

Title: Hybridization

Class: B.Sc part 1 Chemistry (Hons.)

By, SANJEEV KUMAR GAUTAM

Department of chemistry

S.S College Jehanabad

Hybridisation

The process of formation of equal number of equivalent orbitals by intermixing of different orbitals of the same atom is known as hybridisation and equivalent orbitals are known as hybrid orbitals. e.g. -

Pure orbitals

hybrid orbitals

$s+p$

two sp hybrid orbitals

$s+p+p$

three sp^2 " "

$s+p+p+p$

four sp^3 " "

$s+p+p+p+d$

five sp^3d " "

$s+p+p+p+d+d$

six sp^3d^2 " "

$s+p+p+p+d+d+d$

seven sp^3d^3 " "

• Predicting hybridisation formula -

$$\text{Hybridisation (H)} = \frac{1}{2} \left[\begin{array}{l} \text{no. of valence electrons} + \text{no. of monovalent atoms} \\ \text{in valence shell of atom} \quad \text{surrounding the atom} \end{array} \right]$$

- charge on cation + charge on anion

Q Predict hybridisation of given molecules & ions -

CH_4 : $H = \frac{1}{2} [4 + 4 - 0 + 0] = \frac{8}{2} = 4$, sp^3 (Tetrahedral)

BF_3 : $H = \frac{1}{2} [3 + 3 - 0 + 0] = \frac{6}{2} = 3$, sp^2 (Planar)

NH_3 : $H = \frac{1}{2} [5 + 3 - 0 + 0] = \frac{8}{2} = 4$, sp^3 (Tetrahedral)

NH_4^+ : $H = \frac{1}{2} [5 + 4 - 1 + 0] = \frac{8}{2} = 4$, sp^3 (Tetrahedral)

NO_3^- : $H = \frac{1}{2} [5 + 0 - 0 + 1] = \frac{6}{2} = 3$, sp^2 (Planar)

(1) sp hybridisation - when one s and one p orbitals intermix together, two sp hybrid orbitals are formed and the process itself is known as sp hybridisation.

e.g. BeF_2

$\text{Be}(4) \quad 1s^2, 2s^2$

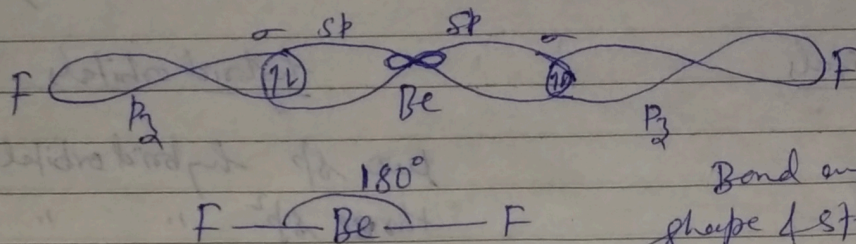
2s

2p

Ground state $\boxed{\uparrow\downarrow} \quad \boxed{} \boxed{} \boxed{}$

Excited state $\boxed{\uparrow} \quad \boxed{\uparrow} \boxed{} \boxed{}$

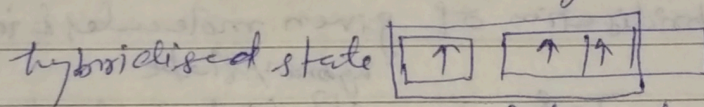
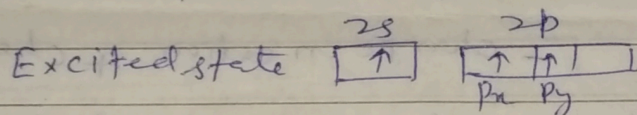
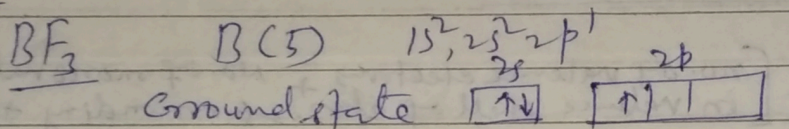
Hybridised state $\boxed{\uparrow} \boxed{\uparrow} \boxed{}$
 $2sp$ -hybrid orbitals



