08.24

CHAPTER : 04

Wednesday

Date : /

Page :

Chemical Bonding

A branch of chemistry which deals with how and why of any bond form.

Types of Bond

- Strong Bond ≈ 200KJ/mole (Bond energy)
  - Covalent Bond
  - Ionic Bond
  - Co-ordinate Bond
  - Metalic Bond
- Weak Bond ≈ 2KJ/mole (Energy)
  - Hydrogen Bond
  - Vander wall's Bond

Except → Noble gas

He, Ne, Ar.

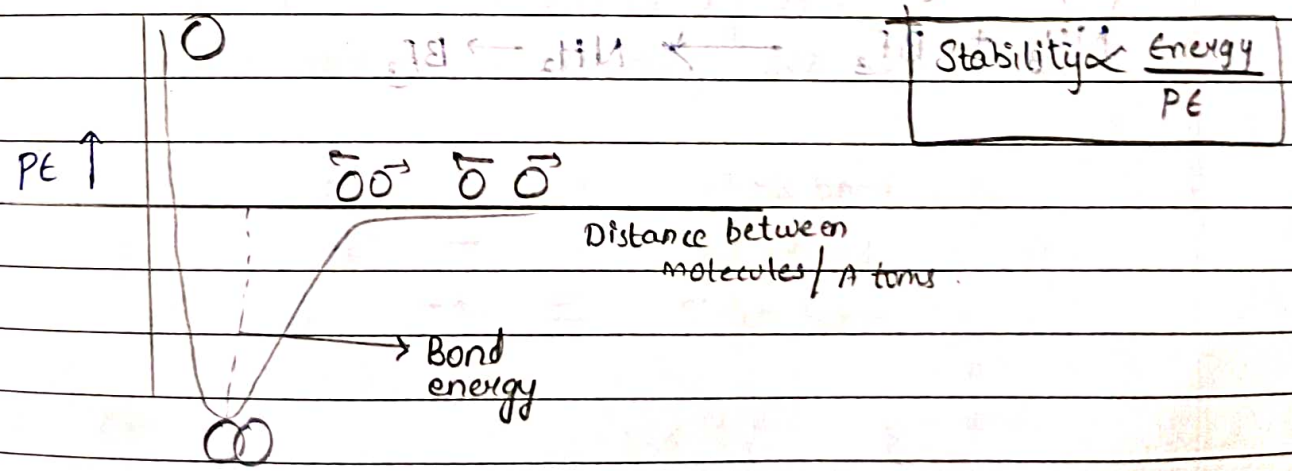
~~H~~ H_2 H_2O

~~N~~ N_2 NH_3

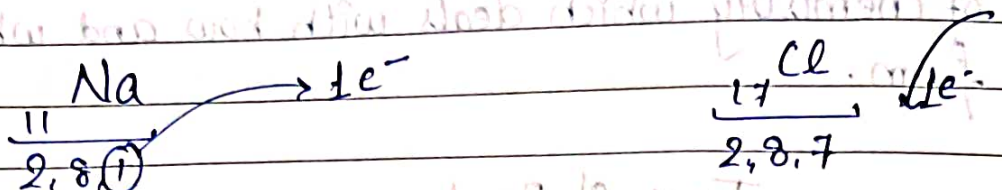
~~O~~ O_2 H_2O O_3

Stability ∝ Bond Strength [Energy]

Stability ∝ $\frac{\text{Energy}}{PE}$

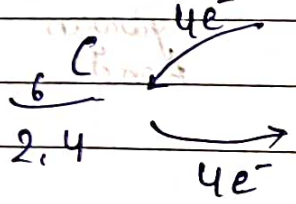


I By Give and Take Of e^- [Ionic Bond]



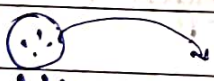
$$Na^+ + Cl^- \longrightarrow NaCl$$

II By Sharing Of e^- (covalent Bond)



$$C + 4H \longrightarrow CH_4$$

III By Sharing Of lone Pair of e^- (co-ordinte Bond)



$$NH_3 + BF_3 \longrightarrow NH_3 \rightarrow BF_3$$

COVALENT BOND

- Octet Bond
  - By Lewis / Kossel
  - Cross dot structure.
- VBT
  - Valence Bond Theory
    - Over lapping
    - Hybridisation
    - VSEPR
      - Valence Shell e⁻ pair repoltion Theory
- MOT
  - Molecular Orbital Theory

Lewis And Kossel Rule

This rule is all about Octet Rule, → for all atoms
Hydrogen ke liye → Duplet

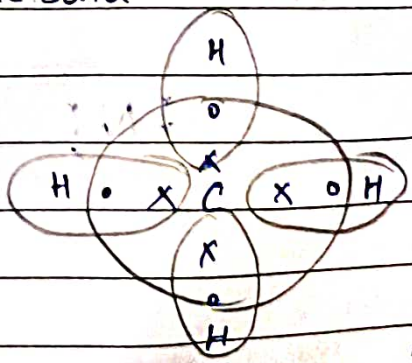
1st atom e⁻ is denoted by cross (×)
2nd atom e⁻ is denoted by dot (·)

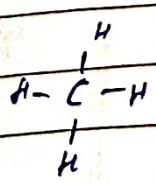
If, 2e⁻ → — Single bond
4e⁻ → = Double bond
6e⁻ → ≡ Triple bond

1) CH_4

C
2, (4) → outer most e⁻

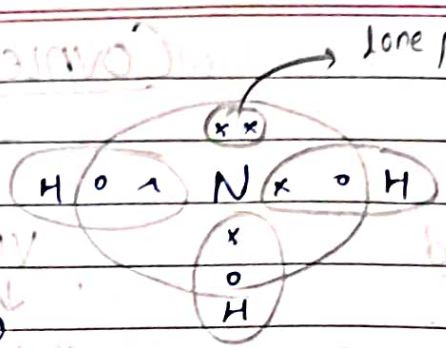
H
1

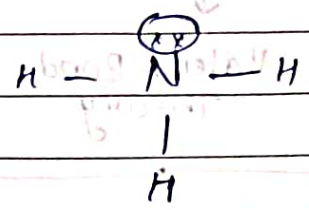




2. NH_3

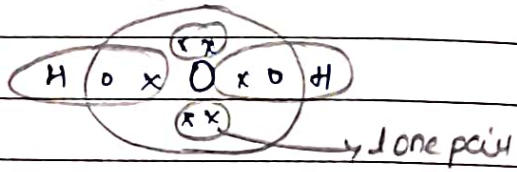
$\underset{2,5}{\overset{7}{N}}$ $\underset{1}{\overset{1}{H}}$

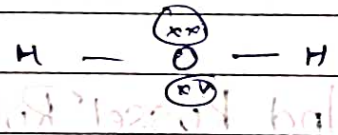




3. H_2O

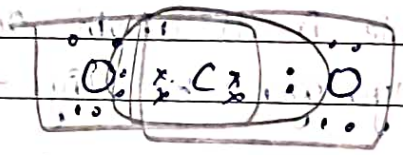
$\underset{2,6}{\overset{8}{O}}$ $\underset{1}{\overset{1}{H}}$





4. CO_2

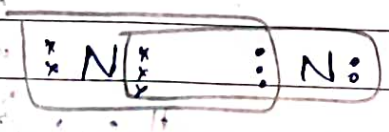
$\underset{2,4}{\overset{6}{C}}$ $\underset{2,6}{\overset{8}{O}}$



$O = C = O$

5. N_2

$\underset{2,5}{\overset{7}{N}}$ $\underset{2,5}{\overset{7}{N}}$

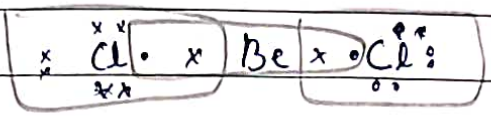


$:N \equiv N:$

6. $BeCl_2$

$\frac{{}_4Be}{2,2}$ $\frac{{}_{17}Cl}{2,8,7}$

Exception of Octet Rule



Cl – Be – Cl

EXCEPTION OF OCTET RULE

I. Incomplete Octet

(1) $\underset{2+2}{BeCl_2} \rightarrow 4e^-$

(2) $\underset{2e^- + 2e^-}{MgCl_2} \rightarrow 4e^-$

(3) $\underset{3+3}{BF_3} \rightarrow 6e^-$

(4) $\underset{3+3}{AlCl_3} \rightarrow 6e^-$

II. Extended Octet

$\underset{5+5}{PCl_5} \rightarrow 10e^-$

$\underset{6+6}{SF_6} \rightarrow 12e^-$

$\underset{6+4}{SF_4} \rightarrow 10e^-$

$\underset{7+3}{ClF_3} \rightarrow 10e^-$

$\underset{7+5}{IF_5} \rightarrow 12e^-$

$\underset{7+7}{IF_7} \rightarrow 14e^-$

III Exception → Noble gas

XeF_4 (8 + 4) → $12e^-$

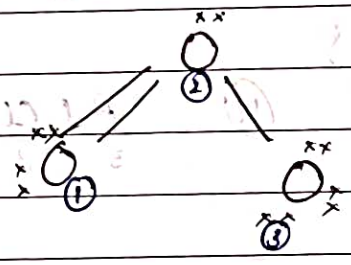
XeF_2 (8 + 2) → $10e^-$

XeF_6 (8 + 6) → $14e^-$

FORMAL CHARGE (FC)

no. of e^- in valence shell − no. of free e^- (non bonding e^- or no. of e^- in loan pair) − $\frac{1}{2}$ no. of e^- in bonding.

eg:

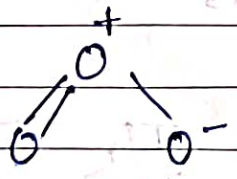


fc in ① O_2 → $6 - 4 - \frac{1}{2} \times 4 = 6 - 4 - 2 = 0$

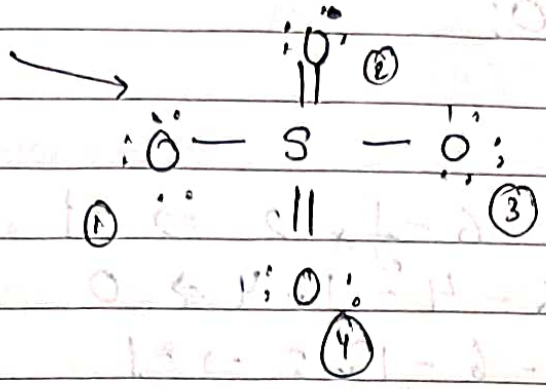
fc in ② O_2 → $6 - 2 - \frac{1}{2} \times 6 = 6 - 2 - 3 = +1$

fc in ③ O_2 → $6 - 6 - \frac{1}{2} \times 2 = 6 - 6 - 1 = -1$

↳



SO_4

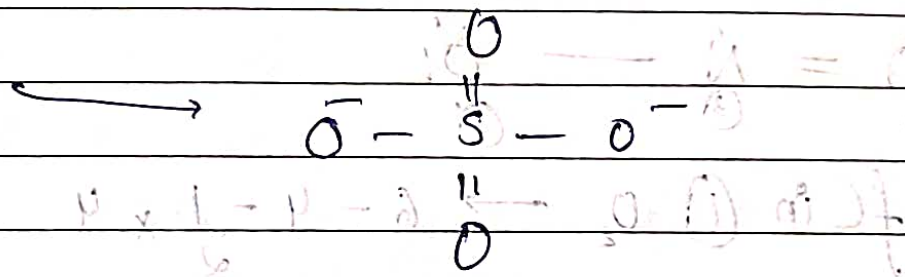


fc in (1) $O_2 \longrightarrow 6 - 6 - \frac{1}{2} \times 2 = -1$

fc in (2) $O_2 \longrightarrow 6 - 4 - \frac{1}{2} \times 4 = 0$

fc in (3) $O_2 \longrightarrow 6 - 6 - \frac{1}{2} \times 2 = -1$

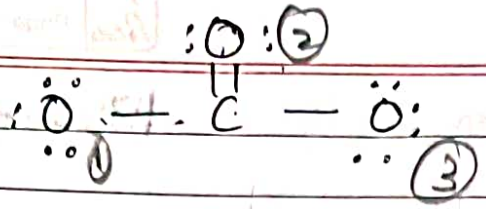
fc in (4) $O_2 \longrightarrow 6 - 4 - \frac{1}{2} \times 4 = 0$



average formula charge $= \frac{\text{no. of charge}}{\text{surrounded atoms}}$

$= \frac{-2}{4} = -0.5$

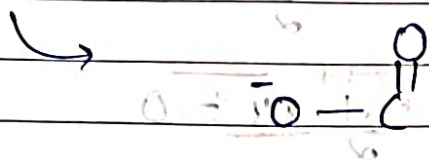
Q.



