Chemical Bonding Class 11 Questions and Answers PDF

Que1. Write the significance of a plus and a minus sign shown in representing the orbitals.

Ans 1: Molecular orbitals are represented by wave functions. A plus sign in an orbital indicates a positive wave function while a minus sign in an orbital represents a negative wave function.

Que 2. How do you express the bond strength in terms of bond order?

Ans 2: Bond strength represents the extent of bonding between two atoms forming a molecule. The larger the bond energy, the stronger is the bond and the greater is the bond order.

Que 3: Define the bond length.

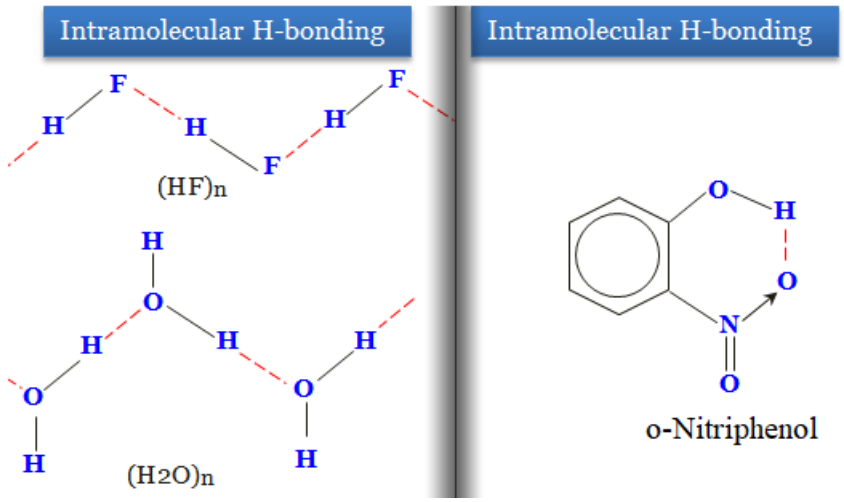
Ans 3: Bond length is defined as the equilibrium distance between the nuclei of two bonded atoms in a molecule.

Que 4: Define hydrogen bond. Is it weaker or stronger than the van der Waals forces?

Ans 4: A hydrogen bond is defined as an attractive force acting between the hydrogen attached to an electronegative atom of one molecule and an electronegative atom of a different molecule (may be of the same kind). There are two types of H-bonds

(i) Intermolecular H-bond e.g., HF, H_2O etc.

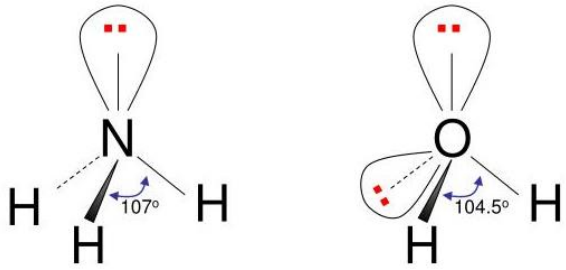
(ii) Intramolecular H-bond e.g., o-nitrophenol



Hydrogen bonds are stronger than Van der Walls forces since hydrogen bonds are regarded as an extreme form of dipole-dipole interaction.

Que 5: Although geometries of NH_3 and H_2O molecules are distorted tetrahedral, bond angle in water is less than that of ammonia. Discuss.

Ans 5: The molecular geometry of NH_3 and H_2O can be shown as:



NH_3, ammonia H_2O, water

The central atom (N) in NH_3 has one lone pair and there are three bond pairs. In H_2O, there are two lone pairs and two bond pairs. The two lone pairs present in the oxygen atom of H_2O molecule repels the two bond pairs. This repulsion is stronger than the repulsion between the lone pair and the three bond pairs on the nitrogen atom. Since the repulsions on the bond pairs in H_2O molecule are greater than that in NH_3, the bond angle in water is less than that of ammonia.

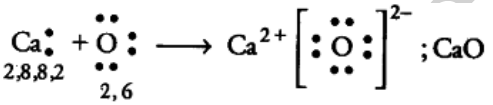
Que 6: Use Lewis symbols to show electron transfer between the following atoms to form cations and anions:

(a) Ca and O (d) Al and N.

