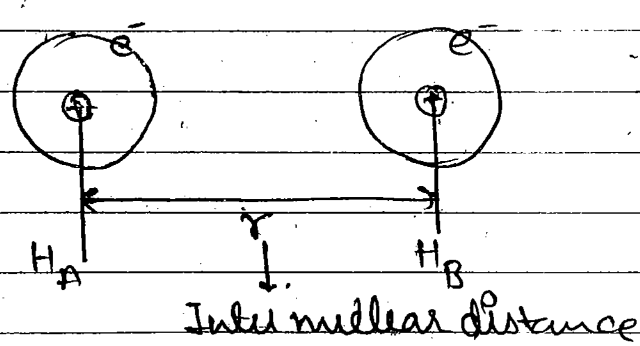
CHEMICAL BONDING

force of attaraction b/w atoms, ions to hold them together is called "chemical bond".

Atoms combine to gain stability by decrease in energy.

Let us consider attaraction b/w two H atoms/ change in energy b/w two H-atoms in formation of H_2 molecule.



i). FORCE OF Attⁿ

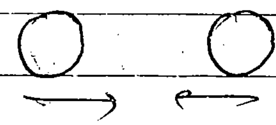
$$f = \frac{kq_1q_2}{r_2}$$

b/w opposite charges

$$f_A = \frac{kq_1q_2}{r_2}\hat{r}$$

$f_A \Rightarrow -\hat{r}$ -ve vector.

⇒ both atoms moves towards each other.



⇒ distance b/w atom decreases.

$$E = \frac{K \overset{+}{q_1} \overset{-}{q_2}}{r}$$

$E_A = -ve$

represent change in energy is −ve.

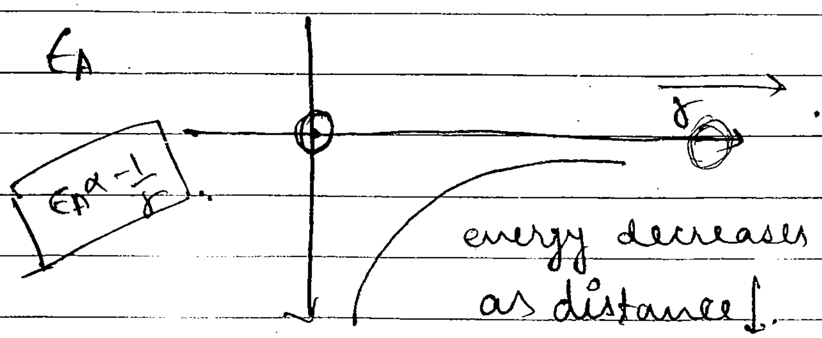
change = final − initial

⇒ final energy < initial energy.

⇒ Energy of system decreases.

⇒ Exothermic process

⇒ Stability of system increases.



2). FORCE OF REPULSION

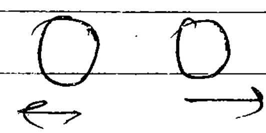
$$f = \frac{kq_1q_2}{r^2}$$

b/w like charges

$$F_R = \frac{k\overset{+}{q_1}\overset{+}{q_2}}{r^2}\hat{r} \quad \text{or} \quad \frac{K\overset{-}{q_1}\overset{-}{q_2}}{r^2}\hat{r}$$

$F_R = +\hat{r}$. +ve vector.

⇒ both atoms moves far away from each other.



⇒ distance b/w atoms increases.

$$f = \frac{k\overset{+}{q_1}\overset{+}{q_2}}{r} \quad \text{or} \quad \frac{K\overset{-}{q_1}\overset{-}{q_2}}{r}$$

F_R = +ve.

represents change in energy is +ve ;

change = final − initial.

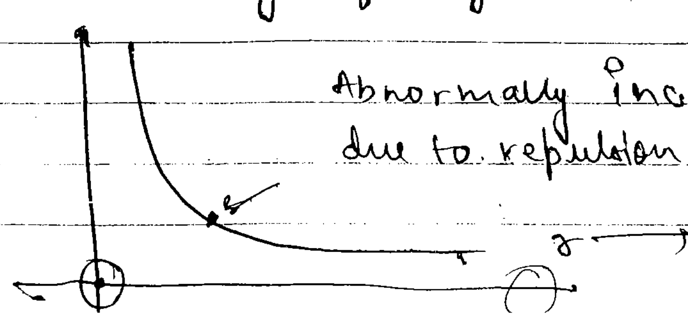
final energy > Initial energy.

⇒ Energy of system de increases.

⇒ Endothermic process

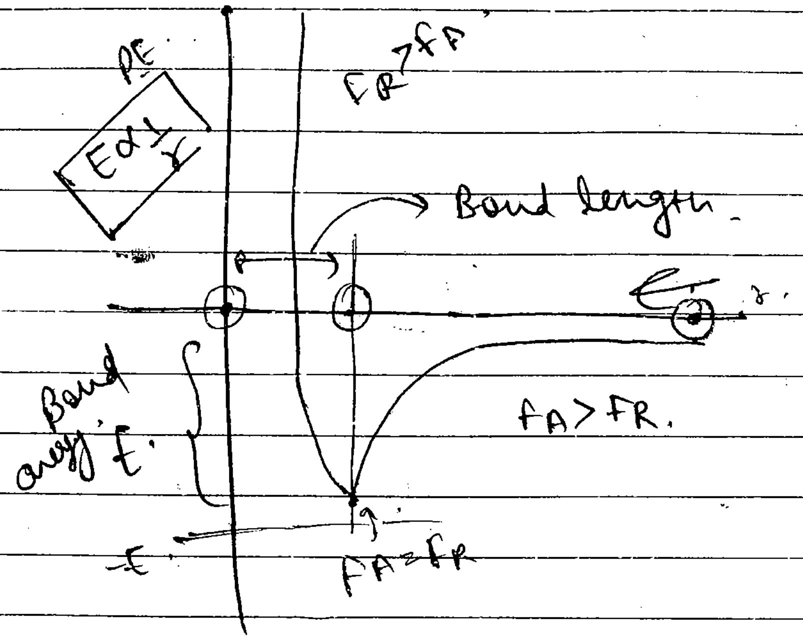
⇒. stability of system decreases

$\boxed{F_R \propto \frac{1}{r}}$



Abnormally inc.
due to repulsion of nucleus.

PE curve (Net energy).



BOND ENERGY

Energy released in bond formation is called "BOND ENERGY" which is calculated in terms of "Bond Dissociation Energy."

$$H_2 \xrightarrow{\text{BDE (required)}} 2H$$
$$\xleftarrow[\text{Bond energy (release)}]{}$$

BOND LENGTH

Internuclear distance b/w two bonded atoms is called "BOND LENGTH."

CLASSIFICATION OF CHEMICAL FORCE OF ATTⁿ ON THE BASIS OF ENERGY.

Atoms are highly reactive. They combine and form stable species molecules, lattice.

MOLECULE

Species having independent existance.

LATTICE

Repetation of unit in a uniform manner doesn't have independent existance are called lattice.

Ex.	Molecule	Lattice
element	1 O_2, S_8	3. Na(s) Dimond.
compound.	2 C_6H_6, CCl_4 H_2O	4 NaCl.

→ Reactivity Atoms > Molecule / lattice
Energy Atoms > Molecule / lattice.
Energy release due to. Atom-Atom > Molecule - Molecule
Type of force Strong Weak.

outer shell e⊖nic configurations (p-block elements)

classification of chemical force of Attraction

Strong force / chemical bond.
(b/w Bonded atoms)
Release energy > 42 kJ/mole.
Interatomic
1). Ionic Bond (EN↓ EN↑)
2). Covalent (EN↑ EN↑)
3). Dative
4). Metallic bond. (EN↓ EN↓).
(free e⊖).

Weak forces.
(B/w non-bonded atoms).
Energy release ≤ 42 kJ/mol.
Inter Molecular

VWF.
1). Keesom (polar-polar)
2). Debye. (NP-polar)
3). London. (NP-NP).

H-bond.
(special polar-polar bond)

Other forces. → 1). ion-dipole (ion-polar)
2). ion-Induced dipole. (ion-Non polar).

$\boxed{\text{IONIC BOND}}$

Bond b/w ions is called "IONIC BOND".
Ions are formed by complete transfer of e⊖s
force of attⁿ b/w ions is electrostatic so
bond formed by complete transfer of e⊖s is also
called electrovalent bond.

ELECTROVALENCY

No. of e^-s transferred by an atom or group of atom is called their "electrovalency"

+ve electrovalency	-ve electrovalency
$Na \longrightarrow Na^+$	$Cl \longrightarrow Cl^-$
2,8,1 alkali metal = 1	2,8,7 2,8,8
alkaline earth metal = 2	halides → 1
Al = 3	oxide O^{-2} = 2
$(NH_4)^+$ = NH_4^+ = 1	Nitride N^{-3} = 3
	Sulphate (SO_4^{2-}) = 2
	phosphate (PO_4^{3-}) = 3

⇒ sodium chloride $NaCl$

$Na^+ Cl^-$

⇒ calcium chloride $CaCl_2$

⇒ Magnesium oxide $\cancel{Mg_2O_2}$ $Mg^{+2} \; O^{-2}$

MgO (Emperical formula)

⇒ valency e^- of $A = 5$

$B = 2$

$B^{+2} \; A^{-3}$

B_3A_2

Que.① write down the formula of Metal Phosphate if its sulphate is $M_2(SO_4)_3$. $~~MPO_4~~$.

MCQ Que. formula of a metal nitride is M_3N_2. Metal can be.

(A) Li (B) Ca ✓ (C) Mg ✓ (D) Al.

(B)(C).

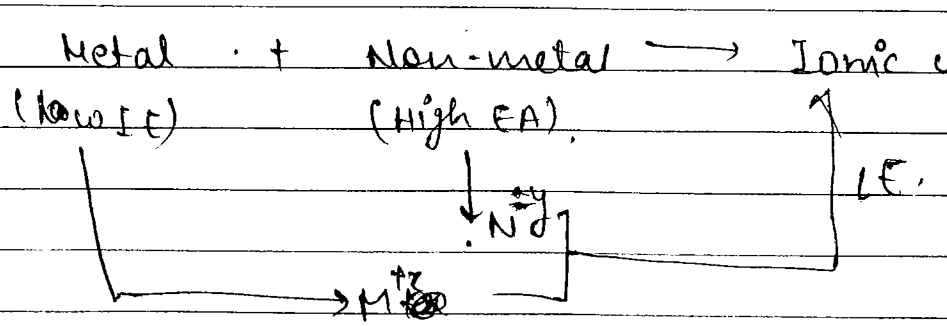
$\boxed{\text{CONDITION FOR IONIC BOND FORMATION}}$

for bond formation process must be exothermic.

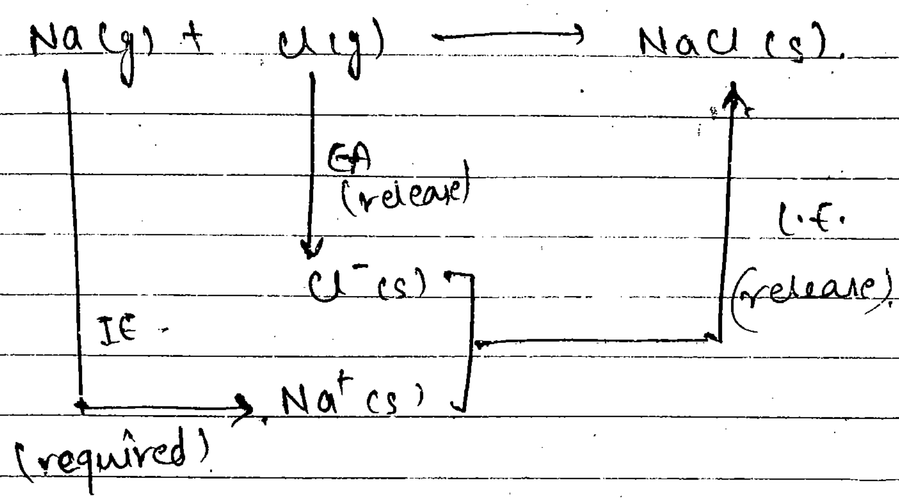
Release energy > Required energy.

L.E + E.A. > I.E.

high LE, High EA   low IE.



NaCl is an ionic compound while Cl_2 is a covalent molecule because Ionisation energy of Na is low which supports formation of ionic compound while Ionisation energy of Cl (non-metal) is very high thats why Cl_2 is not $Cl^+ - Cl^-$, it is a covalent molecule.



$(Na^+ Cl^-)$ ✓

~~(Na – Cl(g))~~

$$Cl(g) + Cl(g) \longrightarrow Cl_2(g).$$

High I.E.

(non metal.

$Cl - Cl$ (g)

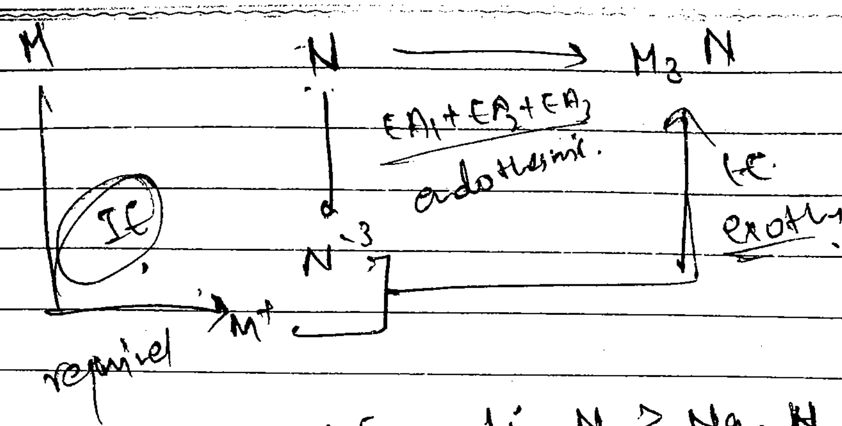
$\cancel{Cl^+ \; Cl^-}$ (g)

⇒ $Mg(g) \longrightarrow Mg^{+2}(g)$ endothermic.
$O(g) \longrightarrow O^{-2}(g)$ endothermic.

MgO exist due to High I.E.

Que Select the reason for given statement.
⇒ Li react with N_2 form Li_3N while Na does not react with N_2, does not form

(A). I.E of Li > Na (High IE cant support Na_3N form)
(B). I.E of Li < Na. (incorrect order of IE)
(C). E.A of N in Li_3N > Na_3N. (EA of $N \longrightarrow N^-$ remain co..)
(d). L.E. of. $Li_3N > Na_3N$.



I.E. $Li_3N > Na_3N$

$E \propto \frac{charge}{size}$

size of $Li^+ < Na^+$.

PROPERTIES OF IONIC COMPOUND

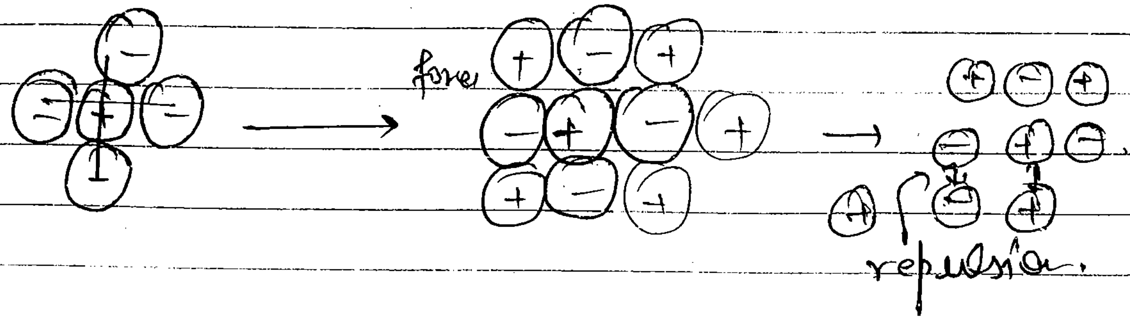
1). charge on ions is spherically/symmetrically distributed so a particular ion can attract opp. charge ions from all directions that's why ionic bonds are non-direction in nature.

2). Strong electrostatic attraction present b/w opp. charge ions so ionic compounds exist in solid state.

3). In solid state ions are arranged in uniform manner ~~with~~ with repetetion of units so they exist in form of lattice.

4). There MP and BP are high because they exist in solid state.

5). They are brittle in nature.



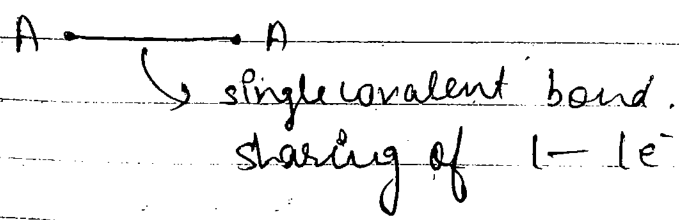
6). They conduct electricity in molten state, in aqueous medium but not in solid state.

7). Due to presence of ions they are more soluble in polar solvent as compare to non-polar solvent. (like dissolves like)

8). They do not show stereo isomerism/space isomerism due to non directional bond.

* $\boxed{\text{COVALENT BOND}}$

Bond formed by equal sharing of e^{-}s.



$A = A$
↳ double cov. bond
sharing of 2 – 2 $e^{\ominus}$.

$A \equiv A$
↳ a triple cov. bond
sharing of 3 – 3 $e^{\ominus}$'

COVALENCY

No. of covalent bond formed by an atom or no. of unpaired $e^{\ominus}$ in ground state or in excited state.

VARIABLE COVALENCY – except N, O, F, H. all element show

(non-metal) show varible covalency more than one type of covalency.

GROUN STATE

Normal e$^{\ominus}$nic configuration.

EXCITED STATE

Higher energy state in which no. of unpaired $e^{\ominus}$s are greater than no. of ground state unpaired $e^{\ominus}$s.
Excitation of $e^{\ominus}$s is possible when atom contain $e^{\ominus}$ pair as well as vacant orbital in its ground state, with each excitation

state covalency increases by 2.

ex. $\underline{C}$ G.S.   [↑↓]   [↑][↑][ ]   covalency 2

E.S.   [↑]   [↑][↑][↑]   4.

$\underline{N}$ G.S.   2s [↑↓]   [↑][↑][↑]   excited state not possible bcoz of absence of vacant orbital.

$\underline{P}$ G.S $3s^2$ [↑↓] $3p^3$ [↑][↑][↑]   3d [ ][ ][ ][ ][ ]

E.S   [↑]   [↑][↑][↑]   [↑][ ][ ][ ][ ]

$\underline{O}$ [↑↓]   [↑↓][↑][↑]   ~~E.S~~

$\underline{S}$ G.S $3s^2$ [↑↓] $3p^4$ [↑↓][↑][↑]

E.S 1st   [↑↓]   [↑][↑][↑]   [↑][ ][ ][ ][ ]

E.S 2nd   [↑]   [↑][↑][↑]   [↑][↑][ ][ ][ ]

Cl.   Xe.

G.S =   G.S =

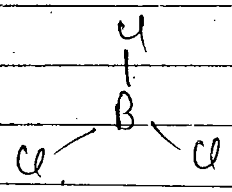
E.S Ist =   E.S Ist =

2nd =   2nd =

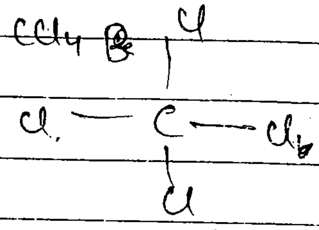
3rd =   3rd =

     4th =

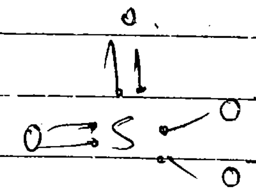
BCl_3



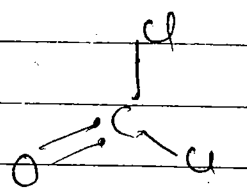
CCl_4



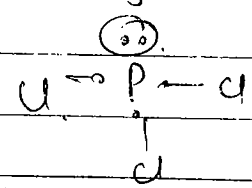
SO_4^{2-}



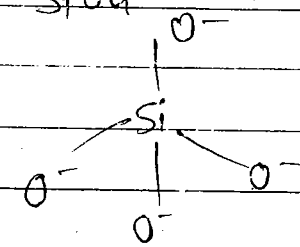
$COCl_2$.



PCl_3.

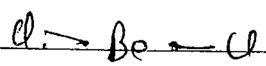


SiO_4^{4-}

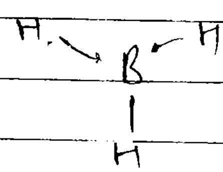


ex.

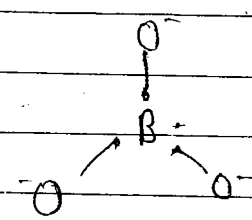
1). $BeCl_2$



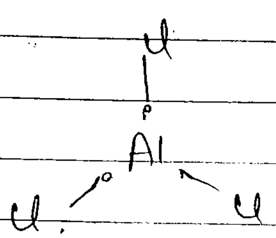
2). BH_3.



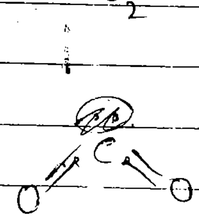
3). BO_3^{3-}



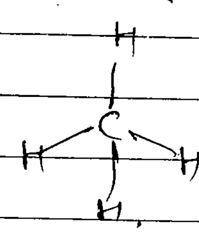
4). $AlCl_3$.



5). CO_2

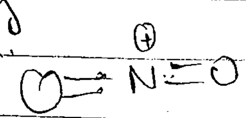


6) CH_4.

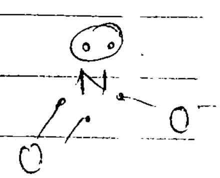


7). NO_2^+

+charg
5 + 4.

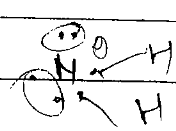


8). NO_2^-



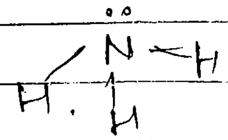
9). NH_2^-

5 → 6

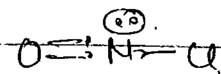


(E CA)

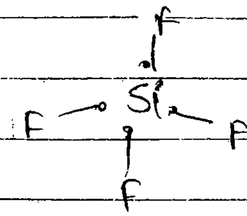
10) NH_3



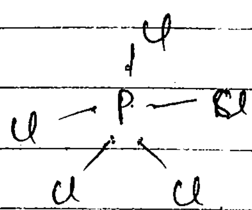
11). $NOCl$



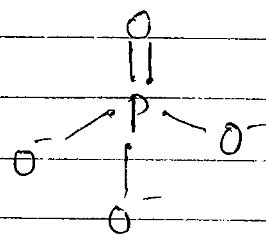
12). SiF_4



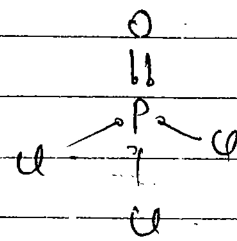
13). PCl_5



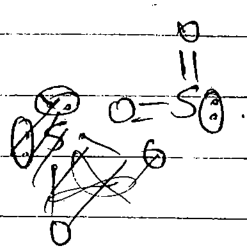
14). PO_4^{3-}



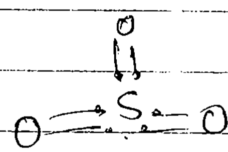
15). $POCl_3$



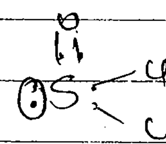
16) SO_2



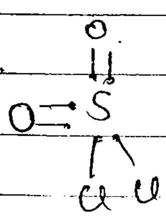
17) SO_3



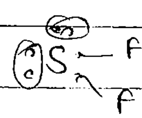
18) $SOCl_2$



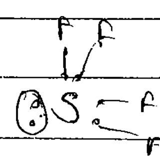
19). SO_2Cl_2



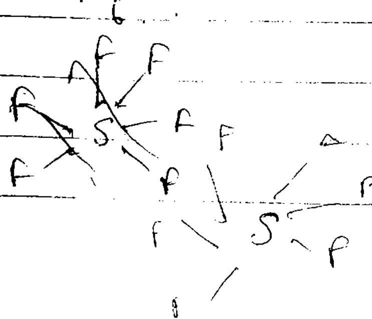
20) SF_2



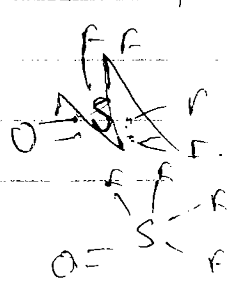
21). SF_4



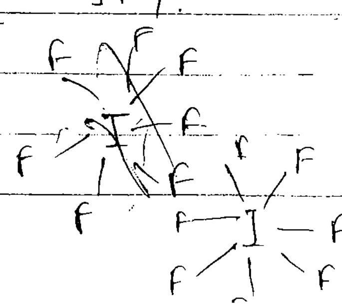
22). SF_6



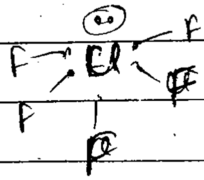
23). SOF_4



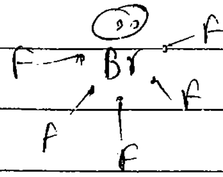
24) IF_7



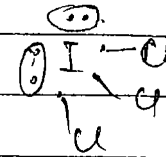
25). ClF_5.



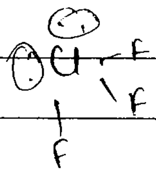
26). BrF_5



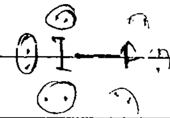
27) ICl_3.



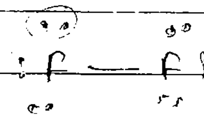
28). ClF_3



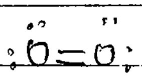
29.) I · F



30) F_2.

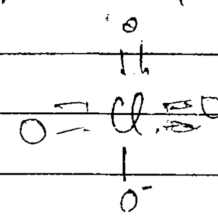


31.) O_2.

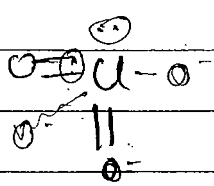


32). N_2.

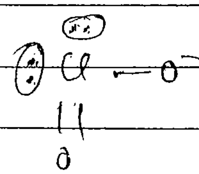
33). ClO_4^-



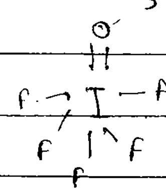
34). ClO_3^-



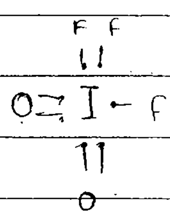
35). ClO_2^-



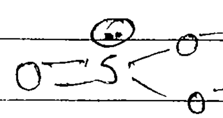
36.) IOF_5.



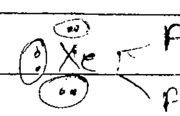
37.) IO_2F_3.



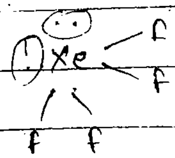
38.) SO_3^{2-}



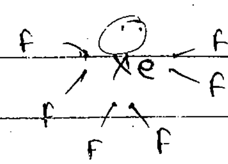
39). XeF_2.



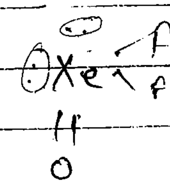
40). XeF_4.



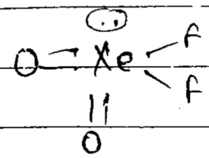
41). XeF_6.



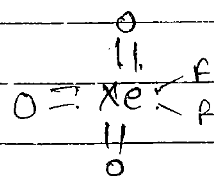
42). $XeOF_2$.



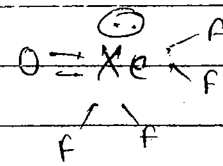
43). XeO_2F_2



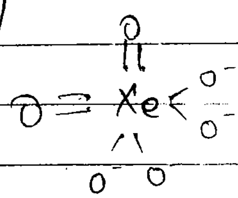
44) XeO_3F_2



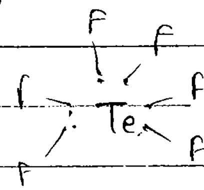
45) $XeOF_4$



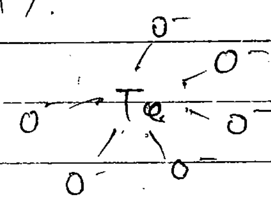
46) XeO_6^{4-}



47) TeF_6



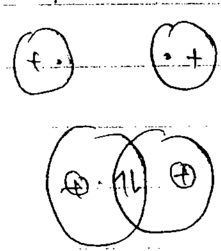
48) TeO_6^{6-}

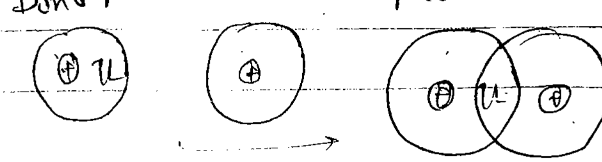


$\boxed{\text{DATIVE BOND}}$

Bond formed by unequal sharing of $e^\ominus$ is called "Dative Bond."

Covalent	Dative	
A — A	Lewis Base	Lewis acid
	A:	B.
	lone pair Donor	vaccant orbital Acceptor

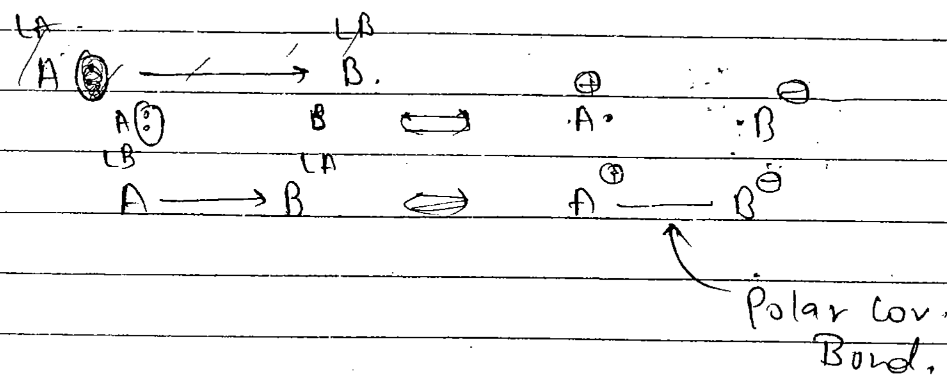




1). Species which provide e⊖ pair / lonepair for Dative Bond formation is called lewis Base.

2). Species which provide vacant orbital, & accept e⊖ pair in Dative Bond formation is called lewis acid.

3). Dative bond is a lewis acid-base interaction. After formation Dative Bond act as Polar Covalent Bond.



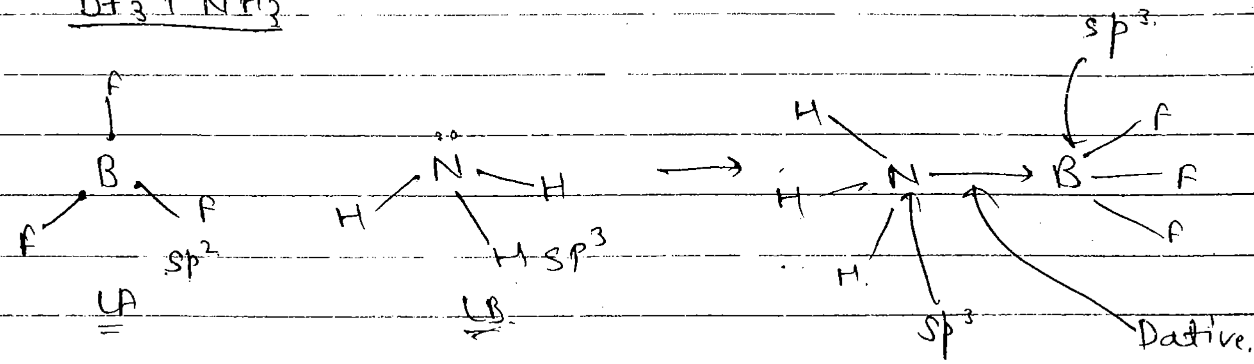
Dative Bond

⇒ σ- Dative	⇒ π- ~~bond~~ Dative
⇒ Intermolecular	⇒ Intramolecular.
⇒ form by Head on / coaxial.	⇒ form by sideways / colateral overlapping
⇒. co-ordinate Bond.	⇒. Back bond.

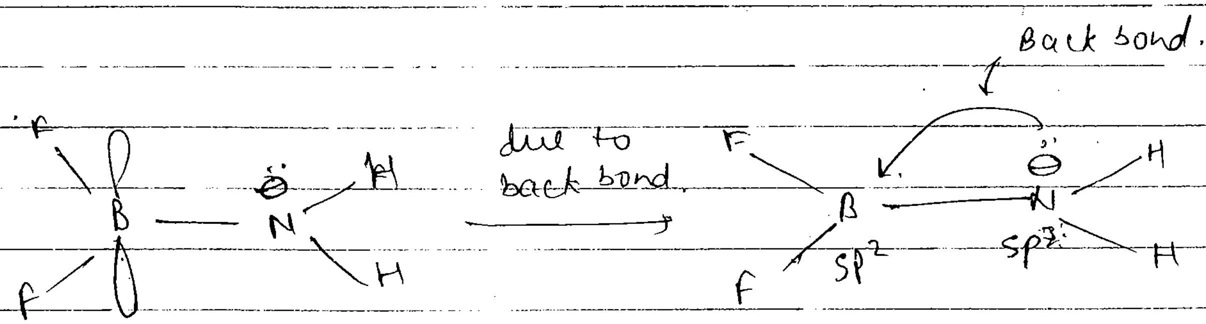
NOTE In co-ordinate bond formⁿ hyb. of donor atom remains same, bcoz lonepair converted to σ bond while hyb. / no of hyb. orbital of acceptor atom increases.

NOTE In back-bond formⁿ hyb. of acceptor atom remaines same b.coz back bond is a π-bond while hyb. of donor atom decreases b.coz lonepair converted to π- bond.

1). $BF_3 + NH_3$



2).



TYPES OF LEWIS ACID

Condition for lewis acid →

1). Presence of vacant orbital.
2). Acceptor atom can expand its co-ordination no.

TYPE

1). All metal cations and H^+.

$x \longrightarrow \boxed{1}$ $1s^1$

$x^+ \longrightarrow \boxed{\ }$ $\longleftarrow$ vacant orbital.
$1s^0$

2). Hypovalent compound

less than 8 e⁻s.

Covalent
- BX_3 (6e⁻) ($X = F, Cl, Br, I, H, OH, CH_3$)
- BeX_2 (4e⁻) ($X = F, Cl, Br, I, H, OH, CH_3$)
- AlX_3 (6e⁻) ($X = \cancel{F}, Cl, Br, I, H, OH, CH_3, C_2H_5, C_6H_5$).

$AlCl_3$

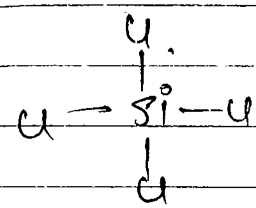
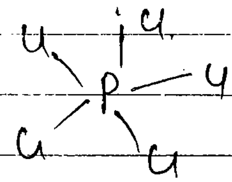
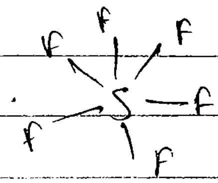
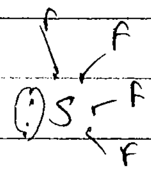
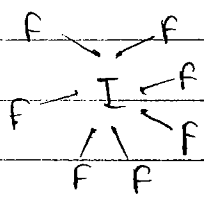
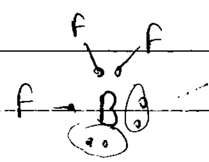
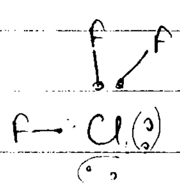
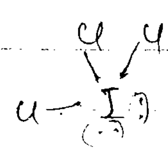
AlF_3 ionic compound
Al^{+3} F^- due to high ΔEN

Ans. Statement I (True) AlF_3 is a lewis Acid (Al^{+3} F^-) All metal cation r lewis Acid
Statement II AlF_3 is a hypovalent compound. False
$\downarrow$
Al^{+3} F^-
$1s^2 2s^2 2p^6$; $1s^2 2s^2 2p^6$
8e⁻ 8.

3). Species which can expand their octet due to presence of vacant d-orbital.

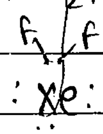
Que. Select the hypervalent species which can act as lewis acid.

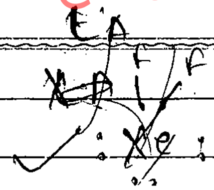
$SiCl_4$, PCl_5, SF_6, SF_4, IF_7, BrF_3, ClF_3, ICl_3.
XeF_2. XeF_4, XeF_6, TeF_6.

		LA.	Hypervalent.
$SiCl_4$		✓	✗
PCl_5		~~✗~~ ✓	✓
SF_6		~~✗~~ ✗	✓
SF_4		~~✗~~ ✓	~~✗~~ ✓
IF_7		✓	✓
BrF_3		✓	~~✗~~ ✓
ClF_3		✓	✓
ICl_3		✓	✓

Hyperval

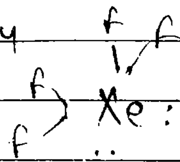
XeF_2





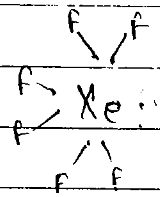
✓ ✓

XeF_4



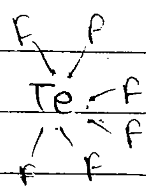
✓ ✓

XeF_6



✓ ✓

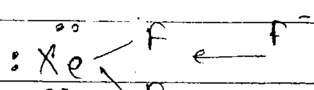
TeF_6

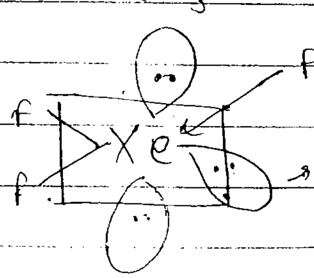


✓ ✓

Element of	type of orbitals in valency shell	No. of orbital in valency shell	Max capacity of e⁻s in valency shell	Max. no of cov. bond	Max. co-ordination number
Ist period	1s	1	2	1	1
2nd period	2s 2p	4	8	4	4
3rd period	3s 3p 3d	(9) >4	>8	>4	6 ← due to small size
4th period & below period	ns np nd nf	>4	>8	>4	>6 except Br

XeF_2 $\qquad XeF_2 + F^- \longrightarrow XeF_3^-$





90° max. repulsion unstable system so XeF_2 can't act as lewis acid

(4). Hypervalent Compound

more than 8 e⁻s.

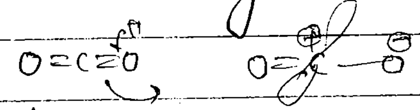
4). Species having multiple bond

⇒ Multiple bond means more than one bond b/w two atoms.

⇒ multiple bond n atleast $1\sigma + 1\pi$ (double bond)

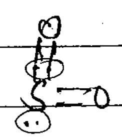
π bond is weak bond
which take part in resonance.

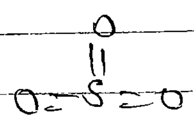
so, in presence of L.B., breaking of π bond take place and vacancy creat on less EN atom.

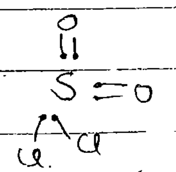
ex. CO_2  LA

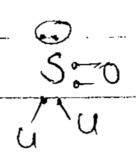
Que Select the species which can act as lewis acid.

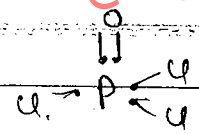
SO_2, SO_3, SO_2Cl_2, $SOCl_2$, $POCl_2$, NO_2^-, $NOCl$, SiF_4, IOF_5

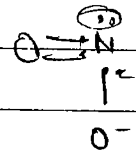
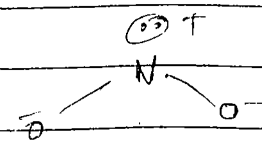
SO_2  ✓

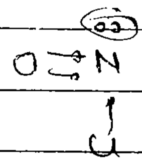
SO_3  ✓

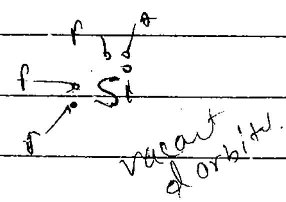
SO_2Cl_2  ✓

$SOCl_2$  ✓

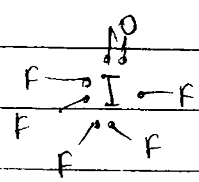
$POCl_3$ 

NO_2^-  

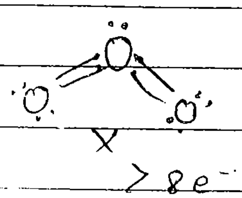
$NOCl$ 

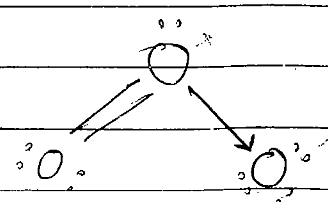
SiF_4 

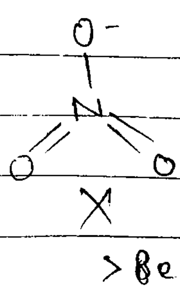
vacant d orbital

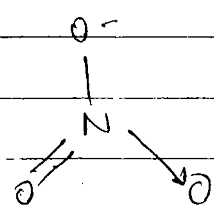
IOF_5 

5). Sometimes six e⊖ atomic species (O, S, N^-) also act as lewis acid.

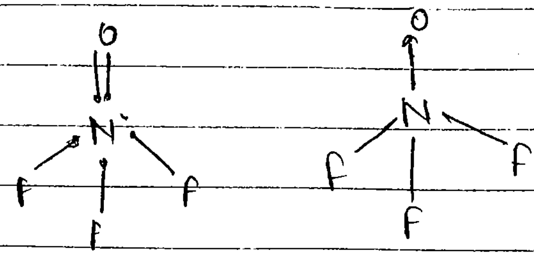
O_3 

$O_2 + O$ 

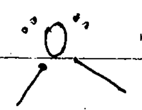
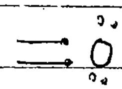
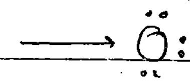
NO_3^- 



NOF_3



'O' can achieve octet by

either  or  or 

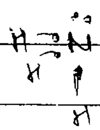
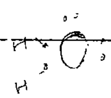
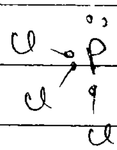
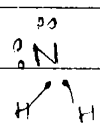
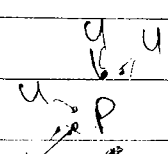
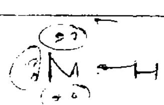
To follow octet rule double bond can be replaced by co-ordinate bond.

$\boxed{\text{LEWIS BASE}}$

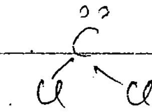
1) lonepair containing species (Generally at central atom) are act as lewis base.
Octet must be completed to act as donor atom.

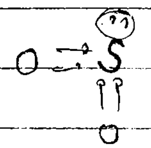
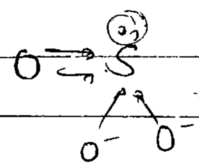
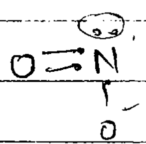
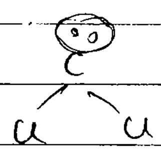
Que Select the species which can act as lewis base.

F^-, Cl^-, Br^-, I^-, OH^-, H^-, NH_3, H_2O, PCl_3, NH_2^-, NH^{2-}, PCl_4^+.

	lone pair ~~octet complete~~	~~lonepair~~ complete octe
~~F^-~~		
F^-	✓	✓
Cl^-	✓	✓
Br^-	✓	✓
I^-	✓	✓
OH^-	✓	✓
NH_3 	✓	✓
H_2O 	✓	✓
PCl_3 	✓	✓
NH_2^- 	✓	✓
PCl_4^+ 	✗	✓
H^-	✓	✓
NH^{2-} 	✓	✓

Que. Select the species which ordination no become acid as well as lewis base no.

SO_2, SO_3^{2-}, NO_2^-, CCl_2 

	lewis acid	lewis base
	✓	✓
	✓	✓
	✓	✓
	✓	✗

$6e^-s$
Hypovalent

FACTORS AFFECTING LEWIS ACIDIC STRENGTH.

1) As +ve charge increases on acceptor atom attraction on lonepair of lewis base increases, lewis acidic nature increases.

LA nature $\overset{+3}{PCl_3} < \overset{+5}{PCl_5}$

2). -I of surrounding atom increases, defficiency of $e^{\ominus}$ at central atom increases, lewis acidic nature increases.

LA nature $\overset{\delta+}{Si}F_4 > \overset{\delta+}{Si}Cl_4 > \overset{\delta+}{Si}Br_4 > \overset{\delta+}{Si}I_4$.

3). In s-block metal cations +ve charge density increases, lewis acidic nature increases

charge density = $\frac{\text{charge}}{\text{size}}$ LA nature

$Li^+ < Be^{+2}$.

$Li^+ > Na^+ > K^+ > Rb^+$

Que. Arrange following in correct order of lewis acidic nature.

(i) $SO_2 < SO_3$.

(ii) $AlCl_3 > AlBr_3 > AlI_3$

(iii) $Ca^{+2} < Mg^{+2} < Be^{+2}$.

(iv) $Na^+ < Mg^{+2} < Al^{+3}$.

☆ ⇒ $BCl_3 > CCl_4$ LA ✗

☆ ⇒ LA $CCl_4 < SiCl_4$

☆ ⇒ ✗ $AlCl_3 < SiCl_4 < PCl_5 > SF_6$ LA ✗

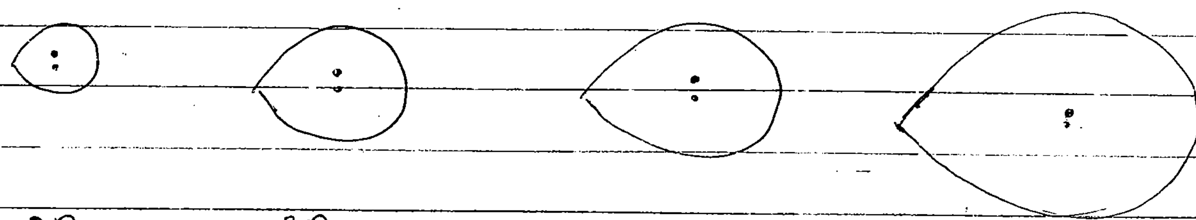
sulfur can't expand its co-

Sulphur can't expand its co-ordination no because it is in its max^m co-ordination no.

FACTORS EFFECTING LEWIS BASIC STRENGTH

1). for different period element

F^- Cl^- Br^- I^-



2p 3p 4p 5p.

size ↑ → -ve. charge density. att^n with lewis acid ↓. LB nature ↓.

2). for same period element as EN of donor atom ↑ LB ↓.

$\ddot{P}H_3 > H_2S > HCl$

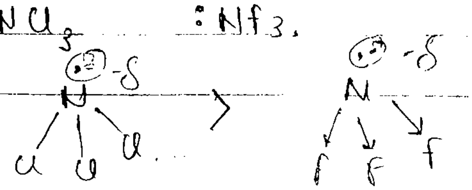
3p 3p 3p.

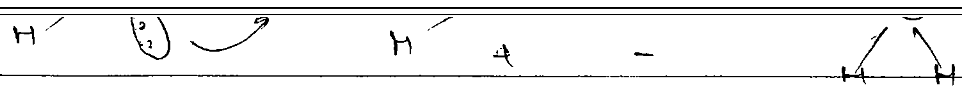
3). for same type of element donor atom.

-I of SA ↑ LB ↓

+I of SA ↑ LB ↑

$:NCl_3$ $:NF_3$

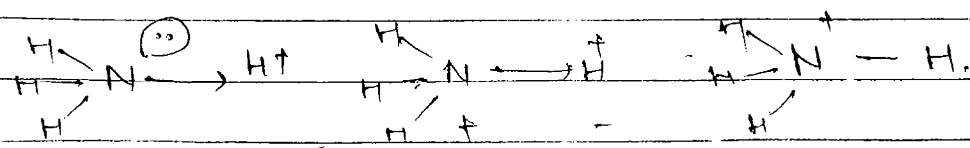




2). Formation of ammonium ion NH_4^+

$NH_3 + H^+ \longrightarrow NH_4^+$.

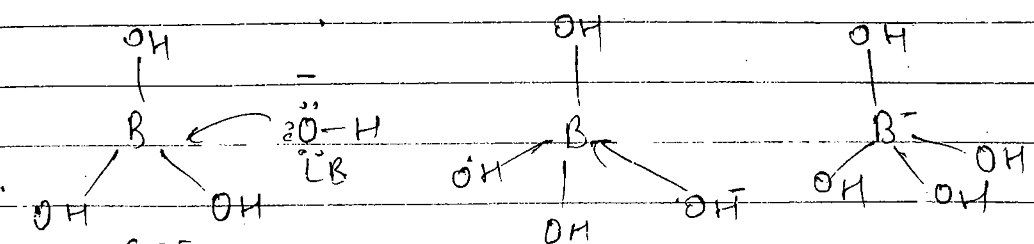
LB LA.



3). Nutralization of Boric Acid $B(OH)_3$ or H_3BO_3

$$B(OH)_3 + OH^- \longrightarrow B(OH)_4^-$$

LA



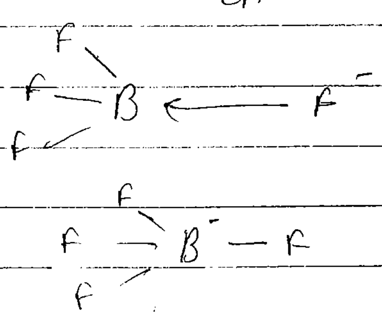
$6e^-$

LA

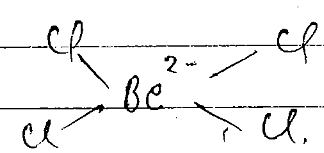
Other examples

BF_4^-

F_3B F^-
LA   LB.

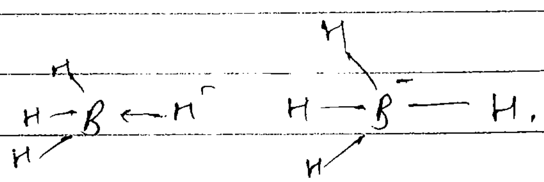


Que $BeCl_4^{2-}$

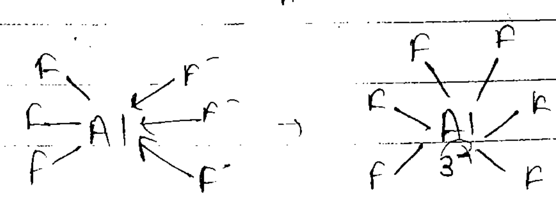


(En of B<H)
2 2.1

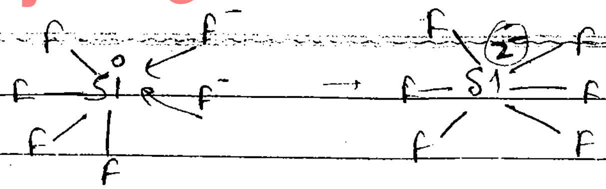
BH_4^- $BH_3 + H^-$



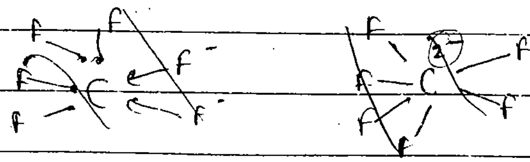
AlF_6^{3-} $AlF_3 + F_3^{3-}$



SiF_6^{2-}



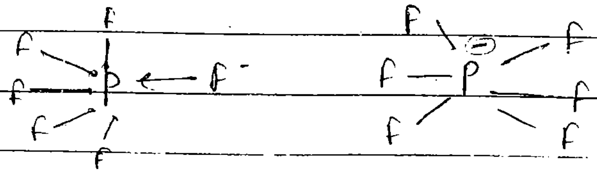
CF_6^{2-}



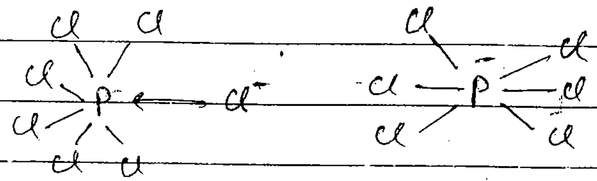
$CF_4 + 2F^-$

LAX LB

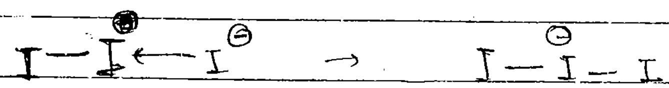
PF_6^-



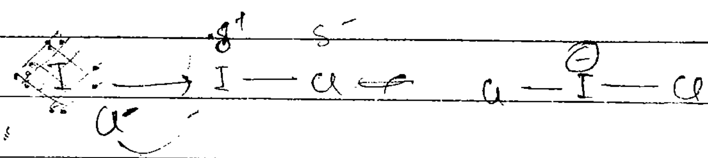
PCl_6^-



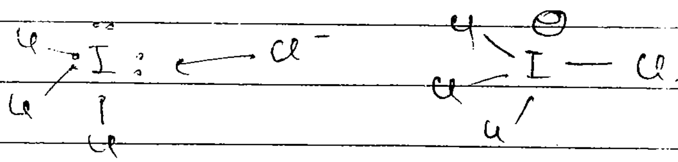
I_3^-



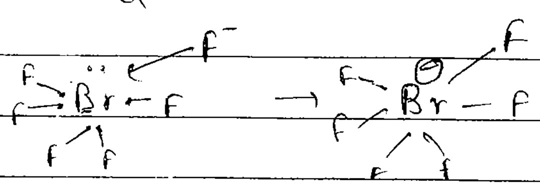
ICl_2^-



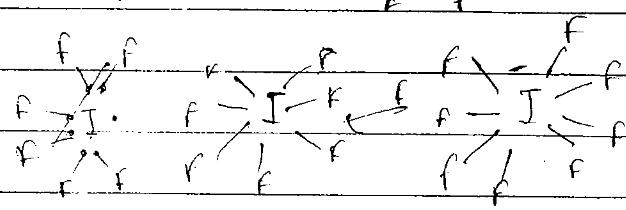
ICl_4^-



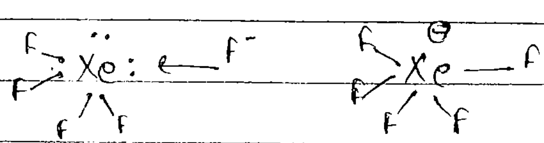
BrF_6^-



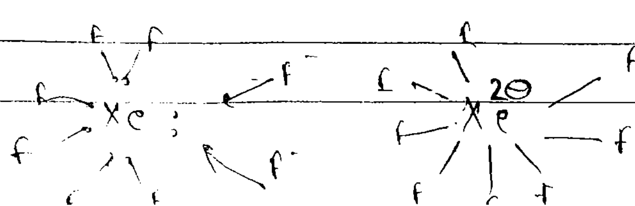
IF_8^-



XeF_5



XeF_8^{2-}



⇒ CO

$\ddot{C}=\ddot{O}:$ $:C\equiv O:$

6e⁻   8e⁻

⇒ HCN

$H-C\equiv N:$

⇒ HNC $H-\ddot{N}=C:$

$H-N\equiv C:$

$H-\overset{\oplus}{N}\equiv \overset{\ominus}{C}:$

Que. Give the reason of non-existance of given species

NCl_5, CF_6^{2-}, BF_6^{3-}; OF_6, OF_4, F_3^-, SF_7^-, ClF_7, BrF_7

NCl_5 → can't expand octet

CF_6^{2-} → can't expand octet

BF_6^{2-} → can't expand octet

OF_6 → can't expand octet

OF_4 → can't expand octet.

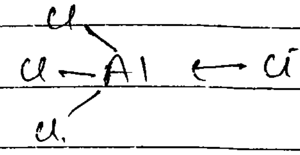
F_3^- → Can't expand octet.

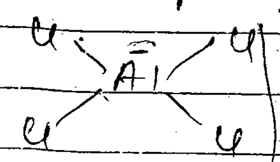
SF_7^- → $SF_6 + F^-$ → ~~can't expand~~. steric crowding.

ClF_7 → steric crowding

Que. Find the species in which dative bond present.

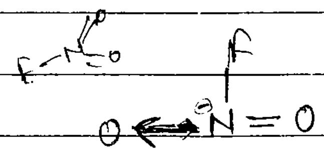
$AlCl_4^-$ $\quad$ $AlCl_3 + Cl^-$





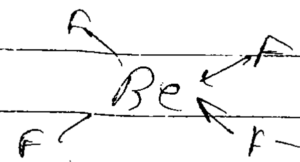
✓

FNO_2

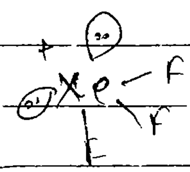


✓

BeF_4^{2-} $\quad$ $BeF_2 + F_2^-$ ✓

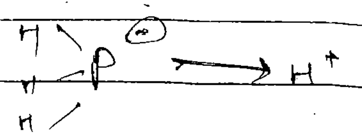


XeF_3^+



✗

(EN of P>H) PH_4^+ $\quad$ $\underbrace{PH_3}_{LB} + \underbrace{H^+}_{LA}$



✓

$\boxed{\text{POLAR AND NON- POLAR COVALENT BOND}}$

⇒ If covalent bond present b/w two diff. atom or in covalent bond $\Delta EN \neq 0$ (diff hybrid same atom). Bond will be polar.

$$\overset{-\delta}{A} - \overset{\delta+}{B} \qquad EN\ A > B.$$

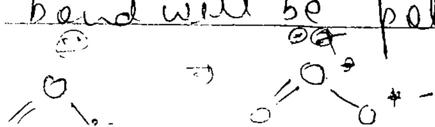
⇒ If $\Delta EN = 0$

Bond will be non-polar.

(polar cov.)

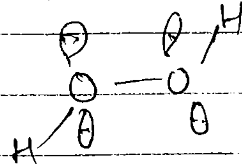
⇒ If Dative Bond present b/w two same type of atoms (~~polar cov~~, bond will be polar.

O_3 ⇒

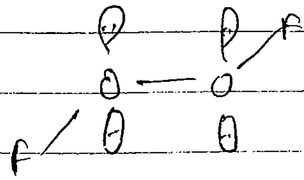


Qu. Select the species in which polar as well as Non-polar bond present.

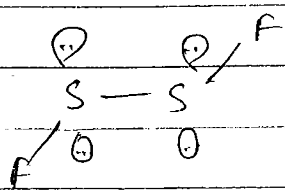
1). H_2O_2 ✓



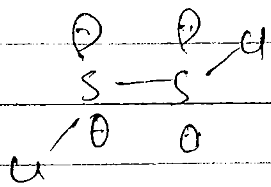
2). F_2O_2 ✓



3). S_2F_2 ✓



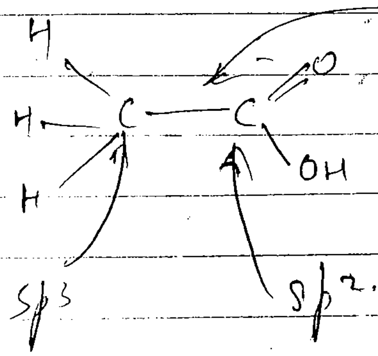
4). S_2Cl_2 ✓



5). Cyanogen $(CN)_2$ $N\equiv C-C\equiv N$ ✓

6). $(SCN)_2$ Thio cyanogen $N\equiv C-S-S-C\equiv N$ ✓

7). CH_3COOH ✗



polar bond due to ΔEN.

EN $\propto$ % S.

EN $sp > sp^2 > sp^3$

part 1 octet th.
formal charge

DIFFERENT THEORIES OF COVALENT BOND FORMATION

LEWIS OCTET RULE

According to lewis every atom tries to complete its outermost shell with 8 $e^{\ominus}$s to gain stability. This rule is based on inertness of noble gases. Octet may be achieved by either transfer of $e^{\ominus}$ or sharing of $e^{\ominus}$.

So, according to lewis bond b/w atoms are

(i) Ionic

(ii) Covalent.

~~LWD~~ LEWIS DOT REPRESENTATION

atom is divided into two parts.

(i) valency $e^{\ominus}$

(ii) Kernel. (except valency $e^{\ominus}$)

atom = Kernel + valence e^-
symbol   Dot

sodium = $\underbrace{1s^2 2s^2 2p^6}_{\text{Kernel}}\ \underbrace{3s^1}_{\text{Valence } e^-}$ Na$\cdot$

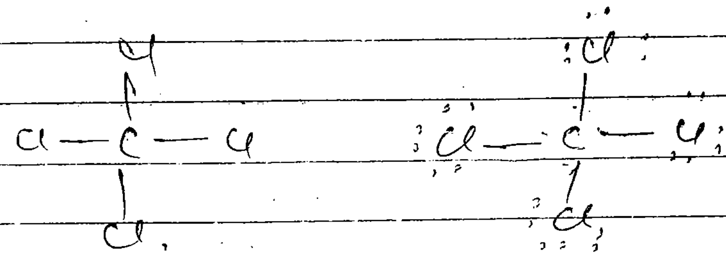
Mg: $\cdot$Al$\cdot$ $\cdot$Si$\cdot$ $\cdot$P$\cdot$ S :Cl$\cdot$

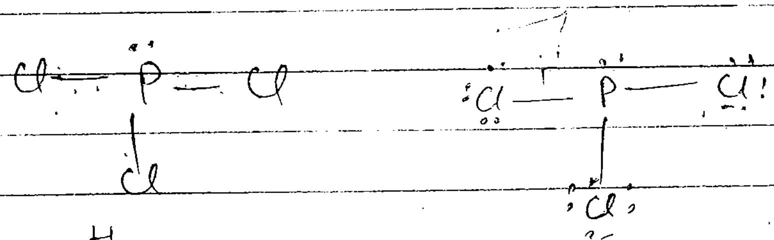
LEWIS DOT STRUCTUR.

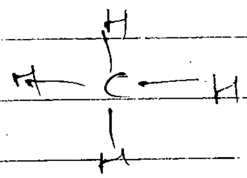
structure in which octet of each element is completed (Duplet for H)

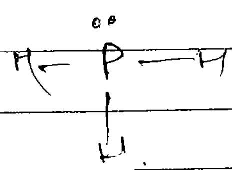
All bonds are covalent in lewis Dot structure.

Que. Select correct lewis structure of given species

(A). CCl_4 

(B). PCl_3 

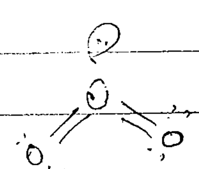
(C). CH_4 

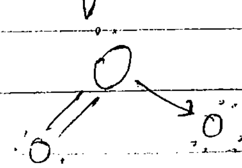
(D) PH_3 

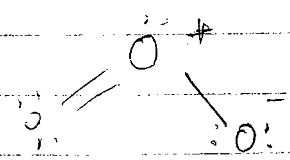
(C) & (D)

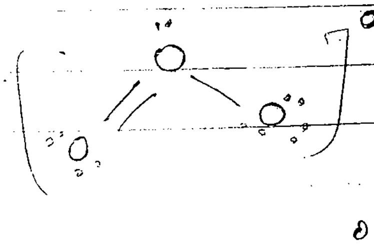
Pramila
Pranali Jain

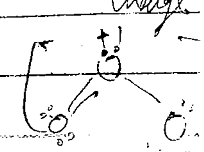
Que Select correct structure of O_3^{0}.

(1) 

(2) 

(3) 

(4) 

Formal charge 

overall = 0

FORMAL CHARGE

Charge generate on perticular atom in lewis dot structure after bond formation is called FORMAL CHARGE.

formal charge = Valence e^- − ~~unpai~~ unshared $e^{\ominus}$ (LP×2) − no. of bond.

Que. find formal charge on each atom in given species

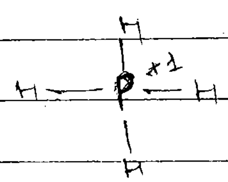
(1). CO_2 $\quad O=C=O \qquad O \rightarrow O \quad C \rightarrow O \quad O \rightarrow O$

(2). N_3^- $\quad \overset{-1}{N}=\overset{+1}{N}=\overset{-1}{N}$

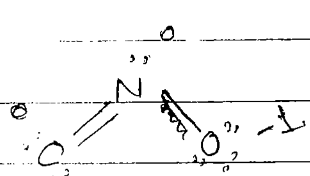
(3). SCN^- $\quad \overset{-1}{N}=\overset{0}{C}=\overset{0}{S}$

(4). NO_2^+ $\quad \overset{0}{O}=\overset{+1}{N}=\overset{0}{O}$

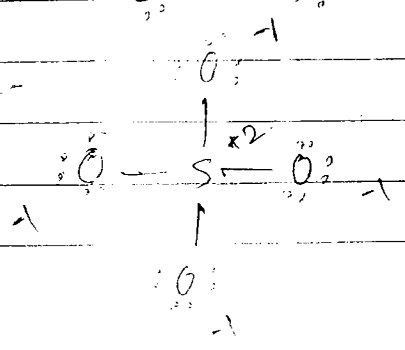
(5). PH_4^+



(6). NO_2^-



7). SO_4^{2-}



APPLICATION OF FORMAL CHARGE

(1). To find stable structure.

Que. Arrange different structures of N_2O in correct order of their contribution.

(a) $\overset{\ominus}{:N}\equiv\overset{+1}{N}-\overset{-1}{\ddot{O}:}$ — -ve charge is more stable on more EN.

(c) $\overset{-2}{:\ddot{N}}-\overset{+1}{N}\equiv\overset{+1}{O}:$ ≈ 0

$a > c > b.$

$a > b > c.$

(b). $\overset{-1}{\ddot{N}}=\overset{+1}{N}=\overset{0}{\ddot{O}}$

like charges at adjacent atom produce repulsion, min^m stable.

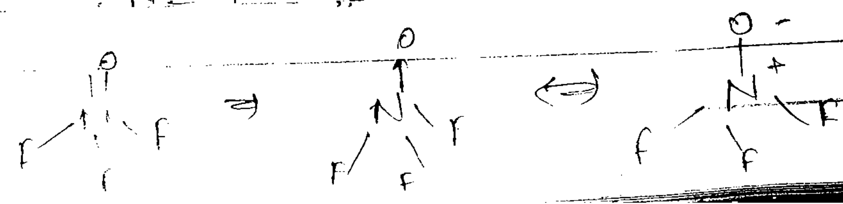
(2). To find Co-ordinate bond in LEWIS DOT STRUCTURE

If +ve charge present on more Electronegative or if -ve charge present on less electronegative or covalent bond present with pair of +ve, -ve there will be a Dative Bond.

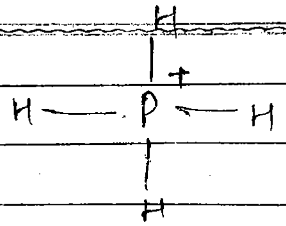
CO $\quad :\overset{-}{C}\equiv\overset{+}{O}: \quad \Leftrightarrow \quad :C\Leftarrow O:$

$N_2O \quad :\overset{0}{N}\equiv\overset{+1}{N}-\overset{-1}{\ddot{O}:} \quad \Leftrightarrow \quad :N\equiv N\rightarrow \ddot{O}:$

NOF_3 ✗

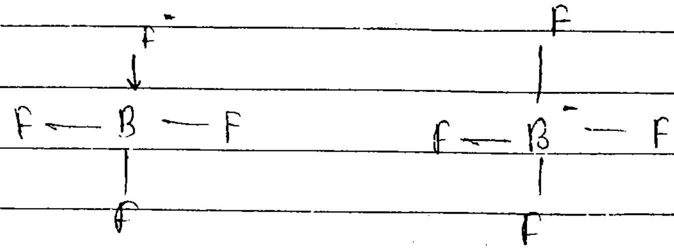


PH_4^+



$H_3P \rightarrow H^+$

BF_4^-



→ Exceptions of LEWIS OCTET RULE

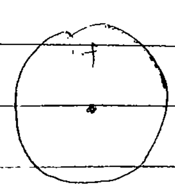
(1) Hypovalent
(2) Hypervalent
(3) Odd e^- species (e^- in odd no).
ex → NO, NO_2, ClO_2, ClO_3.
(4) Compound of inert gases.
ex → XeF_2, XeF_4, XeF_6, KrF_2.

⇒ FAILURE OF LEWIS OCTET RULE

It doesn't explain formation of covalent bond on the basis of energy, shape and geometry of molecule, bond parameters (bond angle, bond length, bond energy).

Orbitals

S-orbital.

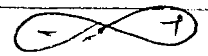


gerade
1 lobe

e^- density equal in all dir^n

Gerade	Ungerade
Nodal plane = even	N.P → odd
cos ✓	cos ✗
w.r.t phase.	w.r.t to phase

p. orbital. (along the axis). Ungerad.

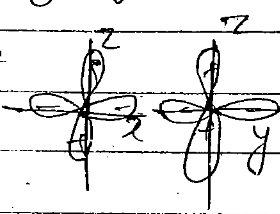
 2lobe.

	e^- density	Nodal plane.
P_x	x axis	yz
P_y	y	xz
P_z	z	xy

$d_{z^2} = d_{z^2-x^2} + d_{z^2-y^2}$

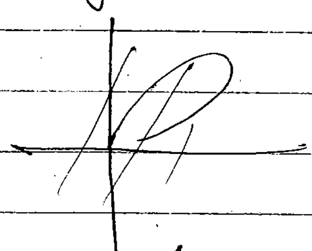
d- orbital

$d_{2z^2-x^2-y^2}$

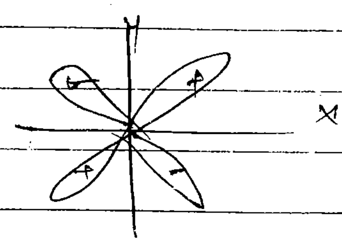


along the axis.

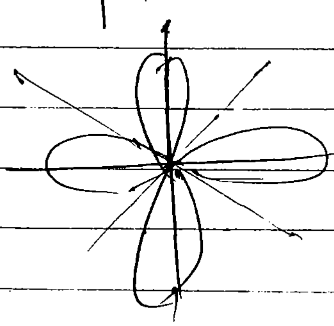
b/w the axis in the plane.



dxy

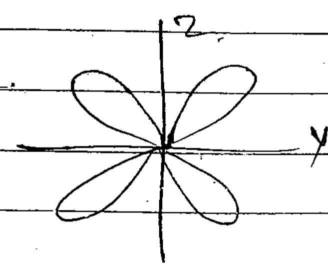


$d_{x^2-y^2}$

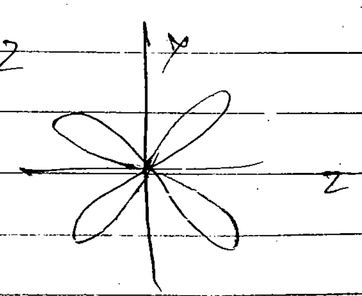


Nodal plane = 2.

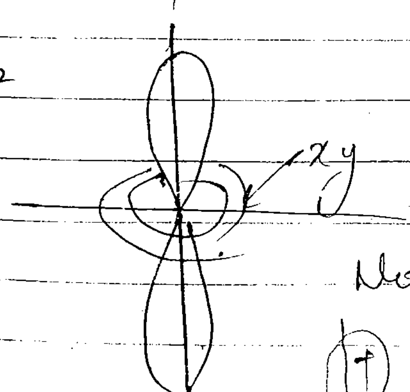
d yz.



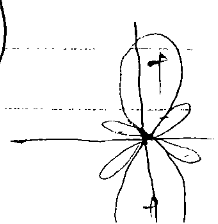
d_{xz}



d_{z^2}



Nodal plane = 0.



VALENCE BOND THEORY.

This theory explains the formation of covalent bond on the basis of energy. (potential energy curve).

According to this theory valency shell e⁻ participate in Bond formⁿ.

This theory is divided into two parts —

(1) Overlapping theory (formation of covalent bond).

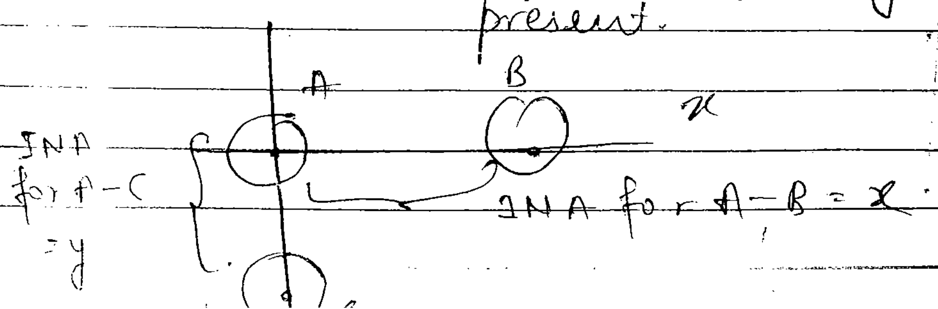
(2). Hybridisation (shape & geometry of molecule and bond parameters).

(1). OVERLAPPING THEORY.

According to this theory valency shell half filled orbitals having opp. spin e⁻ of two atoms overlaps to form covalent bond.

→ OVERLAPPING : common area sharing.

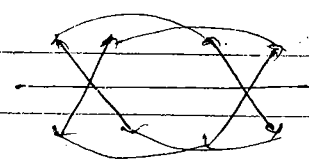
→ Inter nuclear axis : approaching axis of bond forming atoms or axis on which nuclei of bond forming atoms are present.

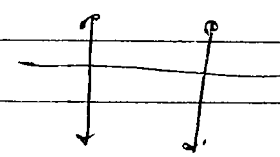


TYPE OF OVERLAPPING

Types of overlapping.

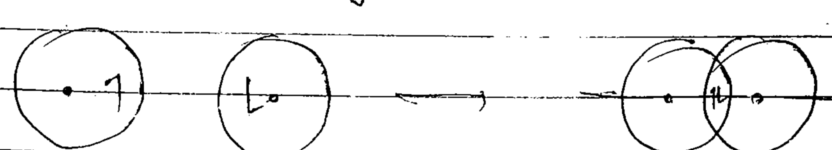
- ~~Planer~~ Coaxial.
  - Head on.
  - Head to Head.
  - along only INA
  - ~~along~~ 1:1 Lobe
  - σ bond.
- Colateral
  - side ways
  - ⊥ to the INA
    - Planer ⊥ to the INA
      - 4-4 Lobe δ bond
    - axis ⊥ to the INA
      - 2-2 lobe π bond





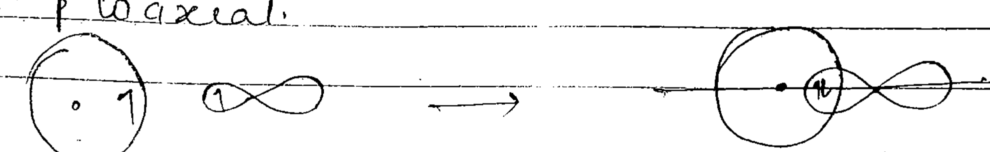
S orbital always form σ bond.
p orbital can form σ or π
d orbital can form σ, π, δ

1). s-s overlapping.

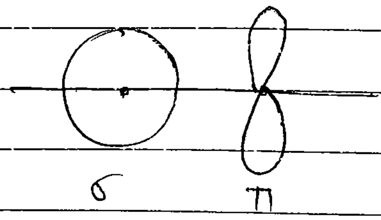


σ bond

2). s-p coaxial.

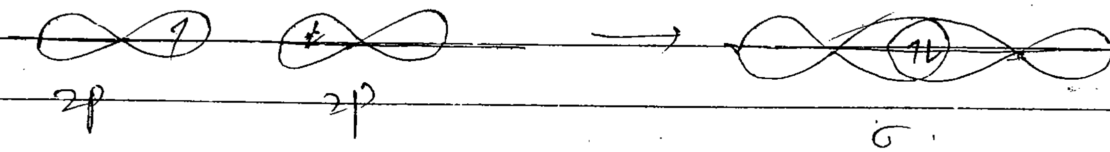


3). s-p colateral.

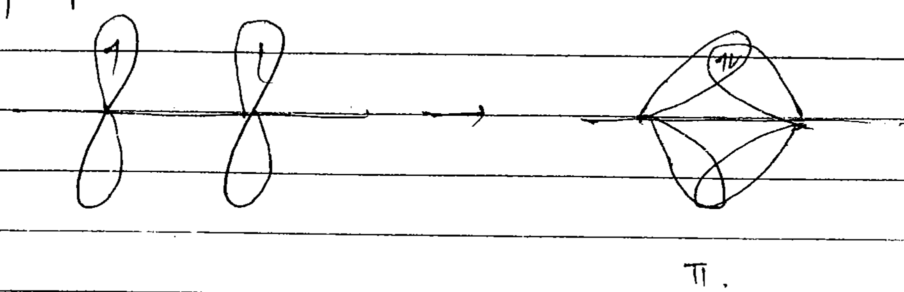


Zero overlapping

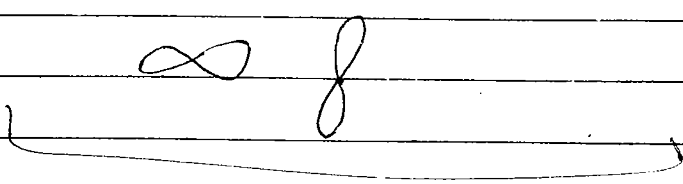
4). p-p coaxial.



5). p-p ~~orb~~ colateral



6). $P_x - P_y$ | $P_y - P_z$ | $P_z - P_{p_z}$



Zero overlapping.

d- orbital overlapping

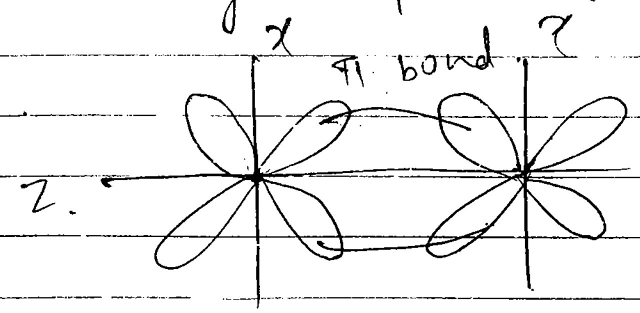
→ d_{xy}, d_{yz}, d_{xz}.

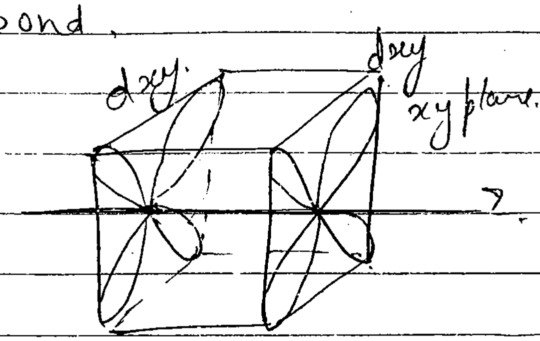
d-orbital overlapping

($d\pi - d\pi$) & ($d\delta - d\delta$).

⇒ dxy, dyz, dxz

$e^{\ominus}$ density present b/w the axis not along the axis, so they do not form σ bond, they can form π or δ bond.

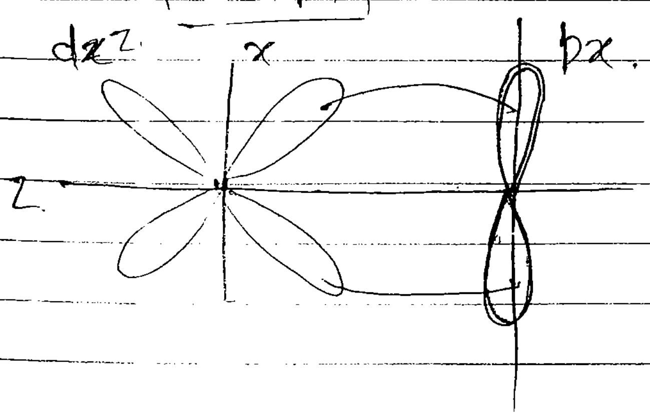




INA	z	y	x
d			
dxy - dxy	δ	π	π
dxz - dxz	π	δ	π
dyz - dyz	π	π	δ

dxy, dyz, dxz ~~memai~~ se wo d orbital π bond ka formation karega jisme internuclear axis ho.

$\boxed{d\pi - p\pi}$ Px Pz.



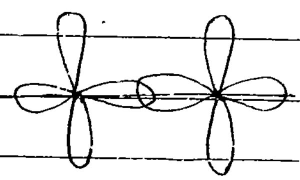
IN A = z	IN A = y.	IN A = x.
d_{xz} - p_x ⇒ π	d_{xy} + p_x ⇒ π	d_{xy} + p_y = π
d_{yz} - p_y ⇒ π	d_{yz} + p_z ⇒ π	d_{xz} + p_z = π.

$\boxed{d_{x^2-y^2}}$

$e^{\ominus}$ density along x axis, along y axis

⊥ to the Z axis.

x/y.



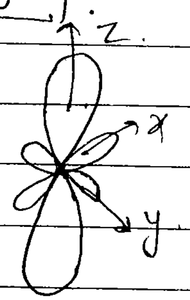
σ.

IN A x ⇒ σ

y ⇒ σ.

z ⇒ δ.

$\boxed{d_{z^2}}$



$e^{\ominus}$ density present along x, y, z axis always forms σ bond.

S — S ⇒ σ (x/y/z)

S + P_x ⇒ σ (x)

S + P_y ⇒ σ (y)

S + P_z ⇒ σ (z).

$P_x + P_x$ → σ (x)
→ π (y/z).

$P_y - P_y$ → σ (y)
→ π (x, z).

