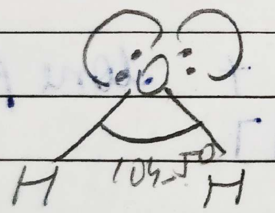
or

Hyb^n = $\frac{1}{2}[M+V+C+A]$

= $\frac{1}{2}[3+5]$

= $4 = sp^3$.

3) H_2O

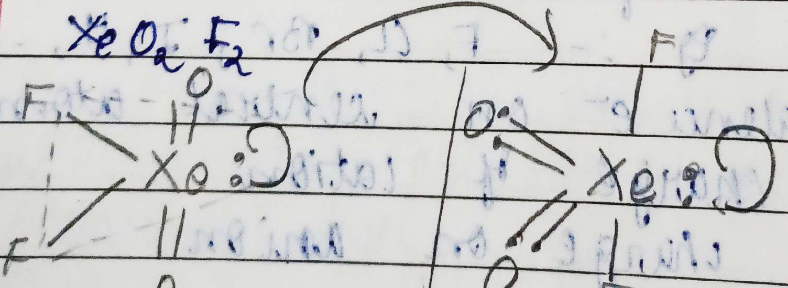


$\frac{1}{2}[M+V]$

$\frac{1}{2}(2+6) = 4 = sp^3$

→ bent / V-shaped.

4) XeO_2F_2



Hyb^n = $4+1$

= 5

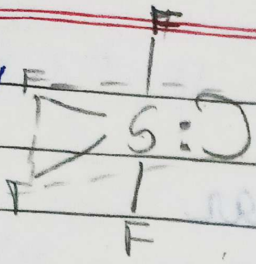
= sp^3d

geometry = trigonal bipyramidal

Shape = see saw

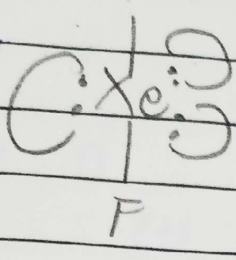
→ In the sp^3d hyb^n, lone pair occupies equitorial position (square planar) & most e-negative element occupy axial position.

5) SF_4



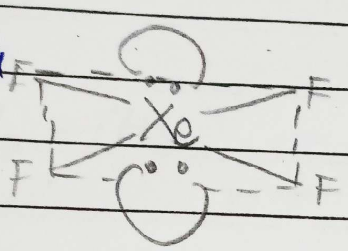
Hyb^n = sp^3d.
geometry :- Trigonal bipyramidal
shape :- See saw.

6) XeF_2



Hyb^n :- $2+3$
$= 5 \rightarrow sp^3d$

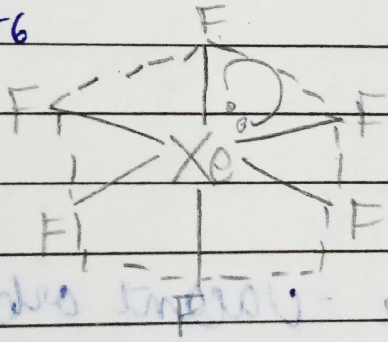
7) XeF_4



Hyb^n $= 4+2 = 6 \rightarrow sp^3d^2$
$= \frac{1}{2}(4+8) = 6 = sp^3d^2$

Note :- In sp^3d^2 hybridisation, lone-pair occupies axial position & most e^- negative elements on equitorial position.

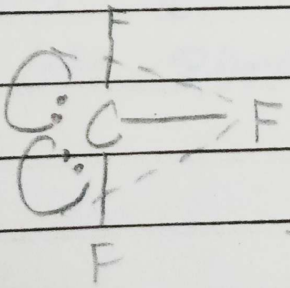
8) XeF_6



Hyb^n $= 6+1$
$= 7 \rightarrow sp^3d^3$

$\rightarrow$ Pentagonal bipyramidal

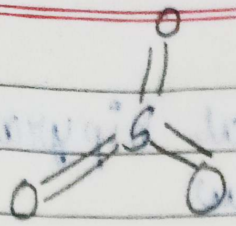
9) ClF_3



Hyb^n $= 3+2 = 5 \rightarrow sp^3d$.
$= \frac{1}{2}[M+V-C+A]$.
$= \frac{1}{2}[3+7]$
$= 5 \rightarrow sp^3d$.

$\rightarrow$ geometry : trigonal bipyramidal
shape : T- Shaped.

10)

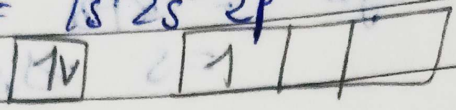


Hyb^n = 3 ⇒ sp^2

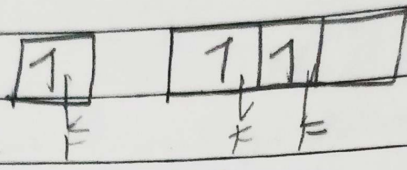
⇒ Trigonal planar

11) BF_3

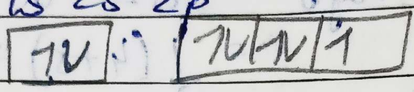
$_5B = 1s^2 2s^2 2p^1$



$_5B^* =$



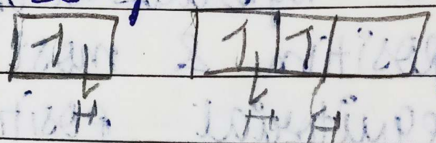
$_9F = 1s^2 2s^2 2p^5$



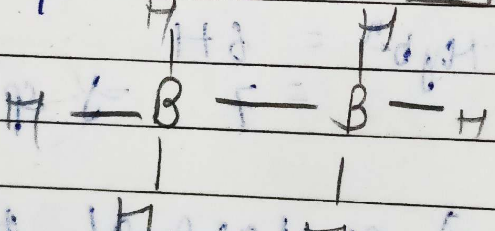
12) $(BH_3)_2$ Or $BH_3 - BH_3$

$_5B = 1s^2 2s^2 2p^1$

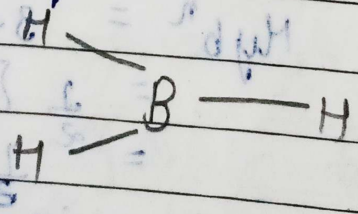
$_5B^* =$



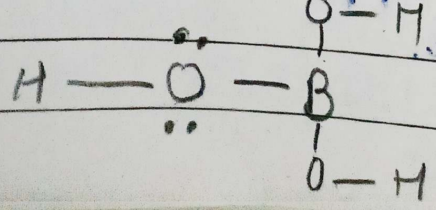
$_1H = 1s^1$



⇒ In the hybridisation vacant orbital also participates.



