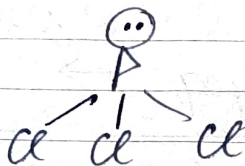
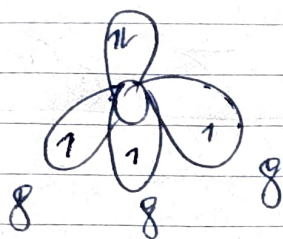
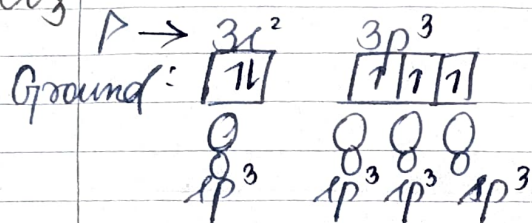
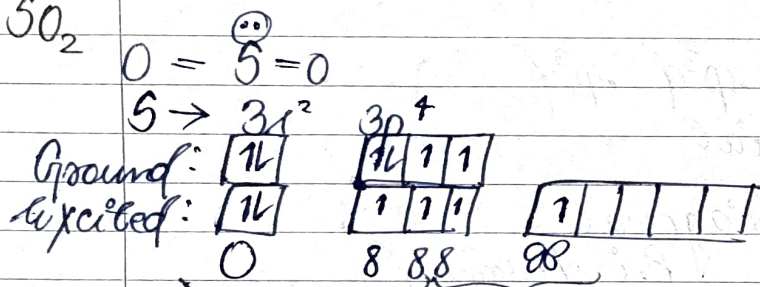


(e) PCl_3

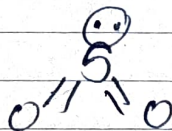
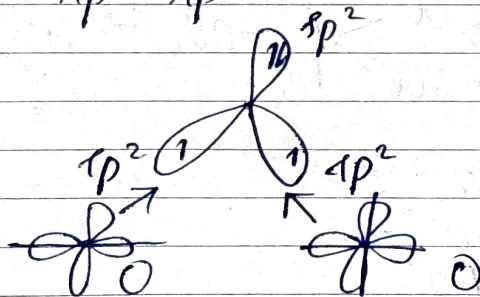
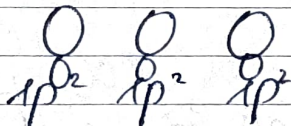


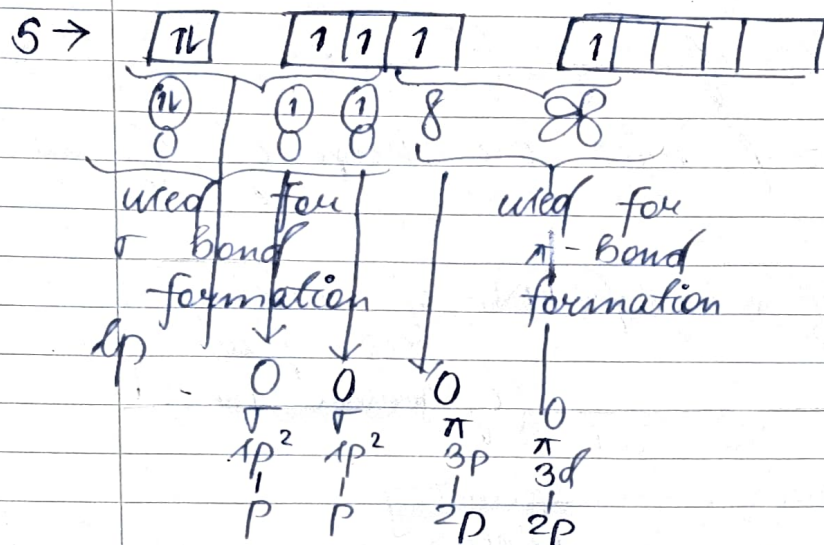
05/11/25

(f) SO_2

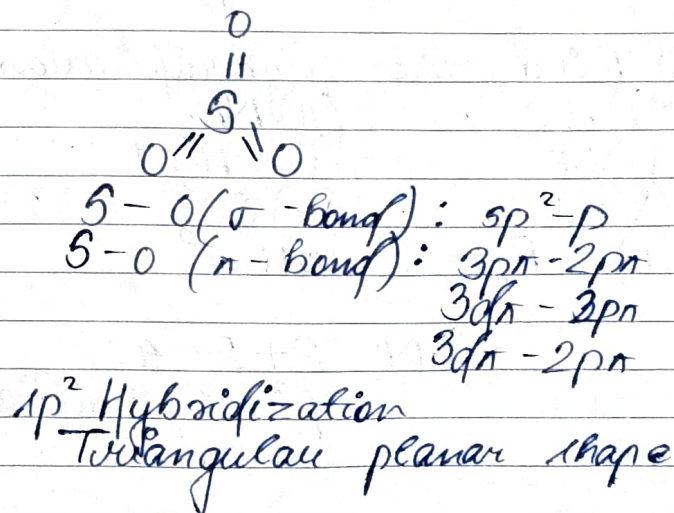
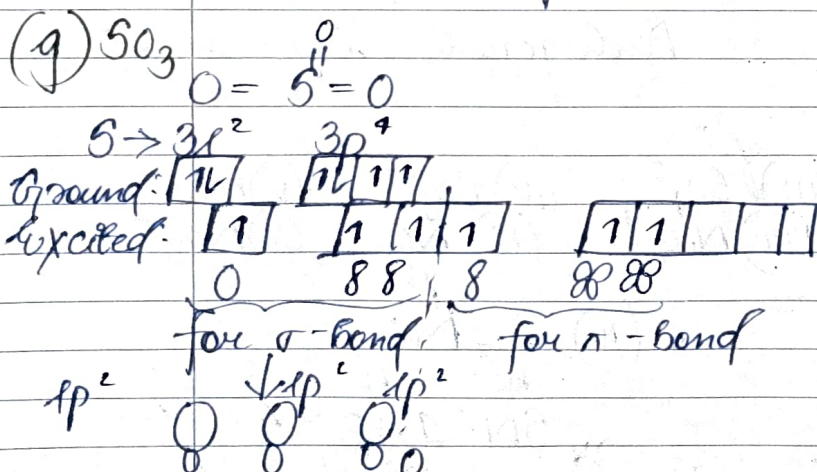


Intermix $\downarrow$ will be utilized for π -bond formation





- S has sp^2 hybridisation.
- lp of S is present in sp^2 hybrid orbital
- $p\pi - p\pi = 1$
- $p\pi - d\pi = 1$
- Angular shape
- Lateral overlapping (π -bond) will take place by overlapping of pure atomic orbitals.
- d-orbital maybe d_{xy} , d_{yz} , d_{zx} .



