Chemistry Study Materials for Class 11 (NCERT Questions -Answers of Chapter- 04)

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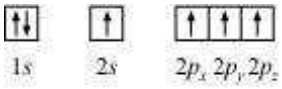
CHEMICAL BONDING AND MOLECULAR STRUCTURE

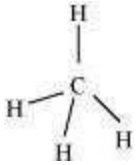
Question 4.21: Apart from tetrahedral geometry, another possible geometry for CH_4 is square planar with the four H atoms at the corners of the square and the C atom at its centre. Explain why CH_4 is not square planar?

Answer: Electronic configuration of carbon atom: ${}_6C$: $1s^2\ 2s^2\ 2p^2$



In the excited state, the orbital picture of carbon can be represented as:

Hence, carbon atom undergoes sp^3 hybridization in CH_4 molecule and takes a tetrahedral shape.



For a square planar shape, the hybridization of the central atom has to be dsp^2. However, an atom of carbon does not have *d*-orbitals to undergo dsp^2 hybridization. Hence, the structure of CH_4 cannot be square planar.

Moreover, with a bond angle of 90° in square planar, the stability of CH_4 will be very less because of the repulsion existing between the bond pairs. Hence, VSEPR theory also supports a tetrahedral structure for CH_4.

Question 4.22: Explain why BeH_2 molecule has a zero dipole moment although the Be–H bonds are polar.

Answer: The Lewis structure for BeH_2 is as follows:

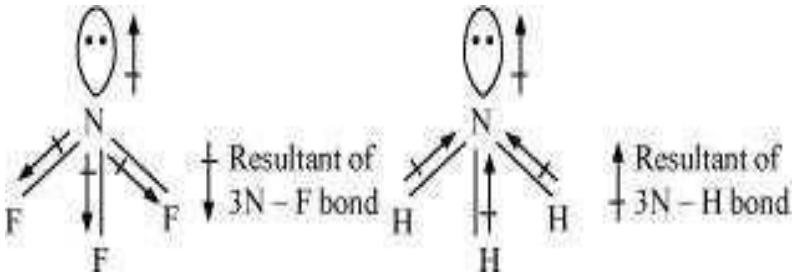
There is no lone pair at the central atom (Be) and there are two bond pairs. Hence, BeH_2 is of the type AB_2. It has a linear structure.

Dipole moments of each H–Be bond are equal and are in opposite directions. Therefore, they nullify each other. Hence, BeH_2 molecule has zero dipole moment.

Question 4.23: Which out of NH_3 and NF_3 has higher dipole moment and why?

Answer: In both molecules i.e., NH_3 and NF_3, the central atom (N) has a lone pair electron and there are three bond pairs. Hence, both molecules have a pyramidal shape. Since fluorine is more electronegative than hydrogen, it is expected that the net dipole moment of NF_3 is greater than NH_3. However, the net dipole moment of NH_3 (1.46 D) is greater than that of NF_3 (0.24 D).

This can be explained on the basis of the directions of the dipole moments of each individual bond in NF_3 and NH_3. These directions can be shown as:



Thus, the resultant moment of the N–H bonds add up to the bond moment of the lone pair (the two being in the same direction), whereas that of the three N – F bonds partly cancels the moment of the lone pair.

Hence, the net dipole moment of NF_3 is less than that of NH_3.

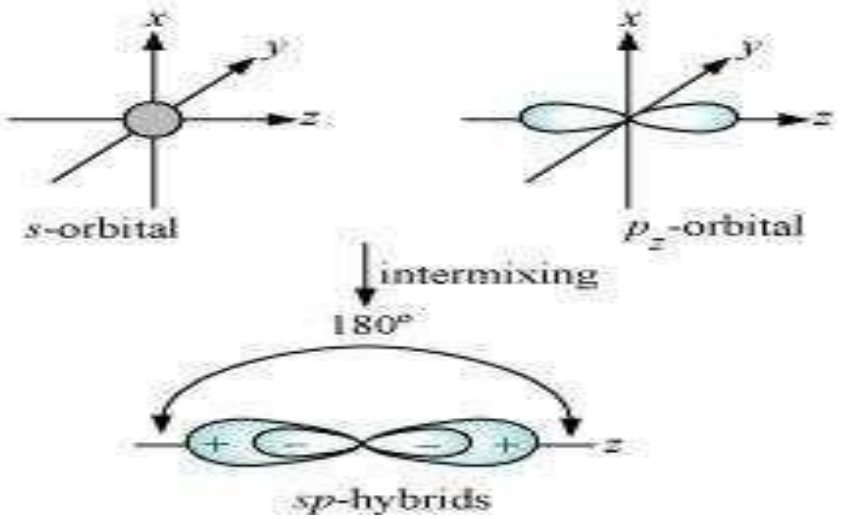
Question 4.24: What is meant by hybridisation of atomic orbitals? Describe the shapes of *sp*, sp^2, sp^3 hybrid orbitals.

