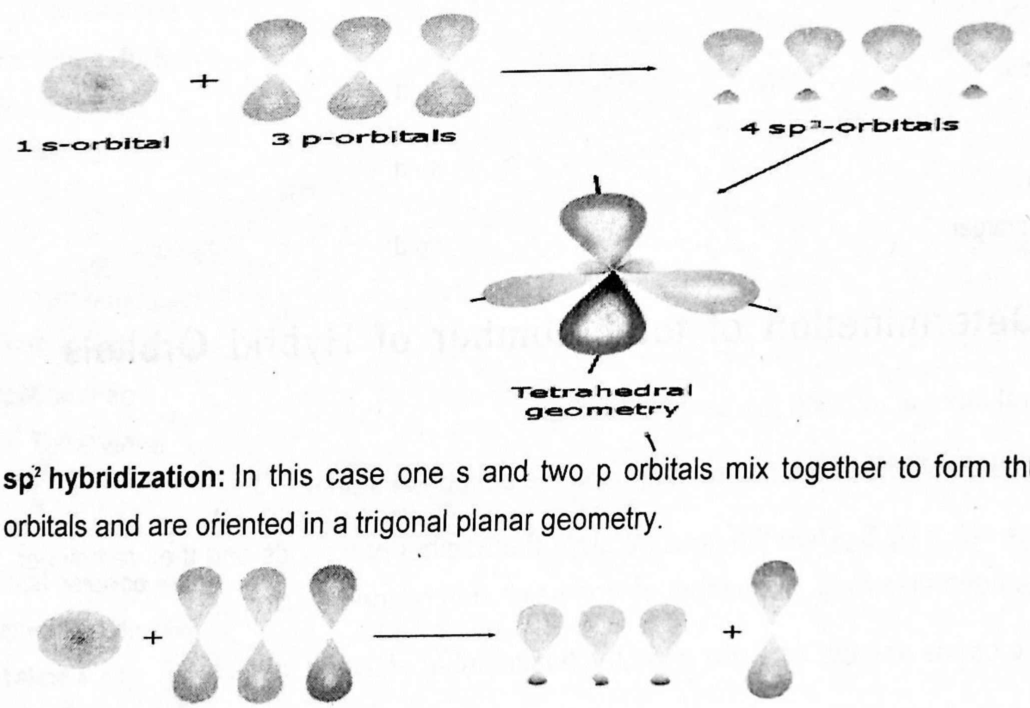
The mixing or merging of dissimilar orbitals of similar energies to form new orbitals is known as **hybridization** and the new orbitals formed are known as **hybrid orbitals**.

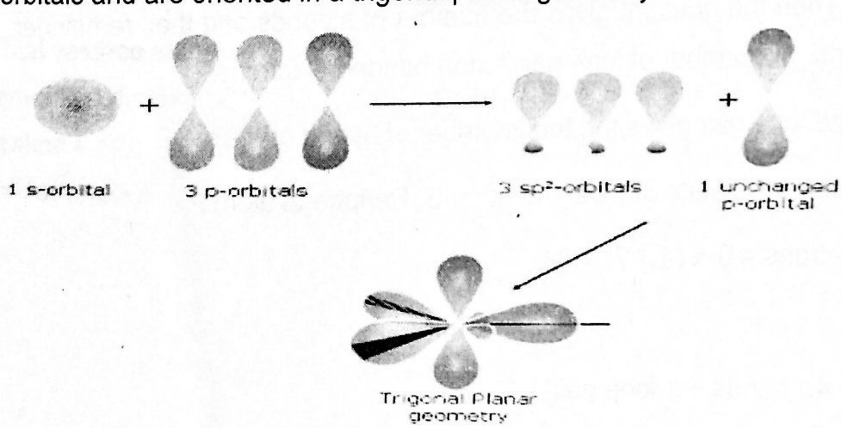
Important Characteristics of Hybridization?