Short-cuts for Analysis of hybridisation:-

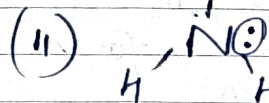
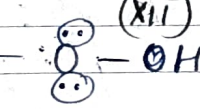
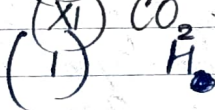
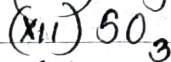
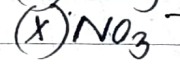
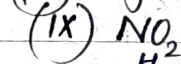
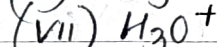
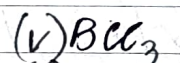
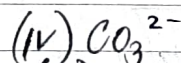
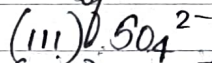
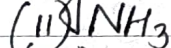
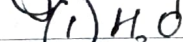
Hybridisation is analyzed with the help of steric number.

$$\boxed{\text{Steric Number} = \text{No. of } \sigma\text{-bond} + \text{No. of localised lone pair (of central atom)}}$$

When

When	Hybridisation	Geometry
$SN = 2$	sp	Linear
$SN = 3$	sp^2	Trigonal planar
$SN = 4$	sp^3	Tetrahedral
$SN = 5$	sp^3d	Trigonal bipyramidal (TBP)
$SN = 6$	sp^3d^2	Octahedral/Square bipyramidal
$SN = 7$	sp^3d^3	Pentagonal bipyramidal

Q Find the hybridisation of:

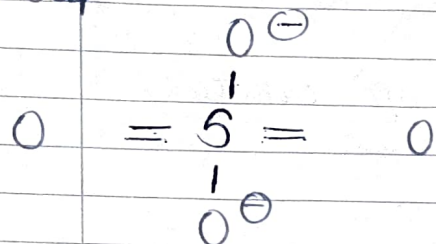
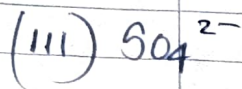


$SN = 2 + 2 = 4$

sp^3 hybridisation

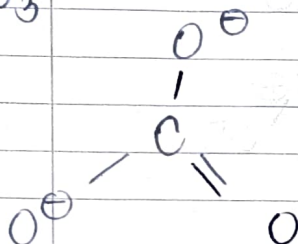
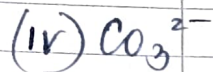
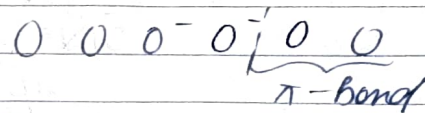
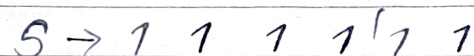
$SN = 1 + 3 = 4$

sp^3 hybridisation



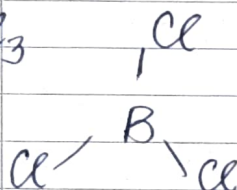
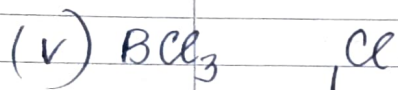
$$\text{SN} = 4$$

sp^3 hybridisation
All 3 sp orbitals
are used, so d is left.
So, p π -d π



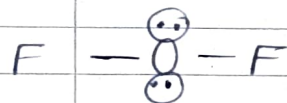
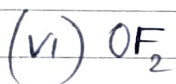
$$\text{SN} = 3$$

sp^2 hybridisation



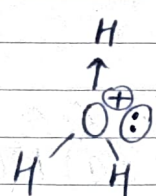
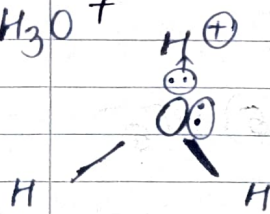
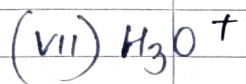
$$\text{SN} = 3$$

sp^2 hybridisation



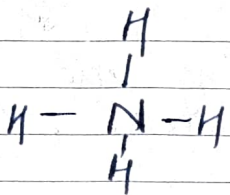
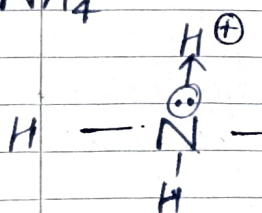
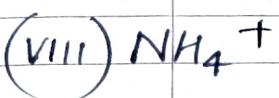
$$\text{SN} = 2 + 2 = 4$$

sp^3 hybridisation



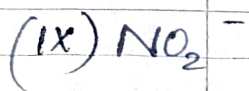
$$\text{SN} = 1 + 3 = 4$$

sp^3 hybridisation



$$\text{SN} = 4 + 0 = 4$$

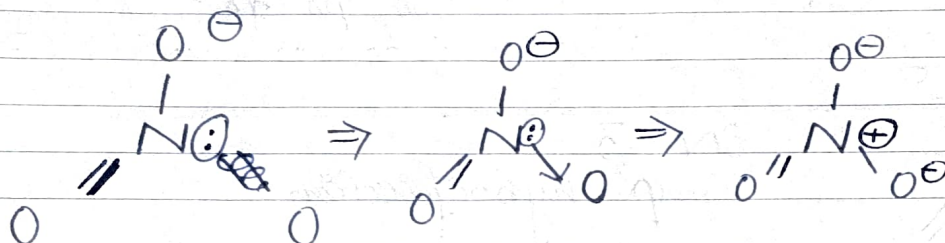
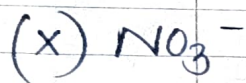
sp^3 hybridization



$$\text{SN} = 2 + 1 = 3$$

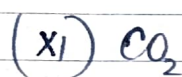
sp^2 hybridization

lp in sp^2 orbital.



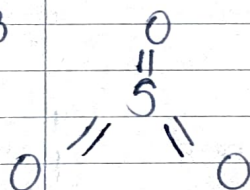
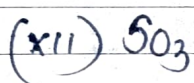
$$\text{SN} = 3$$

sp^2 hybridization



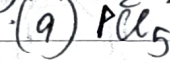
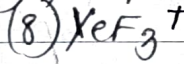
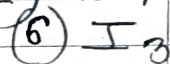
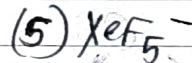
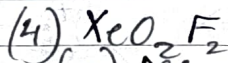
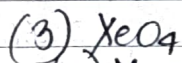
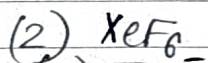
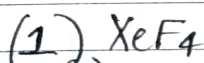
$$\text{SN} = 2$$

sp hybridization



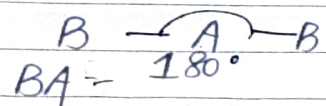
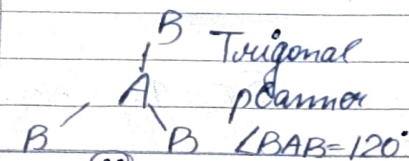
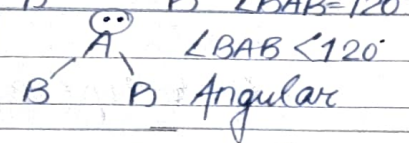
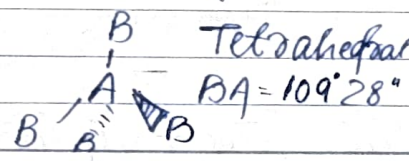
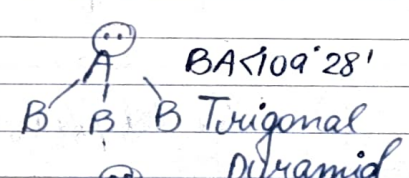
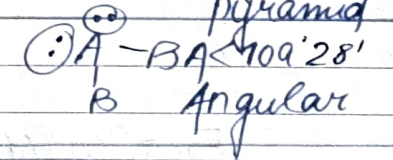
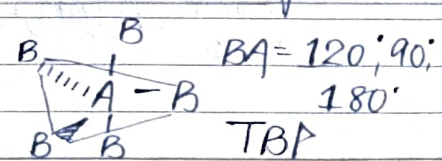
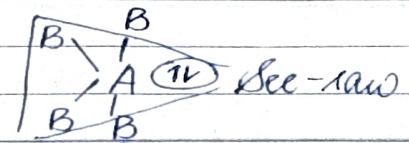
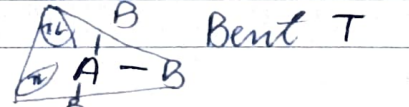
$$\text{SN} = 3$$

sp^2 hybridization



• ~~At~~ When any of surrounding atom is different, then structure is not octahedral, it is square bi-pyramidal.