$p_z - p_z \rightarrow \sigma \quad (z)$
$\quad\quad\quad \rightarrow \pi \quad (x/y)$

$d_{xy} - d_{xy} \rightarrow \pi \quad (x/y)$
$\quad\quad\quad \rightarrow \delta \quad (z)$

$d_{yz} - d_{yz} \rightarrow \pi \quad (y/z)$
$\quad\quad\quad \rightarrow \delta \quad (x)$

$d_{xz} - d_{xz} \rightarrow \pi \quad (x/z)$
$\quad\quad\quad \rightarrow \delta \quad (y).$

$d_{xy} - p_y \Rightarrow \pi \quad (x)$
$d_{xy} - p_x \Rightarrow \pi \quad (y).$
$d_{yz} - p_z \Rightarrow \pi \quad (y)$
$d_{yz} - p_y \Rightarrow \pi \quad (z)$
$d_{xz} - p_z \Rightarrow \pi \quad (x)$
$d_{xz} - p_x \Rightarrow \pi \quad (z).$

$d_{x^2-y^2} - d_{x^2-y^2} \rightarrow \sigma \quad (x/y)$
$\quad\quad\quad \rightarrow \delta \quad (z)$

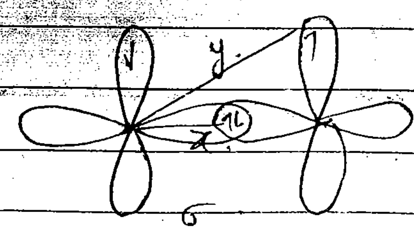
STRENGTH OF OVERLAPPING

(1). σ & π

distance $x < y$

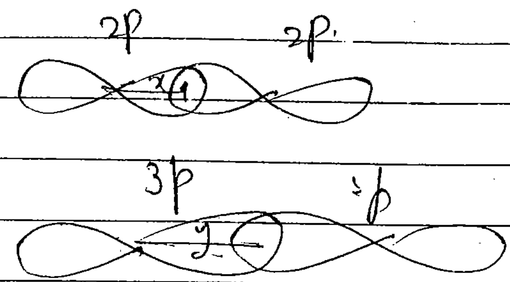
attn $\sigma > \pi$

strength $\sigma > \pi$



2). Size (for diff no of n/shell)

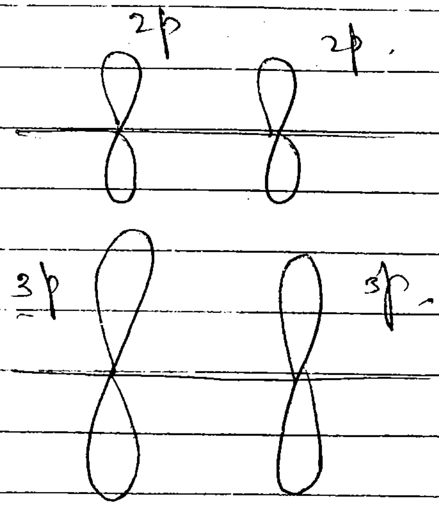
(a).



distance $y > x$.
Strength $2p-2p > 3p-3p$.

size ↑ strength ↓.

(b).

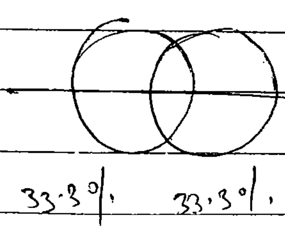


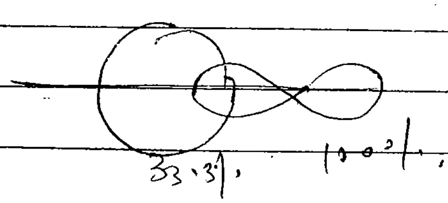
$2p\pi - 2p\pi > 3p\pi - 3p\pi$

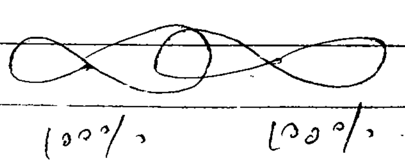
3). directional nature. (for same value of n)

$2s - 2s < 2s - 2p_z < 2p_z - 2p_z$).

S - Nondir
p_z directional







directional nature ↑
$e^{\ominus}$ density ↑
att'n ↑
strength ↑.

Priority order of comparison of strength of overlapping

1). All σ > All π

2). for all σ/π arrange them on the basis of size (n).
size ↑ strength ↓.

3). for same shell
directional nature ↑ strength ↑.

Que. arrange following in correct order of strength of overlapping (INA = 7)

1). 1s-1s, 2s-2s, 3s-3s, 4s-4s distance ↑ > x

2). 1s-2pz ; 1s-3pz , 1s-4pz , 1s-5pz. ~~strength 2p-2p > 3p-3p~~ ~~size ↑ strength ↓~~

3). 2pz-2pz, 3pz-3pz, 4pz-4pz, 5pz-5pz.

4). 2s-2s (3), 2s-2pz (2), 2pz-2pz (1) | 2px-2px (4), 2py-2py (4)
σ σ σ π π

5). 3s-3s, < 3pz-3pz < 2s-2s, < 2pz-2pz
σ σ σ σ

(1). 1s-1s > 2s-2s > 3s-3s > 4s-4s.

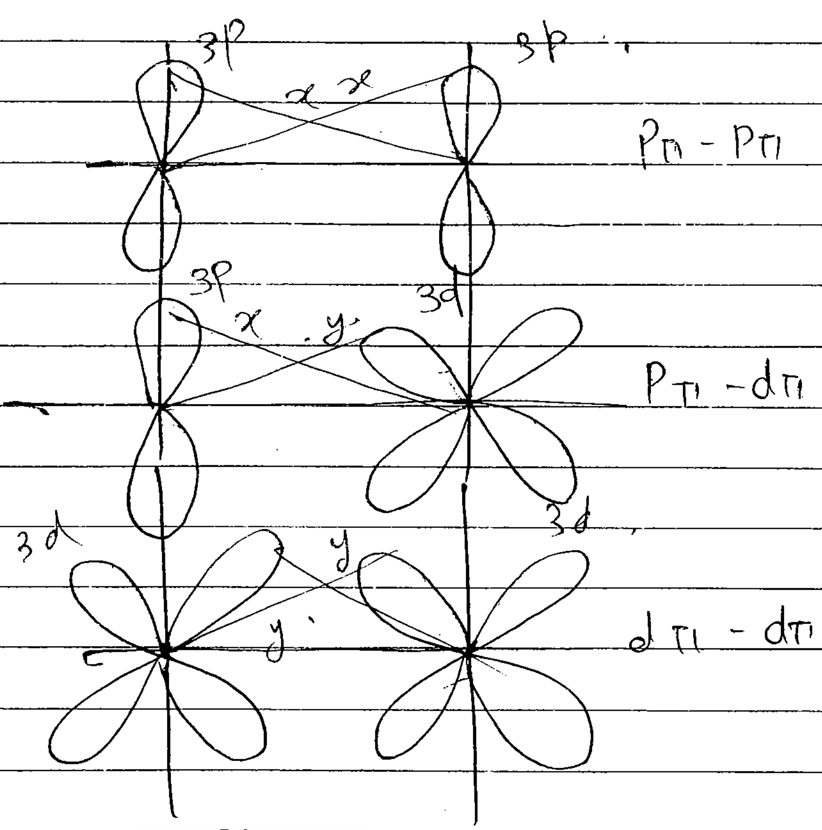
(2). 1s-2pz > 1s-3pz > 1s-4pz > 1s-5pz.

(3). $2p_z - 2p_z > 3p_z - 3p_z > 4p_z - 4p_z > 5p_z - 5p_z$.

(4). 2s

5).

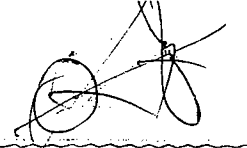
COMPARISON OF $p\pi - p\pi$, $p\pi - d\pi$, $d\pi, d\pi$



distance $x > y$.
Strength $p\pi - p\pi < p\pi - d\pi < d\pi - d\pi$.

Qus. Arrange them in correct order of strength (IN·A ↑ Z)

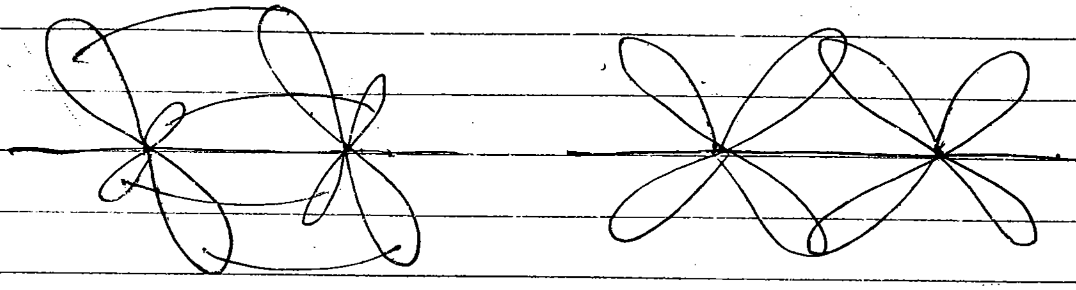
$3s - 3s$, $3s - 3p_x$, $3p_y - 3p_y$, $3d_{xz} - 3p_z$, $3d_{xz} - 3d_{xz}$
$3p_z - 3p_z$



$3p_z - 3p_z > 3s - 3s > 3d_{xz} - 3d_{xz} > 3p_y - 3p_y$ ~~$> 3s - 3p_x = 3d_{xz} - 3p_z$~~

~~$3s - 3p_x$ and $3d_{xz} - 3p_z$~~ $\longrightarrow$ Zero overlapping

$\boxed{d_\delta - d_\delta \text{ and } d_\pi - d_\pi}$



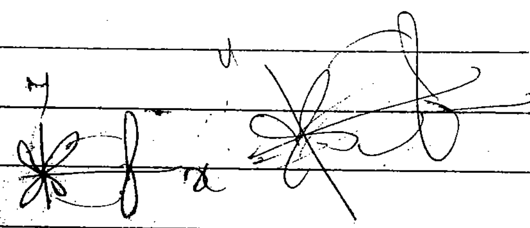
Strength ↑ All (100%) lobes take part in overlapping

50% lobes take part in overlapping

Strength ↓

$d_\pi - d_\pi < d_\delta - d_\delta$

Now $\boxed{\sigma > \delta > \pi}$



Q. Arrange them in correct order of strength (INA = x)

$\overset{\sigma}{3s - 3s}$, $\overset{\sigma}{3p_x - 3p_x}$, $\overset{\pi}{3p_y - 3p_y}$, $\overset{\pi}{3p_z - 3p_z}$, $\overset{\pi}{3d_{xz} - 3d_{xz}}$, $\underset{\pi}{3d_{xy} - 3p_y}$, $3d_{xy} - 3d_{xy}$, $\underset{\delta}{3d_{yz} - 3d_{yz}}$, $\underset{\pi}{3d_{yz} - 3p_y}$.

$3d_{yz} - 3d_{yz} > \pi$

$3p_x - 3p_x > 3s - 3s > 3d_{xy} - 3d_{xy} = 3d_{xz} = 3d_{xz} > 3d_{xy} - 3p_y =$ ~~$3d_{yz} - 3p_y$~~

$> 3p_z - 3p_z = 3p_y - 3p_y$

and they minimise ...

3dyz – 3py so zero
δ π

~~3px – 3px~~ >

Ex $3p_x - 3p_x > 3s - 3s > 3d_{yz} - 3d_{yz} > 3d_{xy} = 3d_{xy} = 3d_{xz} - 3d_{xz}$

>

FORMATION OF H_2

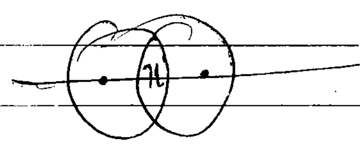
H 1s¹ [↑]

H 1s¹ [↓]

$H_2 \longrightarrow$ H — H.

1s — 1s. (σ bond)

Diamagnetic.

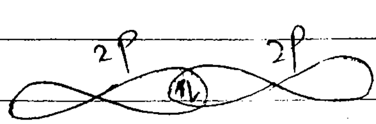


		$2s^2$	$2p^5$
F_2.	F	[↑↓]	[↑↓ | ↑↓ | ↑]
	F	[↑↓]	[↑↓ | ↑↓ | ↓]

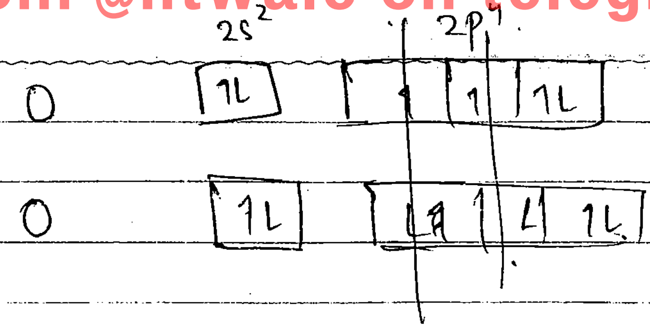
$F_2 \longrightarrow$:Ḟ̤ — Ḟ̤:

↑

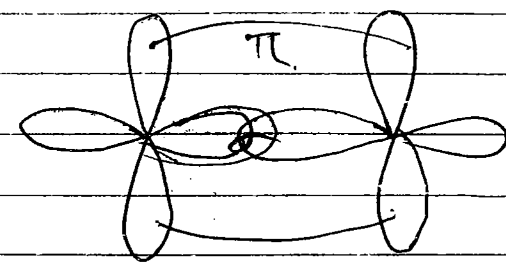
σ bond.



O_2.



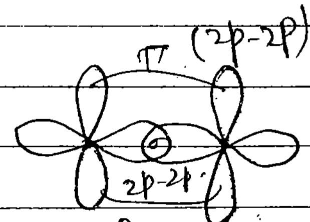
$\ddot{O}=\ddot{O}$ Bond order (No. of bonds b/w two atoms) = 2



According to VBT O_2 is ~~per~~ diamagnetic but practically O_2 is paramagnetic. It is a drawback of VBT.

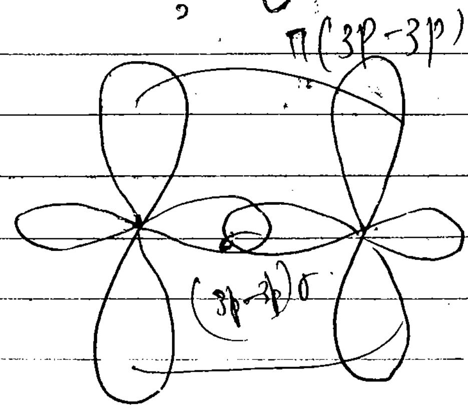
Ans Explain oxygen exist ~~at~~ as O_2 but sulphur doesn't exist as S_2.

O_2.



size effective overlapping

S_2.



Size ↑

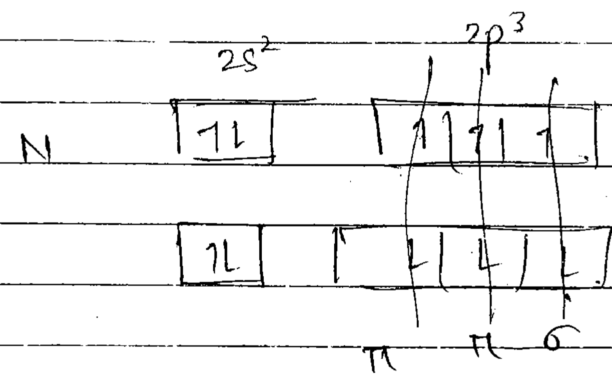
~~overlappe~~ ineffective overlapping ↑

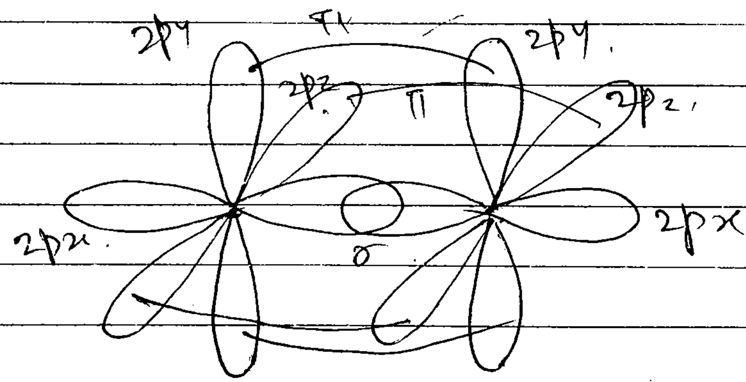
Bond strength ↓

Ⅲ. F_2 ✓ Cl_2 ✓
only σ only σ.

O_2 ✓ S_2 ✗ Se_2 ✗ Te_2 ✗.
σ as well as π σ as well as π not effective due to larger size.

N_2

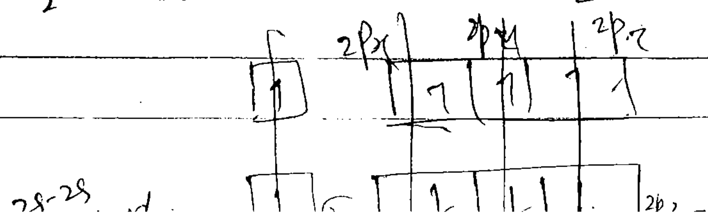




N_2 ✓ , P_2 ✗.
:P≡P: $3p_\pi - 3p_\pi$

N_2 exist but P_2 doesn't exist because $3p_\pi - 3p_\pi$ overlapping is not effective in phosphorus.

C_2 doesn't exist as C≡C. lu INA = X.



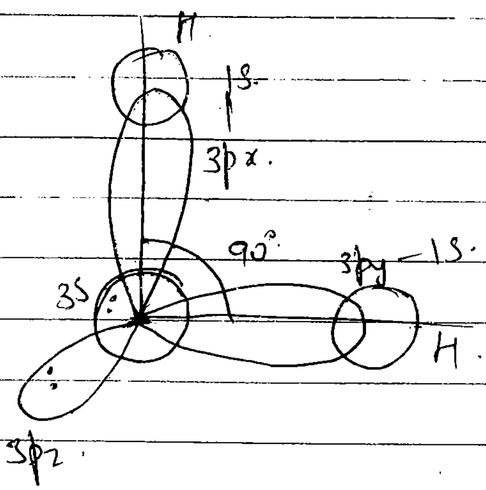
2 sigma bond can't exist b/w two atoms because on internuclear axis (space of 1 orbital) only 2 e⊖s can exist, that's why C≡C doesn't exist.

Formation of H_2S

H_2S. S. $3s^2$ [↑↓] $3p^4$ [↑↓ | ↑ | ↑] ($3p_z$, $3p_y$, $3p_x$)

[↓] [↓]
1s 1s
H H

$\ddot{\underset{..}{S}}$—H
|
H.



3p – 1s two bonds of equal energy.
then Bondangle = 90°
practically BA ≃ 90°
so formation of H_2S can be explained by overlapping of pure atomic orbital, no need of Hybridisation.

Formation of HF

F. $2s^2$ [↑↓] $2p^5$ [↑↓ | ↑↓ | ↑]

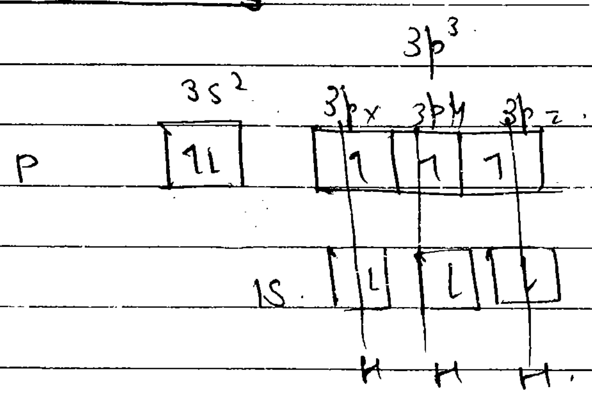
σ

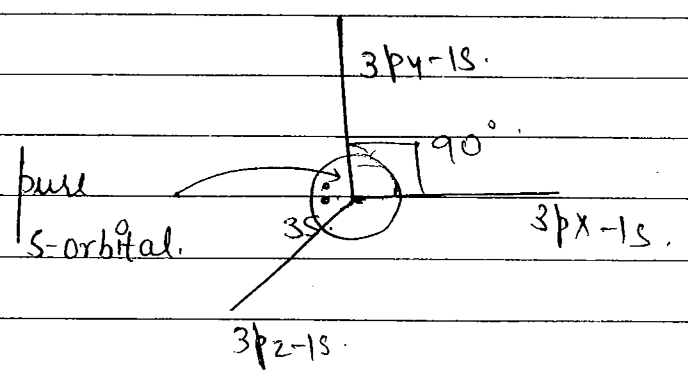
[↓]
H. $1s^1$

H — F	1s — 2p.
H — Cl	1s — 3p
H — Br	1s — 4p
H — I.	1s — 5p.

Strength HF > HCl > HBr > HI.

- <u>formation of PH_3</u>





	theo.	Pract
PH_3	90°	≈90°
AsH_3	90°	≈90°
SbH_3	90°	≈90°
BiH_3	90°	≈90°
NH_3	90°	107°

No need of hybridisation. formation can be explained by overlapping of pure atomic orbitals.

need of Hyb.

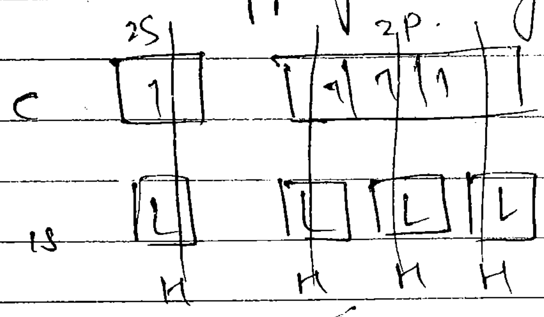
	theo.	prac.	
H_2S	90°	$\approx 90^\circ$	No need of hyb.
H_2Se	90°	$\approx 90^\circ$	
H_2Te	90°	$\approx 90^\circ$	
H_2O	90°	104.5°	need of hyb.

$\boxed{\text{LIMITATION}}$ (1) Overlapping of pure atomic orbitals can explain formation of only diatomic species, PH_3, AsH_3, SbH_3, BiH_3, H_2S, H_2Se, H_2Te.

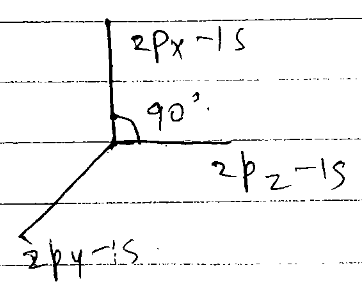
(2) It explains formation of π and δ bonds.

CH$_4$

Acc. to overlapping theory



three bonds (2p-1s) are ⊥ to each other.
other bond direction (2s-1s) is ~~unperpendicular~~ unpredictable.



Strength $2px-1s = 2py-1s = 2pz-1s > 2s-1s$

Practically

Bond angles = 109°28'
All bonds r identical in CH_4, strength of all bonds r same
It meas bond forming orbitals of 'C' are identical.

It is possible when one 2s orbital mix with ~~3~~ three 2p orbitals and form same no. of orbitals identical in shape and energy. This mixing of orbitals is called "HYBRIDISATION" and new equivalent orbitals are called "HYBRID ORBITALS"

These hybrid orbitals are configured in 3d at minm repulsion, which decides geometry of hybrid orbitals.

Almost same energy atomic orbitals take part in mixing.

$\boxed{\text{NOTE}}$ Same type of orbitals of different shell having high energy difference do not take part in mixing.

$\boxed{ns\ np\ nd}$ Mixing ✓

d block (n-1)d & ns.
energy diff. very less.

(n-1)d ns np mixing ✓

(n-1)d ns np nd mixing ✗.

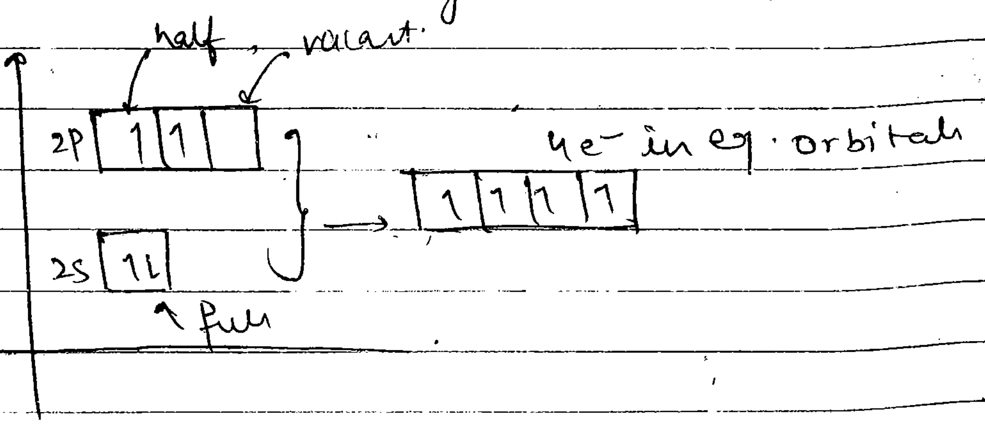
ex. $3s + 3p + 3d$ ✓

$\cancel{2d} + 3s + 3p$ ✗

$3d + 4s + 4p$ ✓

$3d + 4s + 4p + 4d$ ✗

All type of atomic orbitals (half filled / full filled & vacant) take part in mixing and no requirement of excitation in hybridisation.



Name of Hybrid Orbitals depends on orbitals which take part in mixing.

$ns(1) + np(1) \longrightarrow sp\ (2)$

$ns(1) + np(2) \longleftrightarrow sp^2\ (3)$

$ns\ (1) + np(3) \longleftrightarrow sp^3 (4)$

$(n-1)d\ (1) + ns(1) + np(3) \longrightarrow dsp^3 (5)$

$(n-1)\ d\ (3) + ns(1) \rightarrow d^3s\ (4)$

$(n-1)\ d\ (2) + ns(1) + np(3) \longrightarrow d^2sp^3\ (6)$

$ns(1) + np(3) + nd\ (2) \longrightarrow sp^3d^2\ (6)$

~~Geom~~

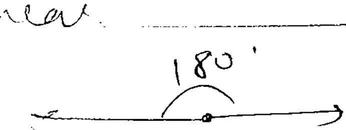
$\boxed{\text{Geometry of Hybrid Orbitals}}$

1). SP. Geometry = linear

$s + p_x \Rightarrow$ x axis

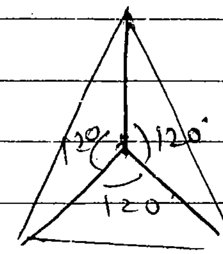
$s + p_y \Rightarrow$ y axis

$s + p_z \Rightarrow$ z axis



2). sp^2 trigonal planar.

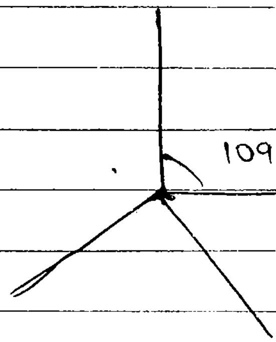
$s + p_x + p_y \Rightarrow xy$
$s + p_y + p_z \Rightarrow yz$
$s + p_x + p_z \Rightarrow xz$.

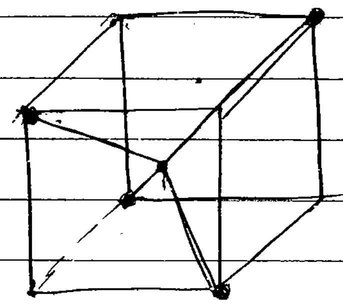


BA = 120° (3).

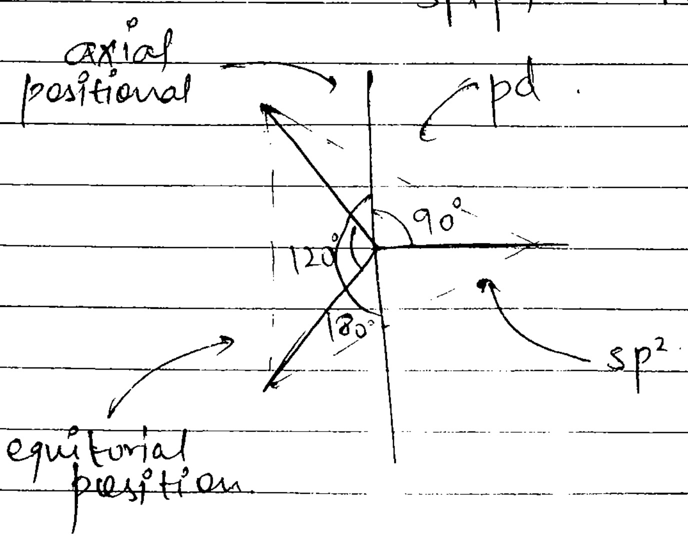
3). sp^3. (tetrahedral). (alternate corner of cube)

$s + p_x + p_y + p_z$. (3D).



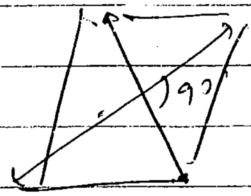


4). sp^3d (sp^2 + pd.).
sp_xp_y $p_z + d_{z^2}$ trigonal bipyramidal



90° = 6
120° = 3
180° = 1.

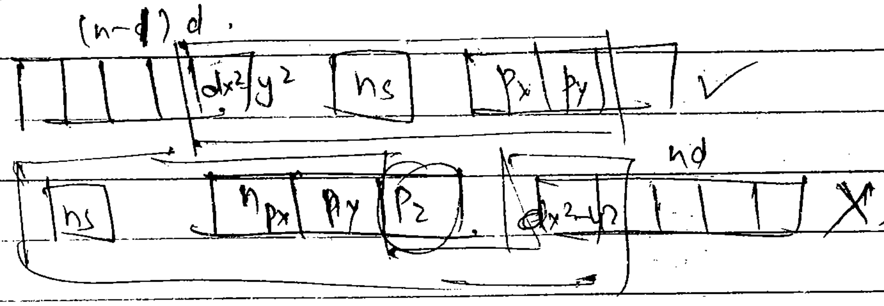
5). dsp^2 (d block element)



xy plane.

S Px Py ~~Pz~~
along the axis.

d_{xy} X $d_{x^2-y^2}$
b/w the axis along the axis.

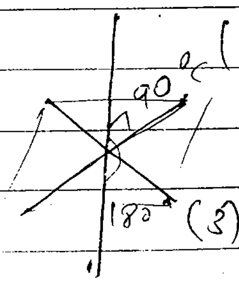


dsp^2
~~sp^2d~~
sp^2d.

6). d^2sp^3 / sp^3d^2.
d-block.

square bipyramidal

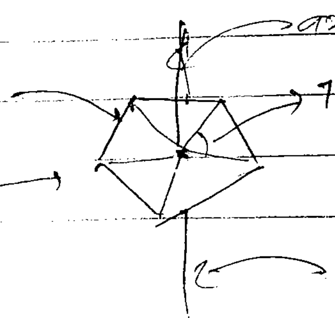
Octahedral



s px py $d_{x^2-y^2}$
Pz d_{z^2}.

7). sp^3d^3 (sp^2d^2 + pd)

equitorial



Pentagonal Bipyramidal.

s px py $d_{x^2-y^2}$
dxy.

pz + d_{z^2}.

Qu. Match them correctly (Matrix Match).

I Geometry of hybrid orbitals	II Atomic orbitals which take part in mixing
(A). trigonal planer (xy plane) sp^2	(i) Non-directional orbital (s)
(B). trigonal bi pyramidal. sp^3d (d_{z^2}, $d_{x^2-y^2}$, d_{xy})	(ii). Axial orbital ($p_x, p_y, p_z, d_{z^2}, d_{x^2-y^2}$)
(C). Pentagonal bi pyramidal. sp^3d^3	(iii). Non-axial orbital (d_{xy}, d_{yz}, d_{xz})
(D). Square bipyramidal. d^2sp^3 ($d_{z^2}, d_{x^2-y^2}$)	(iv). Orbital having no nodel plane. (s, d_{z^2})

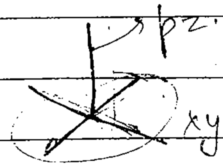
(A) (i), (ii) (iv)

(B) ~~(ii) (iv) (iii)~~ (i) (ii) (iv)

(C) III, IV, II, I

(D) IV, II, I.

Q Select the d- orbital which participate in dsp^3. (square b. pyramidal ✗) Hybridization.



s px py

~~pz~~ ~~d_{z^2}~~, $d_{x^2-y^2}$

Q. Tetrahedral geometry is form by sp^3 or d^3s hyb. In sp^3 hyb. s orbitals is mixed with px, py, pz orbital. Select the 'd' orbitals which take part in d^3s hyb. to form tetrahedral geometry

d_{xy}, d_{yz}, d_{xz}, $d_{x^2-y^2}$, d_{z^2}.

As like px, py, pz, dxy, dyz, dxz are equally perpendicular to each other and cover all dirⁿs in 3D, so, in d_3s hyb. dxy, dyz, dxz orbitals are present.

Ans. dxy, dyz, dxz

Comparison of Hybrid Orbital and Pure Atomic Orbital

Strength

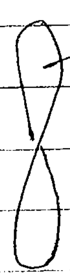
Pure atomic orbital: S < P (Nondirⁿ, dirⁿ) < Hybrid orbital sp^n

1). directional due to presence of 'p' orbital

2). Near to the nucleus as compare to pure p orbital due to presence of 's'. (s is near to the nucleus)

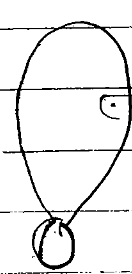
Shape of hybrid orbital

P



50% e⁻ density in a lobe.

Hybrid orbital



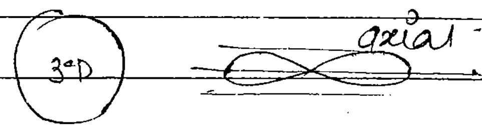
e⁻ density ↑ > 50%,

bigger lobe for better overlapping

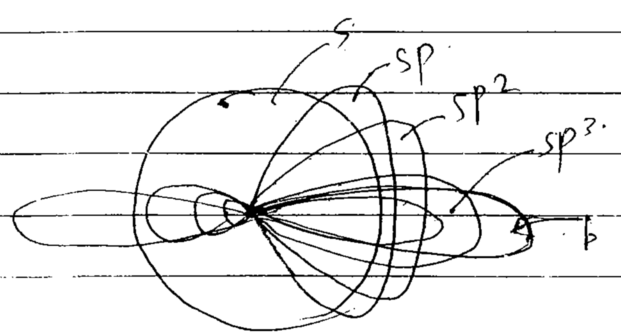
as e⁻ density ↑ attrⁿ with nucleus ↑ strength ↑

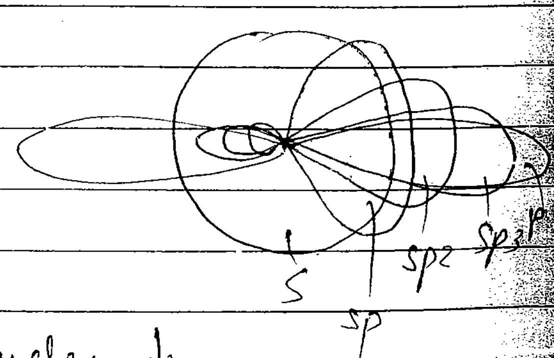
% S CHARACTER

	s		p
distance from nucleus		<	
angular vol. of lobe		>	



	sp		sp²		sp³
% s.	50%		33.3%		25%
distance from nucleus.		<		<	
attⁿ		>		>	
Strength		>		>	
Angle	180°		120°		109°28′
Angular volᵐ		>		>	





% s ↑ distance from nucleus ↓

Bond angle ↓

attⁿ ↑

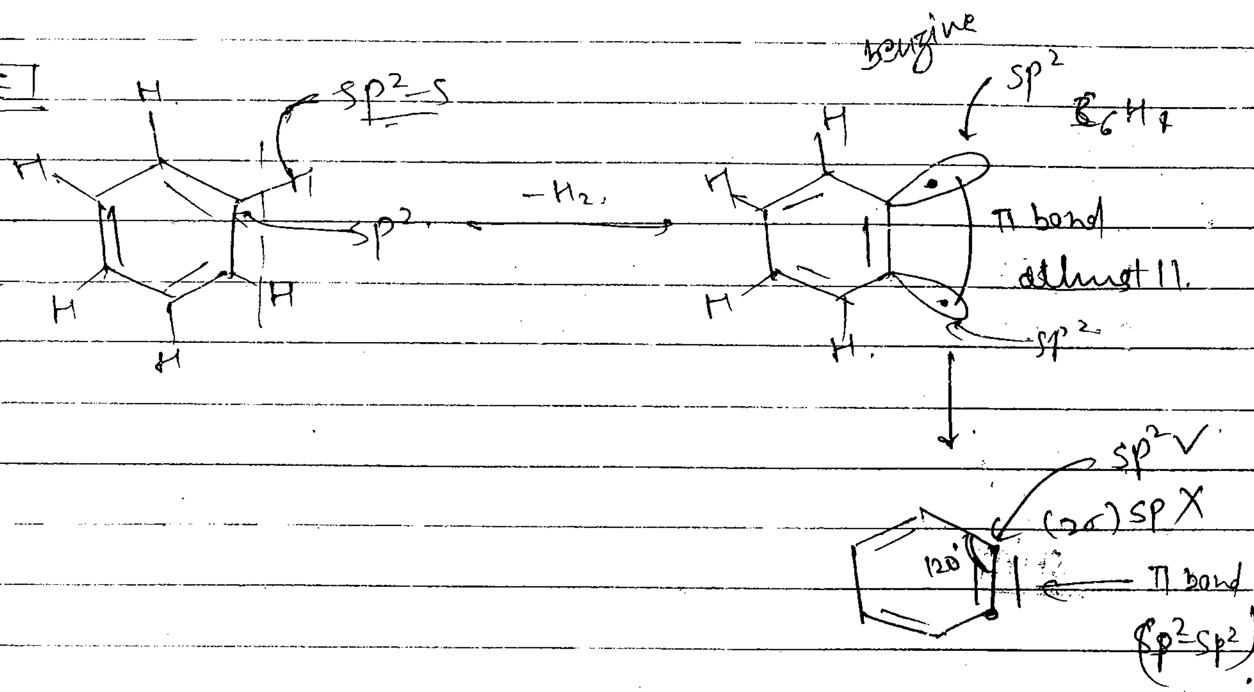
Bond energy ↑

Angular vol ↑

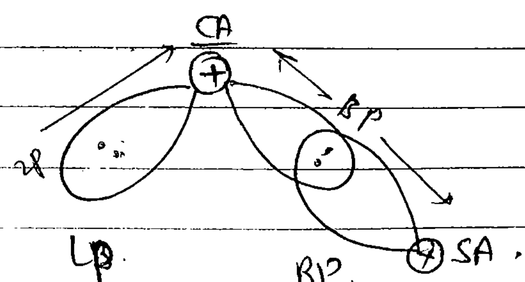
Bond Angle ↑

NOTE Hybridisation is decided by Bond angle but generally no. of hybrid orbital equal to no. of σ bonds + lone pair, it means hybrid orbital contain lonepair and it form only σ bond.

NOTE



EFFECT OF LONEPAIR



Space required in 3-D ↑	Space required in 3-D ↓
Near to the nucleus of CA.	Far away from the nucleus of CA. in comparison of LP
% S ↑, attⁿ ↑	% S ↓ attⁿ ↓.

lone pair bond pair ke comparison me zyada failega, usko space zyada chahiye, sabse zyada repulsion karega.

VALENCE SHELL ELECTRON PAIR REPULSION THEORY (VSEPRT)

Valence shell $e^{\ominus}$pair repel each other and their repul^n order is

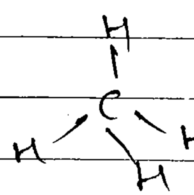
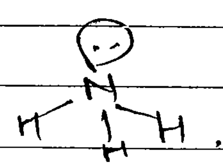
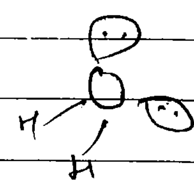
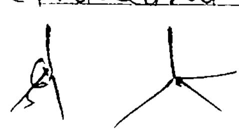
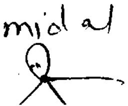
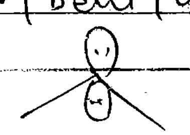
(1) LP-LP > LB-BP > BP-BP

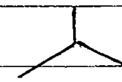
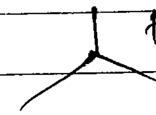
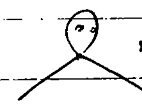
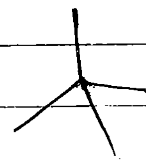
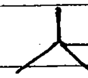
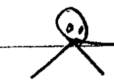
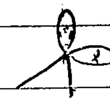
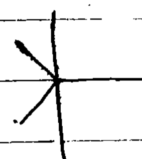
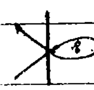
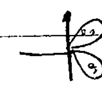
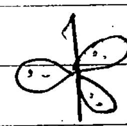
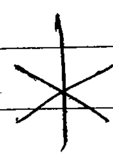
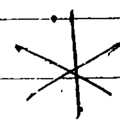
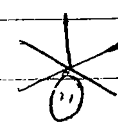
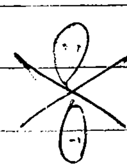
(2) MB-MB > MB-SB > SB-SB'

MB = Multiple bond
SB = Single bond

SHAPE AND GEOMETRY OF MOLECULES

ex.

	CH_4	NH_3	H_2O.
			
σ :	4	3	2
LP.	0	1	2
Total.	4	4	4.
	sp^3	sp^3	sp^3
Geometry/ Geo. of Hybrid orbital/ e$^{\ominus}$nic geo.) (σ + LP).	Tetrahedral	Tetrahedral	Tetrahedral
Shape/molecular geo. (only σ).	tetrahedral 	trigonal pyramidal 	V/ bent / angular 

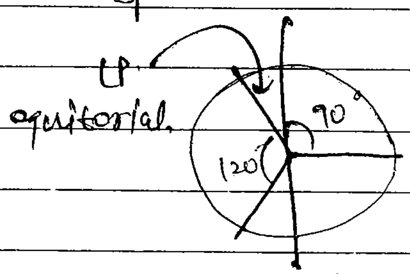
σ	LP	total hybrid orbitals	Hyb.	e^- geo.	Molecular geo. shape
2	0	2	sp	linear	linear.
3	0	3	sp^2	 trigonal planer.	 trigonal planer
2	1	3	sp^2.		 v/bent/angular.
4	0	4	sp^3	 tetrahedral.	 tetrahedra
3	1	4			 trigonal pyramidar.
2	2	4.			 v/bent/ang.
5	0	5	sp^3d.	 trigonal bipyramidar.	 TBP.
4	1	5			 see saw
3	2	5			 T.
2	3	5			 linear.
6	0	6	sp^3d^2	 Octahedral square bip.	 octahedral,
5	1	6			 square pyramidal
4	2	6			 square planer
3	3	6			

not possible
bcoz of LP LP
repulsion

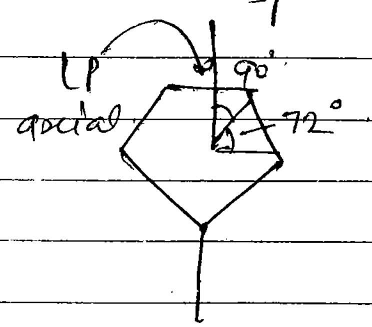
shaps lon 4 2 6

all hybrid orbitals are identical, equatorial bond angle. But in sp^3d, sp^3d^3 LP aquire position where %s are high (Bond angle / morespace).

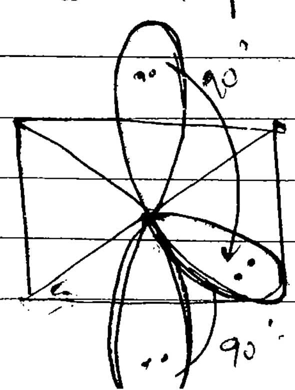
sp^3d.



sp^3d^3.



⇒ 3+3 is not possible.



Due to high repuln less stable molecule.

SPECIES	σ	LP	No. of HYBRID ORBITALS	Hyb.	SHAPE Geometry
$BeCl_2$	2	0	2	sp	linear
$BeCl_3^-$	3	0	3	sp^2	trigonal planar
$BeCl_4^{2-}$	4	0	4	sp^3	tetrahedral
BH_3	3	0	3	sp^2	trigonal planar
BO_3^{3-}	3	0	3	sp^2	trigonal planar
BH_4^-	4	0	4	sp^3	tetrahedral
BF_3	3	0	3	sp^2	trigonal planar
BF_4^-	4	0	4	sp^3	tetrahedral
CO_2	2	0	2	sp	linear
$COCl_2$	3	0	3	sp^2	Trigonal Planar
CH_2Cl_2	4	0	4	sp^3	Tetrahedral
CH_4	4	0	4	sp^3	Tetrahedral

SHAPE	B A.	Equi. or non-eq. hybrid orbitals	Planer/ Non-planer.	Polar/ non-polar.
linear	180°	equi.	Planer.	NP
trigonal planer	120°	equi	Planer.	NP
tetrahedral		equi.	Non Planer	NP
Tri. Planer		equi	Planer	NP
Tri. Planer.		equi.	Planer.	NP
Tetrahedral		equi.	non. planar	NP
Tri Planer		equi	Planer	NP
Tetrahedral		equi.	non planar	NP
linear		equi.	planer	NP
Tri. Planer.		non - equi.	planer	P
Tetrahedral		non - equi.	NP	P
Tetrahedral		equi.	NP	NP

SPECIES	σ	LP	No. of hyb. Orbitals	Hybdi^n	Geometry
CO_3^{2-}	3	0	3	sp^2	Trigonal Planer
NO_2^+	2	0	2	sp	linear
NO_2^-	2	1	3	sp^2	Trigonal Planer
NO_3^-	3	0	3	sp^2	Trigonal planer
NH_4^+	4	0	4	sp^3	Tetrahedral
NH_3	3	1	4	sp^3	Tetrahedral
NH_2^-	2	2	4	sp^3	Tetrahedral
NOF_3	4	0	4	sp^3	Tetrahedral
H_2O	2	2	4	sp^3	Tetrahedral
H_3O^+	3	1	4	sp^3	Tetrahedral
O_3	2	1	3	sp^2	Trigonal Planer
$AlCl_3$	3	0	3	sp^2	Trigonal Planer
$AlCl_4^-$	4	0	4	sp^3	Tetrahedral
AlF_6^{3-}	6	0	6	sp^3d^2	SBP

SHAPE	BA.	Equi. or Equi hybrid orbitals	Planar/ non Planar	Polar/ non Polar
Trig. Planar.		equi.	P	NP
linear		equi.	P	N.P
V/bent)		Non-equi,	P	P
Tri. Planar.		equi.	P	NP
Tetrahedral.		equi.	NP	NP
Trig. Pyramidal		non-equi	NP	P
V/ bent.		non-equi.	P.	P
Tetrahedral		non-equi	NP.	P
bent/V		non-equi.	P	P
Trig. Pyramidal.		non-equi.	NP.	P
V/bent.		non-equi.	P.	P
Tri. Planar.		equi.	P.	NP
Tetrahedral.		equi.	NP	NP
SBP		equi	NP	NP

SPECIES	σ	LP	No. of hybrid Orbitals	Hybrⁿ	Geometry
$SiCl_4$	4	0	4	sp^3	Tetrahedral
SiF_6^{2-}	6	0	6	sp^3d^2	SBP
SiO_4^{4-}	4	0	4	sp^3	Tetrahedral
PCl_3	3	1	4	sp^3	Tetrahedral
PCl_4^+	4	0	4	sp^3	Tetrahedral
PCl_5	5	0	5	sp^3d	PBP
PCl_6^-	6	0	6	sp^3d^2	SBP
$POCl_3$	4	0	4	sp^3	Tetrahedral
PO_4^{3-}	4	0	4	sp^3	Tetrahedral
PH_4^+	4	0	4	sp^3	Tetrahedral
SO_2	2	1	3	sp^2	Trigonal Planar
SO_3	3	0	3	sp^2	Trigonal Planar
$SOCl_2$	3	1	4	sp^3	Tetrahedral
SO_2Cl_2	4	0	4	sp^3	Tetrahedral

SHAPE	BA	Equi or non Equi hybrid orbitals	Planer/ nonplaner	Polar/ non polar
Tetrahedral		equi	NP	NP
SBP		equi	NP	NP
Tetrah.		equi	NP	NP
Trig. Pyramidal		non-equi	NP	P
Tetrah.		equi	NP	NP
TBP		non-equi	NP	NP
SBP		equi	NP	NP
Tetrah.		non-equi	NP	P
Tetrah.		equi	NP	NP
Tetrah.		equi	NP	NP
V/ bent		non-equi	P	P
Trig. Planer		equi	P	NP
Trig. Pyramidal		non-equi	NP	P
Tetrahedral		non-equi	NP	P

SPECIES	σ	LP	No. of Hybrid Orbitals	Hybridi-di^n	Geometry
SO_3^{2-}	3	1	4	sp^3	Tetrahedral
SO_4^{2-}	4	0	4	sp^3	Tetrahedral
SF_2	2	2	4	sp^3	Tetrahedral
SF_4	4	1	5	sp^3d	TBP
SF_6	6	0	6	sp^3d^2	SBP
OSF_4	5	0	5	sp^3d	TBP
TeF_6	6	0	6	sp^3d^2	SpBP
TeO_6^{6-}	6	0	6	sp^3d^2	SBP
IF_7	7	0	7	sp^3d^3	PBP
ClF_6^+	6	0	6	sp^3d^2	SBP
BrF_5	5	1	6	sp^3d^2	SBP
BrF_4^-	4	2	6	sp^3d^2	SBP
ICl_3	3	2	5	sp^3d	TBP
BrF_2^+	2	2	4	sp^3	Tetrahedral
BrF_2^-	2	3	5	sp^3d	TBP
I_3^-	2	3	5	sp^3d	TBP
IO_6^{5-}	6	0	6	sp^3d^2	SBP
ClO_4^-	4	0	4	sp^3	Tetrahedral
ClO_3^-	3	1	4	sp^3	Tetrahedral
ClO_2^-	2	2	4	sp^3	Tetrahedral
IOF_5	6	0	6	sp^3d^2	SBP
XeF_2	2	3	5	sp^3d	TBP
XeF_3^+	3	2	5	sp^3d	TBP
XeF_5^+	5	1	6	sp^3d^2	SBP
XeF_5^-	5	2	7	sp^3d^3	PBP
XeO_3	3	1	4	sp^3	Tetrahedral
XeO_6^{4-}	6	0	6	sp^3d^2	SBP

SHAPE	BA	EQUI OR Non-Equi Hybrid Orbital	Planer/ Non-planer	Polar/ non-Polar
Tri. Pyramidal.		non-equi.	NP	P
Tetrah.		equi	NP	NP
V/bent		~~non eq~~ nonequi	P	P
See Saw		non equi.	NP	P
SBP		equi.	NP	NP
TBP		non equi	NP	NP
SBP		equi.	NP	NP
SBP		equi	NP	NP
PBP		non-equi	NP	NP
SBP		equi.	NP	NP
Square Pyramidal		non equi	NP	P.
Square Planar		non equi.	P	NP
Tshaped		non equi	P	P
V/bent		non equi.	P	P
linear		non equi.	P	NP
linar		non equi.	P	NP
SBP		equi.	NP	NP
Tetrah.		equi.	NP	NP
Tri. Pyramidal.		non equi.	NP	P
v/bent		non equi.	P	P
SBP		non equi	NP	P
Linear		non equi.	P	NP
T shaped		non equi.	P	P
Square Pyramidal		non equi.	NP	P
Pentagonal Planar		non equi.	P	NP
Tri. Pyramidal		non equi.	NP	P
SBP.		equi	NP	NP

SPECIES	σ	LP	No. of Hybrid orbitals	Hyb.	Geometry
$XeOF_2$	3	2	5	sp^3d	TBP
XeO_2F_2	4	1	5	sp^3d	TBP
XeO_3F_2	5	0	5	sp^3d	TBP
$SnCl_2$	2	1	3	sp^2	Trig. planer
$IO_2F_2^-$	4	1	5	sp^3d	TBP
XeF_6	6	1	7	sp^3d^3	PBP
XeF_4	4	2	6	sp^3d^2	SBP

distorted octahedral
in place pentagonal/bipyramidal

SHAPE	BA	Equi/non equi hybrid Orbital	Planar/non-planar	Polar/non-polar
T shaped		non-equi	P	P
see saw		non-equi	NP	P
TBP		non equi	NP	NP
V/bent		non equi	P	P
see saw		non equi	NP	P
capped octahedral		non equi	NP	P
Square Planer		non equi	P	NP

Short Trick (for single C.A.)

$$\frac{\text{total valency } e^{\ominus}}{8} = Q + R.$$

$\sigma = Q.$
$LP = R/2$

* Consider valency e^- of $x = 7$ alike 'F'.

$$PCl_4^{+} \Rightarrow \frac{5 + (4 \times 7) - 1}{8} = 4.$$

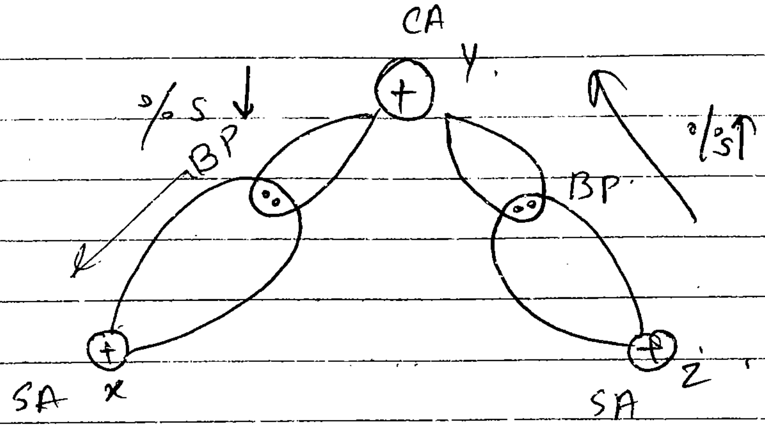
$$NO_3^- = \frac{5 + (6 \times 3) + 1}{8} = 3 + \hat{0}.$$

$$XeF_5^- = \frac{8 + (7 \times 5) + 1}{8} = \frac{44}{8}$$

$Q = 5$ $\quad$ $\sigma = 5$
$R = 4$ $\quad$ $LP = 2.$

EFFECT OF MORE ELECTRONEGATIVE ATOM

when different surrounding atoms are present



EN · $x > y > z$

BENT'S RULE

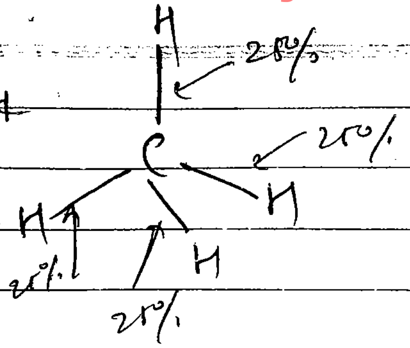
Statement-I

In sp^2, sp^3 and sp^3d^2 hybridisation (before bond form all hybrid orbitals are identical, identical bond angle)

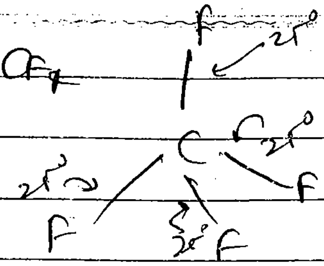
ⓐ. lone Pair can aquire any position but due to presence of LP % s character increases in that hybrid orbitals and % s character decreases in Other hybrid orbitals.

ⓑ. More electronegative atom can aquire any position but due to presence of more electro negative atom % s character decreases in hybrid orbitals and % s character increases in Other hybrid orbitals.

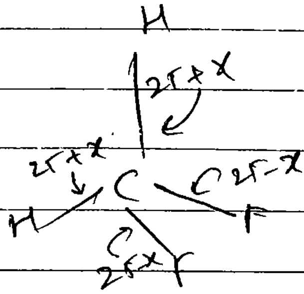
CH_4



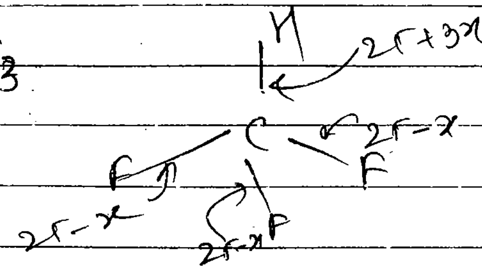
CF_4



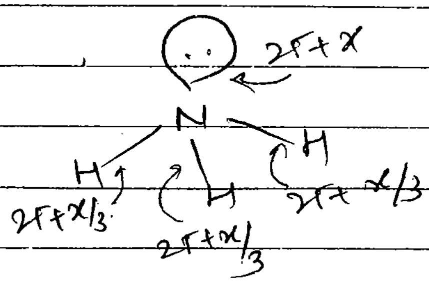
CH_2F_2



CHF_3



NH_3



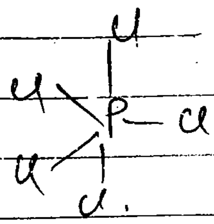
<u>Statement-II</u>

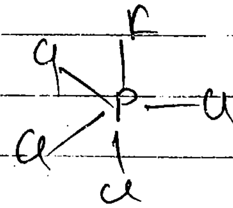
In sp^3d and sp^3d^3 hybridisation (all hybrid orbitals are not equivalent, diff. b.BA).

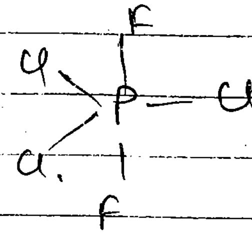
(a). LP aquire position where % s character are high (more space, greater BA). In sp^3d LP present at equitorial position while in sp^3d^3 LP present at axial position.

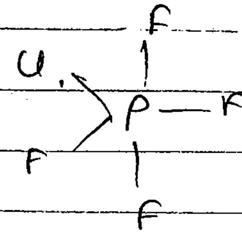
(b) More electronegative atom aquire position where % s character is low (less attⁿ of nucleus of CA). In sp^3d more EN atom present at axial position.

PCl_5 $\quad$ PCl_4F. $\quad$ PCl_3F_2 $\quad$ PCl_2F_3.

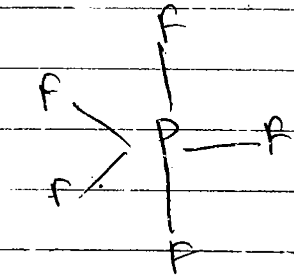








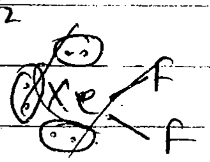
PF_5

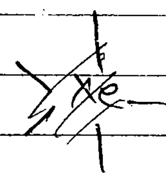


Que. Draw correct structure with proper orientation

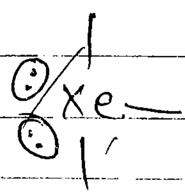
XeF_2 $\quad$ $XeOF_2$ $\quad$ XeO_2F_2 $\quad$ XeO_3F_2.

~~XeF_2~~ $\qquad$ $XeF_2 \longrightarrow sp^3d.$ $\quad$ 2 $\quad$ 3.

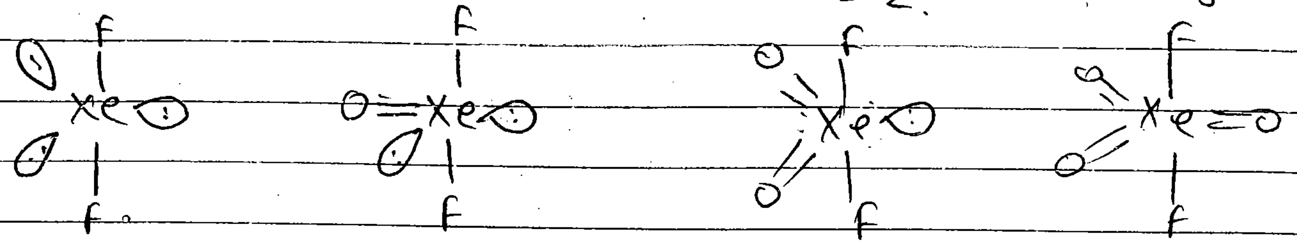




$X\cancel{e}OF_2$.



XeF_2 $\quad$ $XeOF_2$ $\quad$ XeO_2F_2 $\quad$ XeO_3F_2



EQUIVALENT AND NON-EQUIVALENT HYBRID ORBITALS

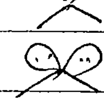
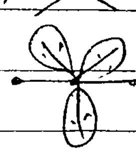
(LP + σ)

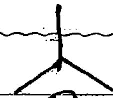
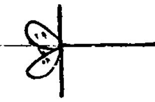
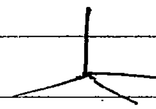
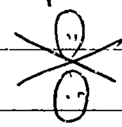
- When all surrounding atoms are identical and lone pair absent at central atom then all hybrid orbitals are equivalent in sp^2, sp^3, sp^3d^2 hybridisation.

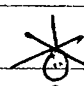
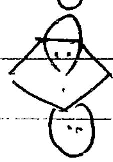
- sp^3d and sp^3d^3 are always non-equivalent hybrid orbitals.

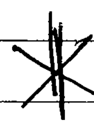
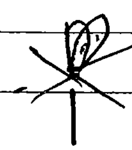
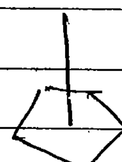
- If lone pair is present on central atom or different surrounding atoms are present hybrid orbitals are always non-equivalent.

EQUIVALENT AND NON-EQUIVALENT BONDING HYBRID ORBITAL

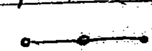
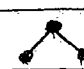
		Shape / mol. geo		All hybrid	Bonding orbitals
AB_2	sp	linear.		eq.	eq
	sp^2	V / bent / ang.		Non eq.	eq
	sp^3	V / bent / ang.		Non eq.	eq
	sp^3d	linear.		Non eq.	eq

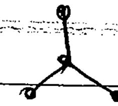
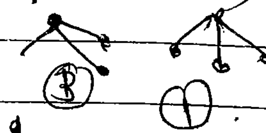
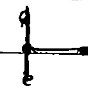
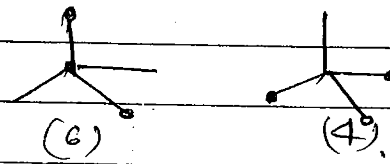
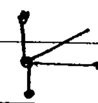
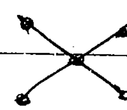
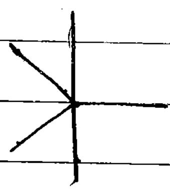
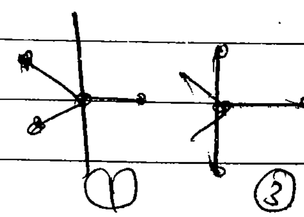
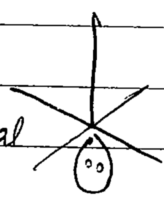
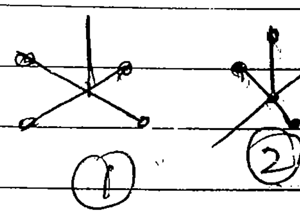
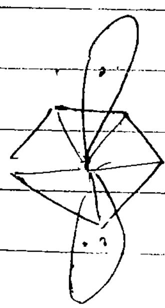
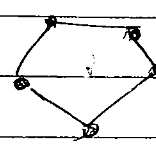
AB_3	sp^2	tri. planer		eq.	eq.
	sp^3	tri pyramidar		Non eq.	eq.
	sp^3d	T shape.		Non eq.	Non eq.
AB_4 ($\sigma = 4$)	sp^3	tetrahedral		eq	eq.
	sp^3d	see saw.		Non eq.	Non eq.
	sp^3d^2	square planer.		Non eq.	Non eq

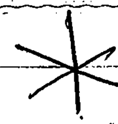
AB_5. ($\sigma = 5$)	sp^3d		Non. eq.	Non. eq.
	sp^3d^2		Non. eq.	Non eq.
	sp^3d^3		Non. eq.	eq.
	~~sp^3d~~			

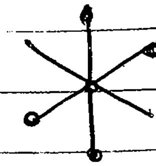
AB_6 ($\sigma = 6$)	sp^3d^2	Octahedral		eq.	eq.
	sp^3d^3	Distorted Octahedral.		non eq.	non eq.
AB_7 ($\sigma = 7$)	sp^3d^3	PBP.		Non eq.	Non eq.

$$\boxed{\text{PLANAR / NON-PLANAR \& MAX. NO. OF ATOMS IN A PLANE}}$$

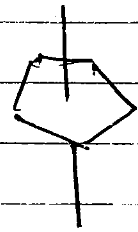
	SHAPE	PLANER.	Max. no. of atoms in a plane.	
AB_2	linear.	✓	3	
	V/ bent / ang.	✓	3	

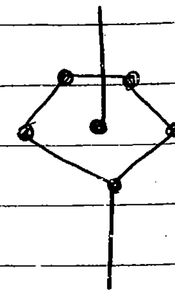
AB_3	trigonal planer	✓	4	
	trigonal pyramidal	✗	3	(4 plane ⇒ 3+1) 
	T shape	✓	4	
AB_4	Tetrahedral	✗	3	(10 plane) 
	see saw.	✗	4 (2 plane)	
	Square planer	✓	5	
AB_5	TBP. 	✗	4 (4 plane)	
	Square pyramidal 	✗	4 (3 plane)	
	Pentagonal planar. 	✓	6	

AB_6 Octahedral  × 5 (3 plane).



AB_7

PBP  × 6



$\boxed{P\pi - P\pi \text{ and } P\pi - d\pi \text{ BONDS}}$

element	orbital(s)	π bond
Ist period	1s	~~1s~~
2nd period	2s, 2p	~~2s~~ 2p ✓

⇒ 2nd period elements always form Pπ bond.

O_2. $\ddot{O} = \ddot{O}$ (π, σ)

Pπ − Pπ

N_2 $:N \equiv N:$

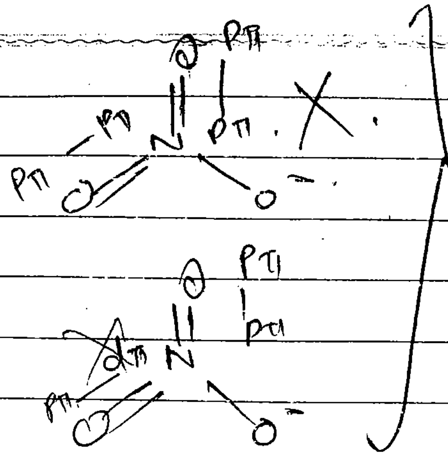
2π (Pπ − Pπ)

CO_3^{2-} $O = C(O^-)(O^-)$ (Pπ — Pπ) σ = 3, LP = 0, π = 1

Hyb of C = sp^2 (σ + LP)

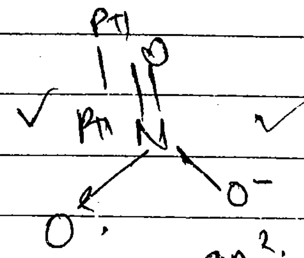
NO_3^- N

NO_3^-



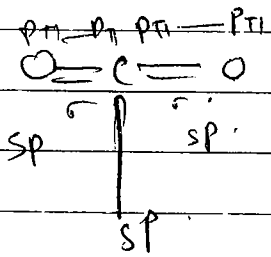
already 2P.

sp^2



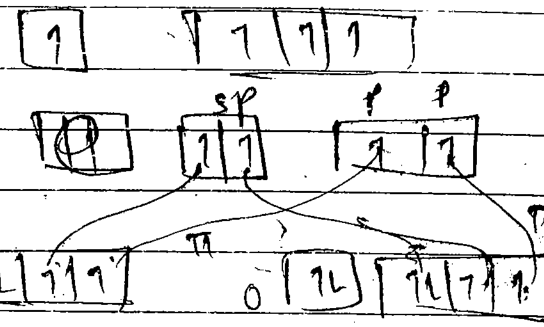
sp^2.

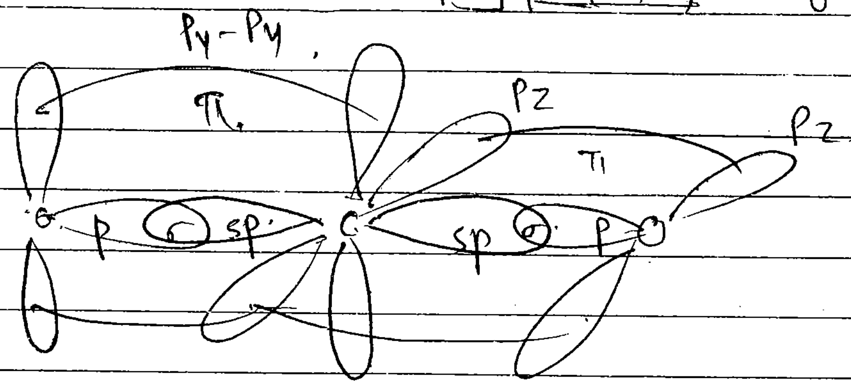
CO_2



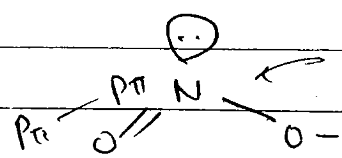
C.

O





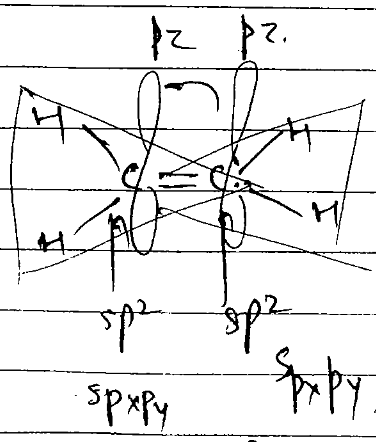
NO_2^-



sp^2 (2σ + 1LP).

C_2H_4

xy plane



xy plane (molecular plane).

Planar π → 1 (pπ − pπ).

Nodal plane for π electrons
Molecular plane (xy).

3^{rd} PERIOD AND BELOW ELEMENTS

Orbitals ns, np ; nd.

π-bond ~~ns~~ np ✓ nd ✓

⇒ hybrid orbital form σ bond & containes lonepairs to form π bond pure orbital required.

sp^2 hybrid atom

$sp^2(\sigma + lp)$.

$\boxed{s \quad p \quad p}$ p d d d d d.

first π bond = pπ
2nd π bond = dπ
3rd π bond = dπ

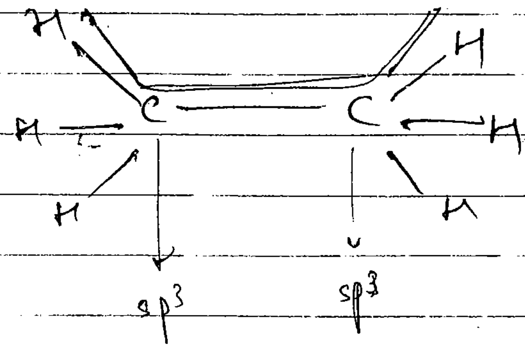
sp^3 hybrid atom.
sp^3d, sp^3d^2
always form dπ bond.

Que. find no. of pπ–pπ & pπ–dπ bonds in

	Hyb	pπ–pπ	pπ–dπ
PO_4^{3-}	sp^3	0	1
		0	4
$POCl_3$	sp^3	0	1
SO_2	sp^2	1	1
SO_3	sp^2	1	2

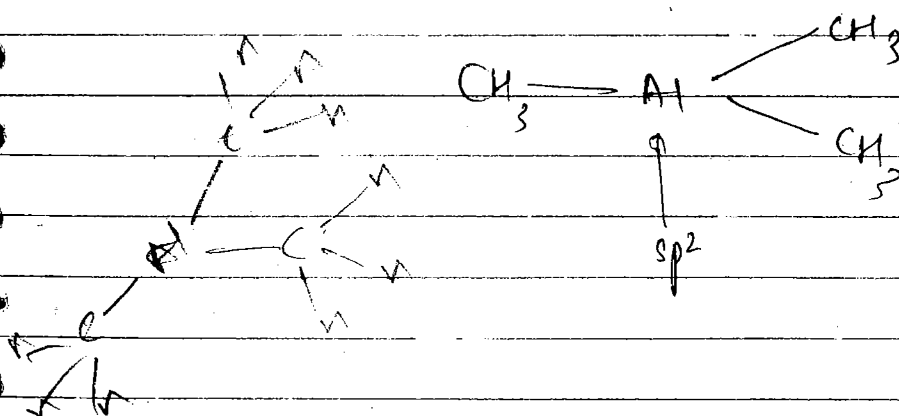
	Hyb.	$p\pi - p\pi$	$p\pi - d\pi$
SO_3^{2-}	sp^3	0	1
SO_4^{2-}	sp^3	0	2
$SOCl_2$	sp^3	0	1
SO_2Cl_2	sp^3	0	2
ClO_4^-	sp^3	0	3
ClO_3^-	sp^3	0	2
ClO_2^-	sp^3	0	1
ClO_2^+	sp^2	1	1
IO_6^{-5}	sp^3d^2	0	1
XeO_3	sp^3	0	3
$XeOF_2$	sp^3d	0	1
XeO_2F_2	sp^3d	0	2
XeO_3F_2	sp^3d	0	3
XeO_6^{4-}	sp^3d^2	0	2
$XeOF_4$	sp^3d^2	0	1
SOF_4	sp^3d	0	1

Que. find max^{m} no. of atoms in a plane in C_2H_6.



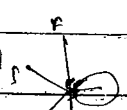
4 atom.

Que: find max no. of atoms in a plane in $Al(CH_3)_3$.

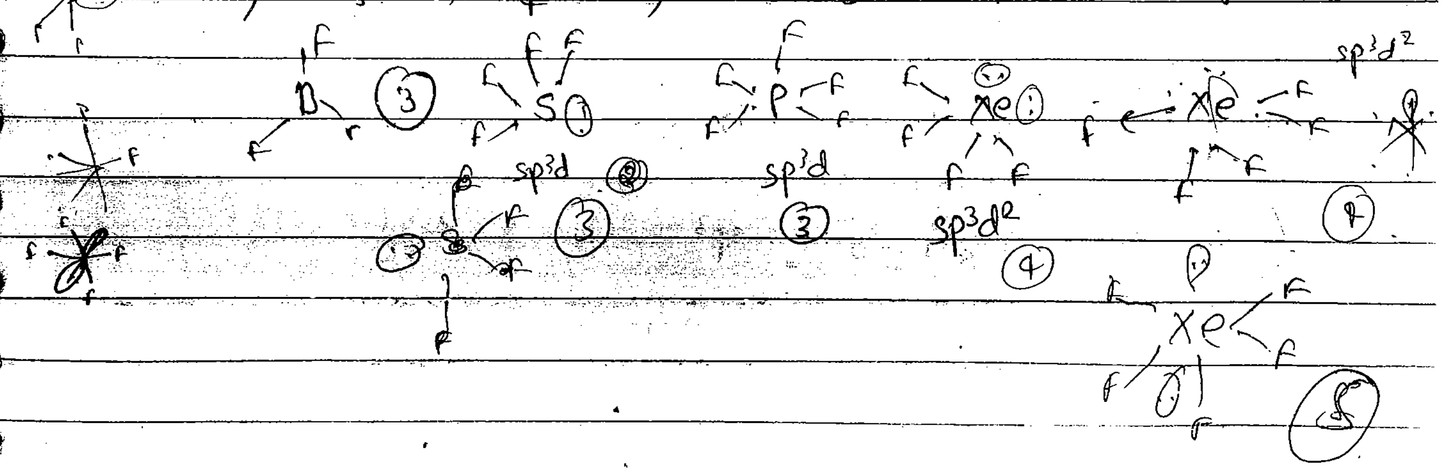


7 atoms.

Que. Find the species in which max 'F' atoms are in a plane.



A) BF_3 B) SF_4 C) PF_5 D XeF_4 E) XeF_5^-



Qn. Select total no. of species in which all oxygen atoms are in a plane.

✓	CO_2,	$O=C=O$		2
✓	NO_2^+	$O=N=O$		2.
✓	NO_2^-	$O=N-O^-$	sp^3	~~3~~ 2.
✓	NO_3^-	$O=N(-O^-)=O$		3
✗	SiO_4^{4-}	$O^- - Si(-O^-)(-O^-) - O^-$	sp^3	2.
✓	SO_2	$O=S=O$	sp^2	2
✓	SO_3	$O=S(=O)=O$	sp^2	3
✓	SO_3^{2-}	$O=S(-O^-)-O^-$	sp^3	3
	SO_4^{2-}	$O=S(=O)(-O^-)-O^-$	sp^3	2.
	ClO_4^-	$O=Cl(=O)(-O^-)=O$	sp^3	2.
✓	ClO_3^-	$O=Cl(-O^-)=O$	sp^2	3
✓	ClO_2^-	$Cl(-O^-)=O$	sp^3	2

CALCULATION OF % S CHARACTER OR HYBRIDISATION INDEX

(3)

	S	p	p/s	θ	cos θ
sp^1	$\frac{1}{1+1}$	$\frac{1}{1+1}$	1	180°	$\frac{-1}{1}$
sp^2	$\frac{1}{1+2}$	$\frac{2}{1+2}$	2	120°	$\frac{-1}{2}$
sp^3	$\frac{1}{1+3}$	$\frac{3}{1+3}$	3	109° 28'	$\frac{-1}{3}$
sp^i	$\frac{1}{1+i}$	$\frac{i}{1+i}$	i		$\frac{-1}{i}$

Any orbital which is made by mixing of s and p orbitals is represent by sp^i where i is p/s ratio, known as "hyb. Index".

Angle b/w two equi. hybrid orbital is represent by θ where cos θ is equal to

~~for any~~ h

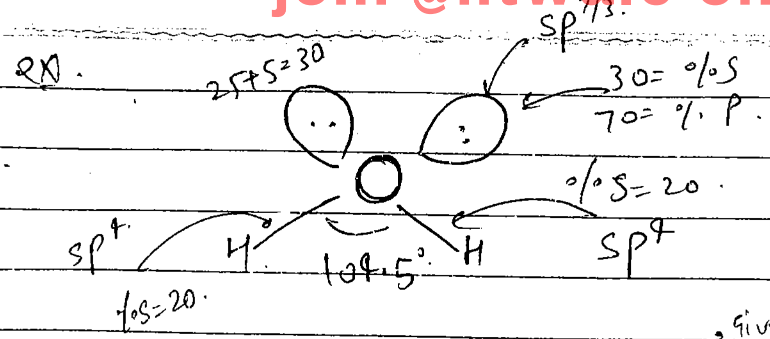
(1) $\cos\theta = \frac{-1}{i} = \frac{-S}{P} = \frac{S}{S-1} = \frac{P-1}{p}$

(2) for any hybrid orbital

$s + p = 1$; $-s = p - 1$

$p/s = i$; $-p = s - 1$

Ex.



$$\cos 104.5^\circ = \overset{\text{given}}{-\frac{1}{4}} = -\frac{1}{l} = \frac{s}{s-1}$$

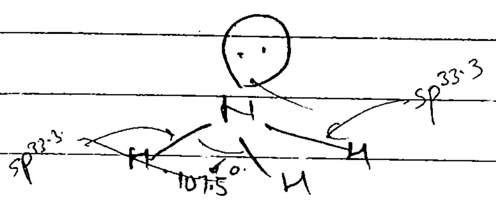
$\underline{l = 4}$ $\quad \% s = 20$

$\% p = 80.$

Que. Find %s in hybrid orbital of 'N' containing lone pair in NH_3

BA in $NH_3 = 107.5^\circ$

$\cos 107.5^\circ = -0.3$



$$\cos 107.5^\circ = -0.3 = -\frac{3}{10} = -\frac{1}{\cancel{33.3}} = -\frac{1}{l}$$

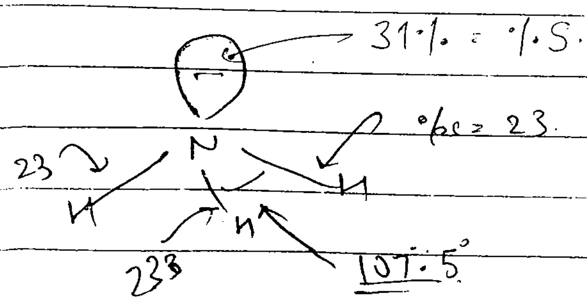
$l = \cancel{33.3}$ $\quad \% s = 33.3$ $\quad l = \frac{10}{3} = \frac{p}{s}$

$\cancel{\% p = 66.7}$

$p = \frac{10 s}{3}$

$s + p = 1$

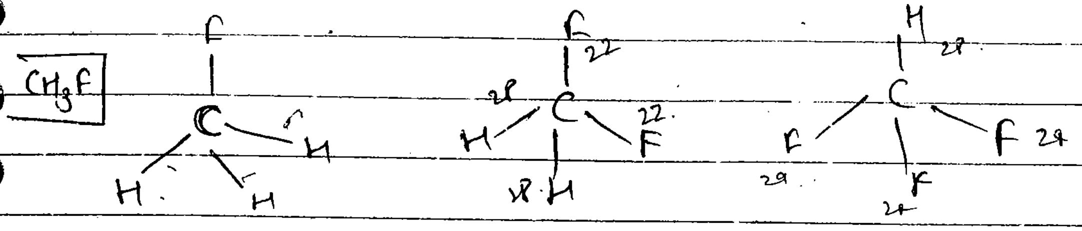
$s + \frac{10s}{3} = 1$ $\quad s = \frac{3}{13} \times 100 = 23\%.$



EXPLANATION FOR HYBRIDISATION

Q. If %S character in CH bond in given species equal to 28% then find %S character in each of C–F bond in given species.

16% CH_3F, CH_2F_2 and CHF_3



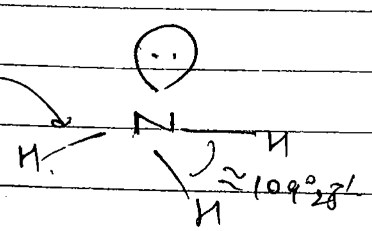
25–9   16%   22%   24%.