fC_{in} ① $O_2 \rightarrow 6 - 6 - \frac{1}{2} \times 2 \Rightarrow -1$

fC_{in} ② $O_2 \rightarrow 6 - 4 - \frac{1}{2} \times 4 \Rightarrow 0$

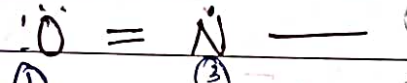
fC_{in} ③ $O_2 \rightarrow 6 - 6 - \frac{1}{2} \times 2 \Rightarrow -1$



avg formula charge $\Rightarrow \frac{-2}{3} \Rightarrow$

$\Rightarrow -0.66$

Q.



fC_{in} ① $O_2 \rightarrow 6 - 4 - \frac{1}{2} \times 4$

$\rightarrow 0$

fC_{in} ② $O_2 \rightarrow 6 - 6 - \frac{1}{2} \times 2$

$\rightarrow -1$

$\rightarrow O = N - O^-$

fC_{in} ③ $N \rightarrow 5 - 1 - \frac{1}{2} \times 6 \Rightarrow +1$

avg formula charge $\Rightarrow \frac{-1+1}{2}$

$= 0/2 \Rightarrow 0$

OVER LAPPING

pearl to nucleus ✗ strength

- It is a phenomemoom in which 2 orbitals come near and form bond.
- Overlapping are of orbitals not an electron
- In overlapping 2 orbitals which have opposite speed of electron form bond.
- When overlapping in one ~~orbital~~ times it forms sigma (σ) bond & 2 it forms pie (π) bond. σ > π
- Overlapping only in the orbitals which are in same axis.

$P_x - P_x$ ✓
$P_y - P_y$ ✓
$P_z - P_z$ ✓
$P_x - P_y$ ✗
$P_y - P_x$ ✗

Strength of Overlapping

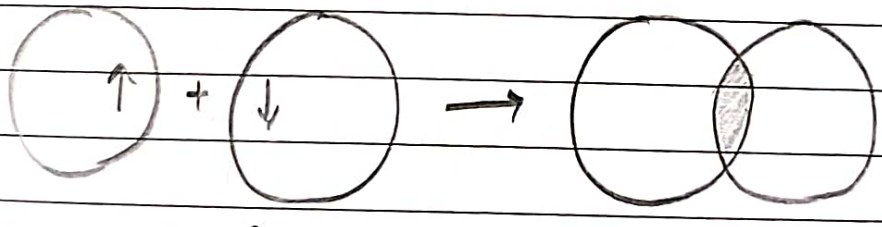
p-p > s-p > s-s

1-1 > 1-2 > 2-2 > 2-3 > 3-3

2pπ - 2pπ > 2pπ - 3dπ > 2pπ - 3pπ > 3pπ - 3pπ

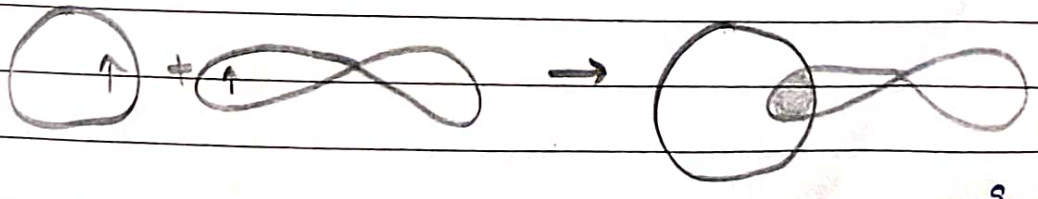
Types of Overlapping

1.) s-s overlapping



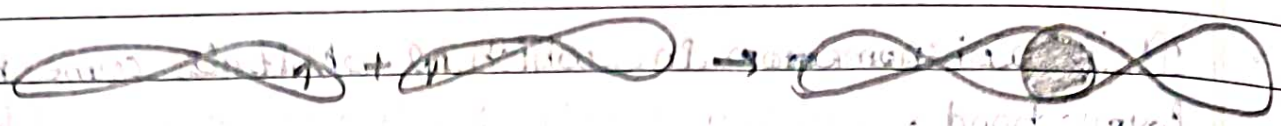
σ bond (sigma bond)
s-s overlapping.

2.) s-p overlapping



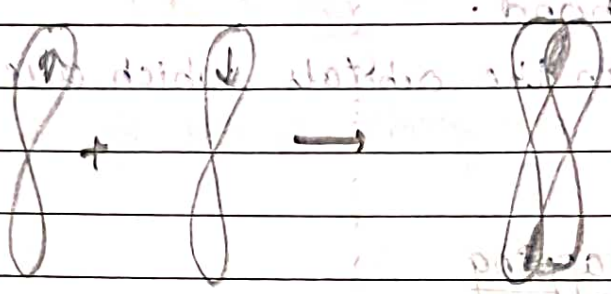
σ bond
s-p overlapping

3.) P-P axial overlapping



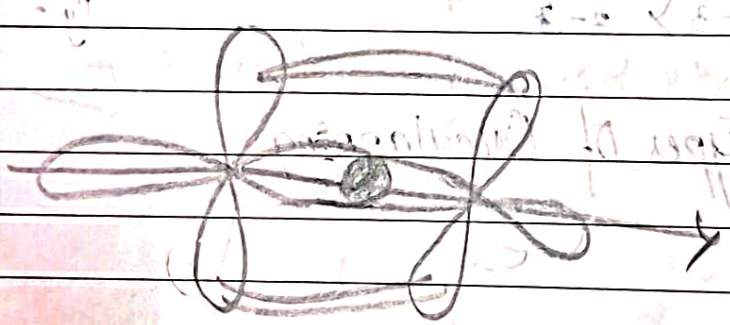
σ bond
p-p axial overlapping

4.) P-P lateral overlapping



π bond (pie bond)
p-p lateral overlapping

5.) $dx^2 - y^2$ — $dx^2 - y^2$



Δ bond (delta bond)
δ-bond

HYBRIDISATION

is a phenomenon

" Hybridisation, in which old orbitals are overlapped and form a new orbital which is total different from old orbital. This old orbital are called Hybridised orbital and the process is called Hybridisation "

This Theory is given by 'Pauling' and 'Slater'

- In Hybridisation, it is compulsory that energy of all orbitals are approximately equal and after hybridisation the new orbitals are of exact same energy.
- In this process, orbitals can participate not electron. i.e In hybridisation vacant fullfilled and ½ filled every type of orbitals participate of outermost shell.
- After hybridisation, Shape angle can be changed according to loan pair, central Atom, EN, no. of bond pair, size of atom, etc.

FORMULA

(either +ve or -ve)

$$\frac{\text{no. of } e^- \text{ in vallence shell of central atom} + \text{No. of single bond} \mp \text{no. of -ve charge} - \text{no. of +ve charge}}{2}$$

Code

2 = Sp
3 = ~~Sp~~ SP_2
4 = SP_3
5 = ~~SP~~ SP_3d
6 = SP_3d_2
7 = SP_3d_3

Code

2 = Sp
3 = SP_2
4 = SP_3
5 = SP_3d
6 = SP_3d_2
7 = SP_3d_3

eg:

(1) BeF_2

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

$\rightarrow sp$

(2) BF_3

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

$\rightarrow sp^2$

(3) CH_4

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

$\rightarrow sp^3$

(4) H_2O

$\frac{6+2}{2} = 4$

$\rightarrow sp^3$

(5) NH_3

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

$\rightarrow sp^3$

(6) SF_4

$\frac{6+4}{2} = 5$

$\rightarrow sp^3d$

(7) SF_6

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

$\rightarrow sp^3d^2$

(8) IF_7

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

$\rightarrow sp^3d^3$

Q. NH_4^+

$\frac{5+4-1}{2}$

$\rightarrow 4$

$\rightarrow sp^3$

Q. SO_4^{-2}

$\frac{6+0+2}{2}$

$\rightarrow 4$

$\rightarrow sp^3$

Wave Theory Of Hybridisation

- ${}_4Be \rightarrow 1s^2\ 2p^2\ 2p^0$

Ground state → [↑↓]$_{2s}$ [ ][ ][ ]$_{2p}$

1st Excited state → [↑↓] [↑↓][ ][ ] val = 2

- ${}_6C \rightarrow 1s^2\ 2s^2\ 2p^2$

Grand state → [↑↓]$_{2s}$ [↑↓][↑][↑] val = 2

1st Excited state → [↑] [↑↓][↑][↑] val = 4

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

Ground state → [↑↓]$_{3s}$ [↑↓][↑↓][↑↓] [ ][ ][ ] val = 2

1st Exi. state → [↑↓]$_{3s}$ [↑↓][↑][↑]$_{3p}$ [↑↓][ ][ ][ ]$_{3d}$ val = 4

2nd Exi state → [↑↓]$_{3s}$ [↑↓][↑][↑] [↑↓][↑↓][ ][ ] val = 6

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

[↑↓]$_{3s}$ [↑↓][↑↓][↑↓] [↑↓][ ][ ][ ]

① $BeCl_2$

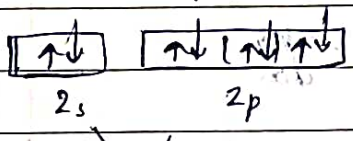
$_4Be \longrightarrow 1s^2\ 2s^2\ 2p^0$

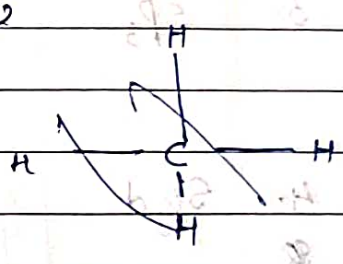
Ground $\longrightarrow$ 

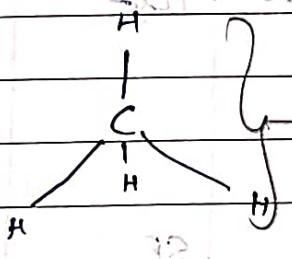
• $CH_4 \longrightarrow 1s^2\ 2s^2\ 2p^2$

G.S $\longrightarrow$ 

Val = 2

1st E.S $\longrightarrow$ 





SP_3

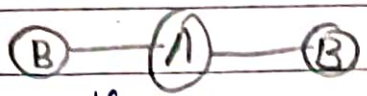
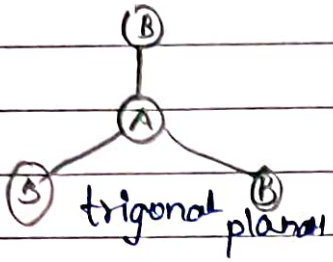
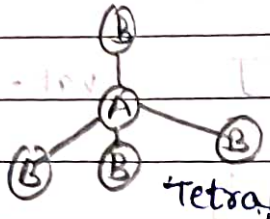
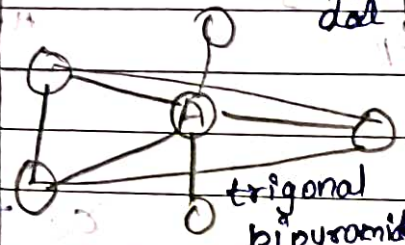
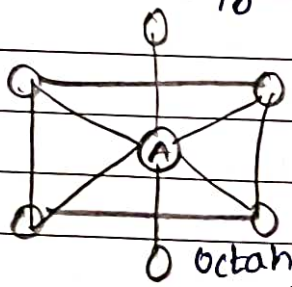
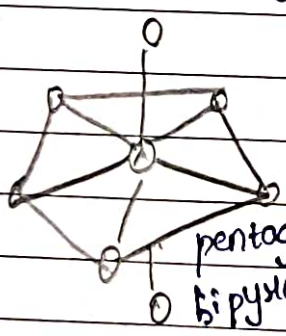
$\longrightarrow$ Tetra hydral