13) $B(OH)_3$ – Boric Acid



-) Hyb^n of B = 3 ⇒ sp^2
" " O = 2+2 ⇒ 4 ⇒ sp^3

14) $CH_3 - CH = CH - CH_2 - C \equiv CH$

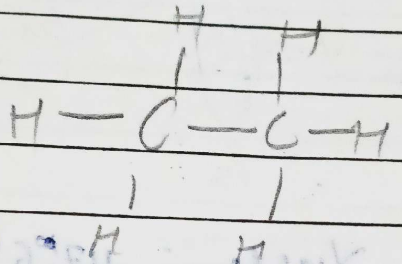
sp^3 sp^2 sp^2 sp^3 sp sp

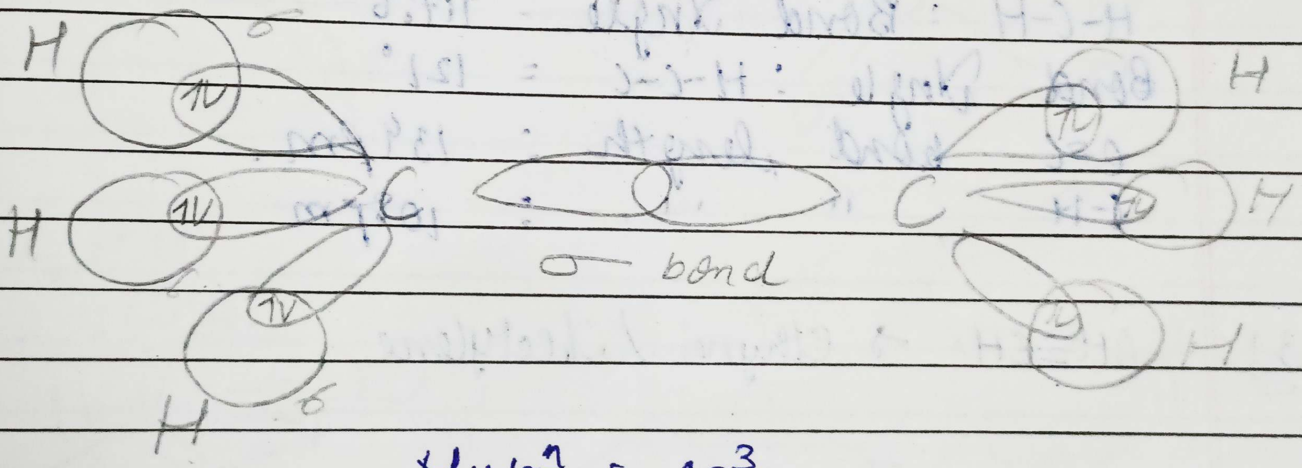
15) $C_5H_{10}O$

$CH_3 - CH_2 - CH_2 - CH_2 - \overset{O}{\overset{\|}{C}} - H$

sp^2

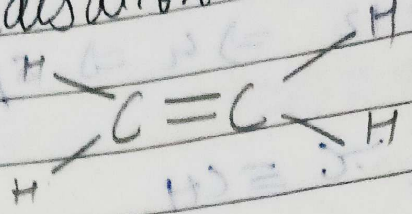
16) $CH_3 - CH_3$

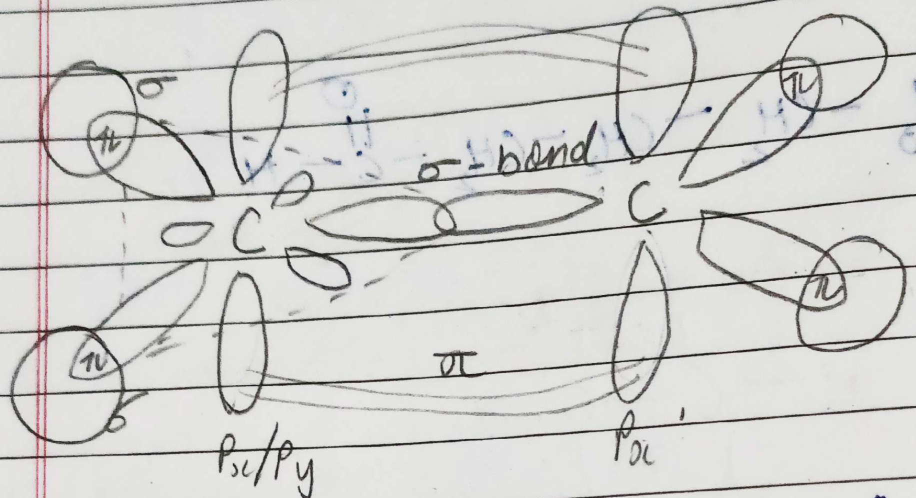




Hyb^n = sp^3.
Bond Angle = 109.5° or 109.28°
C-C Bond length = 154 pm
C-H Bond length = 109 pm

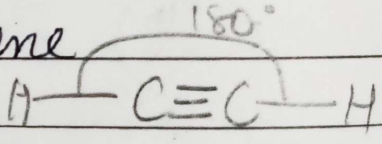
Eg: Hybridisation in $CH_2=CH_2$ / C_2H_4

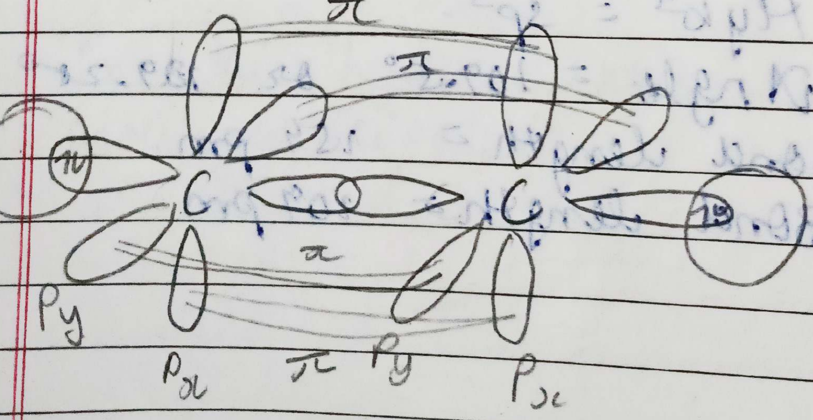




H-C-H : Bond Angle : 117.6°
Bond Angle : H-C-C = 121°
C=C bond length : 134 pm.
C-H " " : 108 pm