1. Orbitals belonging to the same atom or ion having similar energies get hybridized.
2. Number of hybrid orbitals is equal to the no. of orbitals taking part in hybridization.
3. The hybrid orbitals are always equivalent in energy and shape.
4. The hybrid orbitals form more stable bond than the pure atom orbital.
5. The reason hybridization takes place is to produce equivalent orbitals which give maximum symmetry.
6. It is not known whether actually hybridization takes place or not. It is a concept which explains the known behaviour of molecules.
7. The hybrid orbitals are directed in space in same preferred direction to have some stable arrangement and giving suitable geometry to the molecule.

sp^3 hybridization: In this case, one s and three p orbitals hybridise to form four sp^3 hybrid orbitals. These four sp^3 hybrid orbitals are oriented in a tetrahedral arrangement.

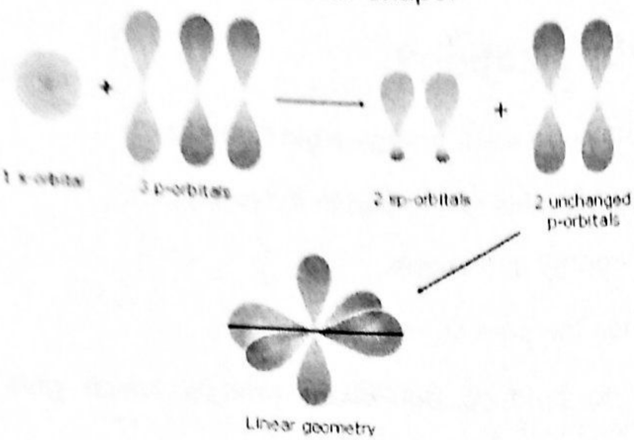


sp^2 hybridization: In this case one s and two p orbitals mix together to form three sp^2 hybrid orbitals and are oriented in a trigonal planar geometry.



The remaining p orbital if required form side ways overlapping with the other unhybridized p orbital of other C atom and leads to formation of $p_2C = CH_2$ bond as in H

sp hybridization: In this case, one s and one p orbital mix together to form two sp hybrid orbitals and are oriented in a linear shape.



The remaining two unhybridised p orbitals overlap with another unhybridised p orbital leading to the formation of triple bond as in HC≡CH.

Shape	Hybridisation
Linear	sp
Trigonal planar	sp^2
Tetrahedral	sp^3
Trigonal bipyramidal	sp^3d
Octahedral	sp^3d^2
Pentagonal bipyramidal	sp^3d^3

Rule for Determination of total Number of Hybrid Orbitals

Detect the central atom along with the peripheral atoms.

Count the valence electrons of the central atom and the peripheral atoms.

Divide the above value by 8. Then the quotient gives the number of s bonds and the remainder gives the non-bonded electrons. So number of lone pair = non bonded electrons/2 .

The number of s bonds and the lone pair gives the total number of hybrid orbitals.

An Example Will Make This Method Clear:- SF_4 Central atom S, Peripheral atom F

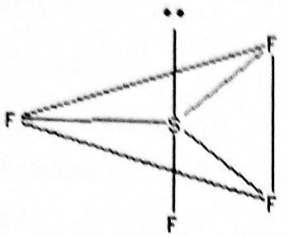
∴ total number of valence electrons = 6 + (4 × 7) = 34

Now 34/8 = 4 2/8

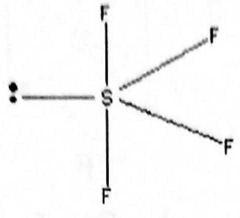
∴ Number of hybrid orbitals = 4σ bonds + 1 lone pair)

So, five hybrid orbitals are necessary and hybridization mode is sp^3d and it is trigonal bipyramidal (TBP).