109.5°

109°. 28'

S charac. $= \frac{1}{4} \times 100$

$= 25\%$

	Hybrisation	Shape	Angle	Example	Spectal:
1.	Sp	 linear	180°	$BeCl_2$	S character = 50%.
2.	sp_2	 trigonal planar	120°	BF_3	S chara. 33.33%.
3.	sp_3	 Tetrahydal	109.5°	CH_4	S chara. = 25%.
4.	sp_3d	 trigonal bipyramidal	90°-120°	PCl_5	
5.	sp_3d_2	 octahydal	90°	SF_6	
6.	sp_3d_3	 pentagonal bipyramidal	72°-90°	IF_7	

VSEPR Theory

(Valence Shell e⁻ pair Repultion theory)

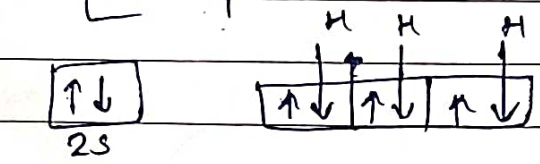
lp-lp > lp-bp > bp-bp

lp → shape
↳ angle

What is lone pair

① NH_3

$N = 1s^2 2s^2 2p^3$



lp → extra power
unbounded e⁻

NH_3: $= \frac{5-3}{2}$ $= 1\,lp$, $3\,bp$ → $4 = sp_3$

② H_2O: $= \frac{6-2}{2}$ $= 2\,lp$, $2\,bp$ → $4 = sp_3$

③ SF_2: $= \frac{6-2}{2}$ $= 2\,lp$, $2\,bp$ → $4 = sp_3$

④ SF_4: $= \frac{6-4}{2}$ $= 1\,lp$, $4\,bp$ → $5 = sp_3d$

⑤ ClF_3: $= \frac{7-3}{2}$ $= 2\,lp$, $3\,bp$ → $5 = sp_3d$

⑥ ClF_5: $= \frac{7-5}{2}$ $= 1\,lp$, $5\,bp$ → $6 = sp_3d_2$

(7) $XeF_2 = \frac{8-2}{2}$

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

$5 = sp_3d$

(8) $XeO_3 = \frac{8-3\times3}{2}$

$= \frac{1lp}{3bp}$

$4 = sp_3$

(9) $XeF_4 = \frac{8-4}{2}$

$= \frac{2lp}{4bp}$

$6 = sp_3d_2$

(10) $XeO_2F_2 = \frac{8-2\times2-2}{2}$

$= \frac{2lp}{2bp}$

$5 = sp_3d$

(11) $XeF_6 = \frac{8-6}{2}$

$= \frac{1lp}{6bp}$

$7 = sp_3d_3$

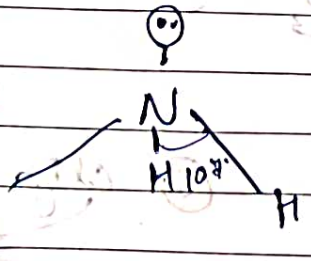
$NH_3 = 1lp + 3bp$

$4 = sp_3$

↓

tetrahydral

$109.5°$



08.08.2024

LCAO → Linear combination of Atomic Orbitals.

Date : / /
Page :

MOT
Molecular Orbital Theory

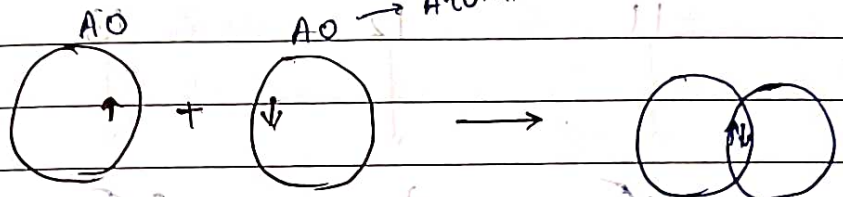
According to this theory, all orbitals are overlapping with two types:

① When e⁻ are in opposite spin that is called Bonding Molecular Orbitals (BMO)

② When e⁻ are in same spin (ABMO) Anti Bonding Molecular Orbitals.

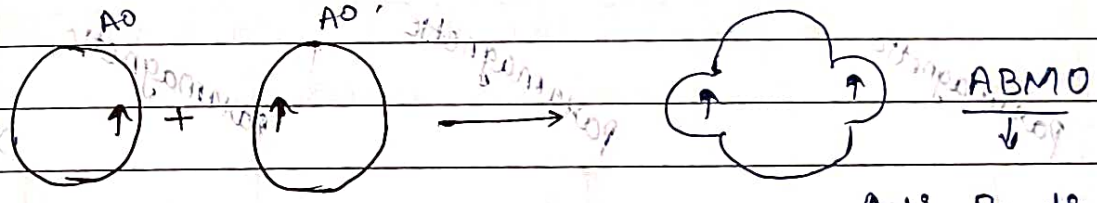
AO → Atomic Orbitals

eg: ①



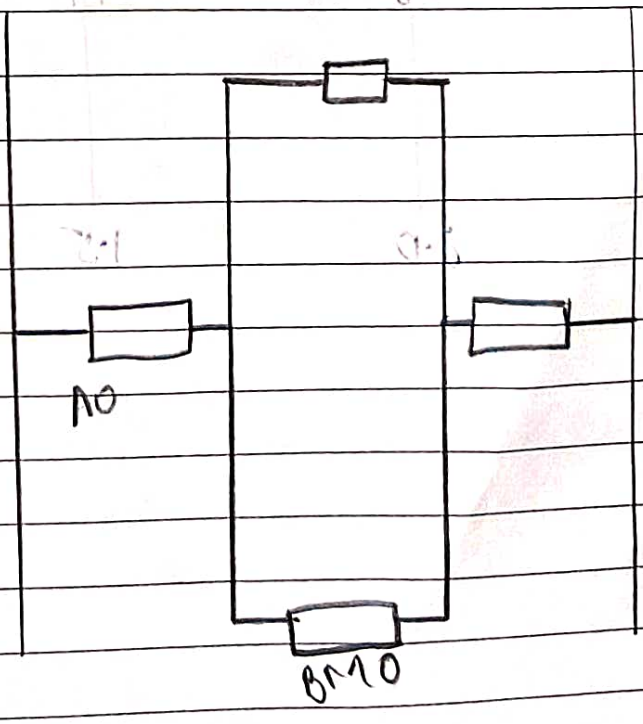
σ bond. (sigma)

②



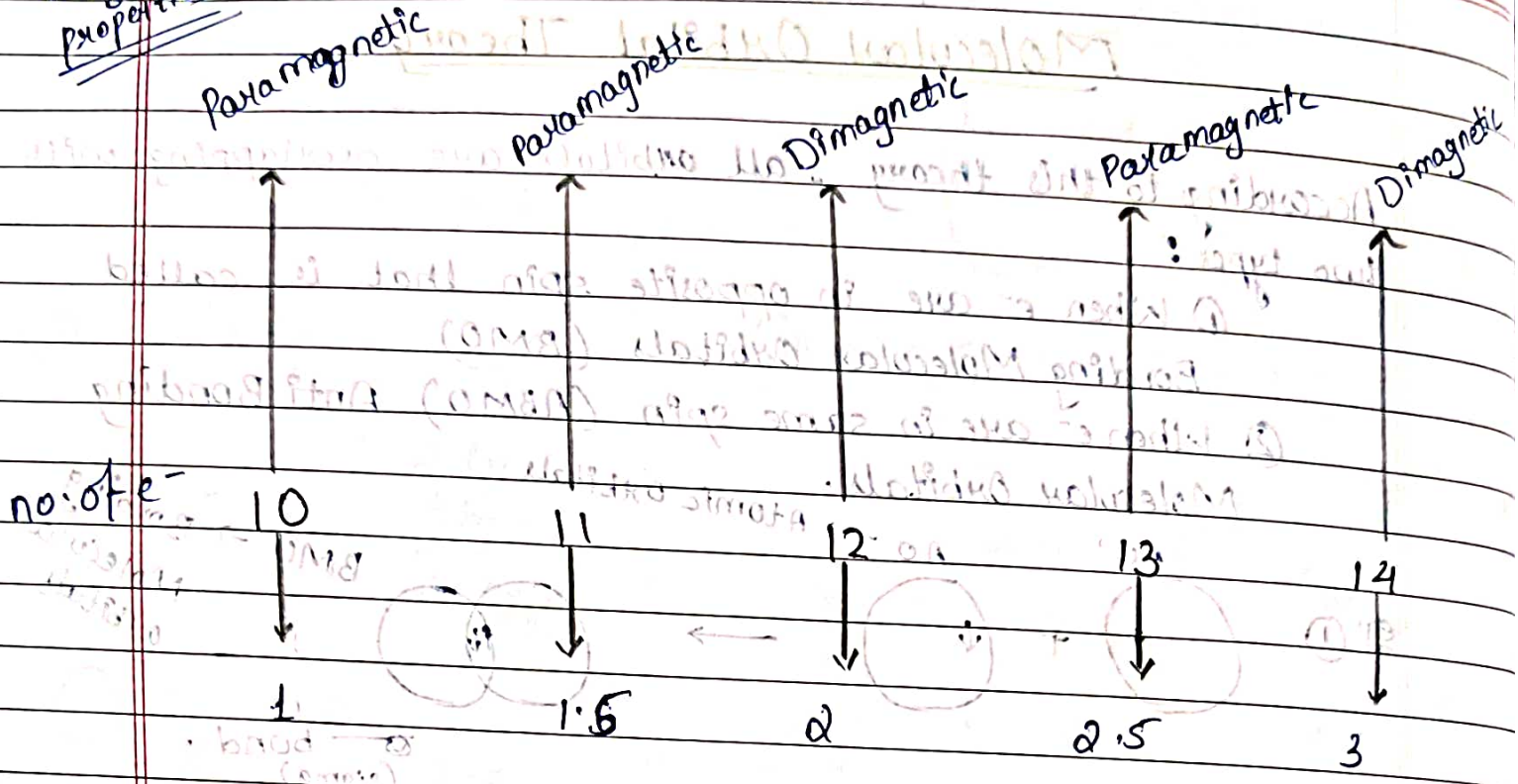
Anti-Bonding Molecular Orbitals.

