

⇒ Hybridisation

Hybridisation is combination/overlapping of two or more atomic orbitals of different shape and energy (orientation) to give equal number of orbitals of equivalent/identical energy & shape, called hybrid orbitals.

- * Necessary conditions for hybridisation: (i) Orbitals must be of comparable energy (same or different orbitals) (ii) Orbitals must be axial symmetrical/proper symmetry. (iii) No. of hybrid orbitals formed must be equal to number of orbitals involved. (iv) Hybrid orbitals must be identical in shape and energy.

⇒ Types of Hybridisation: There are seven types of hybridisation in inorganic molecules:

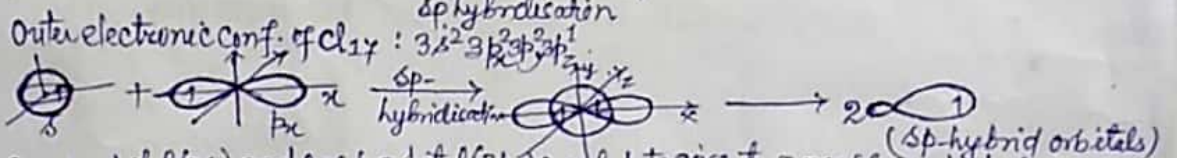
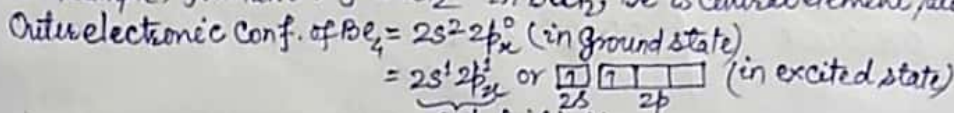
1. sp hybridisation
2. sp^2 hybridisation
3. sp^3 hybridisation
4. dsp^2 hybridisation
5. sp^3d or d^2sp^3 hybridisation
6. sp^3d^2 or d^3sp^3 hybridisation
7. sp^3d^3 or d^5sp^3 hybridisation

* dsp^2 , d^2sp^3 and d^3sp^3 hybridisation occur in coordination/complex compounds.

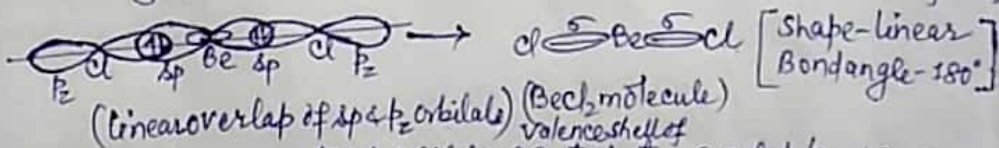
1. sp hybridisation: When one s - & one p -orbitals of ^{valence shell of} central atom overlap/combine to give two new and equivalent (sp) orbitals, the phenomenon is called sp hybridisation, and orbitals formed are called sp hybrid orbitals.

This type of hybridisation occurs in AB & AB_2 type of inorganic compounds.

For example, formation of $BeCl_2$: In $BeCl_2$, Be is central element/atom.



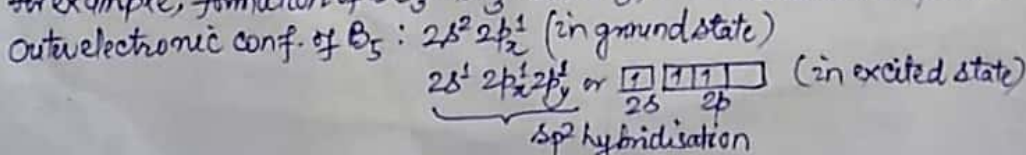
One s -orbital ($2s$) and one p -orbital ($2p_x$) overlap to give two new & equivalent sp hybrid orbitals, each has single/unpaired electron, overlap with $3p_z$ orbital of Cl -atom forming $Be-Cl$ bond.



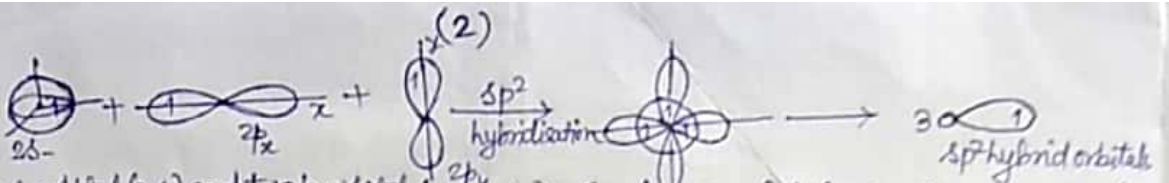
2. sp^2 hybridisation: When one s & two p -orbitals of central atom overlap/combine to give three new and equivalent orbitals, the phenomenon is called sp^2 hybridisation, and the orbitals formed are called sp^2 hybrid orbitals.

This type of hybridisation occurs in AB_2 & AB_3 type of inorganic compounds.