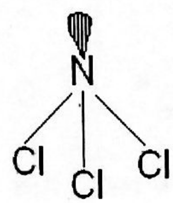
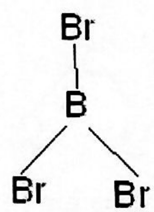
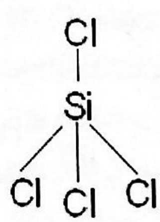
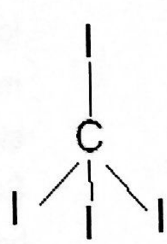
- Note:Whenever there are lone pairs in TBP geometry they should be placed in equatorial position so that repulsion is minimum.



(A)



(B)

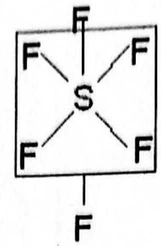
Compound and its Hybridization	Molecular geometry
1. NCl_3 Total valence electrons = 26 Requirement = 3σ bonds + 1 lone pair Hybridization = sp^3 Shape = pyramidal	
2. BBr_3 Total valence electron = 24 Requirement = 3σ bonds Hybridization = sp^2 Shape = planar trigonal	
3. $SiCl_4$ Total valence electrons = 32 Requirement = 4σ bonds Hybridization = sp^3 Shape = Tetrahedral	
4. CI_4 Total valence electron = 32 Requirements = 4σ bonds Hybridization = sp^3 Shape = Tetrahedral	

5. SF_6 Total valence electrons = 48

Requirement = 6σ bonds

Hybridization = sp^3d^2

Shape = octahedral/square bipyramidal



6. BeF_2 Total valence electrons : 16

Requirement : 2σ bonds

Hybridization : sp

Shape : Linear

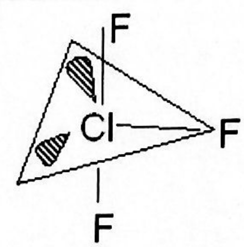
F – Be – F

7. ClF_3 Total valence electrons : 28

Requirement: 3σ bonds + 2 lone pairs

Hybridization : sp^3d

Shape : T – shaped

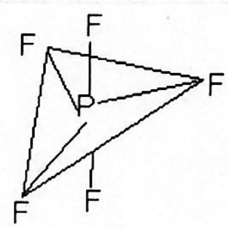


8. PF_5 Total valence electrons : 40

Requirement : 5σ bonds

Hybridization : sp^3d

Shape : Trigonal bipyramidal (TBP)

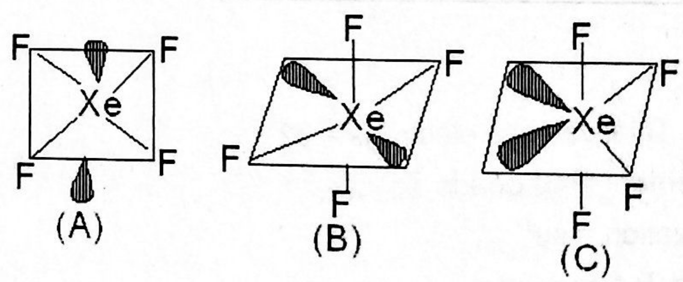


9. XeF_4 Total valence electrons : 36

Requirement:4σ bonds+ 2 lone pairs

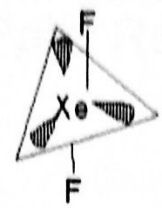
Hybridisation : sp^3d

Shape : Square planar

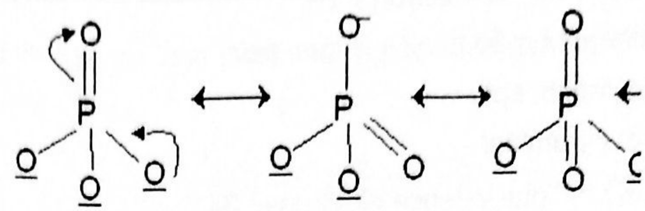


Here three arrangements are possible out of which A and B are same. A and B can be inter converted by simple rotation of molecule. The basic difference of (B) and (C) is that in (B) the lone pair is present in the anti position which minimizes the repulsion which is not possible in structure (C) where the lone pairs are adjacent. So in a octahedral structure the lone pairs must be placed at the anti positions to minimize repulsion. So both structure (A) and (B) are correct.