3) CH≡CH → Ethyne / Acetylene

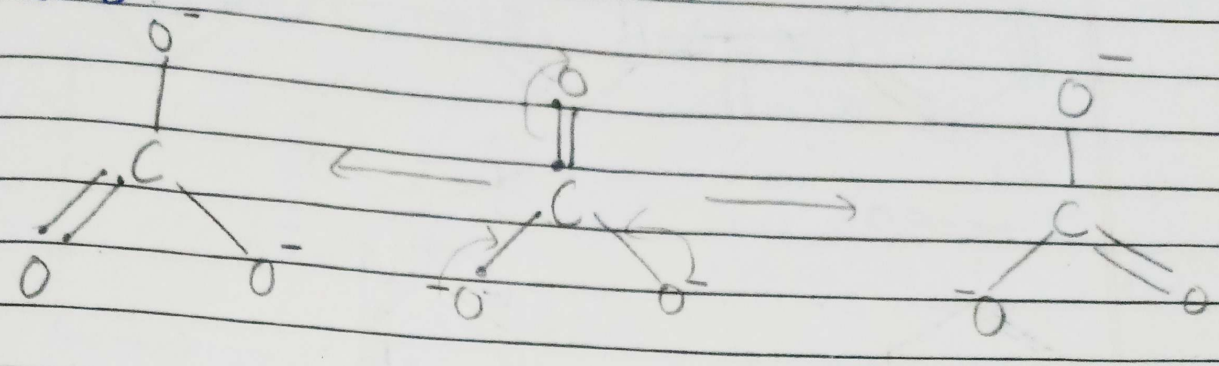




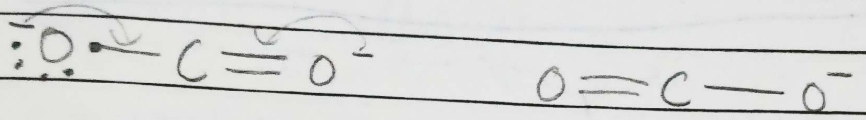
→ C≡C bond length : 120 pm
C-H bond length : 106 pm.