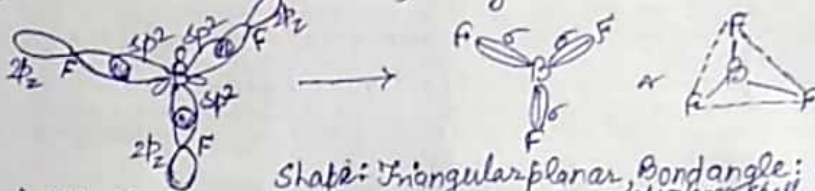
For example, formation of $BCl_3 \sim BF_3$: In BF_3 , B is central element/atom.



Outer electronic configuration of $F_9 : 2s^2 2p_x^2 2p_y^1 2p_z^1$



One s orbital ($2s$) and two p orbitals ($2p_x$ & $2p_y$) of Be atom overlap to give three new and equivalent sp^2 hybrid orbitals. Each sp^2 hybrid orbital has unpaired electron which overlap with $2p_z$ orbital of F atom forming B-F bond.

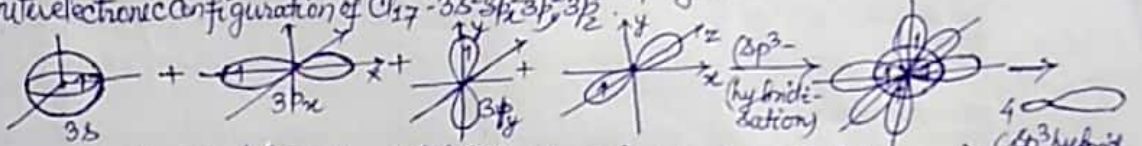


3. sp^3 hybridisation: When one s and three p orbitals of valence shell of central atom overlap/combine to give four new and equivalent orbitals, the phenomenon is called sp^3 hybridisation, and the orbitals formed are called sp^3 hybrid orbitals.

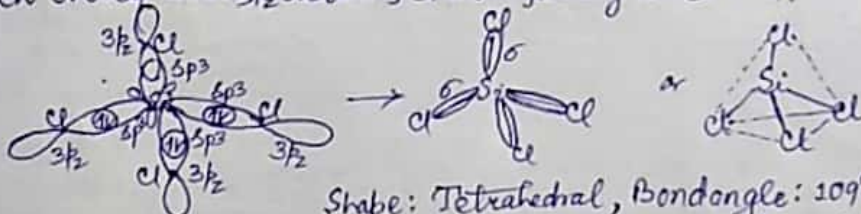
This type of hybridisation occurs in AB_2 , AB_3 & AB_4 type of inorganic compounds. For example, formation of $SiCl_4$: In $SiCl_4$, Si is central atom/element.

Outer electronic configuration of Si_{14} : $3s^2 3p_x^2 3p_y^2 3p_z^0$ (in ground state)
 $3s^1 3p_x^1 3p_y^1 3p_z^1$ (in excited state)

Outer electronic configuration of Cl_{17} : $3s^2 3p_x^2 3p_y^2 3p_z^1$ sp^3 hybridisation



One s orbital ($3s$) and three p orbitals ($3p_x$, $3p_y$ & $3p_z$) of Si atom overlap to give four new and equivalent sp^3 hybrid orbitals. Each sp^3 hybrid orbital has unpaired electron which overlap with $3p_z$ orbital of Cl atom forming Si-Cl bond.



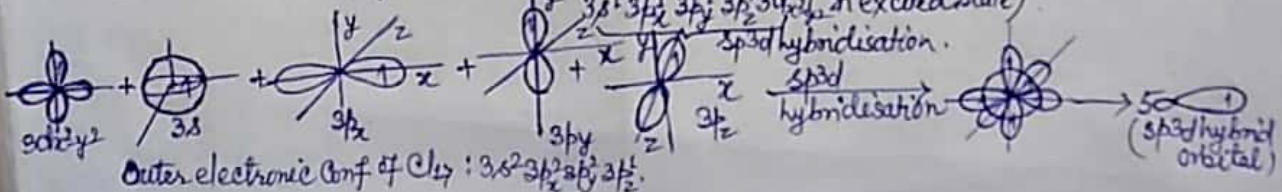
4. sp^3d hybridisation: When one s, three p and one d orbitals of valence shell of central atom overlap/combine to give five new and equivalent orbitals, the phenomenon is called sp^3d hybridisation, and the orbitals formed are called sp^3d hybrid orbitals.

This type of hybridisation occurs in AB_3 , AB_4 & AB_5 type of inorganic compounds. For example, Formation of PCl_5 : In PCl_5 , P is central atom/element.

Outer electronic configuration of P_{15} : $3s^2 3p_x^2 3p_y^2 3p_z^1$ (in ground state)

$3s^1 3p_x^1 3p_y^1 3p_z^1 3d_{xy}^1$ (in excited state)

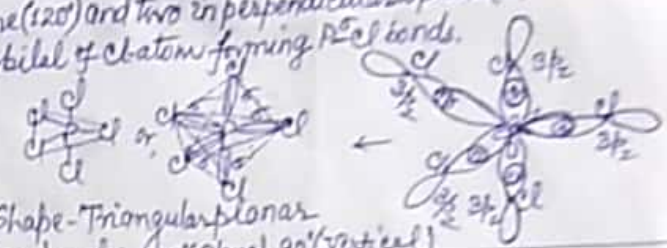
Outer electronic configuration of Cl_{17} : $3s^2 3p_x^2 3p_y^2 3p_z^1$ sp^3d hybridisation.