10. XeF_2 Total valence electrons : 22
Requirements : 2σ bonds + 3 lone pairs
Hybridisation: sp^3d
Shape : Linear

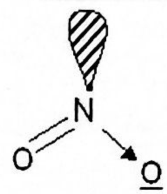


11. Total valence electrons : 32
Requirement : 4σbonds
Hybridisation: sp^3
Shape: tetrahedral



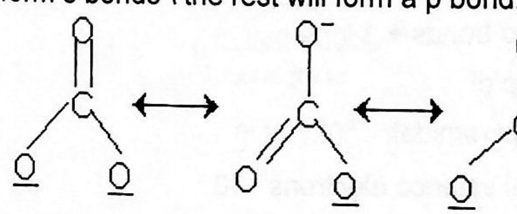
Here all the structures drawn are resonating structures with O^- resonating with double bonded oxygen.

12. NO_2^- Total valence electron: 18
Requirement : 2σ bonds + 1 lone pair
Hybridisation: sp^2
Shape: angular

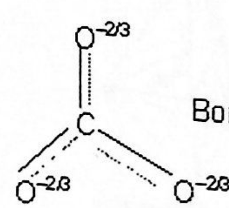


13. CO_3^{2-} Total valence electrons: 24
Requirement = 3σ bonds
Hybrdisation = sp^2
Shape: planar trigonal

But C has 4 valence electrons of these 3 form s bonds \ the rest will form a p bond.



In the structure one bond is a double bond and the other 2 are single. The position of the double bonds keeps changing in the figure. Since peripheral atoms are isovalent, so contribution of the resonanting structures are equal. Thus it is seen that none of the bonds are actually single or double. The actual state is

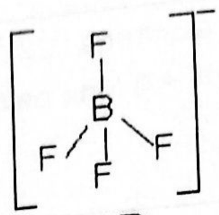


Bond order = 3/2 = 1.5

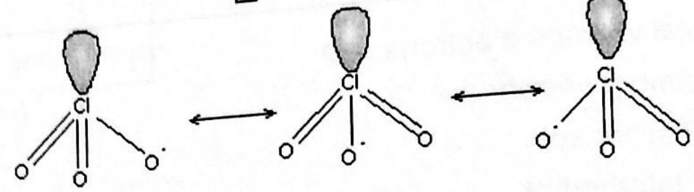
14. CO_2 Total valence electrons:16
Requirement: 2σ bonds
Hybridisation: sp
Shape: linear

O = C = O

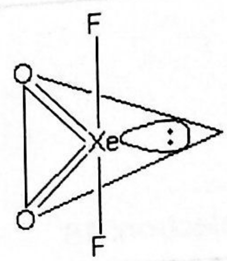
15. Total valence electrons = 32
Requirement= 4σ bonds
Hybridisation: sp^3
Shape: Tetrahedral



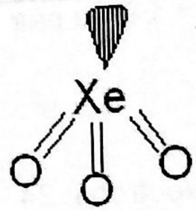
16. Total valence electron = 26
Requirement = 3σ bond + 1 lone pair
Hybridization: sp^3
Shape: pyramidal



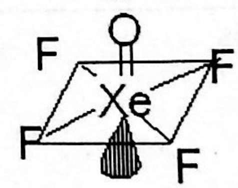
17. XeO_2F_2 Total valence electrons : 34
Requirement: 4σ bonds +1 lone pairs
Hybridization : sp^3d
Shape: Distorted TBP (sea-saw geometry)



18. XeO_3 Total valence electrons : 26
Requirement: 3σ bonds + 1 lone pair
Hybridization: sp^3
Shape: Pyramidal



19. $XeOF_4$ Total valence electrons : 42
Requirement: 5σ bonds + 1 lone pair
Hybridization: sp^3d^2
Shape: square pyramidal.



20. PF_2Br_3 Total valence electrons : 40
Requirements : 5σ bonds
Hybridisation: sp^3d
Shape : trigonal bipyramidal