* Resonance Structure :-

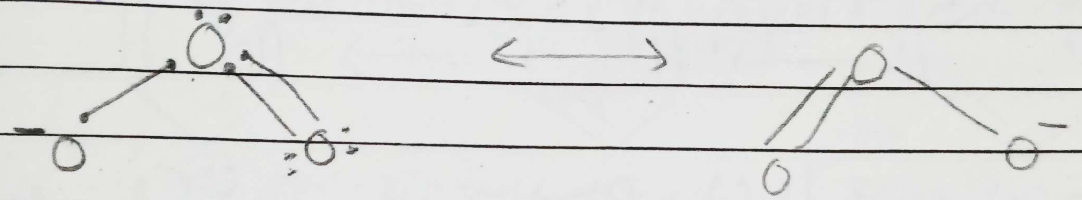
* CO_3^{-2}



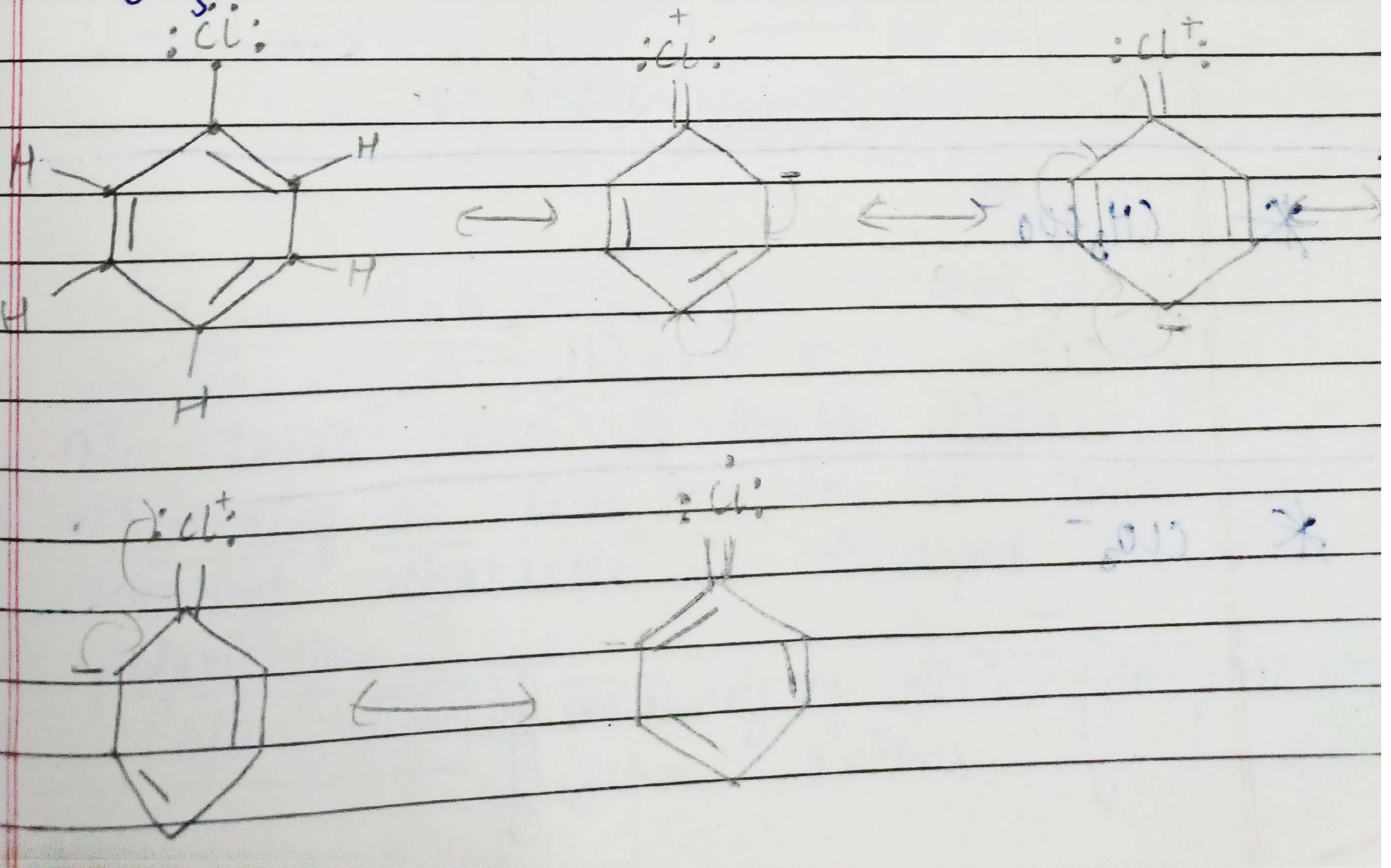
* CO_2



* O_3



* C_6H_5Cl



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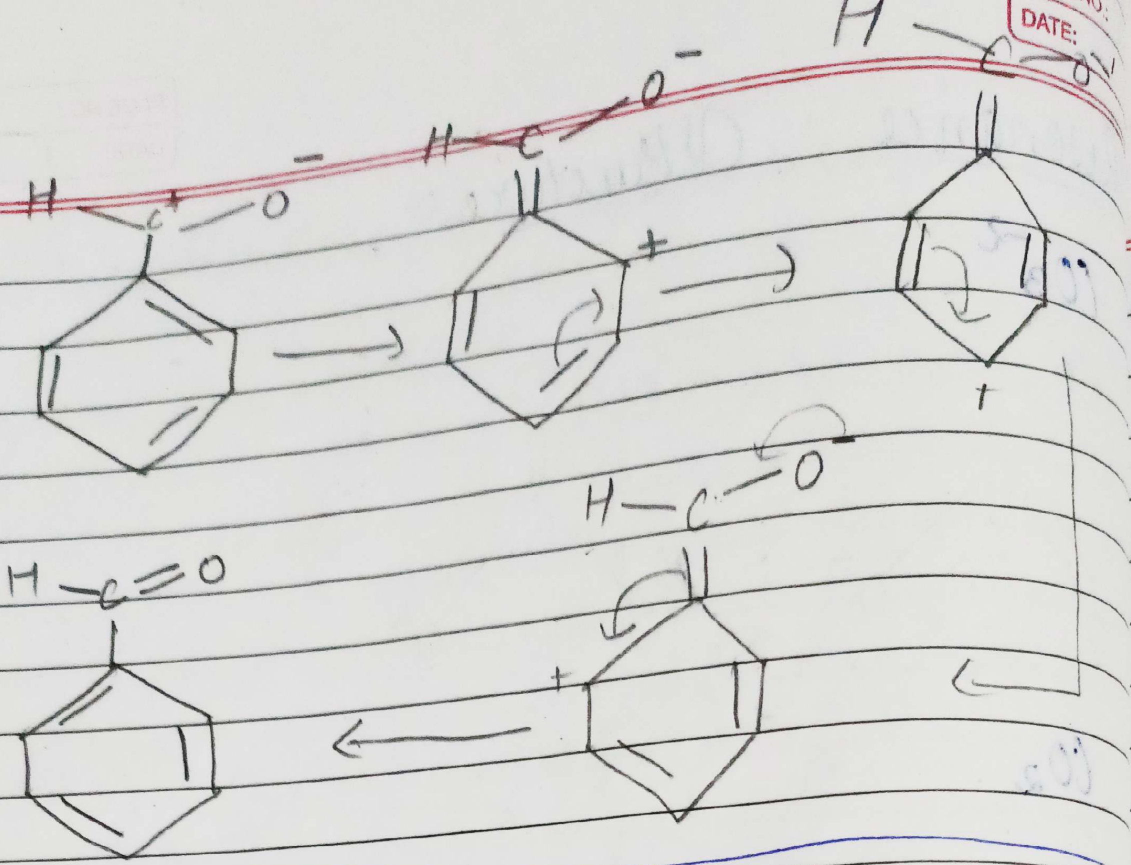

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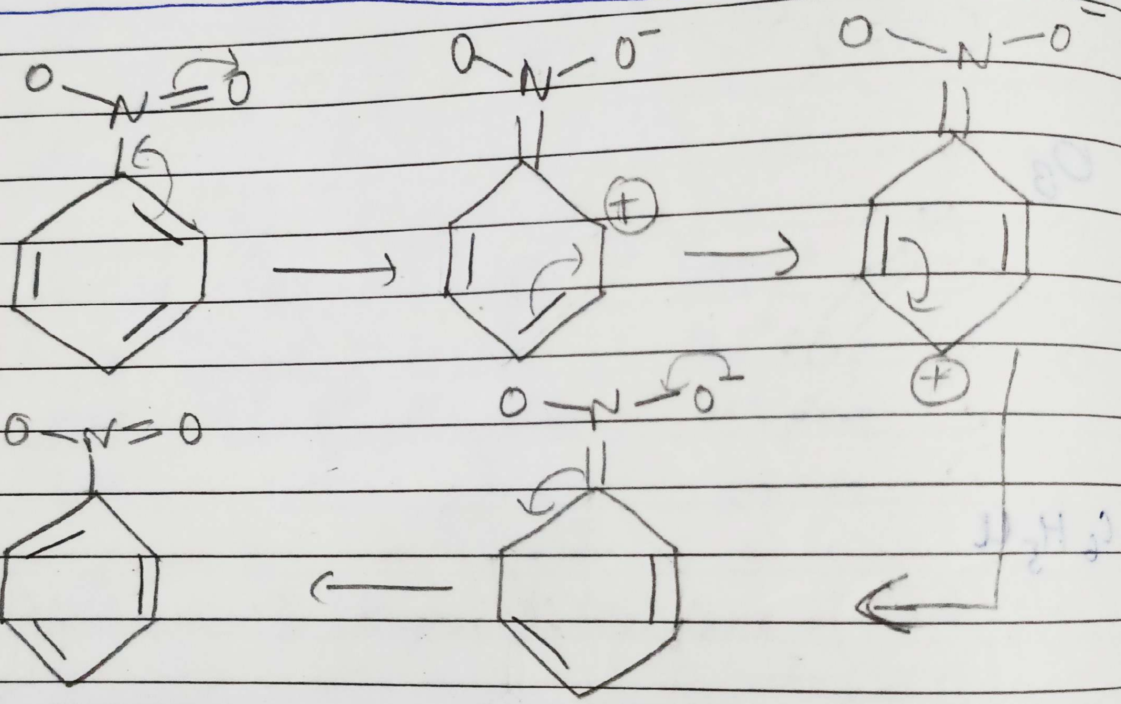
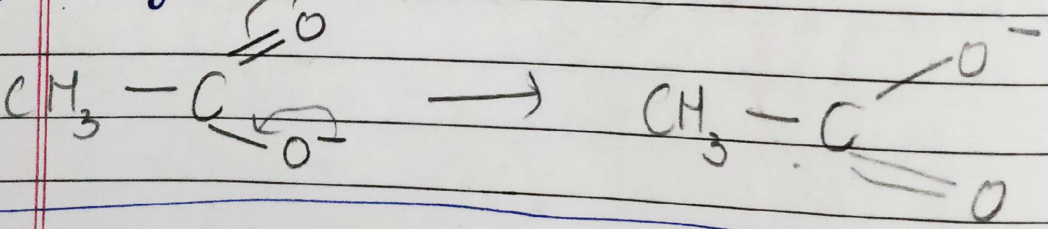
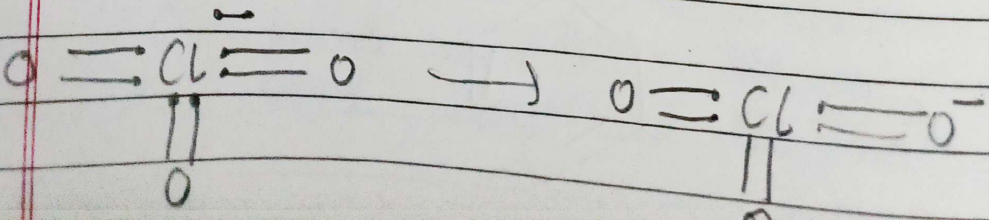