(3) Out of 5 sp^3d hybrid orbitals, three lie in plane (120°) and two in perpendicular to plane (90°). Each sp^3d hybrid orbital of P atom overlap with $3p_z$ orbital of Cl atom forming $P-Cl$ bonds.

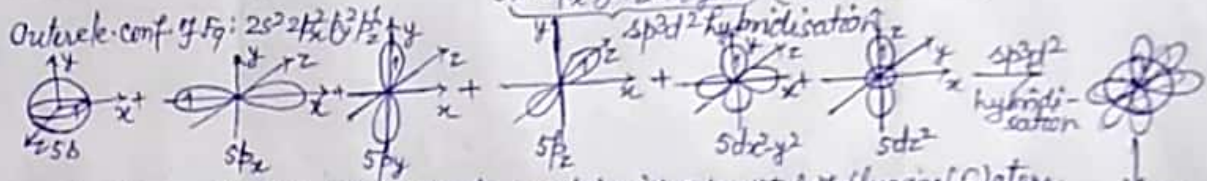
5. sp^3d^2 hybridisation: When one s, three p and two d-orbitals of valence shell of central atom overlap/combine to give five new and equivalent orbitals, the phenomenon is called sp^3d^2 hybridisation, and the orbitals formed are called sp^3d^2 hybrid orbitals.

Shape - Triangular planar
Bond angle: 120° (Plane), 90° (vertical)

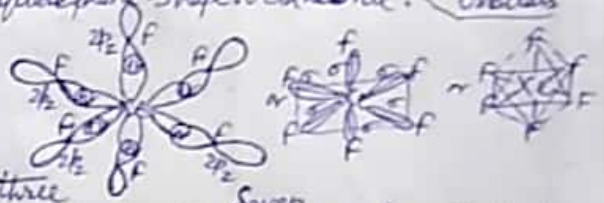


This type of hybridisation occurs in $AB_2, AB_3, AB_4, AB_5, AB_6$ type of inorganic compounds.

For example, formation of XeF_6 : In XeF_6 , Xe is central atom/element.
Outer electronic configuration of Xe: $5s^2 5p^6 3d^5 4f^1 5d^2$ (in ground state)
Outer electronic configuration of Xe: $5s^1 5p^2 3d^1 4f^1 5d^1$ (in excited state)

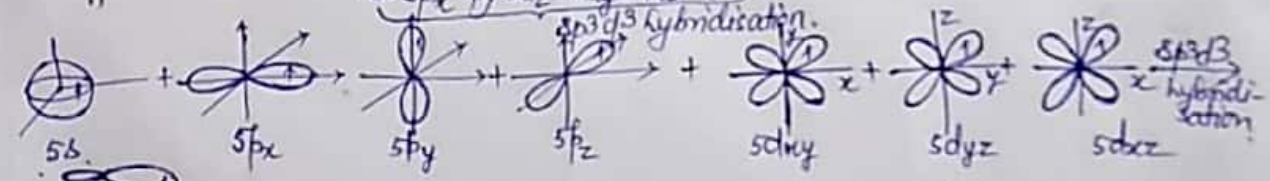


Each of the sp^3d^2 hybrid orbital of Xe atom overlap with $2p_z$ orbital of fluorine (F) atom forming $Xe-F$ bonds. 6 sp^3d^2 hybrid orbitals situated at 90° , 4 sp^3d^2 hybrid orbitals in square plane and two sp^3d^2 at perpendicular to the square plane. Shape: Octahedral.
Bond angle: 90° .



6. sp^3d^3 hybridisation: When one s, three p and three d-orbitals of valence shell of central atom overlap/combine to give ~~five~~ ^{seven} new and equivalent orbitals, the phenomenon is called sp^3d^3 hybridisation, and the orbitals formed are called sp^3d^3 hybrid orbitals. This type of hybridisation occurs in AB_5, AB_6, AB_7 type of inorganic compounds.

For example, formation of IF_7 : In IF_7 , I is central atom/element.
Outer electronic configuration of I: $5s^2 5p^5 3d^5 5d^1$ (in ground state) $F: 2s^2 2p^2 2p^1$
Outer electronic configuration of I: $5s^1 5p^2 3d^1 5d^1 5d^1$ (in excited state)



7. sp^3d^3 hybrid orbitals.
Each of the sp^3d^3 hybrid orbital of I atom overlap with $2p_z$ orbital of F-atom forming $I-F$ bonds. Out of seven sp^3d^3 hybrid orbitals, five hybrid orbitals situated in a plane at 72° and two sp^3d^3 hybrid orbitals at perpendicular to the plane. Thus, shape of IF_7 molecule is pentagonal bipyramid.