EXPLANATION FOR HYBRIDISATION

1). BOND ANGLE / ORBITAL ANALYSIS

Que Explain N–H bond in NH_3 are formed by hybrid orbital while P–H bond in PH_3 are formed by pure P orbital (BA in $NH_3 \simeq 109^\circ 28'$, $\cos 109^\circ 28' = -\frac{1}{3}$ | BA in $PH_3 \simeq 90^\circ$, $\cos 90^\circ = 0$)

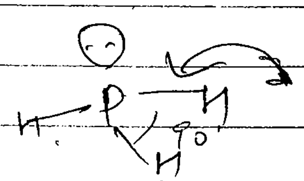
sp³, 25% s, 75% p



$\cos 109^\circ 28' = -\frac{1}{3}$

$s + p_x + p_y + p_z$

Hyb ✓



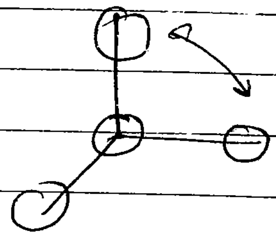
% S = 0
% P = 100
bond formed by pure P orbital

$\cos 90^\circ = 0 = \frac{S}{S-1}$

$\rightarrow \boxed{S = 0}$

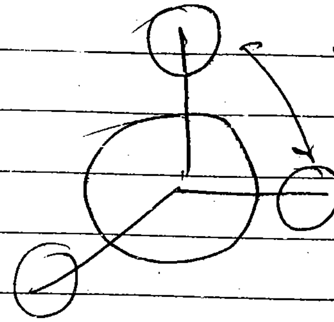
No need of Hyb

2). SIZE OF CENTRAL ATOM. (When L.P. Present)



distance ↓
repuln. ↑
BA ↑
% s ↑

P_4S.
Hyb ✓

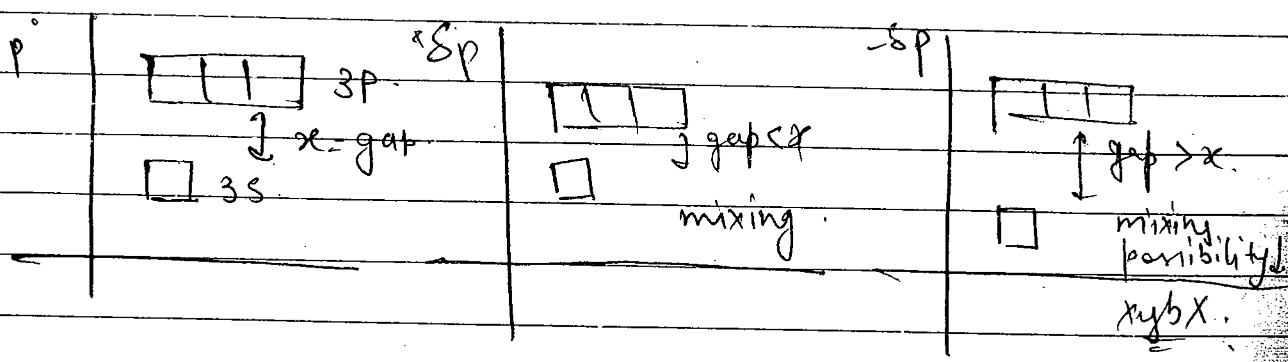


distance ↑
repuln ↓.
Increment in BA ↓
% S ↓.
S+P ✗
Hyb ✗

3). +VE CHARGE ON CENTRAL ATOM

a). +ve ↑, size ↓, BA ↑, Mixing ✓, Hyb ✓

b). $^{+\delta}PF_3 \longrightarrow sp^3$ $\quad$ $^{-\delta}PH_3 \longrightarrow$ No Hyb.



DRAGO RULE

Acc. to Drago.

1). CA belongs to 3rd period or below (size of CA ↑ mixing tendency ↓)

2). LP present on CA (% S ↑ on LP / % S ↓ on BP. mixing of S+P in bond ↓)

3). EN of SA ≤ 2.5 (the charge on CA ↓ mixing of s+p ↓).

⇒ above '3' conditions collectively represents condition of no hybridisation, bond form by pure 'p' orbital.

/NOTE/
⇒. Drago rule is applicable only in nitrogen & oxygen family hydrides.

	LP con. CA ✗	LP cond CA ✓	LP cond CA ✓
2nd period	CH_3 (sp^3)	NH_3	H_2O
3rd period below	SiH_4	$PH_3 \approx 90'$	$H_2S \approx 90'$
	GeH_4	$AsH_3 \approx 90'$	$H_2Se \approx 90'$
	SnH_4	$SbH_3 \approx 90'$	$H_2Te \approx 90$

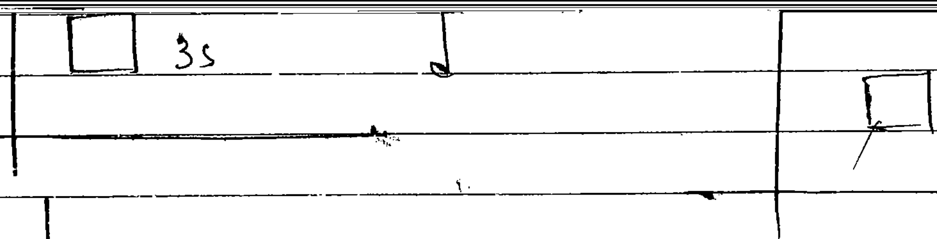
EN of SA = 2.1
Bond form by pure p orbital

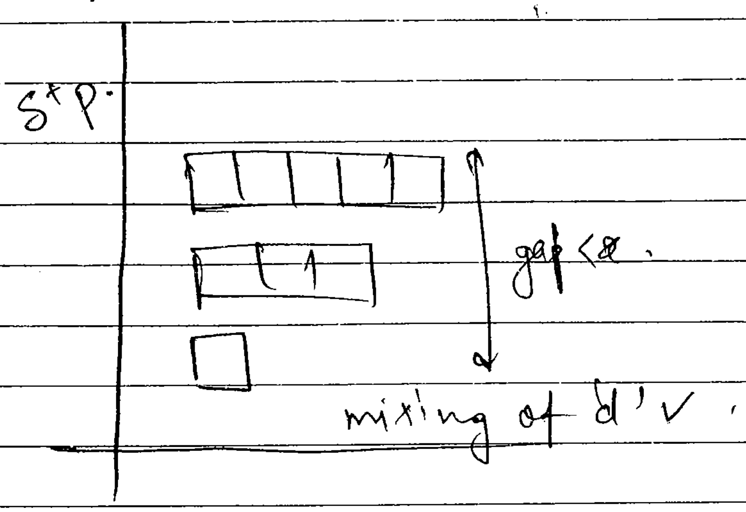
LP✓ EN of H = 2.1.

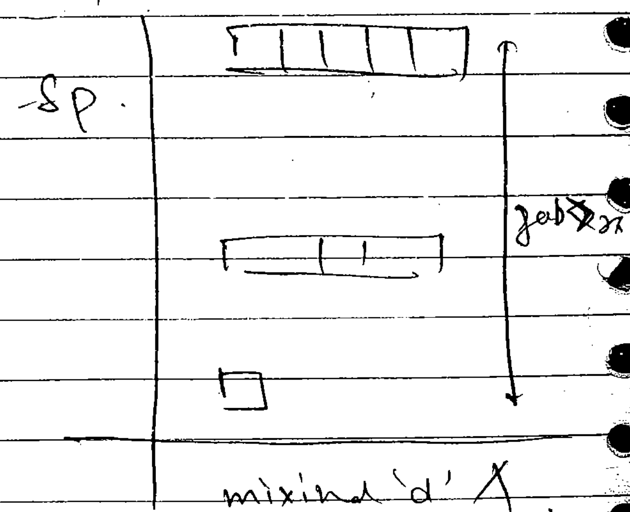
d-orbital contraction or participation of d-orbital in Hyb.

⇒. When bond form by p block element & in g.s there is no requirement of 'd' orbital (3rd period orbeln)

but when p block element (3rd period element) form







sp^3d^3. ✓ IF_7 IH_7 ✗

sp^3d^2. BrF_5 ✓ BrH_5 ✗

sp^3d. ClF_5 ✓. ClH_3 ✗

ClF ✓ ClH ✓

sp^3d. $\overset{+\delta}{I}Cl$ ✓ $\overset{-\delta}{Cl}I_3$ ✗

PF_3 ✓ PH_3 ✓

sp^3d. $\overset{+\delta}{P}F_5$ ✓ $\overset{-\delta}{P}H_5$ ✗

sp^3d^2. SF_6 ✓ SH_6 ✗.

sp^3d SF_4 ✓ SH_4 ✗

SF_2 ✓ SH_2 ✓ / H_2S

BOND PARAMETER

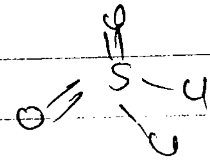
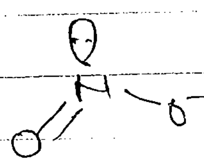
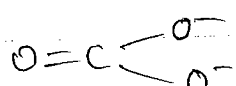
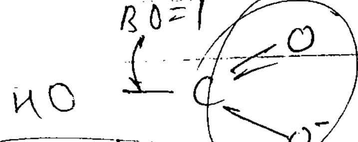
1). BOND ORDER

BO = No. of bond b/w two atoms

$$= \frac{\text{No. of } e^-\text{s present b/w two atom}}{2}$$

for resonating structures.

$$BO = \frac{\text{Total no. of bonds at resonating positions}}{\text{No. of resonating positions}}$$

		BO
H_2	$N \equiv N$	3
O_2	$O=O$	2
F_2, Cl_2, Br_2, I_2, I_2	$X-X$	1.
CO_2	$O=C=O$ $^-O-C\equiv O^+$ $^+O\equiv C-O^-$	2
NO_2^+	$O=\overset{+}{N}=O$	2.
SO_2Cl_2		SO = 2 SCl BO = 1.
NO_2^-		BO = $\frac{3}{2}$.
CO_3^{2-}		BO = 4/3.
HCO_3^-	BO = 1  type of CO BO = 2	BO = 3/2.

Que find XO BO in. X = CA.

~~SO_2~~ SO_2

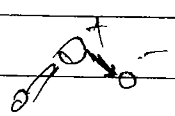
~~SO_3~~

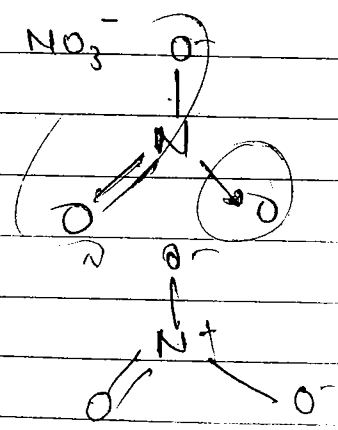
~~SO_3^{2-}~~

~~SO_4^{2-}~~

~~PO_4^{3-}~~

	BO.
SO_2	2.
SO_3	2
SO_3^{2-}	4/3.
SO_4^{2-}	6/4 = 3/2.
PO_4^{3-}	5/4
ClO_4^-	7/4.
ClO_3^-	5/3.
ClO_2^-	3/2.
ClO^-	1
IO_6^{5-}	7/6.
XeO_6^{4-}	8/6 = 4/3. 1.33
O_3	~~1~~ 3/2
NOF_3	1
NO_3^-	~~8~~





~~3~~, ~~4~~

4/3.

$\boxed{\text{BOND LENGTH}}$

⇒ Internuclear ~~molecular~~ distance b/w two bonded atoms.

Comparison of B.L.

b/w diff. species.
(A−B, A−C)

If size of B > C.
BL AB > AC.

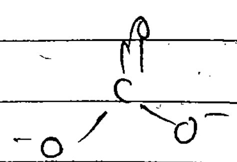
Ex. =O < −F (size)
—O > −F (size)

b/w same species.
(AB, AB)

1). BO ↑ attⁿ ↑ BL ↓.
2) Hyb. %s ↑ attⁿ ↑, BL ↓.
BL $sp < sp^2 < sp^3$
3). Apply Bent's Rule
when BO, & Hyb remain same.

Ex. 1) : HX BL in HF, HCl, HBr, HI X = halogen.
BL : H < HCl < HBr < HI
(size)

2). CO BL in CO_2, CO_3^{2-}, CO.

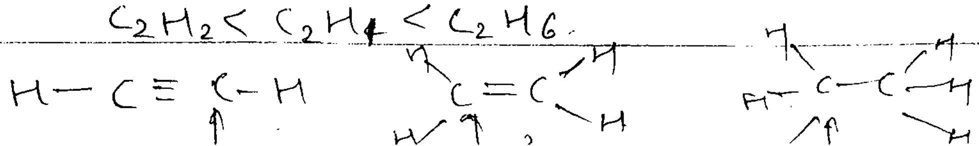
O=C=O  :C≡O:

3

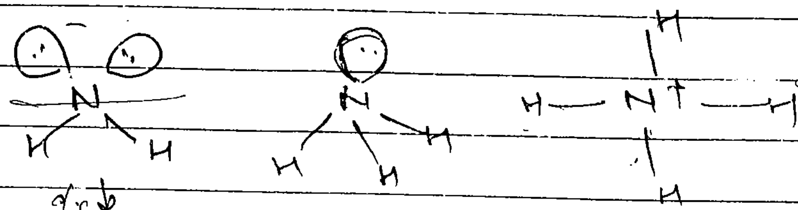
BO. 2 $\frac{4}{3}$

BL CO < CO_2 < CO_3^{2-}

3). C−H BL in
$C_2H_2 < C_2H_4 < C_2H_6$.



4). NH BL in NH_2^-, NH_3, NH_4^+,



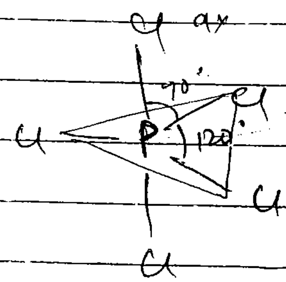
Bent's Rule

%s ↓

BL ↑

$NH_2^- > NH_3 > NH_4^+$

5). PCl_{eq} & PCl_{ax} BL in



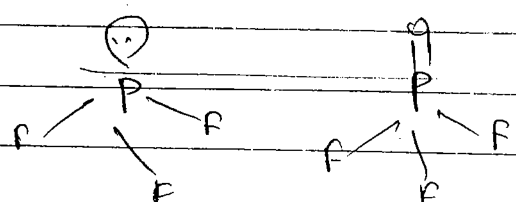
sp

eq %s ↑ BL ↓

sp^3d

$PCl_{eq} < PCl_{ax}$

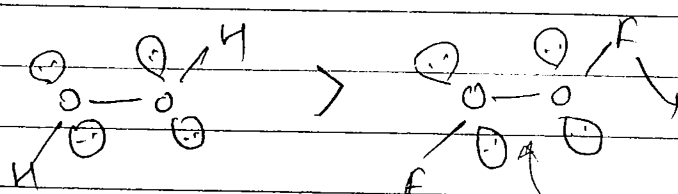
6). PF BL in $PF_3 > POF_3$



%s ↓

BL ↑

7). O—O BL in H_2O_2 & F_2O_2.

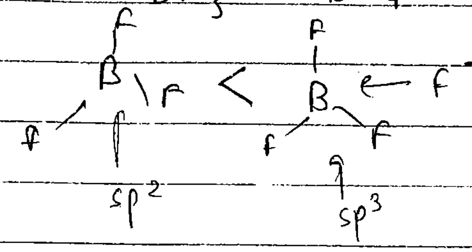


%s ↓

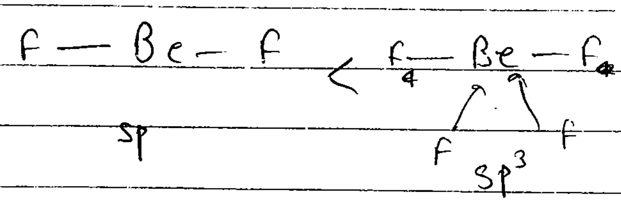
%s ↑

BL

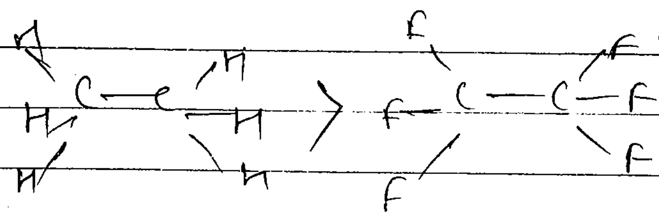
8). B–F BL in BF_3 BF_4^-



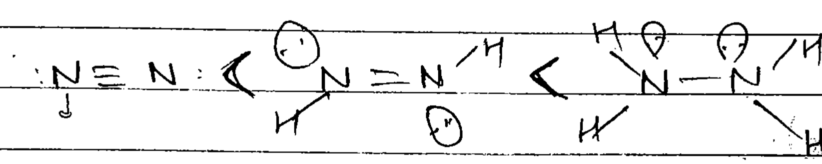
9). Be–F BL in BeF_2 BeF_4^{2-}



10). C–C BL in C_2H_6 C_2F_6

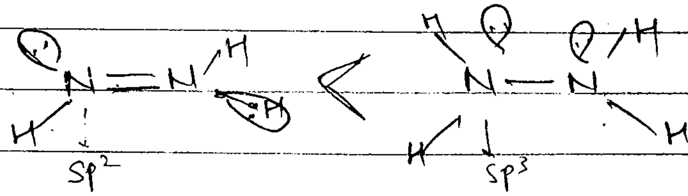


11). N–N BL in N_2 N_2H_2 N_2H_4.

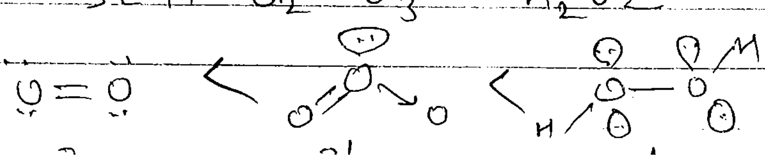


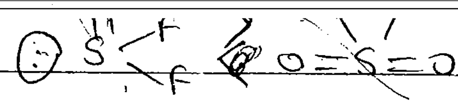
BO :- 3 2 1

12). N–H BL in N_2H_2 & N_2H_4.

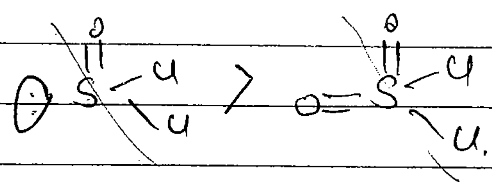


13). O–O BL in O_2 O_3 H_2O_2

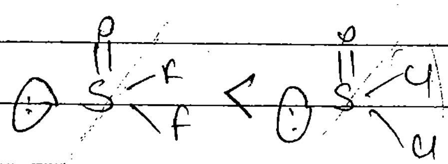




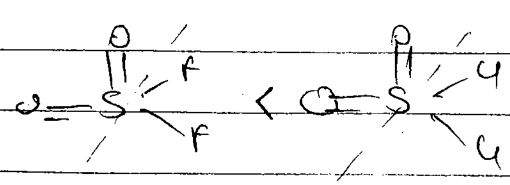
17). SO BL in $SOCl_2$ SO_2Cl_2



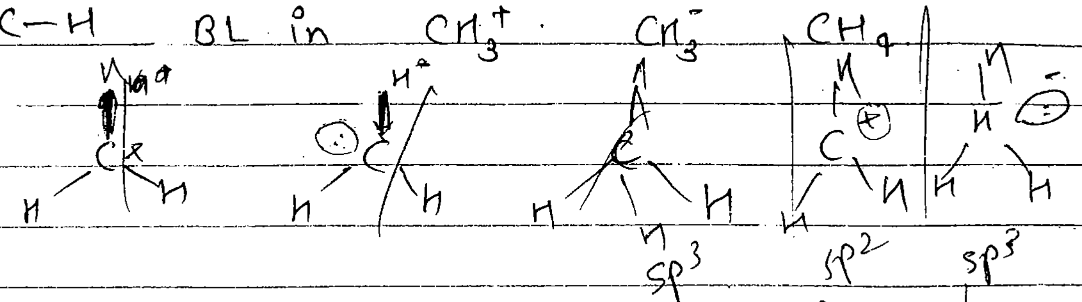
18). SO BL in SOF_2 $SOCl_2$



19). SO BL in SO_2F_2 SO_2Cl_2.



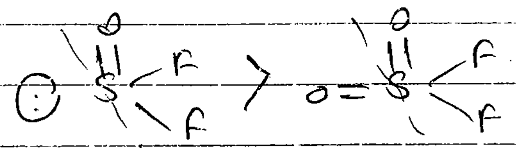
20). C—H BL in CH_3^+ · CH_3^- CH_4



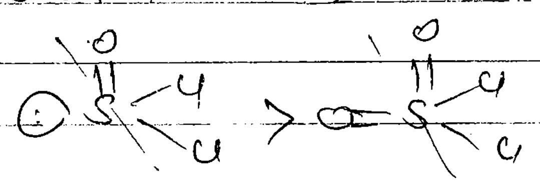
$CH_3^+ < CH_4 < CH_3^-$

sp^2 sp^3 LP

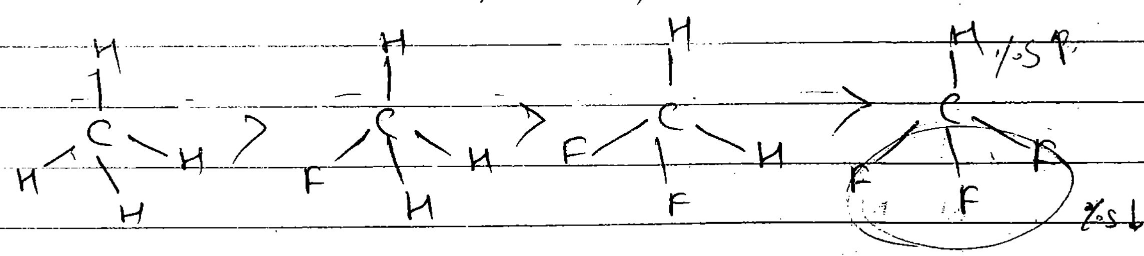
21). SF BL in SOF_2 SO_2F_2.



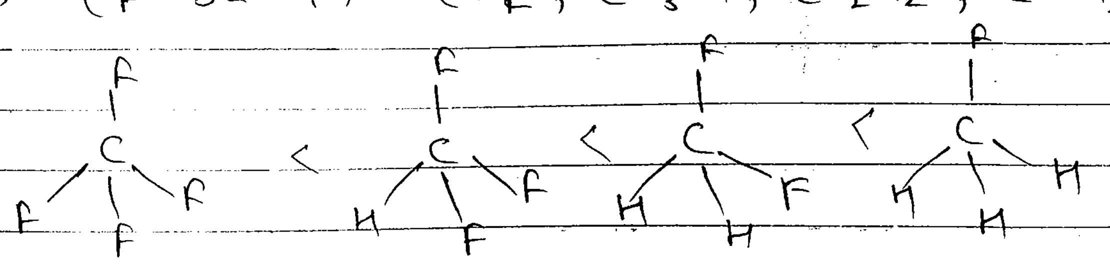
22). SCl BL in $SOCl_2$ SO_2Cl_2



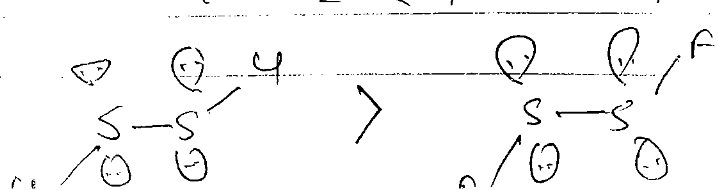
23). CH BL in CH_4, CH_3F, CH_2F_2, CHF_3



24). CF BL in CF_4, CF_3H, CF_2H_2, CFH_3.



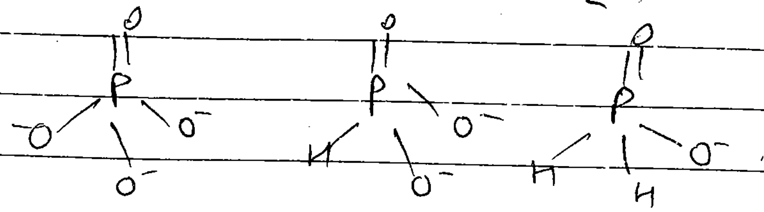
25). SS BL in S_2Cl_2, S_2F_2.



HOMEWORK

1) Cl–O BL in ClO_4^-, ClO_3^-, ClO_2^-, ClO^-

2). PO BL in PO_4^{3-} HPO_3^{2-} $H_2PO_2^-$



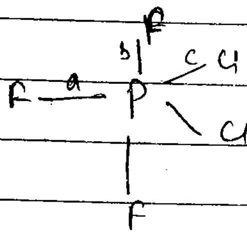
3). NO BL in NO_2^+, NO_2^-, NO_3^-

4). SF_{ax} & SF_{eq} in SF_4

5). BrF_{eq} & BrF_{ax} in BrF_3

6). IF_{ax} & IF_{eq} in IF_7

7).



compare a, b, c.

8). CO BL in COF_2 $COCl_2$

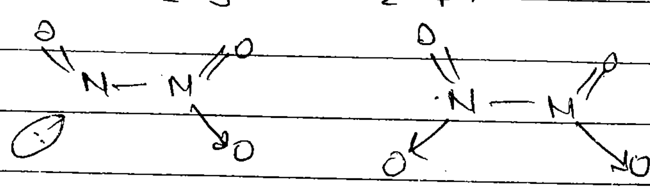
9). PCl BL in $POCl_3$, PCl_3

10) PC BL in $POMe_3$ PMe_3

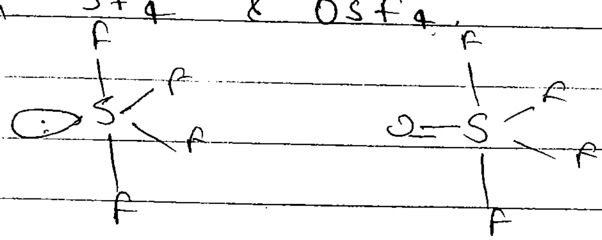
11). PO BL in POF_3 $POCl_3$ $POBr_3$

12). N–N BL in N_2O_3 & N_2O_4.

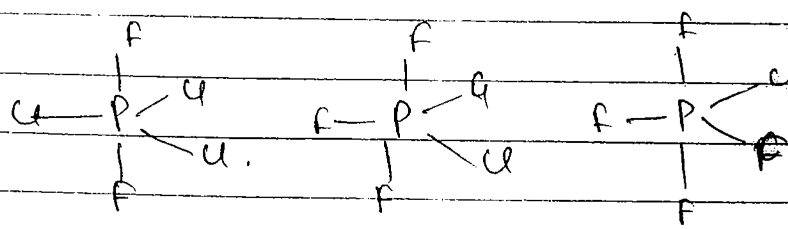
12).



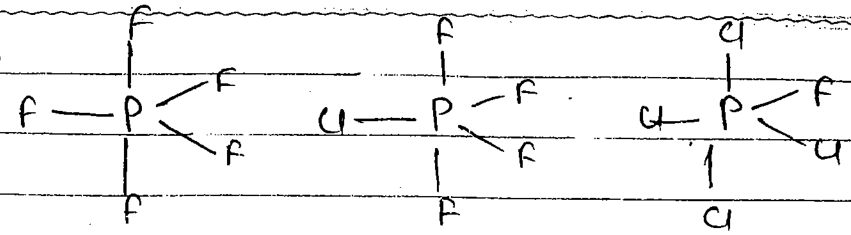
13). SF_{eq} in SF_4 & OSF_4.



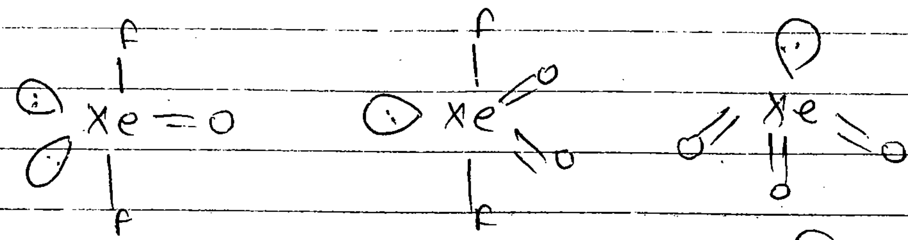
14). P–Cl BL in



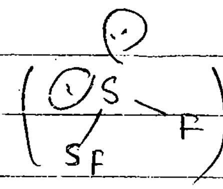
15) Pf_{eq} BL in



16) XeO BL in



17). S–F BL in SF_2 & S_2F_2



18) S–Cl BL in SCl_2 & S_2Cl_2.

19) X–X BL in F_2, Cl_2, Br_2, I_2 (X = halogen)

20). C–X BL in CF_4, CCl_4, CBr_4, CI_4 (x = halogen).

21) H_2O, H_2S, H_2Se, H_2Te

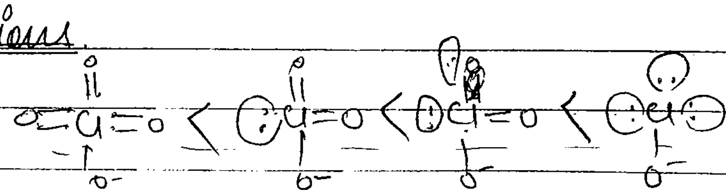
22). NH_3, PH_3, AsH_3, SbH_3

✓23) NCl_3, PCl_3

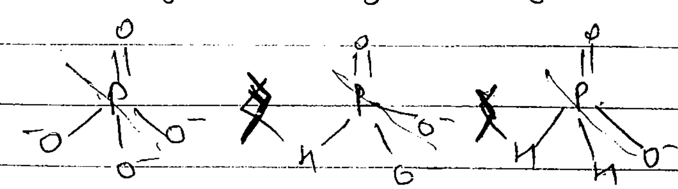
24) CH_4, SiH_4

Solutions.

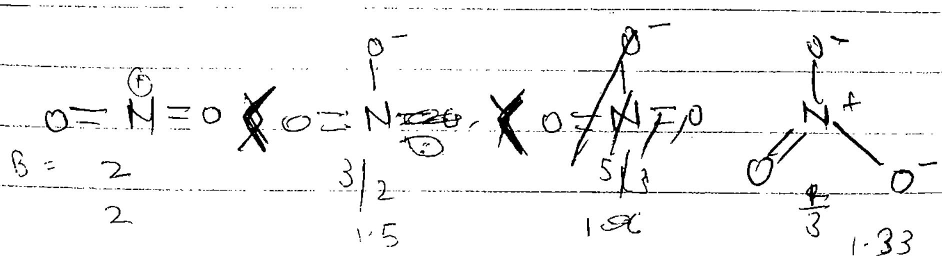
(1).



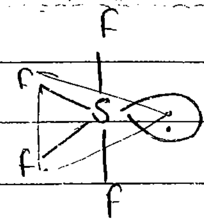
(2)



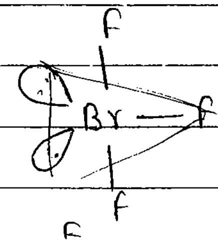
(3)



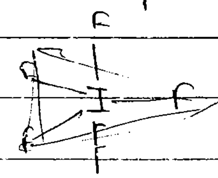
(4). $SF_{ax} > SF_{eq}$



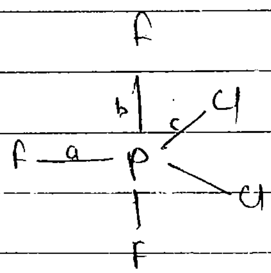
(5) $BrF_{eq} < BrF_{ax}$



(6). $IF_{ax} < IF_{eq}$



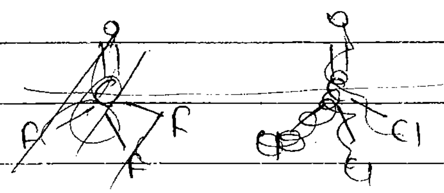
(7).



$c > b > a$

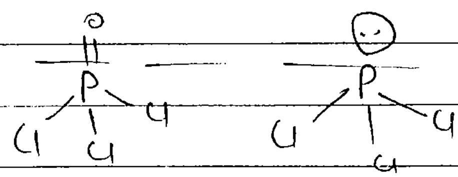
(8). $COF_3 < COCl_3$

CO bond l.



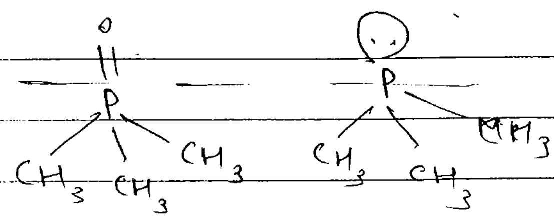
(9). $POCl_3 < PCl_3$

P–Cl BL

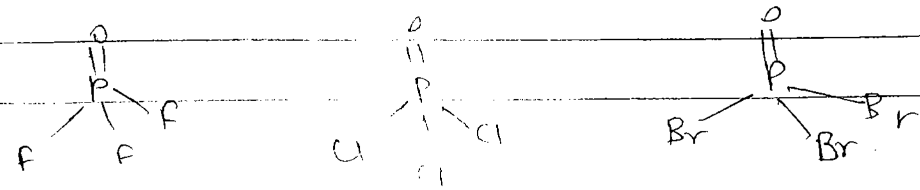


(10). $POMe_3 < PME_3$

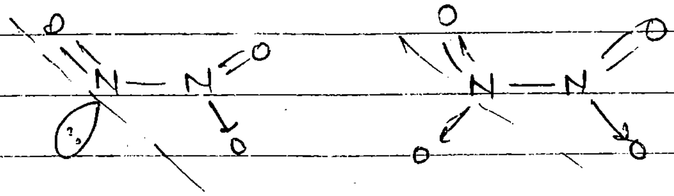
PC BL



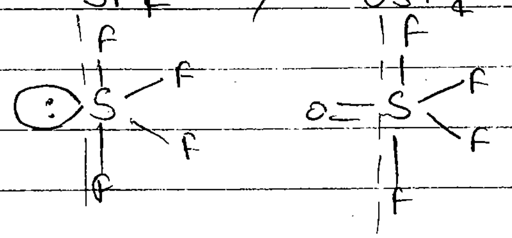
(11). $POF_3 < POCl_3 < POBr_3$ POBL



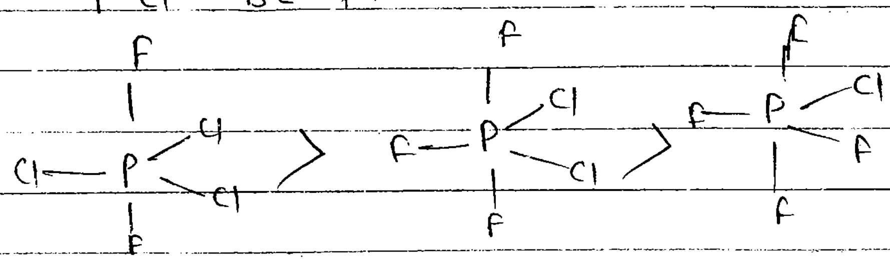
12). N_2O_3 > N_2O_4 N–N BL



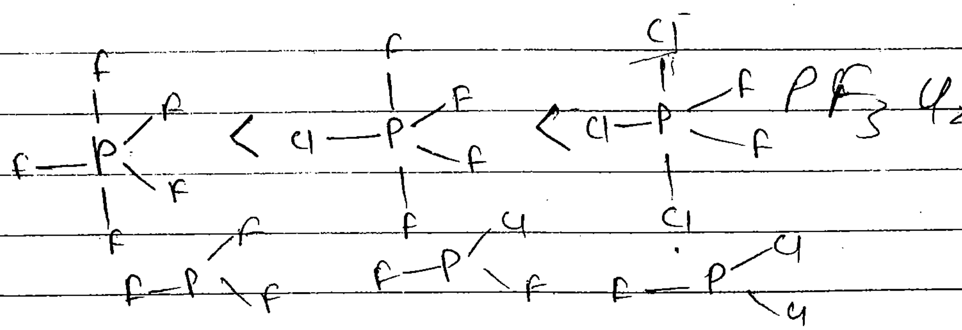
13). SFeq in. SF_4 > OSF_4



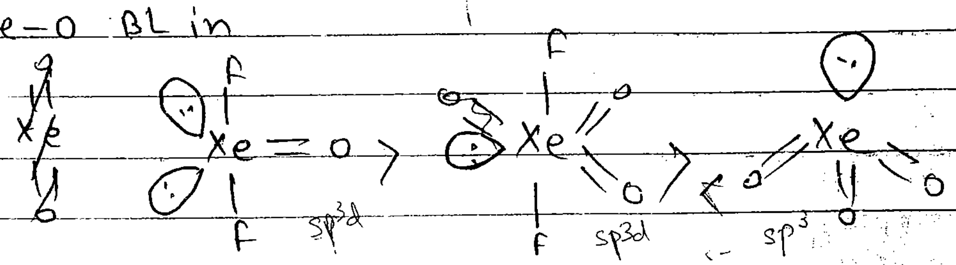
14). P–Cl BL in.



15). PFeq.

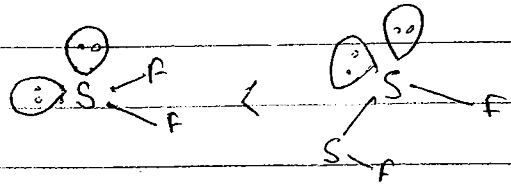


16). Xe–O BL in

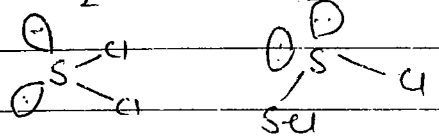


BO = 2 2 2

17). SF BL in. SF_2 < S_2F_2

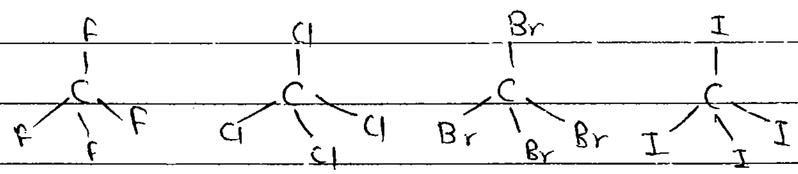


18). $SCl_2 < S_2Cl_2$ S—Cl BL.

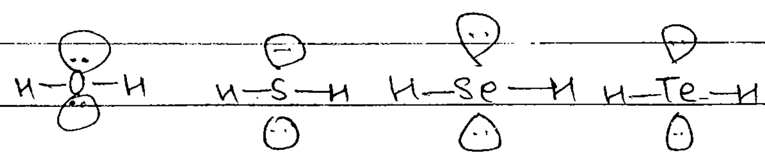


19). $F_2 < Cl_2 < Br_2 < I_2$ X—X BL

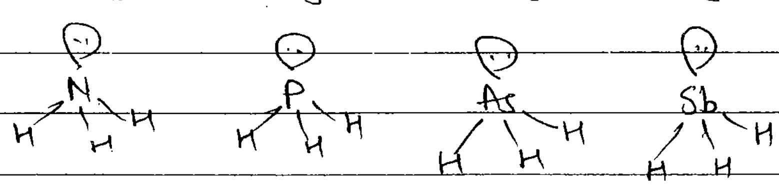
20). $CF_4 < CCl_4 < CBr_4 < CI_4$ C—X BL



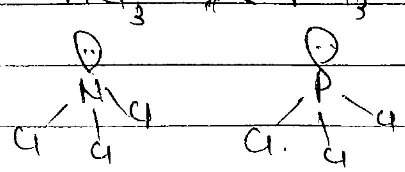
21). $H_2O < H_2S < H_2Se < H_2Te$



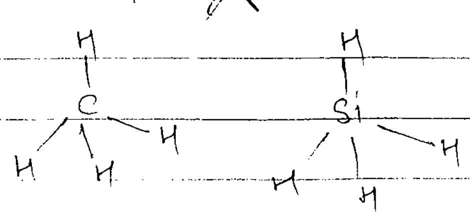
22). $NH_3 < PH_3 < AsH_3 < SbH_3$



23). $NCl_3 < PCl_3$



24). $CH_4 < SiH_4$



BOND ANGLE

Bond Angle

eq. hybrid orbital

⇒ BA acc to hyb.

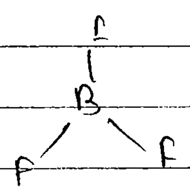
(Note:- Please feel the BA)

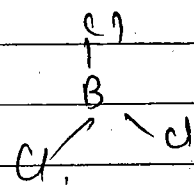
Non-eq. hybrid orbital

1) Hyb.
2) Repulsion of e- pair (for same hyb.)
   LP > double bond > single bond.
3) If hyb. & no. of LP same
   ① Diff CA, same SA
   $\left(BA \propto \frac{1}{\text{size of CA}} \right)$
   ② Diff SA, same CA
   ⇒ 'F' least, BA ∝ size of SA
   %s ↓ hyscam

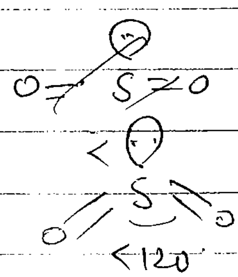
Ex

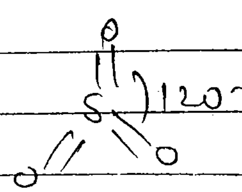
$BF_3 = BCl_3$



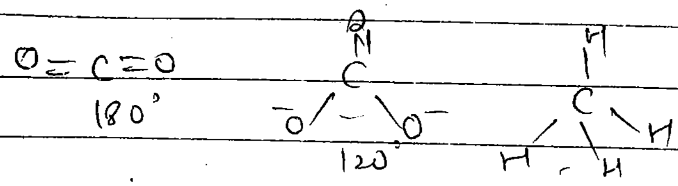


$SO_2 < SO_3$

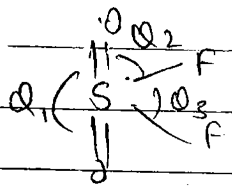




B $CO_2 > CO_3^{2-} > CH_4$

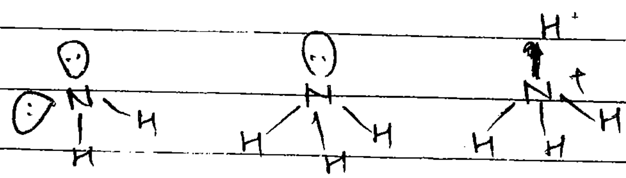


180° 120° 109°28'



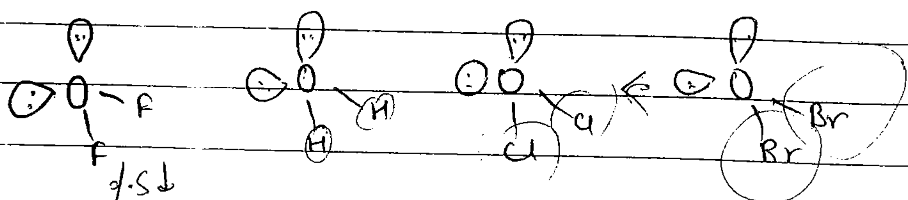
$Q_1 > Q_2 > Q_3$

1). $NH_2^- < NH_3 < NH_4^+$



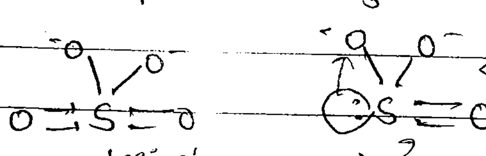
109°

2). $OF_2 < OH_2 < OCl_2 < OBr_2$.



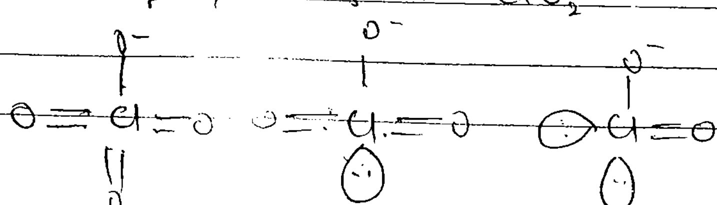
d.s ↓
BA ↑

3). $SO_4^{2-} > SO_3^{2-}$

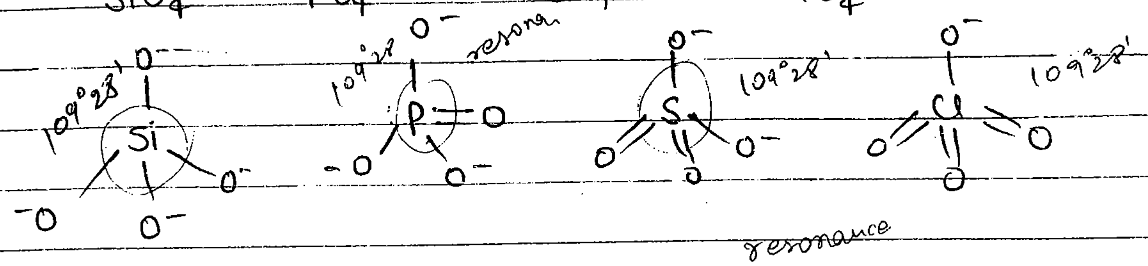


109°28' <109°28'

4). $ClO_4^- > ClO_3^- > ClO_2^-$

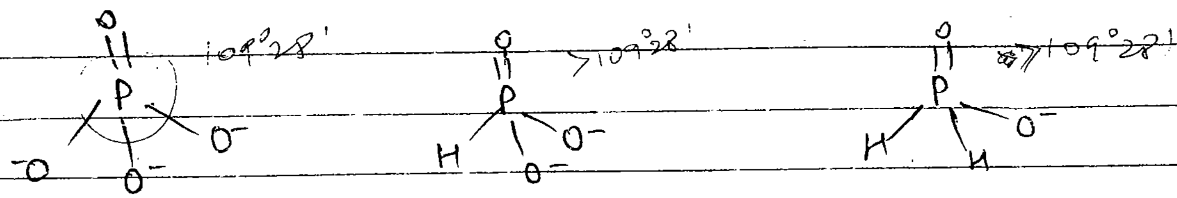


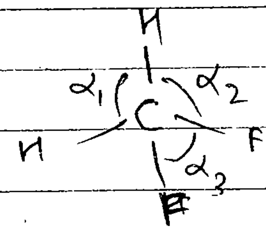
5). $SiO_4^{4-} = PO_4^{3-} = SO_4^{2-} = ClO_4^-$



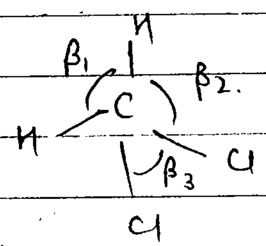
Q. PO BA in

$PO_4^{3-} < HPO_3^{2-} < H_2PO_2^-$



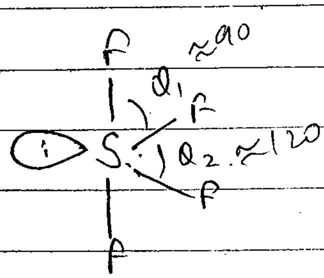


$\alpha_1 > \alpha_2 > \alpha_3$

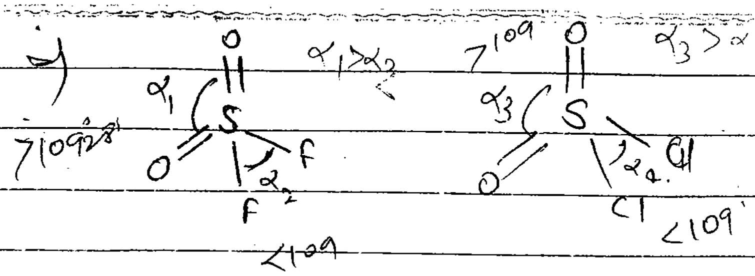


$\beta_1 < \beta_2 < \beta_3$

C
Si ; S



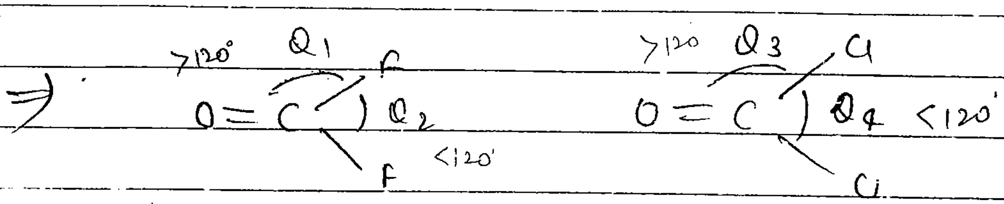
$\theta_1 < \theta_2$



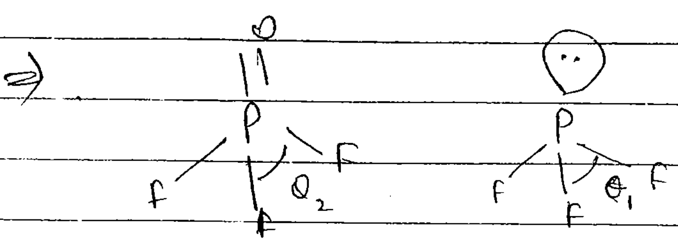
compare $\alpha_1, \alpha_2, \alpha_3, \alpha_4$

$$\alpha_1 \quad \alpha_3 > \alpha_2 \quad \alpha_4$$

$$\alpha_1 > \alpha_3 > \alpha_4 > \alpha_2$$

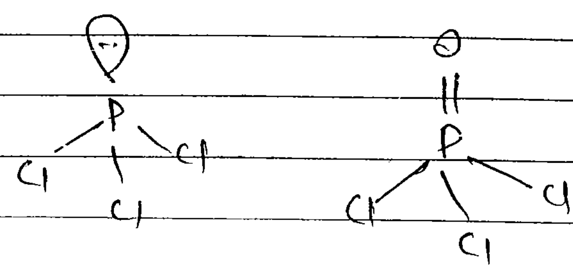


$\theta_1 > \theta_3 > \theta_4 > \theta_2$.

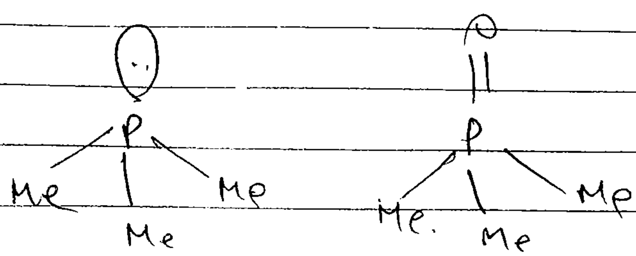


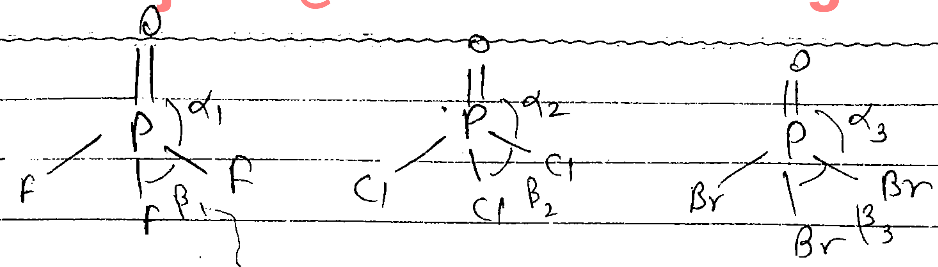
$\theta_2 > \theta_1$

$\Rightarrow$ $Cl\hat{P}Cl$ BA in $PCl_3 < POCl_3$



$\Rightarrow$ CH_3PCH_3 BA in $PMe_3 < POMe_3$



⇒ 

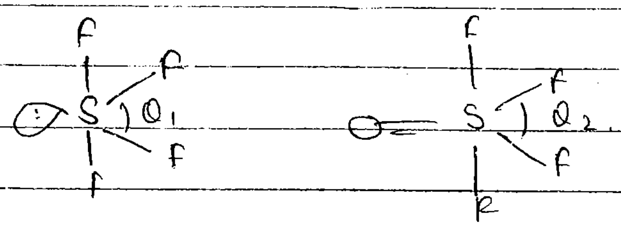
compare 1) $\alpha_1 ; \alpha_2 ; \alpha_3$

2) $\beta_1 , \beta_2 \ \beta_3$

$\cancel{\alpha_1 \ \alpha_2}$

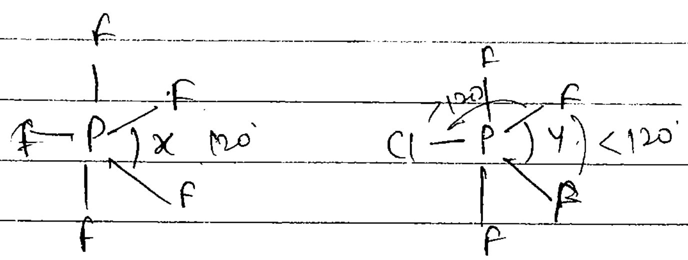
$\alpha_1 > \alpha_2 > \alpha_3$

$\beta_1 < \beta_2 < \beta_3$

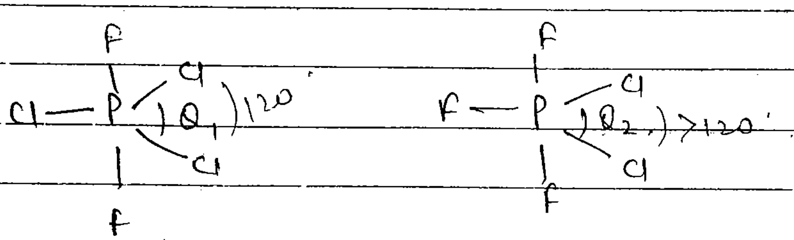
⇒ 

SF_4 $\quad$ OSF_4

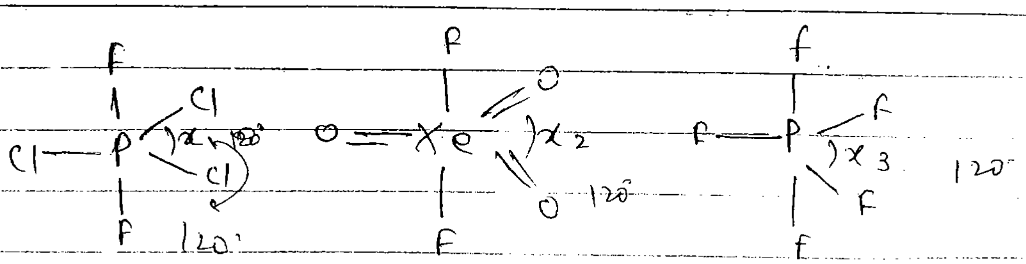
$\theta_2 > \theta_1$

⇒ 

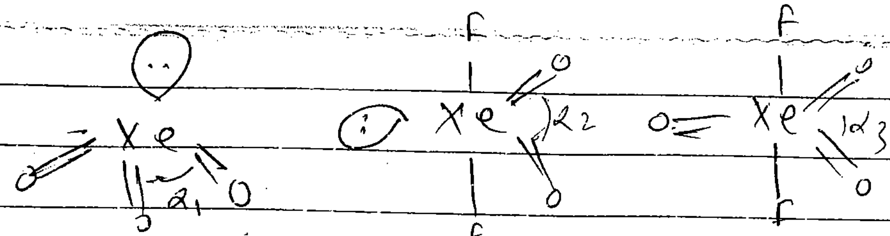
$x > y$

⇒ 

$\theta_2 > \theta_1$

⇒ 

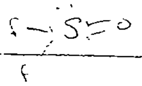
⇒

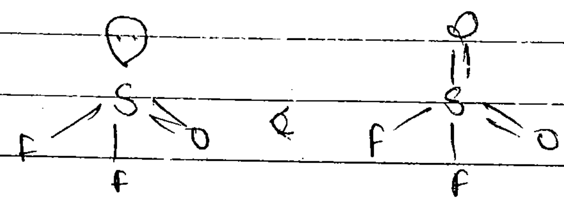


$>109^\circ$ < $>120^\circ$ < 120°

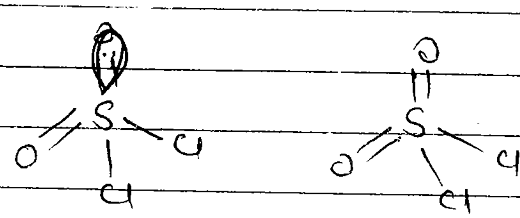
$\alpha_3 > \alpha_2 > \alpha_1$

⇒ FSF BA in $SOF_2 < SO_2F_2$

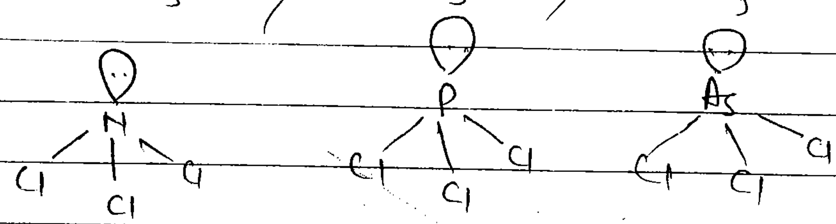




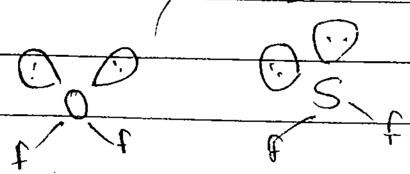
⇒ ClSCl BA in $SOCl_2 < SO_2Cl_2$



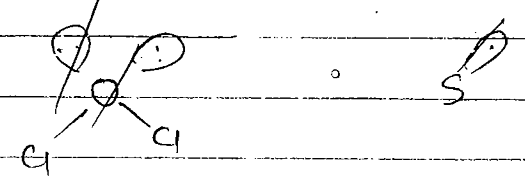
⇒ $NCl_3 > PCl_3 > AsCl_3$



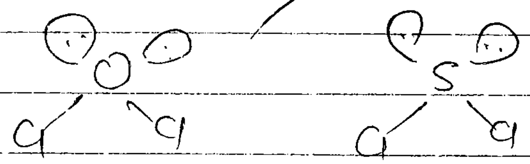
⇒ $OF_2 > SF_2$



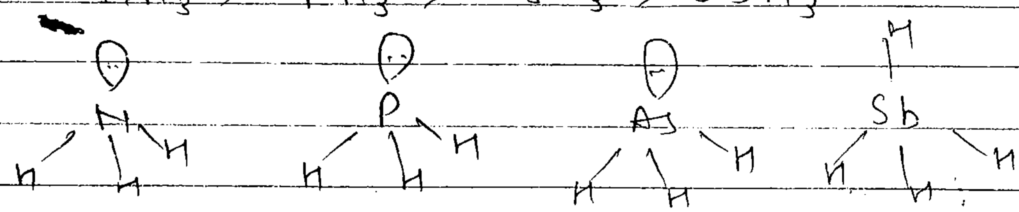
⇒ OCl_2 SCl_2



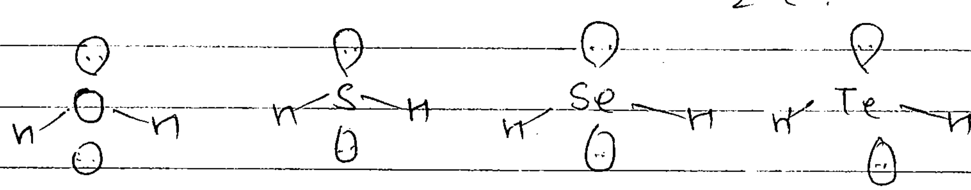
⇒ $OCl_2 > SCl_2$



⇒ $NH_3 > PH_3 > AsH_3 > SbH_3$

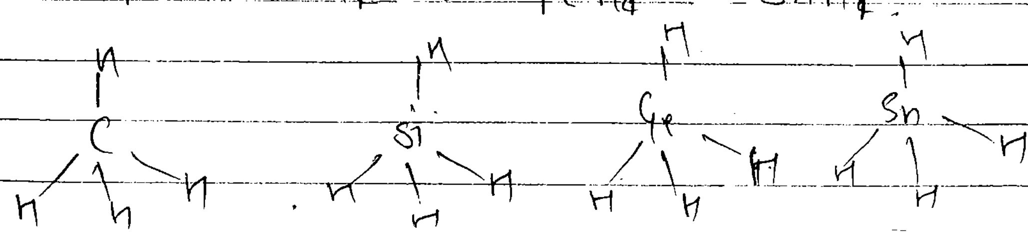


⇒ $H_2O > H_2S > H_2Se > H_2Te$.



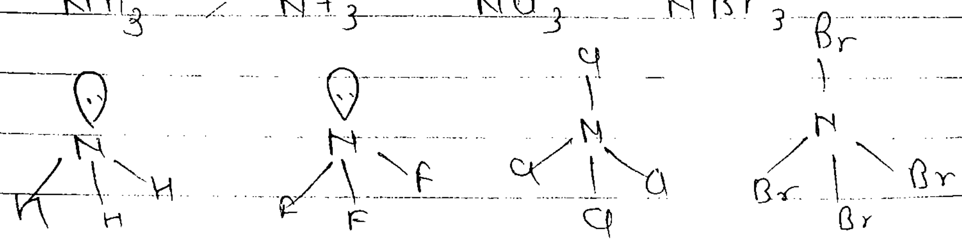
⇒

$CH_4 = SiH_4 = GeH_4 = SnH_4$ no lp.



109°28'

⇒ NH_3 NF_3 NCl_3 NBr_3



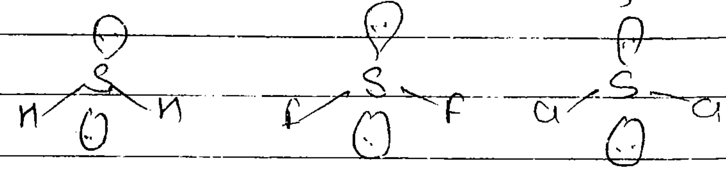
$NBr_3 > NCl_3 > NH_3 > NF_3$

NO Hy

⇒ PH_3 PF_3 PCl_3 PBr_3

$PBr_3 > PCl_3 > PF_3 > PH_3$

⇒ H_2S SF_2 SCl_3



$SF_2 < H_2S < SCl_2$

⇒ AsH_3 AsF_3 $AsCl_3$

$AsF_3 < AsH_3 < AsCl_3$

No hyb.

$PH_3 < PF_3 < PCl_3 < PBr_3$ sp^3

$H_2S < SF_2 < SCl_2$

$AsH_3 < AsF_3 < AsCl_3$

~~BOND ENERGY~~

$\boxed{\text{OXIDATION NO. / OXYDATION STATE}}$

Complete or partial charge on perticular atom in given species due to complete or partial shifting of $e^{\ominus}$ is called "oxidation no. / Oxidation state".

General rules for oxidation no.

(1). F always (−1), Alkali metals always (+1), Alkaline earth metals always (+2), Al always (+3)

(2). H can show (+1) as well as (−1).

Ex. $\overset{+1}{Na}\overset{-1}{H}$ $\qquad$ $\overset{+1}{H}\overset{-1}{F}$

wrt to Na $\qquad$ always

Qu. find O.S of H_2 in CaH_2 (Hydrolith)

$\overset{+2}{Ca}\overset{-2}{H_2}$ $\qquad$ $H \rightarrow -1$

reference

(3). except H_2O_2, F_2O_2, OF_2, KO_2, Na_2O_2, KO_3 oxygen show (−2) oxidation state.

hydrogen peroxide

H_2O_2 (+2, −2) $\qquad$ $\overset{-2}{F_2}\overset{+2}{O_2}$ $\qquad$ OF_2 $\qquad$ $\overset{+1}{K}\overset{-1}{O_2}$ $\qquad$ $\overset{+2}{Na_2}\overset{-2}{O_2}$ $\qquad$ $\overset{+1}{K}\overset{-1}{O_3}$

$O \rightarrow -1$ $\qquad$ $O \rightarrow +1$ $\qquad$ $+2$ $\qquad$ $-\frac{1}{2}$ $\qquad$ -1 $\qquad$ $-\frac{1}{3}$

O_2^{-1} $\qquad$ O_2^{2-} $\qquad$ O_3^{-1}

Superoxide $\qquad$ peroxide $\qquad$ ozonide.

(4). Sum o.s. of atoms/ions present in given species equal to charge present on given species.

$$[Cu(NH_3)_4]^{+2}$$

$$x + 4(0) = +2$$
$$x = +2$$

$\Rightarrow$ $[Fe(CN)_6]^{3-}$

$$x + 6(-1) = 3-$$
$$x = +3$$

(5). O.S of p block elements ~~elements~~

B $\longrightarrow$ -3 to $+3$

C $\longrightarrow$ -4 to $+4$

N $\longrightarrow$ -3 to $+5$

O $\longrightarrow$ -2 to $+6$ O_2F_2

halogen $\longrightarrow$ -1 to $+7$

Inert gas $\longrightarrow$ 0 to $+8$

(6). General o.s of d block element

3d series ~~Sc~~

	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
max	+3	+4	+5	+6	+7	+6	+5	+4	+2	+2
	$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^7 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
	1	2	3	5	5	4	3	2	0	0

$(n-1)\,d\,e^- + ns\,e^-$ constant

Unpaired e^- in 'd'

PEROXYLINKAGE IN SPECIES

(In compound one type ~~thre~~ of atom is oxygen)

⇒ Consider O.S of 'O' = −2

⇒ find the O.S of other element by given formula of compound without help of structure.

⇒ If O.S of other element is greater than maximum O.S ~~their~~ there will be peroxylinkage.

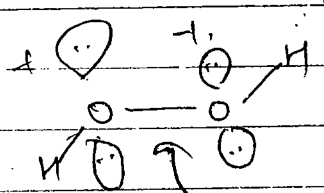
ex H_2O_2

let O.S of H = x

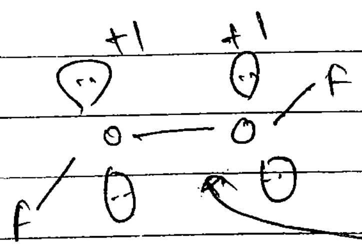
$2x + 2(-2) = 0$

$x = +2$! Not possible

> Max. O.S.



Peroxy linkage



Peoxy linkage ✗

~~CrO_5~~ Peroxy linkage

CrO_5 ✓

$\overset{2+}{H_2}\overset{x+8}{S}\overset{-10}{O_5}$ ✓

$\overset{+4}{H_4}\overset{+12}{P_2}\overset{-16}{O_8}$ ✓

P → +6 ✗

$\boxed{\text{OXY- ACIDS}}$

Acidic oxide

$\overset{+1}{Cl_2O} + H_2O \longrightarrow HClO$ oxyacid.

Basic oxid

$Na_2O + H_2O \longrightarrow NaOH$ hydroxide.

<u>Oxyacid</u> → $H + O +$ Non metal (Generally)

Non metal ↑ OS +ve

ex- H_3PO_4, H_2SO_4, H_3BO_3.

<u>Naming of oxy acid</u>

1) <u>suffix</u> ⇒ ic, ous.

2) <u>Prefix</u> ⇒ Hypo, Pyro, per, peroxy, Meta

ic → अधिक (ईक) OS higher

ous → कम os lower

PARENT 'ic' ACID / REFERENCE ACID / STABLE ACIDS

except halogen all parent 'ic' acids r in their highest O.S.

+3	+4	+5	+6	+5
B	C	N		
$B(OH)_3$ / H_3BO_3	H_2CO_3	HNO_3		
	Si	P	S	Cl
	H_4SiO_4	H_3PO_4	H_2SO_4	$HClO_3$

+O oxidation ↑ +2
+H Reduction ↓ +1
−O Reduction ↓ +2
−H oxidation ↑ +1

ic

'Meta' (atleast 3 'H' in parent acid)

ous

$\xleftarrow{-H_2O}$ 'Meta'

Per/Peroxy mono except halogen (higher) (HNO₃ > 8e⁻) Hyper $\xleftarrow{+O}$ Parent 'ic' Acid $\xrightarrow{-'O'}$ Parent 'ous' acid $\xrightarrow{-'O'}$ Hypo ous acid (कम)

Parent 'ic' Acid $\xrightarrow{+O}$ only per mono for halogens.

Parent 'ic' Acid $\xrightarrow{\times 2,\ -H_2O}$ Pyro/Di

Parent 'ous' acid $\xrightarrow{\times 2,\ -H_2O}$ Di/pyro

Perdi/Peroxydi $\xleftarrow{+O}$ Pyro/Di (Heat) (At least two 'H' in parent acid)

−Hypo $\xleftarrow{-O}$

Q. Identify A to Z &
write down formula & name

$$\begin{tikzcd}
 & H & & \\
G & H_3PO_4 \arrow[l, "+O"'] \arrow[u, "-H_2O"'] \arrow[r, "-O"] \arrow[d, "\times 2,\ -H_2O"] & A \arrow[r, "-O"] \arrow[d, "-H_2O"] & B \\
 & P \arrow[dl, "-O"'] \arrow[dr, "+O"] & C & \\
F & & E &
\end{tikzcd}$$

$$HNO \xrightarrow{+O} X \xrightarrow{+O} Y \xrightarrow{+O} Z$$

$$HClO_4 \xrightarrow{-O} P \xrightarrow{-O} Q \xrightarrow{-O} R$$

$$H_2SO_4 \xrightarrow{-O} I \xrightarrow{\times 2\ -H_2O} J$$

$$\begin{tikzcd}
N & & L & & \\
M \arrow[u, "+O"] \arrow[d, "-O"] & & H_2SO_4 \arrow[ll, "-H_2O\ .\ \times 2"'] \arrow[u, "-H_2O"'] \arrow[d, "+O"] \arrow[r, "-O"] & I \arrow[r, "\times 2\ -H_2O"] & J \\
'O' & & K & &
\end{tikzcd}$$

A	$\longrightarrow$	H_3PO_3	Phosphorous acid
B	$\longrightarrow$	H_3PO_2	Hypophosphorous acid
C	$\longrightarrow$	HPO_2	
G	$\longrightarrow$	H_3PO_5	Peroxyphosphoric acid
H	$\longrightarrow$	HPO_3	Meta phosphoric acid
P	$\longrightarrow$	$H_4P_2O_7$	Pyrophosphoric acid
F	$\longrightarrow$	$H_4P_2O_6$	Hypo phosphoric acid
E	$\longrightarrow$	$H_4P_2O_8$	Peroxydiphosphoric acid

X $\longrightarrow$ HNO_2 Peroxynitric acid

Y $\longrightarrow$ HNO_3

Z $\longrightarrow$ HNO_4

P $\longrightarrow$ $HClO_3$

Q $\longrightarrow$ $HClO_2$

R $\longrightarrow$ $HClO$

I $\longrightarrow$ H_2SO_3 Sulphurous acid

J $\longrightarrow$ $H_2S_2O_5$ Pyrosulphurous acid

K $\longrightarrow$ H_2SO_4 Peroxysulphuric acid

L $\longrightarrow$ SO_3 ×

M $\longrightarrow$ $H_2S_2O_7$ Pyrosulphuric acid

N $\longrightarrow$ $H_2S_2O_8$ Peroxydisulphuric acid

O $\longrightarrow$ $H_2S_2O_6$ Hyposulphuric acid

$\boxed{\text{STRUCTURES OF OXY-ACIDS}}$

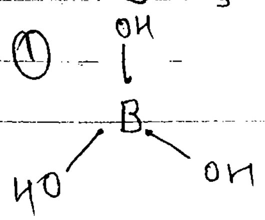
(1). Except H_3PO_2, H_3PO_3, $H_4P_2O_5$

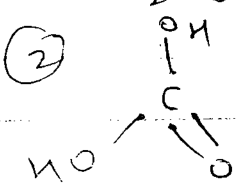
No of 'H' = No of 'OH'
each OH form single bond

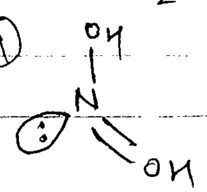
(2). 2nd Period oxy acid C.A. is always sp^2 hybridized

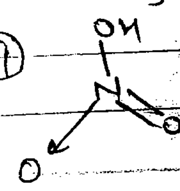
(3). 3rd period oxy acid CA is always sp^3 hybridized.

H_3BO_3 H_2CO_3 HNO_2 HNO_3

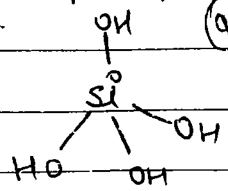
① 

② 

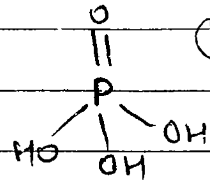
① 

① 

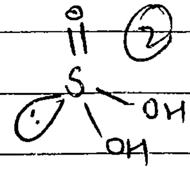
H_4SiO_4 (4)



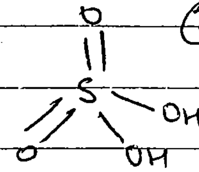
H_3PO_4 (3)



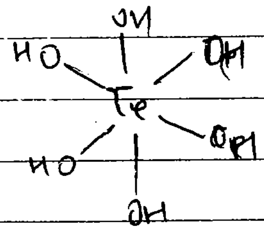
H_2SO_3 (2)



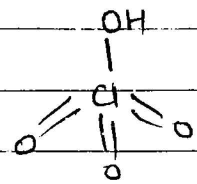
H_2SO_4 (2)



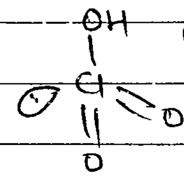
H_6TeO_6 (6)



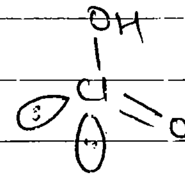
$HClO_4$ (1)



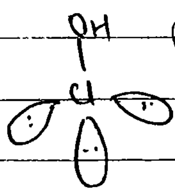
$HClO_3$ (1)



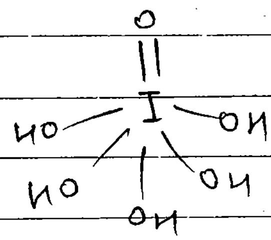
$HClO_2$ (1)



$HClO$ (1)

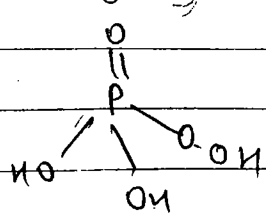


H_5IO_6 (5)

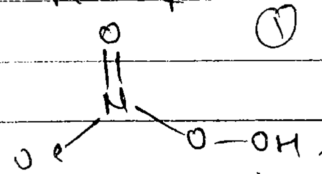


In single central atom (non metal, except O, H) if oxidation state is greater than maximum O.S. there will be Peroxylinkage which is present in structure in form of X—O—OH.

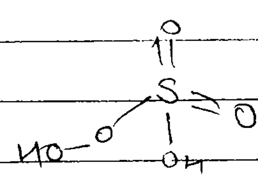
H_3PO_5



HNO_4 (1)



H_2SO_5



Structure of $H_pX_2O_q$ or X_2O_R type species

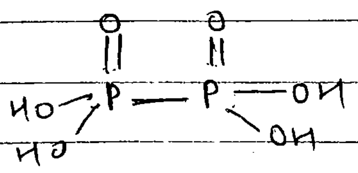
let O.S. of O = −2

If O.S of x < max O.S ⇒ x — x.

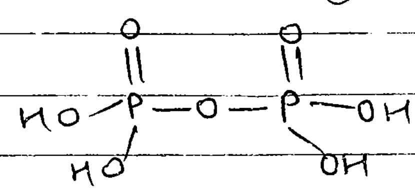
O.S of x = max O.S ⇒ x — O — x

O.S of x > max O.S ⇒ x — O — O — x.

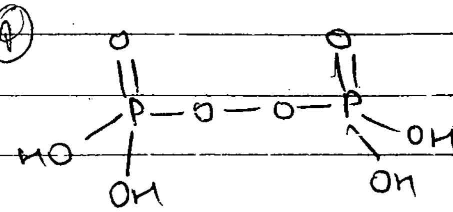
$H_4\overset{+4}{P_2}O_6$ 4



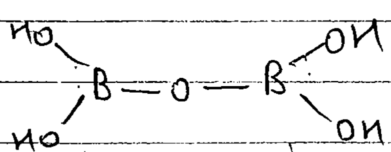
$H_4\overset{+5}{P_2}O_7$ 4



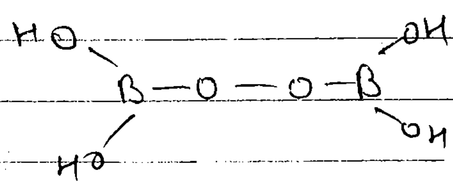
$H_4\overset{+6}{P_2}O_8$ 4



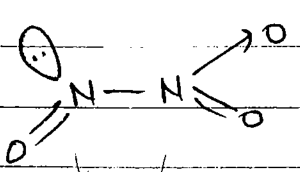
$H_4\overset{+3}{B_2}O_5$ 2



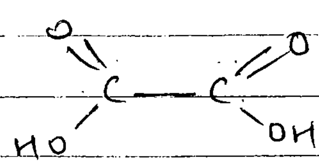
$H_4\overset{+4}{B_2}O_6$ 2



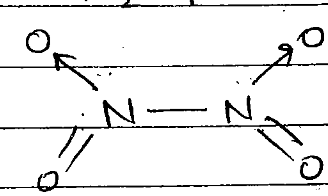
$\overset{+3}{N_2}O_3$



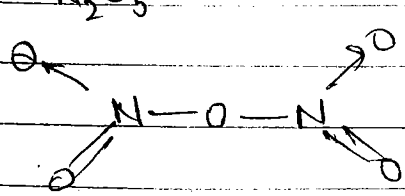
$H_2\overset{+3}{C_2}O_4$ 2



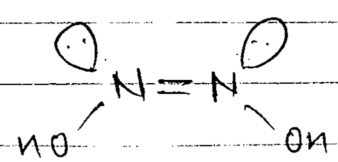
$\overset{+4}{N_2}O_4$



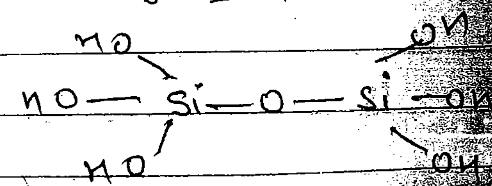
$\overset{+5}{N_2}O_5$



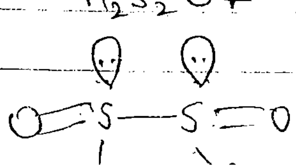
$H_2\overset{+2}{N_2}O_2$ 2



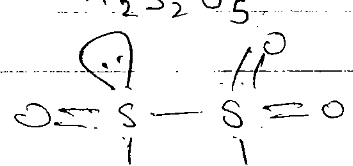
$H_6\overset{+4}{Si_2}O_7$ 6



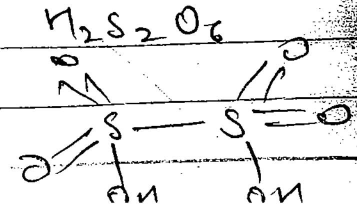
$H_2\overset{+2}{S_2}O_4$ 2



$H_2\overset{+4}{S_2}O_5$ 2



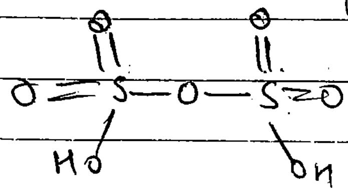
$H_2\overset{+5}{S_2}O_6$ 2



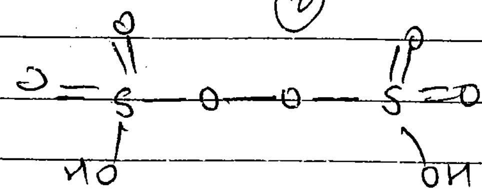
Mn → +7 max

Cr → +6 max

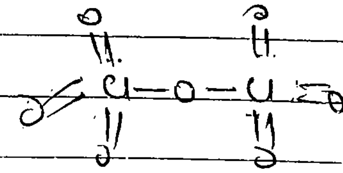
+6 $H_2S_2O_7$ (2)



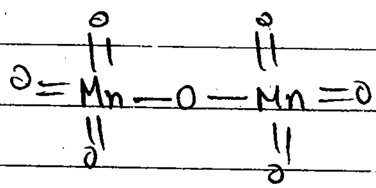
+7 $H_2S_2O_8$ (2)



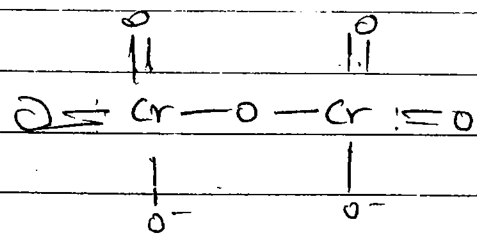
+7 Cl_2O_7



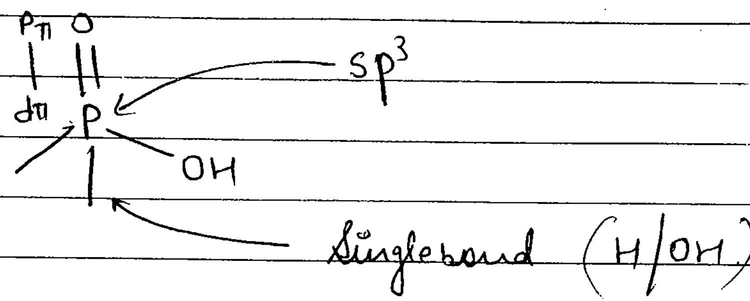
Mn_2O_7



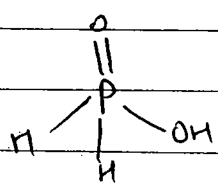
+6 $Cr_2O_7^{2-}$



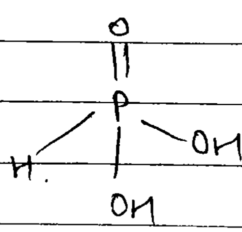
NOTE (1). Bonding pattern of 'P' (Phosphorous) in its oxy-acids.



(1) H_3PO_2

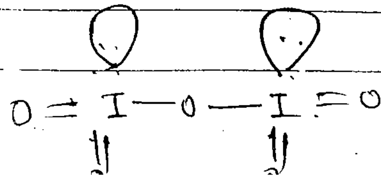


(2) H_3PO_3

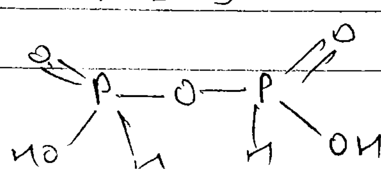


(2). I_2O_5 & $H_4P_2O_5$ don't follow double C.A. rule; they contain X—O—X linkage.

I_2O_5



$H_4P_2O_5$



POLY PHOSPHORIC ACID

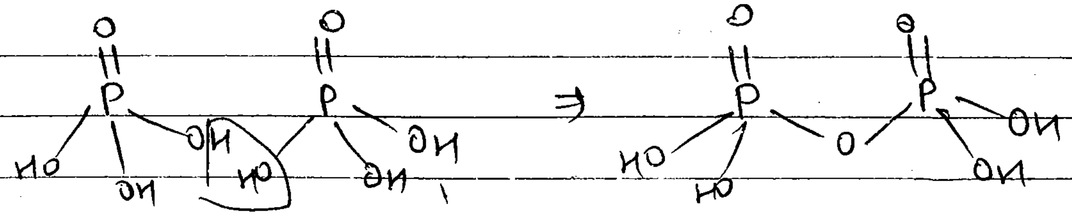
$$nH_3PO_4 \xrightarrow{-(n-1)H_2O} (HPO_3)_n \cdot H_2O$$ Poly Phosphoric Acid (Chain)

$$2H_3PO_4 \xrightarrow{-H_2O} H_4P_2O_7$$ Diphosphoric Acid.