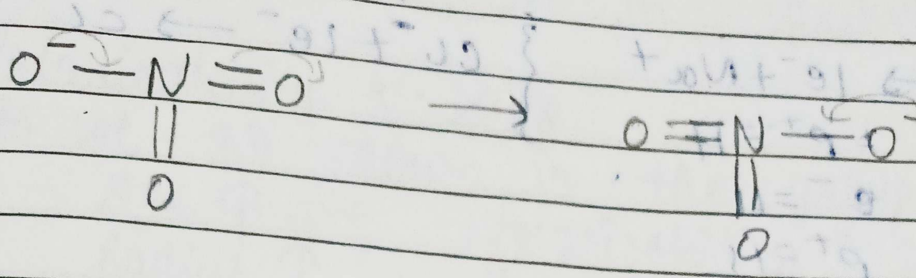
* CH_3COO^-



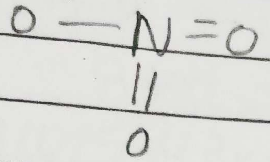
* ClO_3^-



* NO_3^-



$O^- - \underset{\underset{O}{\|}}{N} = O \longrightarrow O = \underset{\underset{O}{\|}}{N} - O^-$

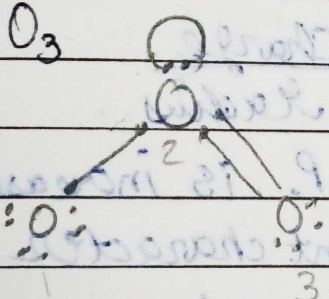


$O^- - \underset{\underset{O}{\|}}{N} = O$

* Formal charge :-

→ F.C = No. of valence e⁻ of free atom − No. of lone pair e⁻ (unpaired e⁻) − $\frac{1}{2}$ No. of shared e⁻ (Bonded e⁻)

① O_3



$FC_1 = 6 - 6 - \frac{1}{2}(2) = 0 - 1 = \boxed{-1}$

$FC_2 = 6 - 2 - \frac{1}{2}(6) = 6 - 2 - 3 = \boxed{1}$

$FC_3 = 6 - 4 - \frac{1}{2}(4) = 6 - 4 - 2 = \boxed{0}$

* Fajan Rule :-

→ No ionic bond is 100% pure.

→ According to Rule :- In the ionic bond covalent character is developed due to the polarization.

- Polarization :- Tendency of cation to pull e⁻ from anions.

ex :- NaCl.

$Na \rightarrow 1e^- + Na^+$ } $Cl^- + 1e^- \rightarrow Cl^-$

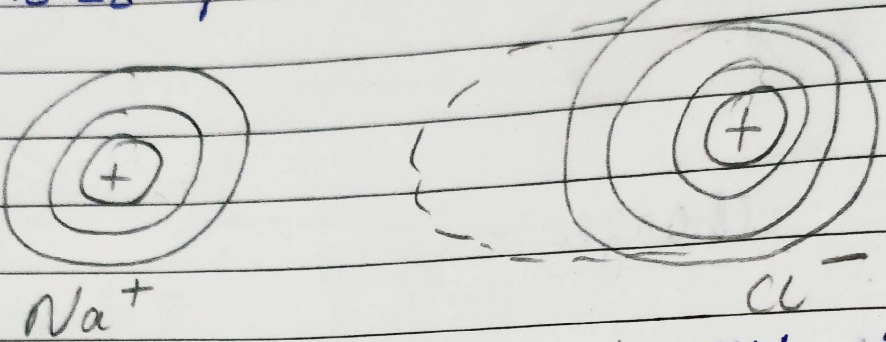
$_{11}Na = p^+ = 11$

$e^- = 11$

$Na^+ = p^+ = 11$

$e^- = 10$

$\rightarrow = 1s^2 2s^2 2p^6 3s^1$



→ Polarization power → polarisability

|—— Polarization ——|

→ polarization power $= \frac{\text{charge}}{\text{size}}$ or $\frac{\text{charge}}{\text{radius}}$.

$$\boxed{\uparrow P.P \propto \frac{1}{\text{radius} \downarrow}}$$

If P.P. is increase covalent character is increased.

→ $\boxed{\text{Polarisability} \propto \text{size.}}$

→ As the size increases polarisability increases & covalent character ↑

* Tendency of Anion in group & period.

→ Polarisability ∝ size.