Answer: Hybridization is defined as an intermixing of a set of atomic orbitals of slightly different energies, thereby forming a new set of orbitals having equivalent energies and shapes.

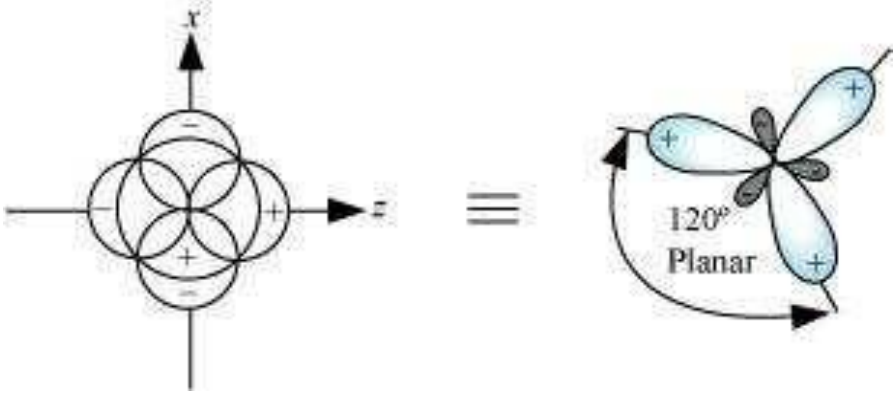
For example, one 2*s*-orbital hybridizes with two 2*p*-orbitals of carbon to form three new sp^2 hybrid orbitals.

These hybrid orbitals have minimum repulsion between their electron pairs and thus, are more stable. Hybridization helps indicate the geometry of the molecule.

Shape of *sp* hybrid orbitals: *sp* hybrid orbitals have a linear shape. They are formed by the intermixing of *s* and *p* orbitals as:

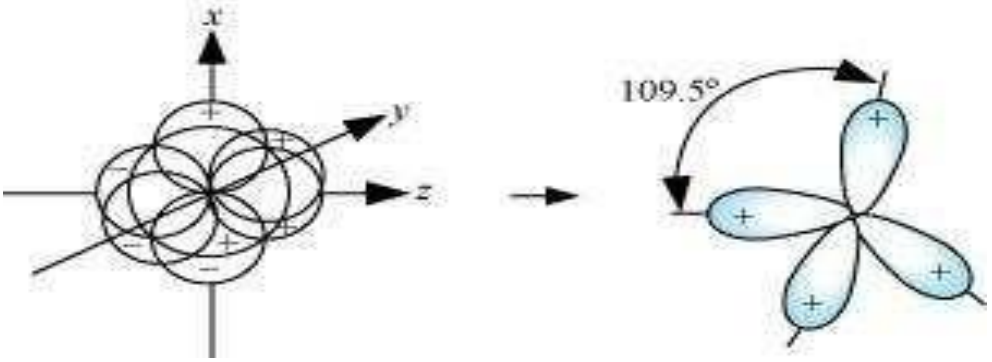


Shape of sp^2 hybrid orbitals: sp^2 hybrid orbitals are formed as a result of the intermixing of one *s*-orbital and two 2*p*- orbitals. The hybrid orbitals are oriented in a trigonal planar arrangement as:



Shape of sp^3 hybrid orbitals:

Four sp^3 hybrid orbitals are formed by intermixing one s-orbital with three *p*-orbitals. The four sp^3 hybrid orbitals are arranged in the form of a tetrahedron as:

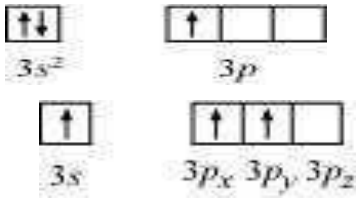


Question 4.25: Describe the change in hybridisation (if any) of the Al atom in the following reaction.

$$AlCl_3 + Cl^- \longrightarrow AlCl_4^-$$

Answer: The valence orbital picture of aluminium in the ground state can be represented as:

The orbital picture of aluminium in the excited state can be represented as:

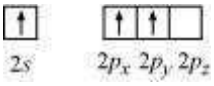


Hence, it undergoes sp^2 hybridization to give a trigonal planar arrangement (in $AlCl_3$).

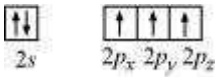
To form $AlCl^-$, the empty 3*p* orbital also gets involved and the hybridization changes from sp^2 to sp^3. As a result, the shape gets changed to tetrahedral.

Question 4.26: Is there any change in the hybridisation of B and N atoms as a result of the following reaction? **$BF_3 + NH_3 \rightarrow F_3B.NH_3$**

Answer: Boron atom in BF_3 is sp^2 hybridized. The orbital picture of boron in the excited state can be shown as:



Nitrogen atom in NH_3 is sp^3 hybridized. The orbital picture of nitrogen can be represented as:



After the reaction has occurred, an adduct $F_3B{\cdot}NH_3$ is formed as hybridization of 'B' changes to sp^3. However, the hybridization of 'N' remains intact.

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