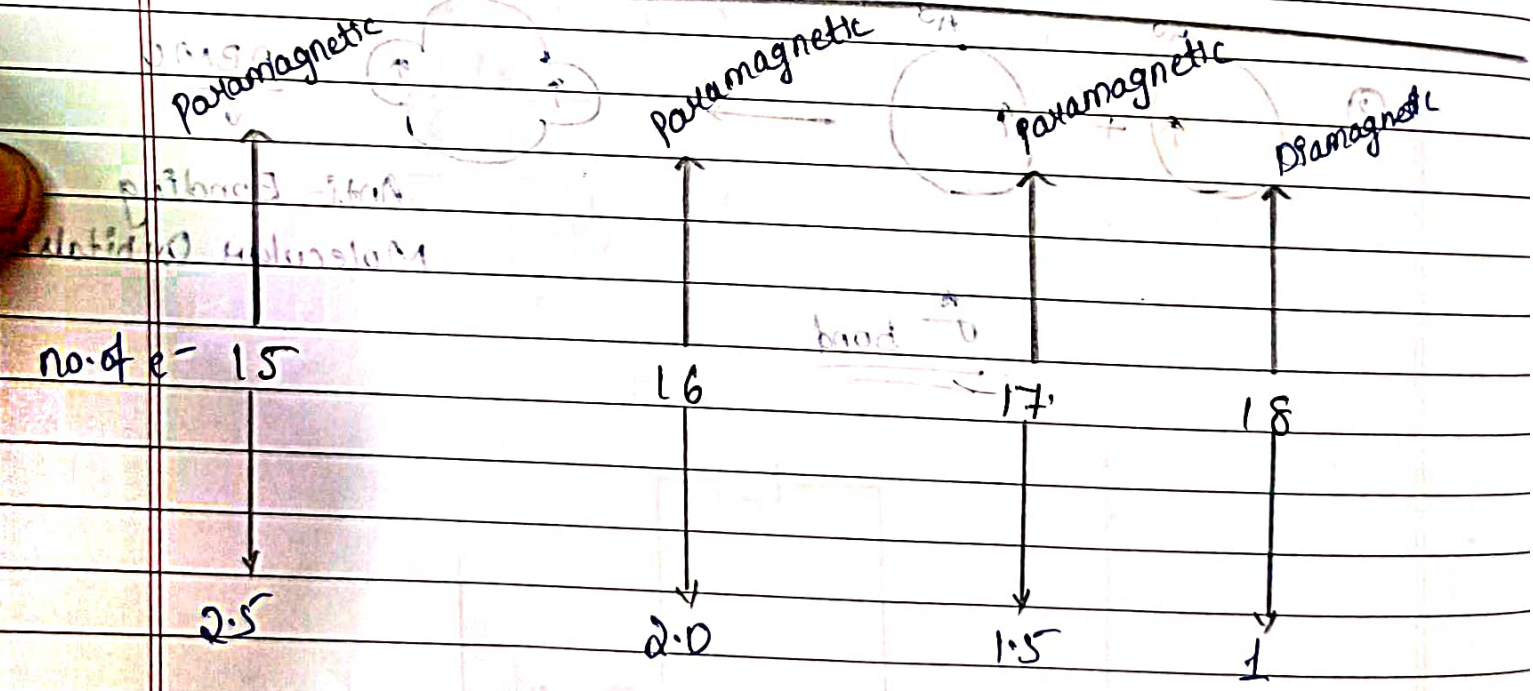
σ* bond



Date : / /
Page :

Magnetic properties





8.2024

BOND PARAMETERS

There are Six types of Bond Parameters :-
(1) Bond length (2) Bond Order (3) Bond Angle
(4) Bond Energy (5) Polarity (Dipole moment) (6) Resonance.

1. Bond LENGTH

The average distance between two atom is called Bond length.

Bond length $\propto$ size of atom
Bond length $\propto \frac{1}{\text{Energy}}$ of atom
Bond length $\propto \frac{1}{\text{Bond Order}}$

Size decreases when we go left to right in a periodic table and increases when we go left to down.

Energy increases when we go left to right in a periodic table and decreases when we go left to down.

$-C \equiv C- \quad -\overset{|}{C}=\overset{|}{C}- \quad -\overset{|}{C}-\overset{|}{C}-$

BO = 3 BO = 2 BO = 1

$BO \propto \frac{1}{BL}$

2. Bond Energy

Energy required to break a bond is called Bond Energy

$BE \propto BO$

$BE \propto \frac{1}{BL}$

$N \equiv N$

$O = O$

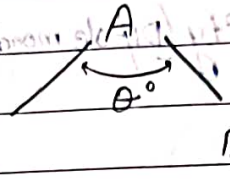
$N_2 > O_2$

HF > HCl > HBr > HI

Date : / /
Page :

3. Bond Angle

Angle between two bonds is called Bond Angle



* It depends upon hybridisation

$sp \rightarrow 180°$
$sp_2 \rightarrow 120°$
$sp_3 \rightarrow 109.5°$
$sp_3d \rightarrow 90°-120°$
$sp_3d_2 \rightarrow 90°$
$sp_3d_3 \rightarrow 72°-90°$

* It also lone pair of e^- ∝ $\frac{1}{BA.}$

	CH_4	NH_3	H_2O
Hybrid.	sp_3	sp_3	sp_3
BA.	109.5°	107°	104°
	0 lp	1 lp	2 lp

4. Polarity (Dipole moment)

→ Electronegativity (EN)

In periodic table → EN↑
↓ EN↓

Type of Covalent Bond

→ Polar (Directional) $\overset{+\delta}{A} — \overset{-\delta}{B}$

→ Non-polar (Non-directional)

$\mu = 0$

polar – dipole moment

$\mu = mu$ δ^+ (partial) आंशिक

$\mu = q \times d$

charge distance

unit → colombs x meter (Cm)

other unit → debye

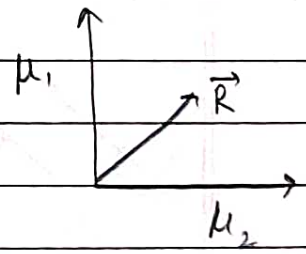
1 debye $= 3.33 \times 10^{-30}$ Cm

A — B → more EN

μ → vector quantity

$\vec{\mu} = \vec{\mu_1} + \vec{\mu_2}$

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



(1) $BeCl_2$

↳ $\frac{2+2}{2} = \frac{4}{2}$ 2 ⇒ 2 → sp

μ_1 ← Cl — Be — Cl → μ_2

$\mu_1 = \mu_2$

$|\vec{\mu}| \Rightarrow \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2\cos 180^\circ}$

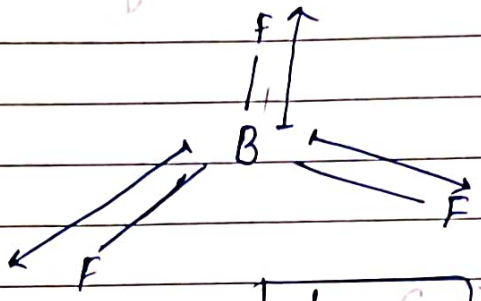
$\Rightarrow \sqrt{\mu_1^2 + \mu_2^2 - 2\mu^2}$

$\Rightarrow \sqrt{2\mu^2 - 2\mu^2}$

$\boxed{\mu = 0}$

② BF_3

↳ $\frac{3+3}{2} = \frac{6}{2}\ 3 \Rightarrow 3 \rightarrow sp_2$ → trigonal



$\mu = 0$

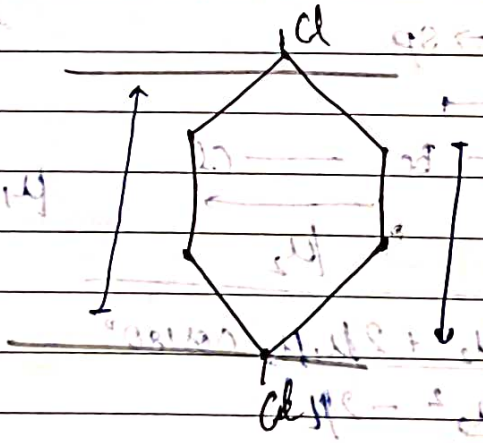
③ CO_2

↳ $\frac{4+0}{2} = 2 \rightarrow sp$

$O = C = O$

$\mu = 0$

④ 1-4 dichlorobenzene



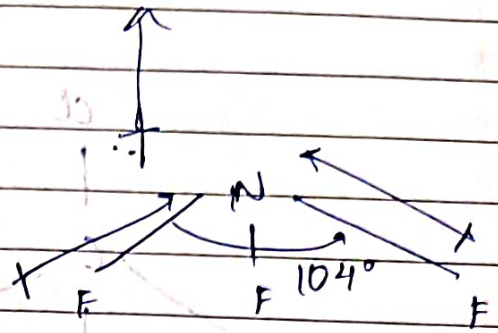
$\mu = 0$

Date : / /
Page :

(5) NH_3

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

$\frac{5-3}{2} = \begin{matrix} 1\,lp \\ 3\,bp \end{matrix} \Big\} \longrightarrow$ pyramidal



(6) NF_3

sp_3

$1\,lp + 3bp \longleftrightarrow$ pyramidal

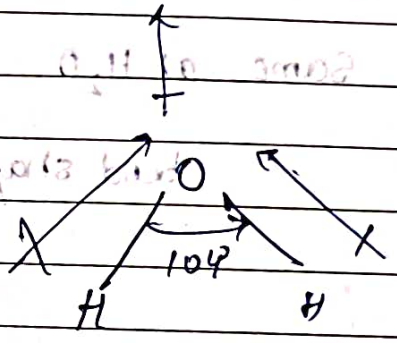
$NH_3 > NF_3$

(7) H_2O

$\frac{6+2}{2} = 4 \longrightarrow$ tetrahydral

$\frac{6-2}{2} = \begin{matrix} 2\,lp \\ 2\,bp \end{matrix}$

bend shape

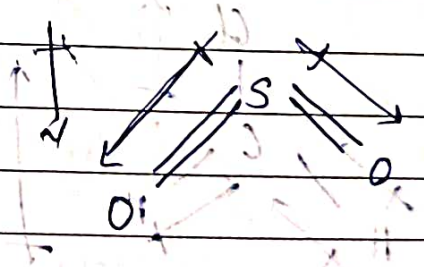


(8) SO_2

$\frac{6+0}{2} = 3 \longrightarrow sp_2$

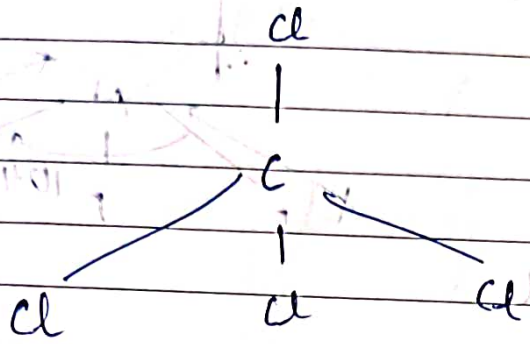
$\frac{6-4}{2} = \begin{matrix} 1\,lp \\ 2\,bp \end{matrix}$