→ As we go down in the group:-

Size ↑ . Polarisability ↑ Ionic
Radius ↑ Covalent character ↑ character ↓

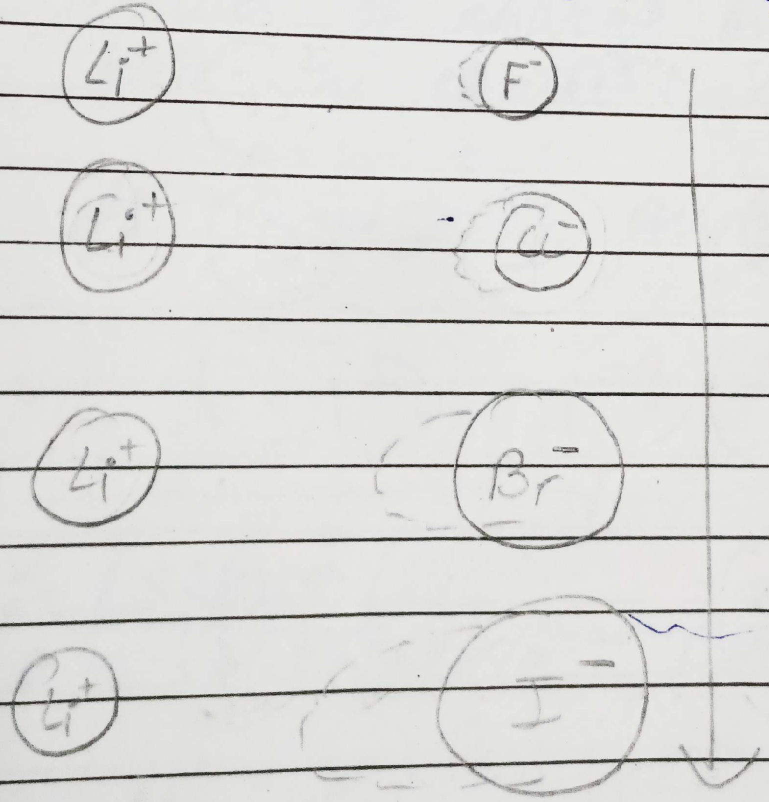
- Covalent Bond Order:-

  $LiF < LiCl < LiBr < LiI$

- Ionic Bond Order:-

  $LiF > LiCl > LiBr > LiI$

JEE :- $LiCl < BeCl_2 < BCl_3 < CCl_4$

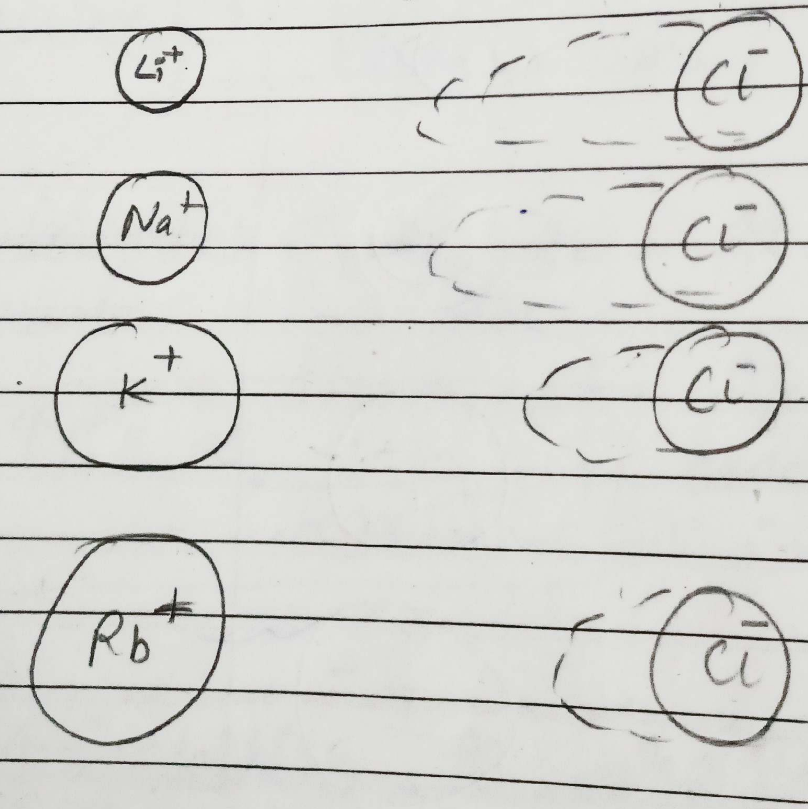


* Tendency of cation in group & period

$$P.P \propto \frac{1}{size}$$

→ As we go down in the group,
size↑ P.P↓
Radius↑ Covalent character ↓
Ionic Character ↑

- Order of Ionic Bond :-
→ LiCl < NaCl < KCl < RbCl.
- Order of Covalent Bond :-
LiCl > NaCl > KCl > RbCl



* Dipole moment (μ) :-
→ It is separation of charge in covalent bond.

Covalent Bond.

Polar Covalent

$H^{+\delta} - F^{-\delta}$

2.2 4

$H^{+\delta} — Cl^{-\delta}$

2.2 3

Non-Polar Co

$H — H$

2.2 2.2

$O = O$

3.5 3.5

$N \equiv N$

3 3

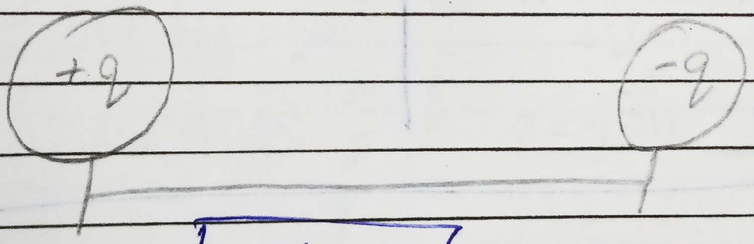
- **Dipole moment :-**

→ It is vector quantity.

→ It depends on direction.

→ It is the product of charge on any atom & distance b/w the centre of cation & anion.

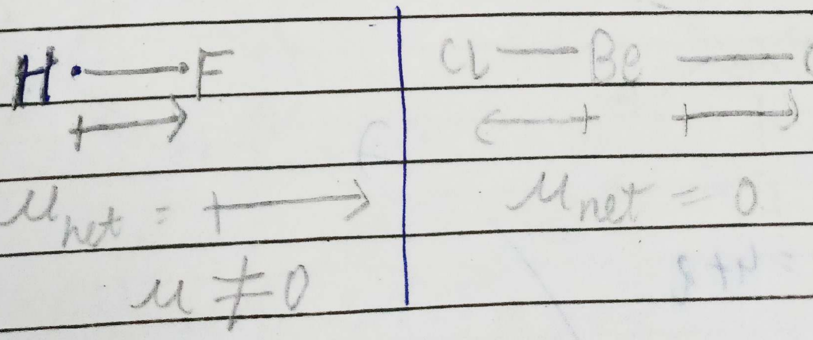
i.e. $\mu = Q \times d$ or charge × distance