Geometry & the structure (shape) of the Hybrid Molecule

Hybridisation	Bond No.	shape	Example
(I) sp Linear geometry	2 (2σ)	 $BA - 180^\circ$	$BeCl_2, BeH_2$
(II) sp^2 Trigonal planar geometry	3 $(3\sigma + 0lp)(AB_3)$ $(2\sigma + 1lp)(AB_2L)$	 $LBAB = 120^\circ$  $LBAB < 120^\circ$ Angular	BCl_3, CH_3^+ NO_3^-, CO_3^{2-} SO_2, NO_2^-
(III) sp^3 Tetrahedral geometry	4 $4\sigma + 0lp (AB_4)$ $3\sigma + 1lp (AB_3L)$ $2\sigma + 2lp (AB_2L_2)$	 $BA = 109.28^\circ$  $BA < 109.28^\circ$ Trigonal pyramid  $BA < 109.28^\circ$ Angular	NH_4^+, XeO_4 XeO_3, SO_3^{2-} OF_2
(IV) sp^3d Trigonal bi-pyramidal (d_z orbital is used because σ -bond forms)	5 $5\sigma + 0lp (AB_5)$ $4\sigma + 1lp (AB_4L)$ $3\sigma + 2lp (AB_3L_2)$	 $BA = 120, 90, 180^\circ$ TBP  See-saw  Bent T	PCl_5, PF_5, XeO_3F_2 SF_4, SF_2Cl_2, XeO_2F_2 $ClF_3, XeOF_2$

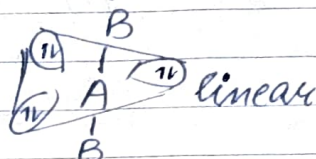
Hybridisation

steric No.

shape

example

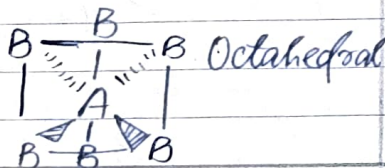
$2\sigma + 3\text{lp} (AB_2L_3)$



$\text{XeF}_2, \text{ICl}_2^-$

(v) sp^3d^2
(dz^2 & dx^2-y^2)
participate

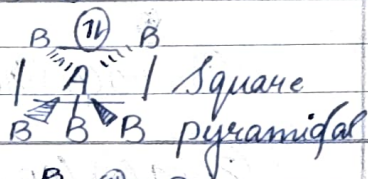
6
 $6\sigma + 0\text{lp} (AB_6)$



$\text{SF}_6, \text{XeO}_2\text{F}_4$
Octahedral Square
bi-pyramidal

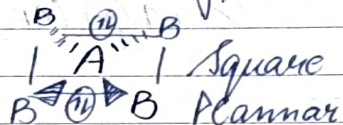
Octahedral
geometry

$5\sigma + 1\text{lp} (AB_5L)$



$\text{XeOF}_4, \text{IF}_5$

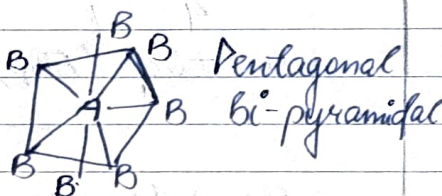
$4\sigma + 1\text{lp} (AB_4L_2)$



XeF_4

(vi) sp^3d^3
Pentagonal bi-
pyramidal
geometry

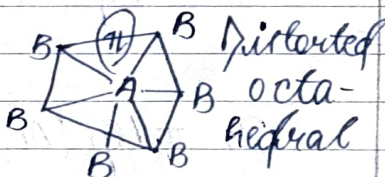
7
 $7\sigma + 0\text{lp} (AB_7)$



IF_7

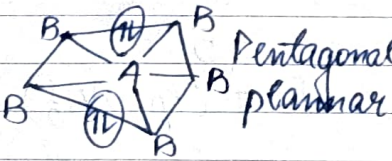
(dz^2, dx^2-y^2 & dxz, dyz)
~~under pressure~~
forcefully dxz, dyz
participate

$6\sigma + 1\text{lp} (AB_6L_1)$



$\text{XeF}_6, \text{ICl}_6^-$

$5\sigma + 2\text{lp} (AB_5L_2)$

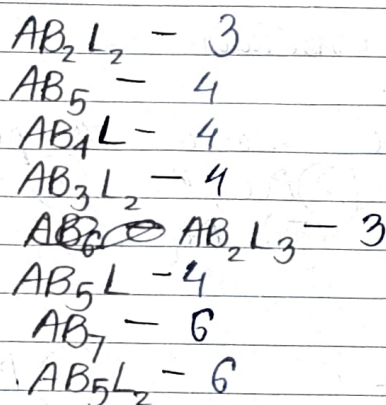
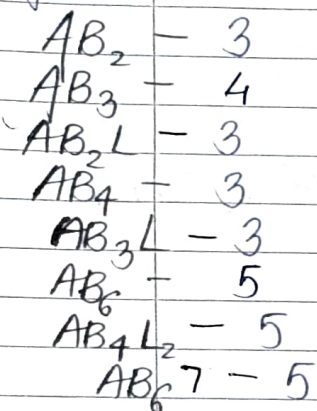


$[\text{XeF}_5]^-$

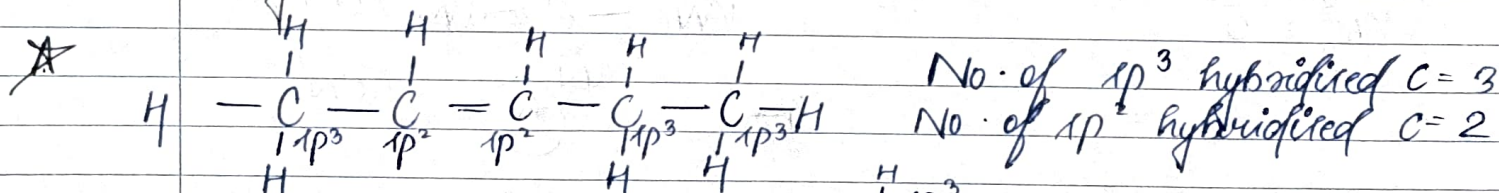
Co-Planar Atom :-

Maximum number of atom lying in one plane are known as co-planar atoms.

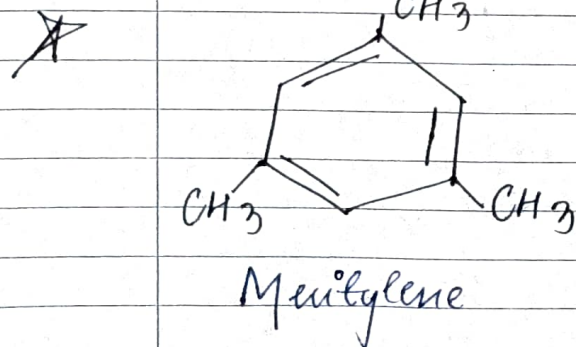
In the above structures, max. co-planar atom can be given :



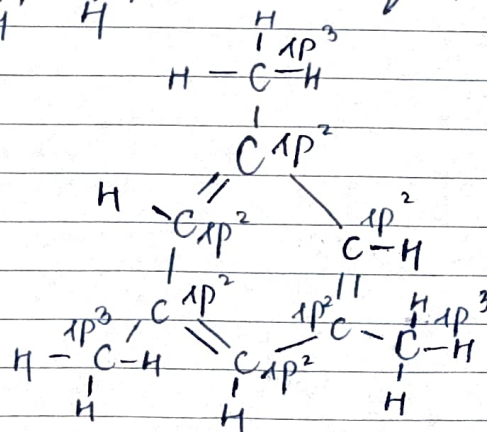
Counting of total number of hybridised carbon in organic molecule :-