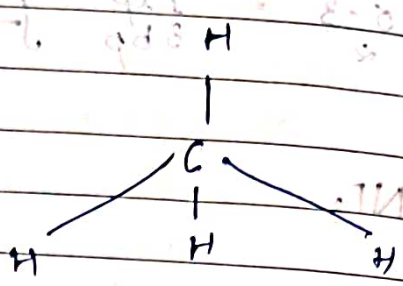
bend shape



(9) CCl_4, CH_4] → O → sp_3

tetrahydral

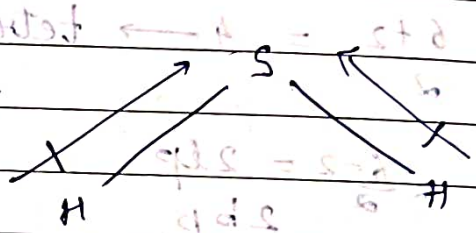




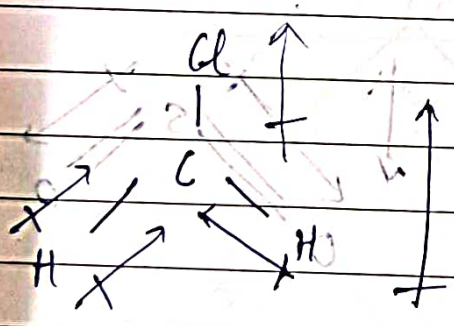
(10) H_2S

Same as H_2O

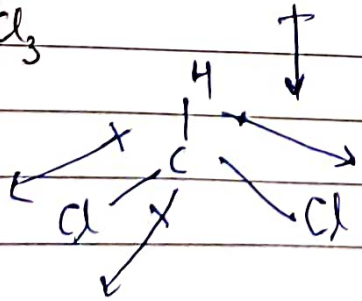
bend shape



(11) CH_3Cl

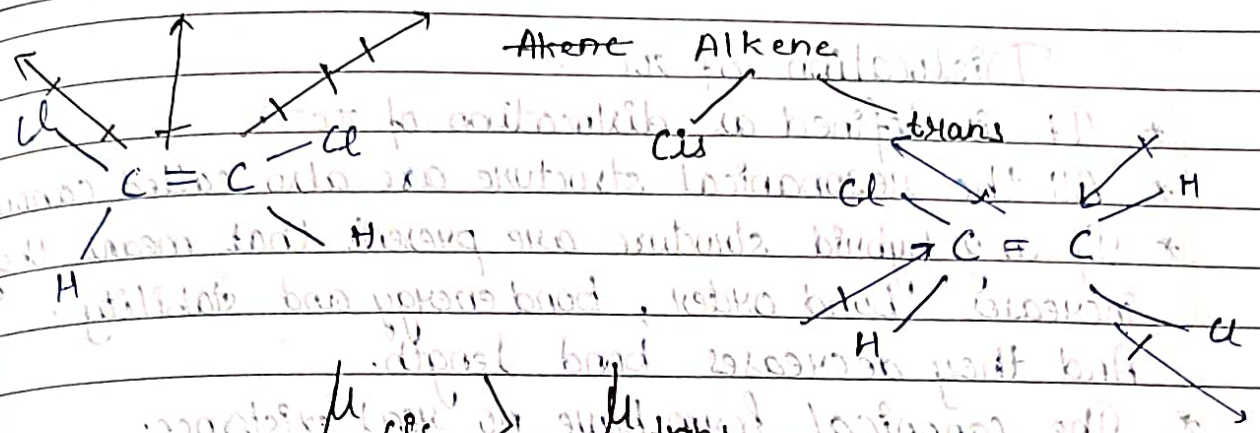


(12) $CHCl_3$

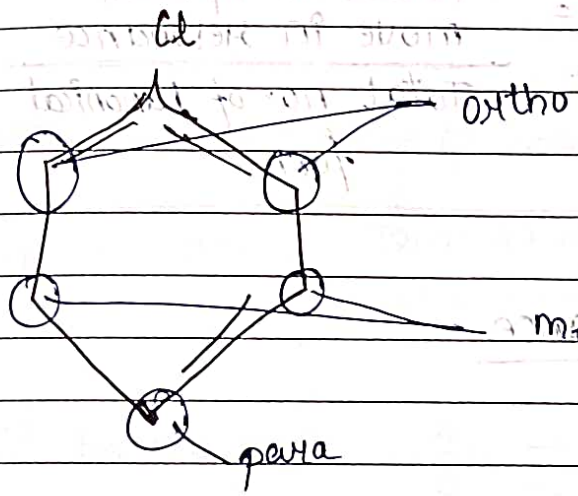


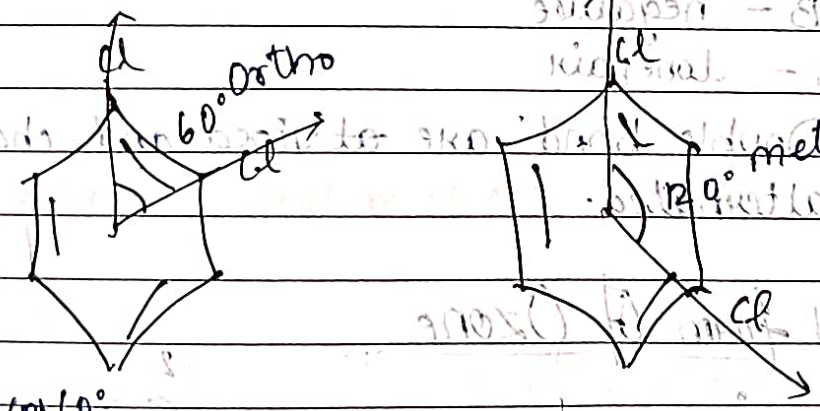
$CH_4 \cong CCl_4 < CHCl_3 < CH_2Cl_2 < CH_3Cl$

~~Alkene~~ Alkene



$\mu_{cis} > \mu_{trans}$





Ortho > meta > para

26.08.24

Resonance

Dislocation of πe^-.

* It is defined as dislocation of πe^-.
* All the resonanical structure are also called canonical form.
* If any hybrid structure are present that means they increases bond order, bond energy and stability. And they decreases bond length.
* The canonical form have no real existance.
*

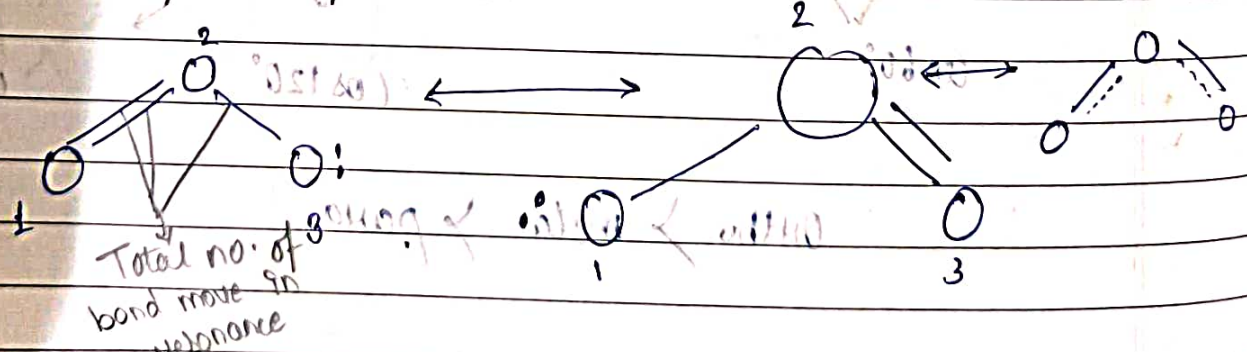
$$\text{Bond Order} = \frac{\text{Total no. of bond move in resonance}}{\text{Total no. of canonical form}}$$

Condition of Resonance

(Double bond) (Single bond)

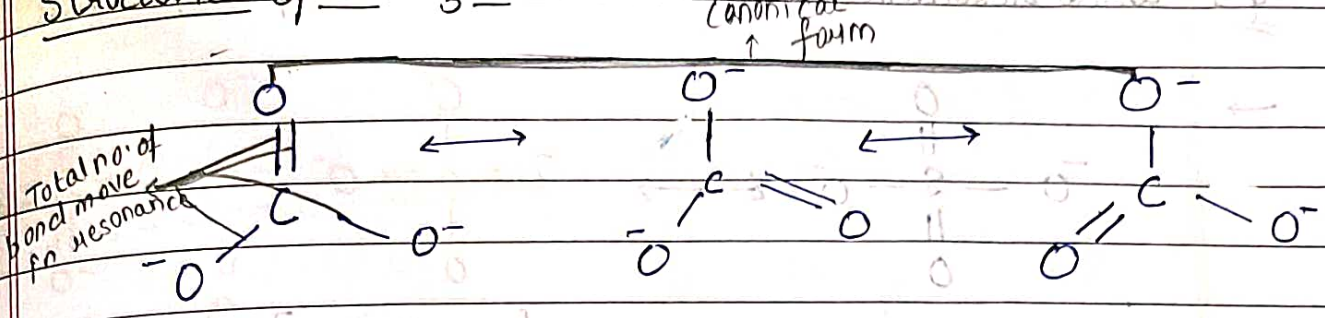
1. DB - SB - DB
2. DB - SB - negative
3. DB - SB - lonepair
4. Note : Double bond are striped and charge are alternated.

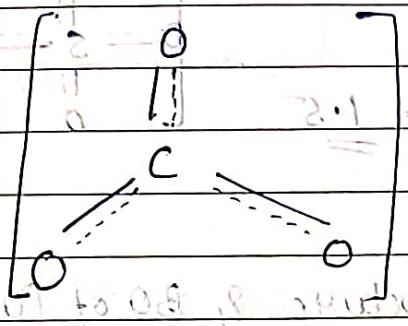
Canonical form Of Ozone



Date : / /
Page :

Structure of CO_3^{-2}





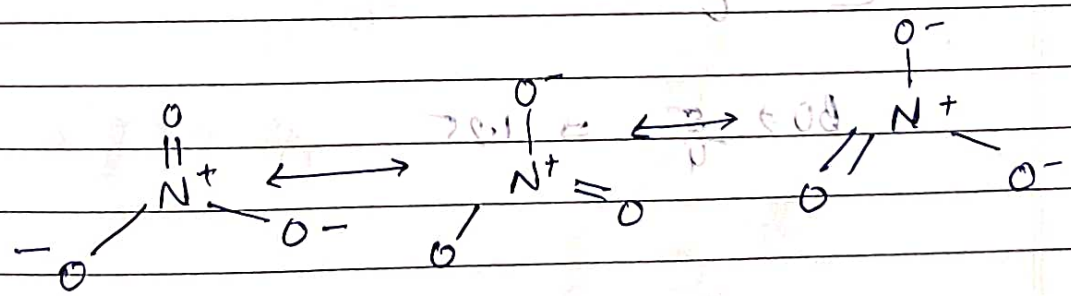
⇒ final structure.

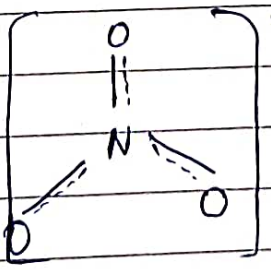
Q.1 Calculate the bond order of Ozone & CO_3^{-2}

→ Ozone ka BO ⇒ $\frac{\text{Total no. of Bond move in Resonance}}{\text{Total no. of Canonical form}} \Rightarrow \frac{3}{2} \Rightarrow 1.5$

CO_3^{-2} ka BO ⇒ $\frac{4}{3} \rightarrow 1.33$

Q.2 Write resonance structure of NO_3^- and also calculate its bond order.



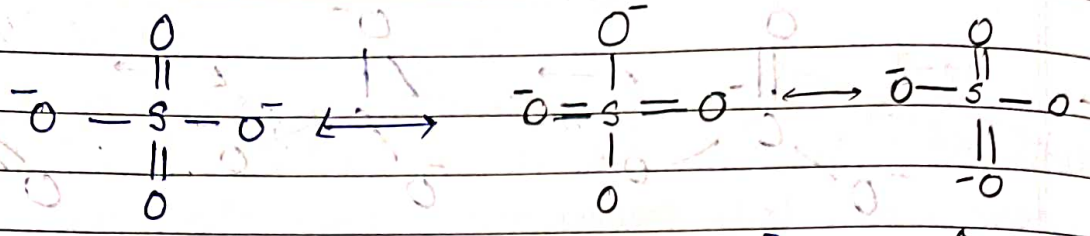


$BO = \frac{4}{3}$

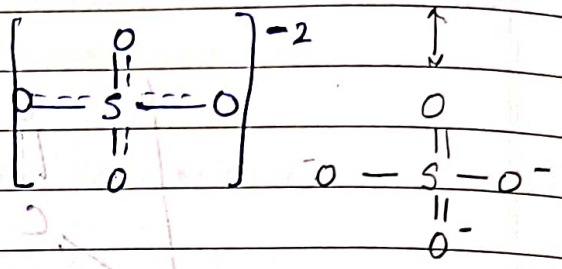
$= 1.33$

Q.3 Write resonanic structure and bond order of SO_4^{-2}.