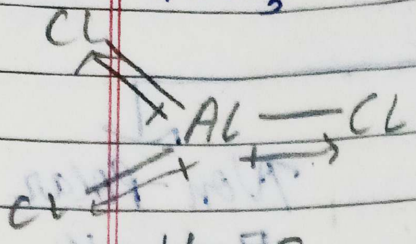
Unit :- $\boxed{\text{debye}}$

$\therefore 1\,D = 3.33564 \times 10^{-30}$ C.m

eg :-

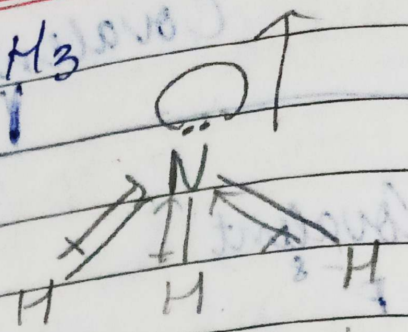


→ $AlCl_3$



$\mu \neq 0$

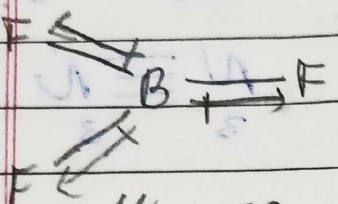
NH_3



4.90×10^{-30} C.m

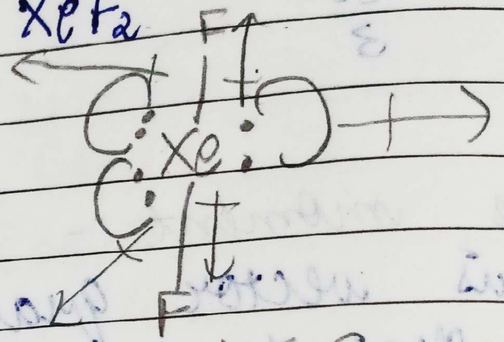
$\mu_{net} \neq 0$

BF_3



$\mu_{net} = 0$

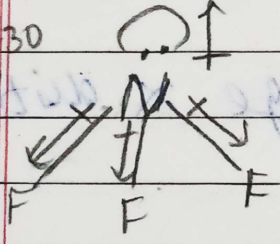
XeF_2



$\mu_{net} = 0$

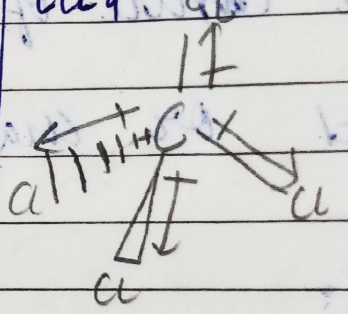
NH_3

0.80×10^{-30} C.m



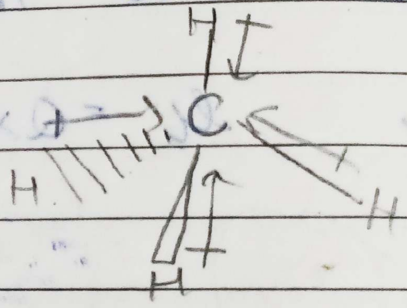
$\mu_{net} \neq 0.$

CCl_4



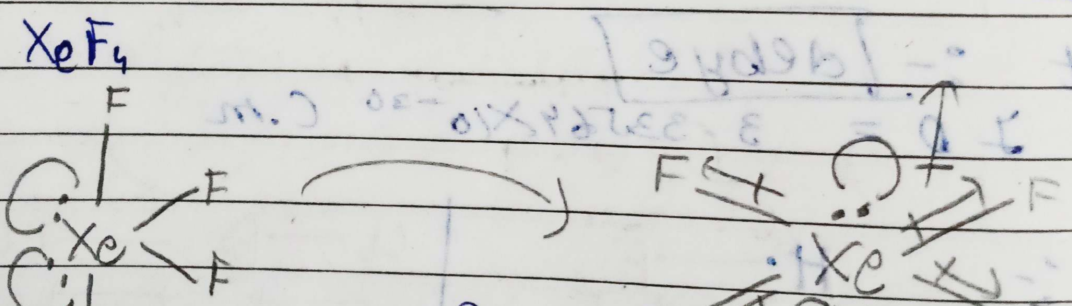
$\mu_{net} = 0$

CH_4



$\mu_{net} = 0$

XeF_4



Hyb^n = 4+2
= 6
= sp^3d^2

$\mu_{net} = 0$

3 HBr

$H - Br$

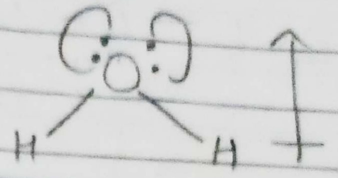
$\longmapsto$

$\mu \neq 0$

$H - H$

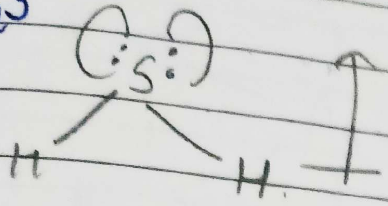
$\mu = 0$

H_2O



$\mu_{net} \neq 0$

H_2S



$\mu \neq 0$