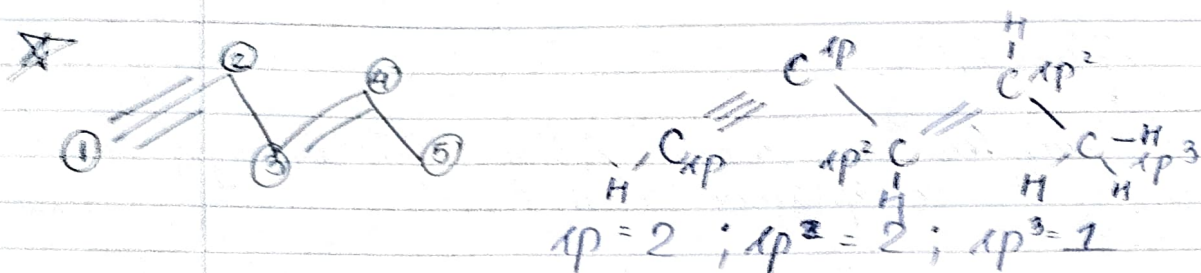
No. of sp^3 hybridised C = 3
 No. of sp^2 hybridised C = 2



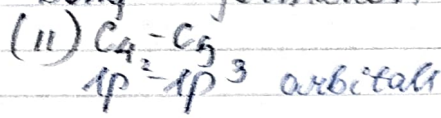
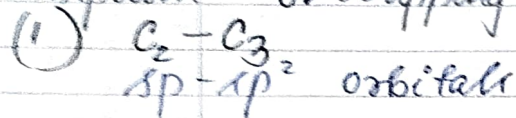
Mesitylene



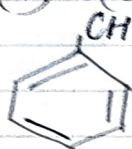
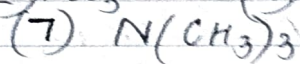
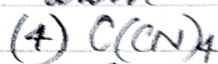
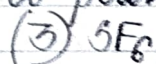
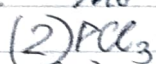
$sp^3 = 3$
 $sp^2 = 6$
 $sp = 0$



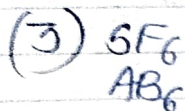
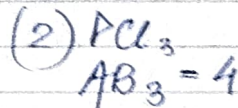
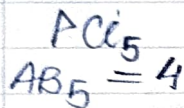
Explain overlapping for σ -bond formation



Count total no. of co-planar atom in

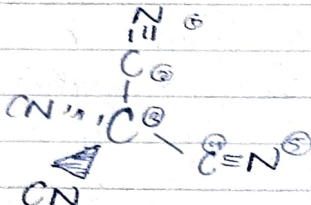


(1)



3d

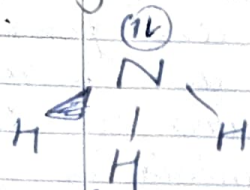
(5)



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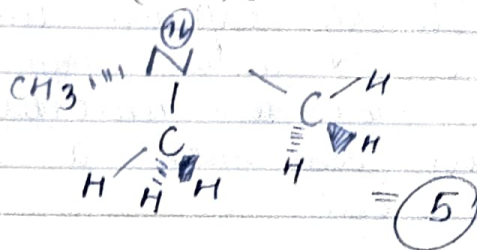
Counting of total no. of co-planar atoms when
side atom is polyatomic :-

#1 NH_3

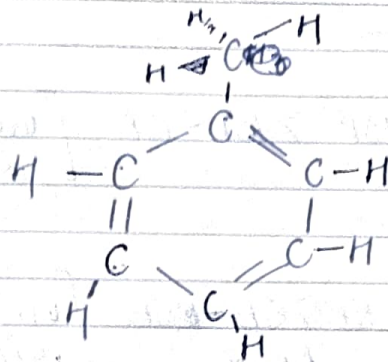
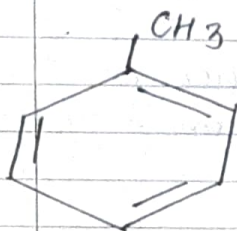


No. of co-planar atom = (3)

#2 $\text{N}(\text{CH}_3)_3$

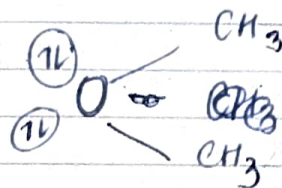


#3

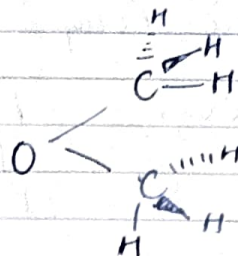


No. of co-planar atom = (13)

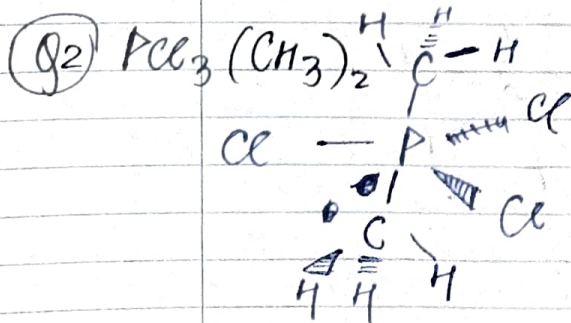
#1 $\text{O}(\text{CH}_3)_2$



$\Rightarrow$



No. of co-planar atom = (5)



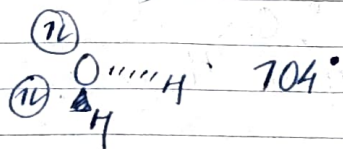
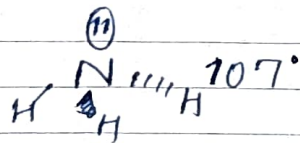
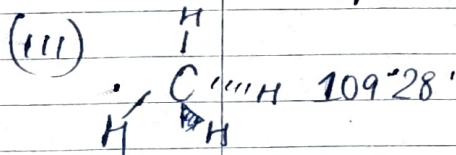
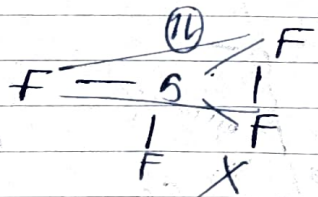
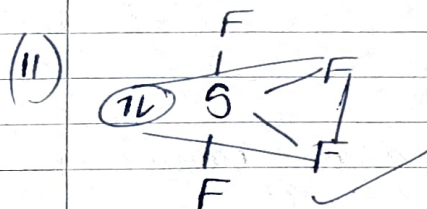
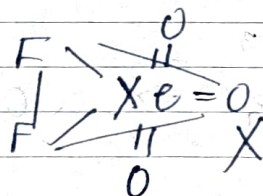
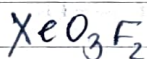
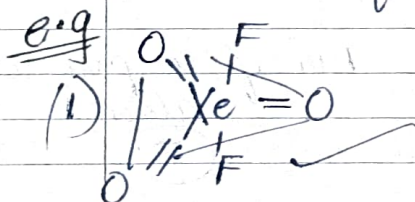
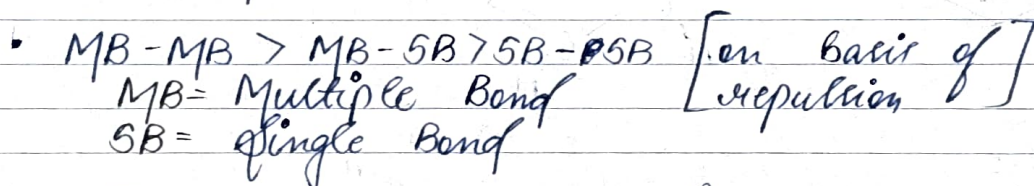
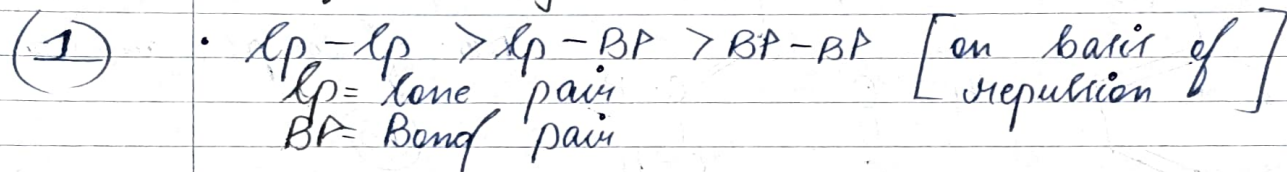
No. of co-planar atom = (6)

★ Peroxide (H_2O_2) is non-planar.

