Chemical Bonding

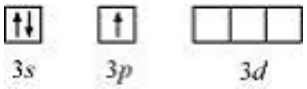
Q. 1. Distinguish between a sigma and a pi bond.

Ans. The following are the differences between sigma and pi-bonds:

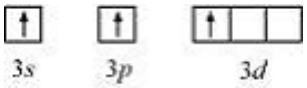
Sigma (σ) Bond	**Pi (π) Bond**
(a) It is formed by the end to end overlap of orbitals.	It is formed by the lateral overlap of orbitals.
(b) The orbitals involved in the overlapping are s–s, s–p, or p–p.	These bonds are formed by the overlap of p–p orbitals only.
(c) It is a strong bond.	It is weak bond.
(d) The electron cloud is symmetrical about the line joining the two nuclei.	The electron cloud is not symmetrical.
(e) It consists of one electron cloud, which is symmetrical about the internuclear axis.	There are two electron clouds lying above and below the plane of the atomic nuclei.
(f) Free rotation about σ bonds is possible.	Rotation is restricted in case of pi-bonds.

Q. 2. Describe the hybridisation in case of PCl_5. Why are the axial bonds longer as compared to equatorial bonds?

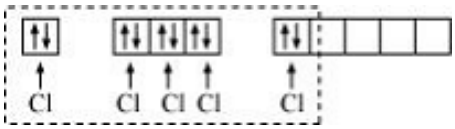
Ans. The ground state and excited state outer electronic configurations of phosphorus (Z = 15) are: Ground state:



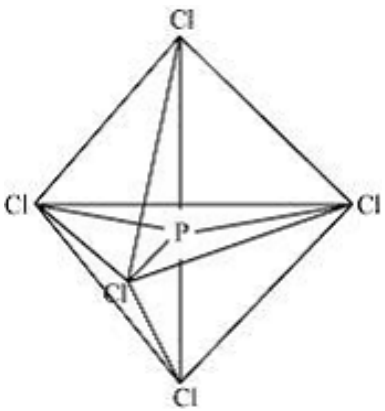
Excited state:



Phosphorus atom is sp^3d hybridized in the excited state. These orbitals are filled by the electron pairs donated by five Cl atoms as:
PCl_5



The five sp^3d hybrid orbitals are directed towards the five corners of the trigonal bipyramidals. Hence, the geometry of PCl_5 can be represented as:



There are five P–Cl sigma bonds in PCl_5. Three P–Cl bonds lie in one plane and make an angle of 120° with each other. These bonds are called equatorial bonds.

The remaining two P–Cl bonds lie above and below the equatorial plane and make an angle of 90° with the plane. These bonds are called axial bonds.

As the axial bond pairs suffer more repulsion from the equatorial bond pairs, axial bonds are slightly longer than equatorial bonds.