Ans 6: (a) Ca and O: The electronic configurations of Ca and O are as follows:

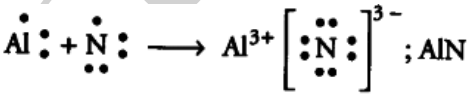
Ca: 2, 8, 8, 2 O: 2, 6

Oxygen requires two electrons more to complete its octet, whereas calcium has two electrons more than the nearest noble gas i.e., Argon. Hence, the electron transfer takes place as:



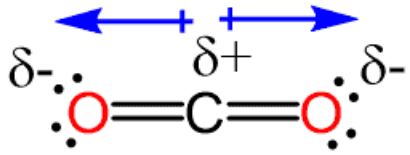
(b) Al and N:

The electronic configurations of Al and N are as follows: Al: 2, 8, 3 N: 2, 5 Nitrogen is three electrons short of the nearest noble gas (Neon), whereas aluminium has three electrons more than Neon. Hence, the electron transference can be shown as:



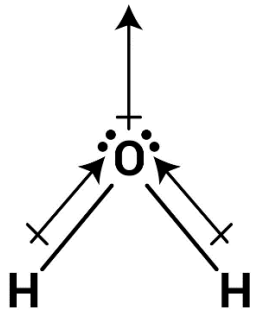
Que 7: Although both CO_2 and H_2O are triatomic molecules, the shape of H_2O molecule is bent while that of CO_2 is linear. Explain this on the basis of dipole moment.

Ans 7: According to experimental results, the dipole moment of carbon dioxide is zero. This is possible only if the molecule is linear so that the dipole moments of C– O bonds are equal and opposite to nullify each other.



Resultant μ = 0 D

H_2O, on the other hand, has a dipole moment value of 1.84 D (though it is a triatomic molecule as CO_2). The value of the dipole moment suggests that the structure of H_2O molecule is bent where the dipole moment of O–H bonds are unequal.



Que 8: Distinguish between a sigma and a pi bond.

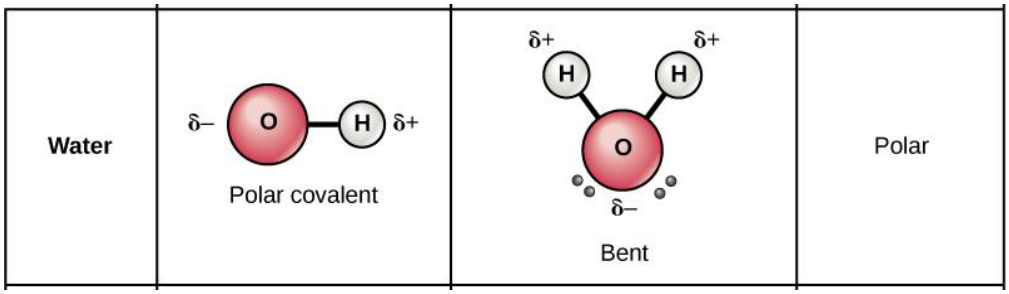
Ans 8: The following are the differences between sigma and pi-bonds:

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–porbitals 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.

Que 9: Explain with the help of suitable example polar covalent bond.

Ans 9: When two dissimilar atoms having different electronegativities combine to form a covalent bond, the bond pair of electrons is not shared equally. The bond pair shifts towards the nucleus of the atom having greater electronegativity. As a result, electron distribution gets distorted and the electron cloud is displaced towards the electronegative atom. As a result, the electronegative atom becomes slightly negatively charged while the other atom becomes slightly positively charged. Thus, opposite poles are developed in the molecule and this type of a bond is called a polar covalent bond. HCl, for example, contains a polar covalent bond.

Chlorine atom is more electronegative than hydrogen atom. Hence, the bond pair lies towards chlorine and therefore, it acquires a partial negative charge.



