Chemistry Study Materials for Class 11 (NCERT Based Notes of Chapter- 04)

Ganesh Kumar Date:- 10/10/2020

CHEMICAL BONDING AND MOLECULAR STRUCTURE

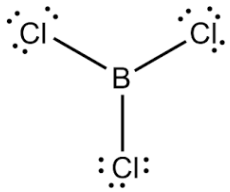
Types of hybridisation

2. sp^2 - hybridisation: It is the process of inter mixing of one s-orbital and two p-orbitals to form three new orbitals having equivalent energy and shape. The 3 new orbitals formed are called sp^2 hybrid orbitals. They are directed to the three corners of an equilateral triangle. So the shape of the molecule is planar triangular or trigonal planar with bond angle 120^0. Each sp^2 hybrid orbitals has 33% s-character and 66% p-character.

e.g. (i) ***Formation of BCl_3***

Here the central atom B has the electronic configuration $1s^2 2s^2 2p^1$. In the excited state, one of the 2s electrons is promoted to vacant 2p orbital. So the configuration becomes $2s^1 2p_x^1 2p_y^1$.

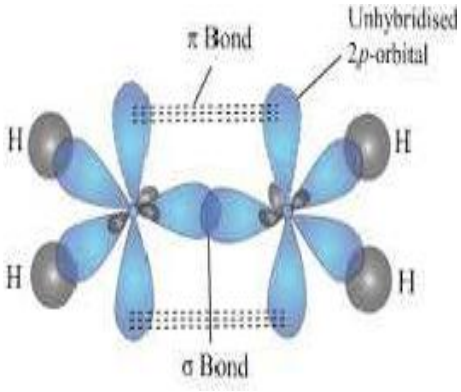
Now one s-orbital and two p-orbitals undergo hybridisation. The 3 hybrid orbitals formed overlap with 2p orbitals of Cl to form 3 B-Cl σ bonds. Since the hybridisation is sp^2, the shape of the molecule is planar triangular with bond angle 120^0.

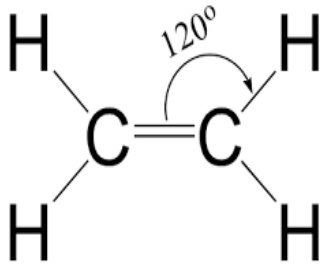


(ii) Formation of ethane or ethylene (C_2H_4)

In ethane, each C atom undergoes sp^2 hybridisation. Out of the 3 sp^2 hybrid orbitals, one of each C overlaps axially to form a C-C σ bond. The remaining two sp^2 hybrid orbitals of each C overlap with the 1s orbital of H to form 4 C-H σ bonds. Now each C atom has one unhybridized p-orbital, which overlaps laterally to form a π bond.

Thus there are 5 σ bonds and one π bond in ethane.



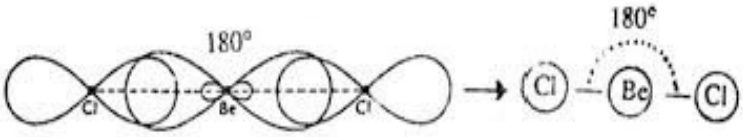


3. sp hybridisation: It is the process of inter mixing of one s-orbital and one p-orbital to form two new orbitals having equivalent energy and shape. The 2 new orbitals formed are called sp hybrid orbitals. They are directed in a line. So the shape is linear with bond angle 180^0. Each sp hybrid orbitals has 50% s-character and 50% p-character.

e.g. (i) *Formation of $BeCl_2$*

in $BeCl_2$, the central atom Be has the electronic configuration $1s^2 2s^2$. In the excited state, one of the 2s electrons is promoted to 2p level. So the configuration becomes $1s^2 2s^1 2p_x^1$.

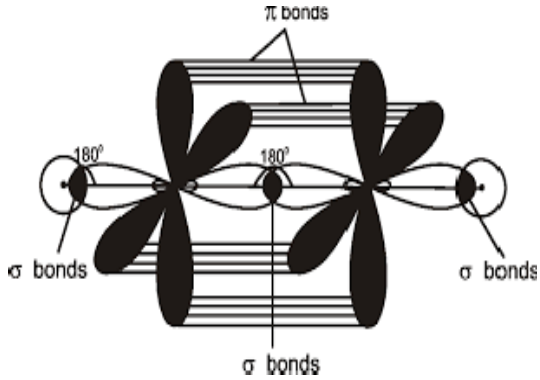
Now one s-orbital and one p-orbital undergo sp hybridisation to form 2 new sp hybrid orbitals. Each of these hybrid orbitals overlaps with the 2p orbitals of Cl to form 2 Be-Cl bonds. So the shape of the molecule is linear with bond angle 180^0.



(ii) Formation of ethyne or acetylene (C_2H_2)

In acetylene, each C atom undergoes sp hybridisation. Out of the 2 sp hybrid orbitals, one of each C overlaps axially to form a C-C σ bond. The remaining two sp hybrid orbitals of each C overlap with the1s orbital of H to form 2 C-H σ bonds.