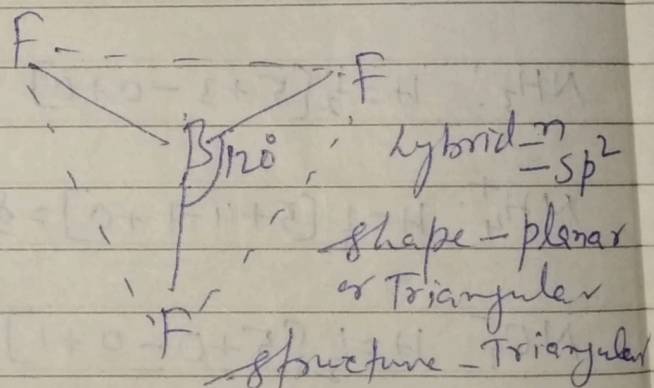
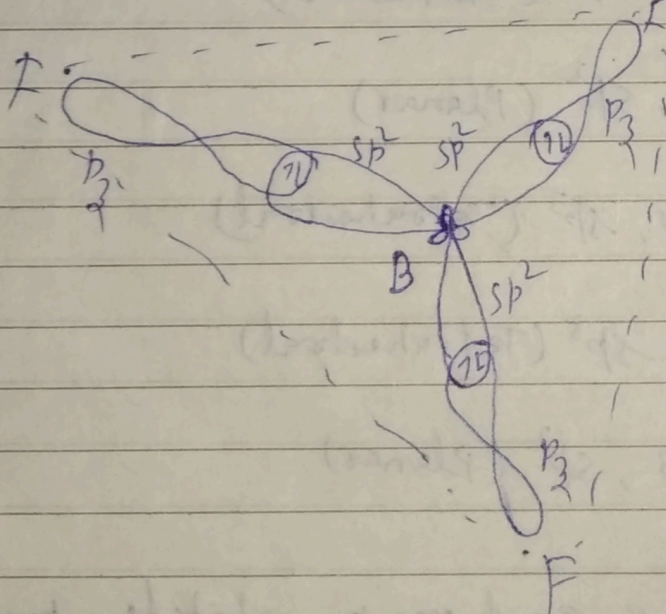
Bond angle $- 180^\circ$
 shape & structure $-$ Linear
 hybrid $- sp$

(II) sp^2 hybridisation — when one s and two p orbitals intermix together, three sp^2 hybrid orbitals are formed and the process itself is known as sp^2 hybridisation.

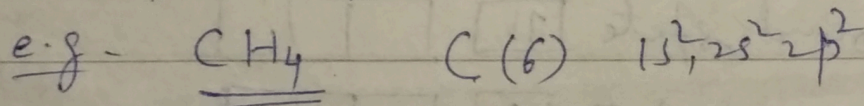
e.g. -



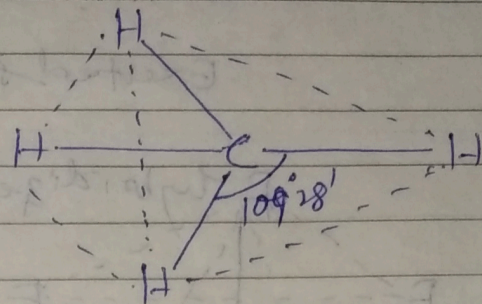
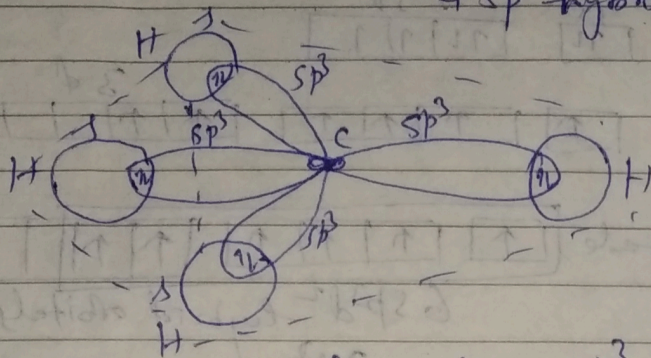
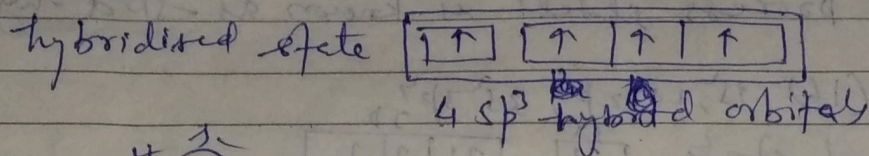
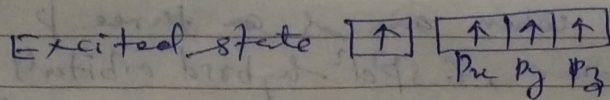
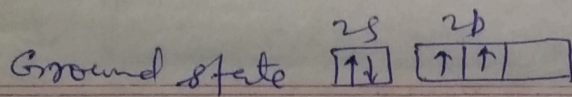
$3sp^2$ -hybrid orbitals



(III) sp^3 hybridisation — when one s and ~~one~~ three p -orbitals intermix together, four sp^3 hybrid orbitals are formed and the process itself is known as sp^3 hybridisation.