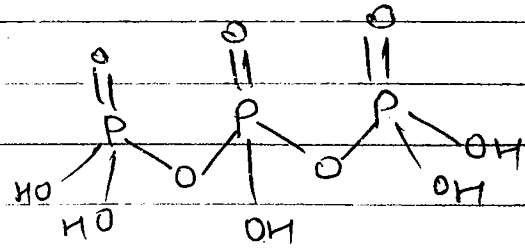
$$3H_3PO_4 \xrightarrow{-2H_2O} H_5P_3O_{10}$$ Triphosphoric Acid.

$$4H_3PO_4 \xrightarrow{-3H_2O} H_6P_4O_{13}$$ Tetraphosphoric Acid.

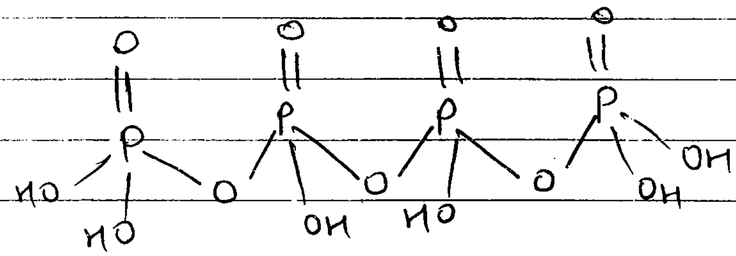
Di.



Tri



Tetra



In General

$$(H_3PO_3)_n \cdot H_2O$$

P—O—P linkage ⇒ $n-1$

P=O ⇒ n

$d\pi - p\pi$ ⇒ n

P—OH ⇒ $n+2$.

$$nH_3PO_4 \xrightarrow{-nH_2O} (HPO_3)_n$$

$$(HPO_3)_n \xrightarrow{H_2O} (HPO_3)_n \cdot H_2O$$

$$nH_3PO_4 \xrightarrow{(n-1)H_2O} (HPO_3)_n \cdot H_2O$$

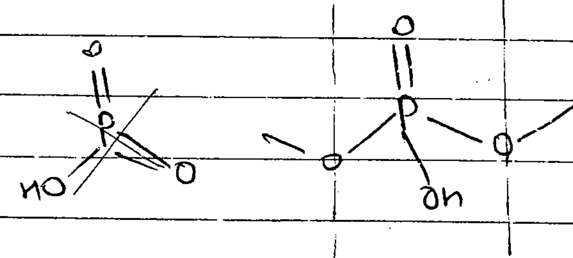
META – ACIDS

⇒ All meta-acids exist in Polymeric form.

⇒ Parent acid which form meta acid is written with "ortho" prefix

$H_3PO_4 \xrightarrow{-H_2O} HPO_3$ →

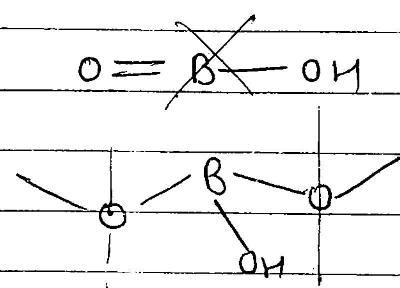
orthophosphoric acid — Meta phosphoric acid



HPO_3 :- Polymeric unit.

$H_3BO_3 \xrightarrow{-H_2O} HBO_2$

Orthoboric acid — Meta boric acid

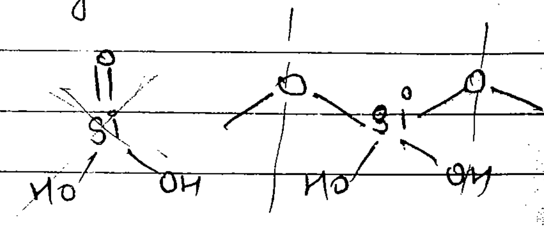


HBO_2

Polymeric unit

$H_4SiO_4 \xrightarrow{-H_2O} H_2SiO_3$

ortho silicic acid — Meta →



META PHOSPHORIC ACID

$(HPO_3)_n$ $n \geq 3$

Cyclic Structure

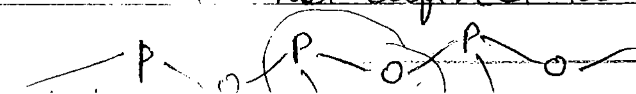
$(ABC_x)_y$ y = cyclic structure

$y \geq 3$

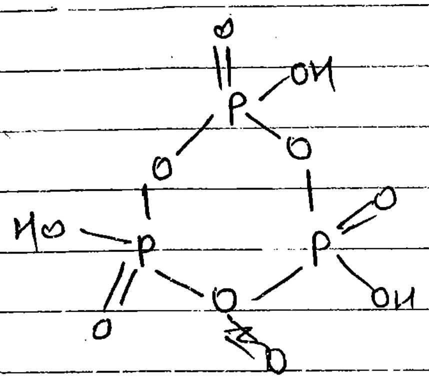
$(HPO_3)_n$

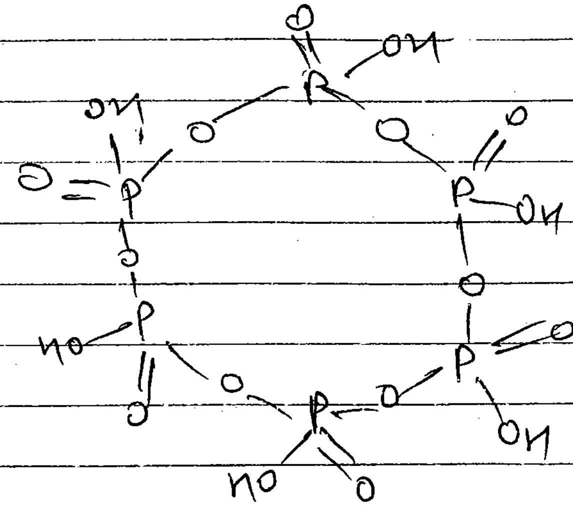
n = ~~not defined~~ = ∞

n = not defined = ∞



$H_3P_3O_9$ $(HPO_3)_3$ $H_6P_6O_{16}$





(HPO_3)

$P-O-P = n$

$P=O = n$

$P-OH = n$

$p\pi - d\pi = n$

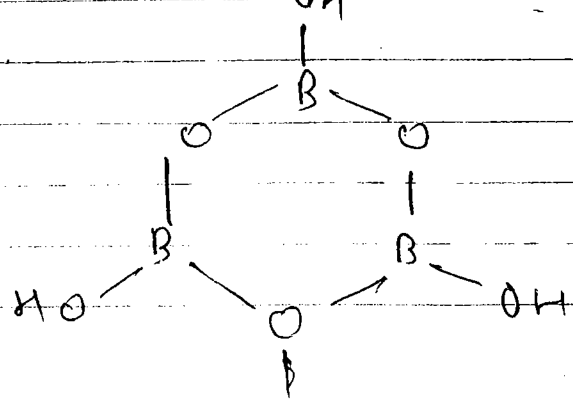
$H_3BO_3 \xrightarrow{-H_2O} HBO_2$

n = defined — $(HBO_2)_n$: $n \geq 3$, cyclic

HBO_2 — $n \neq$ defined, linear chains.

$(HBO_2)_3$ $(BO(OH))_3$

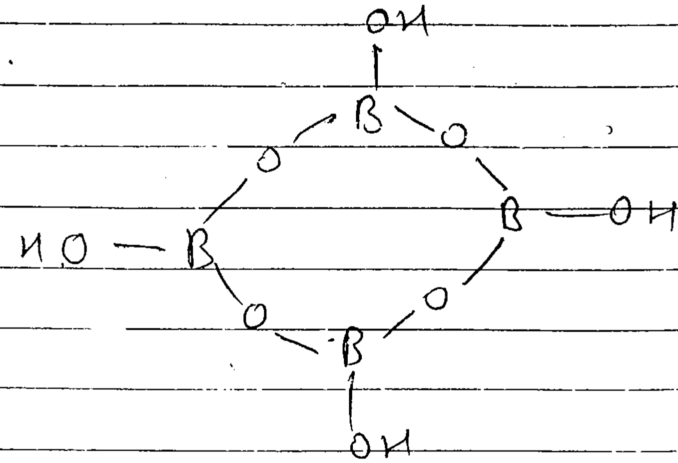
n=3.



if not defined.

$B_4O_4(OH)_4 = (HBO_2)_4$.

$n = 4$.



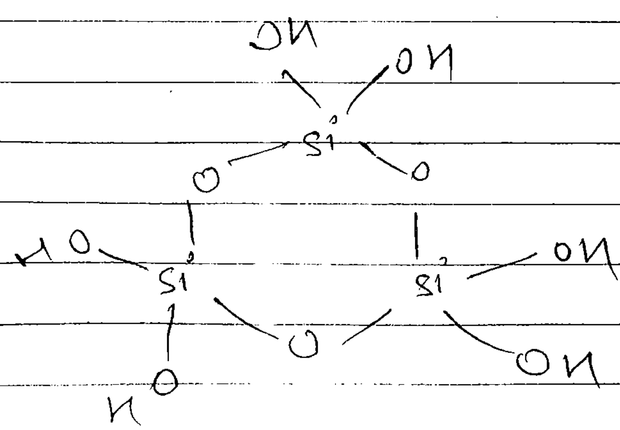
META SILICIC ACID

$H_4SiO_4 \xrightarrow{-1H_2O} H_2SiO_3$

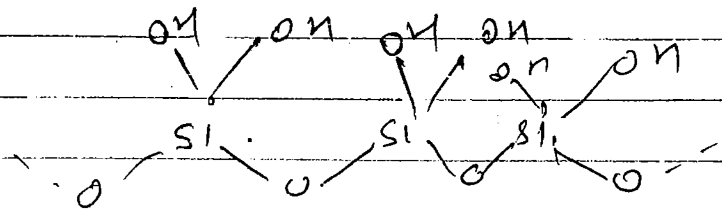
n = defined
$(H_2SiO_3)_n$
$n \geq 3$.
cyclic.

n ≠ defined.
linear chain.

$H_6Si_3O_9$ $\quad$ $(H_2\overset{+4}{Si}O_3)_3$ $\quad$ $[OSi(OH)_2]_3$.



H_2SiO_3

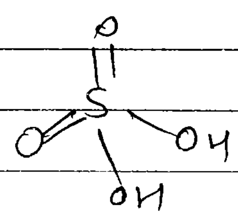


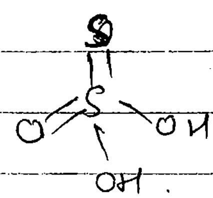
THIO SULPHURIC ACID

$ROH \xrightarrow[+S]{-O} RSH$

$ROR \xrightarrow[+S]{-O} RSR$

$H_2SO_4 \xrightarrow[+S]{-O} H_2S_2O_3$





thio sulphuric acid

THIO SERIES (S–S linkage)

Due to S—S linkage O.S of 'S' is less than from its normal O.S of 'Ic' & ous.

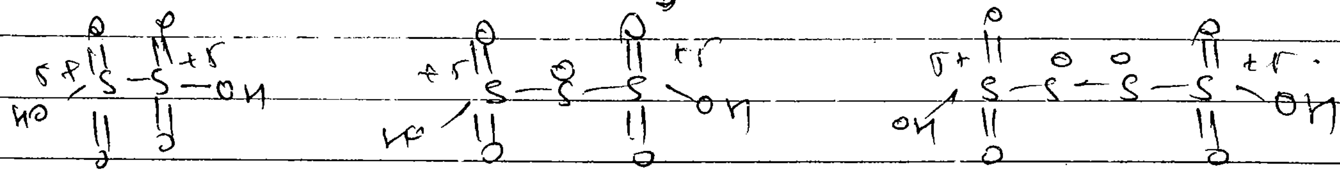
+3	$H_2S_2O_4$	Di thionous Acid
+4	$H_2S_2O_5$	Di sulphurous Acid
+5	$H_2S_2O_6$	Di thionic
+6	$H_2S_2O_7$	Di sulphuric ~~Acid~~ Acid

POLY THIONIC ACID

$H_2S_nO_6$ S–S linkage = $n-1$ $\boxed{\text{avg O.S of } S = \frac{10}{n}}$

$n \geq 2$.

$H_2S_2O_6$ $H_2S_3O_6$ $H_2S_4O_6$.



BASICITY OF OXYACIDS

⇒ No. of OH^- required to neutralize one molecule of Acid represents basicity of that oxyacid.

⇒ Oxy acids of Boron are lewis Acid because they r $e^\ominus$ defficient (B, $6e^-$) so they does not give their H^+ in aq. medium they accept OH^- (L.B) from aq. medium

$$B(OH)_3 + H^+OH^- \longrightarrow H^+[B(OH)_4]^-$$

⇒. Basicity of oxyacids of boron = No. of Boron present in a molecule

$H_3BO_3 \rightarrow$ Mono basic lewis acid

⇒ Except oxyacid of 'B'
All other oxyacid are proton donor acid (H^+).
'H' which is directly bonded to O in oxyacid

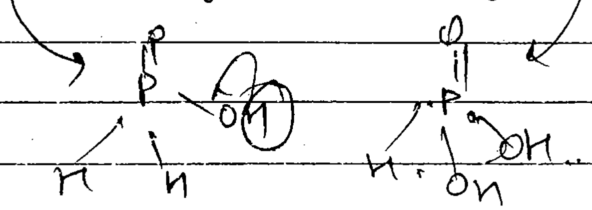
is ionizable in nature is called acidic H' represents basicity of that oxy acid.

~~Naming of oxy Acid~~

~~NAMING OF OXY ANION/SALT~~

⇒ except : H_3PO_2, H_3PO_3, $H_4P_2O_5$ & oxy acid of Boron

No. of H = Basicity.



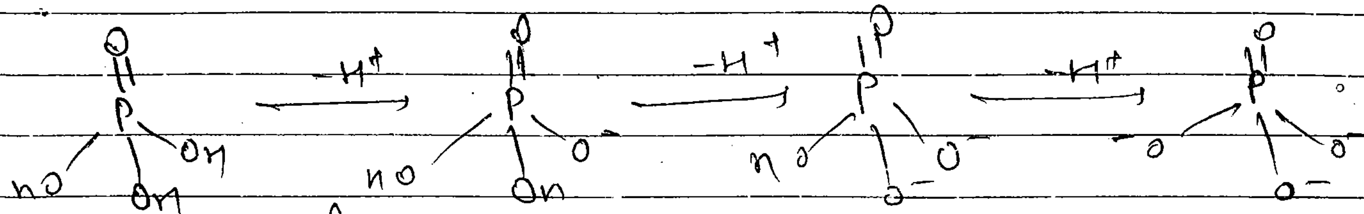
$\boxed{\text{NAMING OF OXY–ANION/SALT}}$

Acid	Anion
'ic'	'ate'
'ous'	'ite'

ex

sulphuric acid	H_2SO_4	⟶	SO_4^{2-}	sulphate
sulphurous acid	H_2SO_3	⟶	SO_3^{2-}	sulphite
Nitrous acid	HNO_2	⟶	NO_2^-	nitrite
Nitric acid.	HNO_3	⟶	NO_3^-	Nitrate
Per chloric acid	$HClO_4$	⟶	ClO_4^-	Per chlorate

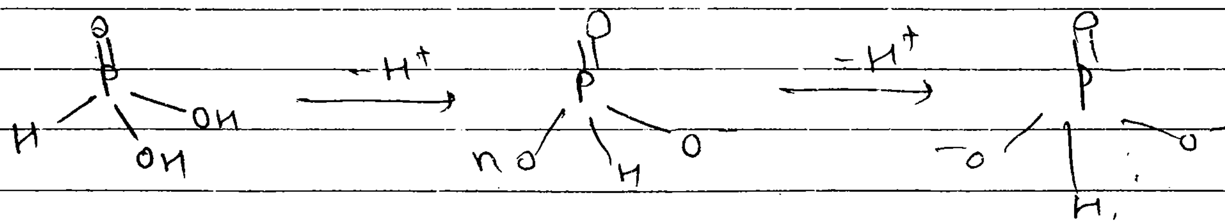
H_3PO_4



Di hydrogen phosphate — Hydrogen phosphate — phosphate

acidic H

H_3PO_3

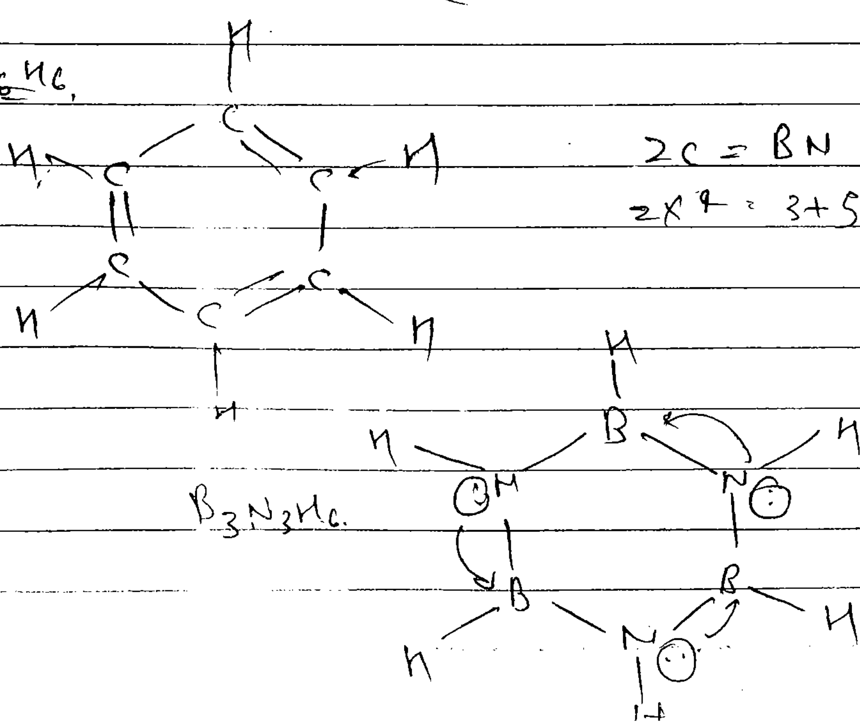


Hydrogen Phosphite — Phosphite

CYCLIC STRUCTURES

$(ABC_x)_y \quad y \geq 3.$

C_6H_6

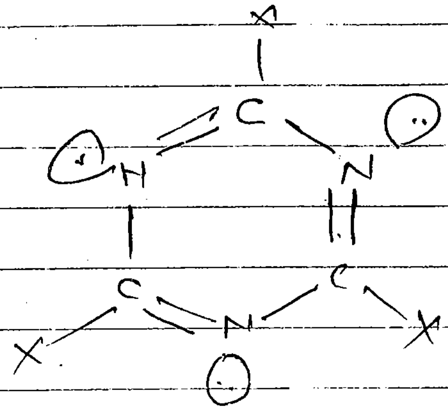


$2C = BN$

$2 \times 4 = 3 + 5$ (valence e⁻)

$B_3N_3H_6$

$C_3N_3X_3$ $(X = Cl, NH_2, N_3)$



$X = -Cl$

$= -NH_2$ (Melanine)

$= -\ddot{N}=\overset{+}{N}=\ddot{N}^{-}$

$(HPO_3)_3$, $(HPO_3)_6$, $(H_2SiO_3)_3$, $(B_3O_3(OH)_3)$

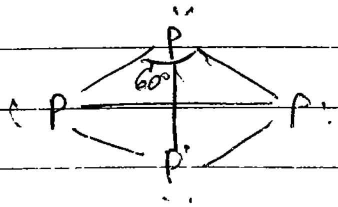
Que which of them can exist

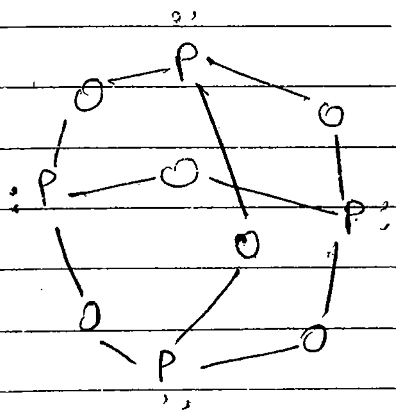
PF_5, PHF_4, PH_2F_3, PH_3F_2, PH_4F, PH_5.

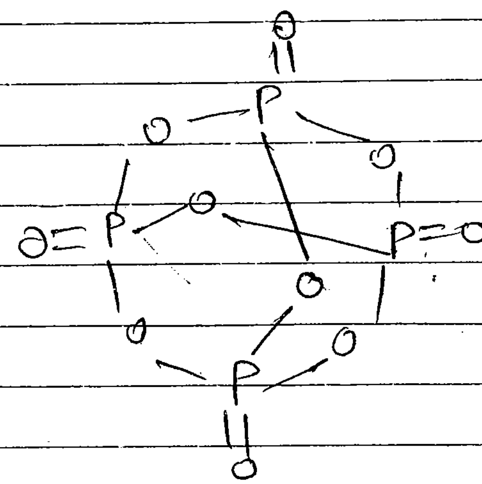
OXIDES OF PHOSPHOROUS

P_4
white 'P'

P_4O_6, P_4O_7, P_4O_8, P_4O_9
P_4O_{10}.







POLAR AND NON-POLAR COMPOUNDS AND DIPOLE MOMENT

COVALENT BOND.

Polar.
A — B.
$\Delta EN \neq 0$.
EN of A > B.

Non Polar
A — A
$\Delta EN = 0$.

$\overset{\delta-}{A} \overset{d}{—} \overset{+\delta}{B}$ bond dipole

$\mu = \delta \times d$

DIPOLE → Equal & opposite charge 'q' seperated by distance 'd' is called "dipole"

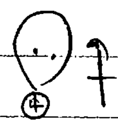
$$\boxed{\mu = q \times d}$$

It is a vector quantity which represent direction of shifting of e⁻ from less EN to more EN.

Unit Debye $1D = 3.3 \times 10^{-30}$ C-M.

Molecule/ ion contain two type of dipole.

1) - Bond Dipole
2). LP Dipole



⇒ If vector sum of all dipoles present in molecule = 0, molecule will be nonpolar.

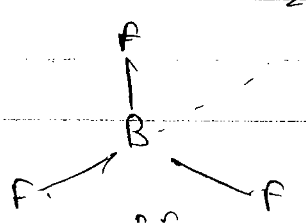
⇒ If vector sum of all dipoles ≠ 0 ; molecule will be polar.

Ex.. $F \longleftarrow Be \longrightarrow F$ = 0. Non polar

BeF_2

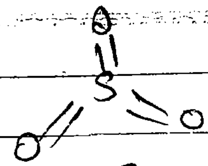
$O \longleftarrow C \longrightarrow O$ = 0: NP.

CO_2

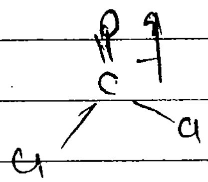


= 0 NP.

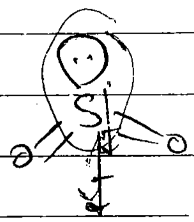
ex 1, 4 : except other forces.



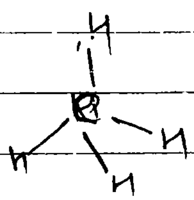
SO_3 NP.



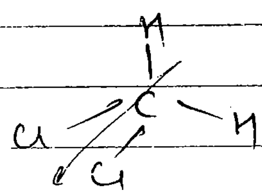
P.



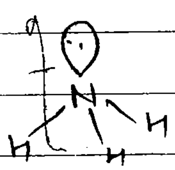
SO_2 P.



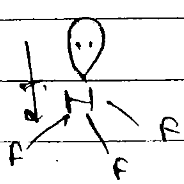
CH_4 NP.



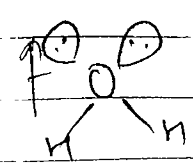
CH_2Cl_2 P.



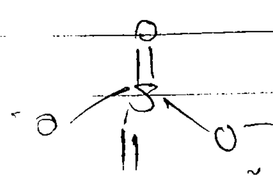
NH_3 P



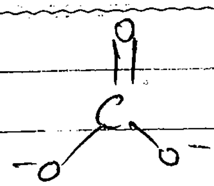
NF_3 P.



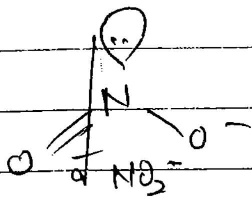
H_2O. P.



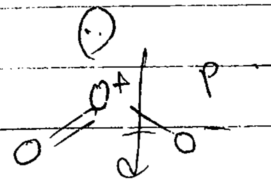
SO_4^{2-} NP.



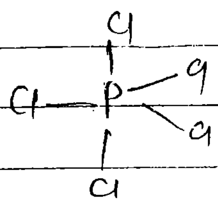
CO_3^{2-} NP



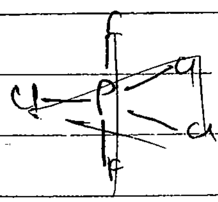
NO_2^- P



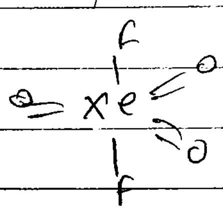
O_3 P



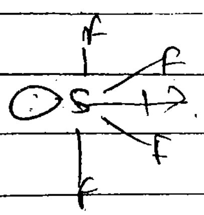
PCl_5 NP



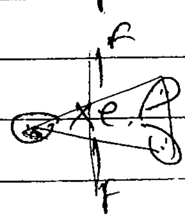
PCl_3F_2 NP



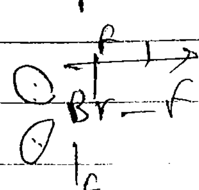
XeO_2F_2 NP



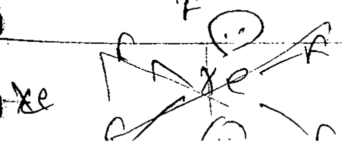
SF_4 P



XeF_2 NP



BrF_3 P

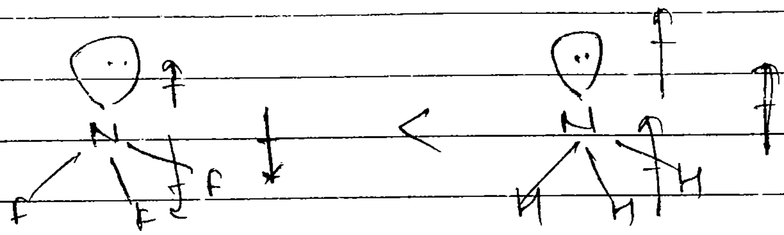


XeF_4 NP

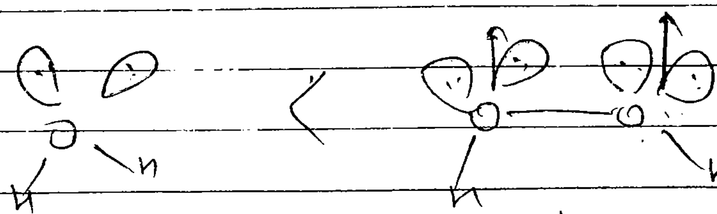
Ou. Comparison of dipole moment

1) NH_3 , NF_3
2) H_2O , H_2O_2
3) NH_3 , H_2O
✡ 4) CH_3F , CH_3Cl , CH_3Br , CH_3I
✡ 5) CH_3Cl , CH_2Cl_2 , $CHCl_3$, CCl_4

1)



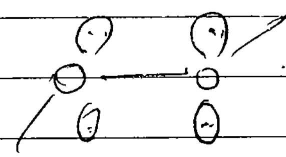
2)

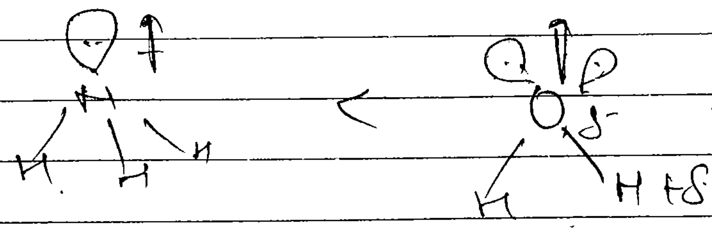


4LP+2H

open book like

2LP+2H.





ΔEN

CH_3-F CH_3-Cl:

$\Rightarrow$ CH_3F < CH_3Cl > CH_3Br > CH_3I

d. q

$\mu = q \times d$.

$CH_3Cl > CH_2Cl > CHCl_3 > CCl_4$

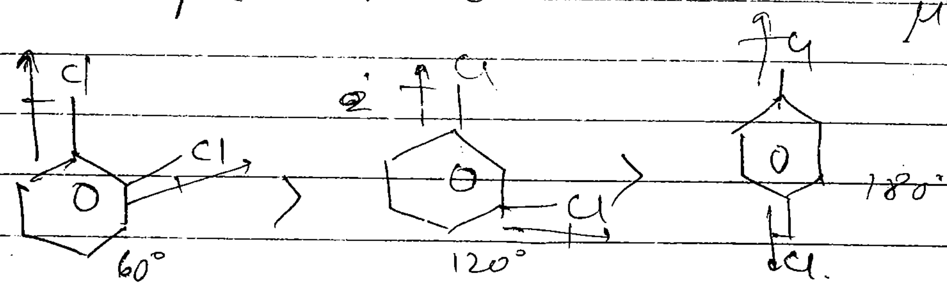
As No of 'Cl' ↑ μ ↓

Ans. Arrange following in correct order of dipole moment.

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

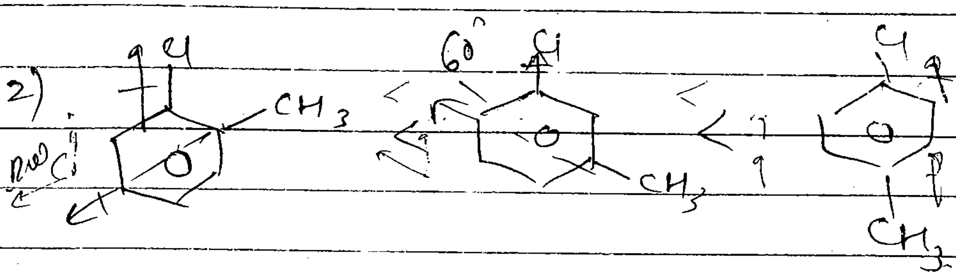
θ ↑ cos ↓ μ ↓

1).



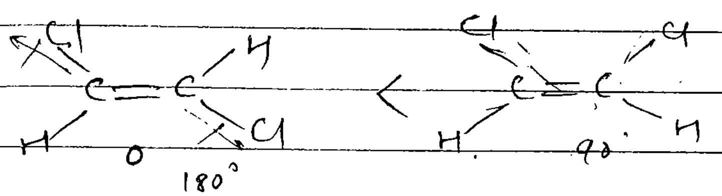
O > M > P

2)

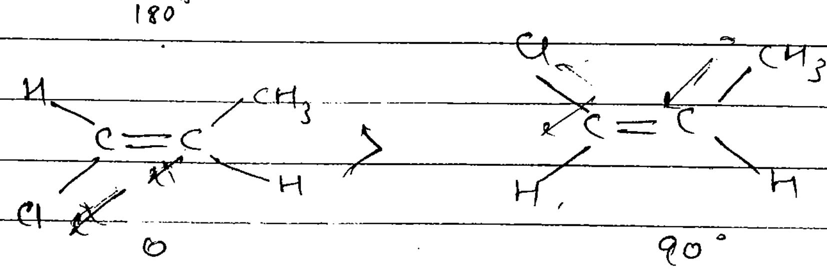


P > M > O.

3).



4).



In O, M, P derivatives

1). for same I gp.

μ O > M > P.

2). for diff I gp.

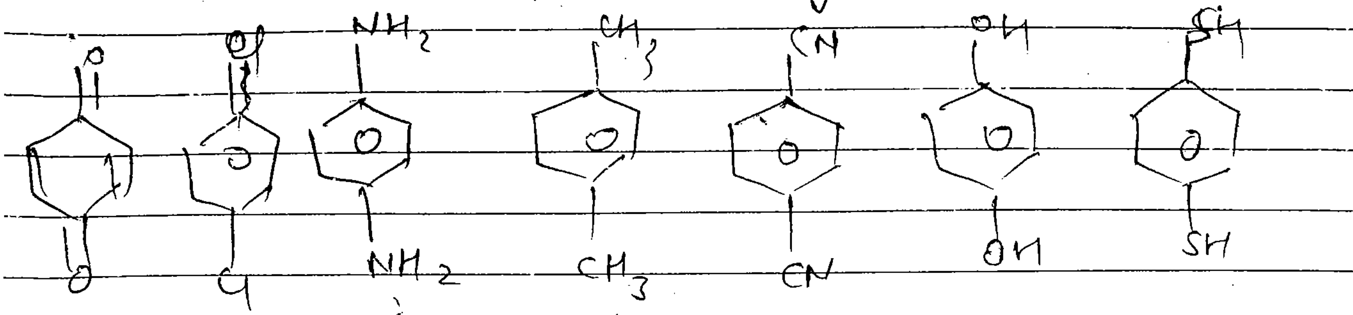
μ O < M < P.

In cis & trans isomers

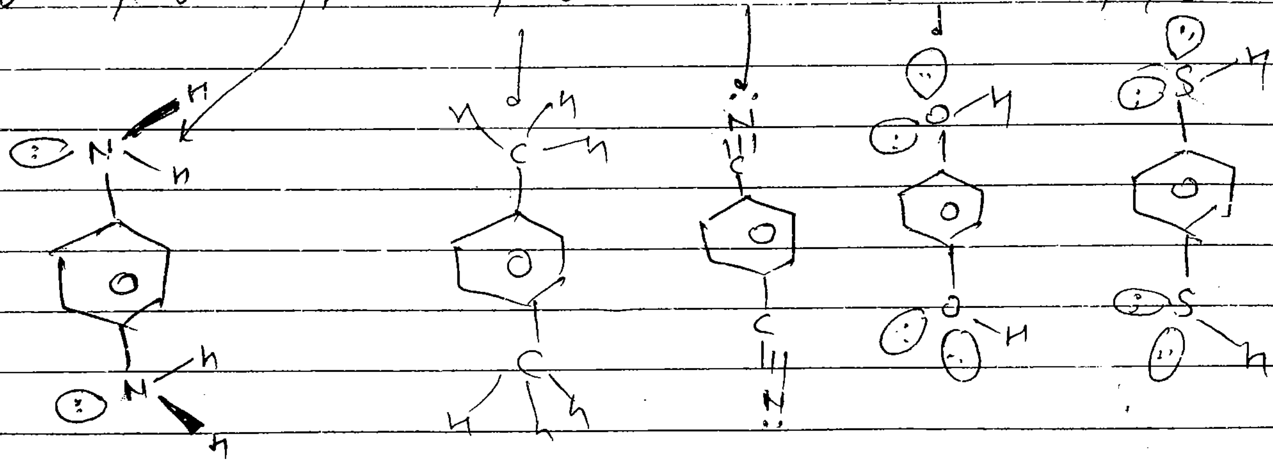
1). for same I. cis > trans.

2). for diff I ...

Que Select the species having $\mu = 0$



$\mu = 0$ $\mu = 0$ $\mu \neq 0$ $\mu = 0$ $\mu = 0$ $\mu \neq 0$ $\mu \neq 0$



% ionic character in covalent bond.

ex^n. HCl

theo.   practically

H^+Cl^- $H \longrightarrow Cl$ $\overset{+\delta}{H} - \overset{-\delta}{Cl}$

100% ionic.   < 100% ionic

$\mu_{theo.} = q \times d$. $\mu_{exp.}$ (given in question)

charge of no. of e^- shifted $\mu_{exp} = \delta \times d$.

d = bond length   fraction of charge.

(given in question).

μ_{exp} given in D (debye)

$$1D = 3.3 \times 10^{-30}\ C \cdot M.$$

$$\%\ \text{ionic character} = \frac{\mu_{exp}}{\mu_{theo}} \times 100$$

$\boxed{\text{BOND ENERGY}}$

⇒ Bond energy $\propto \frac{1}{BL}$.

But in 'p' block 2nd period & 3rd period elements comparison of single bond energy. (effect of LP)

$F—F$ $Cl—Cl$

size of	<	
BL	<	
repulsion b/w LP	>	
Net attn	<	
BE	<	

$—O—O— < —S—S—$

$—N—N— < —P—P—$

$—C—C— > —Si—Si—$

Thermal stability of covalent compounds

⇒ Compound having high thermal stability means more energy required to decompose

⇒ In covalent compound / substance
As covalent bond energy ↑
Decomposition temp. ↑
Thermal stability ↑.

So we can say T.S of covalent compound $\propto$ B.E.

B.E

$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}- \;>\; -\overset{\cdot\cdot}{\underset{|}{N}}-\overset{\cdot\cdot}{\underset{|}{N}}- \;>\; -\ddot{O}-\ddot{O}- \;>\; F-F$$

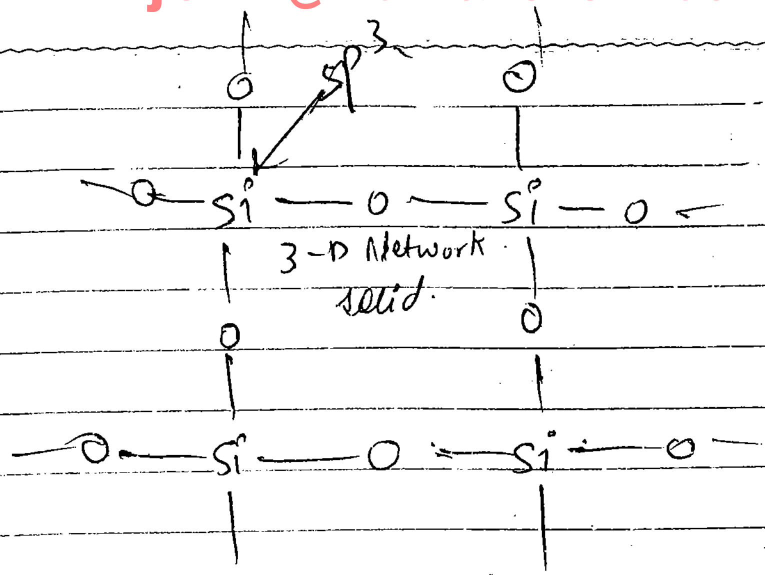
CATENATION PROPERTY / POLYMERIZATION TENDENCY

Catenation property / Polymerisation tendency
$\propto$ Single bond energy (to form stable chain)
$\propto \dfrac{1}{\pi \text{ bond form}^n \text{ tendency}}$ (to form bond with other atoms)

CO_2 exist as $O=C=O$.
while SiO_2 does not exist as $O=\cancel{Si}=O$

3rd period.

Size ↑ π bond form^n tendency ↓



SOLID STATE HYB.

(ion pair form)

$PCl_5(s) = PCl_4^+ \ PCl_6^-$

$PBr_5(s) = PBr_4^+ \ Br^-$ ($\cancel{PBr_6^-}$ due to steric crowding/repulsion)

$PI_5(s) = PI_4^+ \ I^-$ ($\cancel{PI_6^-}$)

NO_2 $\begin{cases} N_2O_3(s) = NO^+ \ NO^- \\ N_2O_4(s) = NO^+ \ NO_3^- \\ N_2O_5(s) = NO_2^+ \ NO_3^- \end{cases}$

$ClO_3(s) = ClO_2^+ \ ClO_4^-$

$XeF_6(s) = XeF_5^+ \ F^-$ (XeF_7^-) ($XeF_6 --- F^-$)

** Acc to NCERT.
Geometry/shape/Molecular geometry. is same for given molecule while electronic geometry is different.

** OCl_2, OBr_2, OMe_2 exception of VSEPR their BA > 109°28' due to steric repulsion of S.A

ODD - ELECTRON SPECIES.

⇒ odd no. of e^-s.

⇒ All odd e^- species r paramagnetic.

Odd e^-

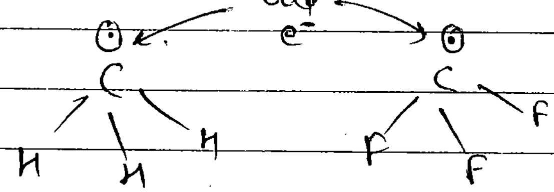
VBT/Hyb.

Polyatomic.	~~Diamagnetic~~ Diatomic
NO_2, ClO_2, ClO_3, CF_3, CH_3.	(NO, CN, OF, O_2^{-1}) & MOT.

Hyb. in odd $e^\ominus$ species

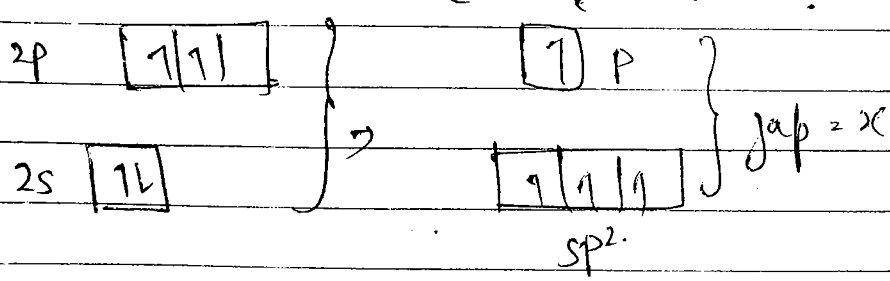
CH_3 CF_3

odd e^-



due to 3 bonds atleast
hyb. of 'C' is sp^2

$e^\ominus$ · ← odd e^-



~~If tv~~

If +ve charge present on 'C' atom

$\boxed{1}$

$\boxed{1 \mid 1 \mid 1}$ } gap < x.

mixing $sp^2 + p \rightarrow sp^3$ ✓

odd e^- present in hybrid orbital.

If -ve charge present on 'C' atom.

$\boxed{1}$

$\boxed{1 \mid 1 \mid 1}$ } gap > x.

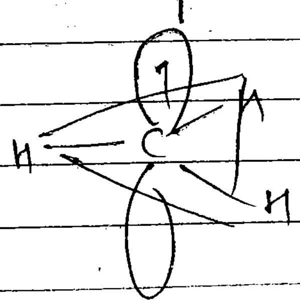
mixing ✗

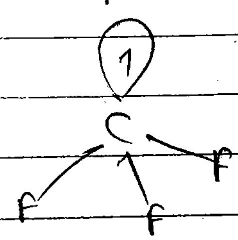
✓ $sp^2 + p \rightarrow sp^3$ ✗

odd e^- present in pure orbital / unhybrid.

$\overset{-\delta}{CH_3}$ — sp^2

$\overset{+\delta}{CF_3}$ — sp^3.



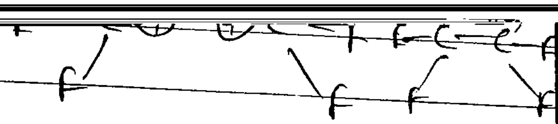


trigonal plane.

trigonal pyramidal.

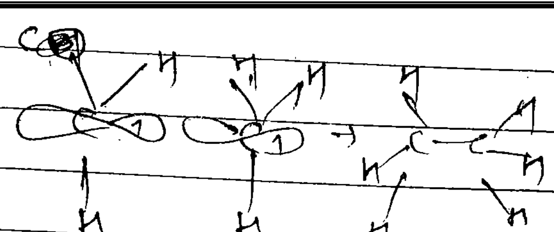
$\overset{-\delta}{CH_2F}$ planar

$\overset{+\delta}{CHF_2}$ Non planar sp^3



⇒ bond formed by hybrid orbital which is stronger than bond formed by pure orbital.

⇒ No change in hyb. & planarity of 'C' so energy barrier is very low.



⇒ Bond formed by pure 'p' orbital

⇒ Change in hyb. & planarity of 'C' so energy barrier is high.

Que Matrix Match.

on dimerization change in

(A) $2CF_3 \rightarrow C_2F_6$ (P) Polarity.

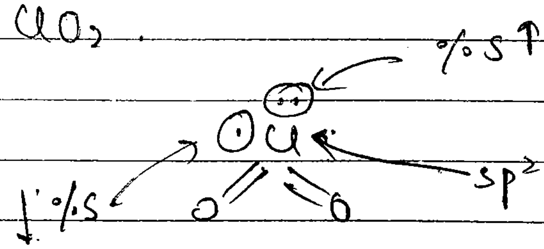
(B) $2CH_3 \rightarrow C_2H_6$ (Q) Planarity.

(R) Bond angle.

(S) Hyb. of 'C'.

A → (R) (P)
B → (Q), (R) (S).

ClO_2.



mixing ✗.
unhybrid/pure,

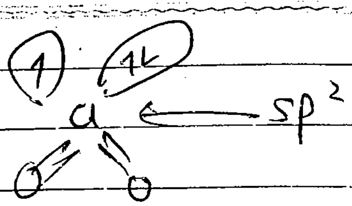
odd e⁻ species.

CA contain LP.
odd e⁻ present in hybrid orbital
False

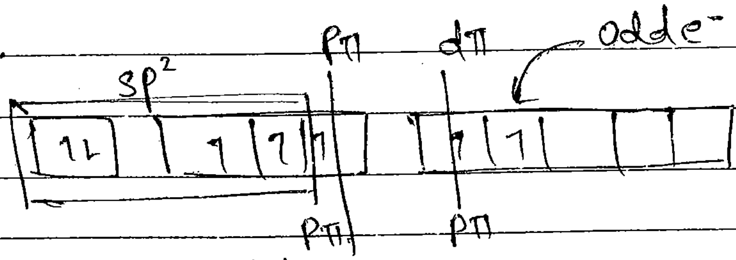
CA doesn't contain LP

EN of SA ↑.
odd e⁻ present in hybrid orbital.

EN of SA ↓.
odd e⁻ present in hybrid orbital.
false



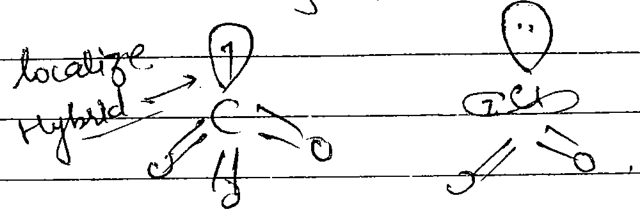
Acc. to VBT



Acc. to VBT odd e^- delocalized in 'd' orbitals.

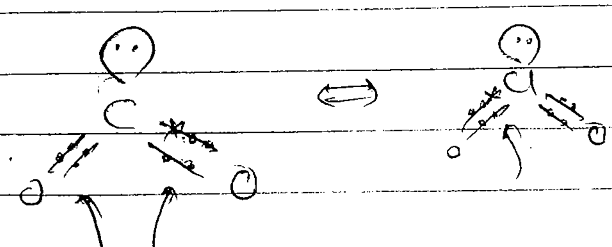
Dimerization tendency.

$ClO_3 > ClO_2$.



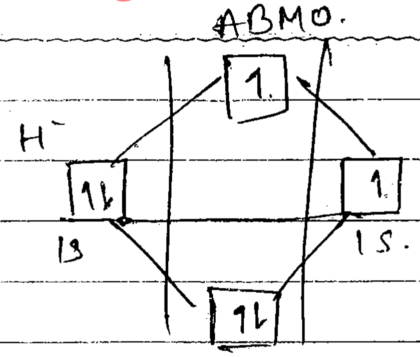
Acc. to MOT odd e^- in ClO_2 present in Anti Bonding orbital and contain two centre three e^- bond odd e^- delocalized b/w three atoms

$O - Cl - O$



$\frac{2+1.5}{2} = 1.75$

ex H_2^-.



Stability ↓
repulsion.

$\frac{2-0}{2} = 1$

$\frac{2-1}{2} = .5$

Stability ↑.
attⁿ

2c–3e⁻

[H ·· × H]

Anti bonding.

Bonding $\frac{2-1}{2} = .5$

Ex ⇒ NO.

Acc. to MOT.

NO is

:N ≡ O:

BO of NO is 2.5

odd e⁻ delocalize b/w two atoms.

⇒ ~~Dimerisa~~

⇒ Dimerization tendency of

(1) ClO_2 < NO.

delocalization of odd e⁻ b/w ↓ 3 atoms ↘ 2 atoms (b). NO < NO_2.

odd e^- delocalize. localize. (present in hybrid orbital)

As delocalization of odd e^- ↑
stability ↑
Reactivity ↓
Dimerization tendency ↓

Que Arrange following in correct order of formation tendency.

$\overset{del}{NO} + \overset{del}{NO} \longrightarrow N_2O_2$ (I)

$\overset{del}{NO} + \overset{loc}{NO_2} \longrightarrow N_2O_3$ (II). Blue colour liquid.

$\overset{loc}{NO_2} + \overset{loc}{NO_2} \longrightarrow N_2O_4$ (III)

colourless gas. (NO)

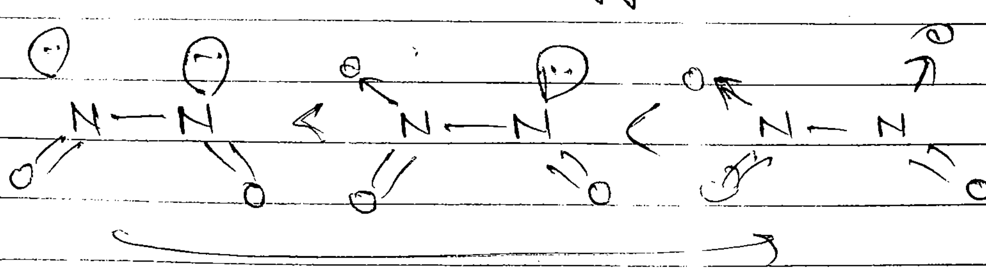
NO_2 ↓ Reddish brown gas.

N_2O_4: colourless liquid,

(III) (III) (I)

(III) > (II) > (I).

Que Arrange $\overset{+2}{N_2O_2}$, $\overset{+3}{N_2O_3}$, $\overset{+4}{N_2O_4}$ in correct order of Bond Energy. N—N



No. of LP ↓, o.s on N–N Bon ↑.
N–N BL ↓.
N–N BE ↑

Structure of

double CA X_2O_m , $X_2O_m^{-n}$, $H_nX_2O_m$.

x = CA   M, n variable.

O = oxygen.

consider O.S of 'O' = −2
'H' = +1

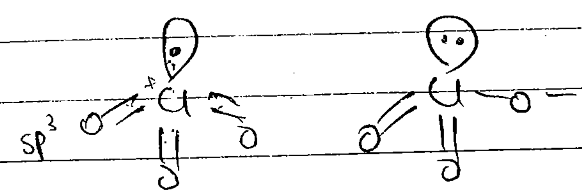
If O.S of X → < Max $X-X$
= Max $X-O-X$
> Max. $X-O-O-X$

exception: I_2O_5, $H_4P_2O_5$

BOND ANGLE

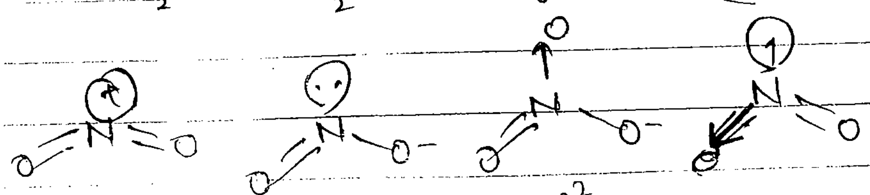
Que. Compare BA in

(1). $ClO_3 > ClO_3^-$



θ > 109°   θ < 109°

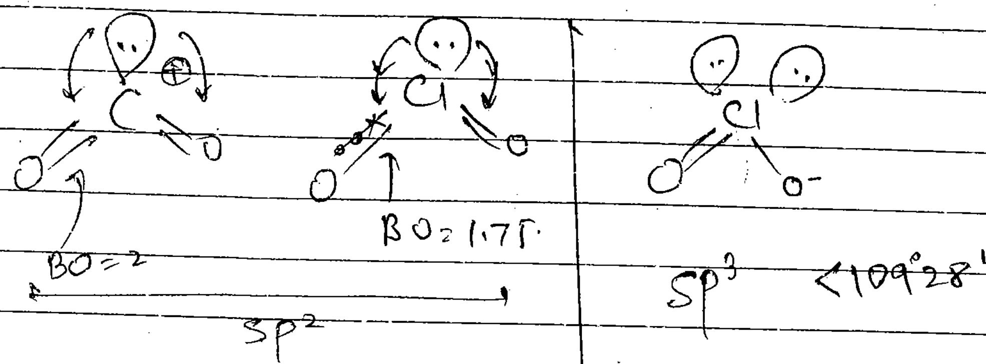
(2). NO_2^+ NO_2^- NO_3^- NO_2



sp   180°   120°   sp²   120°   120°

$NO_2^+ > NO_2 > NO_3^- > NO_2$

⇒ O-Cl-O BA in $ClO_2^+ > ClO_2 > ClO_2^-$



BO ↓

repulsion of LP ↑

BA ↓

⇒ **NO**

colourless paramagnetic gas.

very low tendency of dimerization,

BO = 2.5.

⇒ **ClO_2.**

sp^2, BA < 120°, BO = 1.75.

odd e^-, present in ABMO

very very low tendency of dimerization.

⇒ $NO_2 \longrightarrow N_2O_4 \longrightarrow NO^+ \; NO_3^-$

N_2O_4: liquid. $NO^+ NO_3^-$: solid.

Reddish brown, paramagnetic gas.

sp^2, BA > 120°

BO = 1.5.

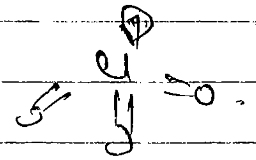
odd e⁻ present in hybrid orbital.

$ClO_3 \longrightarrow Cl_2O_6 = ClO_2^+ \quad ClO_4^-$

Paramagnetic (s).

BO = 2, sp^3, BA > 109°28'

odd e^- present in hybrid orbital.



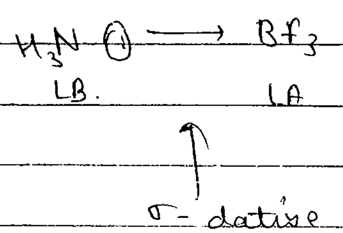
$N_2O_5 = NO_2^+ \quad NO_3^-$
(s)

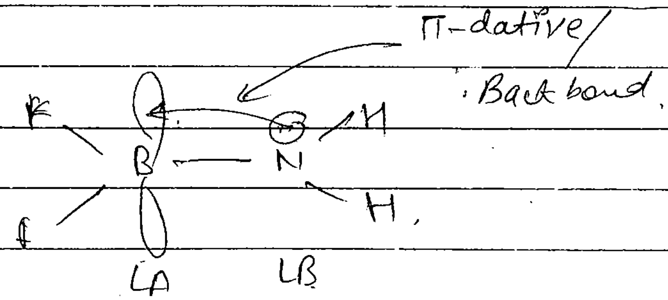
$N_2O_3 = NO^+ \quad NO_2^-$
(s) blue.

BACK BONDING

Dative

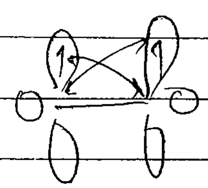
σ-dative	π-dative
⇒ σ-dative.	⇒ π-dative
⇒ Headon.	⇒ sideways
⇒ Co-ordinate bond	⇒ Back bond.
→ Intermolecular lewis Acid bas interaction	⇒ Intramolecular lewis acid base interaction

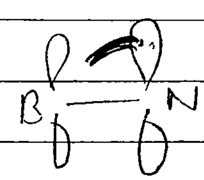


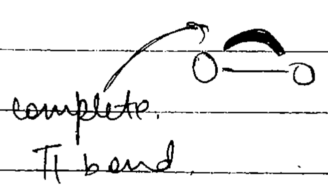


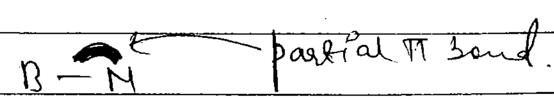
Back bond is a partial π bond.

O_2









CONDITION FOR EFFECTIVE BACK BOND

(1). One of the element must be belongs to second period while other atom can be belongs to either second period or third period.

Back bond

$2p\pi - 2p\pi$ ✓

$2p\pi - 3p\pi$ ✓

$3p\pi - 3p\pi$ ✗

$3p\pi - 3d\pi$ ✗

$2p\pi - 3d\pi$ ✓

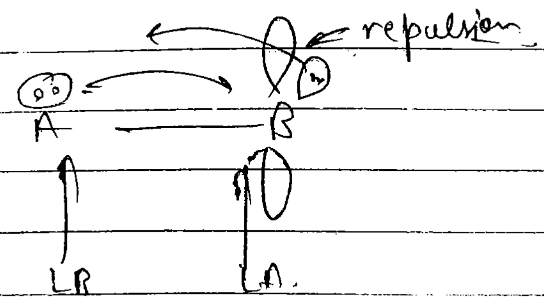
$3d\pi - 3d\pi$ ✗

size ↓ effectiveness of backbond ↑

(2). ~~If acceptor atom containes lone pair effective back bond form when~~

effective back bond form when,

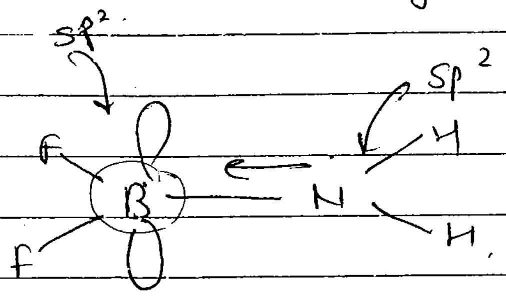
EN of acceptor atom > donor atom.



effective BB formⁿ · en of B > A.

Ineffective BB formⁿ en of A > B

(3). In back bond formation hyb. of acceptor atom remain same while hyb. of donor atom decreases



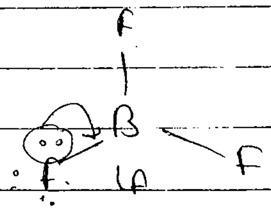
before BB
N → sp³

LA LB

BB ✓ 2nd 2nd.

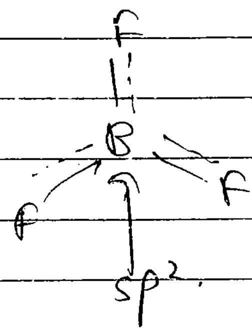
Examples

BF_3



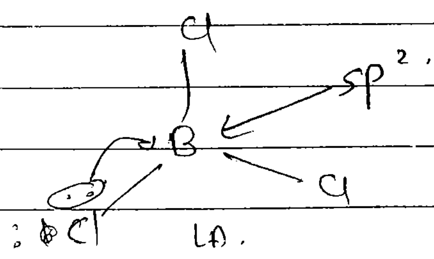
LB. 2nd.

2nd



$2p_\pi - 2p_\pi$ BB ✓ BO > 1

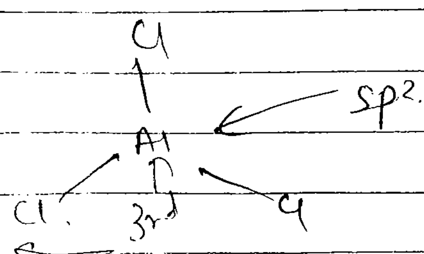
BCl_3



LB

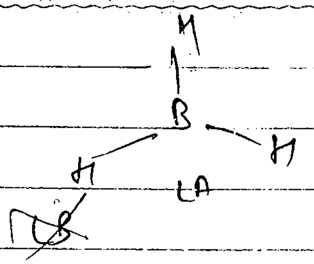
$2p_\pi - 3p_\pi$ BB ✓.

$AlCl_3$.



BB ✗.

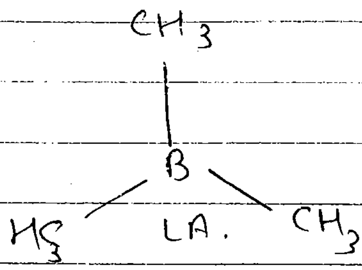
BH_3



BB✗.

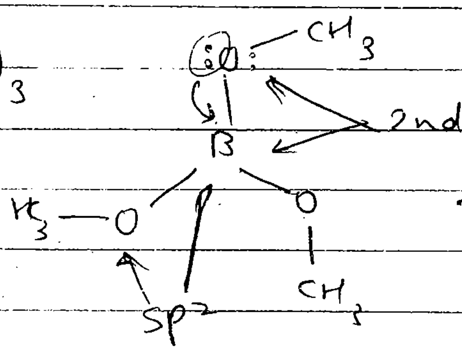
~~NB~~

BMe_3



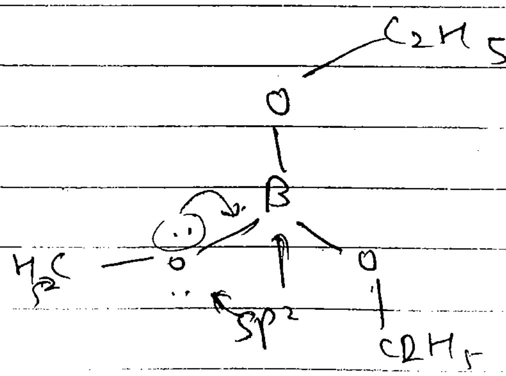
~~NB~~ BB✗.

$B(OCH_3)_3$

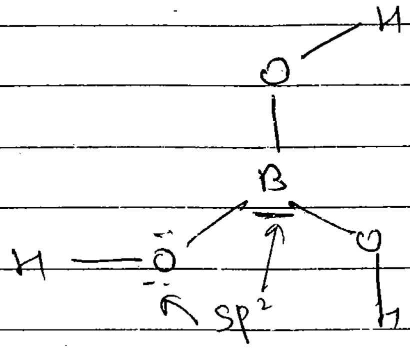


$2p\pi - 2p\pi$ BBV.

$B(OC_2H_5)_3$



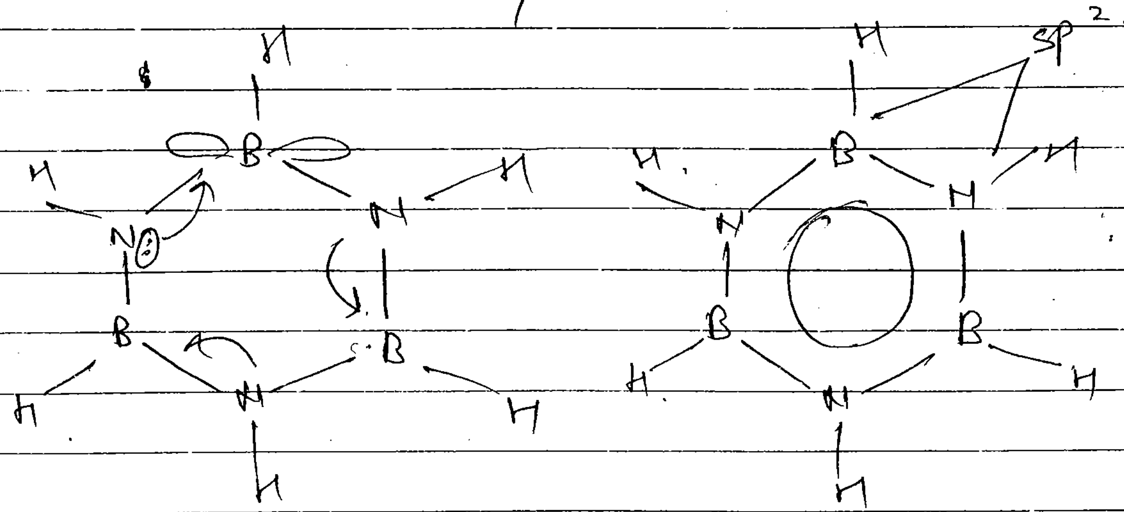
H_3BO_3

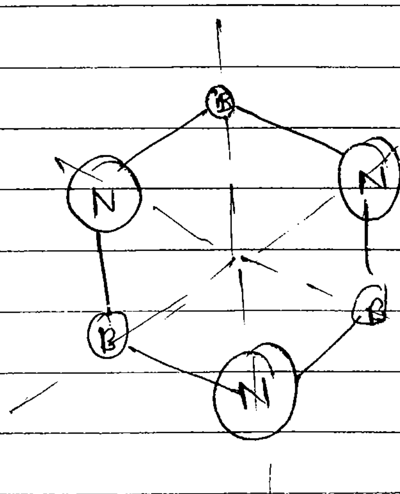


$2p_\pi - 2p_\pi$ BBV.

$B_3N_3H_6$ (Inorganic Benzene)

Borozine/ Borazone.



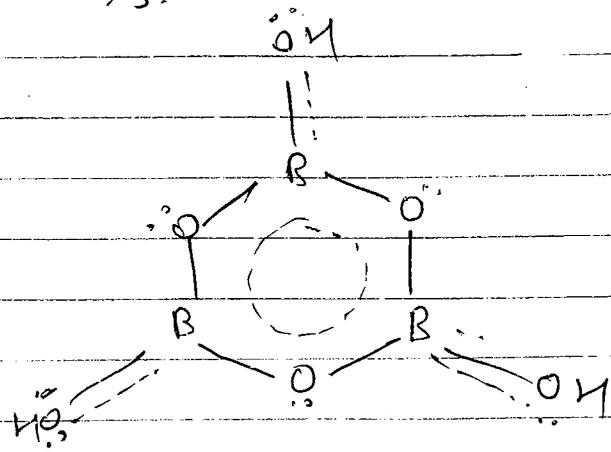


e⁻ rich,

e⁻ defficient.

aromatic but not 100%.

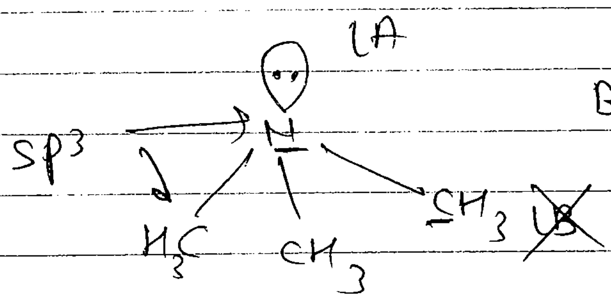
$B_3O_3(OH)_3$



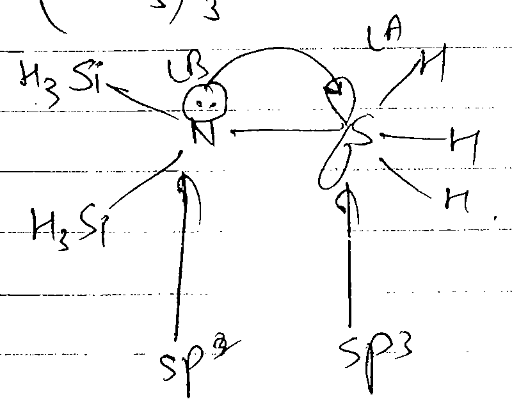
All B & O atoms are sp^2 hybridized.

aromatic but not 100%.

$N(CH_3)_3$

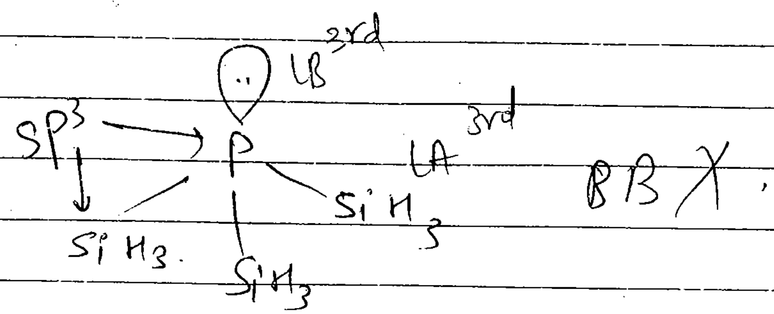


$N(SiH_3)_3$

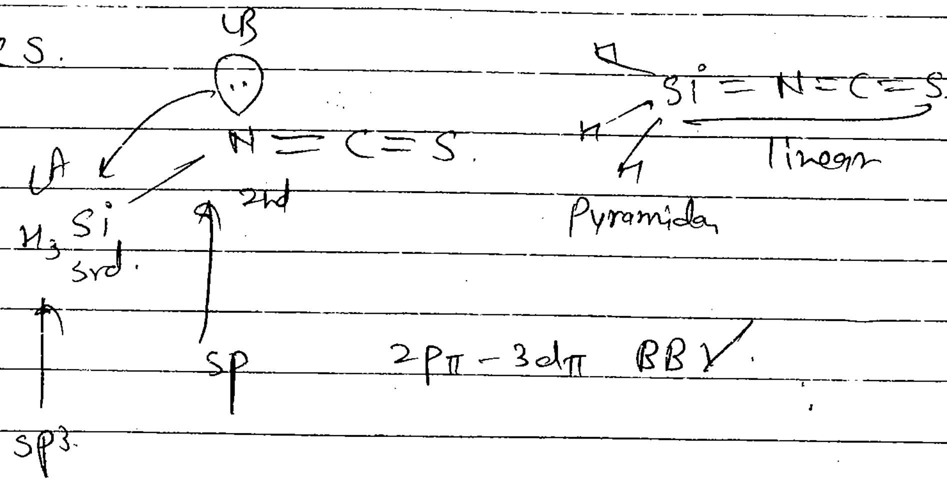


BBV $\quad 2p_\pi - 3d_\pi$

$P(SiH_3)_3$



H_3SiNCS.



Que Find hyb. of underlined atom and comment on back bonding.

1). H_3CNCS
2). R_3SiOH
3). R_3COH
4). $O(SiH_3)_2$
5). $O(CH_3)_2$
6). PF_3
7). H_3GeNCS
8). OCl_2
9). NCl_3
10). $B_4O_4(OH)_4$
11). H_4SiO_4
12). CCl_3^-
13). CF_3^-

(1) LP ✓ ben

$H_3C - N=C=S$

LA ✗ sp^3 sp^2

BBX.

only one LP deloc

(2) $R_3Si - O - H$

sp^3 sp^2

BB ✓

$2p_\pi - 3d_\pi$

(3) $R_3C - O - H$

sp^3

2π bon

+ve charge on O ⇑ unstability

$\theta > 120$

~~steric~~ crowding

(4). $SiH_3 - O - SiH_3$

sp

$H_3Si - O - SiH_3$

sp^2

BB ✓

v shape

$2p_\pi - 3p_\pi$

(5). $CH_3 - O - CH_3$

$H_3C - O - CH_3$

sp^3

BB ✗

$\theta > 109°28'$

(6) PF_3

LA ✓

P → sp^3. BB ✓ ~~eff~~ BBX.

F F F

LA

EN of acceptor (p) < don (F).

(7) 2nd

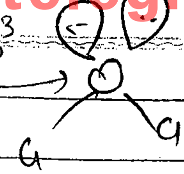
$H_3Ge - N=C=S$

sp^2

sp^3

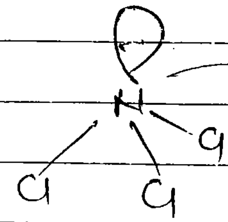
BB ✗.

(8). OCl_2 Cl — O — Cl → sp^3



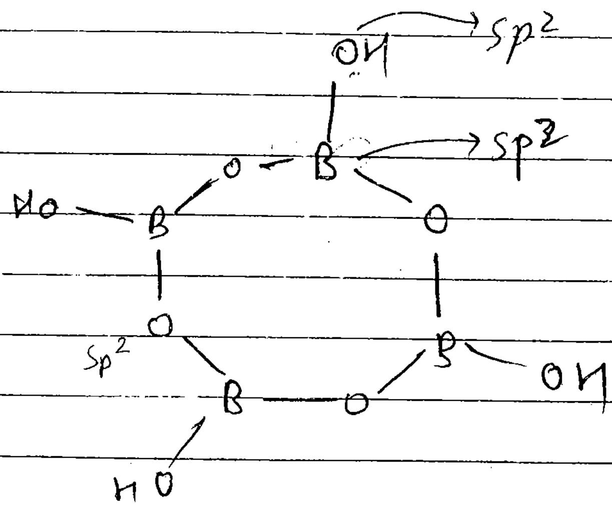
BB ✓
eff BB ✗.
EN of Cl < O.

(9) NCl_3



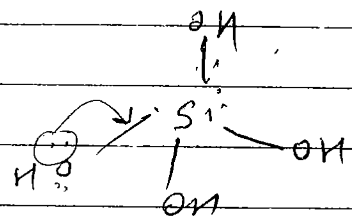
BB ✓
eff BB ✗.
EN of Cl < N.

(10)



BB ✓
all O & B atoms are sp^2 hyb.

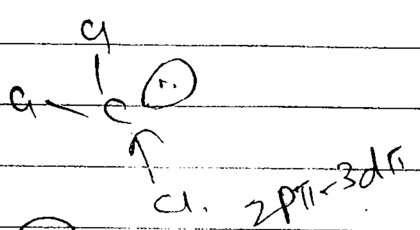
(11). H_4SiO_4

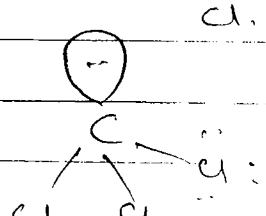


O → sp^2
Si → sp^3

(12) CCl_3^-

$CCl_2 + Cl^-$

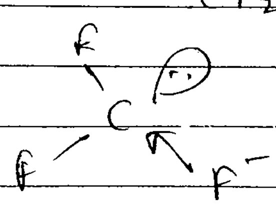




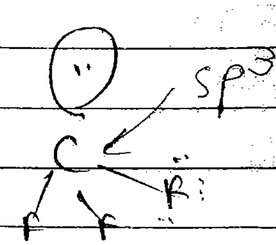
BB ✓
eff BB ✓
EN of Cl > C

(13). CF_3^-

$CF_2 + F^-$



BB ✗



VD

(3). $\overset{(1L)}{C}$ Cl Cl — BB✓ — sp^2

(4) $\overset{(1)(1)}{C}$ δ H H — BB X — sp^3

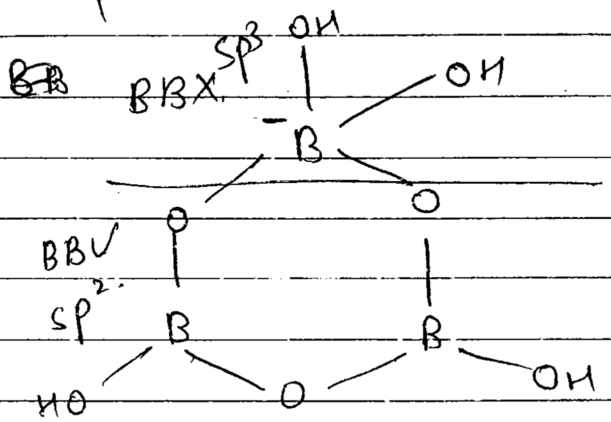
(5) $\overset{(1)(1)}{C}$ S* F F — BB X — sp^3

(6). $\overset{(1)(1)}{C}$ S* Cl Cl — BB X — sp^3

2pπ–3pπ

$Na^+ \mid B_3O_3(OH)_4^-$

$Na^+ \mid B_3O_3(OH)_3 + OH^-$



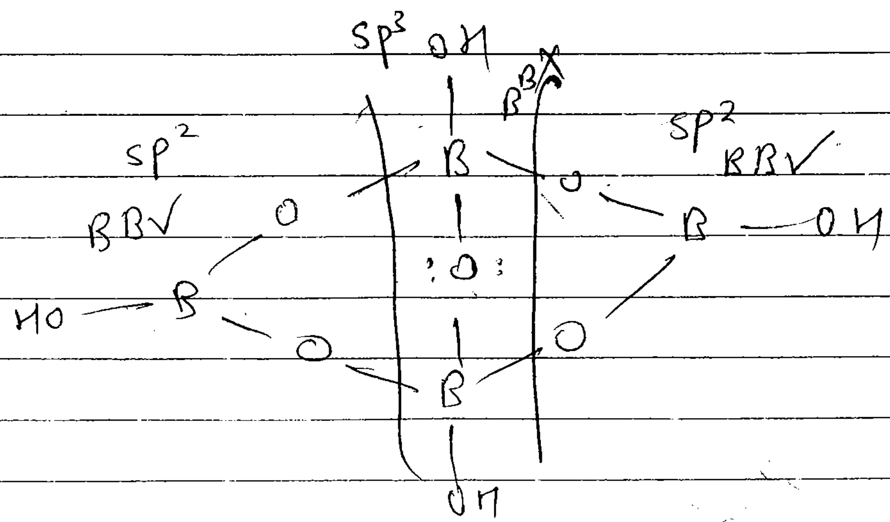
<u>Borax</u>

$Na_2B_4O_7 \cdot 10H_2O$

$Na_2[B_4O_5(OH)_4] \cdot 8H_2O$

$2Na^+ \mid B_4O_5(OH)_4^{-2}$

$B_4O_4(OH)_4 + O^{-2}$



Que. Select correct statement(s) for

$N(CH_3)_3 = A$, $N(SiH_3)_3 = B$.

✓ (1). 'N' in A is sp^3 ~~and~~ while in B sp^2 hyb.

✓ (2). Geometry around 'N' in A is nonplanar while in B is planar.

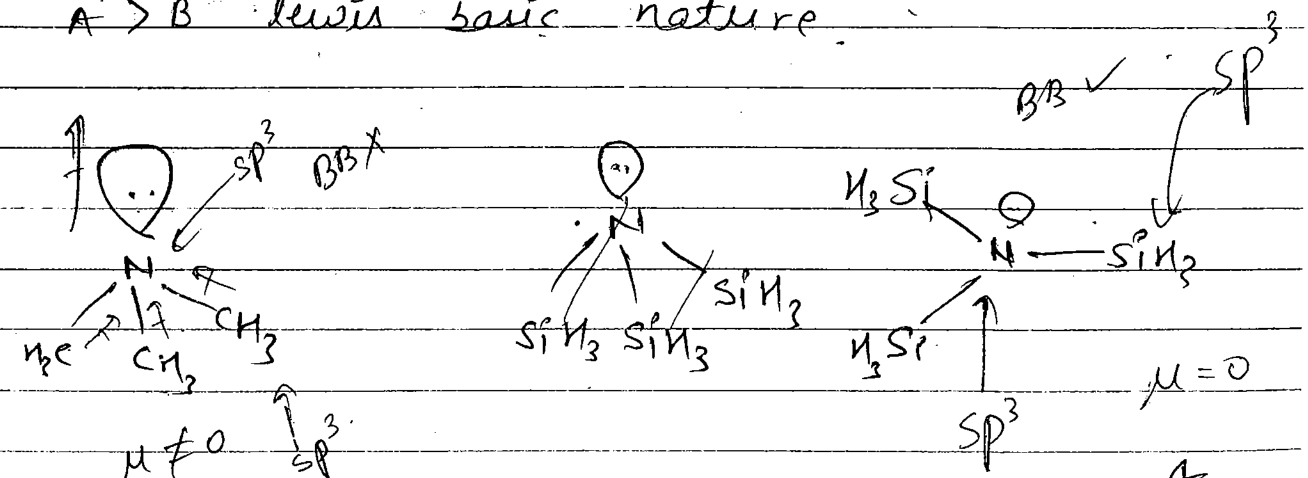
✗ (3). A is non-planar while B is planar.

✓ (4). A is polar & B is non polar.

✓ (5). N–C < N–Si Bond order

✓ (6). N–C < N–Si Bond length. Size ↑ BL ↑ species are different

✓ (7). A > B lewis basic nature.



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

Due to delocalization lewis basic nature decreases.

Que. Select correct statement(s) for.

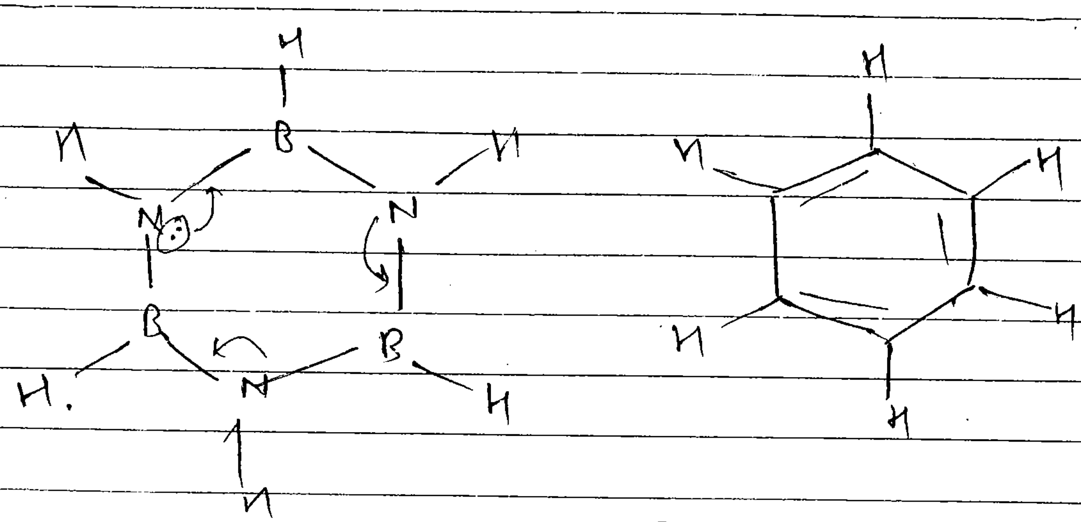
$B_3N_3H_6$ & C_6H_6.

(1) Both are planer

(2). Both are non polar

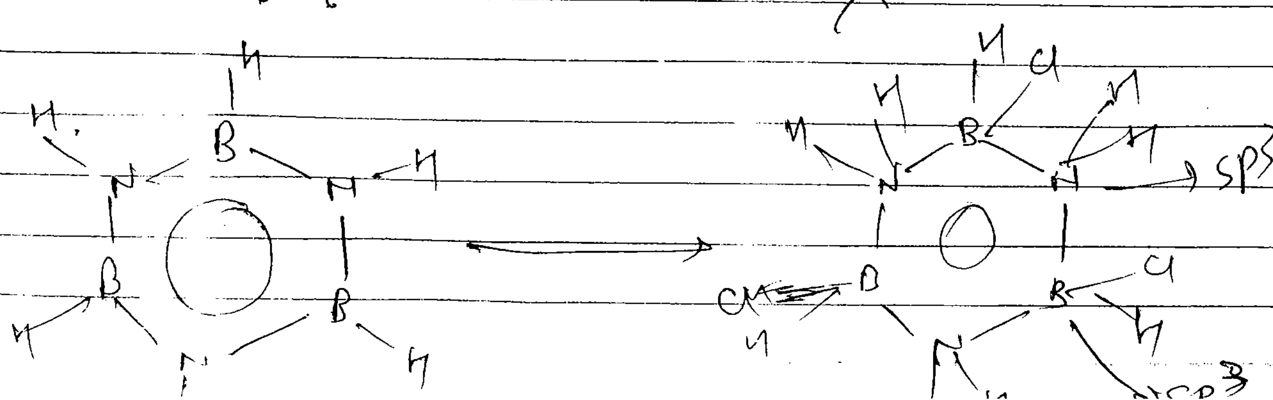
(3). Both are aromatic.