Valence Shell Electron Pair Repulsion theory (VSEPR):-

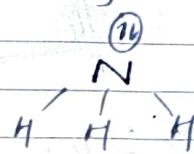
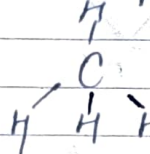
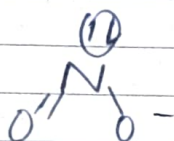
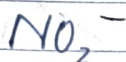
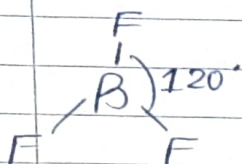
- The theory explain that bond pair or lone pair electron causes repulsion between them and makes the molecule unstable. That's why, it arranges themselves in such a way that it has minimum repulsion.

Conclusion of Theory-

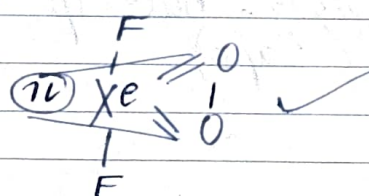
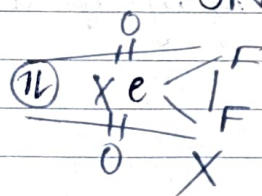
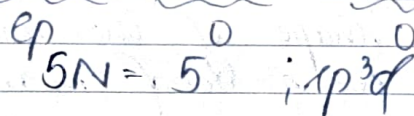
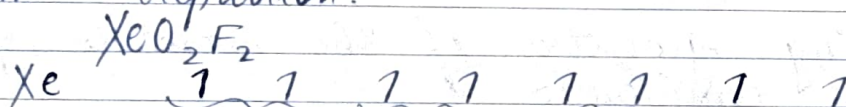


(2) In different structure, the lone pair and double bond can be placed as given -

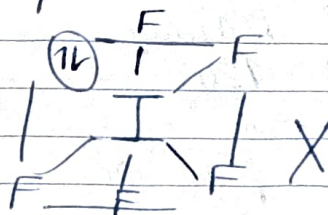
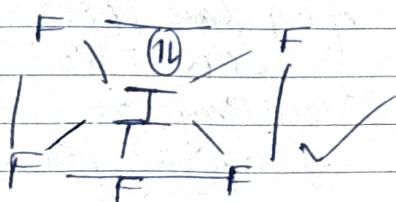
(a) In sp^2 and sp^3 hybridisation, lone pair or double bond can be placed in any hybrid orbital.



(b) In sp^3d structure, i.e., TBP structure, lp or π -bond is placed at equatorial position, so that it has minimum repulsion.

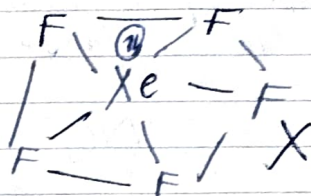
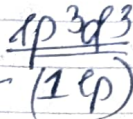
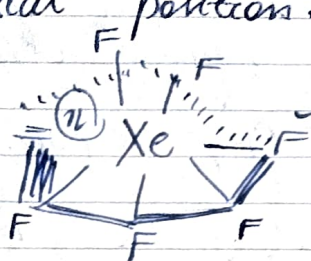
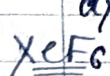


(c) In sp^3d^2 structure, i.e., octahedral, lp or multiple bond is kept at axial position.

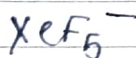
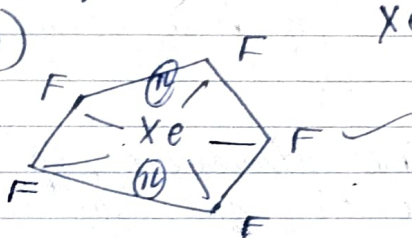


08/11/25

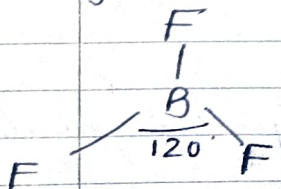
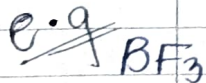
(1) If hybridisation is sp^3d^3 , then if molecule have 1 lp, then it is placed at equatorial position. But if molecule have 2 lp, then both the lp is placed at axial position.



(2 lp)

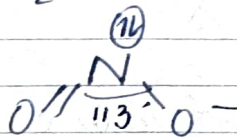
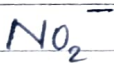


(3) While analysing geometry of the molecule, lp and σ -bond is considered. But while analysing shape of the molecule, only σ -bond is considered. But lp or π -Bond may distort the structure (shape).



Trigonal Planar
 $\angle FBF = 120^\circ$

Geometry is
Trigonal planar

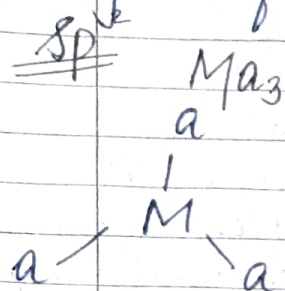


Angular (Bent)
 $\angle ONO = 113^\circ$

Geometry is
Trigonal planar

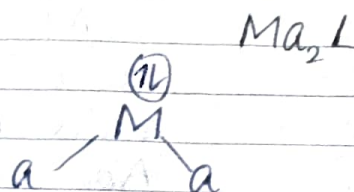
//_

(4) Analysis of different structure considering VSEPR theory

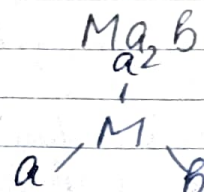


Angle = 120°

This is example of ideal hybridisation in which all 3 sp² hybrid orbital are identical in all respect & bond angle will be 120°.

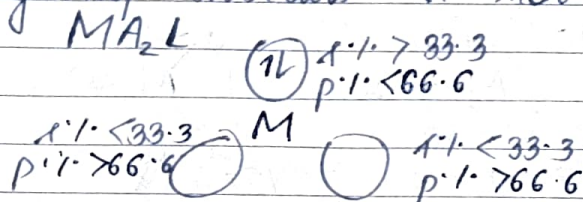


Angle < 120°

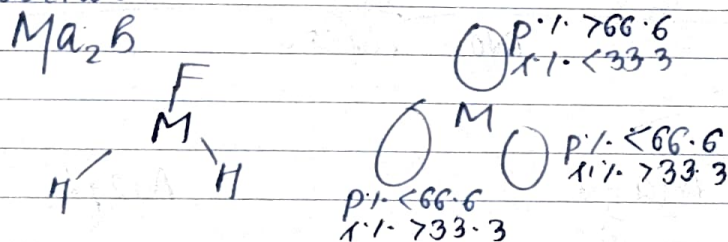


Angle ≠ 120°

In these 2 structures, all 3 hybrid orbital is not same.

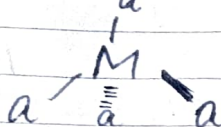
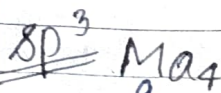


- Whichever orbital contains p-orbital, p% increases of that orbital.



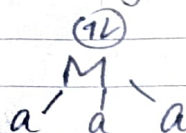
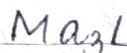
- For Ma₂L, the hybrid orbital in which lp is placed, the % of that hybrid orbital will increase & will become different from two remaining hybrid orbital.

- For Ma₂b, the hybrid orbital in which more electro-ve atom overlap, the hybrid orbital increases its p% & decreases its s%.