→

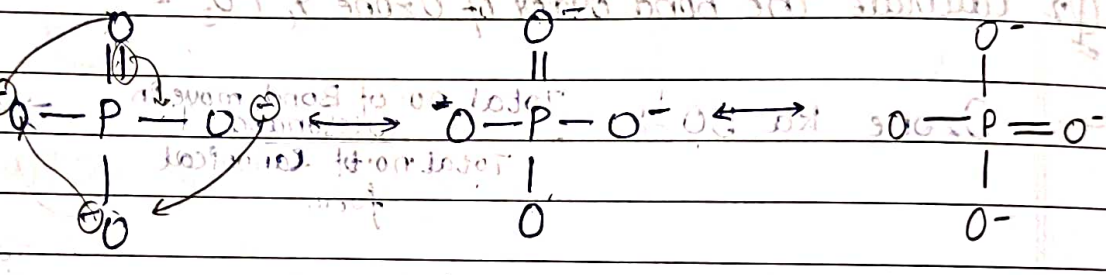


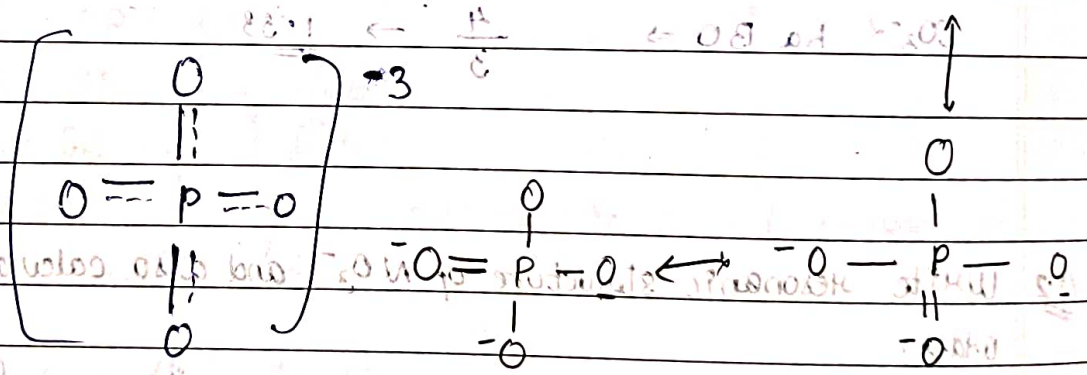
$$BO \Rightarrow \frac{6}{4} \Rightarrow \frac{3}{2} \Rightarrow 1.5$$



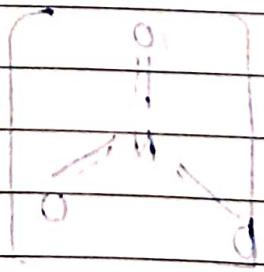
Q.4 Write resonanic structure & BO of PO_4^{-3}

→

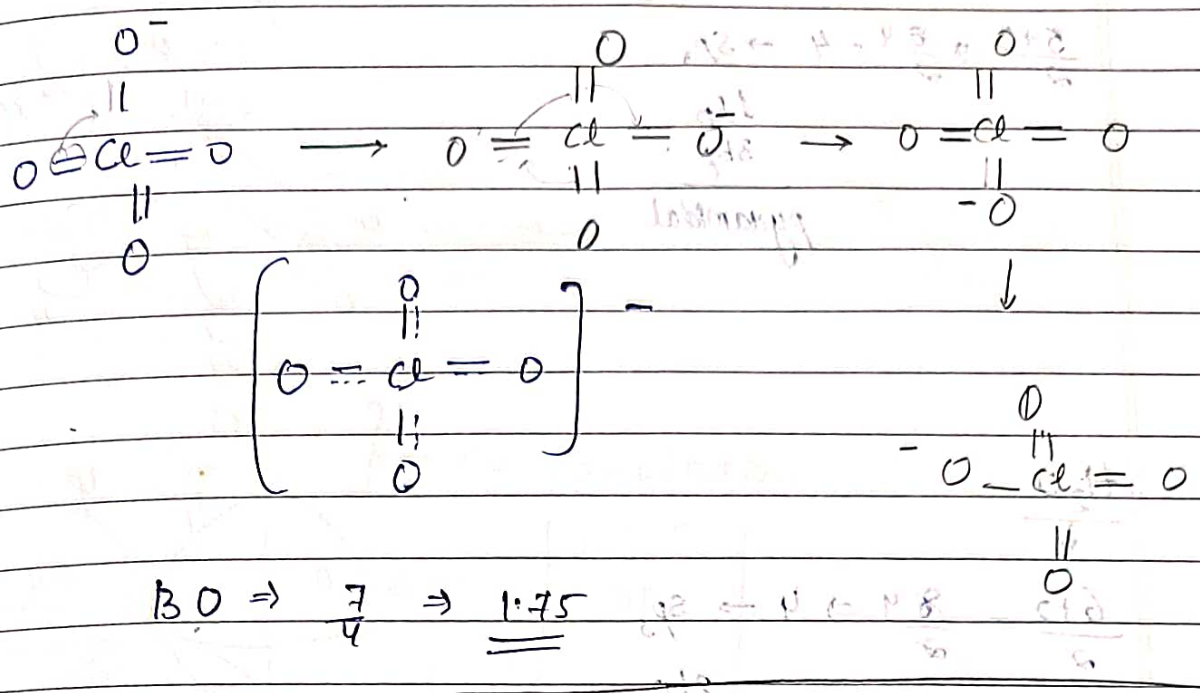




$$BO \Rightarrow \frac{5}{4} \Rightarrow 1.25$$



5 Write resonanic structure & BO ClO_4^-

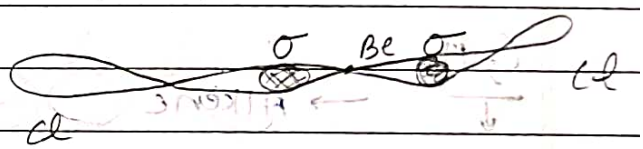


$BO \Rightarrow \frac{7}{4} \Rightarrow \underline{1.75}$

Structure:

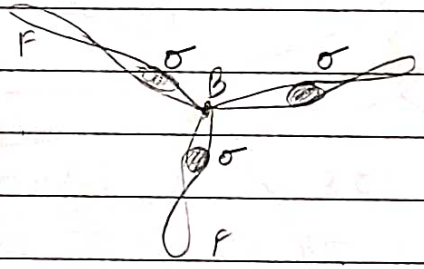
$BeCl_2$

$\frac{2+2}{2} \Rightarrow 2 \rightarrow sp$ (Linear)



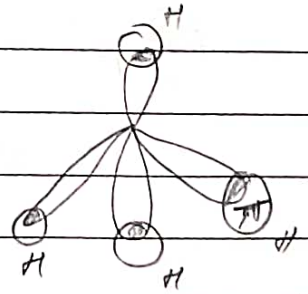
BF_3

$\frac{3+3}{2} \Rightarrow \frac{6}{2}3 \Rightarrow 3 \rightarrow sp_2$



CH_4

$\frac{4+4}{2} \Rightarrow \frac{8}{2}4 \Rightarrow sp_3$



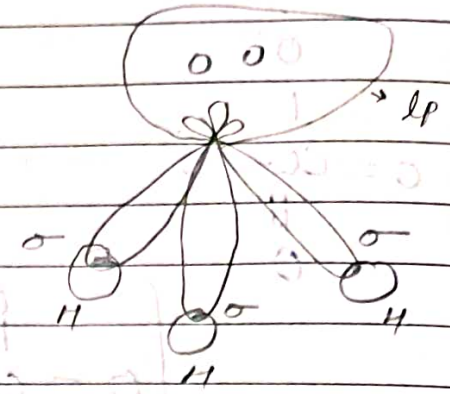
Date : / /
Page :

NH_3

$\frac{5+3}{2} \Rightarrow \frac{8}{2}4 = 4 \rightarrow sp_3$

1 lp
3 bp

pyramidal

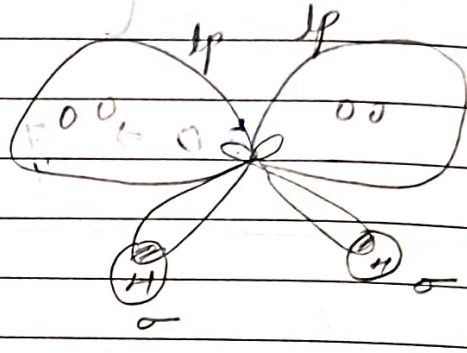


H_2O

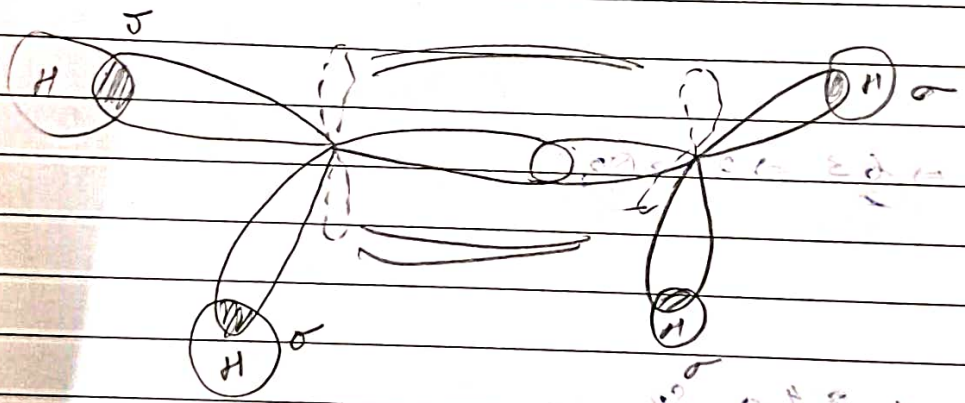
$\frac{6+2}{2} = \frac{8}{2}4 \Rightarrow 4 \rightarrow sp_3$

2 lp
2 bp

bent shape



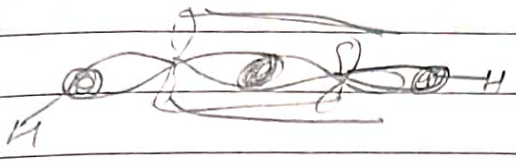
C_2H_4 → Alkene



Date : / /
Page :

C_2H_2 Alkynes

$HC \equiv CH$
Sp Sp



σ
π } → no. calculation

(1)	$-\overset{|}{C}-$ σ	4σ	Sp_3
(2)	$-\overset{|}{C} \overset{\sigma}{=} \overset{|}{C}-$ (π)	$3\sigma, \pi$	Sp_2
(3)	$-C \overset{\sigma}{\equiv} \overset{|}{C}-$ (2π)	$2\sigma, 2\pi$	Sp

Q.) $CH_2 = CH - CH_3$
(1) (2) (3)

C no. (1) → $1\pi, 3\sigma$ = Sp_2
C no. (2) → $1\pi, 3\sigma$ = Sp_2
C no. (3) → $4\sigma, 0\pi$ = Sp_3

Total $\sigma = 8$
Total $\pi = 1$

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Date : / /

Page :

Electrovalent Bond [Ionic Bond]

- Complete transfer of e^-
- Complete Octet

eg: (i) $NaCl$

$_{11}Na$: 2, 8, 1 — $1e^-$ → $_{17}Cl$: 2, 8, 7

EV of Na = 1 ; EV = 1

$Na^+ + Cl^-$

$NaCl$

(ii) $MgCl_2$

$_{12}Mg$: 2, 8, 2 — $1e^-$ → $_{17}Cl$: 2, 8, 7 ; $1e^-$ → $_{17}Cl$: 2, 8, 7

EV = 2 ; EV = 1 ; EV = 1

Mg^{+2} + $2Cl$

2, 8 ; 2, 8, 8

(iii) CaO

$_{20}Ca$: 2, 8, 8, 2 — $2e^-$ → $_{8}O$: 2, 6

EV = 2 ; EV = 2

Ca^{+2} O^{-2}

Ca_2O_2

or

CaO

(iv) $AlCl_3$

$_{13}Al$: 2, 8, 3 ; $_{17}Cl$: 2, 8, 7

$1e^-$ → $_{17}Cl$: 2, 8, 7 ; $1e^-$ → $_{17}Cl$: 2, 8, 7

EV = 3 ; EV = 1

$Al^{+3} + 3Cl^-$

$AlCl_3$

(v) Al_2O_3

$_{13}Al$: 2, 8, 3 — $3e^-$ → $_{8}O$: 2, 6

$_{13}Al$: 2, 8, 3 — $3e^-$ → $_{8}O$: 2, 6

$2Al^{+3} + 3O^{-2}$

Al_2O_3

EV = 2

28.08.2024

Date : / /
Page :

Mechanism Of Formation Of Ionic Bond [Born-Haber Cycle]

Na → Na^+ (Cation)

Cl → Cl^- (Anion)

Na^+ + Cl^- → NaCl

* Formation Of Cation

$M_{(s)} \longrightarrow M_{(g)}$ (enthalpy)

Energy → Exothermic ⇒ ΔH = -ve

Energy → Endothermic ⇒ ΔH = +ve

$M_{(s)} \longrightarrow M_{(g)}$

Heat of Sublimation } +ve

Sublimation Energy } +ve

SE = +ve

two energies required for formation of cation

- Ionization Energy [Ionization Enthalpy]

(IP)

Energy required to remove an e⁻ from its outer most shell of an isolated gaseous atom.