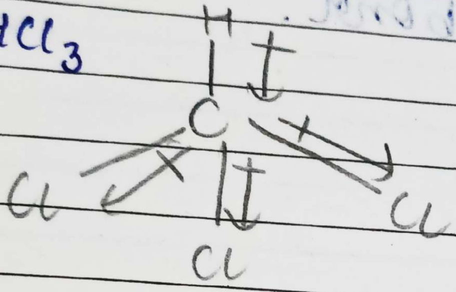
CO_2

$O = C = O$

$\longleftarrow\!\!+\ \ +\!\!\longrightarrow$

$\mu = 0$

$CHCl_3$



$\mu \neq 0$

* H- bond

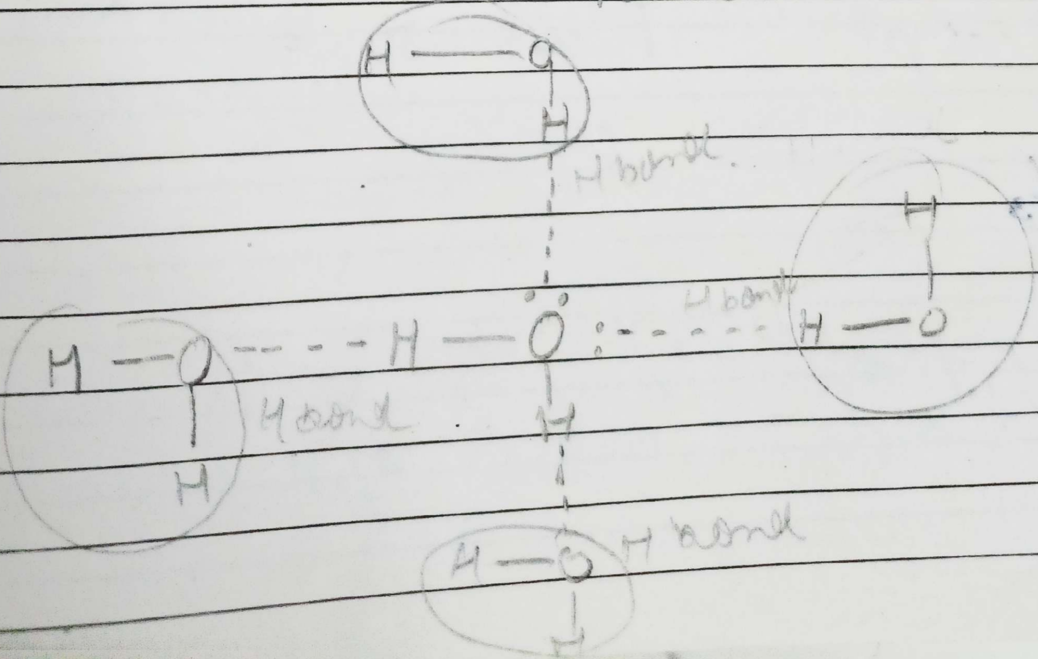
eg $H^{+\delta} - F^{-\delta} \cdots\cdots H^{+\delta} - F^{-\delta}$

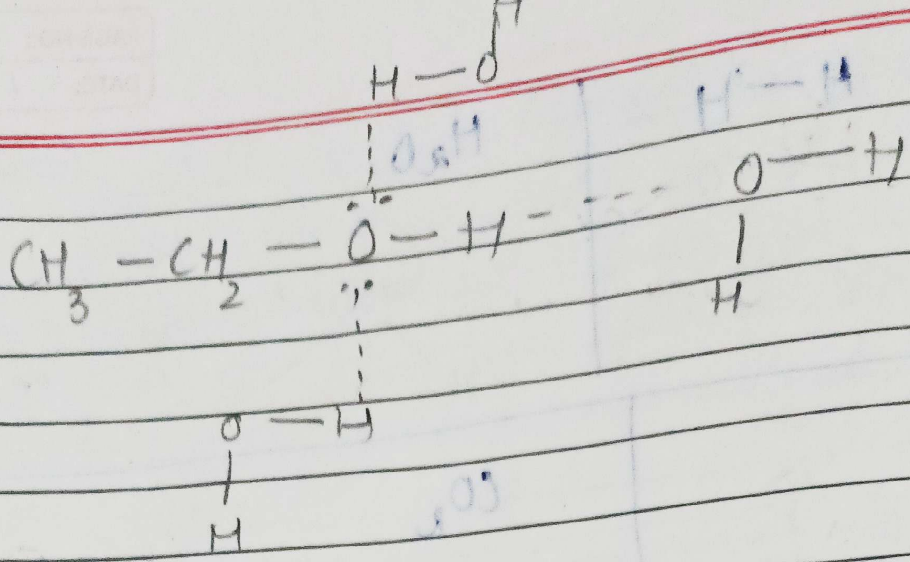
H-bond

most electro-negative

(F>O>N>Cl)

eg :-

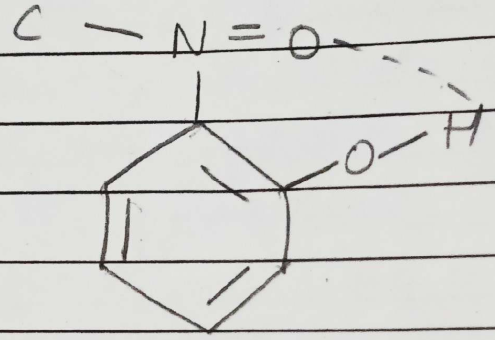




* Types of H- bond :-

1) Intermolecular H- bond.

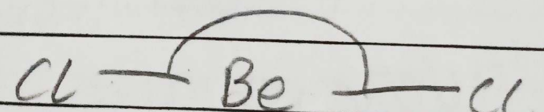
2) Intramolecular H- bond.



Orthonitrophenol.

* Shape of molecule :-

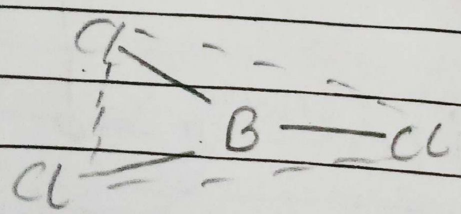
1) $BeCl_2$



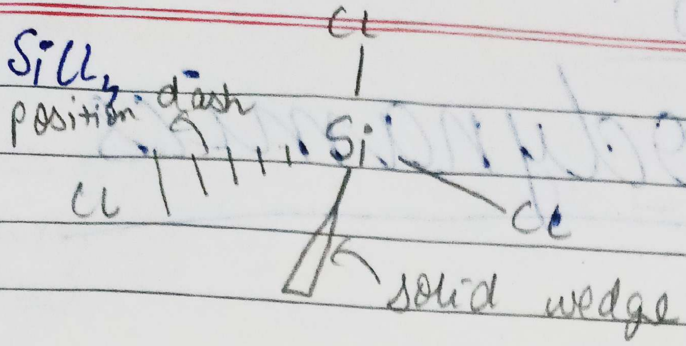
→ linear | 180°

→ sp | %s = 50

2) BCl_3

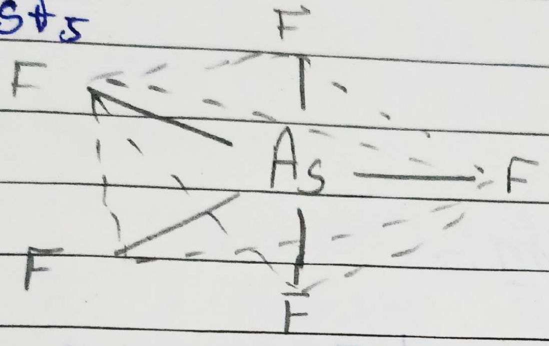


3) $SiCl_4$

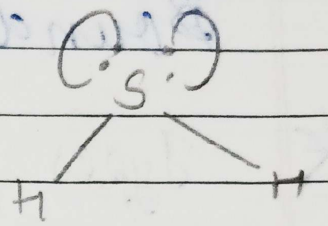


$Hyb^n = sp^3$
→ 109.5°
→ tetrahedral

4) AsF_5



5) H_2S



$Hyb^n = sp^3$