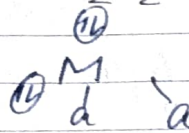
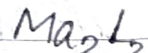
Angle = $109^\circ 28'$

Ideal hybridization
Tetrahedral shape



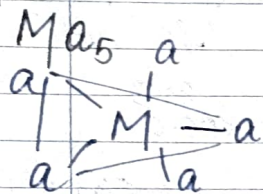
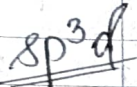
Angle = 107°
Non-ideal

Trigonal pyramid shape



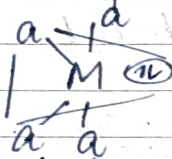
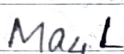
Angle = 104°

Non-ideal
Angular shape



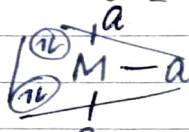
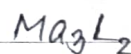
$120^\circ - 3$
 $90^\circ - 6$
 $180^\circ - 1$

TBP
Ideal



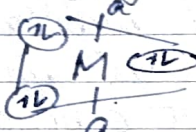
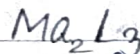
$120^\circ - X$
 $90^\circ - X$
 $180^\circ - X$

Sec-saw



$120^\circ - X$
 $90^\circ - X$
 $180^\circ - X$

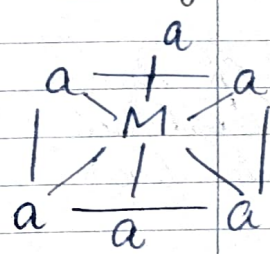
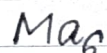
Bent-T



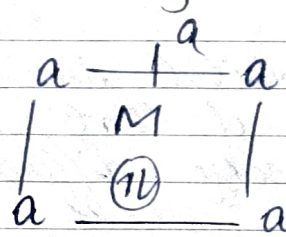
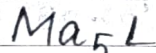
$120^\circ - X$
 $90^\circ - X$
 $180^\circ - 1$

Linear

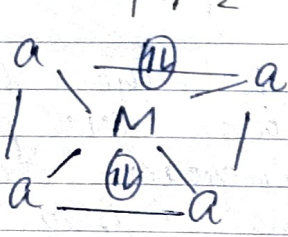
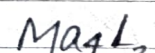
Non-ideal



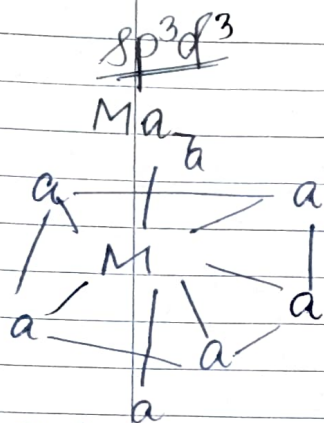
$8-90^\circ$
 $3-180^\circ$



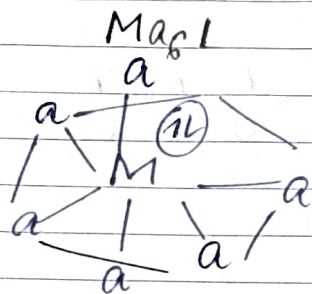
$X-90^\circ$
 $X-180^\circ$



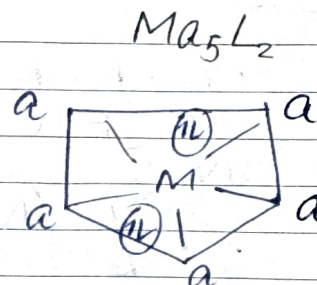
$4-90^\circ$
 $2-180^\circ$



$90^\circ - 10$
 $72^\circ - 5$
 $180^\circ - 1$



$90^\circ - X$
 $72^\circ - X$
 $180^\circ - X$

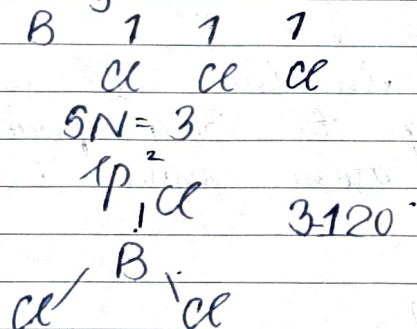


$90^\circ - X$
 $72^\circ - 5$
 $180^\circ - X$

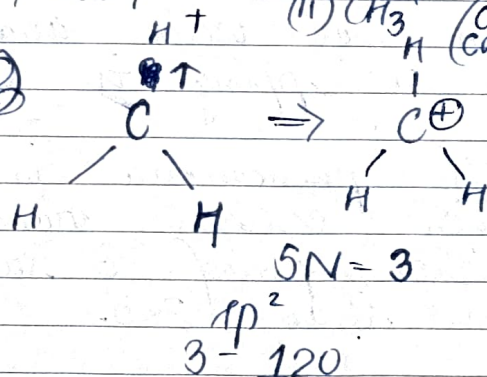
⑧ Count total number of 90° , 120° , 180° & 72° in the given species:

BCl_3 , $AlCl_3$, CH_3^+ , NH_3 , SF_4 , SF_2Cl_2 , PCl_3F_2 , PCl_5 , ClF_3 ,
 XeF_2 , XeF_3^+ , $XeOF_2$, IF_7 , XeO_3F_2 , ICl_4

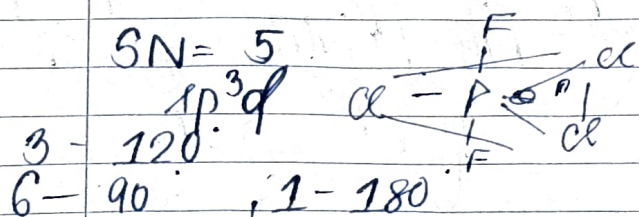
(i) BCl_3



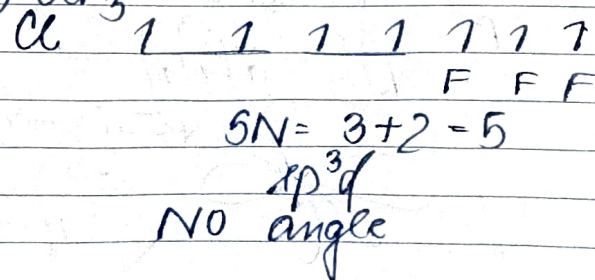
(ii)

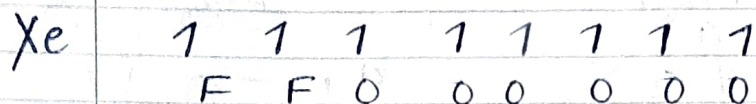


(iii) PCl_3F_2

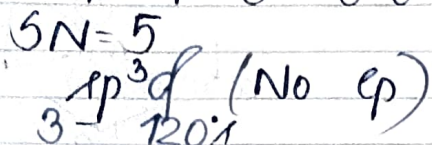


(iv) ClF_3





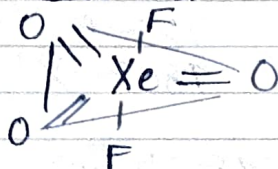
$5N = 5$



$3 - 120^\circ$

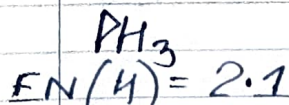
$90^\circ - 6$

$180^\circ - 1$

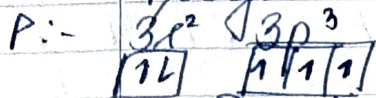


Drago Molecule:-

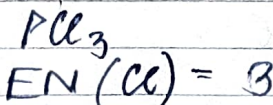
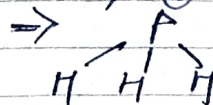
- The molecule in which hybridisation phenomena does not occur and pure atomic orbital participate in overlapping is known as drago molecule.
- This phenomena is observed in the molecule in which central atom belongs to 3rd period or higher period & surrounding atom have electronegativity less than 2.5.