(3)



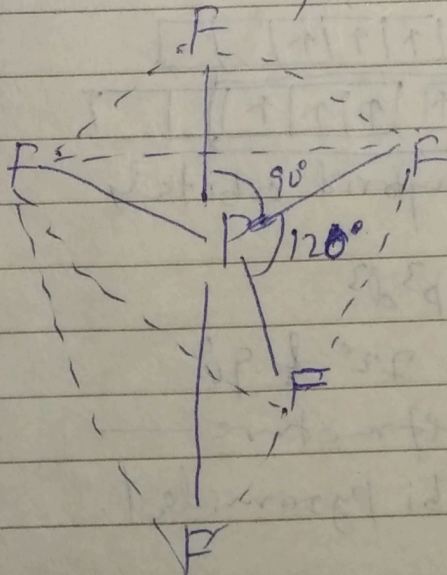
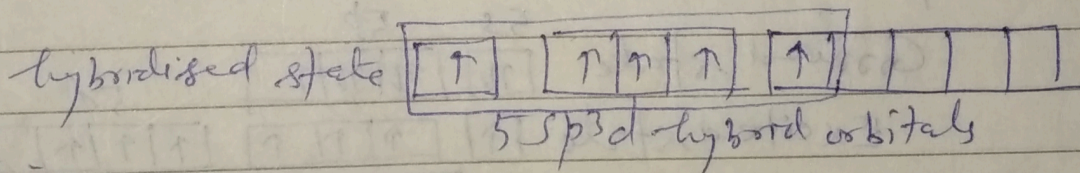
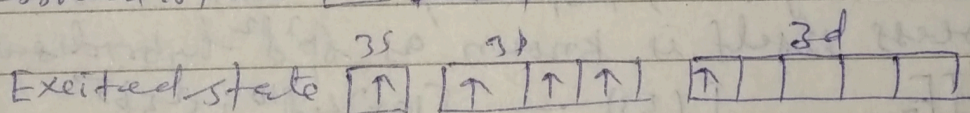
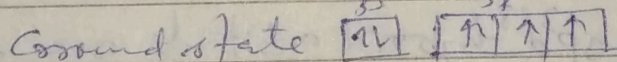
hybrid $n-sp^3$

bond angle $- 109.28' \approx 109.5^\circ$

shape & structure $-$ Tetrahedral

(IV) sp^3d hybridisation $-$ when one s , ~~and~~ three p and one d orbitals intermix together, 5 sp^3d orbitals are formed and the process itself is known as sp^3d hybridisation.

e.g. PF₅ $P(15) \quad 1s^2, 2s^2 2p^6, 3s^2 3p^3$



hybrid $n-sp^3d$

bond angle $- 90^\circ \text{ \& } 120^\circ$

shape & structure $-$

Trigonal bi pyramidal

(V) sp^3d^2 hybridisation — when one s, three p and two d orbitals intermix together, 6 sp^3d^2 hybrid orbitals are formed and the process itself is known as sp^3d^2 hybridisation.

e.g. — SF_6

S (16) $1s^2, 2s^2 2p^6, 3s^2 3p^4$
 Ground state $\boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow} \boxed{\uparrow}$

Excited state $\boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow}$ $3d$

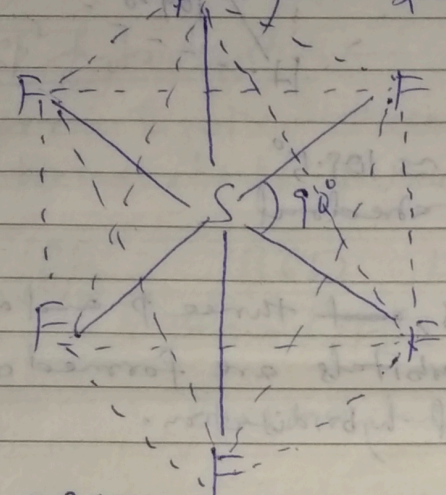
Hybridized state $\boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow}$

6 sp^3d^2 hybrid orbitals

hybridisation — sp^3d^2

bond angle — 90°

shape & structure — octahedral.



(VI) sp^3d^3 hybridisation — when one s, three p and three d orbitals intermix together, 7 sp^3d^3 hybrid orbitals are formed and the process itself is known as sp^3d^3 hybridisation.

e.g. — IF_7

I (53) — $[Kr] 4d^{10}, 5s^2 5p^5$

Ground state $\boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow} \boxed{\uparrow}$ $5s$ $5p$

Excited state $\boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow}$ $5d$

Hybridised state $\boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow} \boxed{\uparrow\downarrow}$

7 sp^3d^3 hybrid orbitals

hybridisation — sp^3d^3

bond angle — 72° & 90°

shape and structure — pentagonal bipyramidal.