(4). Reactivity of $B_3N_3H_6 > C_6H_6$



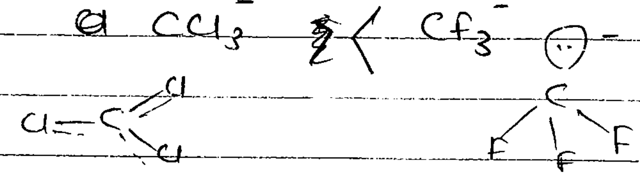
$\underset{LA}{B_3}\underset{LB}{N_3}H_6 + \underset{LA}{H}\underset{LB}{Cl} \xrightarrow{RT}$ ✓

$C_6H_6 + HCl \xrightarrow{RT} \times$



Que — Arrange following in correct order of

1) weak base CCl_3^- < CF_3^- (LB nature)

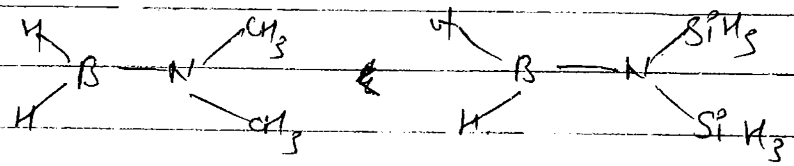


2). strong acid $CHCl_3$ CHF_3 (H^+ donor ability)

3). BF_3 BF_2H BFH_2 (BF BL)

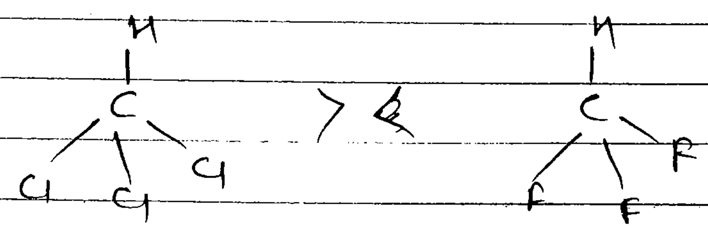
(4). BMe_3 $B(OMe)_3$ $B(OEt)_3$ — (LA nature)

(5).

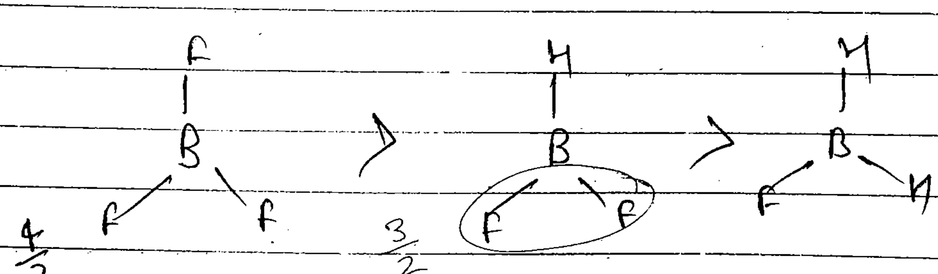


(BN BL)

(2). $\cancel{CCl_3^-}$ $CHCl_3$ CHF_3



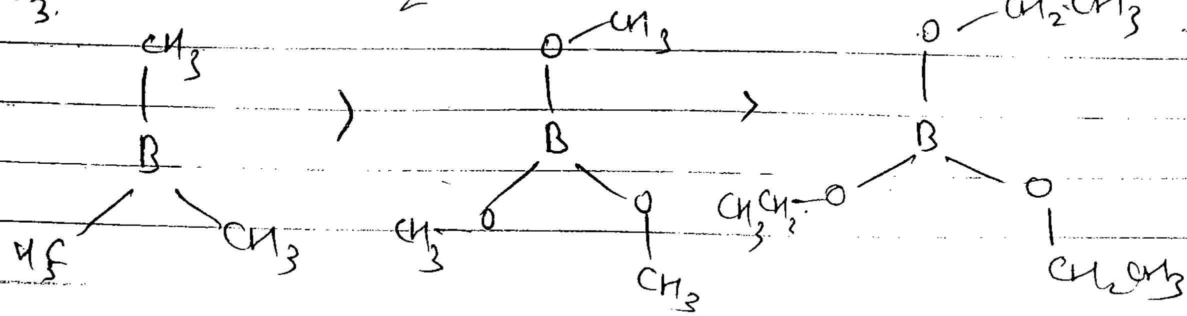
(3).



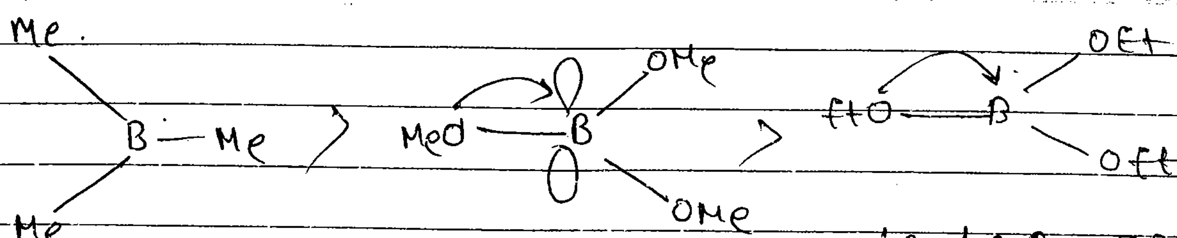
BO↑ BL↓

BO = 2.

(4).



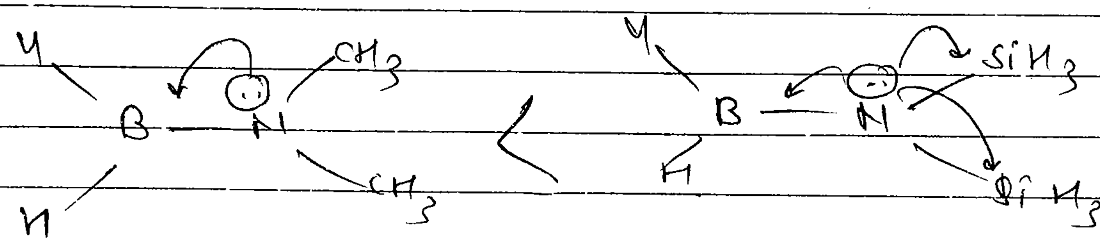
(4).



LB of O ↑ BR ↑.

BR ↑, availability of vacant orbital of boron ↓ LA ↓

(5).



BO = 2 BO = $\frac{4}{3}$.

Que. Arrange following in correct order of

(1). $OSiH_3^-$ OCH_3^- (LB nature)

(2) $OSiR_3^-$ OCR_3^- (LB nature)

(3). H_3SiOH H_3COH (H^+ donor ability)

(4). R_3SiOH R_3COH (H^+ donor ability)

(5). BF_3 BF_2Me $BFMe_2$ (BF BL).

(6). BF_3 BF_2OH $BF(OH)_2$ (BF BL).

(7). BF_3 BF_2OH $\cancel{BF_3}$ BF_2NH_2 (BF BL)

(8). BF_3 H_3BO_3 $B(NH_2)_3$ (LA nature)

(9). H_3SiNCS H_3CNCS (LB nature)

Que In which of these geometry around underlined atom remains same if all CH_3 are replaced By SiH_3

(A). $\underline{N}(CH_3)_3$ (B) $H_3C\underline{N}CO$ (C) $\underline{O}(CH_3)_2$.

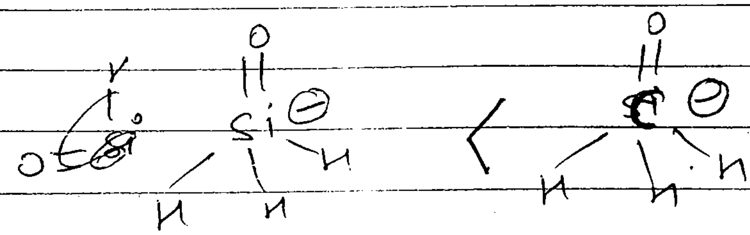
(D). $\underline{P}(CH_3)_3$

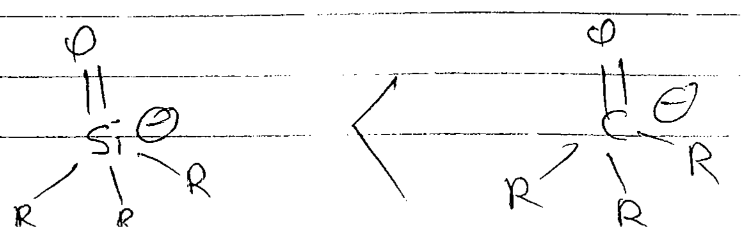
Que. Which of them are/is linear around underlined atom

(A). $H_3C\underline{N}CO$ (B) $H_3\underline{C}CHH$

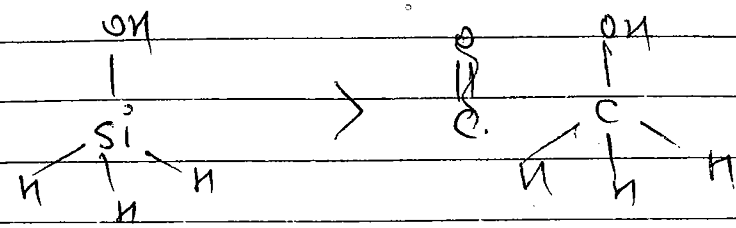
(C) $H_3Si\underline{N}CO$ (D) $H_3CN\underline{C}S$

Solutions

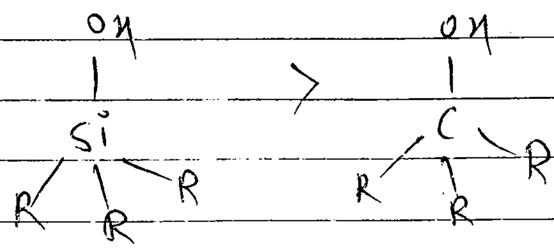
(1) 

(2). 

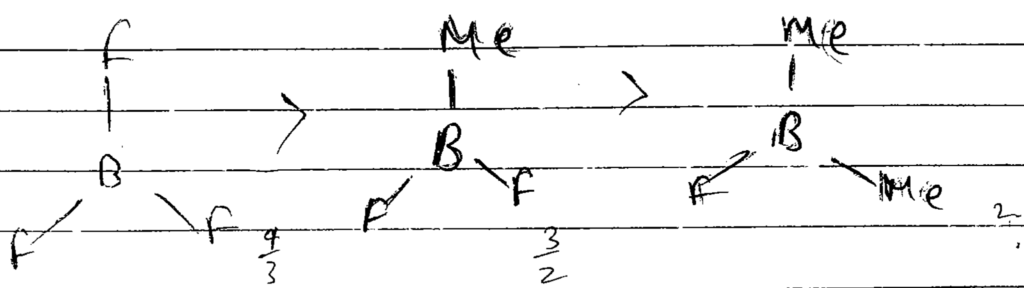
(3)



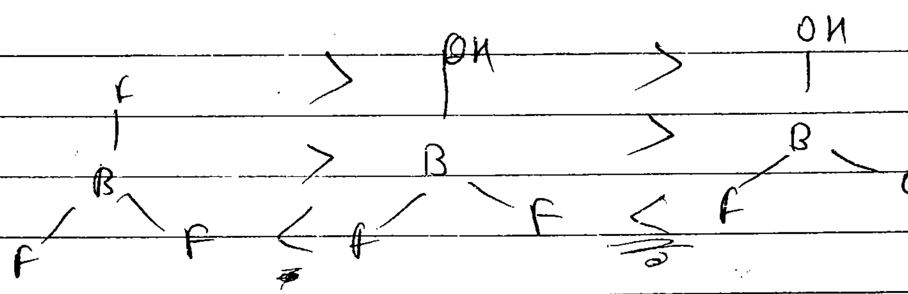
(4)



(5)



(6)

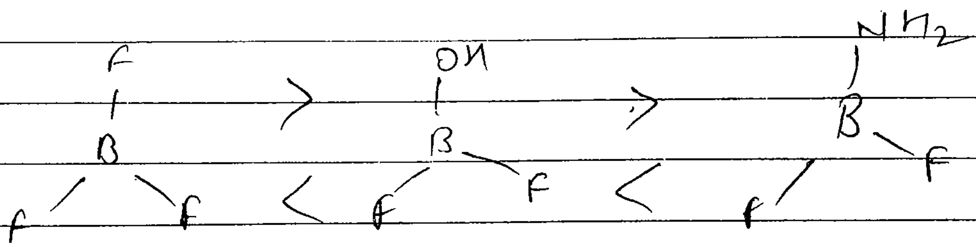


extent of BB in BF bond > →

Practical BF (BO)

BF BL.

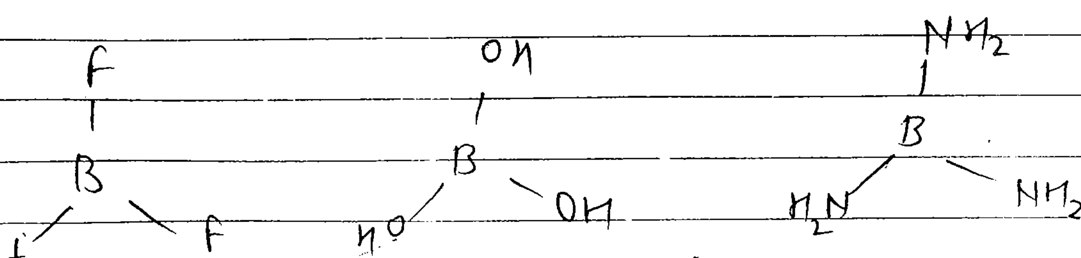
(7)



extent of BB in BF bond

BL BF

(8)



extent of BB: C=O < <

LA ↓ > >

(9) $H_3Si-N=C=S$ $<$ $H_3C-N=C=S$

Que. (A). $\overset{sp^3}{N(CH_3)_3}$ T pyram $\overset{sp^2}{N(SiH_3)_3}$ T planar.

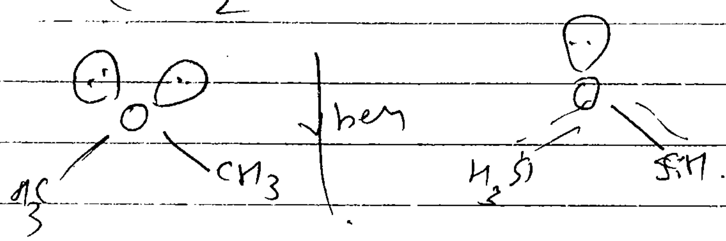
$\times$ · $H_3C\ NCO$ $H_3Si\ NCO$

✓ sp^3 $O(CH_3)_2$ sp^2 $O(SiH_3)_2$

✓ $P(CH_3)_3$ $P(SiH_3)_3$. Ans → (C) (D)

BBX.

$O(CH_3)_2$ $O(SiH_3)_2$



Que $H_3Ge-N=C=O$

BBX. bent.

not to Al.

$H_3C-C\equiv C-H$
sp
linear

wrt C

$H_3C-N=C=O$

linear

$H_3Si-N=C=O$
liner

Complete π bond v/s partial π bond.

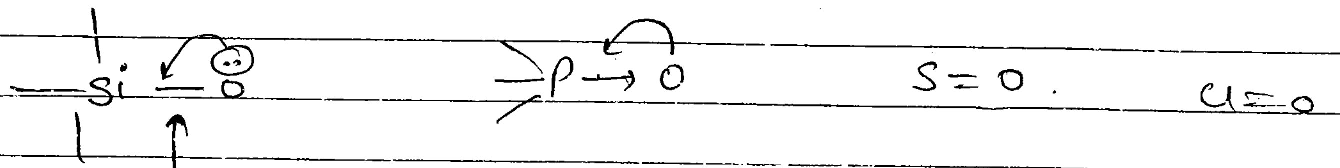
Simple π & dative -π

Si P | S Cl

with 'O' atom — size ↓ effectiveness of π bond ↑.

partial overlapping → complete overlapping

Back bond → ~~single~~ Simple π.



simple σ + π dative /BB.

σ dative + π dative.

simple σ + simple π

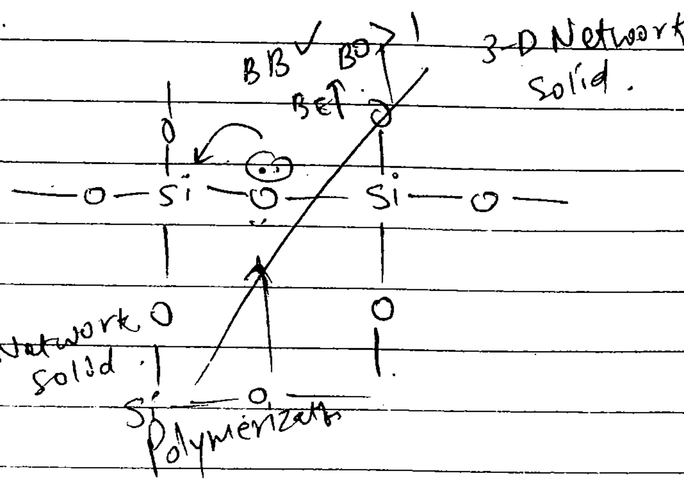
simple σ + simple π.

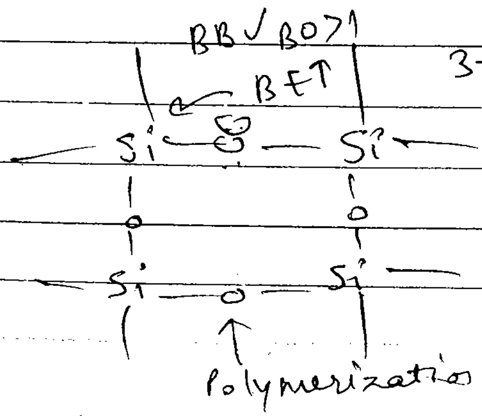
CO_2 O=C=O

SiO_2 O=Si=O ✗.

O ← Si → O ✗.

e^- defficient





PO

expected.

$\overset{+\delta}{>P} = \overset{-\delta}{O}$ ✗

$\overset{+\delta}{>P} \rightarrow \overset{-\delta}{O}$ ✓

due to BB e^- are shifted towards 'P'. so e^- density ↓ on 'O' atom.

$\mu = q \times d$

$\mu_{expected} > \mu_{exp}$.

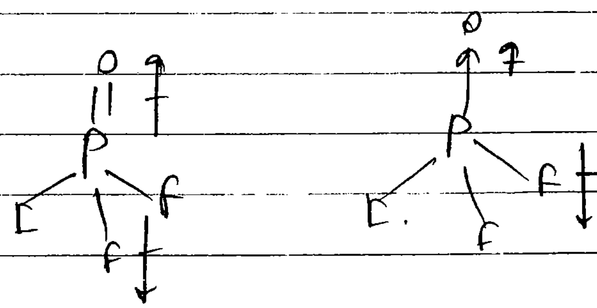
SO

$\mu_{expected} = \mu_{exp}$.

$S=O$ ✓

$S \rightarrow O$ ✗

H.W. Ans. Compare.



expected

experiment.

$\mu_{expected} < \mu_{exp}$.

H.W.

Que Compare μ expected & experimented of

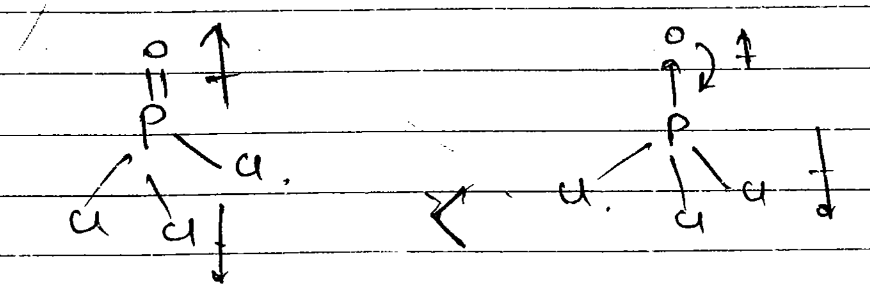
(1) $POCl_3$.

Que compare.

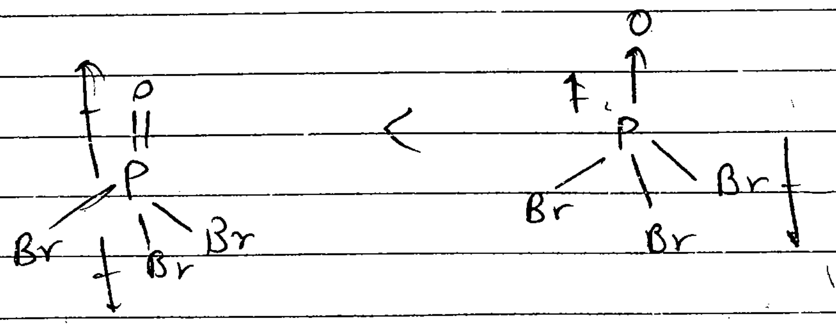
$\mu_{expected}$ & experimented for

expected experimented

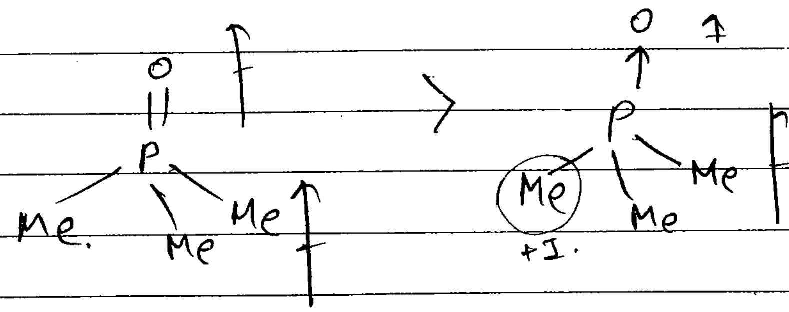
① $POCl_3$



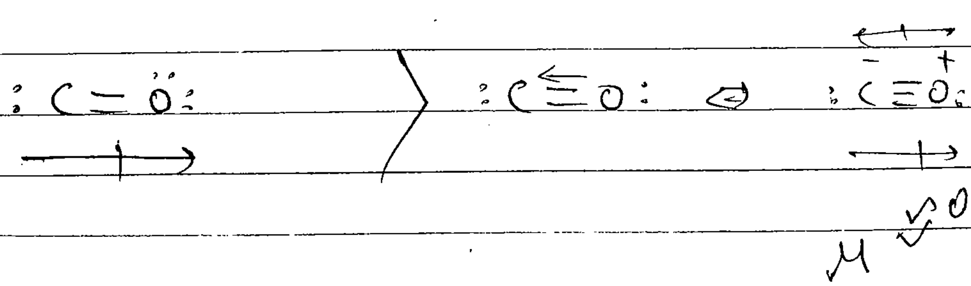
② $POBr_3$



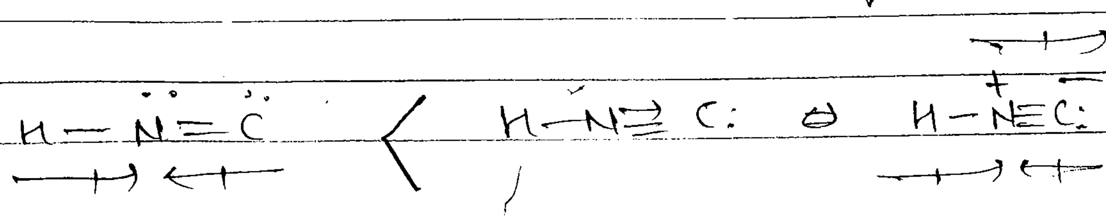
③ $POMe_3$



④ CO.



⑤ HNC



BRIDGE BOND

e^- defficient species are stabalized by.

(1) Back bonding.
(2). Dimerization with the help of unpaired e^- (odd e^-)
(3). Dimerization / Polymerization with the help of "BRIDGE BOND".

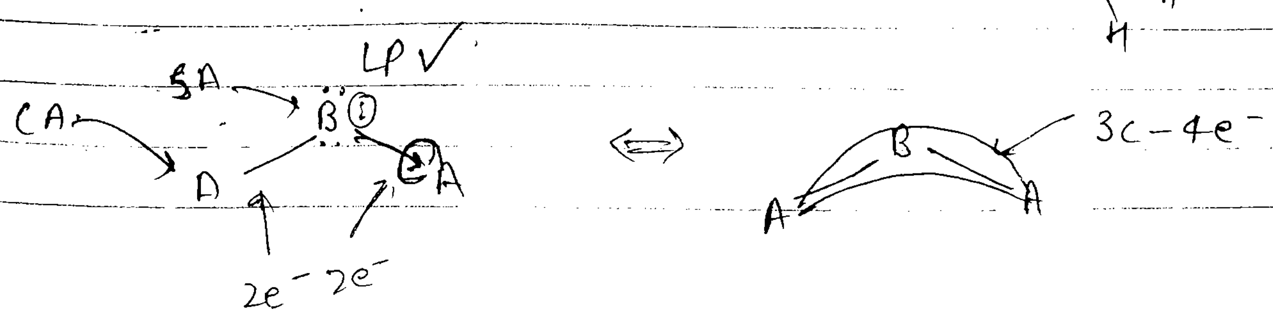
When an atom joins two or more than two central atoms bond formed is called "BRIDGE BOND" and such atoms ~~are~~ are called "Bridging atom."

Conditions for BRIDGE BOND.

(1). Central atom must contain vacant orbital in monomer.
(2) Back bond formation tendency must be low.
(3) Absence of ~~of~~ unpaired e^- (odd e^-)
(4). If lp present on bridging atom in monomer it will form $3c-4e^-$ bond.

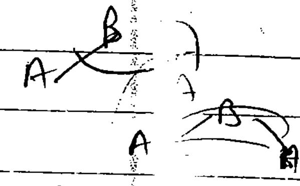
—F: —F: —Br: —OH

—Cl: —I: —NH_2



(5). If lP is absent ~~on b/ in m~~ on bridging ~~bond~~ atom in monomer it will form $2c - 2e^-$ bond,

ex — H — C_2H_5
— CH_3
— C_6H_5 / — ⌬



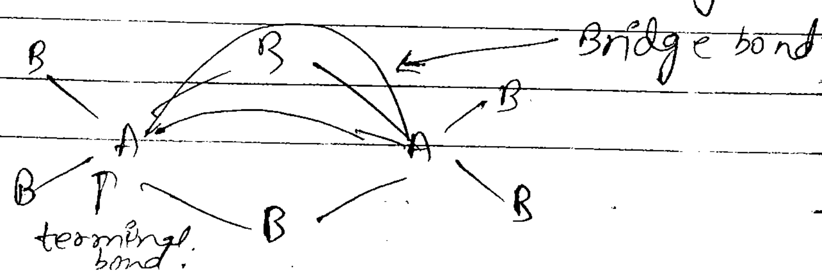
(6). If CA contain one vacant orbital in monomer It will dimerize and hyb. of CA increases by one orbital.

(7). If CA contain more than one vacant orbital in monomer it can polymerise and hyb. of CA depends on max^m co-ordination no.

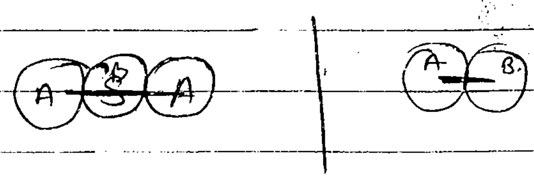
Ex. 2nd period CA, max^m co-ordination no → 4
hyb. → sp^3.

(8) ex. 3rd period CA, max^m co-ordina^n no → 6
hyb → sp^3d^2

(8). Bridge bond are stronger than terminal bond bcoz in bridge bond e^-s are attracted by more than two neuclem while in terminal bond e^-s are attracted by two neclem.

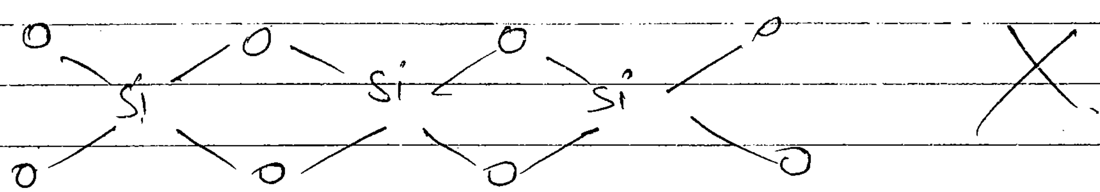


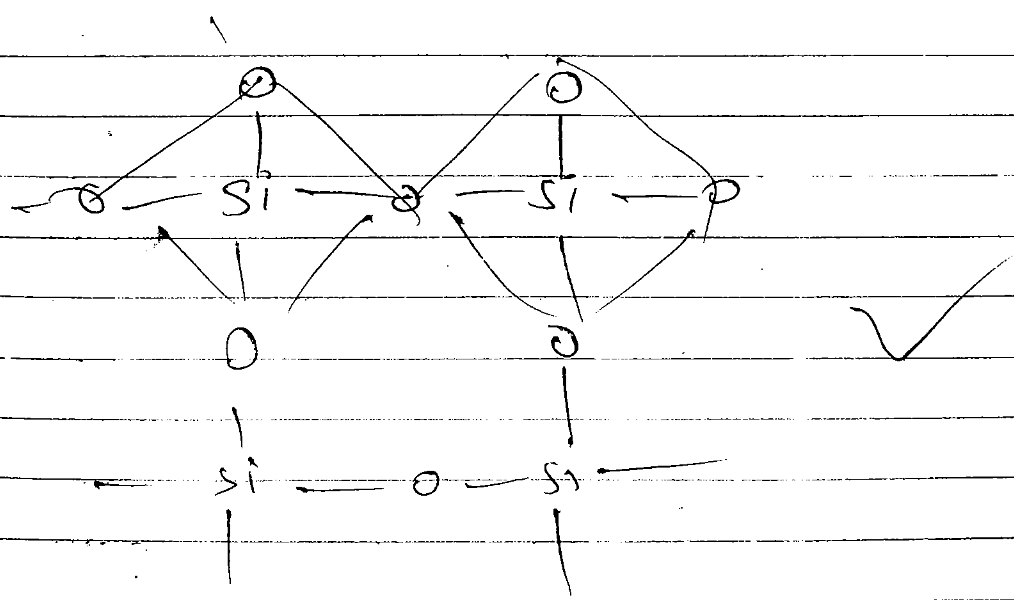
BL. Bridge bond > terminal.



★★★ BL ✓
BE ✓

(9). Generally bridging atoms are present at common edge except 'O' and 'F', 'O' and 'F' are present at common corner, because angle strain in common corner is less than common edge.





COMPOUNDS OF ALUMINIUM

$AlF_3 \Rightarrow$ Ionic compound.

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

$1s^2 2s^2 2p^6 \mid 1s^2 2s^2 2p^6$

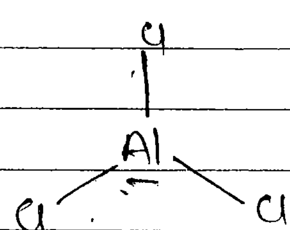
octet complete

Monomer	Dimer	Polymer.
CN = 3	CN = 4	CN = 6
sp^2	sp^3	sp^3d^2
$AlCl_3$	✓	✓
$AlBr_3$	✓	✗
AlI_3	✓	✗
AlH_3	✓	✓
$AlMe_3$	✓	✗
$AlEt_3$	✓	✗
$AlPh_3$	✓	✗

$\rightarrow$ Steric crowding

$AlCl_3$

Monomer

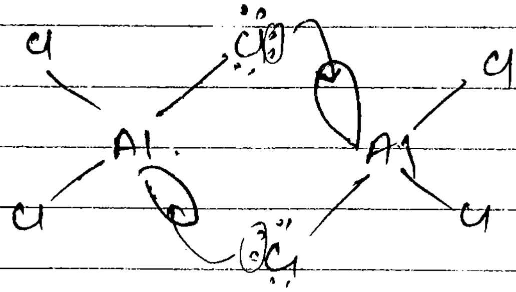


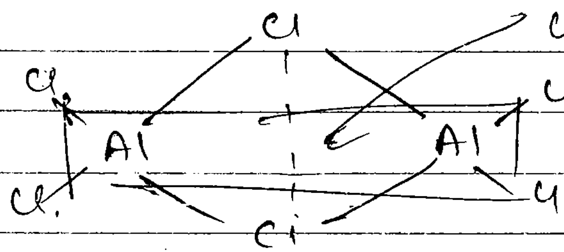
sp^2

$2c-2e^-(3) \Rightarrow sp^2-p$.

Planer, Non polar.

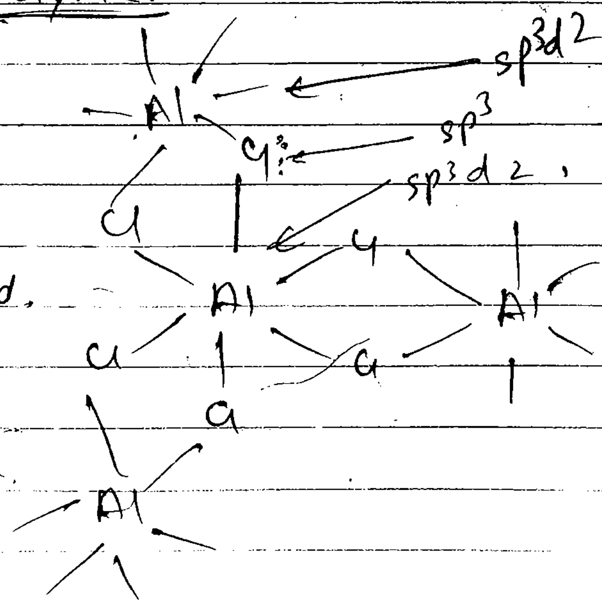
Dimer





3c – 4e⁻ (2) $sp^3 - sp^3 - sp^3$
2c – 2e⁻ (4) $sp^3 - p$
Non Planer, Non polar.
Max. no. of e⁻ in a plane = 6.

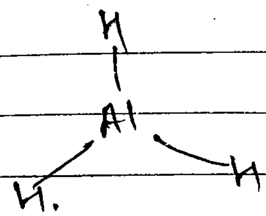
$\boxed{AlCl_3}$ Polymer



All bonds are bridge bond. (3c – 4e⁻)

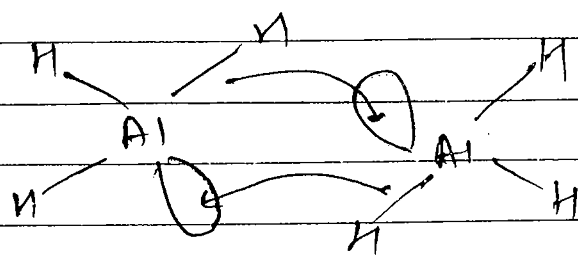
$sp^3d^2 - sp^3 - sp^3d^2$.

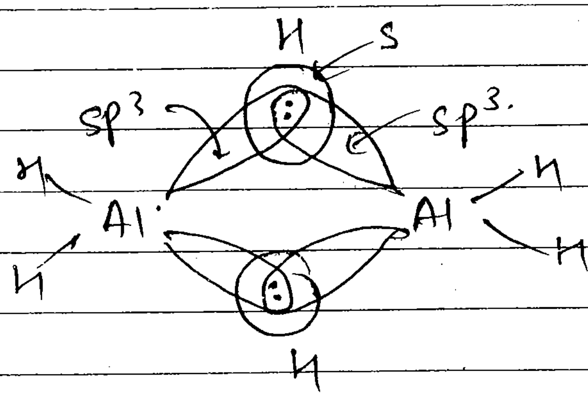
$\boxed{AlH_3}$ monomer.

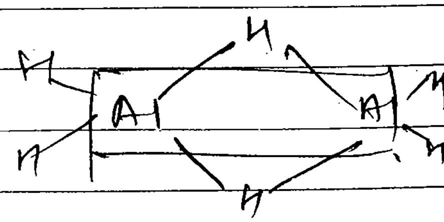


planer.
Non-polar. $(2c-2e^-)$ 3.
$\underline{sp^2 - s}$

$\boxed{\cancel{AlH_3}}$ Dimer.

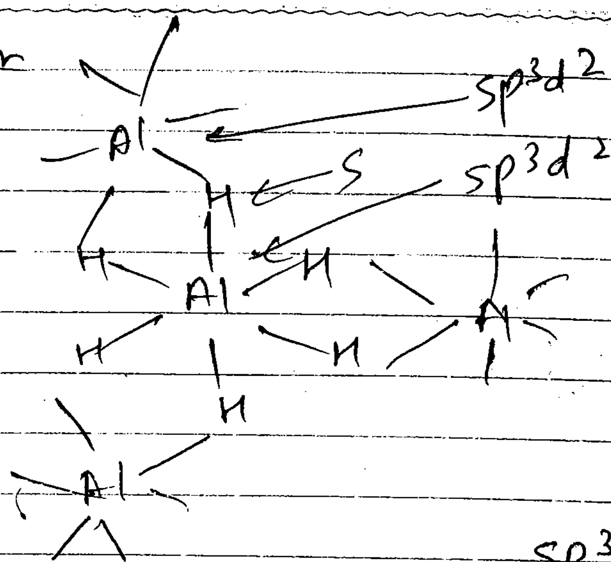






Non planer
Non polar.
$2c-2e^-$ (4)
& $\Rightarrow sp^3 - s$
$\Rightarrow sp^3 - s - sp^3$
e^- defficient.

Polymer

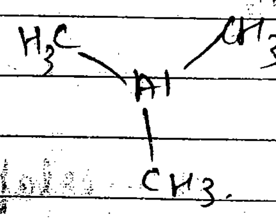


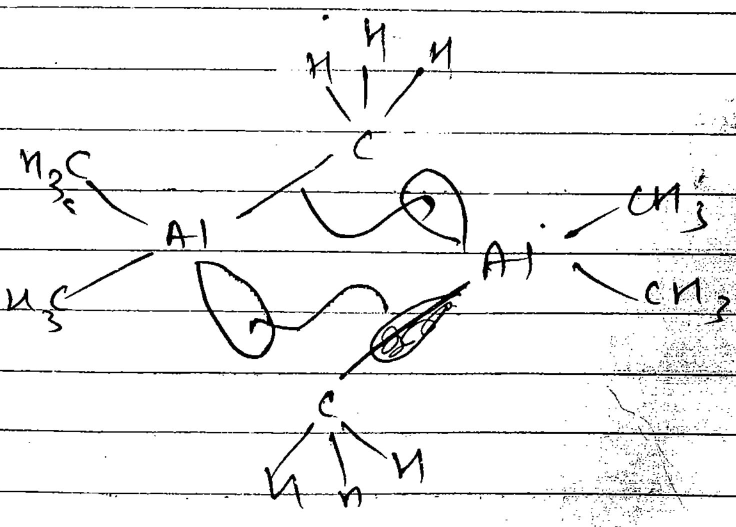
All bonds are bridge bond ($3C-2e^-$)

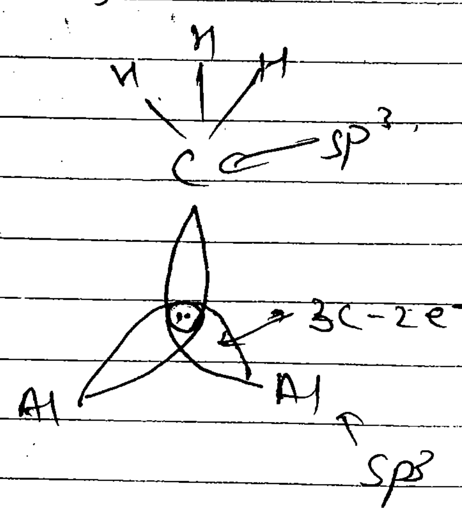
$sp^3d^2 - s - sp^3d^2$

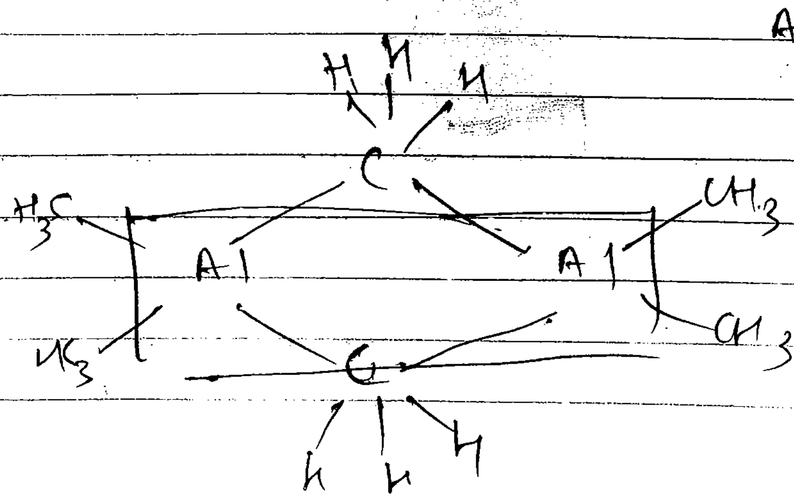
$\boxed{Al_2Me_6}$

Dimer of $AlMe_3$



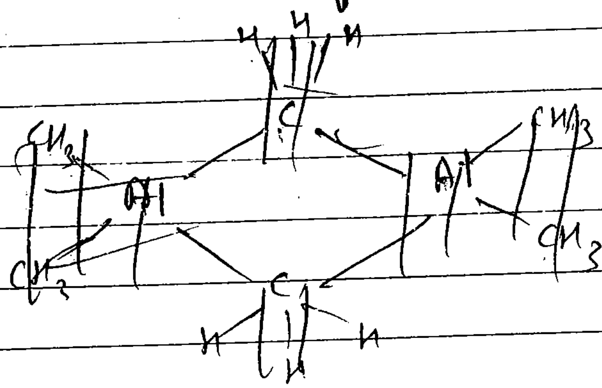






Que. Give answer w.r.t. Al_2Me_6

(1). Total no. of 2c – 2e⁻ bonds.
(2). Total no. of sp^3 hybrid atoms.
(3). Max. no. of atoms in plane.



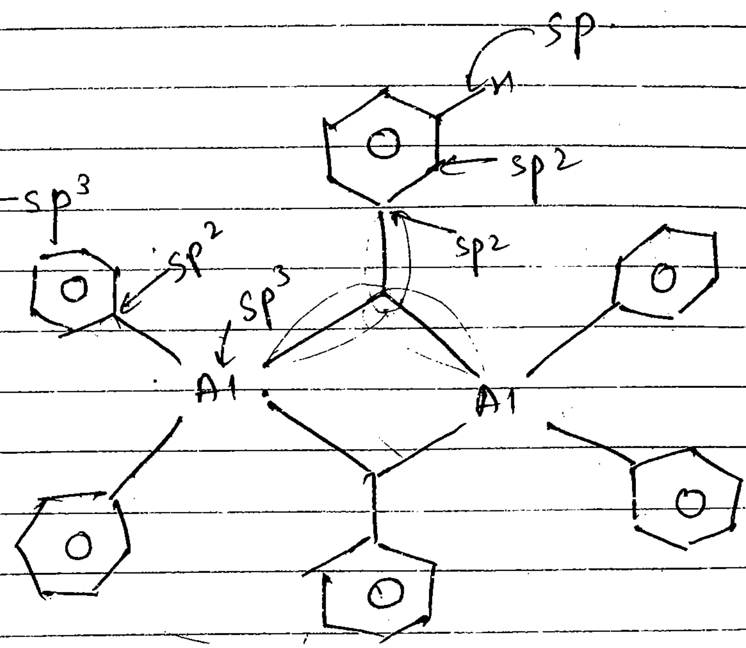
(1) 22 (18 + 4)
(2). 8
(3). 10

(4) Type of overlapping

$sp^3 - sp^3 - sp^3$
$sp^3 - sp^3$
$sp^3 - s$

Que. Select type of overlapping present in Al_2Ph_6.

~~(1)~~ $sp^2 - sp^2$
~~(2)~~ $sp^2 - s$
~~(3)~~ $sp^2 - sp^3$
~~(4)~~ $sp^3 - sp^2 - sp^3$



COMPOUNDS OF (Be)

	Monomer	Dimer	Polymer
	CN = 2	CN = 3	CN = 4
	hyb ⇒ sp	sp^2	sp^3.
BeF_2		✗ due to BB	✓ ← common corner
$BeCl_2$		✓	✓
$BeBr_2$		✓	✓
BeI_2		✓	✓
BeH_2		✓	✓
$BeMe_2$		✓	✓

} common edge.

$2p_\pi - 2p_\pi$

F — Be — F

BB↑ ✓

Cl — Be — Cl

Dimerize ✗.

size ↓ distance ↑

Dimerise ✓.

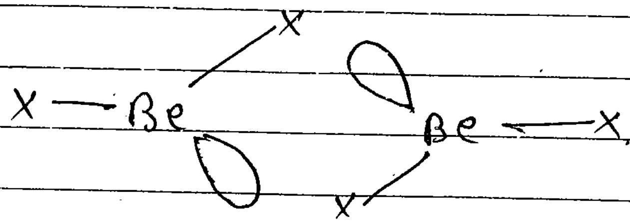
BB ↓

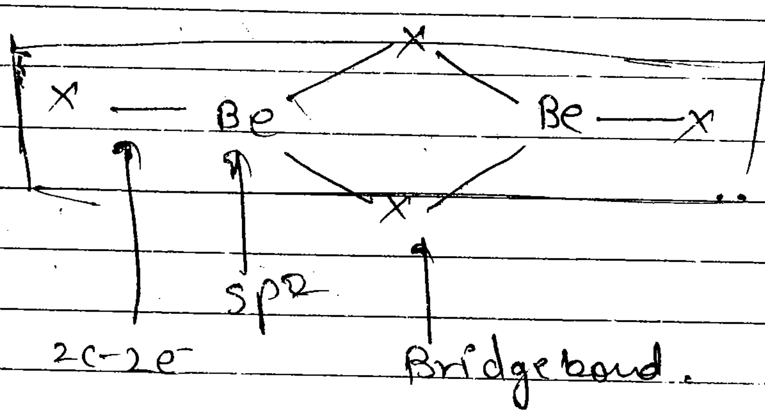
size ↑.

F — Be — F

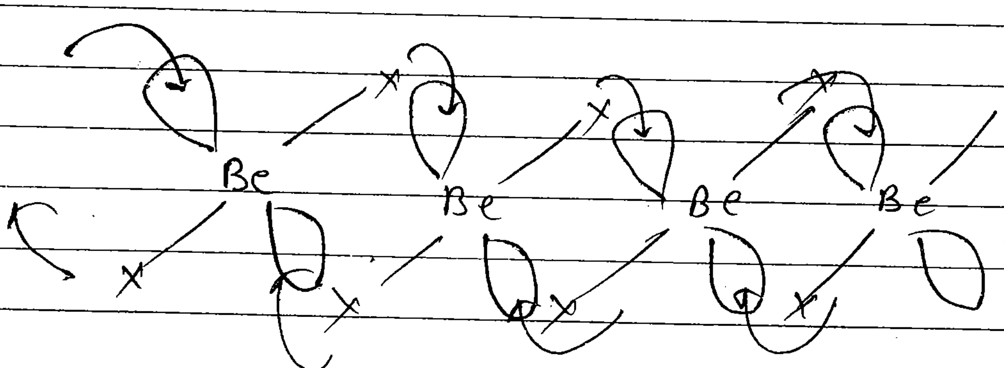
Cl — Be — Cl

Dimer

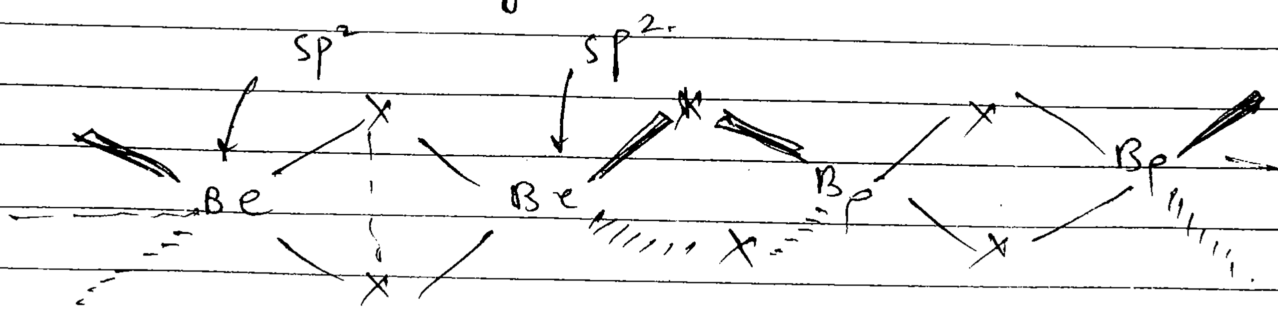




Polymer except BeF_2.

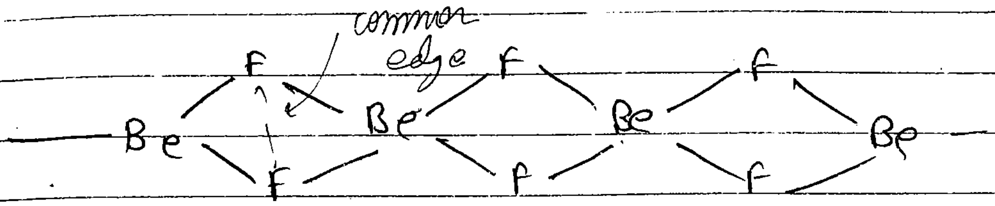


Cross link polymer.

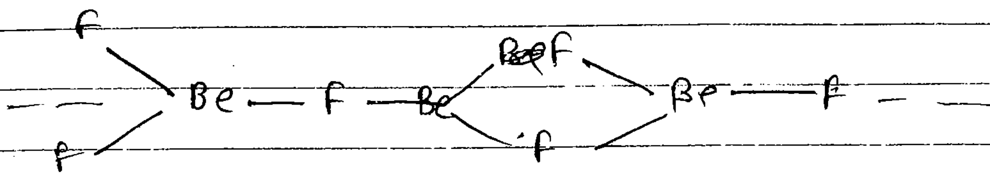


Que Select correct structure of BeF_2 (s).

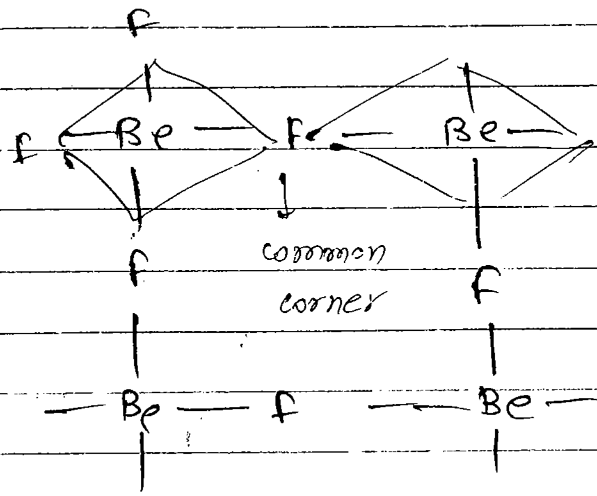
(1)



(2).

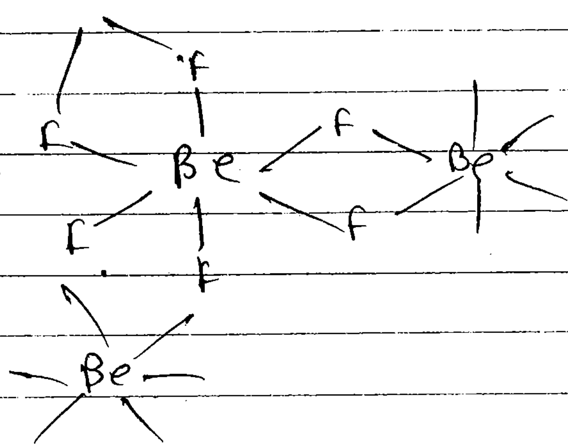


(3)



3-D network solid as like SiO_2

(4).



Ans → (3).

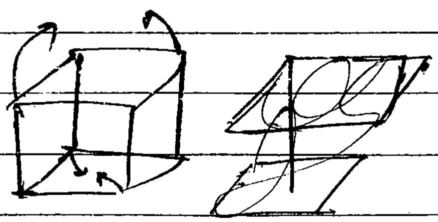
$\boxed{sp^3d^4 \text{ HYBRIDISATION}}$

sp^3d^4 (8 σ bond) IF_8^-

(d-block)

s p_x p_y p_z.
d_{xy} d_{yz} d_{xz} d_{z^2}.

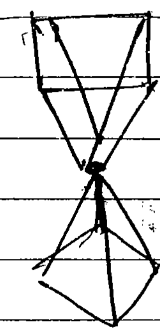
Dodecahedron.



(p block).

s p_x p_y p_z d_{xy} d_{yz} d_{zx},
$d_{x^2-y^2}$

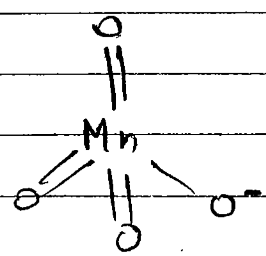
Square-anti prismatic



$Ba(MnO_4)_2$

Ba^{+2} MnO_4^{2-}

$\boxed{3d^5 4s^2}$



tetrahedral.

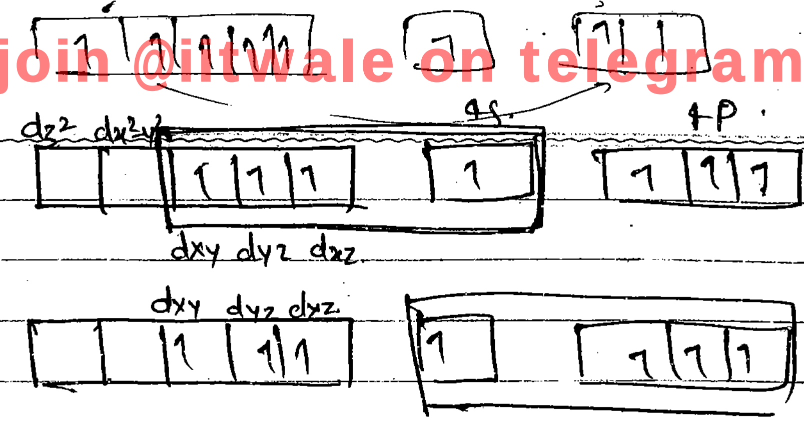
Mn $3d^5 4s^2$

$3d^5$ $4s^2$

G.S. | ↿ | ↿ | ↿ | ↿ | ↿ | | ↿⇂ |

E.S. d^3s

sp^3



Both are possible, both have equal probability.

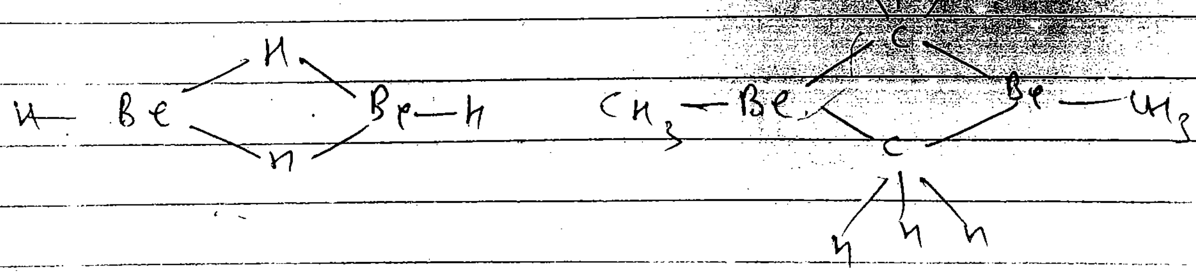
$\boxed{\text{12th NCERT}}$ 1st part d block element ~~section~~ section $KMnO_4$ $(K^+ MnO_4^-)$.

In MnO_4^- 'd' orbital of Mn form π bond with 'p' orbital of 'O'.

Hyb → sp^2

Que Select correct match

		Be_2H_4	Be_2Me_4
(1)	Type of bridge bond	3c − 2e$^-$	3c − 2e$^-$
(2).	No. of 2c-2e$^-$ bonds	2	14
(3).	Max^m no. of atoms in a plane	6	8
(4)	No. of type of overlapping	2	3



Que find the species in which only one type of bond present

either $2c-2e^-$ or $3c-2e^-$ or $3c-4e^-$

$3c-2e^-$; $3c-4e^-$; $3c-4e^-$; $3c-2e^-$; $2c-2e^-$, $3c-2e^-$

$BeCl_2(s)$, $BeBr_2(s)$, $BeI_2(s)$, $BeH_2(s)$, $BeMe(s)$,

AlH_3, Al_2H_6, $AlH_3(s)$, $AlCl_3$, Al_2Cl_6, $AlCl_3(s)$

$2e-2e$; $3c-2e^-$, $2c-2e^-$; $3c-2e^-$; $2c-2e^-$; $3c-4e^-$, $2c-2e^-$; $3c-4e^-$

$\boxed{\text{COMPOUNDS OF BORON (B)}}$

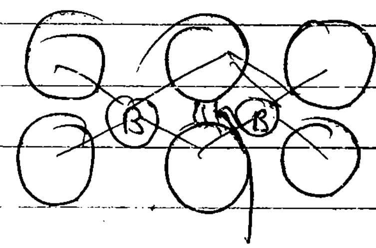
$$Be > B$$
$$\wedge$$
$$Al.$$

Monomer	Dimer	Polymer.
CN = 3	CN = 4	✗.
sp^2	sp^3	

BF_3 — ✗ due to BB

BCl_3, BBr_3, BI_3, BMe_3 — ✗ due to sterric crowding

BH_3 — ✓



repulsion ↑
unstable.

Que. Select correct statements(s) for B_2H_6 (di borane).

✓(1). B is sp^3 hybridized

✓(2). It has ~~two~~ $3c-2e^-$ bonds (banana bond),

✓(3) It has four $2c-2e^-$ bonds.

✓(4). It is non planer.

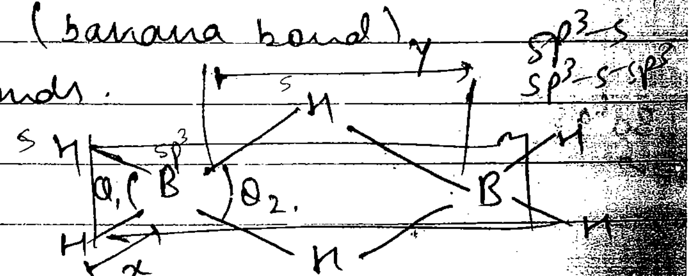
✓(5). It is Non polar.

✗(6) $\theta_1 > \theta_2$

✗(7) $x < y$ ✓(8) It is e^- defficient.

✗(9). plane of $2c-2e^-$ bonds is ⊥ to the plane of $3c-2e^-$ bonds.

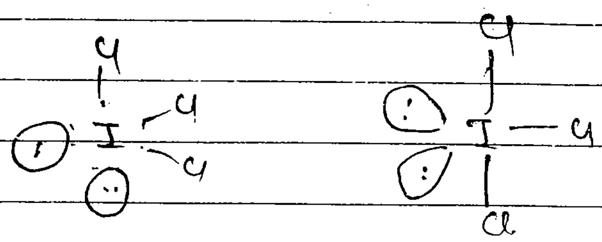
✗(10). two type of overlapping present



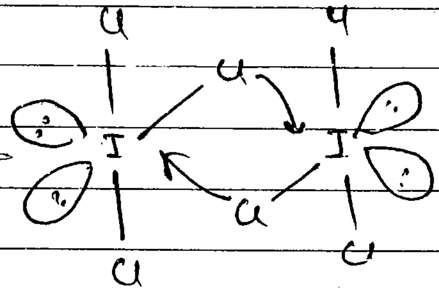
OTHER DIMERS

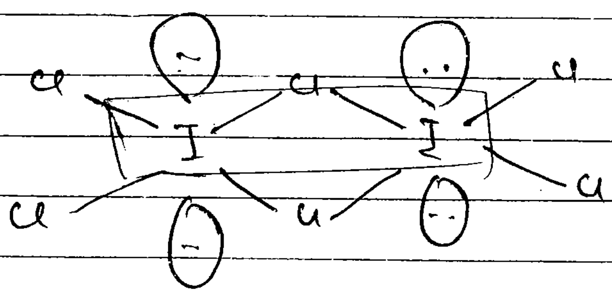
(1). $\boxed{I_2Cl_6}$

ICl_3



sp^3d^2





Planer (square)

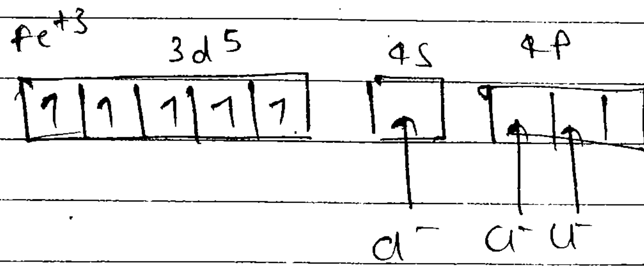
(2). $\boxed{Fe_2Cl_6}$

Monomer $FeCl_3$

$3d^6 4s^2$ Fe

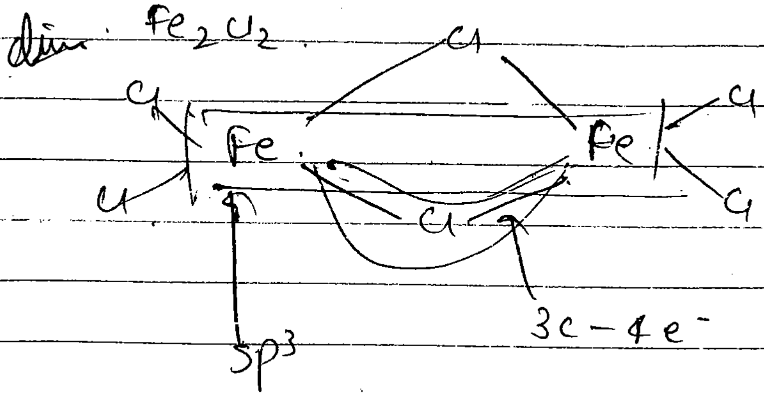
$\underset{LA}{Fe^{3+}} + \underset{LB}{3Cl^-}$

$3d^5$.



$FeCl_3$ sp^2.

dim. Fe_2Cl_2



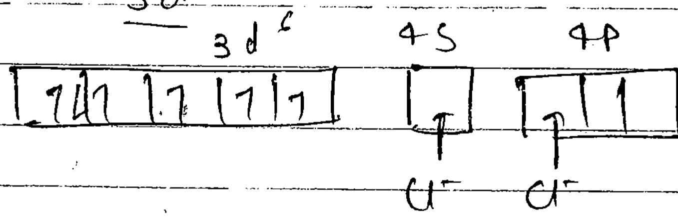
Non-planar.

(3) $\boxed{Fe_2Cl_4}$

Monomer → $FeCl_2$

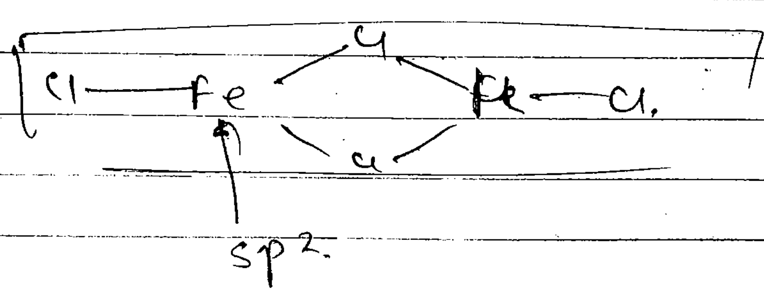
$Fe^{2+} + 2Cl^-$

$3d^6$



sp.

dimer

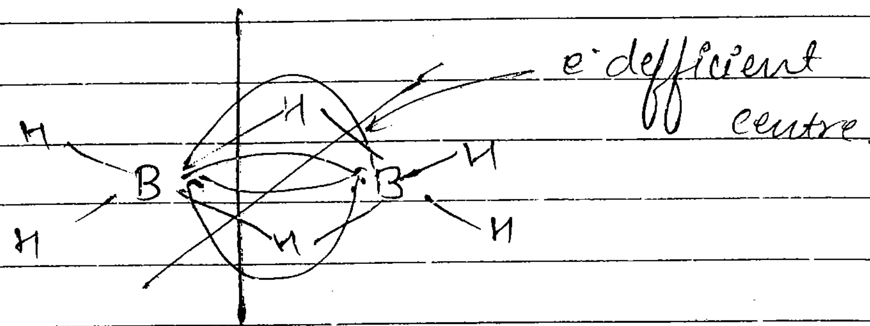


Planar.

NOTE In d block metal, lonepair/unpaired e⁻ are not included in hybrid orbital, they are stereo chemically inactive.

Rxn of B_2H_6

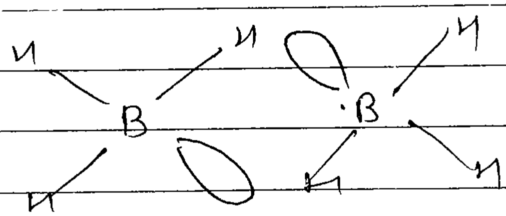
Diborane B_2H_6 is e^- defficient due to $3c-2e^-$ bond, so it act as lewis acid.



LB = x.

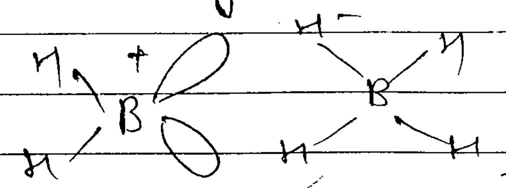
Symm. Unsymm.

Symm.



$BH_2 \leftarrow X$

Unsymm.



$[BH_2X_2]^+$ BH_4^-

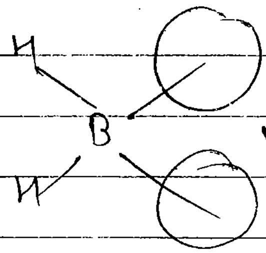
(1). lewis Acidic nature.

$BH_2^+ > BH_3$

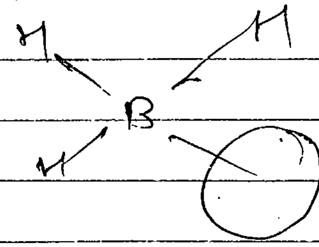
SLA WLA.

STATEMENT : Acc. to hard-soft Acid base theory strong LA forms bond with strong LB and weak LA forms bond with weak LB. So, in presence of SLB B_2H_6 show unsymm. cleavage rxn while in presence

(2). Bulky group.



unstable.



Stable.

General Basic Nature -

SLB — WLB.

$\cancel{N} > O > F.$

$\vee \quad \vee \quad \vee$

$B > S > Cl$

$\vee$

Br

$\vee$

$I.$

Symm — Unsymm.

WLB. — SLB.

H_2O, PH_3, PMe_3, | NH_3 ammine.

H^-, F^-, Cl^-, Br^-, I^-, | CH_3NH_2, $(CH_3)_2NH$ } amine.

R_2S, $(CH_3)_3N$ → Bulky | $\cancel{(CH_3)_3N}$

due to bulkiness

CO weak due to BB.

donor EN $C < O$.

= C

$:C \leftarrow O:$

$B_2H_6 + NH_3 \longrightarrow [BH_2(NH_3)_2]^+ + [BH_4]^-$ unsymmetrical

$B_2H_6 + CO \longrightarrow BH_3CO$ symm

$\boxed{\text{SILICATES}}$

⇒ Silicon, oxygen, binary anions (two type of elements) are called "SILICATES" or ~~OXYANION~~ oxy-anion of silicic acid are called "SILICATES".

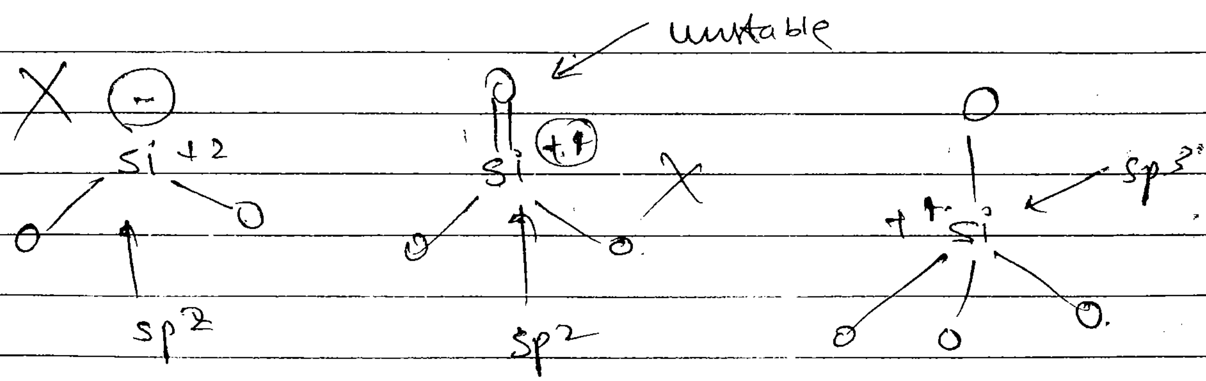
$$\overset{+4}{H_xSi_yO_z} \xrightarrow{-xH^+} Si_yO_z^{-x}$$

Silicic acid — Silicate

O.S of Si = +4.

Hyb of Si = sp^3.

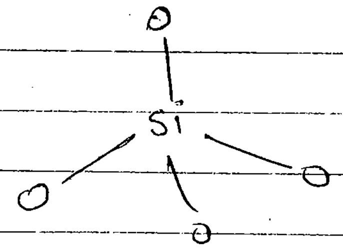
Si – tetravalent



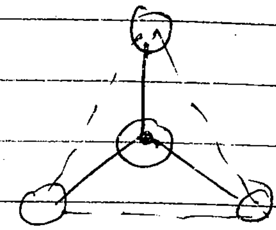
e-defficient.

In silicate, each silicon atom form four bond, with 'O' atom.

Silicate unit.



3-D rep^r.



2-D repres^n.

O → oxygen
• → silicon.

In each silicate unit.

No. of si° = 1
No. of O = 4.

let No. of monovalent/unshared 'O' = x (Si—O⁻)

diavalent / shared 'O' = y. (Si—O—Si).

$x+y=4$..

Participation of each

Monovalent oxy. = 1
Divalent oxy = $\frac{1}{2}$.
in a silicate unit.

charge due to each monovalent oxygen = −1,
Diavalent = 0/zero.

General formula $\boxed{Si\,O^{-mono}_{Mono+\frac{di}{2}} \qquad Si\,O^{-x}_{x+\frac{y}{2}}}$

TYPES OF SILICATES

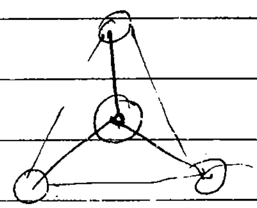
(1). ORTHO SILICATE (s

(Shared oxygen per unit oxy. = 0).

H_3BO_3
H_3PO_4
H_2SO_4

$H_4SiO_4 \xrightarrow{-4H^+} SiO_4^{4-}$

Orthosilicic acid   Ortho silicate.



Ortho silicate.

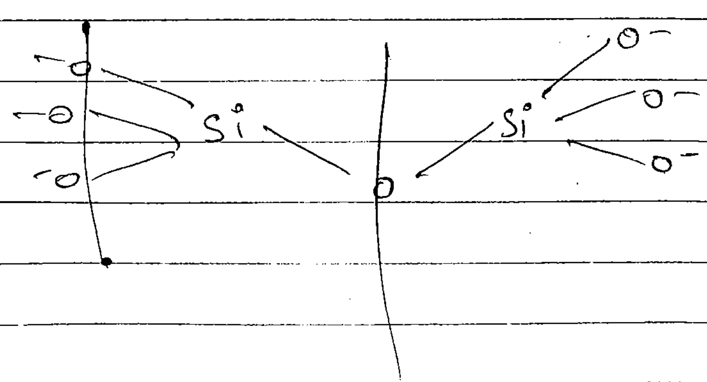
(2). PYRO SILICATE

(shared oxy per unit = 1).

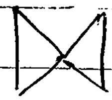
$2H_4SiO_4 \xrightarrow{-H_2O} H_6Si_2O_7 \xrightarrow{-6H^+} \overset{+4}{Si_2}O_7^{6-}$

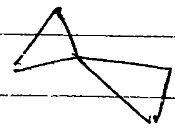
Pyro silicic Acid.

$\left(SiO_{3+\frac{1}{2}}^{-2}\right) \times 2.$

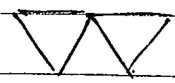


Que Which of them is/are pyro silicate.

(A) 

(B) 

(C) 

(D) 

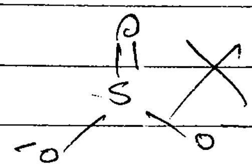
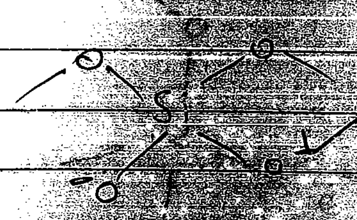
Share 'O'/corner per unit (1).

Ans → (A)(B)(C)(D).

(2) $\boxed{\text{META SILICATE}}$

$$H_4SiO_4 \xrightarrow{-H_2O} H_2SiO_3 \xrightarrow{-2H^+} SiO_3^{2-}$$

Meta silicic acid. Meta silicate.

SiO_3^{-2}  

Shared 'O' per unit = 2.

SiO_3^{2-} 'Meta' exist in polymeric form

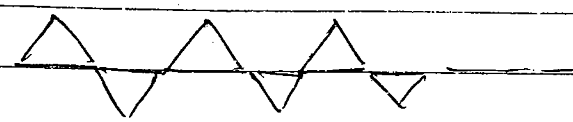
$n \geq 3$ defined. $(SiO_3^{2-})_n$.

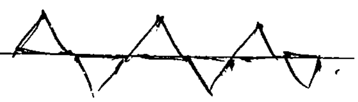
$n = \infty$ not defined SiO_3^{2-}

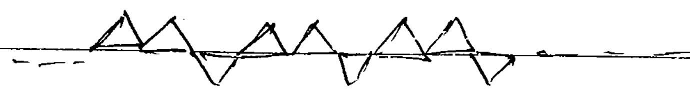
chain silicate

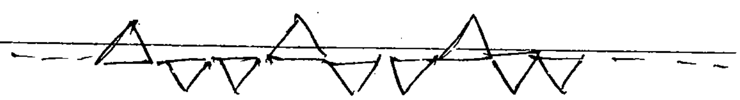
cyclic silicate

Que. which of them is/are a single chain silicate.

(1). 

(2). 

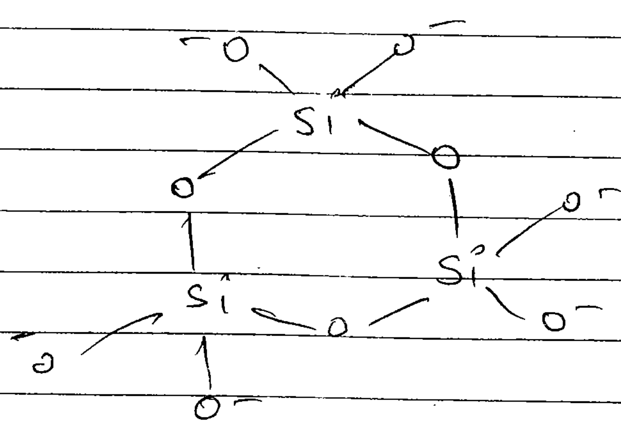
(3). 

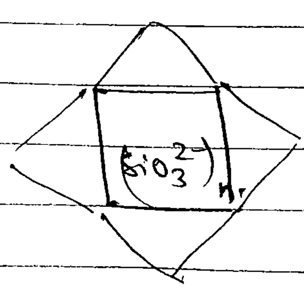
(4). 

cyclic silicate

$(SiO_3^{2-})_n$ $n \geq 0$.

ex :- $\overset{+4}{Si_3O_9^{6-}}$





$(SiO_3^{2-})_n$

In general

No. of 'Si' atoms in a ring = n

No. of 'O' atoms in a ring = n.

No. of atoms in a ring = 2n

No. of Si-O-Si linkage = n

$\boxed{\text{2-D SHEET SILICATE}}$

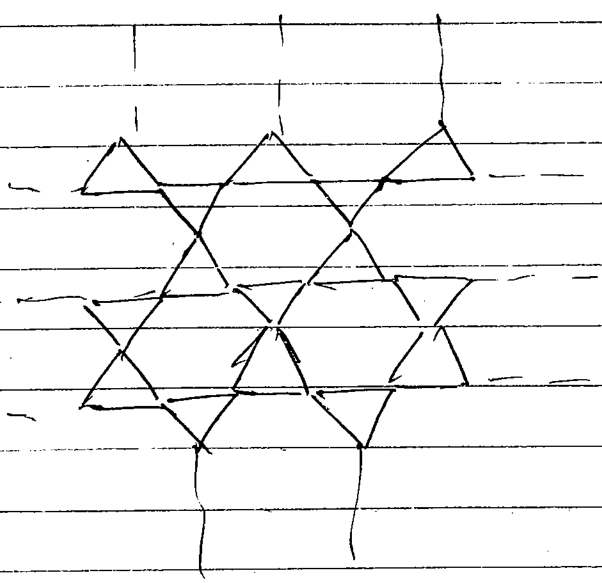
shared 'O' per unit = 3.

All shared 'O' are in a plane.

$SiO_{1+\frac{3}{2}}^{-1}$

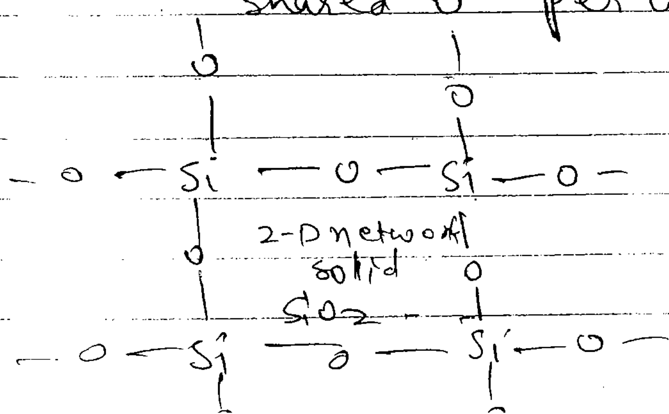
$\downarrow$

$Si_2O_5^{2-}$



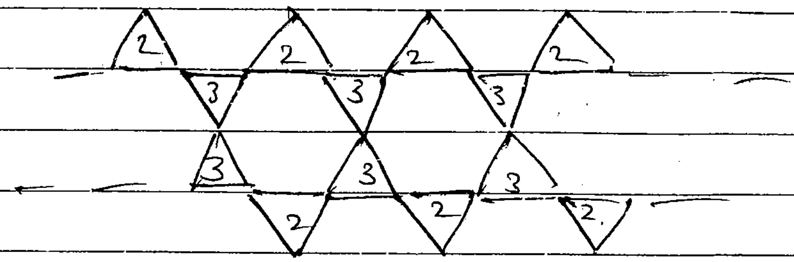
3-D SILICATE

shared 'O' per unit = 4



DOUBLE CHAIN SILICATE

Ex-1



avg. shared 'O' present $= \frac{2+3}{2} = 2.5$.

unshared $= 4 - 2.5 = 1.5$.

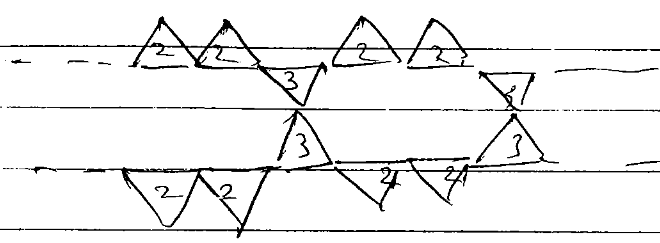
$$SiO_{1.5+\frac{2.5}{2}}^{-1.5} \xrightarrow{\times 4} Si_4O_{11}^{-6}$$

1x double shared + 1x triple shared.

$$SiO_3^{2-} + SiO_{2.5}^{-1}$$

$$Si_2O_{5.5}^{-3} \xrightarrow{\times 2} Si_4O_{11}^{6-}$$

ex-2



shared 'O' per unit $\frac{2+2+3}{3} = 7/3$.

$\Rightarrow$ 2x double shared + 1x triple shared

NAME	SHARED 'O' PER UNIT	FORMULA
Neso/ ortho	0	SiO_4^{4-}
Soro/ Pyro.	1	$SiO_{3.5}^{3-}$
Pyroxene/ ∞ single chain	2	SiO_3^{2-}
cyclo/cyclic.	2	$(SiO_3^{2-})_n$
Phyllo / 2-D sheet.	3	$SiO_{2.5}^{-1}/Si_2O_5^{2-}$
tecto / 3-D.	4	SiO_2.
Amphiboles / Double chain.	$2 < \cdot \leq 3$.	

Que. Find the type of silicates present in given mineral.

(1) Zircon / American Dimond. ⇒ $ZrSiO_4$ $\boxed{\text{Ortho}}$

(2). Spodumene ⇒ $LiAl(SiO_3)_2$. $\boxed{\text{Pyroxene}}$

(3). Clay ⇒ $Al_2(Si_2O_5)_2(OH)_2$. $\boxed{\text{2-D sheet}}$

(4). Egyptian blue ⇒ $CaCu(Si_2O_5)_2$. $\boxed{\text{2-D sheet}}$

(5). Asbestos ⇒ $CaMg_2(Si_4O_{11})$ $\boxed{\text{Double chain}}$

Que Find the value of 'x' & 'y'.