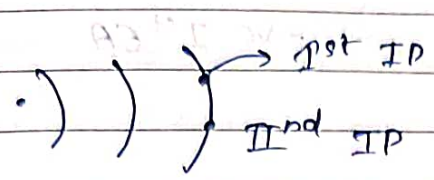
$Na_3 \longrightarrow Na_{(g)}$

2, 8, 1

attraction ↑ IP

$^{12}Mg_{(s)} \longrightarrow Mg_{(g)}$

$2, 8, 2$



SE / IP → +ve → Endothermic

* Formation of Anion

~~O~~ → O_2 → $O \neq O$

~~N~~ → N_2 → $N \equiv N$

~~Cl~~ → Cl_2 → $Cl - Cl$

Bond Dissociation Energy (BDE) [ONLY FOR IIT/JEE NEET]

It is also endothermic (+ve)

$\frac{1}{2} Cl_2 \xrightarrow{\frac{1}{2} BDE} Cl$

Electron Gain Enthalpy (eg)

ΔH_{eg}

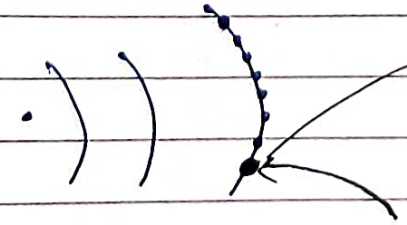
Electron Affinity

E.A

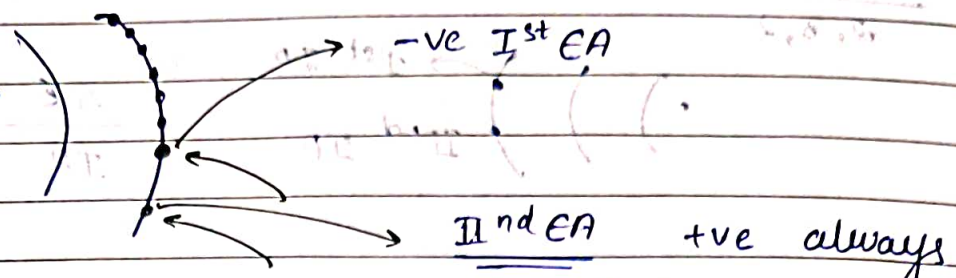
Energy released by gaining of an e⁻ to isolate gaseous atom

^{17}Cl

$2, 8, 7$



$\frac{8}{2,6}O$



Formation Of Cation

- SE = +ve
- IP = +ve

Formation Of Anion

- BDE ⇒ +ve
- EA → 1st = -ve
  → 2nd = +ve

Formation Of NaCl

$Na_{(s)} \xrightarrow{+SE} \underset{2,8,1}{Na(g)} \xrightarrow{I^{st}IP} Na^+(g)$ ∴ U = lattice energy

$\frac{1}{2}Cl_2 \xrightarrow{+\frac{1}{2}BDE} \underset{2,8,7}{Cl} \xrightarrow{-ve\ I^{st}EA} \underset{2,8,8}{Cl^-}$

$Na^+(g) + Cl^- \xrightarrow{-U} NaCl$

$$\Delta H_f\ NaCl \Rightarrow +SE + I^{st}IP + \frac{1}{2}BDE - I^{st}EA - U$$

Date : / /
Page :

Formation Of MgO

$Mg_{(s)} \longrightarrow Mg_{(g)}$ (Mg: 12, 2,8,2) $\xrightarrow{+1^{st}\,IP} Mg^{+}_{(g)} \xrightarrow{2^{nd}\,IP} Mg^{+2}_{(g)}$

$Mg^{+2}_{(g)} + O^{-2} \xrightarrow{-U} MgO$

$\frac{1}{2} O_{2(g)} \xrightarrow{+\frac{1}{2}BDE} O$ (O: 2,6) $\xrightarrow{-1^{st}EA} O^{-} \xrightarrow{+2^{nd}EA} O^{-2}$

ΔH of $MgO \Rightarrow +SE + (I^{st} + II^{nd})\,IP + \frac{1}{2}BDE + (II^{nd} - I^{st})\,EA - U$

Formation Of $AlCl_3$

$AlCl_3 \longrightarrow Al^{+3} + 3Cl^{-}$

$Al_{(s)} \xrightarrow{+SE} Al_{(g)} \xrightarrow{+(I^{st}+II^{nd}+III^{rd})\,IP} Al^{+3}_{(g)}$

$\frac{3}{2} Cl_2 \xrightarrow{+\frac{3}{2}BDE} 3Cl \xrightarrow{-3I^{st}EA} 3Cl^{-}$

$Al^{+3}_{(g)} + 3Cl^{-} \xrightarrow{-U} AlCl_3$

ΔH of $AlCl_3 \Rightarrow SE + (I^{st} + II^{nd} + III^{rd})\,IP + \frac{3}{2}BDE - 3I^{st}\,EA - U$

Date : / /
Page :

formation of $MgCl_2$

$MgCl_2 \longrightarrow Mg^{+2} + 2Cl^-$

$Mg_{(s)} \xrightarrow{+SE} Mg_{(g)} \xrightarrow{+(I^{st}+II^{nd})IP} Mg^{+2}$

$Mg^{+2} \xrightarrow{-U} MgCl_2$

$Cl_2 \xrightarrow{+BDE} 2Cl_{(g)} \xrightarrow{-2\,I^{st}EA} 2Cl^-$

ΔH of $MgCl_2$ $\Rightarrow +SE + (I^{st}+II^{nd})IP + BDE - 2I^{st}EA - U$

Formation of Al_2O_3

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

$2Al_{(s)} \xrightarrow{+SE} 2Al_{(g)} \xrightarrow{+2(I^{st}+II^{nd}+III^{rd})IP} 2Al^{+3}$

$2Al^{+3} \xrightarrow{-U} Al_2O_3$

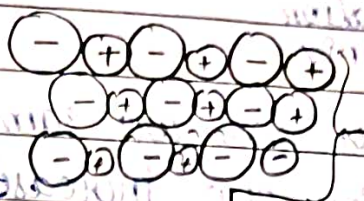
$\frac{3}{2}O_2 \xrightarrow{+\frac{3}{2}BDE} 3O \xrightarrow{3\times(-I^{st}+II^{nd})EA} 3O^{-2}$

ΔH of Al_2O_3 $\Rightarrow +SE + 2(I^{st}+II^{nd}+III^{rd})IP + \frac{3}{2}BDE + 3(II^{nd}-I^{st})EA - U$

Date : / /
Page :

Characteristic (properties) of Ionic Bond :

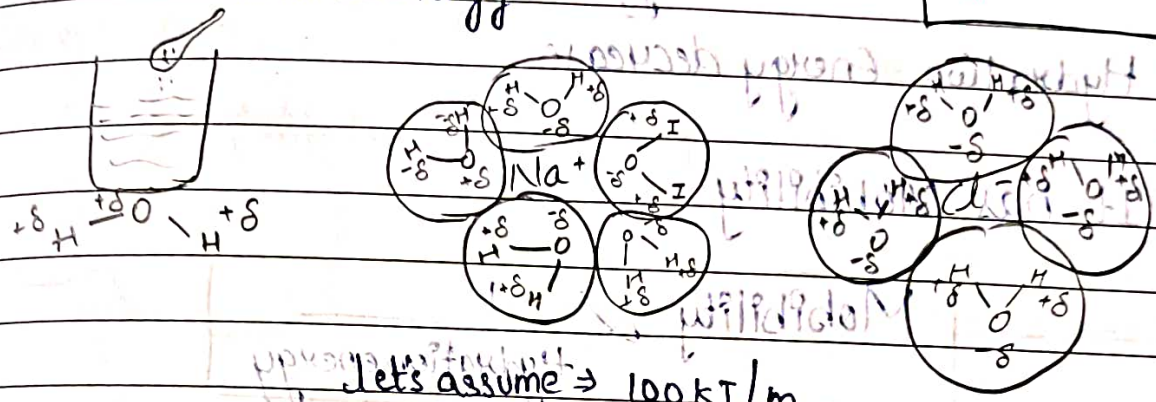
1. They are solid in nature.
2. They are Brittle in nature.
3. Electrostatic bonds are present in it.
4. They are water soluble.



Note:
Water energy is known as Hydration Energy!!

Reason: $NaCl \underset{\text{Energy}}{\overset{\text{lattice}}{\rightleftharpoons}} Na^+ + Cl^-$

here, from where NaCl is getting lattice energy..



Let's assume ⇒ 100 kJ/m

let = $1 H_2O$ – 200k

Water

↳ 111 x 20 = 2220

$-LE = I$

+

Hydration energy is the energy released during mixing of any Ionic substance in water.

$HE \propto \frac{\text{Anion size}}{\text{cation size}}$

Cation → small
Anion → large
} → Hydration Energy ↑

movement of any ion in aq medium
ie called mobility

Date : / /
Page :

$LiCl_{(s)} > NaCl_{(s)} > KCl_{(s)} > RbCl_{(s)} > CsCl_{(s)}$

↳ Cation
Anion

* Anion size are same
* Cation size increases
* Cation size $\propto \frac{1}{\text{Hydration Energy}}$

size ↓
size ↑

* Hydration Energy decrease

5. It has Mobibility (Mobility/Movement of ion)

$$\text{Mobibility} \propto \frac{1}{\text{Hydration energy}}$$

Mobibility: Movement of any ion in aqueous medium that is called mobibility.

Factor Affecting Ionic Bond

In the formation of ionic bond, Ionization Enthalpy, Sublimation Energy and Bond dissociation energy are always less and Lattic energy and electron affinity are always high for good ionic substance.

i.e,

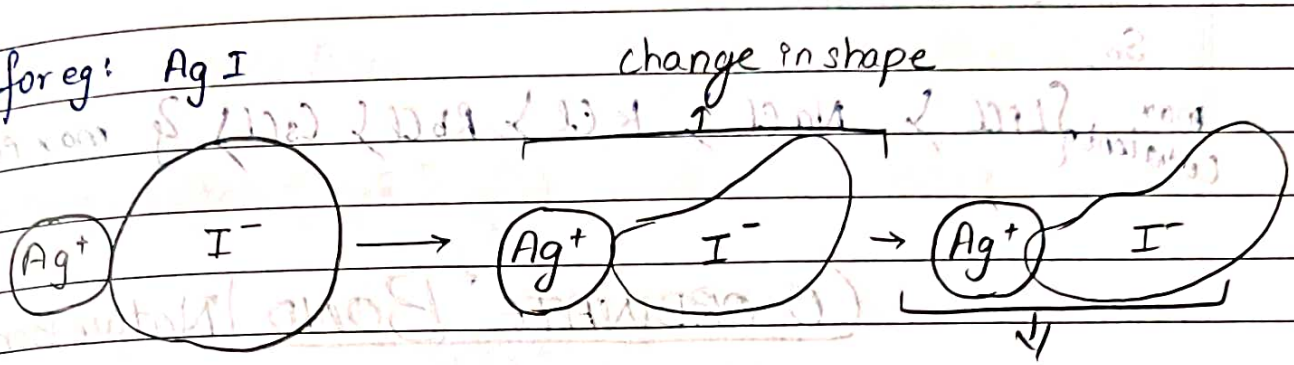
$$\text{Ionic Bond} \propto \frac{1}{IP} \propto \frac{1}{BDE} \propto \frac{1}{SE} \propto EA \propto U$$

Date : / /
Page :

FAJAN'S RULE

According to this rule, 100% ionic substance are not possible but 100% covalent are possible. When cation are small and anion are large there is some induced / polarized effect in anion and orbits of anion are merge in cation. Merging of orbitals are found only in Covalent Bond, so this character is known as "Covalent property in Ionic Bond"

for eg: AgI



Covalent property in Ionic Bond!!