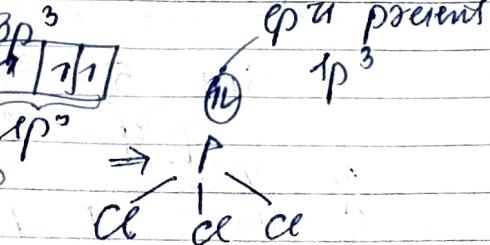
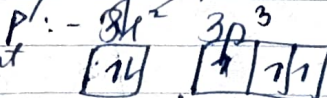
Drago ✓



Intermix X

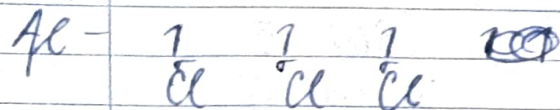


Drago X



Q) Contd.

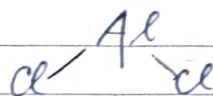
(6) $AlCl_3$



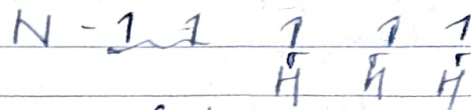
$SN = 3$

sp^2 structure

3 - 120°

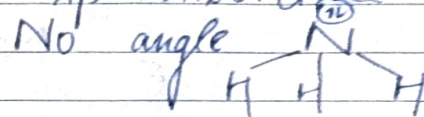


(7) NH_3

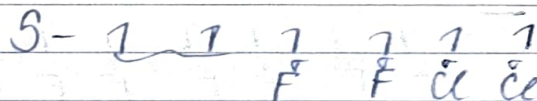


$SN = 4$

sp^3 structure



(9) SF_2Cl_2

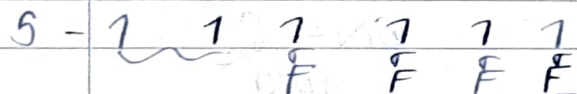


$SN = 5$

sp^3d

No angle

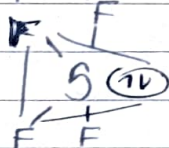
(8) SF_4



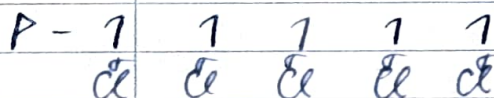
$SN = 5$

sp^3d

No angle



(10) PCl_5

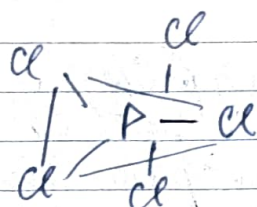


$SN = 5$

3 - 120°

2 - 90°

1 - 180°

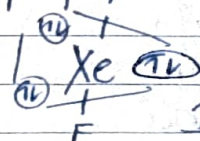


(11) XeF_2



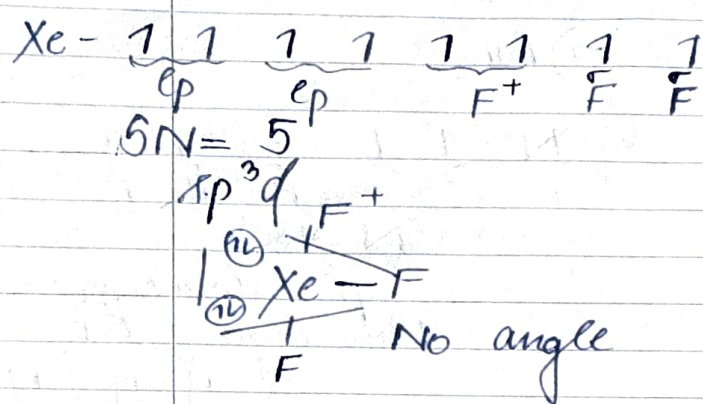
$SN = 5$

sp^3d

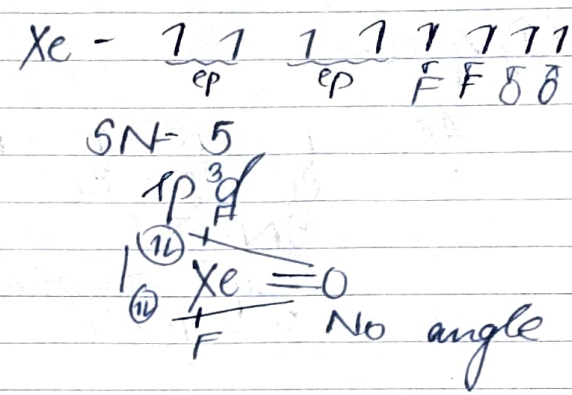


1 - 180°

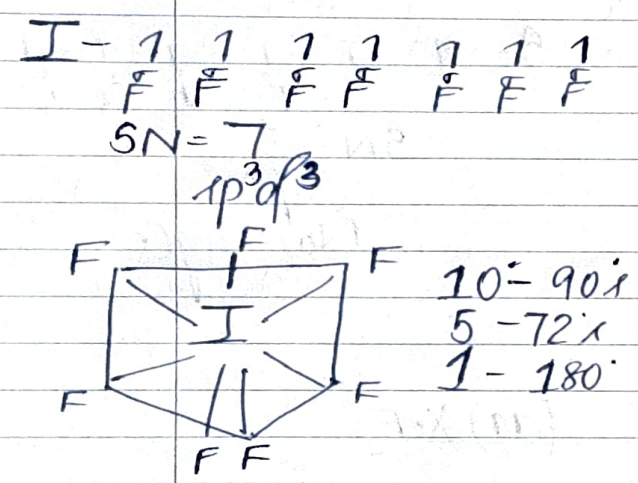
(12) XeF_3^+



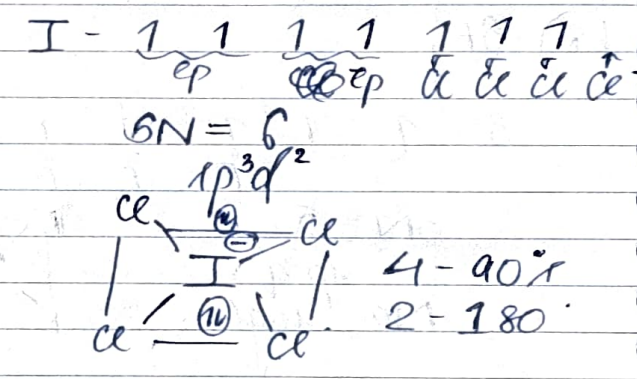
(13) XeOF_2



(14) IF_7



(15) ICl_4^-

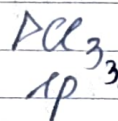
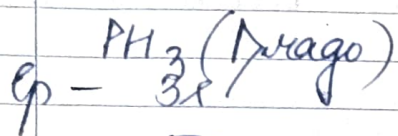


10/11/25 Drago Molecule (contd.) -

N	O
P	S
As	Se
Sb	Te
Bi	Po

All hydride of the given metals does not participate in hybridisation, i.e., MH_3 , AsH_3 , SbH_3 , H_2S , H_2Se , H_2Te

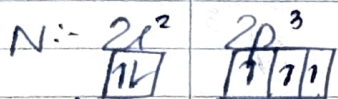
When lone pair is present, ⁱⁿ pure orbital, it does not cause any repulsion & hence, VSEPR theory is not applicable. It does not cause repulsion due to symmetric distribution of electron.



Repulsion is caused due to asymmetric distribution

When sp is present in pure s -orbital, then it is known as stereochemically inactive sp .