(1) Talc / Soap stone $\Rightarrow$ $\overset{+6}{Mg_x}(\overset{-2}{Si_2O_5})(\overset{-4}{OH})_4$ $\boxed{x=3}$

(2) Beryl $\rightarrow$ $\overset{+6}{Be_y}\,\overset{+6}{Al_2}\,\overset{-12}{Si_6O_{18}}$

$\boxed{Y=3}$

$$2\times Y + 2(+3) + 6\times(+4) + 18(-2) = 0$$

$\boxed{Y=3}$

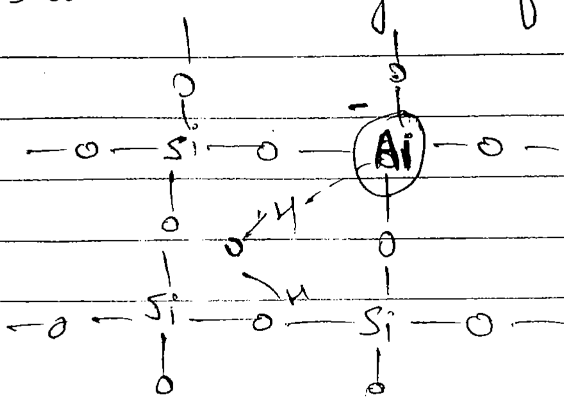
$\boxed{\text{ALUMINO SILICATES}}$

In 3-D silicates upto 50% 'Si' atoms are replaced by 'Al' atom such anions are called "ALUMINO SILICATES".

-ve charge generate b'coz 4 valency of 'Si' atom is replaced by '3' valency 'Al' atom.

-ve charge is satisfied by Alkali metal / Alkaline earth metal cation,

They are also called HYDRATED ALUMINATE b'coz -ve charge of Al attracts water molecule.



$$(x+y)\,SiO_2 \xrightarrow[-x\,Si]{+2\,Al} (AlO_2^{-1})_x\,(SiO_2)_y$$

$$x \leq y.$$

Types of Alumino Silicate.

	$x : y$	
(1)	1 : 3	feld Spar.
(2).	1 : 2	Zeolite.
(3).	1 : 1	Ultramarine
		ex: lapis lazuli blue colour stone

USES

(1) FELD SPAR :

feld spar is used in glass making, in ceramic. Due to high SiO_2 container.

(2). ZEOLITE

* Used as water softner. when hard water passed from ~~a~~ sodium zeolite Na^+ are replaced by Ca^{+2} and Mg^{+2}. ~~then~~ ~~to~~ which are reason of water hardness.

*. As an water adsorber becoz size of voids are almost equal to size of water molecule.

(3). ULTRAMARINES

Used as pigments in paint formⁿ.

$\boxed{\text{SILICONE}}$ (As like silicates O^- is replaced by 'R')

Organo silicons having $Si-O-Si$ linkage are called $\boxed{\text{SILICONES}}$

Silicons are prepared by hydrolysis followed by polymerization condensation of Organo chloro silicon.

Organo chloro silicons are Alkyl / Aryl derivative of silicon tetra-chloride ($SiCl_4$).

They are prepared by (organo chloro silicon)

(1). Rxn of $SiCl_4$ with Grignard reagent.

$$SiCl_4 \xrightarrow[-MgXCl]{RMgX} RSiCl_3 \xrightarrow[-MgXCl]{RMgX} R_2SiCl_2 \xrightarrow[-MgXCl]{RMgX} R_3SiCl$$

(2).

$$R-Cl + Si \xrightarrow{Cu} R_2SiCl_2\ (70\%),\ R_3SiCl\ (10\%)\ RSiCl_3\ (10\%)\ R_4Si\ (5\%)\ SiCl_4\ (5\%)$$

$R =$ CH_3, C_2H_5, C_6H_5

Variety of product are separated by distillation.

HYDROLYSIS AND POLYMERISATION CONDENSATION OF ORGANO CHLORO SILICON

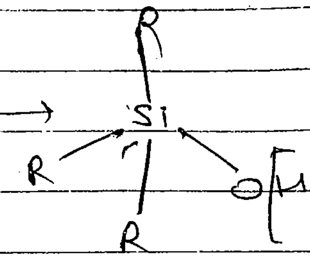
Removal of small groups in polymerization is

 9667667799

called polymerization Conden^n.

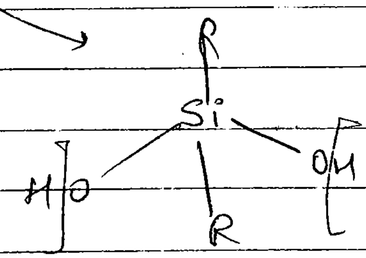
Lewis Basic Nature
$R^- > OH^- > Cl^-$

$R_3SiCl \longrightarrow R_3Si(OH) \longrightarrow$



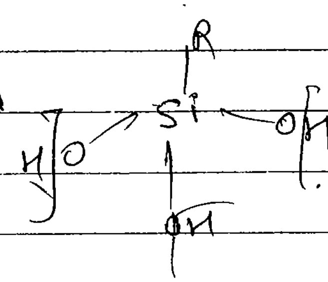
chain terminating unit.

$R_2SiCl_2 \longrightarrow R_2Si(OH)_2 \longrightarrow$



chain forming unit, 2.

$RSiCl_3 \longrightarrow RSi(OH)_3 \longrightarrow$

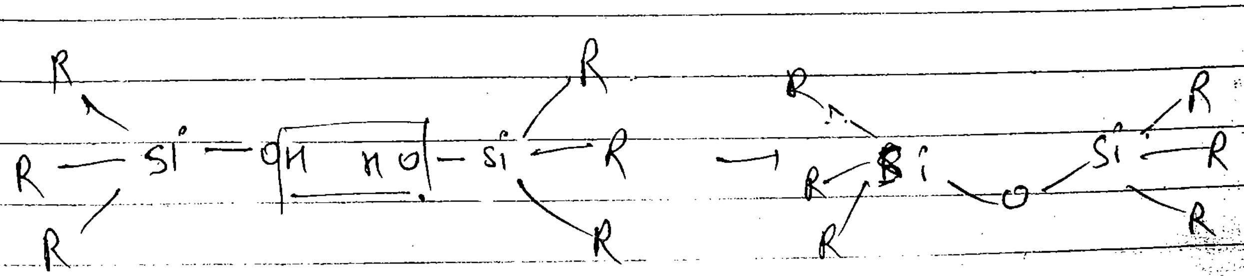


Cross link unit

3.

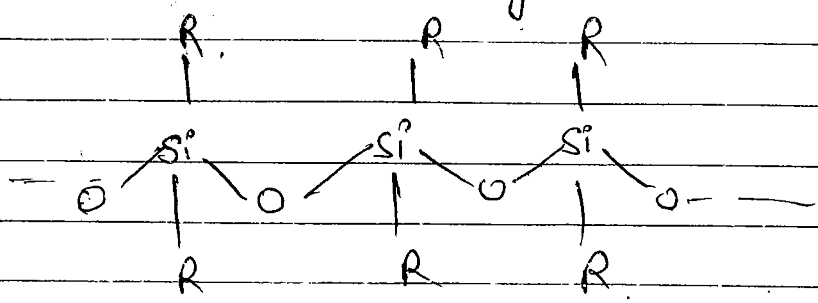
TYPE OF SILICONES

① DI-SILICONE (as like pyro/di silicate).



(2). ∞ SINGLE CHAIN SILICONE

(as like single chain silicate).



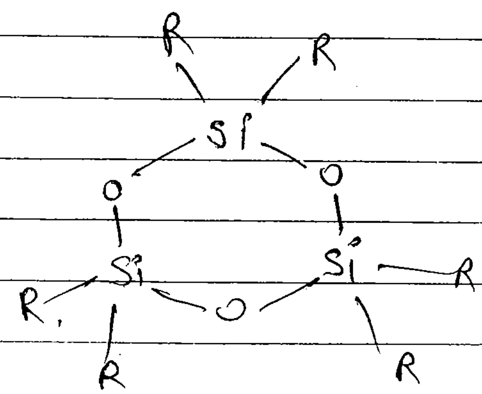
formed by R_2SiCl_2 units.

(3). CYCLIC SILICONE

(as like cyclic silicate).

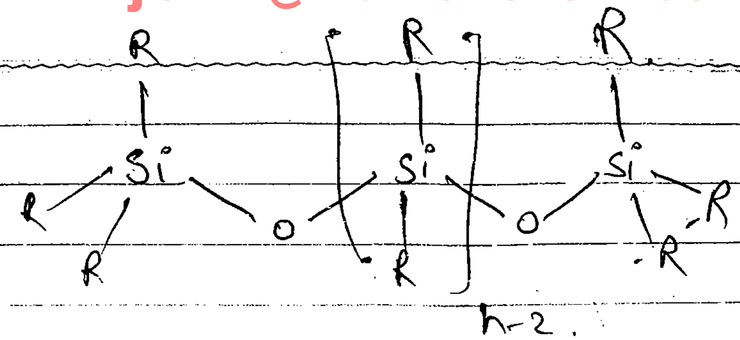
$(R_2SiO)_n$ formed by R_2SiCl_2 units.

n = 3.



(4). FINITE CHAIN SILICONE

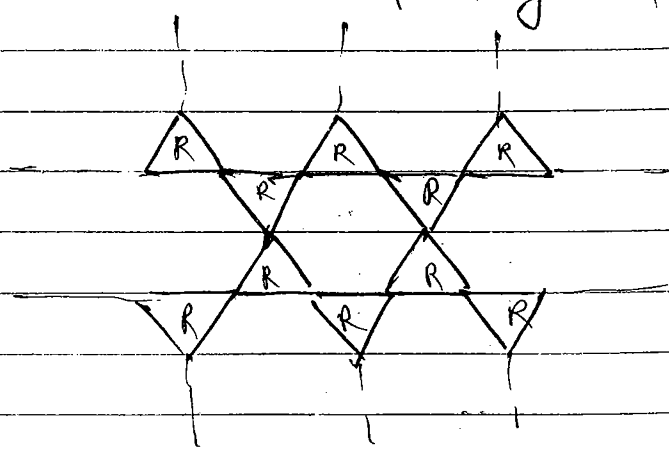
(as like finite chain silicate)



2 units R_3SiCl + (n-2) units R_2SiCl_2

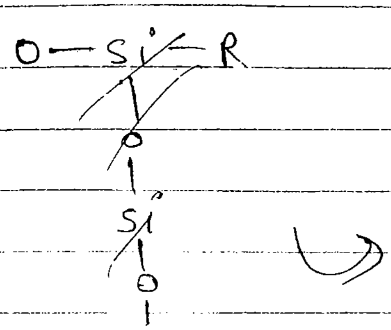
(5). $\boxed{\text{2-D SILICONE}}$

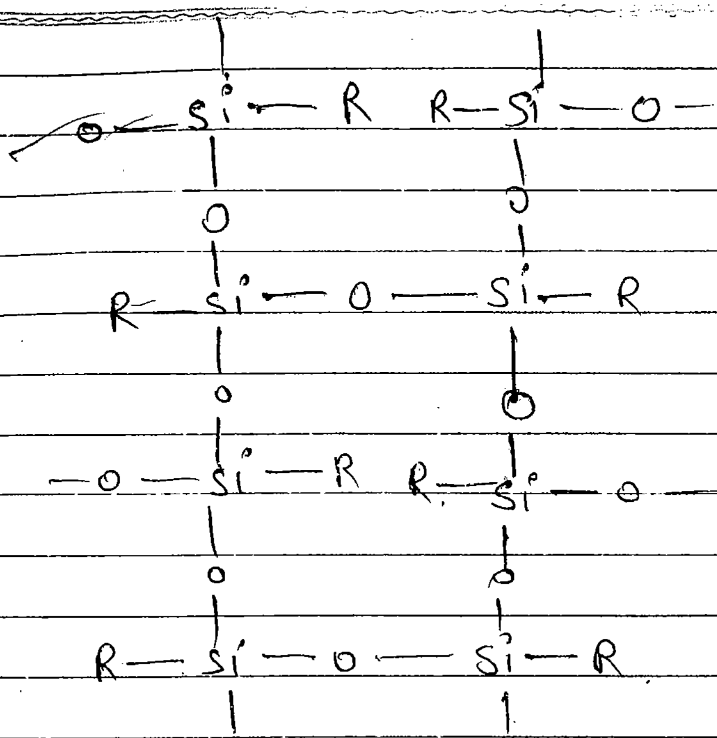
(as like 2-D silicate)
form by $RSiCl_3$ units



(6). $\boxed{\text{CROSS LINK POLYMER}}$

(as like 3-D but one Si–O–Si linkage is replaced by Si–R R–Si.





$\boxed{\text{USES}}$

(1) Due to strong Si–O–Si linkage and presence of hydrophobic group R silicons are used to make fireproof, heatproof, waterproof clothes.

(2). Due to finite and infinite structures they are liquid (oil), semisolid (grease), solid (rubber). Pressure rubber rings are made of silicones.

E
Bent's rule, Odd $e^{\ominus}$ | Bridge bond, silicate, silicon.

DRAWBACK OF VBT

It doesn't explain

(1) Paramagnetic behaviour of O_2
(2). Existance of odd $e^{\ominus}$ species
(3). Fractional bond order.
(4). Bond Order of $CO^+ > 3$
(5). ~~IO~~ IE of $N_2 > N$ while $O_2 < O$
(6). colour of halogens.

$F_2 \rightarrow$ light yellow.
$Cl_2 \rightarrow$ Greenish yellow
$Br_2 \rightarrow$ Reddish brown
$I_2 \rightarrow$ violet.

Que Arrange N_2 ~~and~~ N, O_2, O in correct order of IE

$$N_2 > N > O > O_2$$

Above drawbacks are explained by MOT which is developed by Hunds and Mulliken.

MOLECULAR ORBITAL THEORY

→ As e^- in atom ~~has~~ present in various atomic orbitals, e^- in molecule present in various MO.

→ Almost same energy and proper symmetry atomic orbitals are mixed to form new MOs

→ In formⁿ of MO, AO looses their identity.

→ No. of MO = No. of AO which take part in mixing.

→ all type of AO take part in mixing.

→ According to VBT s,p,d orbitals form σ, π, δ bonds by diff. overlapping. MOs form by mixing of AO so they are named as σ, π, δ. depends on type of overlapping/mixing.

→ Mo are different in shape, size, energy, orientation which depends on AO which take part in mixing.

→ AO are monocentric (one nucleus) while MOs are Polycentric.

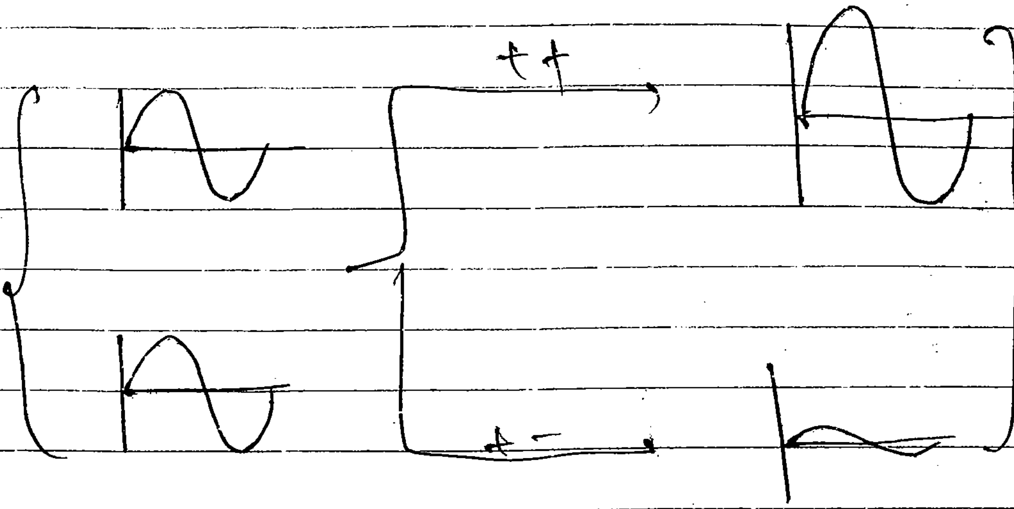
→ MOs are filled by e^-s using (n+l), hunds rule, Pauli ~~excl~~ principle.

→ Total energy of two MO however remains same as that of two original AO.

BONDING & ANTI BONDING MOLECULAR ~~INTE~~ ORBITALS

ex.

These are not AO



These are not MO.

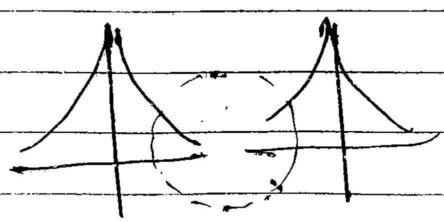
Dual nature of e^- 1) Particle 2) Wave.

Acc to wave nature

ψ ψ^2.

Amplitude e^- density.

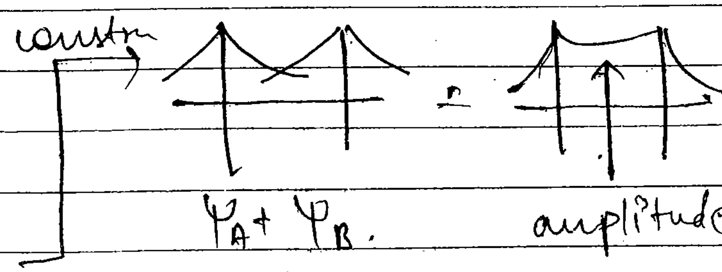
ψ_A ψ_B.



AO AO

(1s) (1s).

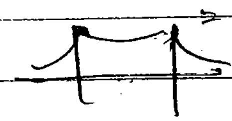
constn



$\psi_A + \psi_B$. amplitude ↑

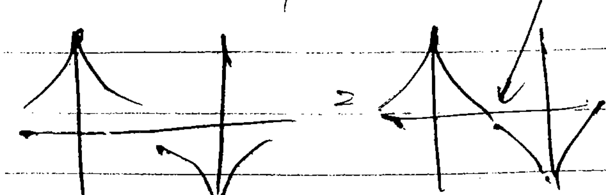
BMO.

e^- density. $(\psi_A + \psi_B)^2 = \psi_A^2 + \psi_B^2 + 2\psi_A\psi_B$



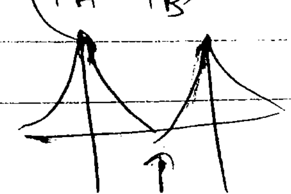
Destructive +-

zero.



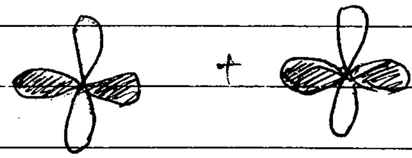
$\psi_A + (-\psi_B)$

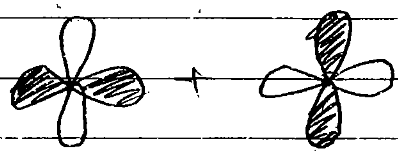
$(\psi_A - \psi_B)^2 = \psi_A^2 + \psi_B^2 - 2\psi_A\psi_B$

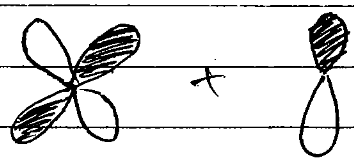


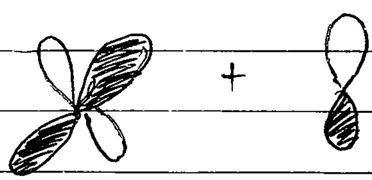
Que. Match the column.

AO + AO

1)  A). $d_\pi - p_\pi$ bonding.

2)  B). $d_\pi - p_\pi$ antibonding.

3)  C). $(d-d)_\sigma$ bonding.

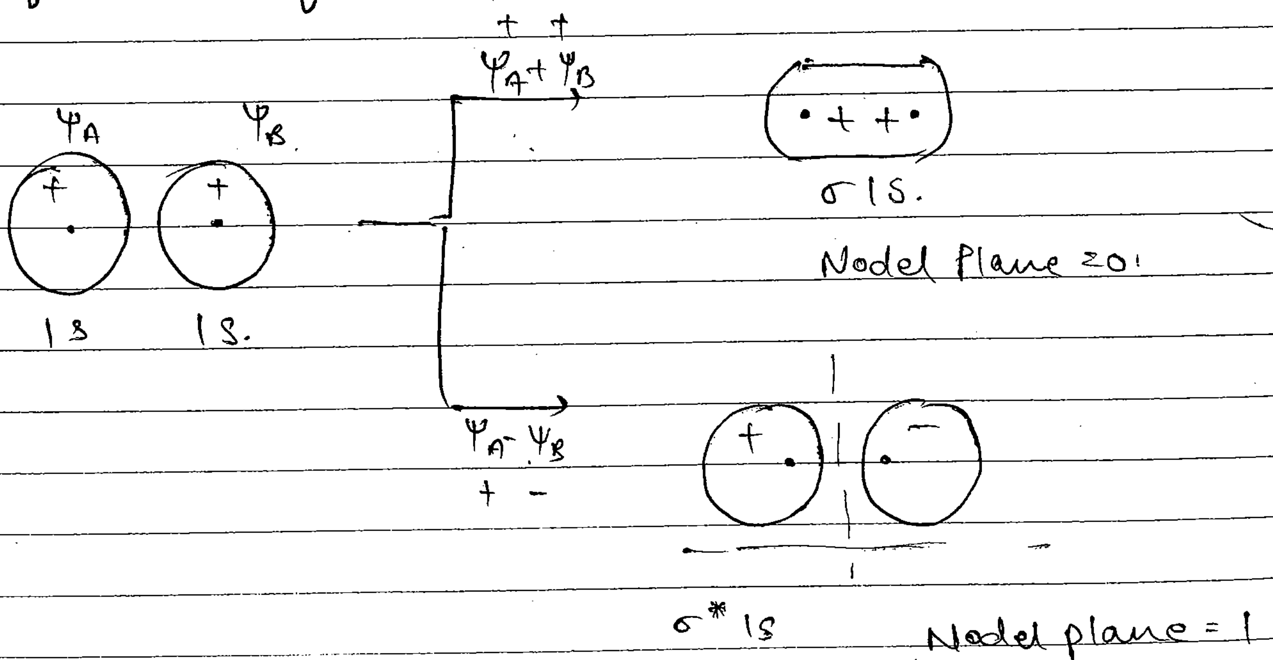
4)  D) $(d-d)_\sigma$ antibonding.

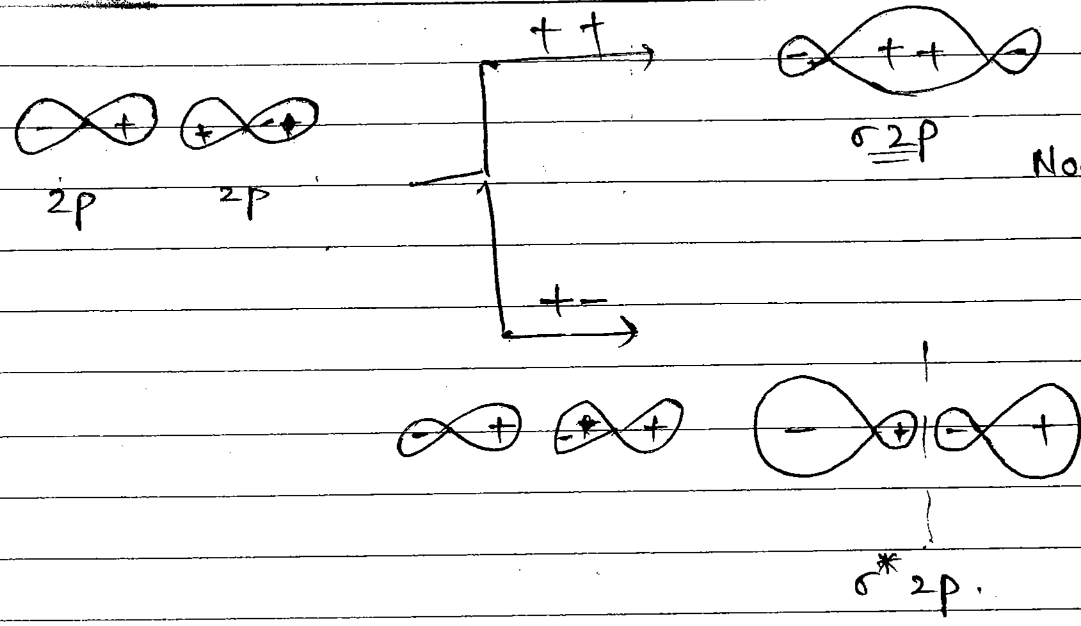
1) ~~(D)~~ ~~(C)~~ . (C)
2) (D)
3) (A).
4) (B).

	BMO (σ, π, δ)	ABMO ($\sigma^*, \pi^*, \delta^*$)
(1)	AO must be in same phase (++/−−).	AO must be in diff phase (+−/−+).
(2)	e^- density max. at mid point.	e^- density zero at mid point.
(3)	Represent att^r.	Represents repulsion.
(4)	Energy is less than AO	Energy is greater than AO
(5)	stability > AO	stability < AO
(6)	e^- in BMO, BO ↑	e^- in ABMO, BO ↓

$\boxed{\text{LINEAR COMBINATION OF AOs}}$

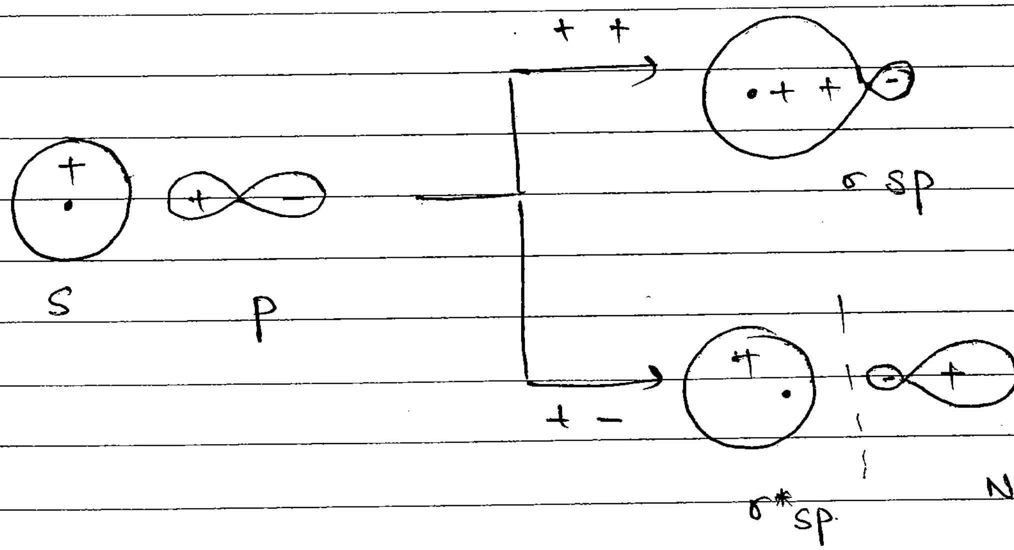
(formation of $\sigma, \sigma^*, \pi, \pi^*, \delta, \delta^*$).





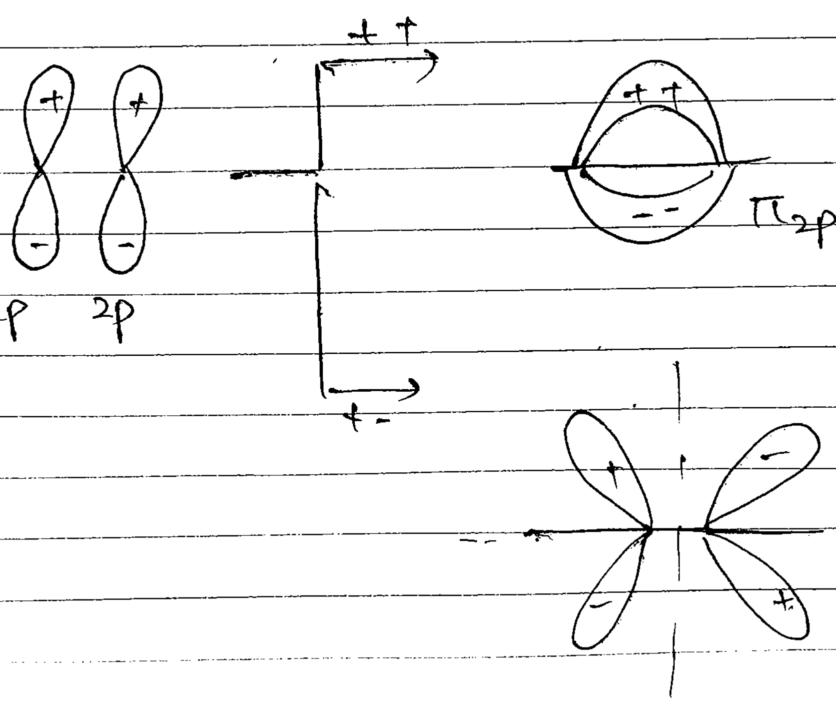
Nodel plane = 0.

Nodel plane = 1



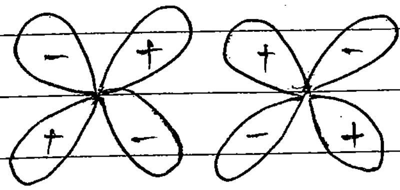
Nodel plane = 0

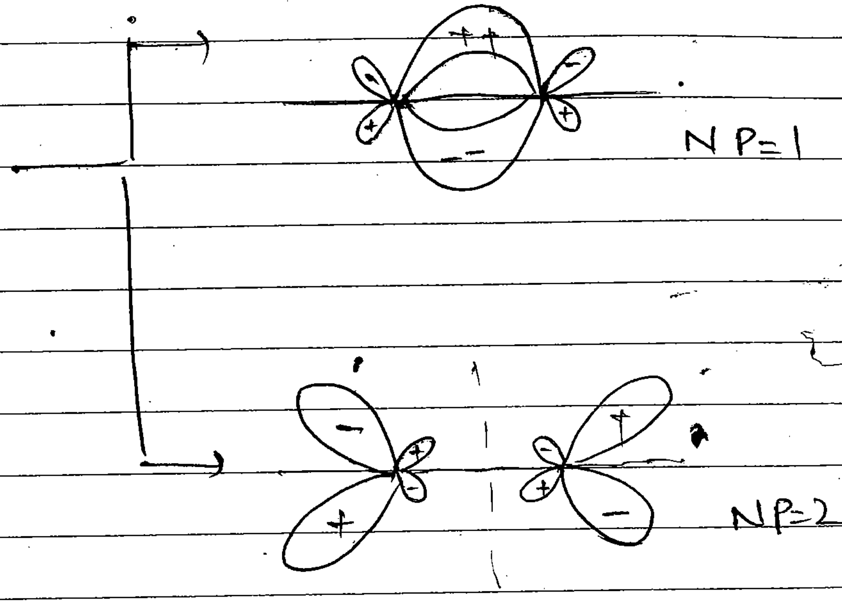
Nodel plane = 1



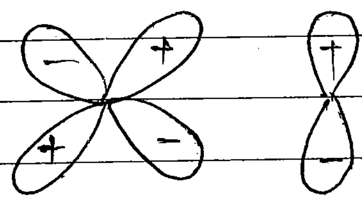
Nodel plane = 1

Nodel plane = 2

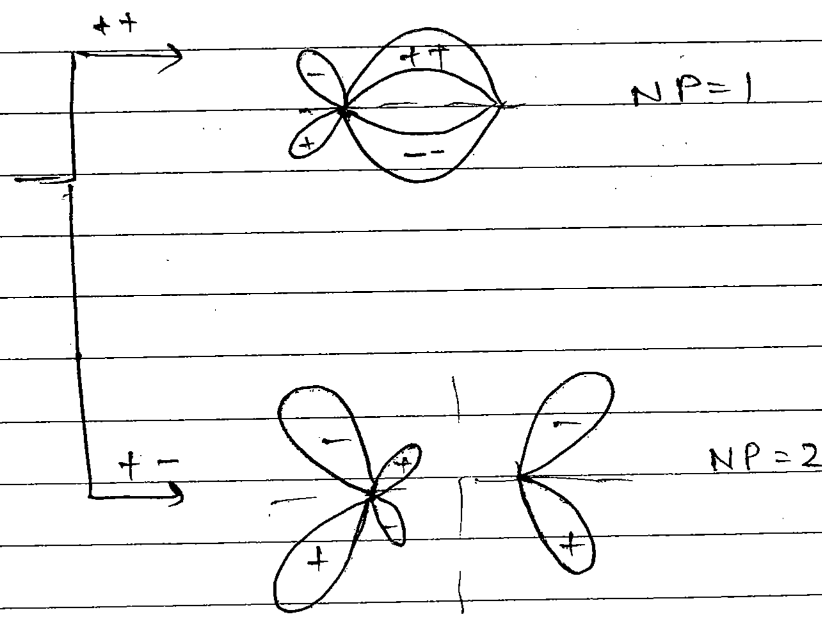


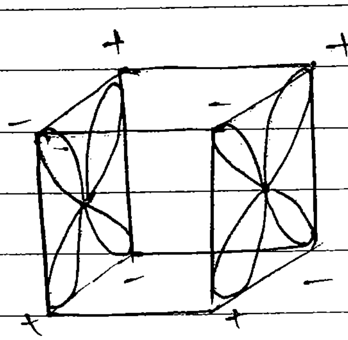


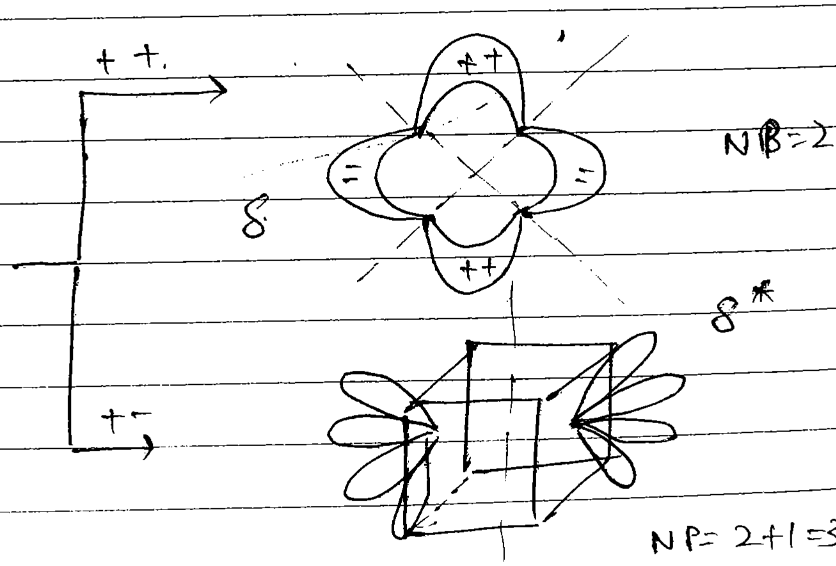
$d\pi - d\pi$



$d\pi$ $p\pi$





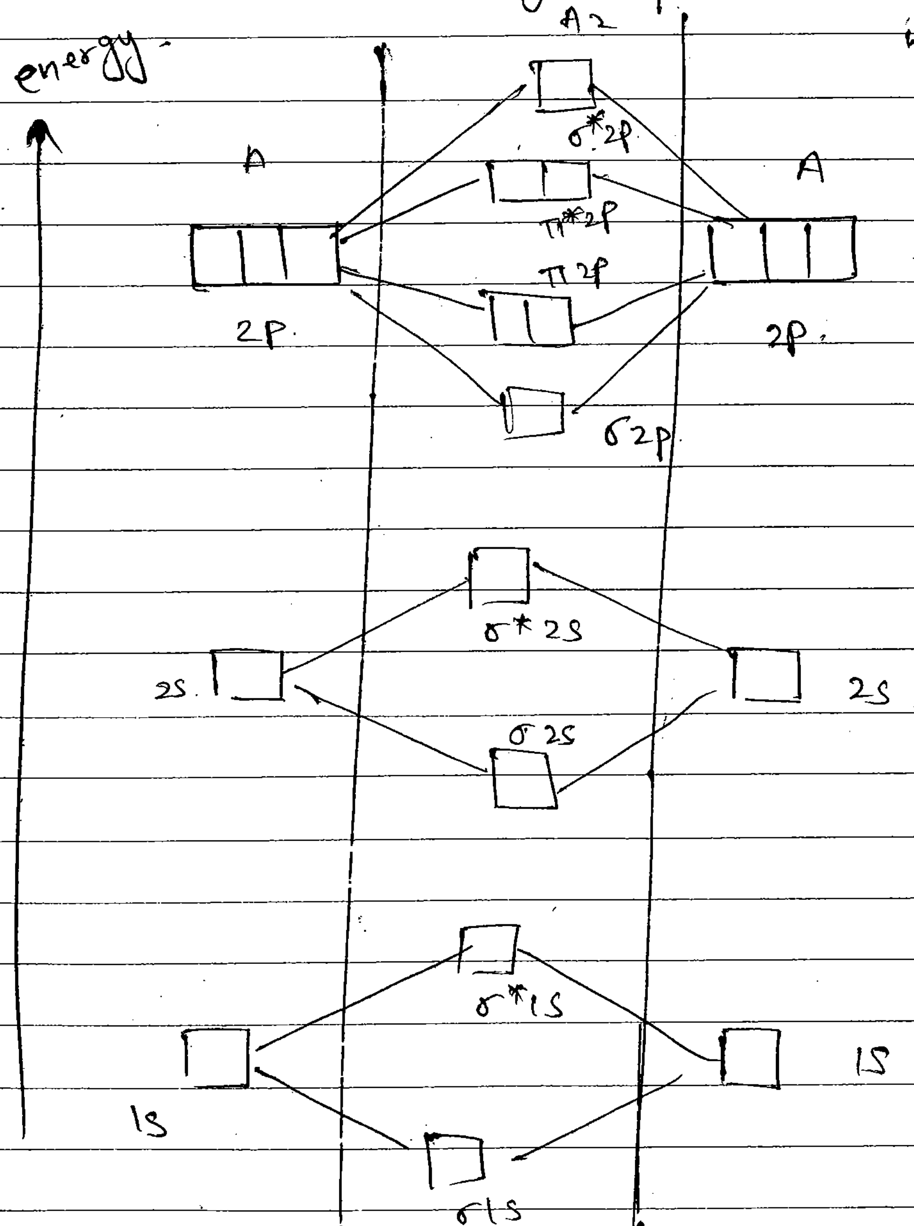


ENERGY LEVEL DIAGRAM

UPTO 20 e⁻ HOMO DIATOMIC SPECIES

H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2
& their charged species.

without sp mixing



O_2, F_2, Ne_2 & their charged species

s-p mixing

$\longrightarrow$

$Z_{eff} \uparrow$, size $\downarrow$, outer e^- moves towards nucleus.

B C N O F

energy $\uparrow$

B	C	N	O	F
$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$
$2s^2$	$2s^2$	$2s^2$	$2s^2$	$2s^2$

mixing ✓

gap ≤ 16 eV

mixing ✗

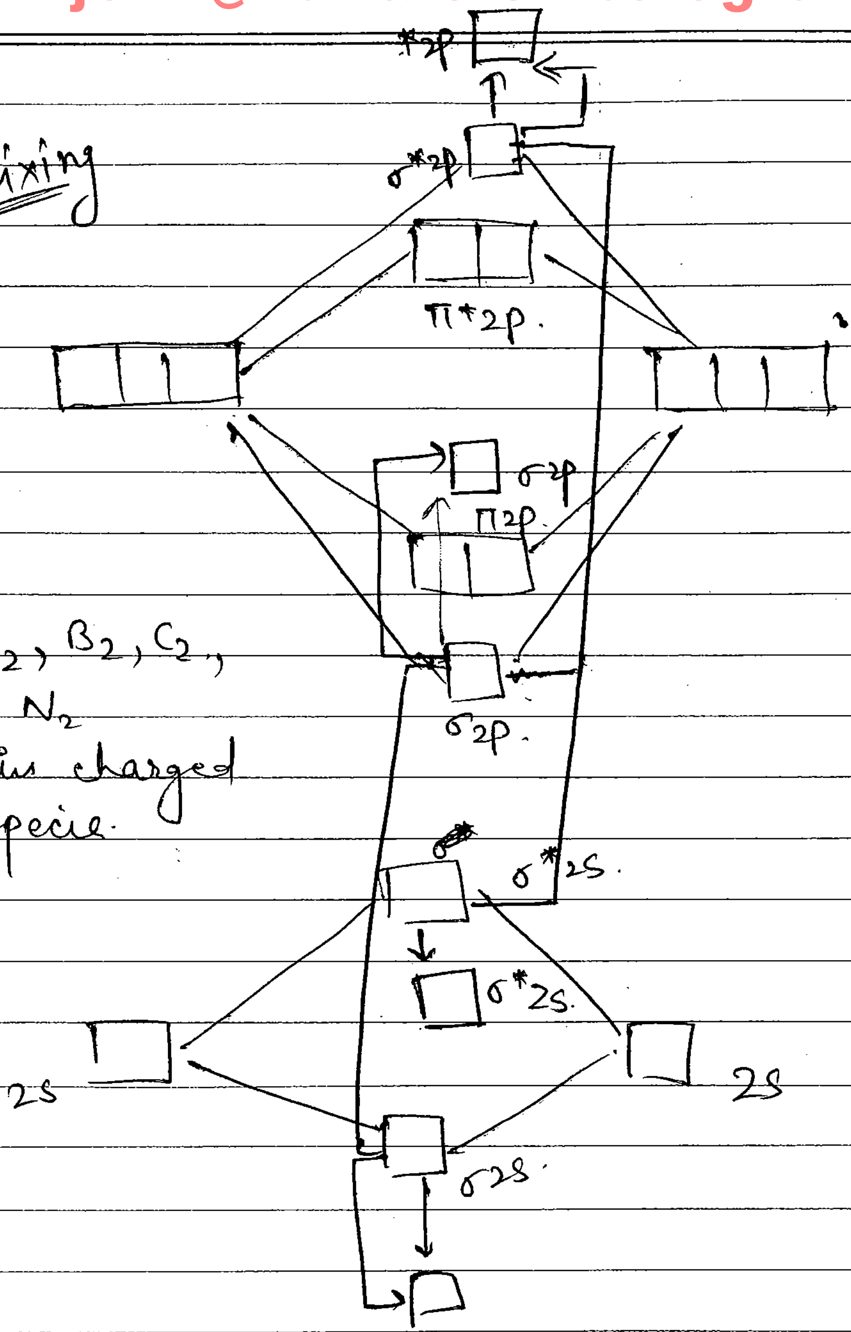
gap > 16 eV

No of 2p $e^- \uparrow$

~~repuem~~ repulsion b/w 2s & 2p $\uparrow$

gap b/w 2s & 2p $\uparrow$

sp mixing



Li_2, Be_2, B_2, C_2, N_2 and their charged specie.

2s obrital is mixed with 2p.

$\sigma 2s$ —— $\sigma 2p$.

$\sigma^* 2s$ —— $\sigma^* 2p$.

ELECTRONIC CONFIGURATION

⇒ H_2 & He_2 & their charged species

$\sigma 1s, \sigma^* 1s$

⇒ Li_2, Be_2, B_2, C_2, N_2 & their charged species.

$\sigma 1s, \sigma^* 1s, \sigma 2s, \sigma^* 2s, \underline{(\pi 2p_x = \pi 2p_y), \sigma 2p_z}$
$(\pi^* 2p_x = \pi^* 2p_y), \sigma^* 2p_z$.

⇒ O_2, F_2, Ne_2 & their charged species

$\sigma 1s, \sigma^* 1s, \sigma 2s, \sigma^* 2s, \underline{\sigma 2p_z, (\pi 2p_x = \pi 2p_y)},$
$(\pi^* 2p_x = \pi^* 2p_y), \sigma^* 2p_z$.

$\boxed{\text{BOND ORDER}}$

$$BO = \frac{N_B - N_A}{2}.$$

If $N_B > N_A$; $BO > 0$
species = exist.

If $N_B \leq N_A$, $BO \leq 0$.
species doesnot exist.

If e^- enters in

BMO ↑   ABMO ↓

BO ↑   BO ↓

If e^- is removed from.

BMO — ABMO

BO ↓ — BO ↑

BOND LENGTH

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

(1). BO ↑. BL ↓.

(2). If BO remains same.

size ↑ BL ↑.

	N_2^+	N_2^-
BO.	2.5	2.5
BL	>	

	C_2	O_2
BO	2	2.
BL	>	

PARAMAGNETIC NATURE

All odd e^-, $10e^-$, $16e^-$ diatomic species are paramagnetic

No. of unpaired — $\mu = \sqrt{n(n+2)}$ B.M.

odd	1	1.
$10e^-$/$16e^-$	2	2.

Que. Select the species which are paramagnetic in nature.

~~H_2, Li_2~~.

H_2 Li_2 B_2 C_2 N_2 O_2

F_2 C_2^+ C_2^- N_2^+ N_2^- O_2^+ O_2^-

~~Ans~~ B_2, O_2, C_2^+, C_2^-, N_2^+, N_2^-, O_2^+, O_2^-

PARAMAGNETIC NATURE

If s-p mixing absent

All odd e^-, 12 e^-, 16 e^- species are paramagnetic.

		sp mixing ✓	sp mixing ✗
B_2	10 e^-	Para	Dia
C_2	12 e^-	Dia	Para

Que. Select the species which are dia. if sp mixing absent.

H_2 Li_2 B_2 C_2 N_2 O_2 F_2

PARAMAGNETIC NATURE

If Hund's rule "do not obeyed"
(e⁻ ki pairing karate chale).

only odd e^- species.

Que. Select the species which are paramagnetic if hund's rule does not obey.

C_2^+ C_2^- N_2^+ N_2^- O_2^+ O_2^-

GERADE AND UNGERADE

GERADE	UNGERADE
Symmetrical wrt phase.	Unsymmetrical wrt phase.
Nodel plane → 0/even	Nodel plane → odd.
σ, δ, π^*	σ^*, π, δ^*

	N.P.
σ	0
σ^*	1
π	1
π^*	2
δ	2
δ^*	3

last e^-	1-2	3-4	5-6	7-8	9-12	13-14	15-18	19-20
	σ_{1s}	σ^*_{1s}	σ_{2s}	σ^*_{2s}	π_{2p}	σ_{2p}	π^*_{2p}	σ^*_{2p}
	g	ung	g	ug.	ug	g	g	ug

$\boxed{\text{HOMO}}$ → HIGHEST OCCUPIED MO.

(Jisme last e⁻ enter karta h.)

$\boxed{\text{LUMO}}$ → LOWEST UNOCCUPIED MO.

(Homo ke just upar wala MO).

$\boxed{\text{SOMO}}$ → SINGLE OCCUPIED MO.

Paramagnetic species mai jo HOMO hota hai vahi SOMO hota h.

	No. of $e^{\ominus}$	Electronic configuration.
	1	$\sigma 1s^1$
	2	$\sigma 1s^2$
	3	$\sigma 1s^2 \sigma^* 1s^1$
	4	$\sigma 1s^2 \sigma^* 1s^2$
	5	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^1$
	6	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2$
	7	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^1$
	8	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2$
with sp mixing	9	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2px^1 = \pi 2py^0$
	10	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2px^1 = \pi 2py^1$
	11	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2p^2x = \pi 2p^1y$
	12	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2p^2x = \pi 2p^2y$
	13	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2p^2x = \pi 2p^2y \; \sigma 2p^1z$
	14	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \mid \pi 2p^2x = \pi 2p^2y \; \sigma 2p^2z$
	15	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \; \pi 2p^2x = \pi 2p^2y \; \sigma 2p^2z \; \pi^* 2px^1 = \pi^* 2py^0$
	16	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \; \pi 2p^2x = \pi 2p^2y \; \sigma 2p^2z \; \pi^* 2p^1x = \pi^* 2p^1y$
	14	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \; \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \cancel{\sigma 2p^2z \; \pi^* 2p^2x = \pi^* 2p^1y}$
	15	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \; \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^1x = \pi^* 2p^0y$
without sp mixing	16	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^1x = \pi^* 2p^1y$.
	17	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^2x = \pi^* 2p^1y$.
	18	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^2x = \pi^* 2p^2y$
	19	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^2x = \pi^* 2p^2y \; \sigma^* 2p^1z$
	20	$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2z \; \pi 2p^2x = \pi 2p^2y \; \pi^* 2p^2x = \pi^* 2p^2y \; \sigma^* 2p^2z$

N_A	N_B	BO	Existance	Para/Dia	HOMO	LUMO	Ex.
1	0	.5	✓	P	$\sigma 1s$	$\sigma^* 1s$	H_2^+
2	0	1	✓	D	$\sigma 1s$	$\sigma^* 1s$	H_2, He^{2+}
2	1	.5	✓	P	$\sigma^* 1s$	$\sigma 2s$	HeH, H_2^-, He_2^+
2	2	0	✗	—	$\sigma^* 1s$	$\sigma 2s$	Li_2^+, He, H_2^{2-}
3	2	.5	✓	P	$\sigma 2s$	$\sigma^* 2s$	Li_2^+
4	2	1	✓	D	$\sigma 2s$	$\sigma^* 2s$	Li_2
4	3	.5	✓	P	$\sigma^* 2s$	$\pi 2p$	Li_2^-, Be_2^+
4	4	0	✗	—	$\sigma^* 2s$	$\pi 2p$	Li_2^{2-}, Be_2
5	4	.5	✓	P	$\pi 2p$	$\sigma 2p$	B_2^+, Be^{2-}
6	4	1	✓	P	$\pi 2p$	$\sigma 2p$	B_2, C_2^{2+}
7	4	1.5	✓	P	$\pi 2p$	$\sigma 2p$	B_2^-, C_2^+
8	4	2	✓	D	$\pi 2p$	$\sigma 2p$	C_2
9	4	2.5	✓	P	$\sigma 2p$	$\sigma^* 2p$	C_2^-, N_2^-
10	4	3	✓	D	$\sigma 2p$	$\sigma^* 2p$	C_2^{2-}, NO^{+2}, N_2, $\cancel{CN^-}$
10	5	2.5	✓	P	$\pi^* 2p$	$\sigma^* 2p$	N_2^-, NO
10	6	2	✓	P	$\pi^* 2p$	$\sigma^* 2p$	N_2^{2-}, NO^-
10	4	3	✓	D	$\pi 2p$	$\pi^* 2p$	O_2^{2+}
10	5	2.5	✓	P	$\pi^* 2p$	$\pi^* 2p$	O_2^+
10	6	2	✓	P	$\pi^* 2p$	$\sigma^* 2p$	O_2
10	7	1.5	✓	P	$\pi^* 2p$	$\sigma^* 2p$	O_2^-, F_2^+, OF
10	8	1	✓	D	$\pi^* 2p$	$\sigma^* 2p$	O_2^{2-}, F_2
10	9	.5	✓	P	$\sigma^* 2p$	$\sigma^* 2p$	Ne_2^+, $\cancel{Fe}$ F_2^-
10	10	0	✗	—	$\sigma^* 2p$	$\sigma 3s$	Ne_2

BOND ENERGY & BOND LENGTH

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

for same BO
size ↑ BL ↑

$BE \propto BO$

for same BO. No. of ABe⁻ ↑ BE ↓
Repulsion ↑

(1). H_2 H_2^+ H_2^-

BO 1 .5 .5

BE: $H_2 > H_2^+ = H_2^-$

BL. $H_2 < H_2^+ < H_2^-$

$\mu(\sqrt{n(n+2)})$ $H_2^+ = H_2^- > H_2$

(2). C_2 O_2

BO $C_2 = O_2$

BL $C_2 > O_2$

μ $O_2 > C_2$

Que. Arrange following in correct order -

BO, BL, BE, μ (Paramagnetism,

PAGE NO.:
DATE: / /

(1) Li_2, Li_2^+, Li_2^-

BO: 1 .5 .5

$Li_2 > Li_2^+ = Li_2^-$

BL: $Li_2 < Li_2^+ < Li_2^-$

BE = $Li_2 > Li_2^+ > Li_2^-$

μ = $Li_2 < Li_2^+ = Li_2^-$

$C_2 \quad C_2^+ \quad C_2^- \quad C_2^{-2} \quad C_2^{+2}$

BO $C_2^{2-} > C_2^- > C_2 > C_2^+ < C_2^{2+}$

BL < < < <

BE > > > >

μ. $C_2^{2+} > C_2^+ = C_2^- > C_2 = C_2^{2-}$

(2). $O_2, O_2^+, O_2^-, O_2^{2-}$

BO: 2 2.5 1.5 1

$O_2^+ > O_2 > O_2^- > O_2^{2-}$

BL: $O_2^+ < O_2 < O_2^- < O_2^{2-}$

BE = $O_2^+ > O_2 > O_2^- > O_2^{2-}$

~~μ = $O_2^{2-} > O_2^+ = O_2^- >$~~

μ = $O_2 > O_2^+ = O_2^- > O_2^{2-}$

N_2, O_2, C_2, B_2, F_2

BO. $N_2 > O_2 = C_2 > B_2 = F_2$

BL. $N_2 < O_2 < C_2 < F_2 < B_2$

BE $N_2 < C_2 < O_2 < B_2 < F_2$

μ: $O_2 = B_2 > N_2 = C_2 = F_2$

(3). $N_2, N_2^+, N_2^-, N_2^{+2}, N_2^{-2}$

BO: 3 2.5 2.5 2 2

$N_2 > N_2^+ = N_2^- > N_2^{+2} = N_2^{-2}$

BL: $N_2 < N_2^+ < N_2^- < N_2^{2+} < N_2^{2-}$

BE > > > >

μ. $N_2^{2-} > N_2^+ = N_2^- > N_2 = N_2^{2+}$.

(4) B_2, F_2

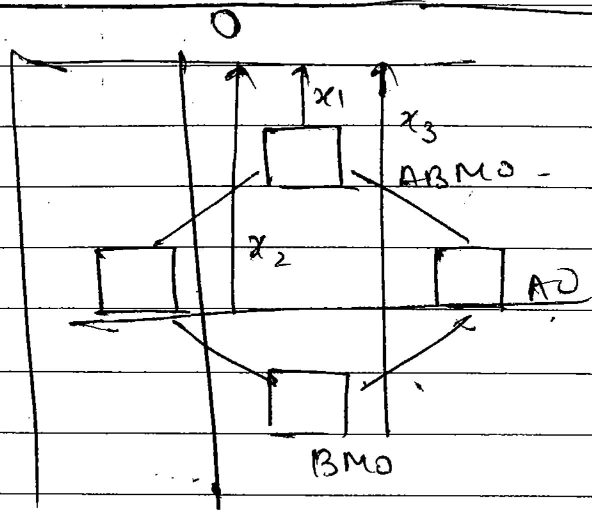
BO: 1 = 1

BL = $B_2 > F_2$

BE = $B_2 > F_2$

μ = $B_2 > F_2$

COMPARISION OF MOLECULAR & ATOMIC IE



$x_3 > x_2 > x_1$

IE BMO > AO > ABMO.

$\underbrace{H_2^+ > H_2}_{BMO} > \underbrace{H}_{AO} > \underbrace{H_2^-}_{ABMO}$

+ve ↑ IE ↑.

If last e^- of all species present in BMO/ABMO

$$IE \propto +ve\ charge \propto \frac{1}{-ve\ charge}$$

Que. Compare IE of

(1). Li_2^+, Li_2, Li, Li_2^- ⇒ $Li_2^+ > Li_2 > Li > Li_2^-$

(2) $N_2^+, N_2^-, N_2, N_2^{2-}, N_2^{+2}, N$

(3). $O_2, O_2^+, O_2^-, O_2^{-2}, O$.

(2) ⇒ $N_2^{+2} > N_2^+ > N_2 > N > N_2^- > N_2^{2-}$

(3) ⇒ $\cancel{O_2^+ > O_2 > O > O_2^- > O_2^{2-}}$ $O > O_2^+ > O_2 > O_2^- > O_2^{2-}$

NOTE

Except ~~oxy~~ O_2, F_2 and their charged species sp mixing present in all diatomic species in which p-orbital take part/present.

Homodiatomic species of same group (applicable in all groups) having same type of HOMO and same magnetic behaviour

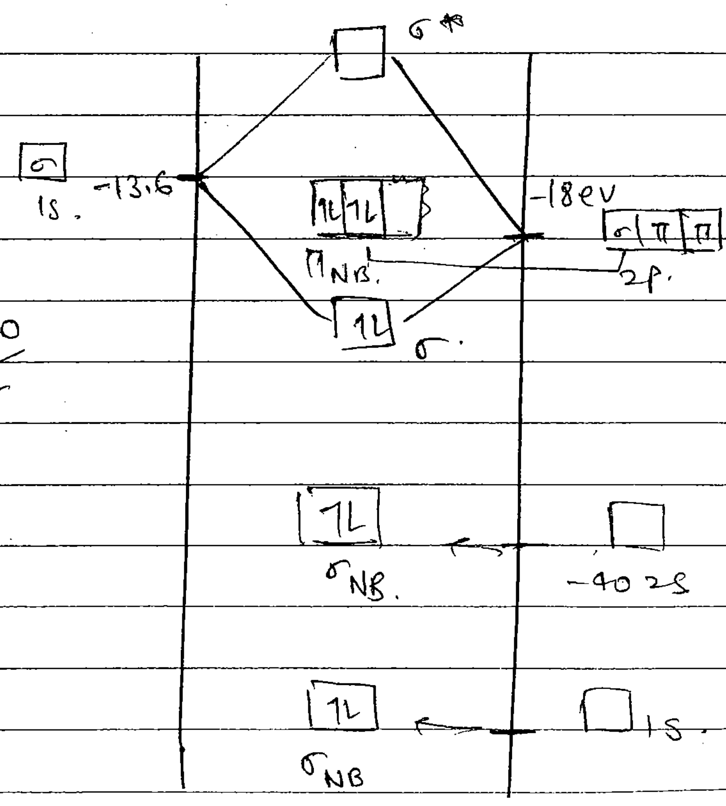
~~HOMO~~	F_2	Cl_2	Br_2	I_2	S_2	O_2
HOMO	π^*2p	π^*3p	π^*4p	π^*5p	π^*3p	π^*2p
	Dia	Dia	Dia	Dia	Para	Para

as no. of shell ↑es energy ~~gap~~ ~~↓es.~~ gap b/w sub-shells ↓es.

(gap b/w ~~diff b/w~~)

HETERODIATOMIC SPECIES

HF



$BO = \frac{2-0}{2}$

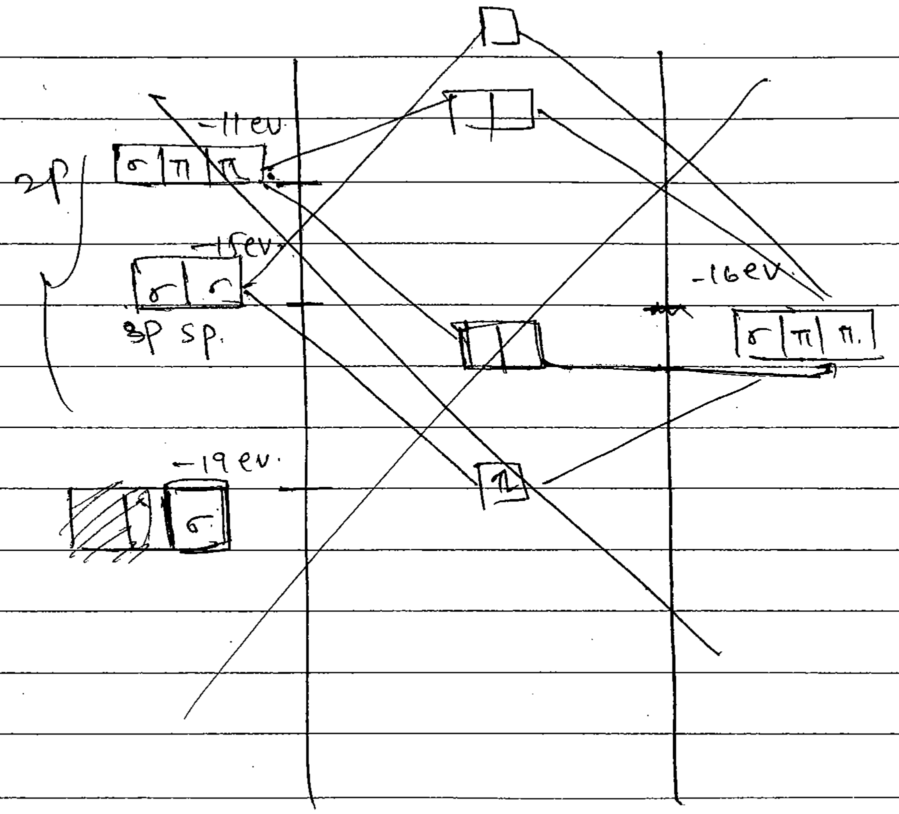
$= 1$.

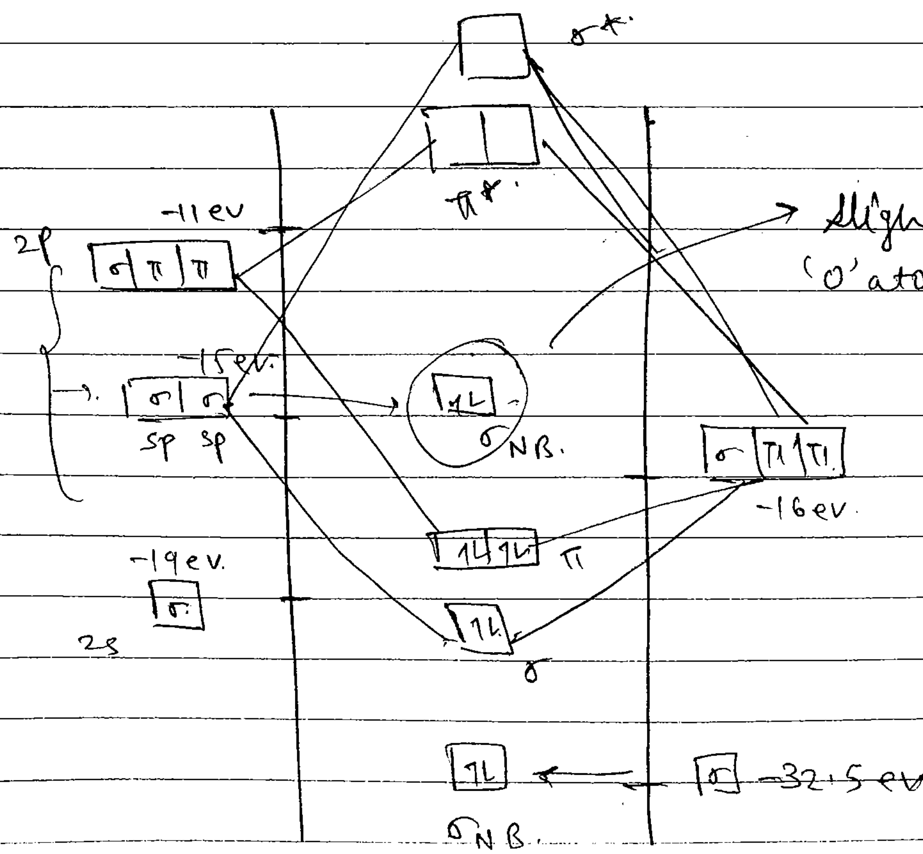
H
1s 2 − 13.6 ev
F 2p² −18 ev.
2s = −40 ev.

$\boxed{CO}$: a C O

2p −11ev −16ev

2s −19ev −32.5ev





Slightly AB wrt 'O' atom

$N_B = 8, N_A = 2$

BO = 3.

$CO \xrightarrow{-e^-} CO^+$

e^- removed from NBMO having slightly Anti Bonding character so, AB char.↓ Bonding char↑.

COLOUR OF COMPOUNDS / SUBSTANCES

Colour spectrum = VIBGYOR

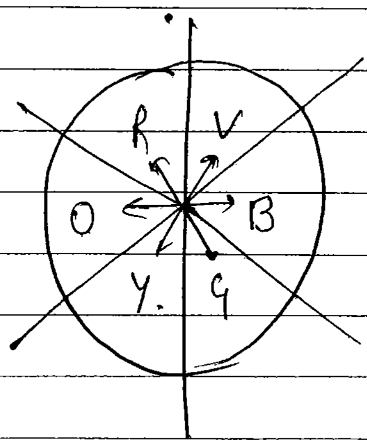
$\xrightarrow{\hspace{3cm}}$

$\lambda \uparrow$

If all colours are absorbed specie will be black.
If all colours are emitted species will be white.

COMPLEMENTARY COLOUR RELATIONSHIP

In colour spectrum each colour has its complementary colour, these pairs of colour form Neutral colour (White/Black).



V ⟷ Y
R ⟷ G
B ⟷ O

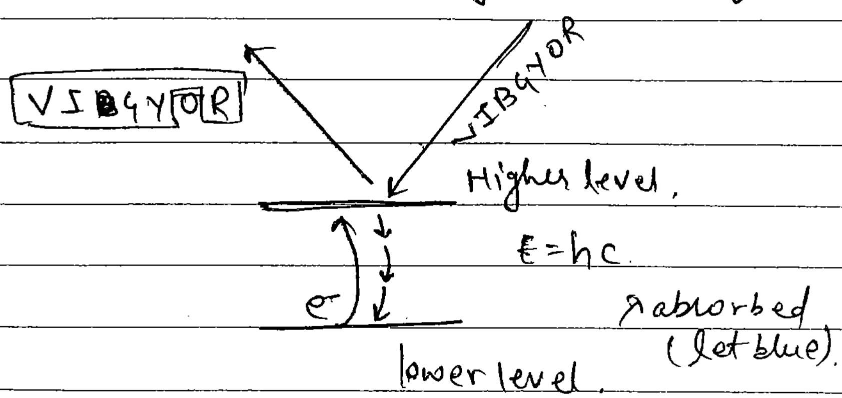
COLOURED COMPOUND

⇒ When loosely bonded e^- absorbs energy for vibration which is related to colour spectrum, compound show COLOUR.

⇒ Colour of compound depends on absorbed energy (energy gap).

⇒ When compound absorbe perticular wavelength for transition it reflects/emits all colours except absorbed.

⇒ Except complementary colour of absorbed wave-length ~~each~~ all colours nautralize each other so compound show complementary colour of absorbed λ.

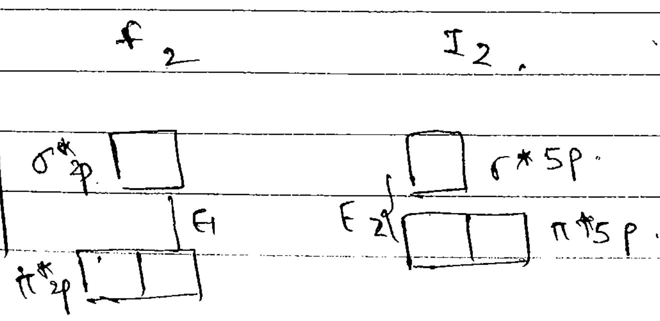


$$\left(E \propto \frac{1}{\lambda_{ab}} \propto \nu_{ab}\right)$$

COLOUR OF HALOGENS

(HOMO & LUMO transfer).

	F_2	I_2
colour	Y	V
abs	V	Y.



R

$E_1 > E_2$.

$\lambda_{ab} < \lambda_{ab}$.

$(F_2)\ (I_2)$

$V < Y$

$F_2 \quad Cl_2 \quad Br_2 \quad I_2$

$\longrightarrow$

gap b/w HOMO & LUMO ↓.

No. of transition/sec ↑.

Intensity ↑

Darkness ↑

Different types of Electronic Configurations

$O_2 \rightarrow \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p^2 \pi 2p_x^2 = \pi 2p_y^2 \; \pi^* 2p_x^1 = \pi^* 2p_y^1$

$\rightarrow$ ———————— $\pi 2p^4 \qquad \pi^* 2p^2$.

$\Rightarrow \underline{K \quad K'} \; \sigma 2s^2 \sigma^* 2s^2 \; \sigma 2p^2 \; \pi 2p^4 \; \pi^* 2p^2$.

used when shell (B) (AB)
is completely
filled.

$\Rightarrow \sigma_{1g}^2 \; \sigma_{1u}^2 \; \sigma_{2g}^2 \; \sigma_{2u}^2 \; \sigma_{3g}^2 \; \sigma \; \pi_{1u}^4 \; \pi_{1g}^2$.

MCQ
Que. Select correct e-nic configuration of N_2.

(1). $\sigma_{1s}^2 \; \sigma^*_{1s}{}^2 \; \sigma 2s^2 \; \sigma^* 2s^2 \; \pi 2p_x^2 = \pi 2p_y^2 \; \sigma 2p_z^2$.

(2). $K \; K' \; \sigma_{2s}^2 \; \sigma^* 2s^2 \; \pi 2p^4 \; \sigma_{2p}^2$

(3). $\sigma_{1g}^2 \sigma_{1ug}^2 \sigma_{2g}^2 \sigma_{2ug}^2 \sigma_{3g}^2 \pi^4_{1ug}$.

(4). $K \; K' \; \sigma_{2g}^2 \; \sigma_{2ug}^2 \; \sigma_{3g}^2 \; \sigma_{1ug}^4$

(1) (2)

WEAK FORCES

WEAK FORCES

- VWF (0–8 kJ/mole)
  - (1) Dipole-Dipole (Kesom)
  - (2). Dipole – Induced (Debye)
  - (3). ~~Induced~~ Inst- Induced &
    (London / Dispersion).
- H bond
  - (10–100 kJ/mole)
- Other forces
  - ion – dipole.
  - ion – induced dipole.

Some Important Definitions

DIPOLE

Equal and opp. charge q separated by distance d is called DIPOLE (μ), where $\boxed{\mu = q \times d}$. It is a vector quantity, in chemistry it represents dirⁿ of shifting of e^- from less EN to more EN.

INSTANTANEOUS DIPOLE.

Due to momentary imbalance of e⁻ / vibration of e⁻ at perticular instant symmetrical e⁻density becomes unsymmetrical in non-polar species, at that instant dipole is called "INSTANTANEOUS DIPOLE."

In non-polar.

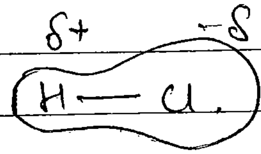
H_2 avg. time

H —⫲— H. $\mu_{avg} = 0$.

on time

H ⫲——— H H ———⫲ H $\mu_{avg} = 0$.
δ− +δ +δ δ− $\mu_{ins.} \neq 0$.

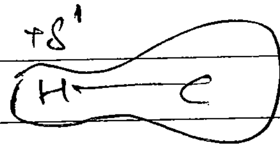
Polar. δ+ −δ Avg time. $\mu_{avg} \neq 0$.
HCl.



H — Cl.

on time.

+δ′ δ′



H — C $\mu_{avg} + \mu_{ins}$.

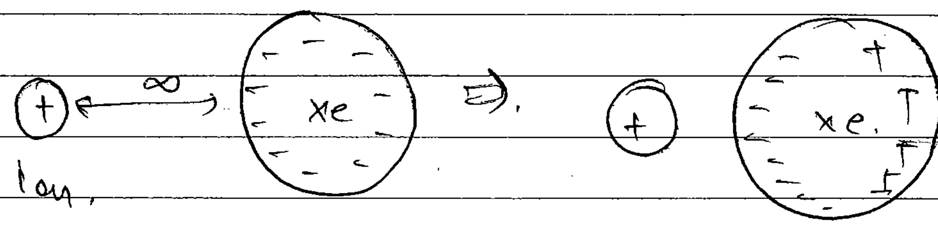
At perticular instant polar species represent permanent dipole as well as inst. dipole, while non-polar species represents only inst. dipole.

~~whe~~

INDUCED DIPOLE.

When any charged specie approaches any non-polar specie, symmetrical e^- density of non-polar specie becomes unsymmetrical. Such dipole is called "INDUCED DIPOLE."

Ex.



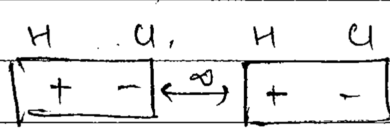
$\mu_{avg} = 0$

$\mu_{ins} \neq 0$.

$\mu_{induced}$.

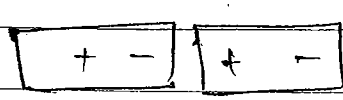
DIFFERENT TYPE OF V.W.F.

(1). B/W polar-polar species



$\mu_{avg} + \mu_{ins}$ $\mu_{avg} + \mu_{ins}$.

↓

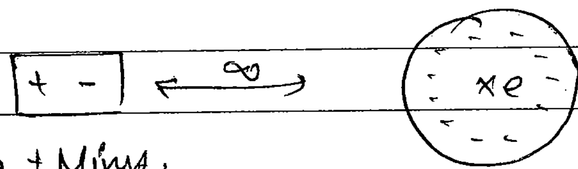


$\mu_{avg} +$ μ_{ins} $\mu_{avg} + \mu_{induced}$.

two type of forces

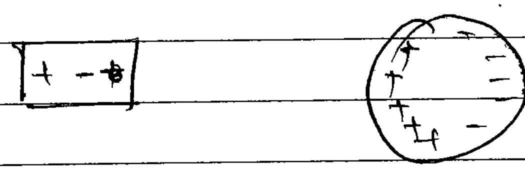
dipole - dipole (Keesom)
inst. dipole - induced dipole. (london).

(2). B/w Polar & Non-polar



$\mu_{avg} + \mu_{inst}$.

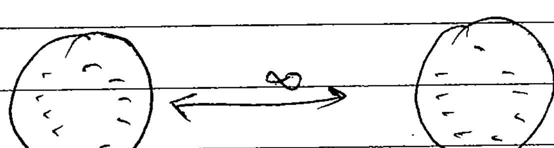
μ_{inst}.



$\mu_{avg} + \mu_{inst}$. $\mu_{induced}$,

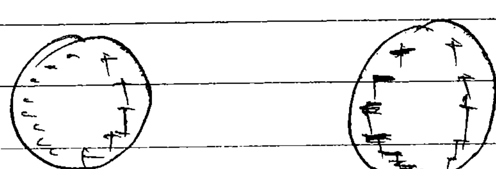
$\mu_{avg} - \mu_{ind}$. dipole - induced debye.
$\mu_{inst} - \mu_{ind}$. inst - induced london.

(3). B/w N.P - NP



μ_{inst} μ_{inst}

↓



μ_{inst}. $\mu_{induced}$.

Que. HCl --- HI

London, Keesom, Debye.

Que. One to One match

(A). O_2 --- H_2O (P) Debye

(B). O_2 --- O_2 (Q) London

(C). HI --- HI. (R) Keesom

(D). CO_2 --- HCl. (S).

(A) → (P)
(B) → (Q)
(C) → (R)
(D) → (P)

Que. Matrix Match.

(A). O_2 --- H_2O (P). Debye.

(B). O_2 --- O_2 (Q) London.

(C). HI --- HI (R). Keesom.

(D). H_2O_2 --- H_2O. (S). H-bonding.

(A). → (P) (Q) (D). R, Q, S.
(B) → (Q)
(C). → (R) (Q).

FACTORS EFFECTING VWF

(1) TYPE OF FORCES

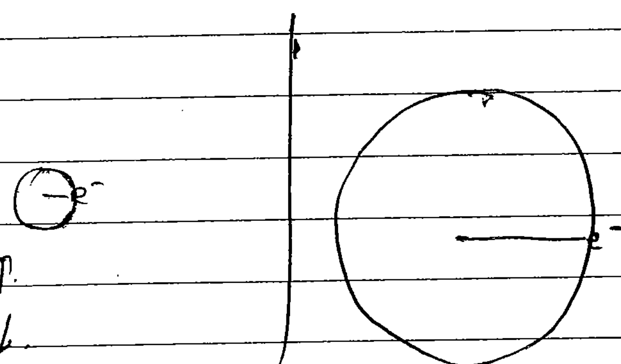
charge

ion → complete + permanent
μ_{perm} → partial + permanent
μ_{inst}/ind. → partial + temp.

order ⇒ stronger

(1) ion – ion
(2). ion – dipole
(3). dipole-dipole (Keesom)
(4). ion – induced dipole.
(5). dipole – dipole-induces. (Debye)
(6). inst. – induces (london).

(2). SIZE / MOLECULAR VOL. / POLARIZABLE e^- (movable e^-)



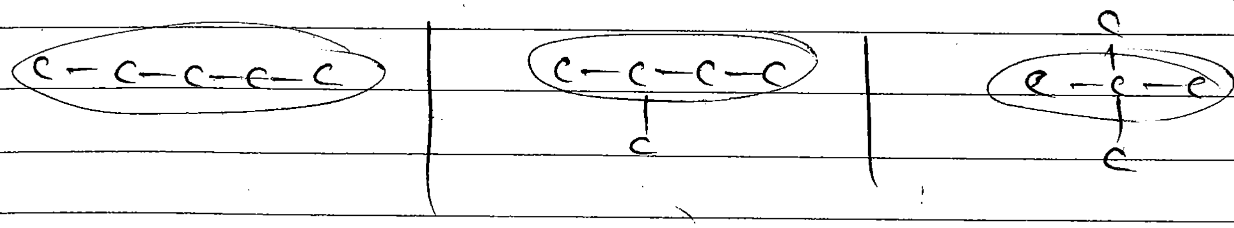
Size ↓.
att^n on itse$^-$ ↑.
Movement of e^- ↓.
Polarizable e^- ↓.
Induced charge ↓
vwf ↓.

Size ↑.
att^n on its e^- ↓.
Movement of e^- ↑.
Induced charge ↑.
vwf ↑.

vwf ∝ size / MV / polarizable e^-

SURFACE AREA / BRANCHING.

Branching ↑ surfacearea ↓ Inducedchargepoints ↓ VWF ↓.



NOTE Molecular weight doesnot affect VWF.

\# Species having higher Molecular weight ~~low~~ require more temp^r to convert liq. to gas, higher BP. rep^r greater att^n b/w molecules, So. we can say, VWF $\propto$ Mol. wt.

Que Arrange following in correct order of VWF.

⇒ $F_2 < Cl_2 < Br_2 < I_2$

⇒. $He < Ne < Ar < Kr < Xe$

⇒. $HCl < HBr < HI$

⇒. $PH_3 < AsH_3 < SbH_3$.

⇒ $H_2S < H_2Se < H_2Te$.

⇒. $CH_4 < SiH_4 < GeH_4 < SnH_4$.

size ↑

⇒ $NMe_3 > NF_3$ — Size/Mol vol.

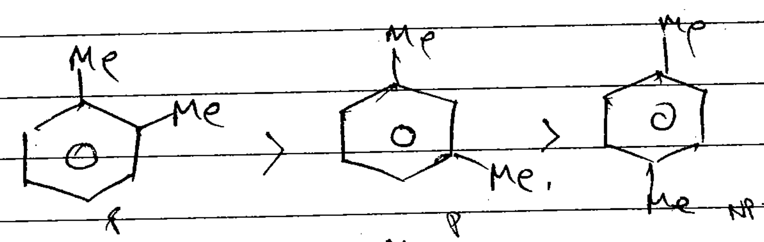
⇒ $BMe_3 > BF_3$ — "

⇒ $CO_2 < CS_2$ — "

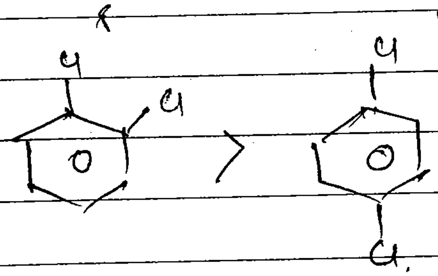
⇒ $PF_5 < PCl_5$ — "

⇒ ROR < RSR

⇒ $CH_3Cl > CH_3F$

⇒ 

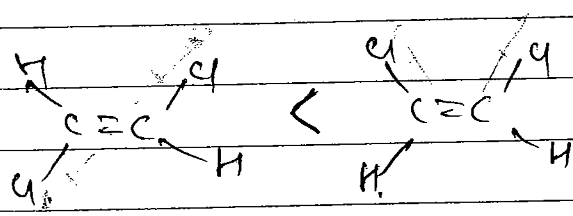
Polarity
O > M.

⇒ 

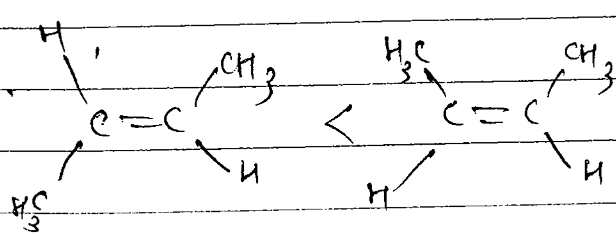
Polar, Non polar

⇒ $CCl_4 > CF_4 > CH_4$

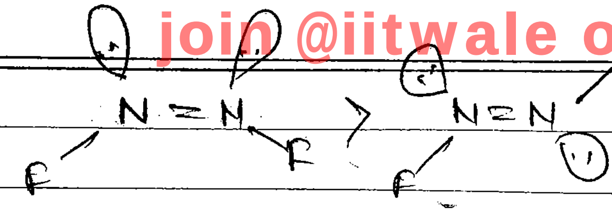
⇒ B_2F_4 ~~R_4~~ $< B_2Cl_4$

⇒ 

polar, nonpolar

⇒ 

" "

⇒  Polar, NP

⇒ $BF_3 < BCl_3 < BBr_3 < BI_3$ size

⇒ $NCl_3 < PCl_3 < AsCl_3 < SbCl_3$ size

⇒ $NF_3 < NCl_3 < NBr_3 < NI_3$

⇒ $ICl > Br_2$ Polar non polar

⇒ n, iso, neo pentane

n > iso > neo (branching)

⇒ $H_2O\cdots Xe$, $H_2O\cdots Kr$, $H_2O\cdots Ar$, $H_2O\cdots Ne$, $H_2O\cdots He$

$Xe > Kr > Ar > Ne > He$

Among inert gases Xe is more soluble in water due to high vdf^n.

⇒ $Cl_2 + Cl^- < Br_2 + Br^- < I_2 + I^-$

~~PHYSICAL~~

PHYSICAL PROPERTIES OF INERT GASES

	He.	Ne	Ar	Kr	Xe
	$1s^2$	$[He]2s^2 2p^6$	$[Ne]3s^2 3p^6$	$[Ar]3d^{10} 4s^2 4p^6$	$[Kr]4d^{10} 5s^2 5p^6$

No. of shells	He < Ne < Ar < Kr < Xe.
Size.	He < Ne < Ar < Kr < Xe
VWF	He < Ne < Ar < Kr < Xe.
BP	He < Ne < Ar < Kr < Xe
MP.	He < Ne < Ar < Kr < Xe
Volatile nature	He > Ne > Ar > Kr > Xe
liquification	He < Ne < Ar < Kr < Xe
solubility in water.	He < Ne < Ar < Kr < Xe. (~~Induced~~) (dipole-induced.) (P-NP)
IE.	He > Ne > Ar > Kr > Xe

PHYSICAL PROPERTIES OF HALOGENS.