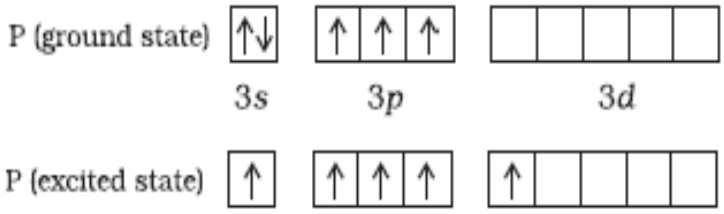
Now each C atom has 2 unhybridized p-orbitals, which overlap laterally to form 2 π bonds. Thus the molecule has linear shape with bond angle 180^0. Here there are 3 σ bonds and 2 π bonds in ethyne.



4. sp^3d hybridisation: It is the process of inter mixing of one s-orbital, three p-orbitals and one d-orbital to form five new orbitals having equivalent energy and shape. The 5 new orbitals formed are called sp^3d hybrid orbitals. These are directed to the five corners of a regular trigonal bipyramid with bond angles 120^0 and 90^0.

E.g. ***Formation of PCl_5***

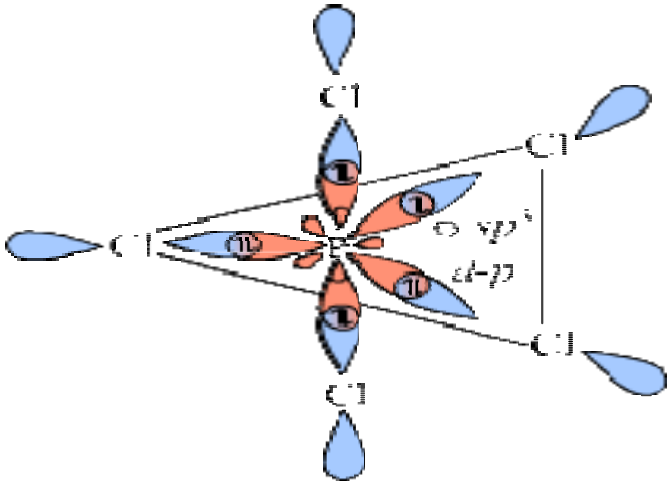
In PCl_5, the central atom P has the electronic configuration $_{15}P$ – [Ne] $3s^2 3p^3 3d^0$ To satisfy the penta valency of P, one of the 3s electrons is promoted to 3d level.



Now, one s-orbital, three p-orbitals and one d-orbital undergo sp^3d hybridisation.

These 5 sp^3d hybrid orbitals are directed to the five corners of a regular trigonal bipyramidal with bond angles 120^0 and 90^0.

In PCl_5, three P-Cl bonds lie in one plane, at an angle of 120^0. These three bonds are called equatorial bonds. The other two P-Cl bonds lie one above and one below this plane. They are called axial bonds. The axial bond pairs suffer more repulsion from the equatorial bond pairs. So the axial bond length is greater than the equatorial bond length. So PCl_5 is highly unstable and is very reactive.

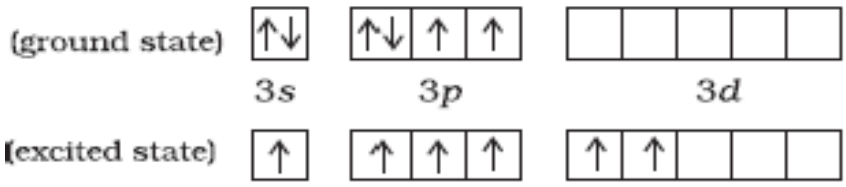


bipyramidal structure of PCl_5

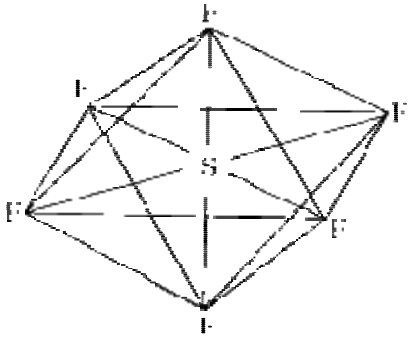
5. sp^3d^2 hybridisation: It is the process of inter mixing of one s-orbital, three p-orbitals and two d-orbitals to form six new orbitals having equivalent energy and shape. The 6 new orbitals formed are called sp^3d^2 hybrid orbitals. These are directed to the six corners of a regular octahedron with bond angle 90^0.

e.g. ***Formation of SF_6***

In SF_6 the central sulphur atom has the ground state outer electronic configuration $3s^23p^4$. In the exited state one electron each from 3s and 3p orbitals are promoted to 3d level.



Now one s-orbital, three p-orbitals and two d-orbitals undergo sp^3d hybridisation.



These hybrid orbitals overlap with p- orbitals of fluorine atoms to form 6 S–F sigma bonds. Thus SF_6 molecule has a regular octahedral geometry with bond angle 90^0.

****