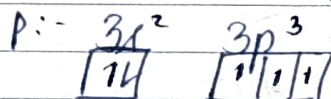
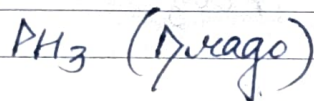
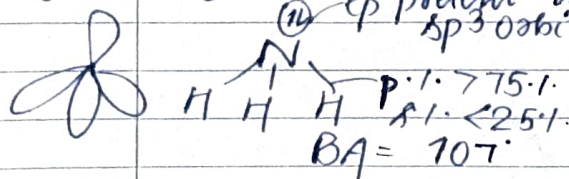
Analysis of Ammonia (NH_3) and Phosphine (PH_3) -



Intermix



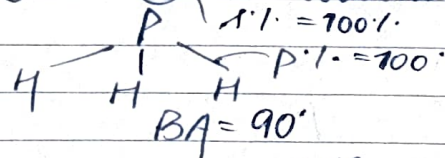
sp^3 present in sp^3 orbital



Intermixing X



sp in pure s -orbital



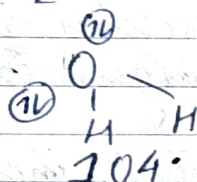
NH_3 is more basic than PH_3 because sp of ~~NH_3~~ Nitrogen is present in sp^3 -hybrid orbital but sp of phosphorus is present in pure s -orbital. sp^3 -hybrid orbital has less electronegativity and

more electron-donating tendency but pure s-orbital have more electronegativity & hence, less electron donating tendency.

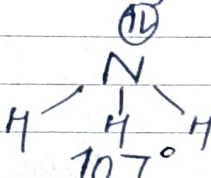
Q Compare the bond angle in the following molecules:-

(1) H_2O , NH_3 , PH_3

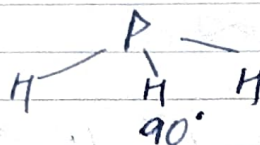
H_2O



NH_3

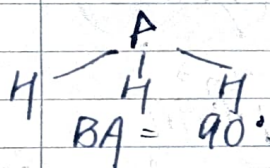


PH_3

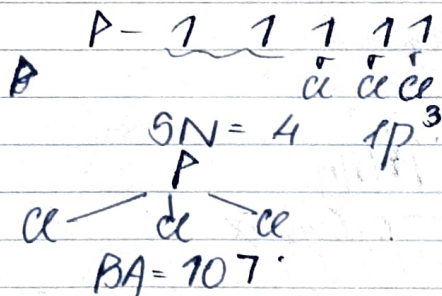


BA : $NH_3 > H_2O > PH_3$
Comparison

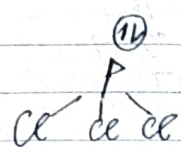
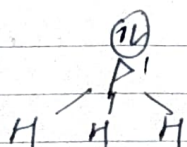
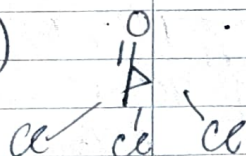
(2) PH_3 , PCl_3



$PCl_3 > PH_3$

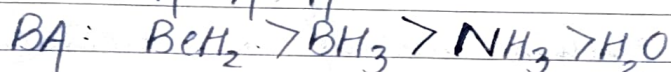
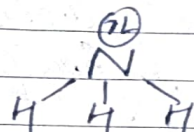
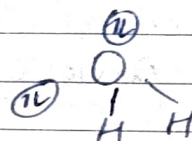
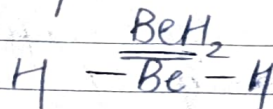
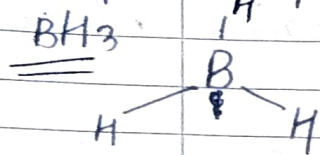
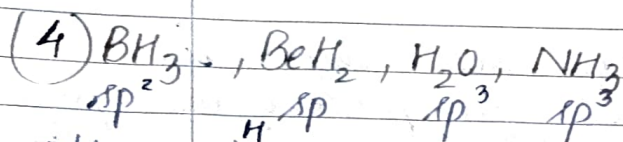


(3)



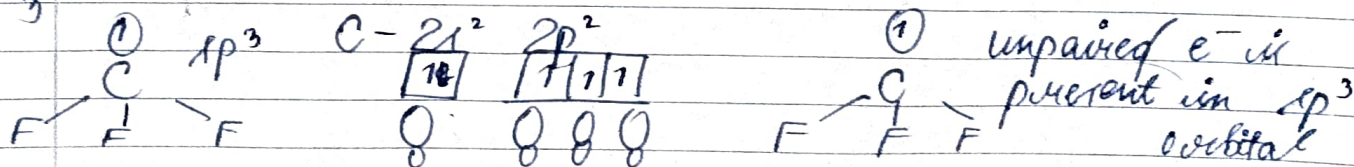
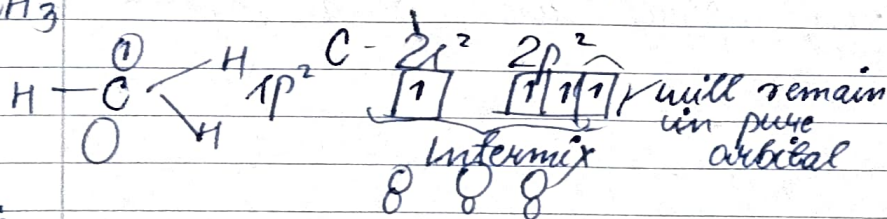
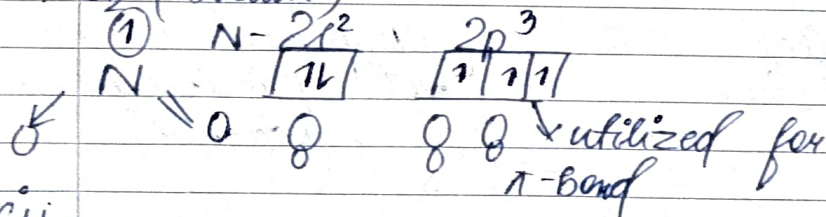
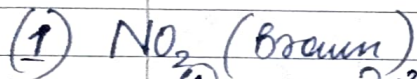
lp repels more than multiple bond.
lp always $\downarrow$ the bond angle but multiple bond $\downarrow$ the bond angle of other but $\uparrow$ angle adjacent to it.

BA : $POCl_3 > PCl_3 > PH_3$



Hybridisation of odd electron species:-

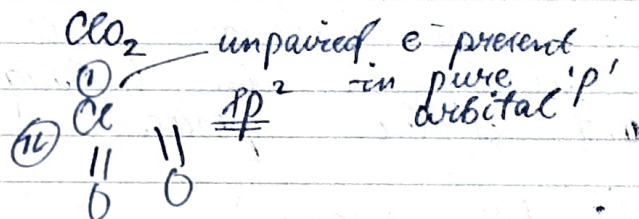
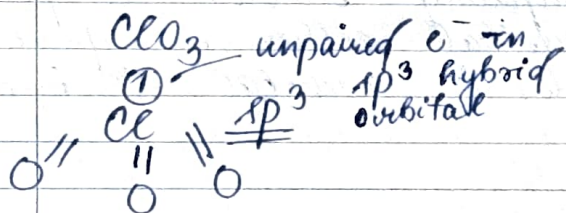
The molecule in which unpaired electron is present in their valence shell orbital either in pure atomic orbital or in hybrid atomic orbital is known as odd electron species.



In the given example, we can see that in CH_3 (free radical) unpaired electron is present in pure p -orbital but in CF_3 free radical, unpaired electron is present in sp^3 hybridised orbital.

There are certain rules which decide that unpaired electron will participate in hybridisation or not:-

- (1) The surrounding atom should be electronegative.
- (2) Central atom should not contain any lone pair other than unpaired electron.



unpaired e^- Conditions fulfilled.
 unpaired e^- participates in hybridisation

unpaired e^- does not participate in hybridisation

• All the odd electron species are paramagnetic in nature.