F, Cl, Br, I.

Mono (X)	size	F < Cl < Br < I.
	Atomic radius	F < Cl < Br < I.
	IE	F > Cl > Br > I.
	EA	~~F < Cl < Br < I.~~ F < Cl > Br > I.
	EN.	F > Cl > Br > I.
dia (X_2)	BL	$F_2 \cancel{<} Cl_2 \cancel{<} Br_2 \cancel{<} I_2$
	BE	$F_2 < Cl_2 > Br_2 > I_2$
	Oxidising nature	$F_2 > Cl_2 > Br_2 > I_2$
	VWF	$F_2 < Cl_2 < Br_2 < I_2$
	BP	$F_2 < Cl_2 < Br_2 < I_2$ → solid (gas, liq)
	MP	$F_2 < Cl_2 < Br_2 < I_2$
	Volatile nature	$F_2 > Cl_2 > Br_2 > I_2$

e^- ionic repulsion (BL, BE)

STABILITY OF TRIHALIDE

$$\underset{\text{induced dipole}}{X_2} + \underset{\text{ion.}}{X^-} \longrightarrow X_3^-$$

→ trihalide ion.

size ↑
VWF ↑
att^n.
stability ↑

$F_2 + F^- \longrightarrow F_3^-$ DNE ~~d-orbital~~

$Cl_2 + Cl^- \longrightarrow Cl_3^-$

$Br_2 + Br^- \longrightarrow Br_3^-$

$I_2 + I^- \longrightarrow I_3^-$ Triiodide ion

Ion-induced dipole

* HYDROGEN BONDING

When H is bonded with more electronegative atom partial +ve charge generate on H atom. So, H atom attracts lp of adjacent non-bonded atom. such type of attn is called "H-BOND" in which released energy $\geq$ 8 KJ/mol.

$\overset{\delta^-}{D}\cdot\ddot{O}\cdot - - \overset{\delta^+}{H} - \underline{A}$ EN ↑

F, O, N, Cl

H-Bond $\geq$ 8 kj/mol.

≥ 3
F, O, N, ~~Cl~~ (3.0)
sp hyb. C' $-C\equiv C$
$-CF_3$, $-CCl_3$

EN

In periodic table

EN ↑ (across)

EN ↓ (down)

EN α % s character.

EN $sp > sp^2 > sp^3$.

EN α +ve charge

EN $\overset{+\delta}{-CF_3} > \overset{\delta^+}{-CCl_3} > -CH_3$

Lewis Basic Nature

(1). for diff. period element

$LB \alpha \frac{1}{size}$ $\quad F^- > Cl^- > Br^- > I^-$
2p 3p 4p 5p

(2). for same period element.

$LB \propto \frac{1}{EN}$ $\quad N > O > F$
$\quad\quad\quad\quad\quad\quad\quad 2p \quad 2p \quad 2p$.

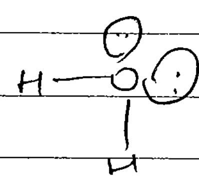
(3). for same donor atom.

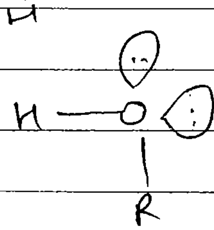
LB $\propto$ +I of SA.

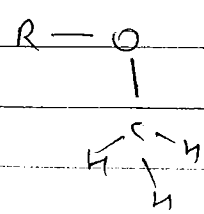
i.e. ROR > ROH > HOH

LB nature N > O > F > Cl > Br > I.

Que Select the species which can show H-bonding in pure form.

H_2O  ✓

ROH  ✓

ROR  ✗

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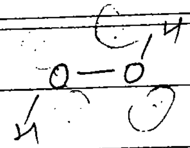
DATE: / /

H_2O_2  ✓

$CH_3-\underset{\underset{O}{||}}{C}-CH_3$ ✗

$CH_3-\underset{\underset{O}{||}}{C}-NH_2$. ✓

$CH_3-\underset{\underset{O}{||}}{C}-OH$ ✓

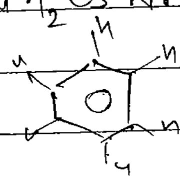
$CH_3-\underset{\underset{O}{||}}{C}-OCH_3$ ✗.

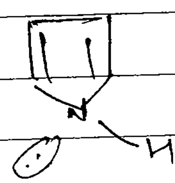
HF ✓ $MeNH_2$ ✓ Me_2NH ✓

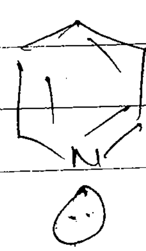
NH_3 ✓ Me_3N ✗ N_2H_4 ✓

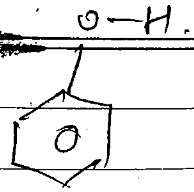
HN_3 urea (NH_2CONH_2). ✓

thio urea (NH_2CSNH_2). ✓

Benzene.  ✗

Pyrol.  ✓

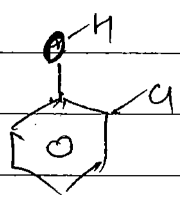
Pyridine  ✗



✓

Glycerol. CH_2 — OH
|
HC — OH
|
CH_2 — OH. ✓

Glycol H_3C — OH ✓
|
H_3C — OH.



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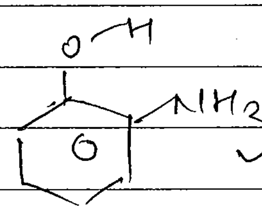

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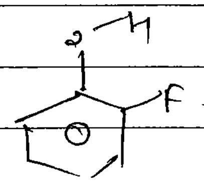

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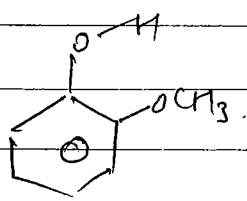
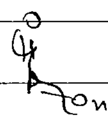
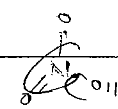


✓

H_3BO_3 ✓ H_3PO_4 ✓



HNO_3

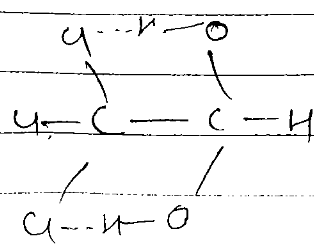


✓

H_4SiO_4 ✓ $HClO_4$ ✓ HCl. ✗

HCN ✓ H_2C_2 No lP ✗ H—C—H ✗
‖
O.

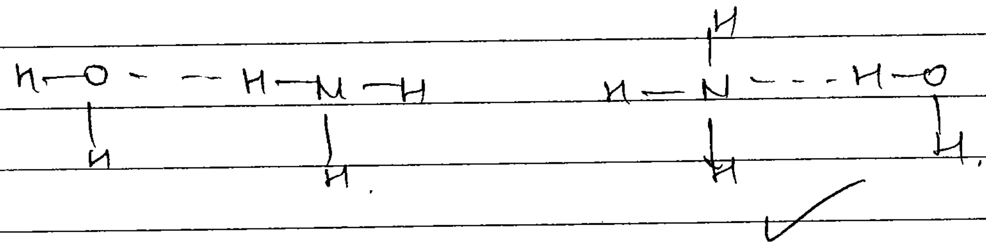
Chloral
Hydrate.



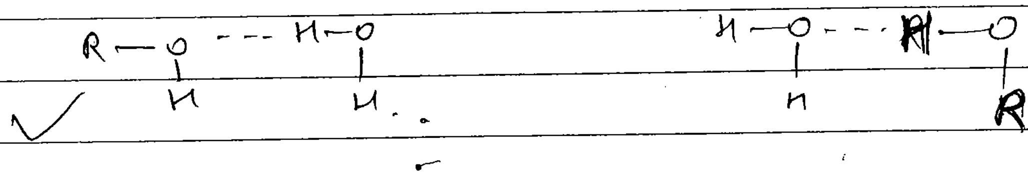
✓

Que Select best rep^n of H-bonding in given pair.

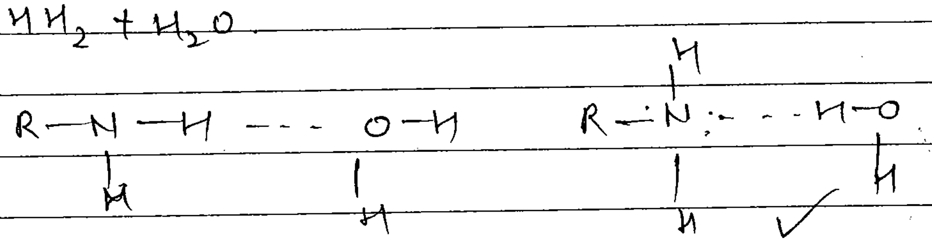
(1) $H_2O + NH_3$.



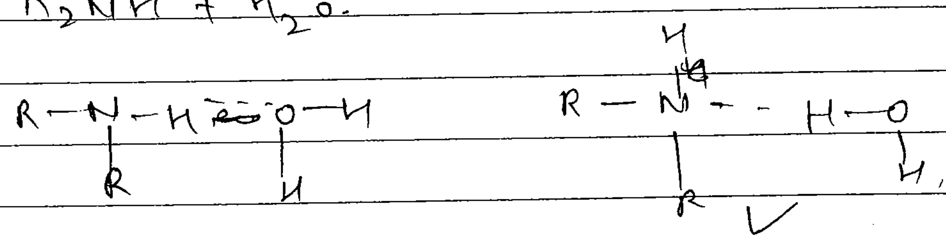
(2) $H_2O + ROH$.



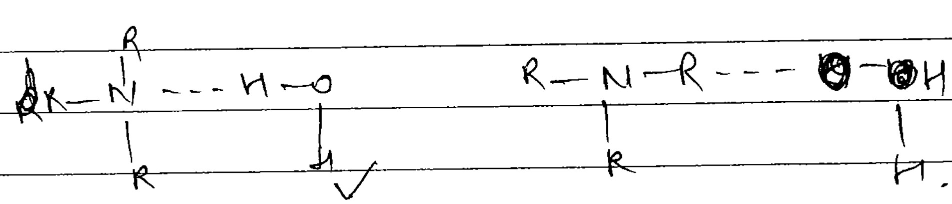
(3). $RNH_2 + H_2O$.



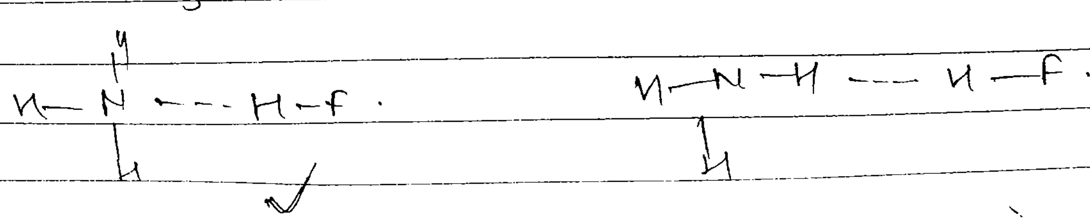
(4). $R_2NH + H_2O$.



(5). $R_3N + H_2O$,



(6). $NH_3 + HF$.



(7). $H_2O + HF$.

$H-\underset{|}{\overset{}{O}}---H-F$ ✓ (with H below O)

$O-H---F-H$ (with H below O)

(8). $HCl + H_2O$.

$H-Cl---H-O$ (with H below O) ✓

$Cl-H---O-H$ (with H below O)

(9). $H_2C_2 + H_2O$.

$H-C\equiv C-H---O-H$ (with H below O) ✓

$H-C\equiv C-H$ (vertical) $---H-O$ (with H below O)

(10). $HCN + H_2O$.

$H-C\equiv N---H-O$ (with H below O) ✓

$N\equiv C-H---O-H$ (with H below O)

$\boxed{\text{STRENGTH OF H-BONDING.}}$

(1). $A_1-H---B > A_2-H---B$. EN $A_1 > A_2$

(2). $A-H---B_1 > A-H---B_2$. LB $B_1 > B_2$

(3). $A-H---A > B-H---B > C-H---C$.

(dipole-dipole)

EN of $A > B > C$.

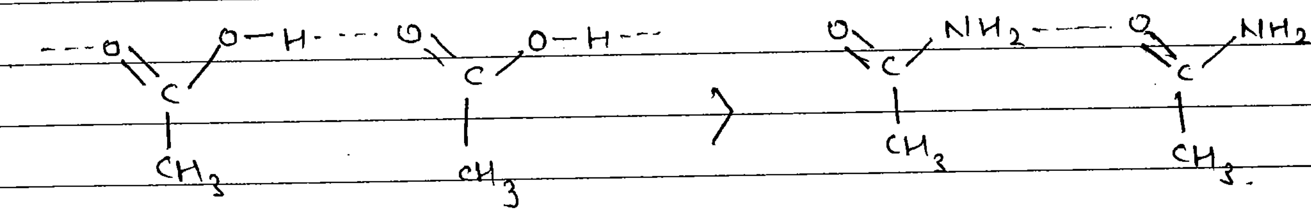
Que Arrange following in correct order of H-Bond strength.

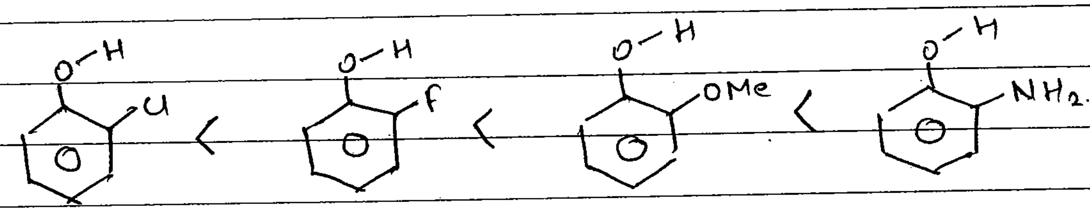
(1). $HF --- HF$ > $H_2O --- H_2O$ > $NH_3 --- NH_3$.
10 kcal | 7 kcal. | 4 kcal.

(2). $FH --- FH$ < $FH --- OH_2$ < $FH --- NH_3$

(3). $NH_3 --- NH_3$ < $OH_2 --- NH_3$

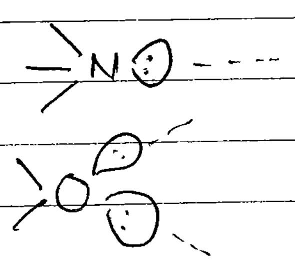
(4). RNH_2 in water > ROH in water (donorability)

(5). 

(6). 

\# $\boxed{\text{EXTENT OF H-BONDING}}$ (No. of H-Bonds)

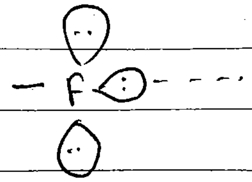
A—H--- (1).
(F, O, N, sp hyb. "C")



(1).

(2)

PAGE NO.:
DATE: / /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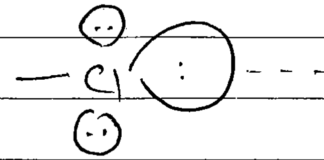
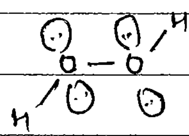
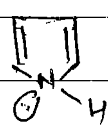
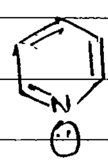
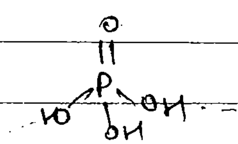
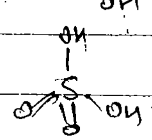
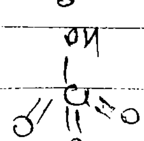
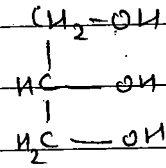

1

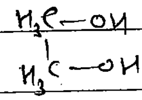
due to most EN — due to large size.

Que find max^m possible no. of H-bond formed by a molecule

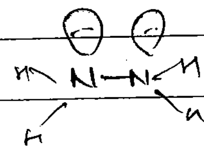
(1).	HF		2
(2).	H_2O		4
(3).	H_2O_2		6
(4)	NH_3		4
(5).	RNH_2.		3
(6)	R_2NH.		2
(7)	R_3N {in water.		1
(8).	Pyrol.		~~8~~ 2
(9).	Pyridine in water		1
(10).	H_3PO_4		~~9~~ 11
(11).	H_2SO_4		~~6~~ 10
(12).	$HClO_4$		~~8~~. 9

(13). ROH — 3.

(14). Glycerol  — 9.

(15) Glycol.  — 6.

(16). HCN ··· H—C≡N: ··· — 2

(17). N_2H_4  — 6

(18). CH_3COOH  — 5

(19). CH_3CONH_2 — 5

(20). NH_2CONH_2 — 8

(21). NH_2CSNH_2 — 6

$\boxed{\text{TYPE OF H-BONDING}}$

(1) SYMMETRYCAL & UNSYMMETRICAL (on the basis of energy)

SYMMETRICAL	UNSYMMETRICAL
(1) Released energy ≥ 42 kJ/mol.	Release energy ≤ 42 kJ/mol.
(2). It is ~~an~~ strong ion-dipole. att^n. (3c-4e$^-$)	It is a strong dipole-dipole. att^n.
(3). It is a strong H-bond.	weak H-bond.
(4) H-atom present at mid-pt.	doesn't present at mid-point.

Ex ~~Ri...H~~ $F^- --- HF$

$F^- --- H - F \Leftrightarrow F^- --- H^+ --- F^-$

$\Updownarrow$

$F - H --- F^-$

Same energy

$\left[F \overset{E_1}{\underset{x_1}{—}} H \overset{E_2}{\underset{x_2}{—}} F \right]^{-1}$

$E_1 = E_2$ (covalent + H-bond)

3c - 2e$^-$ $\quad x_1 = x_2$

strength
covalent $\downarrow$
H-bond $\uparrow$

Ex. $HF --- HF$

stable. unstable.

$F - H --- F - H \Leftrightarrow F^- H^+ F^- H^+ \Leftrightarrow \overset{-}{F} --- H - F --- \overset{+}{H}$

$x_3 \quad x_4$

$E_3 \quad E_4$

✓ ✗

H-bond = 2

covalent = 2 Covalent = 1

H-bond = 1. $\quad x_4 > x_3$

$\underset{\text{H bond}}{\underline{E_4}} < \underset{\text{covalent}}{\underline{E_3}}$

Bond Energy, $E_1 = E_2 < E_3 > E_4$.

$\Rightarrow E_4 < E_1 = E_2 < E_3$.

Distance $x_4 > x_1 = x_2 > x_3$.

Que Arrange following in correct order of H-bond strength.

(1). $H_2O --- \overset{+}{H}OH_2$ (1) ROH --- O–H(R) (2)

(3). FH --- O–R(H) (3) RNH_2 --- N(H)(H)(R) (4)

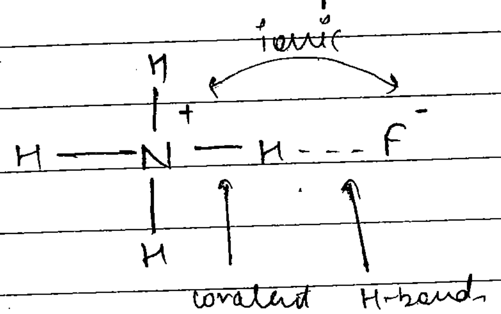
1 > 3 > 2 > 4

(2) $HCOOH --- F^-$ > $FH --- F^-$

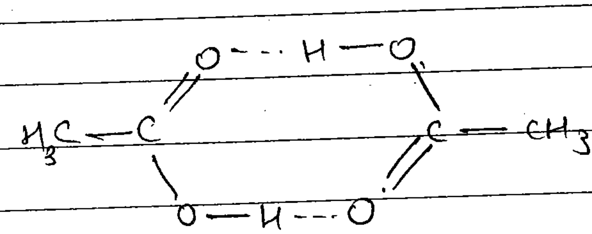
Due to greater acidic nature H⁺ donation tendency ↑, so covalent char. in H–F ↑.

(acidic nature of HCOOH > HF due to reso.)

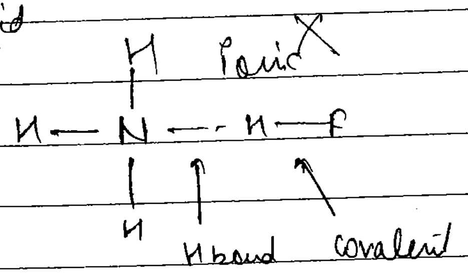
Que Find the species in which H-bond energy > 42 kJ/mol



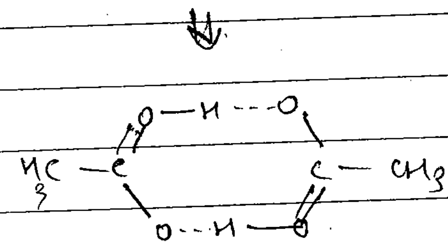
<



Hybrid



unstable.



Hyb.

(2). INTER & INTRA MOLECULAR H-BONDING.

INTER	INTRA
(1) B/w two or more than 2 molecules.	In a molecule.
(2). Association ↑es.	Discreteness ~~inc~~ ↑.
(3). No chelation.	chelation, ring like structure.

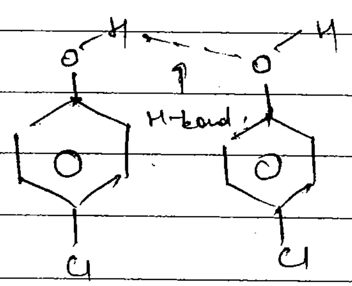
COMPARISON OF ORTHO PARA DERIVATIVES WHICH SHOW H- BONDING.

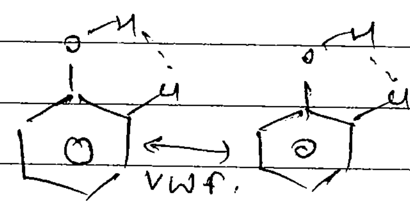
(1) FORCE OF ATTⁿ B/W MOLECULES.

Para > Ortho

H-bond VWF.

chelation.





(2) BOILING POINT

Para > Ortho.

(3) VOLATILE NATURE

Ortho > Para.

(4) VAPOUR PRESSURE

Ortho > Para.

(5) VISCOCITY (attⁿ b/w molecules / resistance wrt to flow).

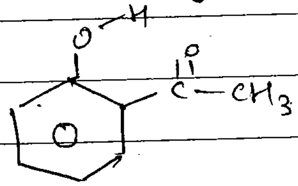
Para > Ortho.

(6) SOLUBILITY IN WATER

Para > Ortho.

(H-bonding with water) (VWF with water)

Que Select the species which can show intramolecular H-bonding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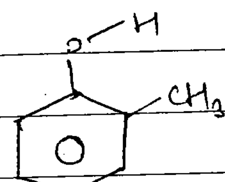
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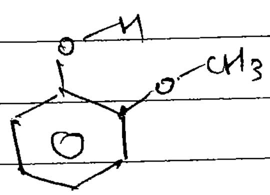
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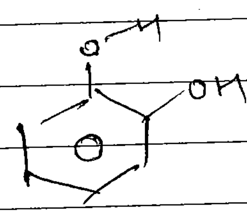
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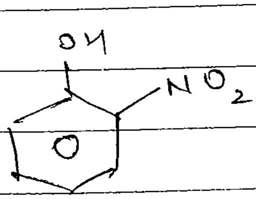
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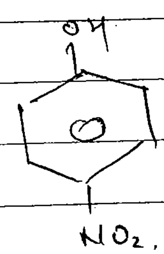
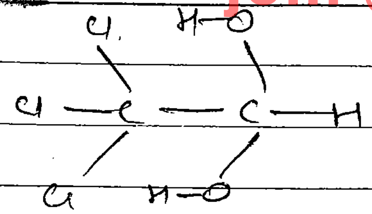

✗

DATE: / /

acetylacetone



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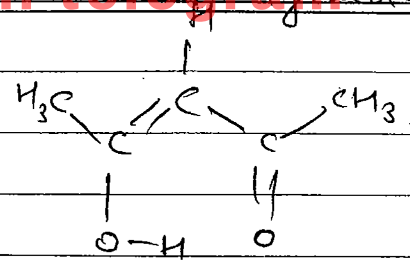

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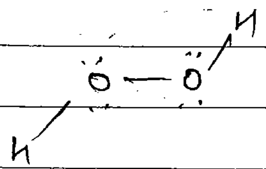

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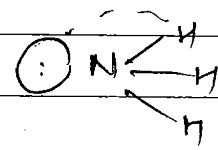
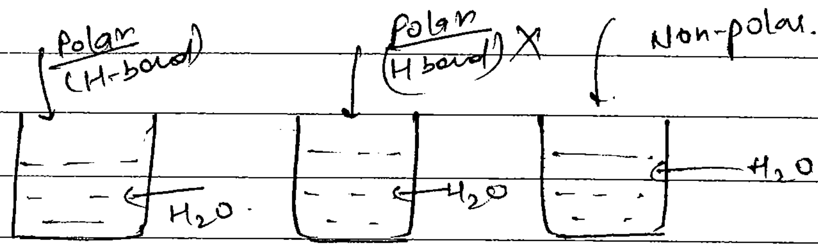


✗

due to angle strain

APPLICATION OF H-BONDING

(1). SOLUBILITY IN WATER



Strength ⇒ Hbond > Keesom > Debye.

Solubility Polar(H-bond) > Polar (H-~~bond~~) > Non polar

strength (same no. of bond)

$O-H\cdots O < O-H\cdots N$

solubility <

Same strength, diff. extent

solubility ↑ extent ↑

Que Arrange following in correct order of solubility in water.

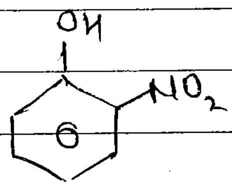
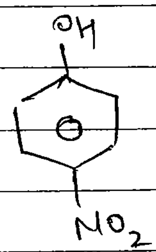
(1). $NH_4Cl > NMe_4Cl$.

(2). 1° amine (RNH_2) > Alcohol (ROH)

(3). Pyrol > Pyridine > benzene.

(4). glycol ② < glycerol ① > ethanol ③

(5). $NH_2CONH_2 > NH_2CSNH_2$

(6).  < 

(7). $CH_3COCH_3 < CH_3CONH_2 < NH_2CONH_2$.

(8). Alcohol (ROH) < Ic-acid (COOH) ($RCOOH$)

(9). $CH_3CH_2OH > CH_3-O-CH_3 > CH_3CH_2CH_3$

(10). $H_3BO_3 > Me_3BO_3$

(2) $\boxed{\text{VISCOCITY}}$

Que Arrange following in correct order of viscosity-

$\boxed{\text{Vicocity} \propto \text{att}^n \text{ b/w molecules}}$

(1). $H_2O_2 > H_2O$

(2). $N_2H_4 > NH_3$

(3). $H_2O_2 > N_2H_4$

(4) $H_3BO_3 > H_2O$

(5). $\overset{3OH}{H_3PO_4} > \overset{2OH}{H_2SO_4} > \overset{1OH}{HClO_4}$.

(6) o-Nitrophenol < P-Nitrophenol.

(7) Pyrol > pyridine > Benzene.

(8). Glycerol > Glycol > ethanol.

(9). $H_3PO_4 > Me_3PO_4$

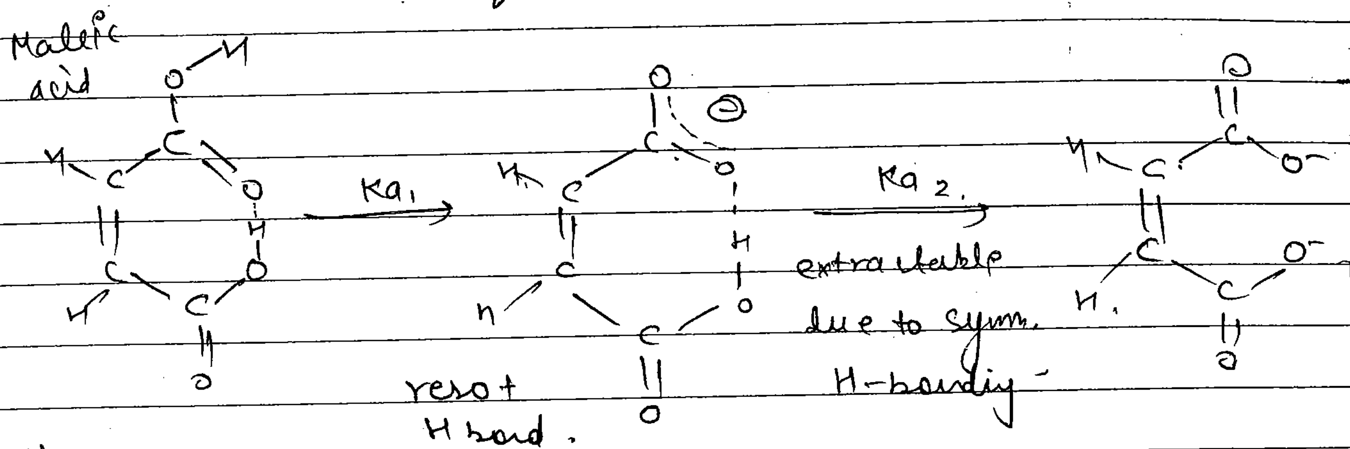
(10). $H_3BO_3 > Me_3BO_3$

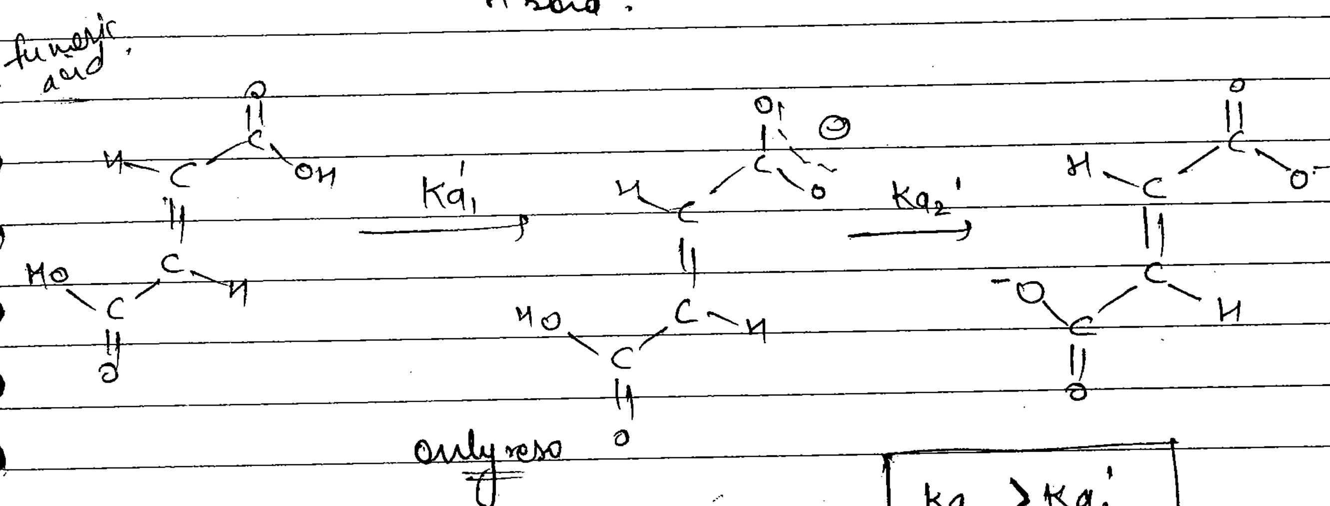
(3) <u>ACIDIC NATURE</u>

$$HA \xrightarrow{k_1} H^+ + A^-$$
$$HB \xrightarrow{k_2} H^+ + B^-$$

stability of $A^- > B^-$.
$K_1 > K_2$.

Ex(1). Acidic nature of Maleic acid and fumeric acid.

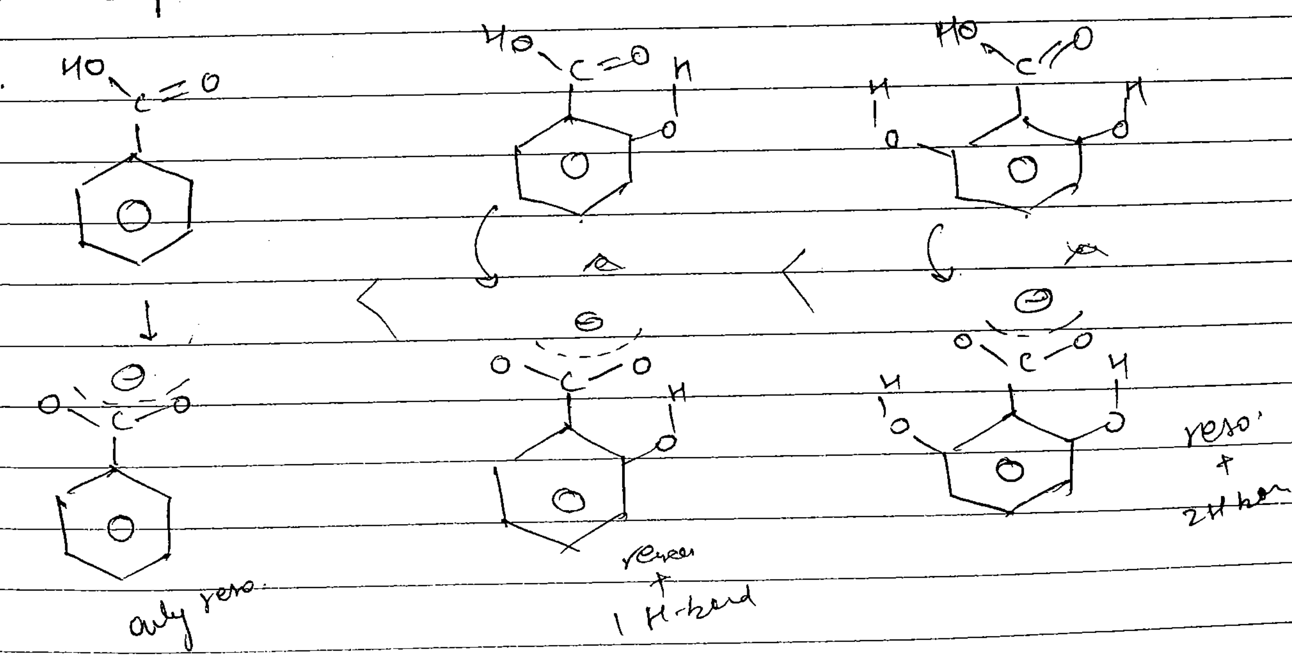




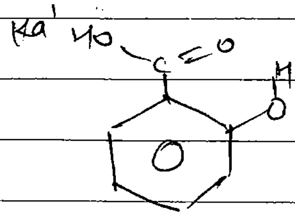
$$\boxed{\begin{array}{l} Ka_1 > Ka_1' \\ Ka_2 < Ka_2' \end{array}}$$

→ Compare

(1).

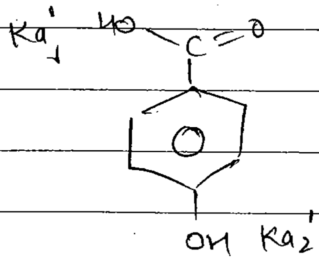


(2) · ⇒ Ka_1 & Ka_1'
⇒ Ka_2 & Ka_2'

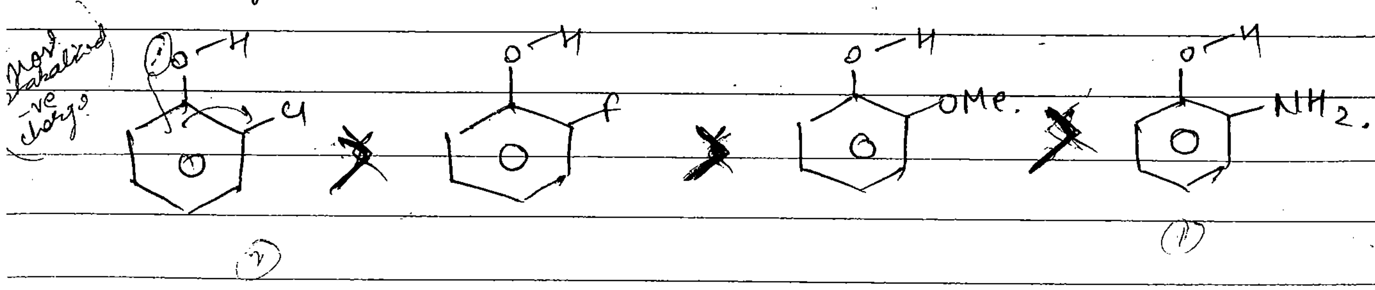


Ka2

$Ka_1 > Ka_1'$
$Ka_2 < Ka_2'$



(3). ka of.



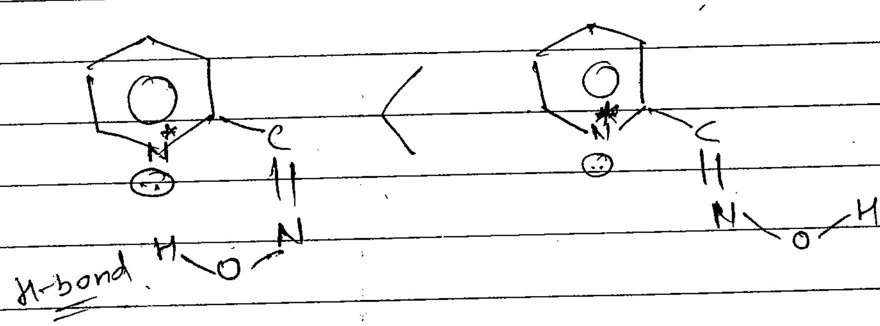
H-bond strength ↑

Que. Which of them gives more no. of OH^- in aq. medium

NH_4OH & NMe_3OH
↓
NH_4^+ OH^-

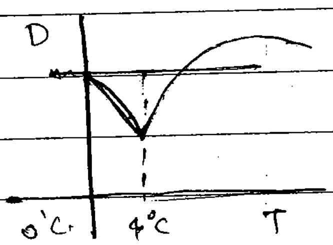
form H-bond
with H_2O.
release energy ↑.
rxn moves in forward dirⁿ.

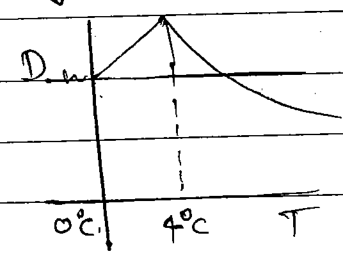
Que: Arrange following in correct order of lewis basic nature wrt N^*.

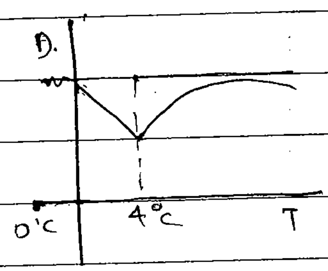


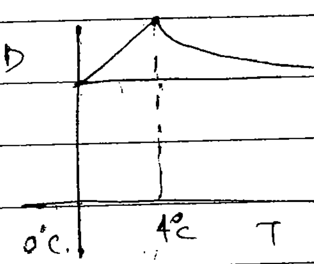
Abnormal behaviour of H_2O

Que: Select correct relation b/w density & temp^n of H_2O.

(1) 

(2). 

(3). 

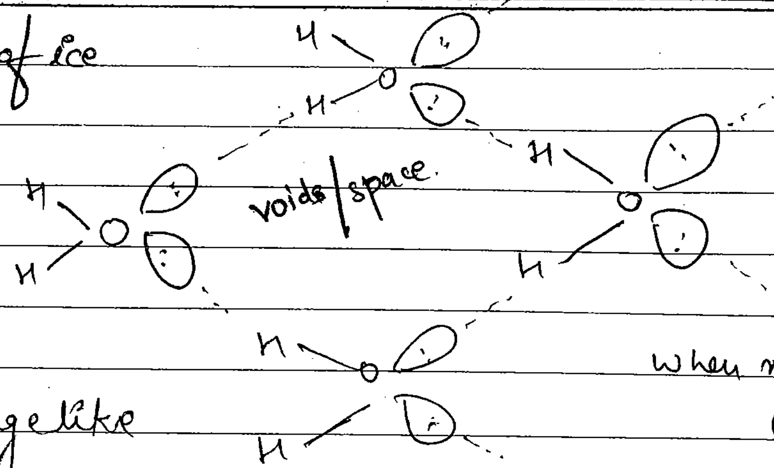
(4). 

0°C ⟶ 4°C ⟶

bcoz Density ↑ — H_2O molecules enters in voids.

Density ↓ — thermal energy of molecules ↑, repultion b/w molecules ↑, Distance ↑.

Structure of ice



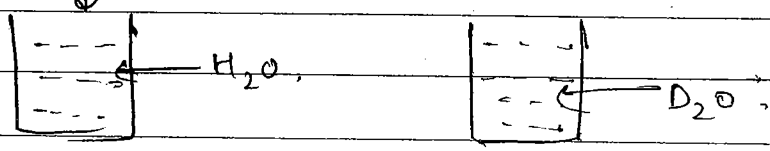
→ open cage like structure

→ Molecular solid

→ H-bond & covalent ~~bond~~ both are present.

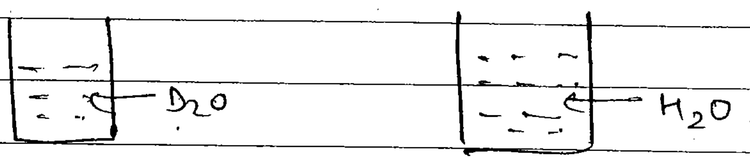
when non polar CH_3, Xe, CO_2. Molecule enters in voids, compound are called clatherates.

Que. $\boxed{H_2O}$ ice $\boxed{D_2O}$ ice.



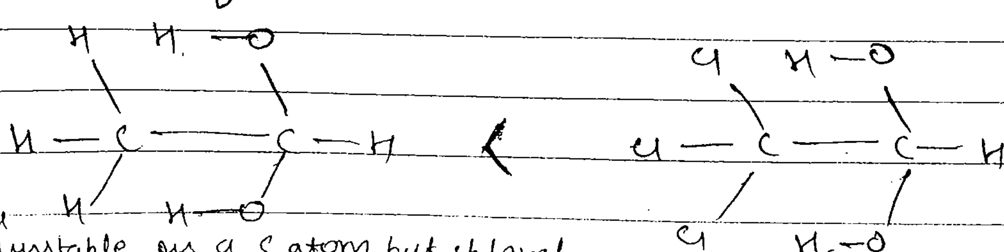
✓ float/sink   ✓f/s.

$\boxed{H_2O}$ ice $\boxed{D_2O}$ ice.



✓f/s   f/s ✓

Que Which of them is more stable



two OH are unstable on a C atom but chloral hydrate exists due to stability provided by ...

due to H-bonding.

Que which of them exist

(A) KHF_2 K^+ HF_2^- $F^- \cdots H - F \Leftrightarrow [F-H-F]^-$

3c-2e⁻

(B) $KHCl_2$

(C) $KHBr_2$ K^+ HX_2^- $[X^- \cdots H - X]$

(D) KHI_2 (A). $\cancel{\quad}$

II $\boxed{\text{BOILING POINT}}$

H bond > VWF.

① BP ∝ extent.	BP ∝ MW.
② for same extent b/w diff. groups	for almost same MW. BP ∝ VWF.
BP ∝ strength	

BP.
Que. ⇒ $H_2O < H_2O_2$. (extent, MW)

⇒ $NH_3 < N_2H_4$, (" ")

⇒. $H_2O < H_2O_2 > NH_3 < N_2H_4$. (extent, strength)
(③ ① ④ ②)

⇒. $H_2SO_4 > Me_2SO_4$ H-bond, VWF

⇒. $H_3PO_4 > Me_3PO_4$. H-bond VWF

⇒. $NH_3 > PH_3$ " "

⇒. $D_3BO_3 \rightsquigarrow H_3BO_3 > Me_3BO_3$ (MW H-bond)

⇒ $H_2O < D_2O$. (MW)

⇒. $H_2 < D_2 < T_2$. [MW]

⇒. $H_2S < H_2O$ [H-bonding]

⇒. $HF > HCl$ [H bonding]

⇒. $N_2H_4 > N_2F_4$.

⇒. $\underbrace{NH_3}_{H\ bond} > NF_3$ ② $\underbrace{NMe_3}_{surface}$ ② $NH_3 > N_3Me$. (H-bond)

⇒ 1° amine < alcohol. (strength.)

⇒. $CH_3COOH > CH_3CONH_2 > CH_3COOCH_3$. [strength H-bond]

⇒. O-Nitro phenol < p-Nitro phenol. Intra Inter.

⇒ Pyrol > Pyridine > benzene. (H-bond, P, NP)

⇒. Glycerol > Glycol > Ethanol. (extent MW)

⇒. C_2H_5OH ① alc > $CH_3CH_2CH_3$ ④ > CH_3-O-CH_3 ③ $CH_3-\underset{O}{\underset{\|}{C}}-H$ ②

⇒. 1° > 2° > 3° alcohol (branching, surface area)

⇒. $CH_3OH < C_2H_5OH < C_3H_7OH$. (MW).

⇒. 1° > 2° > 3° amine (extent)
RNH_2 R_2NH R_3N

⇒ $CH_3NH_2 < C_2H_5NH_2 < C_3H_7NH_2$ (MW)

⇒ $BMe_3 > BF_3$ (surface area)

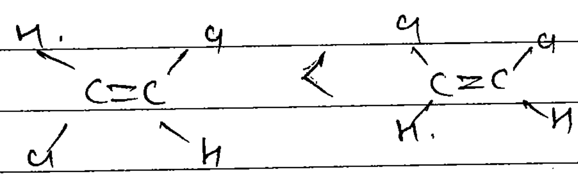
⇒ $CO_2 < CS_2$ (MW)

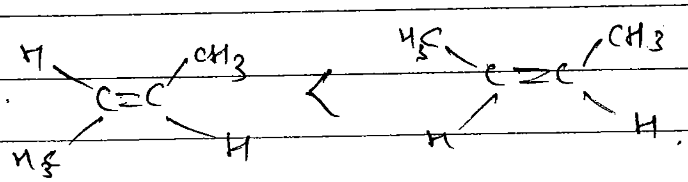
⇒ $PCl_5 > PF_5$ (MW)

⇒ $CH_3Cl > CH_3F$ (MW)

⇒ $CCl_4 > CF_4 > CH_4$ (MW)

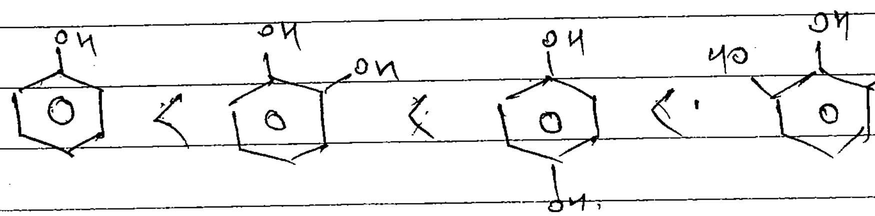
⇒ $B_2F_4 < B_2Cl_4$ (MW)

⇒  cis (P-NP)

⇒  ,, ,,

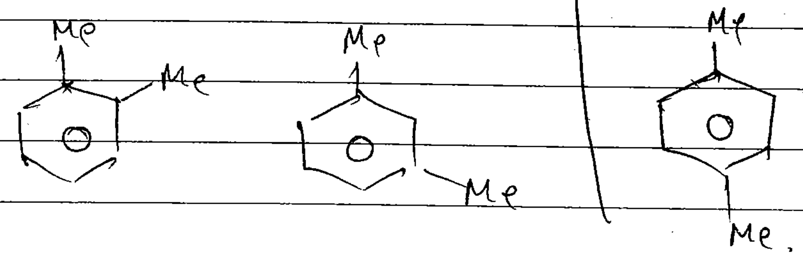
⇒ cis N_2F_5 > trans N_2F_5 (P-NP)

⇒ $BF_3 < BCl_3 < BBr_3 < BI_3$ (MW)

⇒  both inter, intra (M.W)

(1) BP / MW $CHCl_3 < CCl_4$

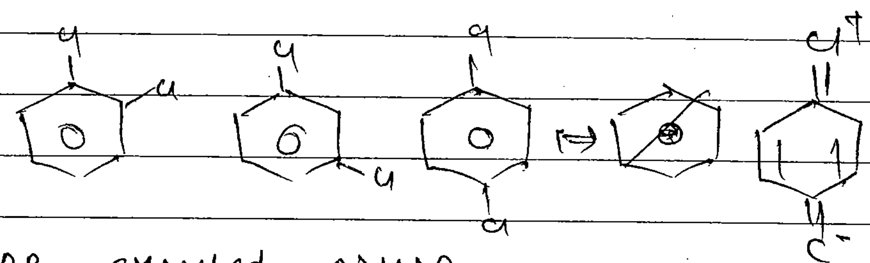
(2). (A).



BP O > M > P

Polar → Non polar.

(B)



BP expected O > M > P
experi O > P > M.

(3). repulsion of -ve charge present on surface (limited ex.)

(A). O_2 & F_2.

expected $O_2 < F_2$ (MW) Ö=Ö Ö=O

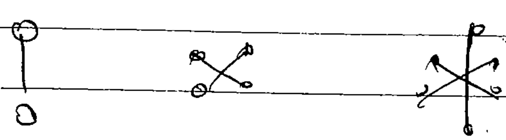
experi $O_2 > F_2$.

:F̈—F̈: ⟺ :F̈—F̈:

repulsions

(B) ~~XeF_2 < XeF_4 < XeF_6~~

BP $XeF_2 > XeF_4 > XeF_6$



repulsion.

(C) CCl_4 ~~$SiCl_4$~~ δ-

(C) $CCl_4 > SiCl_4$

Bond polarity $C-Cl^{\delta-}$ $Si-Cl^{\delta-}$

(4). BP $H_2O < I_2$.

$I_2 \rightarrow$ solid at room temp^n
$H_2O \rightarrow$ liq at room temp^n
Based on general knowledge.

⇒ $\boxed{\text{Important tables of NCERT.}}$

(1)

	CH_4		SiH_4		GeH_4		SnH_4
BL.		<		<		<	
BE		>		>		>	
T.S ∝ BE		>		>		>	
Bond angle. ($109°28'$)		≃		≃		≃	
μ (dipole)		≐		≃		≐	
VWF/BP/MP		<		<		<	

(2)

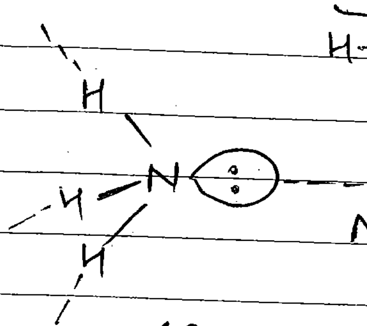
	NH_3		PH_3		AsH_3		SbH_3
BL		<		<		<	
BE		>		>		>	
T.S		>		>		>	
Bond angle.		>		>		>	

$\approx 90°$

Bond Polarity $\overset{3.0}{N}-\overset{2.1}{H} > \overset{2.1}{P}-\overset{2.1}{H} < \overset{1.9}{As}-\overset{2.1}{H} < \overset{1.8}{Sb}-\overset{2.1}{H}$

$NH > SbH > AsH > PH$

MP. $\underbrace{NH_3}_{\text{H-bond}} > \underbrace{PH_3 < AsH_3 < SbH_3}_{\text{VWF}}$



$NH_3 > SbH_3 > AsH_3 > PH_3$

No flipping in solid state.

BP $\underbrace{NH_3}_{\text{H-bond}} > \underbrace{PH_3 < AsH_3 < SbH_3}_{\text{MW/VWF}}$

$SbH_3 > \underset{\uparrow}{NH_3} > AsH_3 > PH_3$

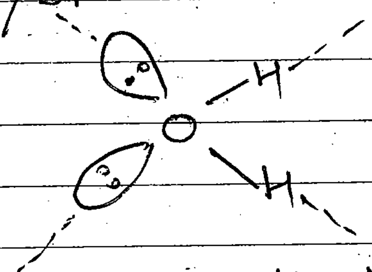
due to flipping extent of H bond ↓
BP ↓ from its expected value.

	NH_3	PH_3	AsH_3	SbH_3	
Reducing nature	<	<	<		H donating tendency
Lewis basic nature	>	>	>		

$\propto \frac{1}{\text{size}}$

3

	H_2O		H_2S		H_2Se		H_2Te
BE		>		>		>	
BL		<		<		<	
T.S.		>		>		>	
Acidic nature		<		<		<	
bond polarity		>		>		>	
Bond angle	104.5	>	≈90°	>		>	
MP/BP							



$\underbrace{H_2O}_{\text{H-bond}} > \underbrace{H_2S < H_2Se < H_2Te}_{\text{MW / VWF}}$

$H_2O > H_2Te > H_2Se > H_2S$

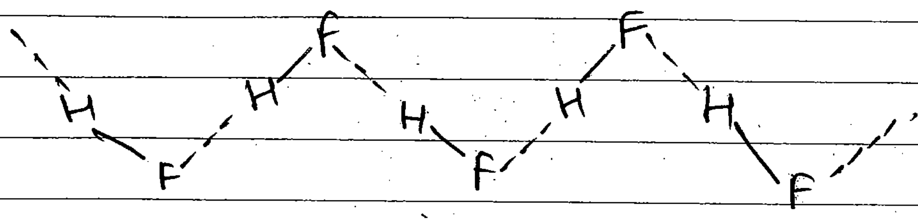
no flipping

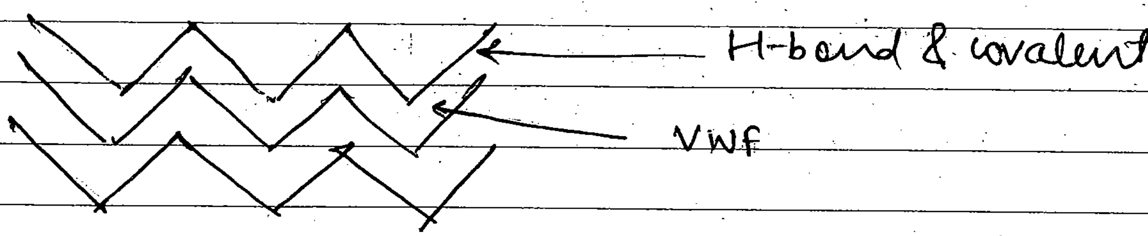
all bonds are H-bonds.

	HF		HCl		HBr		HI
BE		>		>		>	
BL		<		<		<	
T.S		>		>		>	
Acidic nature		<		<		<	

BP/MP $\underbrace{HF}_{\text{H-bond}} > \underbrace{HCl < HBr < HI}_{\text{VWf / MW}}$

almost linear. V/bent/angular.





MP HI > HF > HBr > HCl

MP ↓ from its expected value bcoz VWF present b/w chains.

BP. HF > HI > HBr > HCl.

Que Arrange NH_3, H_2O, HF in correct order of BP and MP.

NH_3 H_2O HF.

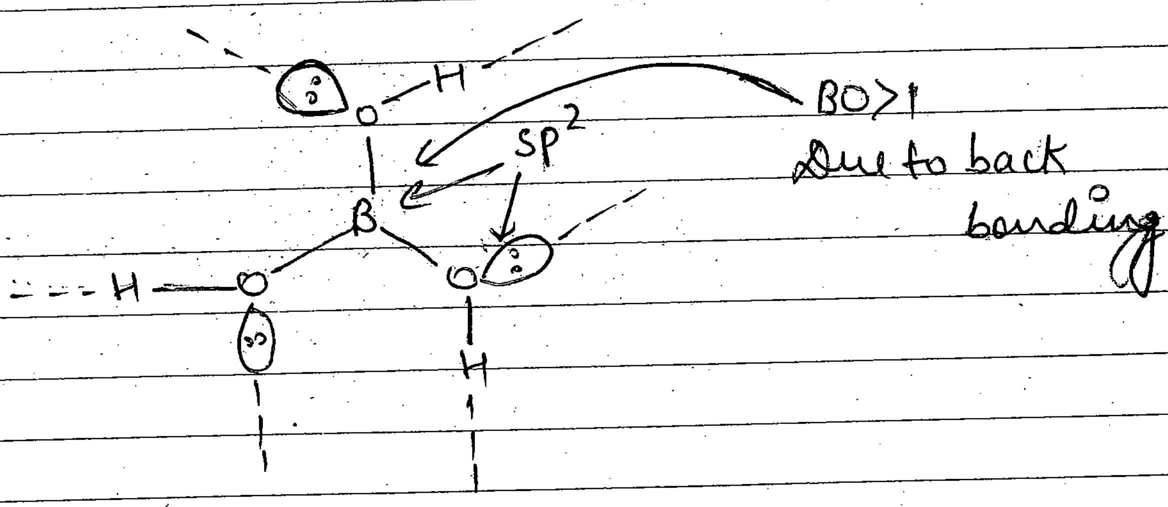
BP $H_2O > HF > NH_3$ → due to flipping extent ↓
extent.

MP $H_2O > NH_3 > HF$ ↪ VWF b/w chains.
strength

Ans Draw the structure of HCN in solid state.

$$---H-C\equiv N:---H-C\equiv N:---H-C\equiv N:---$$

⇒ Structure of ortho-boric Acid.



⇒ Layer like structure (sp² hyb.)
Hexagonal H-bond rings in the layer.

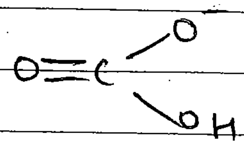
⇒ In the layer ⇒ H-bond & covalent.

⇒ B/w the layers ⇒ VWF.

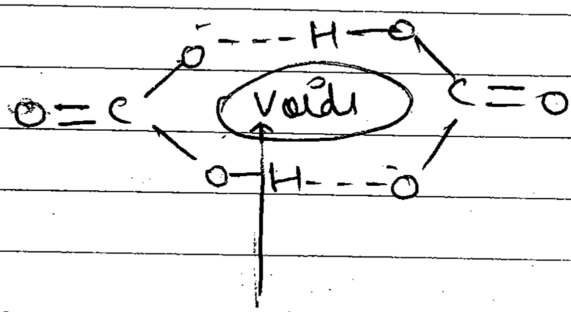
⇒ Slippery nature due to VWF b/w layers.

e) $NaHCO_3$ and $KHCO_3$

HCO_3^-

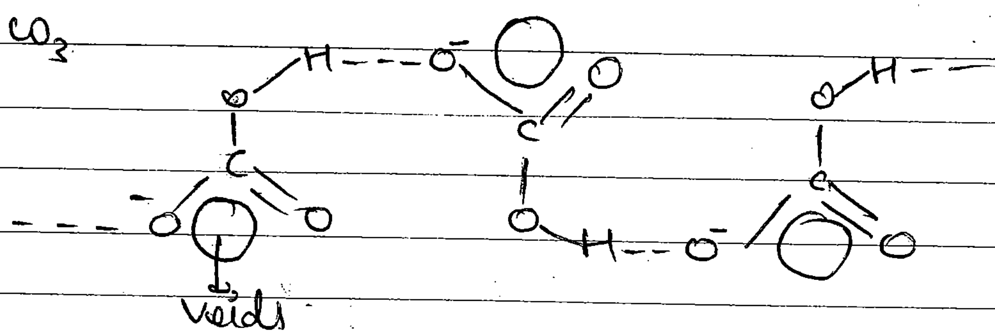


$KHCO_3$



large size voids
large size cation stable.

$NaHCO_3$



Solubility in water. $NaHCO_3 < KHCO_3$

b/w HCO_3^- H-bond VWF (b/w dimers)

energy required to separate HCO_3^- from lattice >

Ques Which of them exist?

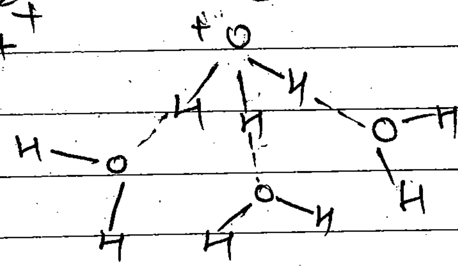
$(H_2O)_n + H^+$ ✓
$(H_2O)_n + OH^-$ ✓

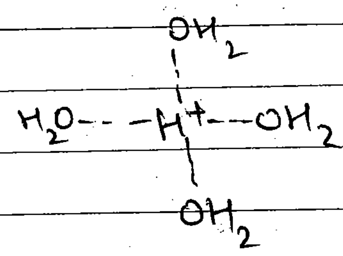
(1) H_3O^+ ✓

(2) $H_5O_2^+$ ✓ $H_2O---H_3O^+$ $H_2O—H^+—OH_2$ exists due to symmetric H-bond.

(3) $H_3O_2^-$ ✓ OH_2---OH^-

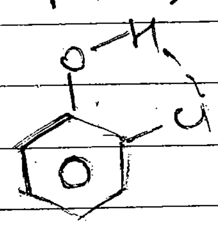
(4) $H_9O_4^+$ ✓





Ques Compare μ expected & μ experimental of

(1)

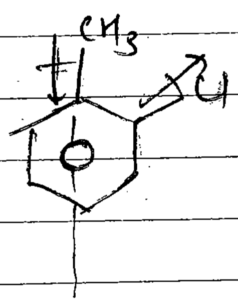


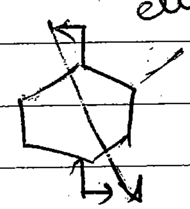
$\theta = 60°$ $\theta < 60°$ (due to H-bond)

$\cos\theta \uparrow \mu \uparrow$.

μexpected < μexperi.

(2).



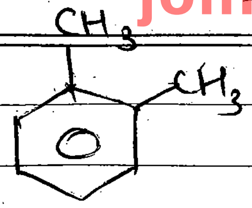


due to repulsion.

μexpected < μexp.

$\theta = 120$ $\theta < 120°$

$\cos\theta \uparrow \mu \uparrow$

(3). 

$\mu_{expected} > \mu_{exp.}$

$\theta = 60°$ $\quad\quad$ $\theta > 60°$

$\cos\theta \downarrow$ $\quad$ $\mu \downarrow$

⇒ Select reason for colour of O_2 in diff states.

distance b/w molecules ↓ transition ↑ intensity ↑

$O_2(g)$	$O_2(l)$	$O_2(s)$
colourless	light blue	blue.

Reason ⇒ HOMO – LUMO transition ✗

or

molecule to molecule transition. ✓

	$O_2(g)$		$S_2(g)$
	Colourless		Blue.
VWf		<	
distance		>	
transition		<	
Intensity		<	

IONIC COMPOUND

Assertion-Reason.

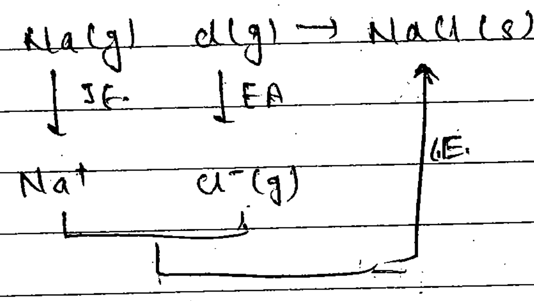
Assertion

1). NaCl is Ionic while, Cl_2 is covalent molecule.

Reason : Ionisation energy of Metals < Non-Metals generally.

(A)//

Condition for Ionic Bond.



Release > Required.

EA + LE > IE.

EA↑ LE↑ IE↓

Non-Metal Metals.

Que Mg O exist as Mg^{+2} O^{-2} due to.

(1). IE_1 of Mg < IE_2 of Mg

(2). EA_1 of O > EA_2 of O

(3). EA_1 of 'O' is exothermic (+ve).

(4). High LE. (4).

Que. Select correct statement.

1, 2, 3, 4.

$$O \xrightarrow[+EA_1]{+e^-} O^- \xrightarrow[-EA_2]{e^-} O^{-2}.$$

exothermic endo,

$$|EA_1| < |EA_2|$$

Que On exposure lithium form oxide (in small amount; peroxide) sodium form peroxide (in small amount, oxide) and potassium, Rubidium & Caesium form super oxide.

$$O_2 \longrightarrow O_2^- \longrightarrow O_2^{-2} \longrightarrow \cancel{O_2^{-4}} \quad 2O^{-2}$$

	O_2	O_2^-	O_2^{-2}		
e^-	16	17 super oxide	18 peroxide	20	oxide
BO	2	1.5	1	0	

Li^+ compensate formation of oxide.
Na^+ compensate formation of oxide.
While K, Rb, Cs compensate formation of super-oxide.

TYPE OF CATIONS

(i). S-BLOCK CATIONS

Alkali metals → +1
Alkaline earth metals → +2

$\left.\begin{matrix} M^{+1} \\ M^{+2} \end{matrix}\right]$ ns^2np^6 noble gas configuration

Que. Identify the anions present in compounds.

KO_2	O_2^-	Superoxide / paramagnetic.
K_2O_2	O_2^{2-}	Peroxide ion
NaN_3	N_3^-	Azide ion
CsI_3	I_3^-	Tri iodide ion
BaO	O^{2-}	oxide

BaO_2	O_2^{2-}		Peroxide.
$Ba(N_3)_2$	N_3^{-1}		Azide ion.
Ba_3N_2	$2N^{3-}$		Nitride ion.
CaC_2	$C_2^{2-} \xrightarrow{H^+} C_2H_2$		acetylide. $:C\equiv C:$
Be_2C.	$C^{4-} \xrightarrow{H^+} CH_4$		Methanoid.
Mg_2C_3	$C_3^{-4} \xrightarrow{+H} C_3H_4$		Propenoid.
Na_2C_2	C_2^{-2}		acetylide
KO_3	O_3^-		ozonide.

(2) <u>P- BLOCK CATIONS</u>

					He.
B	C	N	O	F	Ne.
Al	Si	P	S	Cl	Ar.
Ga	Ge.	As	Se	Br	Kr
In.	Sn	Sb	Te.	I.	Xe.
Tl.	Pb.	Bi			

Non metals.

Metalloids.

Metals.

(ns^2np^1) 13 (ns^2np^2) 14 15. (ns^2np^3).

[Ne] $3s^2 3p^x$ Al. } (+3)

[Ar] $3d^{10} 4s^2 4p^x$. Ga } Ge. } (+4) As } (+5)

[Kr] $4d^{10} 5s^2 5p^x$ In } Sn } Sb. }

[Xe] $4f^{14} 5d^{10} 6s^2 6p^x$. Tl < (+1) Pb. < (+2) Bi < (+3) +5.

Top to bottom

d and f e^- ↑, poor shielding ↑, σ ↓

Z_{eff} ↑ = Z − e ↓ attⁿ ↑.

attⁿ on se^- ↑ pe^- ↑.
near to
the nucleus.

Inertness of se^- pair towards bond formⁿ ↑.
stability of higher o.s ↓
stability of lower o.s ↑.

Que Arrange following in correct order of stability.

⇒ $Tl^{+1} > Tl^{+3}$

⇒ $Pb^{+2} > Pb^{+4}$

⇒ $Sn^{+2} < Sn^{+4}$,

⇒ $Al^{+1} < Al^{+3}$.

⇒ $Bi^{+3} > Bi^{+5}$

⇒ $As^{+3} < As^{+5}$

⇒ $Tl^{+3} > Al^{+1}$

⇒ $Bi^{+3} > As^{+3}$

⇒ $Pb^{+2} > Sn^{+2}$.

⇒ $As^{+5} > Bi^{+5}$.

⇒ $Sn^{+4} > Pb^{+4}$

⇒ $Tl^{+3} < Al^{+3}$

Sn^{+2} act as reducing agent while Tl^{+3}, Pb^{+4}, Bi^{+5} act as oxidising agent.

(3) $\boxed{\text{d- BLOCK CATIONS}}$

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	+2	+2	+2	+2	+2	+2	+2	+1	+2
+3	+3	+3	+3	+3	+3	+3	+3	+2	+3
	+4	+4	+4	+4	+4	+4	+4	+4	
		+5	+5	+5					
			+6	+6	+6				
				+7					

Stability of O.S in aq. medium

$$M^{+x}(aq) \longrightarrow M^{+1+x}(aq)$$

IE + H.E.

⇒ M^{+x} is more stable than M^{+x+1} IE > HE.

⇒ M^{+1+x} is more stable than M^{+x} HE > IE.

⇒ Cr^{+2} is a reducing agent

⇒ Mn^{+3}, Fe^{+3} are oxidising agent.

⇒ $Sc \longrightarrow Sc^{+3}$

⇒ $\boxed{Zn, Cd} \longrightarrow +2$ always

⇒ Cu^{+2} is more stable than Cu^{+1} in aq. medium.

HE > IE.

⇒ left to right $de^- \uparrow$, IE $\uparrow$.
so solubility of $+3 \downarrow$ & $+2 \uparrow$.

⇒ $Cu^+ \rightleftharpoons Cu^{+2} + Cu$.
rxn moves in backward dir^n when Cu^+ form insoluble compound.

⇒ $Hg \longrightarrow \underbrace{Hg(I), Hg(II)}_{\text{diamagnetic}}$.

Hg $5d^{10}\ 6s^2$

$Hg(II) \Rightarrow Hg^{+2}$ $5d^{10}$ diamagnetic.

$Hg(I) \longrightarrow 5d^{10} 6s^1$
~~Hg^{+1} para~~

Hg_2^{2+} $\quad \underbrace{Hg^{+1} — Hg^{+1}}_{\text{dimer.}}$ Diam.

* POLARIZATION

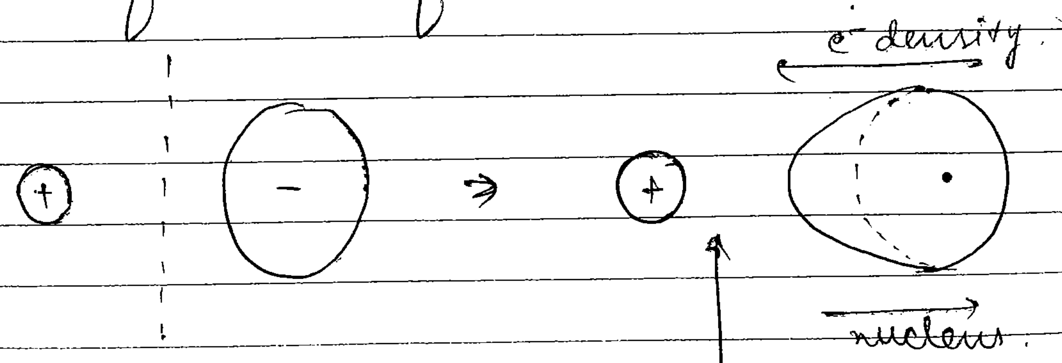
No bond is hundred percent covalent and hundred percent ionic.

Covalent bond contain ionic char. which can be calculated practically in form of dipole moment. But covalent char. in ionic bond can't be calculated practically, they can be compared by phenomena of polarization explained by - "FAJAN'S RULE".

In isolated form $e^{\ominus}$ density is spherically symm. in ions but as opp. charged ions approaches each other to form ionic compound, +ve charge on cation attracts $e^{\ominus}$ cloud of anion and at same time it repels nucleus of anion, so, symm. $e^{\ominus}$ density becomes unsymm. in anion.

Distortion of anion by cation is called "POLARIZATION".

Same distortion is also observed in cation due to repulsion of nucleus of anion.



$e^{\ominus}$density ↑ b/w nucleus of both atoms.

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Power of cation to polarize anion is called ~~POLI~~ "POLARISING POWER".

Ability of anion to polarize towards cation is called "POLARISABILITY."

As polarization increases (polarizing power / polarizability) $e^{\ominus}$ density shifted b/w two nucleus, sharing tendency increases, covalent char. increases, ionic char. decreases.

Factors affecting polarization are explained by "fajan's rule".

$$\left.\begin{aligned} \text{Polarization} &\propto \frac{\text{charge on cation}}{\text{size of cation}} \\ &\propto \text{charge on anion} \\ &\propto \text{size of anion} \end{aligned}\right\}$$

$\boxed{\text{POLARIZING POWER}}$ (ϕ) / Ionic potential $\propto \frac{\text{charge}}{\text{size}}$

for same charge & diff period/ group elements.

(1) <u>s-block.</u>

top to bottom size $\uparrow$, P.P $\downarrow$

② s < d/p (Al^{+3})

ns^2np^6 — $ns^2np^6nd^{10}$ — ns^2np^6

$ns^2np^6nd^{1-9}$ — $(n-1)s^2p^6d^{10}ns^2$

$r\downarrow$ $Z_{eff}\uparrow$ — $(Tl^{+1}, Pb^{+2}, Bi^{+3}, Sn^{+2})$

~~att~~$^n\uparrow$ p.p $\uparrow$.

s d p.

Non metallic nature ↑

covalent ↑

P.P ↑.

③. <u>for d-block</u>

In a period.

(a) p.p.

$d^{1-9} > d^{10}$ (stable)

partially filled — completely

(b). $d^1\ d^2 --- d^9$.

No. of $de^-\uparrow$, $r\downarrow$, $Z_{eff}\uparrow$, P.P ↑.

In a group.

3d 4d 5d.

$de^-\uparrow$ — d & $fe^-\uparrow$

$r\downarrow$ $Z_{eff}\uparrow$ P.P ↑

for d & p block cation

In a period.

d block > p block.

P.P. d^{10} $d^{10} s^2$.

sheilding (d) orbital < s orbital.
Zeff > ,

for diff. group.

Top to bottom $z \uparrow$, d & f $e^- \uparrow$, $r \downarrow$,
Zeff $\uparrow$, pp $\uparrow$

Que. Arrange following in correct order of P.P.

(1). $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

(2). $Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$

(3). $Li^+ < Be^{+2}$ (isoelectronic)

(4). $Na^+ < Mg^{+2} < Al^{+3}$ (isoelectronic)

(5). $Pb^{+2} < Pb^{+4}$ (charge)

(6). $Sn^{+2} < Sn^{+4}$

⇒ $Fe^{+2} < Fe^{+3}$

⇒ $Cu^{+} < Cu^{+2}$

⇒ $Mn^{+2} < Mn^{+4} < Mn^{+7}$

⇒ $Cr^{+2} < Cr^{+3} < Cr^{+6}$

(charge) ↑

⇒ $Tl^{+} < Pb^{+2} < Bi^{+3}$ (Isoelectronic)

⇒ $\underset{d^5}{Mn^{+2}} < \underset{d^6}{Fe^{+2}} < \underset{d^7}{Co^{+2}} < \underset{d^8}{Ni^{+2}} < \underset{d^9}{Cu^{+2}}$ (d e⁻s)

⇒ $\underset{3d}{Cu^{+}} < \underset{4d}{Ag^{+}} < \underset{5d}{Au^{+}}$

⇒ $\underset{d^9}{Cu^{+2}} > \underset{d^{10}}{Zn^{+2}}$

⇒ $\underset{d^6}{Fe^{+2}} > \underset{d^{10}}{Zn^{+2}}$

⇒ $Na^{+} < Cu^{+}$

⇒ $Ca^{+2} < Cd^{+2}$

⇒ $Mg^{+2} < Hg^{+2}$

⇒ $Ba^{+2} < Pb^{+2}$

$s < d/p$

⇒ $Cs^{+1} < Tl^{+1}$

⇒ $\underset{d^{10}}{Cd^{+2}} > \underset{d^{10}s^2}{Sn^{+2}}$

⇒ $Hg^{+2} > Pb^{+2}$

⇒ $Pb^{+2} > Cd^{+2} > Zn^{+2}$.

2) $Li^{+} < Mg^{+2}$. (charge/size)

size of ↓

Li^{+}	Be^{2+}	
Na^{+}	Mg^{2+}	Al^{+3}
K^{+}	Ca^{+2}	
Rb^{+}	Sr^{+2}	
Cs^{+}	Ba^{+2}	

Que Statement 1: BeF_2 is covalent while AlF_3 is ionic.

Statement 2: Polarizing power of $Be^{+2} > Al^{+3}$.

Ans → (A). Covalent char. ↑ Polarization ↑ and viceversa

Que Compare polarizing power of Cu^{+}, Pb^{+2}, Ag^{+}, Hg^{+2}, Hg_2^{2+}, Bi^{+3} on the basis of given data.

CuI → white

PbI_2 → yellow.

~~Pb~~ AgI ~~Hg_2I_2~~ → yellow.

Hg_2I_2 → Green

HgI_2 → Red.

BiI_3 → Black-brown

Bi^{+3} Hg^{2+} Hg_2^{2+} Pb Ag Cu

$PbBr_2$ white $AgBr$ pale yellow.

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4d. Ag^{+} ($Hg^{+2} > Hg_2^{2+}$) Bi^{+3}.
d^{10} on the basis of size

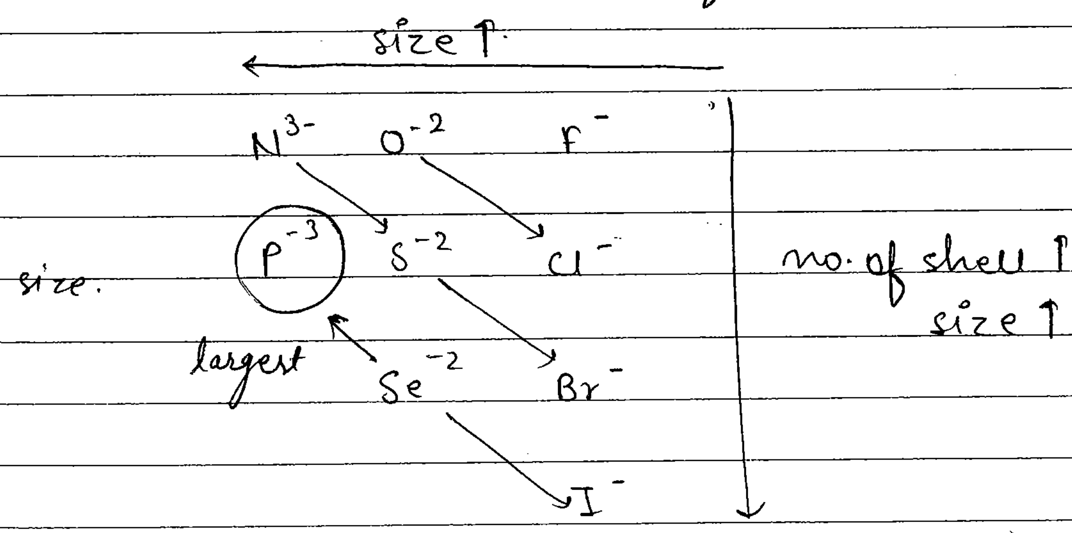
B

P.P. $Bi^{+3} > Hg^{+2} > Hg_2^{2+} > Ag^{+} > Pb^{+2} > Cu^{+}$.

Sometimes, PP / Polarizability is compared on the basis of physical properties (covalent char. and colour).

$\boxed{\text{POLARIZABILITY}}$

Polarizability $\propto$ charge on anion
$\propto$ size of anion.



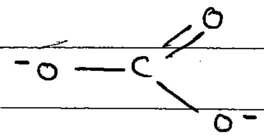
Polarizability $\underbrace{P^{-3} > S^{-2} > O^{-2}}_{\text{charge}} \approx \underbrace{I^{-} > Br^{-} > Cl^{-} > F^{-}}_{\text{size}}$

- all phosphites are black in colour.
- Most of the sulphites are black in colour.
- Generally fluorides and chlorides are ~~b~~ white in colour.

Que compare polarizability of.

(1). O^{-2} CO_3^{2-}

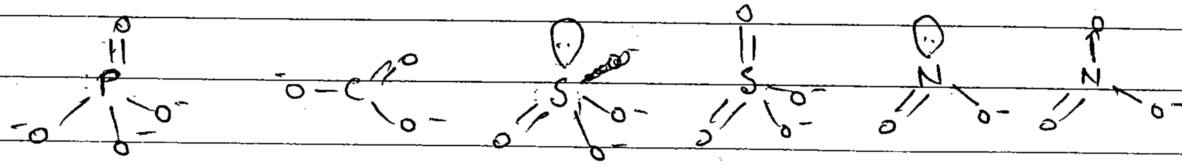
O^{-2} >



due to delocalization polarizability ↓.

Generally polarizability of monoatomic anion > polyatomic anion.

(2) $PO_4^{3-} > CO_3^{2-} > SO_3^{2-} > SO_4^{2-} > NO_2^- / NO_3^-$



Polarizability

$\overset{2.1}{PO_4^{3-}} > \overset{2.5}{CO_3^{2-}} > \overset{2.6}{\overset{+4}{S}O_3^{2-}} > \overset{2.6}{\overset{+6}{S}O_4^{2-}} > \overset{3.0}{\overset{+3}{N}O_2^-} / \overset{+5}{N}O_3^-$

⟶

EN of CA ↑.
e^- holding capacity of CA ↑.
e^- density on O atom ↓.
Polarizability ↓

(3). $AsO_4^{3-} > PO_4^{3-}$

⟵

EN As < P

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APPLICATION OF POLARIZATION

(1). COVALENT CHAR. & IONIC CHAR.

As polarization ↑ covalent char ↑
ionic char. ↓

$\boxed{P.P.}$ ⇒ $Be^{+2} > Al^{+3} > Mg^{+2} > Li^{+} > Na^{+}$.

properties — isoelectronic size & charge — size.

$\boxed{\text{Polarizability}}$ ⇒ $F^- < Cl^- < Br^- < I^-$.
size

covalent ↗ most cov.

BeF_2	$BeCl_2$	$BeBr_2$	BeI_2
AlF_3	$AlCl_3$.	$AlBr_3$	AlI_3.
MgF_2.	$MgCl_2$	$MgBr_2$	MgI_2.
LiF.	LiCl	LiBr.	LiI.
NaF.	NaCl.	NaBr.	NaI.

lattice = ionic
predominant covalent.

ionic

Que. NaCl is ionic then KCl is
(1). ionic ✓ (3). covalent
(2). predominantly covalent (4). None of these.

P.P. $Na^+ > K^+$
ionic char. $NaCl < KCl$

Que which of them is most covalent

(A) $AgCl$ (B) $PbCl_2$
(C). $HgCl_2$ (D) Hg_2Cl_2.

P.P. $Hg^{+2} > Hg_2^{2+} > Ag^+ > Pb^{+2}$

(2). $\boxed{\text{THERMAL STABILITY}}$

→ Stability towards tempr / heat.
→ Compounds having high / greater thermal stability means high tempr ~~do~~ required to decompose them.