This ~~solvanet~~ covalent property are measured by polarization power.

Polarization : Power $\propto$ $\frac{\text{Anion size (-ve)}}{\text{Cation size (+ve)}}$

polarization power $\propto$ $\frac{\text{Covalent property}}{\text{Ionic property}}$

Q. Write the correct order of covalent property in ionic substance?

NaF^- , $NaCl^-$, $NaBr^-$, NaI^-

→ Cation size same (Na)
→ Anion size increasing
→ Anion size $\propto$ polarization power $\propto$ covalent property.
→ Covalent property increases

So,

max ionic charge { NaF < NaCl < NaBr < NaI } Max covalent charge

Q.2 Write correct order of covalent property in ionic substance ?
LiCl , NaCl , KCl , RbCl , CsCl

→ Anion size same (Cl^-)
→ Cation size increasing
→ Cation size $\propto \frac{1}{\text{polarization power}} \propto \frac{1}{\text{covalent property}}$
→ Covalent property decreasing

So,
max covalent {LiCl > NaCl > KCl > RbCl > CsCl} max ionic

CO-ORDINATE BOND [Dative Bond]

- Denoted by a arrow {⟶}
- This type of Bond only form in complete transfer of lone pair of electron - AKA Dative Bond.
- There are 2 species in this bond :

(i) Doner → Ligands → lewis Base

↳ Doner is a species which has minimum one extra lone pair and complete their octet

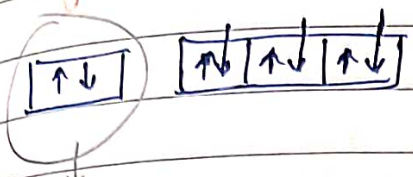
(ii) Acceptor → Central metal atom → lewis Acid

↳ Must incomplete their octet also a vacant space for accepting lone pair of e^-

eg: (1) NH_3

$1s^2\ 2s^2\ 2p^3 \longrightarrow 8e^-$

octet complete



lone pair

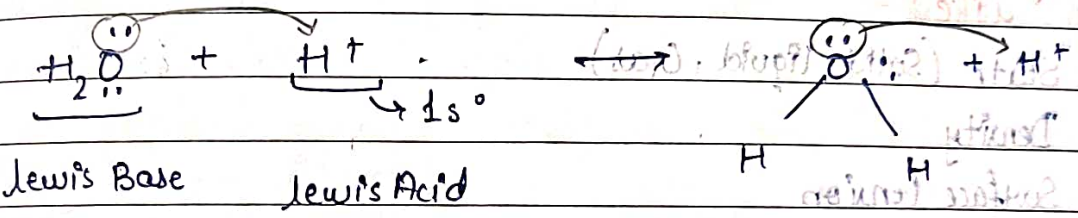
Hence, Lewis Base

(2) BF_3

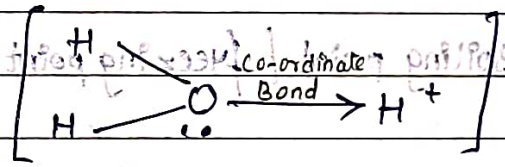
$\longrightarrow 1s^2\ 2s^2\ 2p^1 \longrightarrow 6e^-$

Hence, Lewis Acid.

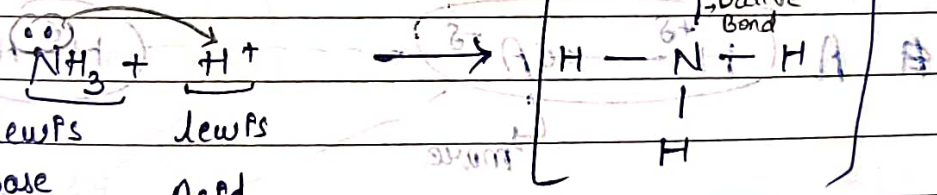
(3) Hydronium Ion: H_3O^+



Lewis Base Lewis Acid



(4) Ammonia Ion:



Lewis Base Lewis Acid

02-09-2024

Date : / /
Page :

HYDROGEN BOND [Weak Bond]

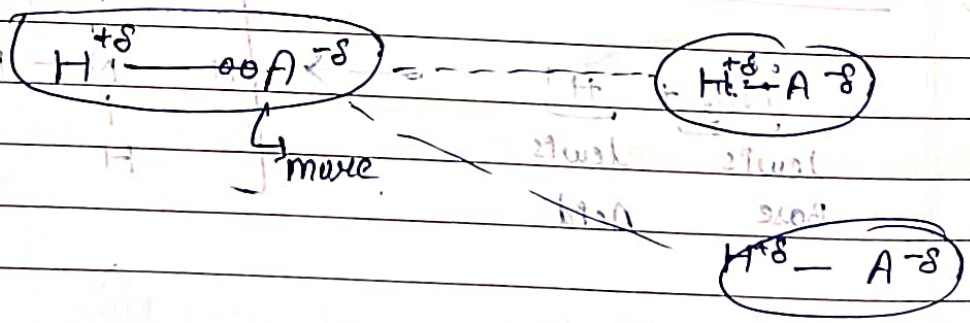
- It is weak bond.
- This bond only form in high EN entity are directly attached in hydrogen.

Condition of:

1. Must present hydrogen.
2. High EN entity.

Hydrogen bond can change only in physical state of compand.
like :-

1. State (Solid, liquid, Gas)
2. Density
3. Surface tension
4. Viscosity
5. Melting point / Boiling point / freezing point
6. Colour change
7. Solubility.



Strength of Hydrogen bond ∝ EN of Entity which is attached with Hydrogen

eg: 1 HF > HCl > HBr > HI

Cuz, fluorine have highest EN.

HF > H_2O > NH_3 > CH_4

4-09-2024

Types of Hydrogen Bond

I. Inter molecular Hydrogen bond

Between Two different molecules

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

BP/MP high

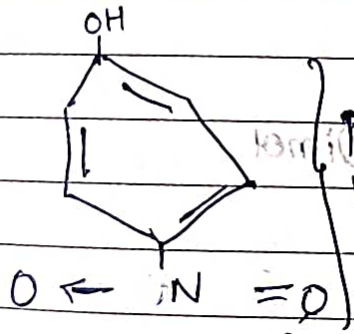
less volatile

II. Intramolecular Hydrogen Bond.

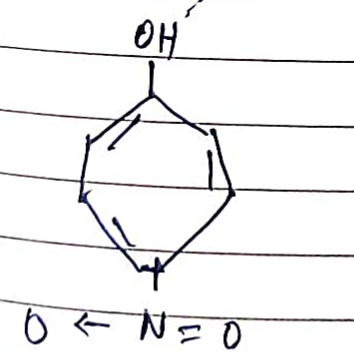
In between single molecules

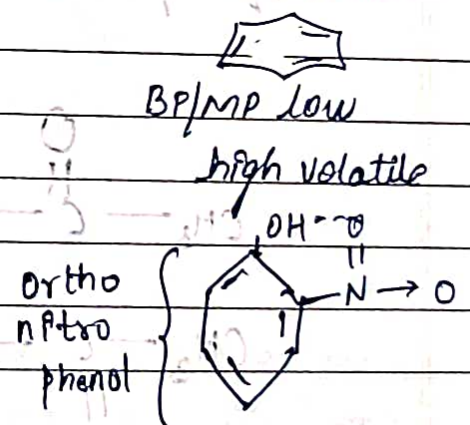
BP/MP low

high volatile

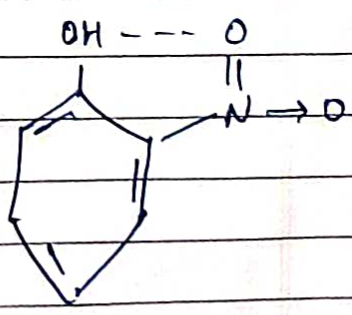


Para nitro phenol





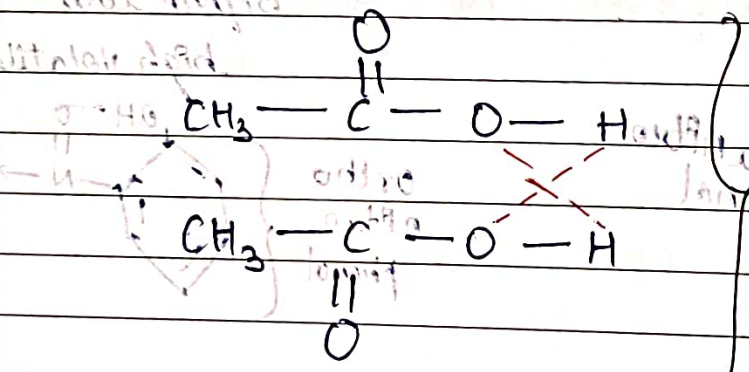
Ortho nitro phenol

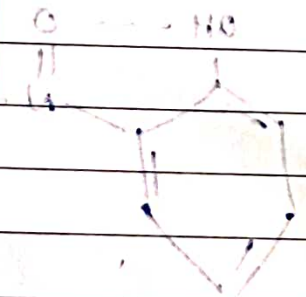


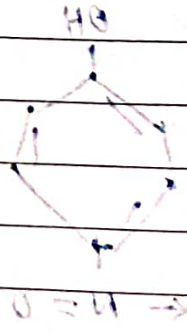
04-09-2024

Some Properties Affected By Hydrogen Bond

1. Alcohol and water are easily soluble
2. Ammonia are soluble in water
3. Boiling point of H_2O are higher than H_2S.
4. Ortho nitro phenol are more volatile than para nitro phenol.
5. Boiling point of Alcohol is greater than ketone ----
   i.e → Alcohol > ketone > Aldehyde > ether
6. Salicylic and Mallic acid both are more acidic in water.
7. Sugar and Glucose both are soluble in water.
8. Glycerin are more viscous.
9. Ice have less density cuz ice forms 6 hydrogen bond and form cage like structure but water form 4 hydrogen bond.
10. Acetic acid form dimer, they form dimer in both gaseous phase and liquid phase.

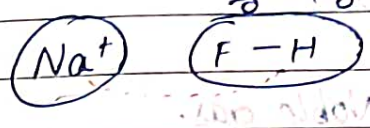






Vanderwall's Bond [very-very-weak]

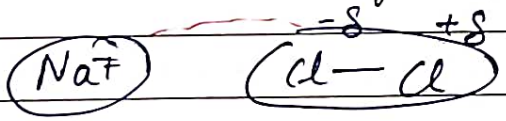
1. Ion-Dipole type of Vander wall's Bond



2. Dipole-Dipole type of attraction force

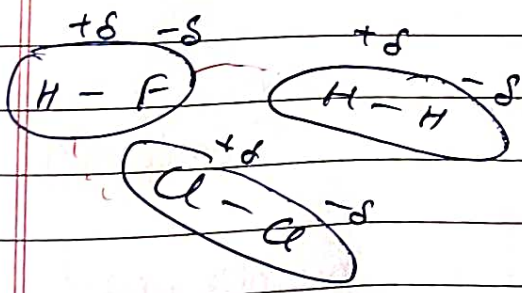
Same as Hydrogen bond

3. Ion-Induced dipole type of att. force



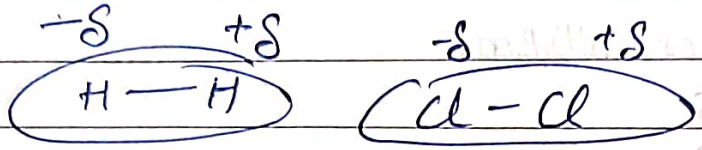
eg:- ion → any noble gas
ion → Cl_2, H_2, etc.

4. Dipole - Induced Dipole



eg:- Dipole → Noble gas
Dipole → H_2, Cl_2, etc.

5. London force OR Induced Dipole - Dipole



eg:- H_2, Cl_2 any gas, Noble gas.