$MX(s) \xrightarrow[\Delta]{\text{Melting}} MX(l) \xrightarrow[\Delta]{\text{Boiling}} MX(g)$.

Decomposition

$\xrightarrow{\Delta} M^+ \overset{\infty}{\longleftrightarrow} X^-$ or $M \overset{\infty}{\longleftrightarrow} X$.

Thermally stable. $MX(s) \xrightarrow{\text{Melting}} MX(l)/(g) \xrightarrow{\text{Decomp.}} M \overset{\infty}{\longleftrightarrow} X$
$M^+ \overset{\infty}{\longleftrightarrow} X^-$.

Decomposition after state change.

Thermally unstable. Decomposition before state change.

$$MX(s) \longrightarrow M^+ \xleftrightarrow{\infty} X^-$$
$$M \xleftrightarrow{\infty} X$$

(1). Thermal stability of covalent compounds.

Decomposition. Breaking of covalent bonds.

$\boxed{T.S. \propto B.E.}$

Que Assrange following in correct order of thermal stability.

(1) $O_2 \times O_3$

(2). $F_2 \times O_2 \times N_2$.

(3). $F_2 \times Cl_2 \times Br_2 \times I_2 \Rightarrow Cl_2 > Br_2 > F_2 > I_2$

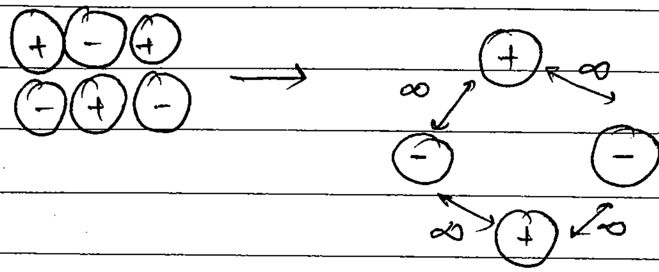
(4). $BF_3 > BCl_3 > BBr_3 > BI_3$

THERMAL STABILITY OF IONIC COMPOUND

(1). Ionic compound containing monoatomic anion.
ex: $O^{-2}, N^{-3}, F^-, Cl^-, Br^-, I^-, S^{-2}, P^{-3}$ etc.

⇒ only ionic bond present

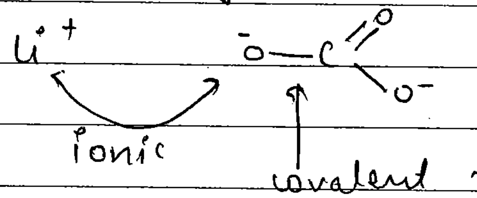
$$MX(s) \xrightarrow{I.E.} M^+ \xleftrightarrow[\infty]{} X^-$$



Breaking of lattice / separation of ions.

(2). Ionic compound containing polyatomic anion

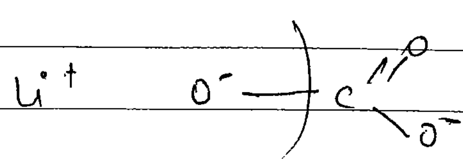
Rxn $\quad Li_2CO_3$

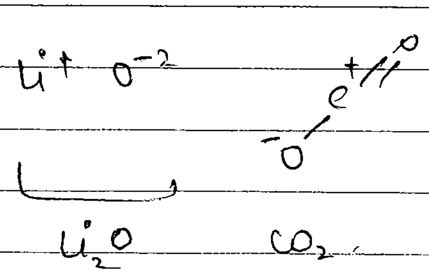


strength ionic bond > covalent bond.
Decomposition = Breaking of covalent bond.

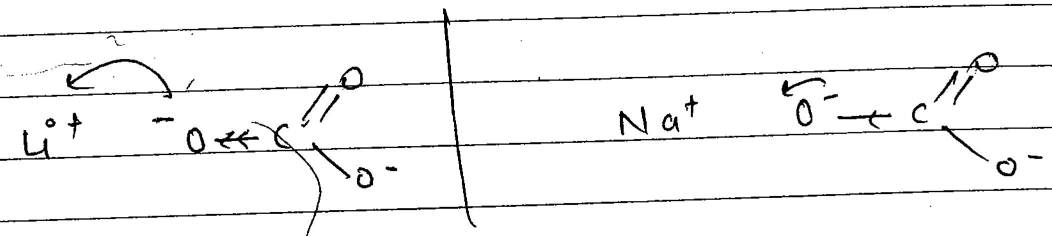
$Li_2CO_3 \xrightarrow{\Delta} Li^+ \quad CO_3^{2-}$ ✗

$\quad\quad \hookrightarrow Li_2O + CO_2$ ✓





Li_2CO_3 | Na_2CO_3



as u/pp. $Li^+ > Na^+$.

shifting of e⁻ density from o atom — $Li_2CO_3 > Na_2CO_3$.

so. ~~stability~~ shifting of e^- from $C \rightarrow O$. — $Li_2CO_3 > Na_2CO_3$.

e^- density in O–C bond — $LiCO_3 < Na_2CO_3$.

O–C B·E. — $Li_2CO_3 < Na_2CO_3$.

T·S. — $Li_2CO_3 < Na_2CO_3$.

$$\boxed{T.S. \propto \frac{1}{\text{polarization / PP}}}$$

Que Arrange following in correct order of Thermal Stability.

(1) $Li_2O > Na_2O > K_2O$. (O^{-2})

(2). $Li_3N > Na_3N$. (N^{3-})

(3). $LiO_2 < NaO_2 < KO_2$ (O_2^{-1})

(4) $LiHCO_3 < NaHCO_3 < KHCO_3$. (HCO_3^-)

(5) $BeCO_3 < MgCO_3 < CaCO_3$ CO_3^{2-}

(6). $AgNO_3$ (4) KNO_3 (1) $Pb(NO_3)_2$ (3) $Zn(NO_3)_2$ (2) NO_3^{-1}

same charge.

PP → $Ag^+ > Pb^{+2} > Zn^{+2} > K^{+1}$

p/d s block

Properties.

COLOUR OF COMPOUNDS

→ Ionic compounds show colour due to polarization.

→ Transition of e^- is called LMCT.

→ ~~As polar~~ LMCT

L → Ligand (anion)

M → Metal (cation)

CT → charge transfer.

→ As polarization increases distance b/w e^- ~~cloud~~ cloud of anion and +ve charge of cation decreases, no. of transition increases, intensity / darkness increases.

~~(1) Colour of ionic compounds containing monoatomic~~

(1) $\boxed{\text{COLOUR OF IONIC COMPOUNDS CONTAINING MONOATOMIC ANION}}$

⇒ s/p block cation / Zn. + Any monoatomic Anion = white / coloured.

PP↓ (s/p block cation), $3d^{10}$ (Zn)

except Pb^{+2} & Bi^{+3}, $As^{+3,+5}$, $Sb^{+3/+5}$, $Sn^{+2/+4}$ (O^{-2}, P^{-3}, S^{-2}, Cl^-, Br^-, I^-, F^-, N^{-3})

PP↑ due to 4f e^-s.

⇒ colour of d-block ionic compounds containing monoatomic anion except Zn.

⇒ All compound of Zn are white in colour.

(a) All phosphides are black in colour.

(b) All sulphides are black in colour except ZnS → white, CdS → yellow

$ZnS \rightarrow$ white
$CdS \rightarrow$ yellow.
$MnS \rightarrow$ pink
As, Sb, Sn $\rightarrow$ coloured.

$\Rightarrow$ All d-block and lead oxides are coloured except Zn.

$\Rightarrow$ All CBI is soluble except aaj kyu honge pagal.

CBI: Cl^-, Br^-, I^-

Ag^+ Cu^+ Hg_2^{+2} Pb^{+2} & HgI_2, BiI_3.

$\Rightarrow$ All chlorides and fluorides are white in colour.

white

$CuCl$	$CuBr$	CuI.	
$PbCl_2$	$PbBr_2$	$PbI_2 \rightarrow$ yellow	
$AgCl$	$AgBr$ Pale yellow.	$AgI \rightarrow$ yellow	
Hg_2Cl_2	Hg_2Br_2 $\downarrow$ yellow.	Hg_2I_2	Green
		HgI_2	Red
		BiI_3	Black-brown.

(2) $\boxed{\text{COLOUR OF POLYATOMIC}}$

⇒ p-block oxy anions

They have no colour / they are colourless in aqueous medium, due to fulfilled configurⁿ ~~no~~ transition is not possible.

s-block / p-block / Zn, Cd + polyatomic anion of 'p' block (oxyanion) = white
ppt ↓

Polarizability ↓
< monoatomic

⇒ d-block

Polarizability $AsO_4^{3-} > PO_4^{3-} > CO_3^{2-} >$ | $SO_4^{2-}, SO_3^{2-}, NO_3^-, NO_2^-, C_2O_4^{2-}, CH_3COO^-, HCOO^-$

+ d block cation (except Zn, Cd). | + d block cation (~~except Zn, Cd~~).

coloured (yellow) | = White.

except Ag_3AsO_4 → Reddish brown.

(3) $\boxed{\text{COLOURED OF HYDROXIDES}}$

⇒ all hydroxides of s-block / p-block / Zn, Cd are white in colour.

⇒ d-block hydroxides are coloured except Zn, Cd.

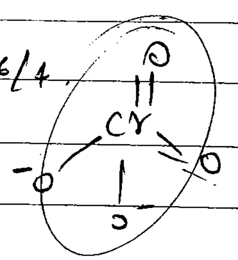
Cu^{+2} Cr^{+2} ⇒ Blue.
Fe^{+2} Ni^{+2} ⇒ green.
Mn^{+2} Co^{+2} ⇒ Pink
Fe^{+3} ⇒ Rusting of iron ⇒ Reddish brown.

$\boxed{\text{d-block oxyanion}}$

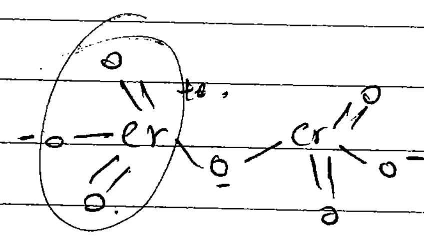
	$\overset{+7}{MnO_4^-}$	$\overset{+6}{CrO_4^{2-}}$	$\overset{+5}{VO_4^{3-}}$
⇒ d^0 (aq)	purple	yellow	colourless.

⇒ $\overset{+6}{CrO_4^{2-}}$ $\overset{+6}{Cr_2O_7^{2-}}$

8026/4.



yellow.



s/p block Zn, Cd.

permanganate.
MnO_4^- ⟶ purple.
CrO_4^{2-} ⟶ yellow.
$Cr_2O_7^{2-}$ ⟶ orange.
MnO_4^{2-} ⟶ green
manganate.

d block + except Zn/Cd.

$\left.\begin{array}{l} MnO_4^- \\ CrO_4^{2-} \\ Cr_2O_7^{2-} \\ MnO_4^{2-} \end{array}\right\}$ Mix colour due to both cation & anion.

s-block, p-block & d^{10} cyanides are white in colour.

d-block cyanides are yellow coloured except d^{10}.

Cr_2O_3, $Cr(OH)_3$, $Cr^{+3}(aq.)$ are green coloured.

Que. Select the compounds which are white in colour.

→ Ag_2SO_4	~~white~~ red	$Ag_2C_2O_4$	white
→ $BaSO_4$	white.	$Zn_2C_2O_4$.	white
→ $PbSO_4$	white.	CH_3COOAg.	white.
→ $SrSO_4$	white.	$(CH_3COO)_2Zn$.	white.
→ $SrSO_3$	white.	$(CH_3COO)_2Hg$.	white.
→ $BaSO_3$	white	CH_3COONa	white.
$CaSO_3$	white.	$HCOOAg$.	white.
Ag_2SO_3.	white.	$(HCOO)_2Zn$	white.
$PbSO_3$.	white.	$HCOONa$.	white.
CdC_2O_4.	white.	Ag_2CO_3	yellow.
PbC_2O_4.	white.	$PbCO_3$	white

$CaCO_3$	white	$ZnSO_4$	white.
$ZnCO_3$	white.	$SnSO_4$	white
$BaCO_3$	white.	$BaCrO_4$	~~white~~ yellow.
$MgCO_3$	white.	$PbCrO_4$	yellow.
$AgNO_2$	white.	Ag_2CrO_4	Red ~~yellow.~~
Ag_3PO_4	yellow.	Hg_2CrO_4	Red ~~yellow.~~
$Ca_3(PO_4)_2$	white.	K_2MnO_4	green. ~~purple.~~
$FePO_4$	yellow. ~~Reddish brown.~~	$CuCl$	white.
As_3PO_4	Red-brown. ~~white.~~	$CuBr$	white
$KMnO_4$	Purple.	CuI	white.
$K_2Cr_2O_7$	orange.	$AgCl$	white.
Na_2CrO_4	Yellow.	$AgBr$	pale yellow
$FeSO_4$	white.	AgI	yellow.
$Fe_2(SO_4)_3$	white. ~~Reddish brown~~	$PbCl_2$	white.
$CrSO_4$	white ~~Blue.~~	$PbBr_2$	white
$Cr_2(SO_4)_3$	white ~~green.~~	PbI_2	yellow

Hg_2Cl_2	white.	$Co(OH)_2$.	Blue ~~White~~.
Hg_2Br_2.	yellow.	$Ni(OH)_2$.	$\boxed{\text{green}}$
$Hg_2\cancel{Cl_2}I_2$	green.	$Al(OH)_2$	white
HgI_2.	red	$Pb(OH)_2$.	white.
BiI_3.	Black-brown	$Mg(OH)_3$	white.
CaF_2	white.	~~$Ca(OH)_2$~~.	—
MgF_2.	white.	~~$Ni(OH)_2$~~.	—
SrF_2.	white	ZnO.	white
$Zn(OH)_2$	white.	Al_2O_3.	white.
$Cd(OH)_2$	white	BeO	white
$Cu(OH)_2$	Blue.	CaO.	white
$Mn(OH)_2$.	Pink.	MgO.	white.
$Cr(OH)_2$	Blue.	BaO.	white.
$Cr(OH)_3$	green.	Ag_2O	black-brown
$Fe(OH)_2$.	green	Hg_2O	black-brown
$Fe(OH)_3$	Reddish brown	*** HgO.	~~coloured~~ yellow

$\overset{+2}{Cu}O$	Black.
$\overset{+1}{Cu_2}O$.	Red
$\overset{+2}{Pb}O$.	Red and Yellow.
$\overset{+8/3}{Pb_3}O_4$. $2PbO \cdot PbO_2$.	Red orange
$\overset{+3}{Pb_2}O_3$. $PbO \cdot PbO_2$.	Reddish brown
$\overset{+4}{Pb}O_2$	Black brown
$CuCN$	white
$AgCN$	white.
$Pb(CN)_2$	white,
$Zn(CN)_2$.	white,
$Fe(CN)_2$.	yellow
$Fe(CN)_3$.	yellow. brown.
$Cr(OH)_3$	green
Cr_2O_3	green.

* SOLUBILITY OF IONIC COMPOUNDS

force of att^n b/w ions

$$f = \frac{Kq_1q_2}{r^2} = \frac{1}{4\pi\varepsilon}\frac{q_1q_2}{r^2}$$

ε_{medium} = ε (dielectric strength)

ε_0 for air = 1

alcohol = 32

water = 81.

⇒ As polarity of solvent ↑.

ε ↑

att^n ~~betw~~ b/w ions & solvent ↑.

att^n b/w ions ↓

solubility ↑

⇒ like dissolves like.

ionic compound are more soluble in polar solvent in comparison of non-polar solvent.

strength ion-dipole > ion-induced dipole.

(polar) (non-polar).

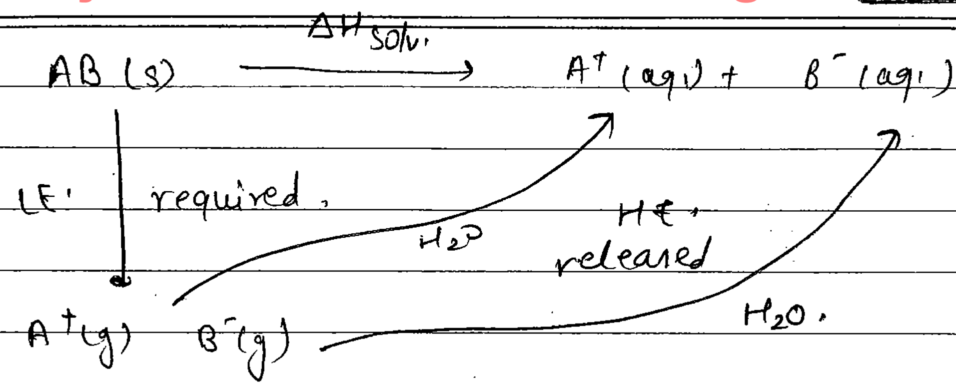
⇒ ionic compound in water -

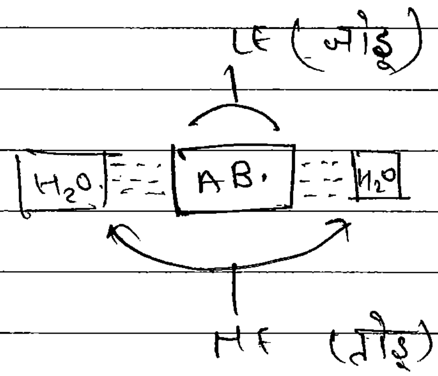
$$AB(s) \xrightarrow{\Delta H_{sol.}} A^+(aq) + B^-(aq).$$

L.E. (required)

H_2O

$A^+(g)\ B^-(g)$





⇒ for any rxn $\boxed{\Delta G = \Delta H - T\Delta S}$

ΔS is +ve for dissolution of ionic compound in water.

$$AB(s) \longrightarrow A^+(aq) + B^+(aq)$$

Entropy increases

→ If $\Delta G \rightarrow +ve$
rxn is non-spontaneous
moves in backward dirn.

→ If $\Delta G \rightarrow -ve$
rxn is spontaneous
moves in forward dirn

If $\Delta G \rightarrow 0$
Equilibrium condition

3 am.

(1) HE > LE.

$\Delta H = -ve$ $\Delta S \rightarrow +ve$,
$\Delta G = -ve$, water soluble.

(2). HE < LE.
$\Delta H \rightarrow +ve$ $\Delta S \rightarrow +ve$.

(A). $\Delta H > T\Delta S$.
$\Delta G = +ve$,
insoluble,
compound is water insoluble but as temp^r ↑ solubility ↑.

Ex→ $PbCl_2$ is insoluble but soluble in hot water.

(B). $\Delta H < T\Delta S$.
$\Delta G = -ve$,
compound is water soluble due to support of entropy.

Ex → NaCl.

$\boxed{\text{SOLUBILITY OF HEAVY METAL HALIDES}}$ (Ag^+, Hg_2^{+2}, Pb

Due to presence of d and f e^-s high polarizing power, their halides are pre-dominantly covalent or covalent.

Their solubility in water is explained by like dissolves like.

As ionic char. ↑ solubility in water ↑

(ionic char. $\propto \dfrac{1}{\text{polarization}}$)

F^- Cl^- Br^- I^- ⟶

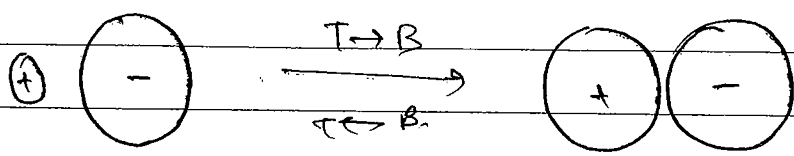
Polarizability ↑ ~~polarization~~ ↑, polarization ↑.
covalent ↑, ionic ↓, solubility ↓.

Ksp / solubility. $AgF > AgCl > AgBr > AgI$.

$PbF_2 > PbCl_2 > PbBr_2 > PbI_2$.

$\boxed{\text{S-block compounds}}$

Anion is bigger in size / large anion.



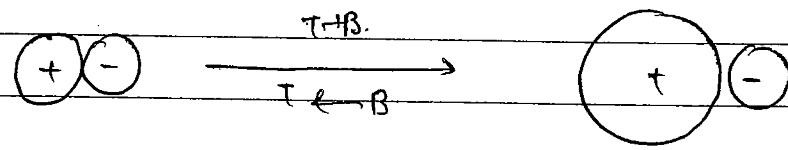
$(r^- >> r^+)$.

Top to bottom
LE almost constant
size of cation ↑, HE ↓.
solubility ↓

$LE \propto \left(\dfrac{1}{r^+ + r^-} \approx \dfrac{1}{r^-}\right)$

$HE \propto \dfrac{1}{r^+} + \dfrac{1}{r^-} \approx \dfrac{1}{r^+}$.

Small anion



Top to bottom
solubility ↑

$r^+ >> r^-$

$H.E \propto \frac{1}{r^+} + \frac{1}{r^-} \approx \frac{1}{r}$ almost constant

$LE \propto \frac{1}{r^+ + r^-} \approx \frac{1}{r^+}$

Bottom to top
size of cation ↓.
LE ↑
Solubility ↓.

Reason for.

(i) Increasing order of solubility from top to bottom.

lattice energy decreases more rapidly in comparison of Hydration Energy.

(ii) for decreasing order of solubility from top to bottom.

~~the~~ HE decreases more rapidly in comparison of ~~la~~ LE.

Order.

(i) Generally anion are larger in size so solubility decreases as we move top to bottom in a group. but in case of

IA F^-, O_2^{2-}, OH^-, CO_3^{2-}, HCO_3^-, SO_4^{2-}, SO_3^{2-}

IIA F^-, O_2^{2-}, OH^-, $C_2O_4^-$

★ (1). $BeF_2 > BaF_2$
$BeC_2O_4 > BaC_2O_4$ } due to High H.E. of Be^{2+}.

(2). $LiCl > NaCl > KCl < RbCl < CsCl$.

⇒ $LiCl > CsCl > RbCl > NaCl > KCl$.
high H.E of Li^+ — low L.E. of Cs^+ — low L.E. of Rb^+ — High of H.E of Na^+

Que Arrange following in correct order of solubility-

IA. F^-
OH^-
$Cr_2O_7^{2-}$
ClO_4^-
HCO_3^-

IIA F^-
$C_2O_4^{2-}$
OH^-
SO_4^{2-}
SO_3^{2-}
CrO_4^{2-}
CO_3^{2-}

S.P.

⇒ $LiF < NaF < KF < RbF < CsF$

⇒ $LiOH < NaOH < KOH < RbOH < CsOH$.

⇒ $Li_2Cr_2O_7 > Na_2Cr_2O_7 > K_2Cr_2O_7 > Rb_2Cr_2O_7 > Cs_2Cr_2O_7$.

⇒ $LiClO_4 > NaClO_4 > KClO_4 > RbClO_4 > CsClO_4$.

⇒ $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$.

II A.

⇒ $BeF_2 \cancel{>} MgF_2 < CaF_2 < SrF_2 < BaF_2 < BeF_2$

⇒ $BeC_2O_4 < MgC_2O_4 < CaC_2O_4 < SrC_2O_4 < BaC_2O_4 < BeC_2O_4$

⇒ $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$.

⇒ $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

⇒ $BeSO_3 > MgSO_3 > CaSO_3 > SrSO_3 > BaSO_3$

⇒ $BeCrO_4 > MgCrO_4 > CaCrO_4 > SrCrO_4 > BaCrO_4$.

⇒ $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$.

Que. Select the compound in each series which is most insoluble / has lowest Ksp.

series ①	$BaCO_3$	$SrCO_3$	$CaCO_3$	$BaCO_3$
series ②	$BaSO_4$	$SrSO_4$	$CaSO_4$	$BaSO_4$
series ③	$BaCrO_4$	$SrCrO_4$	$CaCrO_4$	$BaCrO_4$
series ④	BaC_2O_4	SrC_2O_4	CaC_2O_4.	CaC_2O_4.

Que Which of them is/are correct.

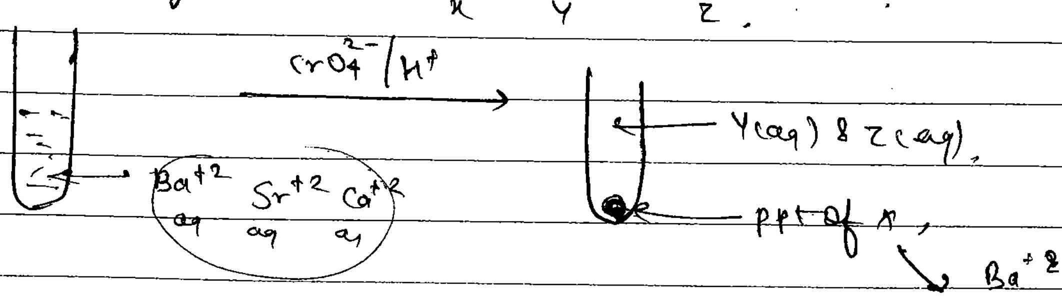
(1). Saturated solⁿ of $Na_2Cr_2O_7 + K^+ \not\longrightarrow$ ppt of $K_2Cr_2O_7$

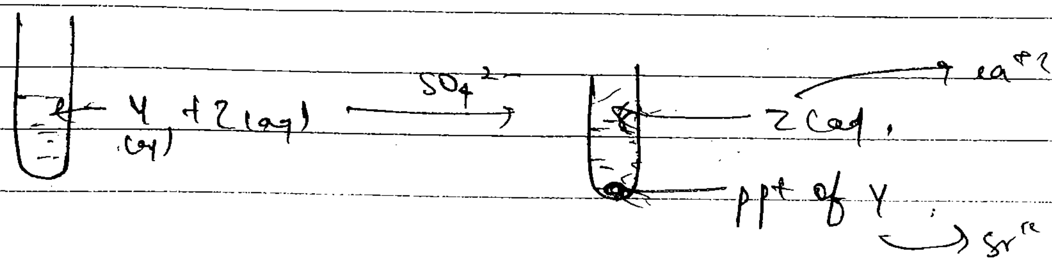
(2). Saturated solⁿ of $K_2Cr_2O_7 + Na^+ \longrightarrow$ ppt of $Na_2Cr_2O_7$.

(3). Saturated solⁿ of $NaHCO_3 + K^+ \longrightarrow$ ppt of $KHCO_3$

(4). Saturated solⁿ of $KHCO_3 + Na^+ \rightarrow$ ppt of $NaHCO_3$

Que. Identify x, y, z Ba^{+2}, Sr^{+2}, Ca^{+2}
x y z.





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~~Rxxx~~

⇒ Jiski ksp/solubility ki value kam hoti h uska ppt pahle aata h.

⇒ X ke saturated solⁿ me Y ka ppt tbhi aayega jab Y ka ksp X se kam hoga.

Que Select the compounds which are yellow in colour.

$\overset{W}{AgCl}$, $\overset{Y}{AgBr}$, $\overset{Y}{AgI}$, $\overset{Y}{Ag_2CO_3}$, $\overset{W}{Ag_2SO_3}$, $\overset{W}{Ag_2SO_4}$

$\overset{W}{CH_3COOAg}$, $\overset{W}{AgNO_2}$, ~~Ag_2SO_4~~, $\overset{\text{Brick red}}{Ag_2CrO_4}$, $\overset{\text{Black brow}}{Ag_2}$

$\overset{Y}{Ag_3PO_4}$, $\overset{\text{Red brown}}{Ag_3AsO_4}$, $\overset{W}{Ag_2C_2O_4}$.

→ Ag_2CO_3, Ag_3PO_4, $AgBr$, AgI.

$\boxed{\text{SOLUBILITY CHART}}$

Insoluble	Exception
SO_3^{2-}, PO_4^{3-}, CO_3^{2-}, $C_2O_4^{2-}$	NH_4^+, IA, FeC_2O_4.
CN^-, S^{2-}	NH_4^+, IA, IIA, $Hg(CN$
O^{-2}/OH^-	NH_4^+, IA, Ba^{+2}, Sr^{+2}, Ca

soluble | Exception

1) F^- — Mg^{+2} Sr^{+2} Ca^{+2}
Full — maje wali sarkar

(2). CH_3COO^- (Acetate) — Ag^+ Cu^+ Hg_2^{+2}
aisa — aaj kyu hogaya?

(3) NO_2^-, HCO_3^- / HSO_3^- / HSO_4^-, NO_3^-, MnO_4^- — $AgNO_2$
Naughty Bai nhi maane — aaj

(4) Cl^-, Br^-, I^- — Ag^+ Cu^+ Hg_2^{2+} Pb^{+2}, HgI_2, BiI_3
CBI wale — aaj kyu hougayepgl.

5). SO_4^{2-} — Sr^{+2} Ba^{+2} Pb^{+2}
Sali ko dekh kr — saare barati pgl.

(6). CrO_4^{2-} (...) — Red: Ag^+ Hg_2^{2+} Sr^{+2} Ba^+ yellow: Pb^{+2}
Crodh me ~~ao~~ — Aaj ho gayi hai saare barati pgl.

(7). $S_2O_3^{2-}$ (Thio sulphate) — Ag^+ Bi^{+3} Cu^+ Hg_2^{2+} ~~Sr^{+2}~~ Ba^{+2} Pb^{+2}
Thi ... — aaj bhi kyu n hounge ~~Sar~~ barati pgl.

Q. Select total no. of compounds which are insoluble

white	white	pale yellow.	yellow.
AgF,	$AgCl$	$AgBr$	AgI.
yellow	white	white.	white.
Ag_2CO_3	Ag_2SO_3	Ag_2SO_4	$Ag_2C_2O_4$.
~~Anti x colours.~~ Brick red	yellow.	white.	white
Ag_2CrO_4	Ag_3PO_4	$Ag_2S_2O_3$	$AgNO_2$.
white.	~~yellow~~ white (dl°)	Black brown.	
$AgNO_3$	$AgCN$	Ag_2O.	

→ $AgCl$, $AgBr$, Ag_2CO_3, $AgSO_3$, Ag_2CrO_4, $Ag_2C_2O_4$, Ag_3PO_4, $Ag_2S_2O_3$, $AgNO_2$, $AgCN$, Ag_2O, AgI.

$\boxed{\text{HEATING EFFECT}}$

(1) $\boxed{\text{OXIDES}}$

*· Noble metal Au and Pt doesn't form oxide while oxides of Ag and Hg are thermally unstable.

Black brown $Ag_2O \xrightarrow{300°} Ag + O_2$ colourless gas. Paramagnetic.

yellow $HgO \xrightarrow{400°} Hg + O_2$

Metallic residue.

Black brown $PbO_2 \xrightarrow{\Delta} PbO + O_2$ Red ~~and~~ yellow

Reddish brown $Pb_2O_3 \xrightarrow{\Delta} PbO + O_2$. Red ~~and~~ yellow
($PbO \cdot PbO_2$)

Red orange $Pb_3O_4 \xrightarrow{\Delta} PbO + O_2$.
($2PbO \cdot PbO_2$) Red or yellow

$\overset{+2}{CuO} \xrightarrow{\Delta} \overset{+1}{Cu_2O} + O_2$.
Black Red

(2) $\boxed{\text{HYDROXIDE}}$ (OH^-) (polyatomic anion)

→ All hydroxides are water insoluble except.
NH_4^+, IA, Ba^{+2}, Sr^{+2}, Ca^{+2}.

→ sblock / pblock / Zn, Cd ⟶ white

Thermal stability $\propto \frac{1}{\text{polarization}}$

Decomposition

Hint Oxide + H_2O ⟶ hydroxide.
hydroxide $\xrightarrow{\Delta}$ oxide,

→ Due to lowest polarizing power hydroxides of Na, K, Rb, Cs are thermally stable

→ Due to highest polarizing power of Be^{+2}, Ag^{+}, Hg^{+2}, their hydroxides are decomposed at room temp.

$$AgOH \xrightarrow{\Delta} \underset{\text{Black brown}}{Ag_2O} \xrightarrow{\Delta} Ag + O_2$$

$$Hg(OH)_2 \xrightarrow{RT} \underset{\text{yellow}}{HgO} \xrightarrow{\Delta} Hg + O_2$$

$$\underset{\text{white}}{Pb(OH)_2} \xrightarrow{\Delta} \underset{\text{Red/yellow}}{PbO} + H_2O$$

$$\underset{\text{white}}{Zn(OH)_2} \xrightarrow{\Delta} \underset{\text{white}}{ZnO} + H_2O$$

$$\underset{\text{reddish }\cancel{\text{green}}\text{ brown}}{Fe(OH)_3} \xrightarrow{\Delta} \underset{\text{Reddish brown}}{Fe_2O_3}$$

$$\underset{\text{green}}{Cr(OH)_3} \xrightarrow{\Delta} \underset{\text{green}}{Cr_2O_3}$$

$$\underset{\text{Blue}}{Cu(OH)_2} \xrightarrow{\Delta} \underset{\text{Black}}{CuO} \xrightarrow{\Delta} \underset{\text{Red}}{Cu_2O} + O_2$$

$$\underset{\text{white}}{Ca(OH)_2} \longrightarrow \underset{\text{white}}{CaO} + H_2O$$

(8). $\boxed{\text{CARBONATE}}$ (CO_3^{2-}) (Polyatomic anion)

Solubility → All r insoluble except NH_4^+, IA

colour → S, P, Zn, Cd → white
other → yellow.
(pure)

ex:- Ag_2CO_3 → yellow.

Melachite $\underbrace{CuCO_3}_{\text{yellow}} \cdot \underbrace{Cu(OH)_2}_{\text{blue}}$ yellow + blue = green

Basic copper carbonate

$Pb(OH)_2 \cdot PbCO_3$
white

Basic lead carbonate

$TS \propto \frac{1}{\text{polarization}}$

Decomposition Hint $H_2CO_3 \longrightarrow H_2O + CO_2$.

$$\text{Metal carbonate} \xrightarrow{\Delta} \text{Metal oxide} + CO_2$$
$$\downarrow \Delta (Ag/Hg)$$
$$\text{Metal} + O_2.$$

yellow. Black brown.

$$AgCO_3 \xrightarrow{\Delta} \text{1) } Ag_2O + CO_2$$
$$\text{2) } Ag + O_2 + CO_2.$$

Red/yellow.

$$PbCO_3 \cdot Pb(OH)_2 \xrightarrow{\Delta} PbO + CO_2 + H_2O.$$

$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} CuO + CO_2 + H_2O$
green. black
$\xrightarrow{\Delta} Cu_2O + O_2$
red.

$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$
white. white.

$CaCO_3 \xrightarrow[>800]{\Delta} CaO + CO_2$
white white.

$Na_2CO_3 \xrightarrow{\Delta}$ ~~NaO~~ X.

$CO_2 \rightarrow$ colourless
odourless
acidic gas
brisk effervescence.

→. Due to lowest polarizing power of Na, K, Rb, Cs, their carbonates r thermally stable.

→. P.P of Na / K / Rb / Cs < Ca^{+2} / Sr^{+2} / B^{+2} < other metal.
Ca, Sr, Ba carbonates are decompose over 800°C.

→. due to high P.P. of Be^{+2}, $BeCO_3$ is unstable, so it is kept in atmosphere of CO_2 to move rxn in backward dirn.

$$BeCO_3 \rightleftharpoons BeO + CO_2$$

→. White lead $PbCO_3 \cdot Pb(OH)_2$ is used to make white paints but it produce black stain due to formatn of PbS, on rxn with atmospheric sulpher / H_2S.

Heating effect of

HCO_3^-, $C_2O_4^{2-}$, $HCOO^-$, CH_3COO^-

Bicarbonate, oxalate, formate, acetate

Hint

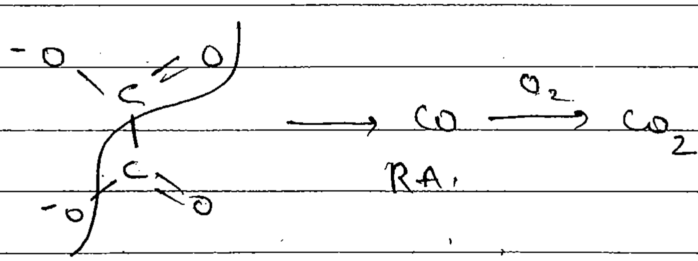
Metal $(HCO_3^- / C_2O_4^{2-} / CH_3COO^- / HCOO^-) \xrightarrow{\Delta}$ Metal carbonate + other product

Metal carbonate $\xrightarrow{\Delta}$ Metal oxide + CO_2 (~~Na, K, Rb, Cs~~)

Metal oxide $\xrightarrow{\Delta}$ Metal + O_2 (Ag / Hg)

Other product : carbonate $(HCO_3^- / C_2O_4^{2-} / CH_3COO^- / HCOO^-)$.

HCO_3^-
HCO_3^- $\longrightarrow H_2CO_3 \longrightarrow H_2O + CO_2$.



$HCOO^-$
$HCOO^-$ $\longrightarrow \underset{\text{RA.}}{HCHO} \xrightarrow{O_2} HCOOH$.

CH_3COO^-
CH_3COO^- $\longrightarrow \underset{\text{Not a RA.}}{CH_3COCH_3}$

⇒ $\underset{\text{white}}{NaHCO_3} \xrightarrow{\Delta} \underset{\text{white}}{Na_2CO_3} + H_2O + CO_2$.

⇒ $CH_3COOAg \xrightarrow{\Delta}$ 1) $Ag_2CO_3 + CH_3COCH_3$.

$\downarrow \Delta$

$Ag_2O + CO_2$.

2). $\underset{OA}{Ag_2O} + CO_2 + \underset{\cancel{RA}}{CH_3COCH_3}$

Black brown

3). $Ag + O_2 + CO_2 + CH_2COCH_3$

⇒ $HCOOAg \longrightarrow$ 1) $Ag_2CO_3 + HCHO$.

$\downarrow$

$\underset{OA}{Ag_2O} + CO_2 + \underset{RA}{HCHO}$

2). $Ag + CO_2 + HCOOH$

⇒ $Ag_2C_2O_4 \xrightarrow{\Delta}$ 1) $Ag_2CO_3 + CO$.

$\downarrow$

$\underset{OA}{Ag_2O} + CO_2 + \underset{RD}{CO}$.

2). $Ag + CO_2$.

⇒ $PbC_2O_4 \xrightarrow{\Delta}$ 1) $PbCO_3 + \underset{RA}{CO}$.

2) $PbO + CO_2 + CO$.

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2). $(CH_3COO)_2Pb \xrightarrow{\Delta}$ 1) $PbCO_3 + CH_3COCH_3$

2) $PbO + CO_2 + CH_3COCH_3$.

2) $(HCOO)_2Pb \xrightarrow{\Delta}$ 1) $PbCO_3 + HCHO$.

2) $\underbrace{PbO}_{\text{not an O.A.}} + CO_2 + \underbrace{HCHO}_{\text{RA}}$.

AMPHOTERIC OXIDE / HYDROXIDE.

Zn Be Al Ga Sn Cr^{+3} Mn^{+4} V^{+5} Sb As Pb

पता है अली गाय सुना करे मन को वो राजी आसमा के प्रभु

Que Matrix Match

Product of decomposition.

1) CaC_2O_4 — (A). white colour oxide

2) HgC_2O_4 — (B). Amphoteric oxide.

3) ZnC_2O_4 — (C). paramagnetic gas

4). $(HCOO)_2Hg$. — (D). Diamagnetic gas.

5). $(CH_3COO)_2Zn$ — (E). Metallic residue.

6). $(CH_3COO)_2Hg$.

1) A D
2) D E
3) A B D
4) D E
5) A B D
6) C D E

$CaC_2O_4 \longrightarrow CaCO_3 + CO$.
$\quad\hookrightarrow CaO + CO_2 + CO$

$HgC_2O_4 \longrightarrow HgCO_3 + CO$
$\quad\hookrightarrow HgO + CO_2 + CO$
$\quad\hookrightarrow Hg + \cancel{CO_2} + CO_2$

$ZnC_2O_4 \longrightarrow ZnCO_3 + CO \longrightarrow ZnO + CO_2 + CO$.

$(HCOO)_2Hg \rightarrow HgCO_3 + HCHO \rightarrow Hg + HCOOH + CO_2$

$(CH_3COO)_2Zn \rightarrow ZnCO_3 + CH_3COCH_3 \rightarrow ZnO + CO_2 + CH_3COCH_3$.

$(CH_3COO)_2Hg \rightarrow HgCO_3 + CH_3COCH_3 \longrightarrow HgO + CO_2 + CH_3COCH_3$

, TS ↑ $NaHCO_3(aq) \xrightarrow{\Delta} NaHCO_3(s) \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

TS ↓ $Ca(HCO_3)_2\,aq \xrightarrow{\Delta} CaCO_3 \xrightarrow{\Delta} CaO + \cancel{H_2O}\ CO_2$

$Na_2C_2O_4 \xrightarrow{\Delta} \cancel{Na_2CO_3 + CO}$

$\xrightarrow[\approx 700^\circ]{\Delta} Na_2CO_3 + CO + \cancel{CO_2} + C$

$CO \underset{}{\overset{\approx 700}{\rightleftharpoons}}$

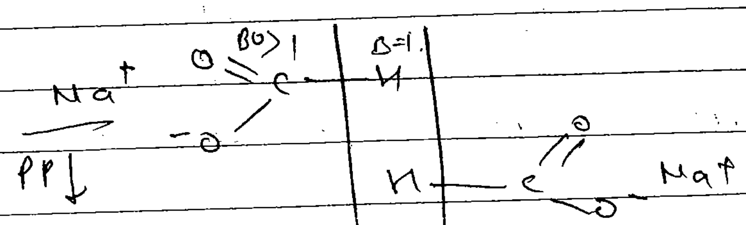
only Na, K, Rb, Cs bicarbonates exist in solid state, other bicarbonates are stable only in aq. medium. ~~Due~~ Due to high polarizing power of other cation their bicarbonates can't be crystallized from their aq. salt solⁿ.

$Na_2C_2O_4 \xrightarrow{\Delta} \cancel{Na_2CO_3 + CO}$

$\xrightarrow[\approx 700^\circ]{\Delta} Na_2CO_3 + CO + CO_2 + C$

$CO \overset{\approx 700}{\rightleftharpoons} CO_2 + C$. C-bed rxn refer to metallurgy

$HCOONa \longrightarrow Na_2C_2O_4 + H_2\uparrow$



Heating effect of phosphate salt

$H_3PO_4 \longrightarrow H_2PO_4^- \longrightarrow HPO_4^{2-} \longrightarrow PO_4^{3-}$

1° phosphate   2°   3°   (degree by charge)

3° phosphate / PO_4^{3-}

solubility   insoluble except NH_4^+ IA.

colour   white   d-block → yellow

Decomposition

Hint: Minimum moles me se water remove kare.

$$NaH_2PO_4 \longrightarrow \underset{\text{Meta}}{NaPO_3} + H_2O$$

$$2Na_2HPO_4 \longrightarrow \underset{\text{Di/pyro}}{\underline{Na_4P_2O_7}} + H_2O$$

$$Na_3PO_4 \longrightarrow \times \quad \text{(no hydrogen)}$$

$$\underset{\text{Microcosmic salt}}{\underline{NaNH_4HPO_4}} \xrightarrow{\Delta} NH_3\uparrow + H_2O\uparrow + NaPO_3$$

$$2MgNH_4PO_4 \xrightarrow{\Delta} H_2O + 2NH_3 + Mg_2P_2O_7$$

Heating effect of Nitrate (NO_3^-)

⇒ all ~~are~~ nitrates are water soluble.

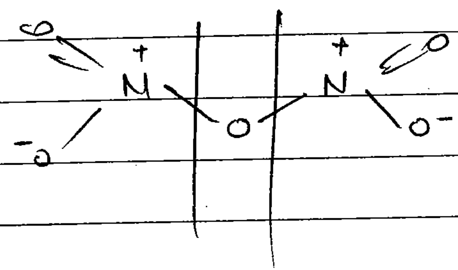
Hint of Decomposition

$$HNO_3 \xrightarrow[30°]{\Delta} H_2O + N_2O_5$$

$$N_2O_5 \xrightarrow[90°]{\Delta} 2NO_2 + \frac{1}{2}O_2$$

NO_2: para, coloured, Reddish brown

O_2: para, colourless



$$\text{Metal nitrate} \xrightarrow{\Delta} \text{metal oxide} + NO_2 + O_2$$

~~(Na, K, Rb, Cs)~~

$$\xrightarrow{\Delta} \text{metal} + O_2$$

(Ag/Hg)

$$AgNO_3 \xrightarrow{\Delta} Ag_2O + NO_2 + O_2$$

$$Ag + O_2 + NO_2$$

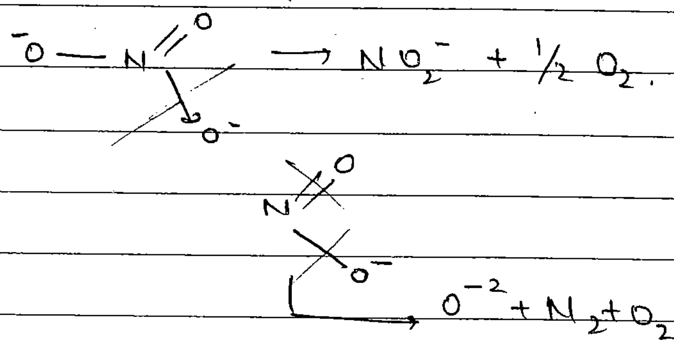
$$Ba(NO_3)_2 \xrightarrow{\Delta} BaO + NO_2 + O_2$$

$$Pb(NO_3)_2 \xrightarrow{\Delta} PbO + NO_2 + O_2$$

$$LiNO_3 \xrightarrow{\Delta} Li_2O + NO_2 + O_2$$

Metal nitrate ⟶ metal nitrite + O_2.
(Na, K, Rb, Cs)
Bad size ke cation
ko bade size ke anion
ke sath acha lagtah.

metal nitrite $\xrightarrow[\text{High temp}^r]{\Delta}$ Metal oxide + N_2 + O_2



Que which of the properties are common for product of decomposition of KNO_3 & $Zn(NO_3)_2$.

(A) Paramagnetic gas
(B). Coloured gas
(C). colourless gas.
(D). white oxide.
(E). can react with HCl
(F). can react with NaOH.

$KNO_3 \xrightarrow{\Delta} KNO_2 + O_2$

$\xrightarrow{\Delta}$ $K_2O + N_2 + O_2$
white Para dia
basic colourless colourless

$Zn(NO_3)_2 \xrightarrow{\Delta} ZnO + NO_2 + O_2$
white Para Para
Ampho RB. colourless

Ans ⟶ (A) (C) (D) (E)

Heating effect of sulphate

solubility

all sulphates are soluble except Sr^{+2}, Ba^{+2}, Pb^{+2}.

colour

anhydrous sulphate $\rightarrow$ white.
hydrated sulphate $\rightarrow$ except Fe^{+3} ($Fe^{+3}(aq) \rightarrow$ yellow) perticular metal hydroxide ke jo colour honge wo hi unke hydrated compound ya aq. medium ke color honge.

Ex. $CuSO_4 \rightarrow$ white
$CuSO_4 \cdot 5H_2O \rightarrow$ Blue vitrol.
$FeSO_4 \rightarrow$ white.
$FeSO_4 \cdot 7H_2O \rightarrow$ green.
$ZnSO_4 \rightarrow$ white
$ZnSO_4 \cdot 7H_2O \rightarrow$ white

TYPE OF HYDRATED SULPHATE

~~Decomposition~~

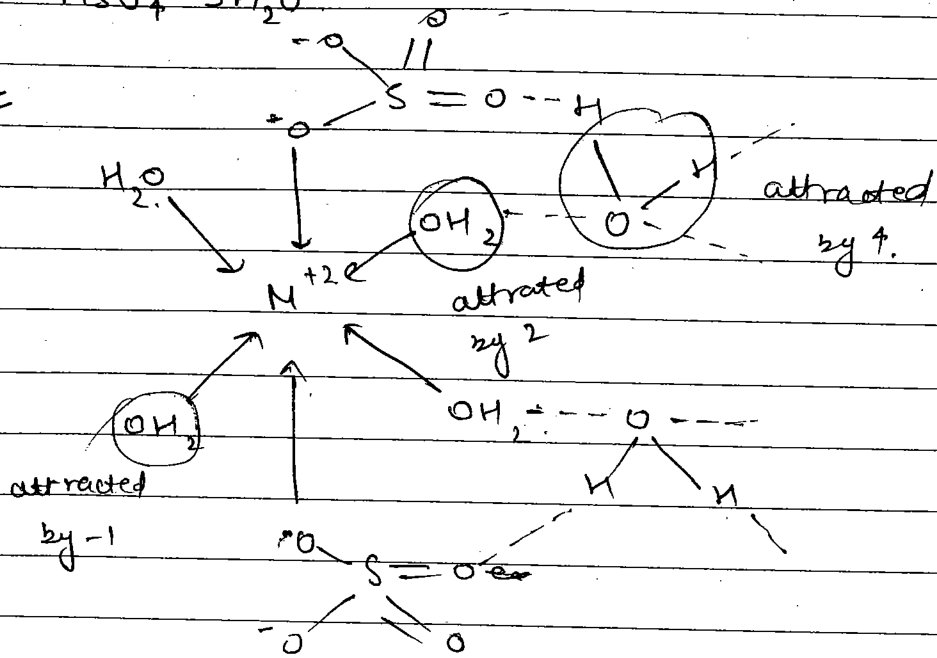
$MSO_4 \cdot 5H_2O \rightarrow [M(H_2O)_4]SO_4 \cdot H_2O$

$\underbrace{(H_2O)_4}_{\text{co-ordinate water}}$ $\underbrace{H_2O}_{\text{H-bonded water}}$

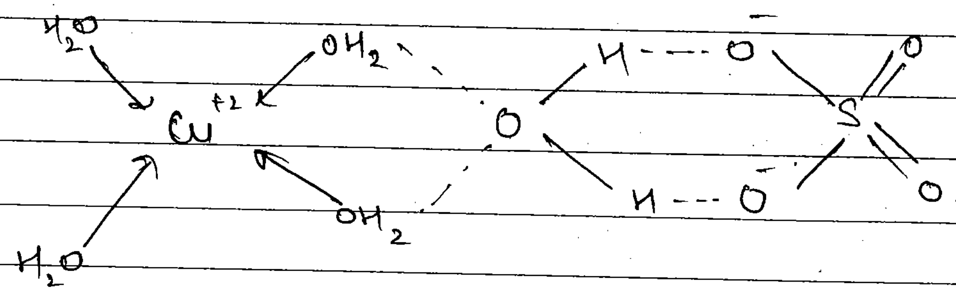
$MSO_4 \cdot 7H_2O \rightarrow [M(H_2O)_6]SO_4 \cdot H_2O$.

$MSO_4 \cdot 5H_2O$

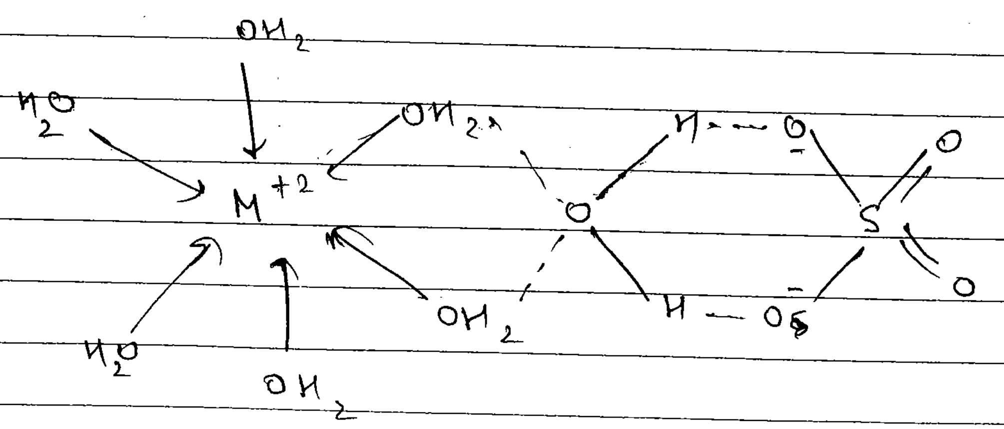
solid



aq. medium



$MSO_4 \cdot 7H_2O$



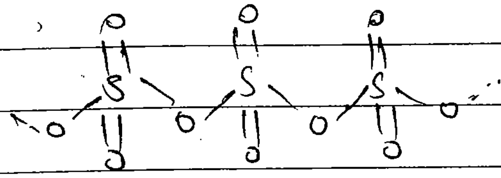
Decomposition

$$H_2SO_4 \xrightarrow{\Delta} H_2O + SO_3 \xrightarrow{800^\circ} SO_2 + O_2.$$

SO_3 OA

α. β γ

chain trimeric. S_3O_9.



$$Cr^{+2} \xrightarrow{OA} Cr^{+3}.$$

$$Fe^{+2} \xrightarrow{OA} Fe^{+3}.$$

$$Sn^{+2} \xrightarrow{OA} Sn^{+4}.$$

stable $Pb^{+2} \cancel{\longrightarrow Pb^{+4}}$. unstabe.

$$\overset{+3}{Fe_2(SO_4)_3} \xrightarrow[<800^\circ]{\Delta} Fe_2O_3 + SO_3.$$

white. Fe_2O_3 (Red Brown).

$$\xrightarrow{>800^\circ} Fe_2O_3 + SO_2 + O_2.$$

$$Fe.SO_4 \cdot 7H_2O \longrightarrow FeSO_4 \xrightarrow{<800^\circ} Fe_2O_3 + SO_2 + SO_3.$$

$$\xrightarrow{>800^\circ} Fe_2O_3 + SO_2 + O_2.$$

$$\left(FeSO_4 \xrightarrow{\Delta} \cancel{FeO} + SO_3\right) \times 2.$$

RA OA

$$2\cancel{FeO} + SO_3 \longrightarrow Fe_2O_3 + SO_2.$$

$$2FeSO_4 \longrightarrow SO_3 + Fe_2O_3 + SO_2.$$

⇒ $\overset{+2}{CrSO_4}$ $\xrightarrow{<800°}$ $\overset{+3}{Cr_2O_3} + SO_3 + SO_2$
(as like $FeSO_4$)

$\xrightarrow{>800°}$ $Cr_2O_3 + SO_2 + O_2$.

$\overset{+3}{Cr_2(SO_4)_3}$ $\xrightarrow{<800}$ $\underset{green}{Cr_2O_3} + SO_3$

$\xrightarrow{>800°}$ $Cr_2O_3 + SO_2 + O_2$

⇒ $\overset{+2}{SnSO_4}$ $\xrightarrow[\text{(any temp)}]{\Delta}$ $\overset{+4}{SnO_2} + SO_2$

(bcoz SO_3 is not present in product)

$\left[\overset{+2}{SnSO_4} \longrightarrow \overset{+2}{\cancel{SnO}} + \cancel{SO_3}\right]$.

$\overset{+2}{\cancel{SnO}} + \cancel{SO_3} \longrightarrow \overset{+4}{SnO_2} + SO_2$.

$SnSO_4 \longrightarrow SnO_2 + SO_2$.

⇒ $CuSO_4\cdot 5H_2O \xrightarrow{\Delta} \underset{blue}{CuSO_4\cdot 3H_2O} \xrightarrow{\Delta} \underset{blue}{CuSO_4\cdot H_2O} \xrightarrow{\Delta} \underset{white}{CuSO_4}$

$\downarrow \Delta$

$\underset{Red}{Cu_2O + SO_2 + O_2} \xleftarrow[1200°]{\Delta} \underset{Black}{CuO + SO_3}$

Hint:- (jo water jitne zyada se attracted h use type ke water utne baad mai niklegae.)

* 'Gypsum'

$$CaSO_4 \cdot 2H_2O \xrightarrow[-H_2O]{100-150^\circ} CaSO_4 \cdot \tfrac{1}{2} H_2O$$

Interstatial water.
(neither - H-bonded nor co-ordinated present in lattice voids).

POP

$$CaSO_4 \cdot \tfrac{1}{2} H_2O \xrightarrow{220^\circ} CaSO_4$$

$\cancel{H_2O}$

$CaSO_4$.
Dead burnt plaster.

Δ

$\cancel{H_2O}$

→ Gypsum is used to increase settling time / recrystallization time of cement so that strength of cement increases by proper locking.

~~NOTE~~

* HEATING EFFECT OF ~~OXIDE~~/ PEROXIDE/, SUPEROXIDE AND OZONIDE.

$$O_2^{2-} \longrightarrow O^{-2} + O_2$$

$$O_2^{-} \longrightarrow O^{-2} + O_2.$$

$$O_3^{-} \longrightarrow O^{-2} + O_2.$$

M^{+x} $^-O - | O^-$

O^{-2} O

KO_2 is used ~~to~~ in submarines/ space crafts as a source of O_2 & as a CO_2 absorber.
(acidic)

$$KO_2 \xrightarrow{\Delta} \underset{\text{basic}}{K_2O} + O_2(g)$$

$$K_2O \xrightarrow{CO_2} K_2CO_3(s).$$

KO_2

Que. Which of them is correct sets of products of decomposition of NaN_3 (sodium azide).

(A). $Na(s) + N_2(g)$.
(B). $Na_3N(s) + N_2(g)$.
(C). $Na(s) + Na_3N(s)$.
(D). $Na(s) + Na_3N(s) + N_2(g)$.

Ans → (A).

$$NaN_3(s) \xrightarrow{\Delta} Na(s) + N_2(g)\uparrow$$

Preparation of pure N_2. (only gaseous product N_2).

HEATING EFFECT OF PERCHLORATE.

⇒ $2HClO_4 \longrightarrow H_2O + Cl_2O_7$ (covalent molecule)

$Cl_2O_7 \longrightarrow Cl_2 + O_2$

$\overset{\delta+}{Cl} - \overset{\delta-}{Cl}$ (Inst. dipole)

$H_2O \longrightarrow OH^-$ H^+

$HOCl$ HCl

Bleaching agent. $HOCl \xrightarrow{\Delta} HCl + O_2$.

⇒ $KClO_4(s) \xrightarrow{\Delta} KCl(s) + O_2(g)$ Pure O_2.

$KClO_4 \longrightarrow K_2O + Cl_2O_7$

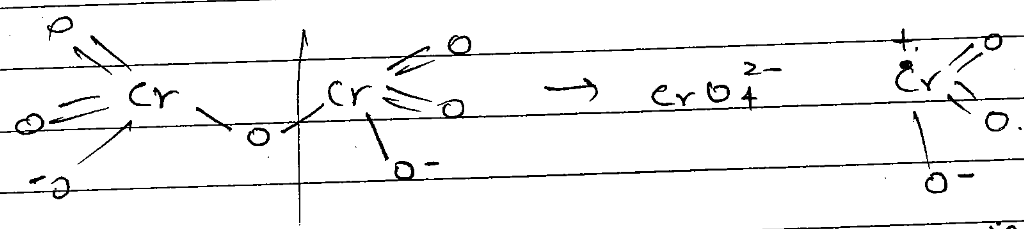
$Cl_2O_7 \longrightarrow Cl_2 + O_2$

Cl^+ Cl^-

KO^- K^+.

POTASSIUM DICROMATE

$$\underset{\text{orange}}{K_2Cr_2O_7} \longrightarrow \underset{\text{yellow}}{K_2CrO_4} + \underset{\text{green}}{Cr_2O_3} + \underset{\text{colourless}}{O_2}.$$



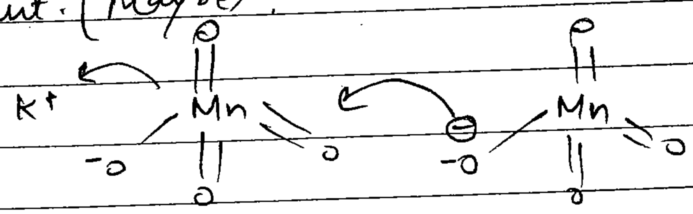
$\rightarrow CrO_4^{2-}$

$\overset{+6}{CrO_3(O_2)} \downarrow \overset{+3}{Cr_2O_3} + O_2.$

POTASSIUM PERMAGNATE.

$$\underset{\text{purple/pink}}{KMnO_4} \longrightarrow \underset{\text{Green}}{K_2MnO_4} + \underset{\text{Black}}{MnO_2} + O_2.$$

Hint. (Maybe).

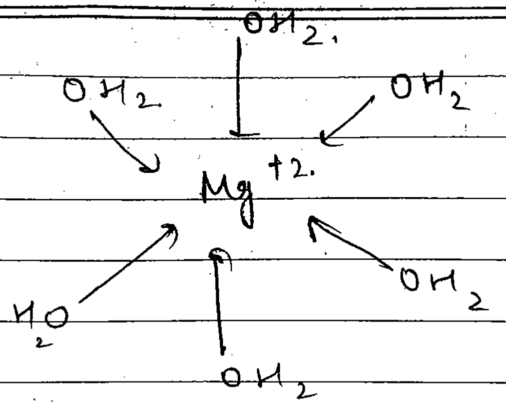


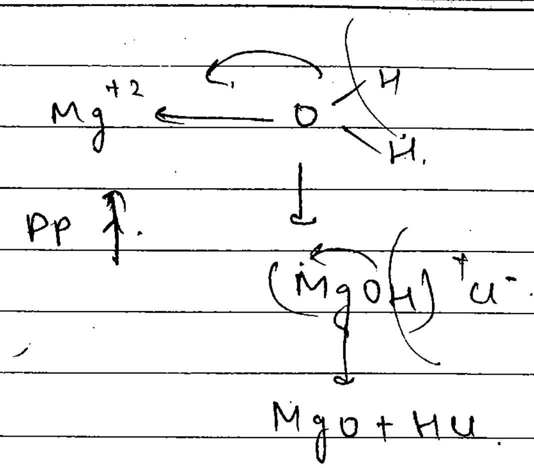
MnO_4^{2-} $\quad \underset{\text{unstable}}{\overset{+8}{MnO_4}} \longrightarrow \overset{+4}{MnO_2} + O_2.$

HEATING EFFECT OF HYDRATED HALIDE.

ex. $MgCl_2 \cdot 6H_2O \longrightarrow MgO + 2HCl + 5H_2O.$

$[Mg(H_2O)_6]Cl_2$





$FeCl_3 \cdot 6H_2O \rightarrow Fe_2O_3 + HCl + H_2O$

$ZnCl_2 \cdot 6H_2O \rightarrow ZnO + HCl + H_2O$

$MgCl_2\,(aq) \rightarrow \underset{(s)}{MgCl_2 \cdot 6H_2O} \rightarrow MgO + HCl + H_2O$

$NaCl\,(aq) \rightarrow NaCl\,(s) + H_2O \uparrow$

pp ↓ water affinity ↓

can't attract water molecules.

→ Na, K, Rb, Cs halides are obtained in anhydrous form by heating of their aq. salt solution. but due to high polarizing power other halides can't be crystallized in anhydrous form by heating of their aq salt solution, on heating they crystallize in hydrated form.

To obtain anhydrous halide of other cations dry hydrogen halide is used.

$MgCl_2 \cdot 6H_2O \xrightarrow{\Delta} MgO + HCl + H_2O$

$ \xrightarrow{\Delta} MgCl_2 + 6H_2O$

→ As P.P ↑ water affinity ↑

Ex.

1). from S-block

Pure NaCl is not deliquecent but impure NaCl is, b.coz impure NaCl contain impurity of $CaCl_2$ and $MgCl_2$

$\boxed{\text{PP of } Na^+ < Ca^{+2}, Mg^{+2}}$

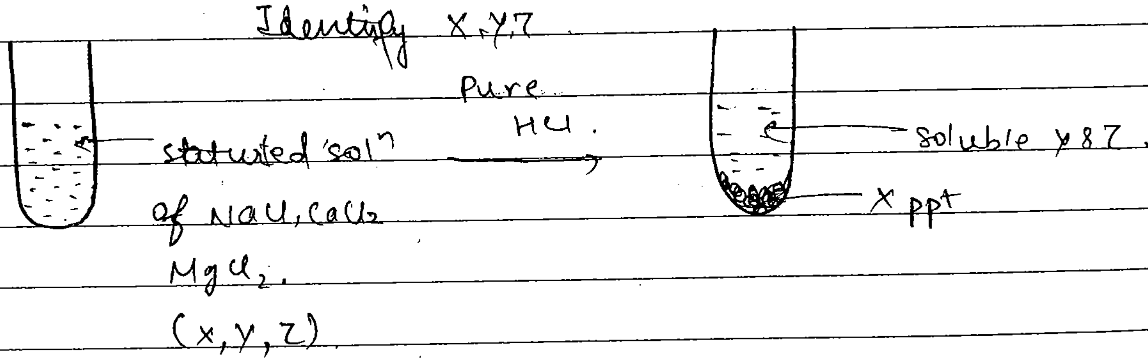
2). from d-block

$Na_2Cr_2O_7$

Sodium dicromate is not used as primary standard in titrations, $K_2Cr_2O_7$ is used because $Na_2Cr_2O_7$ is hygroscopic in nature while $K_2Cr_2O_7$ is not.

$\boxed{\text{PP of } Na^+ > K^+}$

Que Identify X, Y, Z.



Ksp NaCl < $CaCl_2$ / $MgCl_2$
↓
slightly soluble due to support of entropy.

TYPE OF OXIDE

→ **NATURE OF OXIDE**

$$Cl_2O + H_2O \longrightarrow ClOH$$
$$Na_2O + H_2O \longrightarrow NaOH$$

2.9	3.5	2.1		0.9	3.5	2.1
Cl	O	H		Na	O	H

Δ EN: 0.6, 1.4 | 2.6, 1.4

↓ H^+ acid | ↓ OH^- Base

As EN ↑, acidic nature ↑, Basic nature ↓.
+ve charge
(for same atom)

+1 < +3 < +5 < +7
EN↑

In periodic table

EN ↑ acidic nature ↑

EN ↓
acidic nature ↓
basic ↑.

Que. Arrange following in correct order of acidic nature.

⇒ $CO < CO_2$

⇒ $CO_2 > SiO_2$

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⇒ $B_2O_3 < CO_2 < N_2O_5$

⇒. $N_2O_5 > P_2O_5$.

⇒. $N_2O_3 > P_2O_3$.

⇒ $SO_2 < SO_3$

⇒. $\overset{+1}{N_2O} < \overset{+2}{NO} < \overset{+3}{N_2O_3} < \overset{+4}{NO_2} < N_2O_5$.

⇒ $Cl_2O > Br_2O > I_2O$.

⇒. $Na_2O < MgO < Al_2O_3 < SiO_2 < P_4O_{10} < SO_3 < Cl_2O_7$,

⇒, $Cl_2O < \overset{4}{ClO_2} < \overset{8}{Cl_2O_6} < \overset{7}{Cl_2O_7}$.

⇒ $CaO < ZnO < SO_3$.

⇒ $FeO < Fe_2O_3$

⇒ $SnO < SnO_2$

⇒. $PbO < PbO_2$

⇒. $Na_2O < H_2O < Cl_2O$.

⇒. $MnO < MnO_2 < Mn_2O_7$.

⇒. $CrO < Cr_2O_3 < CrO_3$.

Type of oxide -

(1). Neutral
(2) d block Amphoteric
(3) Acidic
(4). Basic.

(1) NEUTRAL OXIDE

Neither acidic nor basic.
CO, NO, N_2O ($H_2O \rightarrow$ Amphoteric H^+/OH^-)

(2). AMPHOTERIC

Acidic as well as basic.
Zn, Be Al Ga Sn Cr^{+3} Mn^{+4} V^{+5} Sb As Pb.

d-block oxides

+1, +2, +3 Basic (excep^n ZnO, Cr_2O_3)

+4 Amphoteric

+5, +6, +7. Acidic. (excep^n V_2O_5)

(3). ACIDIC

(a). All non-metallic oxides except CO, NO, N_2O.

(3). Metallic oxides in their +5, +6, +7 oxidaⁿ state.

(4) BASIC

All metallic oxides having +1, +2, +3 Oxidaⁿ state except amphoteric

Que. Select correct statements -

(1) All non metallic oxides are acidic oxides
(2). All acidic oxides are non-metallic oxides.
(3). All neutral oxides are non-metallic oxides.
(4). All. basic oxides are metallic oxides.
(5). All metallic oxides are basic oxides.

(3) (4)

Que find total no. of oxides which can react with NaOH.

PbO, SnO_2, SO_3, CO_2, Fe_2O_3, CaO, Basic.
ZnO, Al_2O_3, Cr_2O_3, Cl_2O_7, CrO_3, MnO.

★ H_2O is amphoteric (NCERT).
bcoz it gives H^+ as well as OH^-
Due to $PH = 0$, H_2O acts as neutral oxide.

DIAGONAL RELATIONSHIP

Due to almost same size of Li^+ and Mg^{+2} and due to almost same P.P. (charge/size ratio) of Be^{2+} and Al^{+3} their properties are similar and ~~their~~ they present diagonal positions in periodic table they show diagonal relationship.

ANAMOLOUS BEHAVIOUR

Due to abnormally small size of Li^+ and Be^{+2} in their group they show diff. properties from other elements of their group.

APPLICATION OF INERT PAIR EFFECT

(1). Tl^{+3}, Pb^{++}, Bi^{+5} act as strong oxidizing agent.
(2). Among oxides of Pb, Pb_3O_4, Pb_2O_3 and PbO_2 act as strong O.A.
(3). In particular group (13, 14, 15) stability of lower halide increases while stability of higher halide decrease as we move top to bottom.

T.S. $GeX_2 < SnX_2 < PbX_2$

$GeX_4 > SnX_4 > PbX_4$

(4). ~~T.S. of~~ — PbX_4

(4) T.S of PbX_4.

$$\underline{PbF_4} \xrightarrow{\text{High temp}^n\ \Delta} \overset{+2}{PbF_2} + F_2$$

not a RA

$$\underline{PbCl_4} \xrightarrow{>50^\circ} PbCl_2 + Cl_2.$$

weak RA.

$$\underline{PbBr_2} \xrightarrow{PT<<50^\circ} PbBr_2 + Br_2$$

mild RA.

$$\underline{Pb}\ \underline{I_4} \xrightarrow{RT} PbI_2 + I_2.$$

SOA SRA.

O nature of halogen / Reducing nature of halide.

$$\tfrac{1}{2}X_2 \longrightarrow X^- (aq).$$

(required). $\downarrow$ $\frac{BDE}{2}$. HE $\uparrow$ $F^- > Cl^-$ (release)

$F_2 < Cl_2$.

$$X(g) \xrightarrow{EA} X^-$$

(release)

$Cl > F$.

BDE $Cl_2 > Br_2 > F_2 > I_2$.

EA $Cl > F > Br > I$.

HE. $F^- > Cl^- > Br^- > I^-$.

O. nature $\underline{F_2} > Cl_2 > Br_2 > I_2$.

Due to high HE of F^- & low BDE of F_2.

(NCERT).

R. nature. $I^- > Br^- > Cl^- > F^-$

Que which of them can't exist together in aq. medium.

(A). Pb^{+4} & I^- (SOA, SRA)

(B). Tl^{+3} & I^-

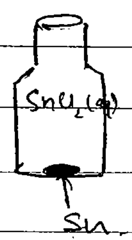
(C). Bi^{+5} & I^-

(D). $SnCl_2$ & O_2 (RA, OA)

(A)(B)(C)(D).

→ $SnCl_2$ act as reducing agent.

(i) A piece of tin is kept in a glass bottle of $SnCl_2(aq)$ to prevent aerial oxidan of $SnCl_2$.



$$SnCl_2 \xrightarrow{O_2} Sn^{+4}$$
$$Sn^{+4} \xrightarrow{Sn} Sn^{+2}$$

(ii) when it react with OA. It is converted into +4.

Sn^{+2} → Sn^{+4}

Purple/pink. $KMnO_4/H^+$	→ Mn^{+2}	light pink / colourless
orange $K_2Cr_2O_7/H^+$	→ $Cr^{+3}(aq)$	green.
yellow. Fe^{+3}	→ $Fe^{+2}_{(aq)}$	green.
$HgCl_2$	→ Hg_2Cl_2.	white ppt.
Hg_2Cl_2	→ Hg	black.
$AuCl_3$	→ Au.	purple of cassius.

purple of cassius
↓
used in photographic toning

PSEUDO HALIDES & PSEUDO HALOGENS

Nitrogen containing mononegative ions are called "Pseudo Halides"

Their properties almost similar to Halides.

ex. CN^-, SCN^-, OCN^-, N_3^-

	Cl^-	CN^-
lewis base	✓	✓
Acid	HCl	HCN
Salt	$NaCl$	$NaCN$
Molecular form	Cl_2	$(CN)_2$.

$$Pb^{+4} \xrightarrow{I^-} PbI_2 + I_2$$
$$Pb^{+4} \xrightarrow{CN^-} Pb(CN)_2 + (CN)_2$$
$$Pb^{+4} \xrightarrow{SCN^-} Pb(SCN)_2 + (SCN)_2.$$

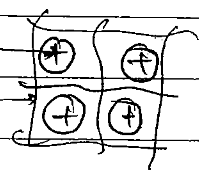
$$Cu^{+1} \rightleftharpoons Cu^{+2}$$

$$Cu^{+2} \xrightarrow{I^-} CuI + I_2.$$
$$Cu^{+2} \xrightarrow{CN^-} CuCN + (CN)_2$$
$$Cu^{+2} \xrightarrow{SCN^-} CuSCN + (SCN)_2$$

TYPE OF SOLID

Type of solid

- Non-metal – Nonmetal
  - Infinite: covalent network solid
  - finite: Molecular solid
- Metal–Metal: Metallic solid
  - Kernel
  - thin film of free e^-



  - $MP \propto \frac{1}{\text{size}} \propto \text{packing}$
- Non metal – metal
  - ionic: $MP \propto LE$, $\propto$ Packing
  - predominant covalent/covalent: $MP \propto \frac{1}{BL} \propto BE$, $\propto$ ionic char.

Network (all bonds are covalent): Dimond, SiO_2, SiC, Black phosphorous.

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

finite: H_2, O_2, CO_2, C_6H_6 etc ----

$MP \propto$ VWF/H bond (depend on physical state)

Isomers: MP ⇒ $O < P$. (packing)(symmetry).
⇒ cis < trans.

Que. ~~Arrange following in correct order of MP.~~

~~(1) SiO_2~~

Strength of Bond

Ionic > covalent > Metallic > H-bond > VWf.

order of MP

covalent network > Ionic ≈ metallic > predominantly covalent/cov. > Molecular solid.

ex. $\underbrace{SiO_2}_{\text{network}}$. $\underbrace{KBr \quad NaCl \quad LiF}_{\text{Ionic}}$: $\underbrace{F_2 \quad Cl_2 \quad Br_2}_{\text{molecular}}$

$SiO_2 > LiF > NaCl > KBr > Br_2 > Cl_2 > F_2$.

Que. Arrange following in correct order of MP.

(1) $\underbrace{SiC}_{\text{network}}$ $\underbrace{NaCl}_{\text{ionic}}$ $\underbrace{H_2O \quad H_2}_{\text{molec.}}$

(2). Dimond (network). $AgCl$ (predom. coval.) $\underbrace{I_2 \quad HF \quad CO_2}_{\text{molec.}}$

(3). Dimond SiC

(4). AlF_3 $AlCl_3$ $AlBr_3$ AlI_3.

(5). BeF_2 $BeCl_2$ $BeBr_2$ BeI_2

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(6). NaF , NaCl, NaBr NaI.

(7). BF_3 BCl_3 BBr_3 BI_3.

(8). LiCl NaCl KCl RbCl CsCl.

(1) SiC > NaCl > H_2O > H_2

(2). Dimond > AgCl > I_2 > HF H_2
solid liq. gas.

(3). Dimond > SiC.
C–C Si–C.

(4). AlF_3 < $AlCl_3$ < $AlBr_3$ < AlI_3
dimer.
ionic predom cov. molecular.
Polym

AlF_3 > $AlCl_3$ > AlI_3 > $AlBr_3$

(5). BeF_2 > $BeCl_2$ > $BeBr_2$ > BeI_2
polymeric. chain.
SD

(6). NaF > NaCl > NaBr > NaI.
Ionic
MP ∝ LE.

(7). BF_3 < BCl_3 < BBr_3 < BI_3

molecular solid MP ∝ vwf.

(8). LiCl NaCl KCl RbCl CsCl.
Predomi. cov. ionic MP ∝ LE.

NaCl > KCl > RbCl > CsCl > LiCl.

(1), Pesticular metal halide.

$F^- > Cl^- > Br^- > I^-$ (exception Al).

2). LiX NaX KX RbX CsX.

Predom. cov. — Ionic. X = Cl, Br, I

NaX > KX > RbX > CsX > LiX.

Exception.

(1). First element middle position.

(A) Alkali F^- — NaF > KF > LiF > RbF > CsF.

(B) Alkaline O^{2-} — MgO > CaO > BeO > SrO > BaO.

(2). Reverse order

Alkaline — $Cl^-/Br^-/I^-$

$BeX_2 < MgX_2 < CaX_2 < SrX_2 < BaX_2$

③. BeF_2 MgF_2 CaF_2 SrF_2 BaF_2

covalent — ionic.

$CaF_2 > MgF_2 > SrF_2 > BaF_2 > BeF_2$

ALLOTROPES

Same type of elements having same physical state but diff. bonding patterns are called "ALLOTROPES".

C → Graphite, Dimond, fullerens

Graphite $\xrightarrow[\text{high pr.}]{\Delta}$ Dimond

Graphite $\xrightarrow[\text{low pr.}]{\Delta}$ fullerens

P → white, Red, Black.

white $\xrightarrow{\Delta}$ Red $\xrightarrow{\Delta}$ α β

white $\xrightarrow{\Delta}$ β

S → α, β

$\alpha \underset{369K}{\overset{\Delta}{\rightleftharpoons}} \beta$

O → O_2, O_3

$O_2 \overset{\Delta}{\rightleftharpoons} O_3$

Sn → grey, white

grey $\overset{18^\circ}{\rightleftharpoons}$ white

amorphous crystalline.

→ ALLOTROPES OF C

Graphite	Dimond
(1) hyb. C → sp^2	C → sp^3
(2) π-bond present	π-bond absent
(3) in the layer → covalent. b/w the layers → VWF	All bonds are cov.
4) layer structure	3-D network.
5) Soft and slippery	Hard
6) electrical conductivity due to presence of π e⁻s.	

(7). Thermal conductivity $<$

(8) Kinetic stability $\left(\propto \frac{1}{\text{reactivity}}\right)$ $<$

(9). Thermodynamic stability $>$

(10) ~~Gra~~ $\Delta H_f = 0$ $\Delta H_f = +ve$

(11) MP. $<$

(12) density $<$

(13) C–C Bond length $<$
$(sp^2 - sp^2)$ $(sp^3 - sp^3)$

Fullerens (C_n)

→ Molecular solid

→ Purest form of carbon due to closed packed structure.

→ due to closed packed structure dangling bonds absent.

C_n $n = 20$ to 350.

In all C_n contains.

$12 \Rightarrow$ 5 members 'C' ring.

$\frac{n}{2} - 10 \Rightarrow$ six member 'C' rings.

2) All 'C' atom r sp^2 hybridized.

2) due to π bond in six member ring, it is aromatic

2). two type of 'C–C' bond length present.
(two type of rings.
diff BD)

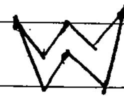
Allotrops of S

Rhombic $\xrightleftharpoons{369K}$ Monoclinic
(α-sulphur) (β-sulphur)

MP $\Rightarrow \alpha < \beta$
Density $\alpha > \beta$

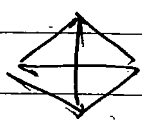
20th

→ r insoluble in H_2O
→ r soluble in CS_2
→ contain S_8 rings.

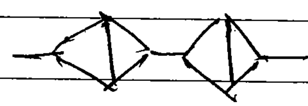


Allotrops of P

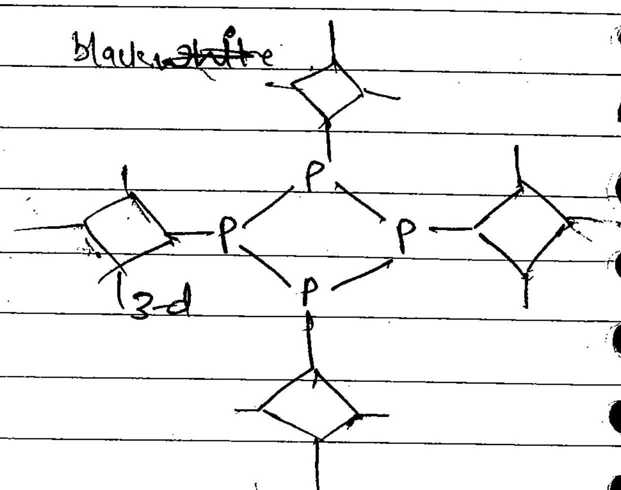
White Red Black



Molecule.



chain



MP. B > R > W
Reactivity. W > R > B.
Density. B > R > W.

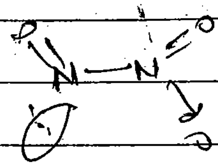
~~Que.~~ ~~Find no. of lone pair in~~ $\cancel{N_2O_3}$

Red	White
→ Non poisonous	Poisonous
→ Insoluble in water	Insoluble in water.
→ Insoluble in CS_2	Soluble in CS_2.
→ Doesn't glow in dark.	Glow in dark.

Tues. → Ionic bond
ex I, II, IV

Que. Find no. of lone pairs in N_2O_3

(8).



Que. find no. of species which are linear but does not use 'd' orbital in Hyb.

$BeCl_2$, NO_2^+, NO_2, O_3, CO_2, XeF_2, SCl_2, ICl_2^-

Cl–Be–Cl

Que. Select correct statement(s) for

(I) HClO (II) $HClO_2$ (III) $HClO_3$ (IV) $HClO_4$ → max oxygen

H–O–Cl: O=Cl–OH O=Cl(=O)–OH O=Cl(=O)(=O)–OH

(A). two Cl=O in I & II together.

(B). three lp on Cl atom in II & III together.

(C). Among all (I) is most acidic.

(D). Cl in (IV) is sp^3 hyb.

Que. Select correct statement(s) for Cr^{+2} & Mn^{+3}.

(A). Both are d^4.

(B). Cr^{+2} is a reducing agent

(C). Mn^{+3} is an oxidising agent.

(D). $\underset{d^3}{Cr^{+3}}$ & $\underset{d^5}{Mn^{+2}}$ both are d^5.