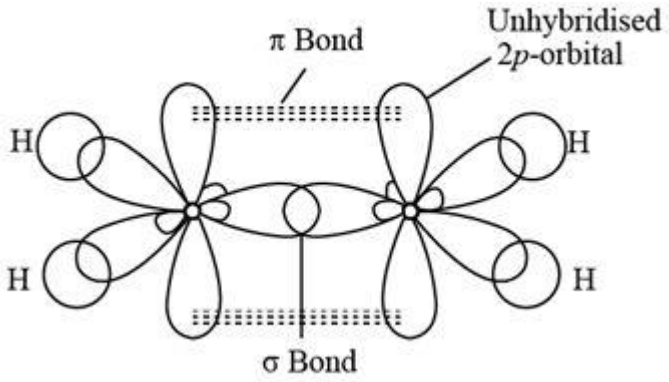
Que 10: Draw diagrams showing the formation of a double bond and a triple bond between carbon atoms in C_2H_4 and C_2H_2 molecules.

Ans 10: C_2H_4:

The electronic configuration of C-atom in the excited state is:

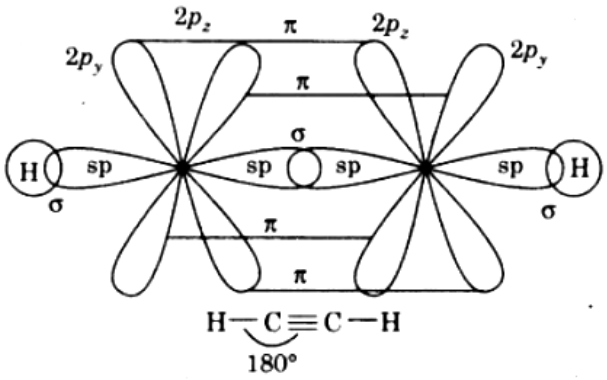
C – 6, $1s^2$, $2s^2$, $2p_x^1$, $2p_y^1$, $2p_z^1$

In the formation of an ethane molecule (C2H4), one sp 2 hybrid orbital of carbon overlaps a sp^2 hybridized orbital of another carbon atom, thereby forming a C-C sigma bond. The remaining two sp^2 orbitals of each carbon atom form a sp^2 -s sigma bond with two hydrogen atoms. The unhybridized orbital of one carbon atom undergoes sidewise overlap with the orbital of a similar kind present on another carbon atom to form a weak π-bond.



C_2H_2:

In the formation of C_2H_2 molecule, each C–atom is sp hybridized with two 2p-orbitals in an unhybridized state. One sp orbital of each carbon atom overlaps with the other along the internuclear axis forming a C–C sigma bond. The second sp orbital of each C–atom overlaps a half-filled 1s-orbital to form a σ bond. The two unhybridized 2p-orbitals of the first carbon undergo sidewise overlap with the 2p orbital of another carbon atom, thereby forming two pi (π) bonds between carbon atoms. Hence, the triple bond between two carbon atoms is made up of one sigma and two π-bonds.



Que 11: Explain the formation of H_2 molecule on the basis of valence bond theory.

Ans 11: Let us assume that two hydrogen atoms (A and B) with nuclei (N_A and N_B) and electrons (e_A and e_B) are taken to undergo a reaction to form a hydrogen molecule. When A and B are at a large distance, there is no interaction between them. As they begin to approach each other, the attractive and repulsive forces start operating.

Attractive force arises between:

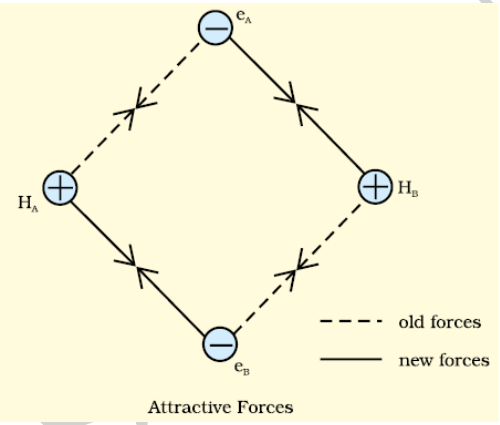
(a) Nucleus of one atom and its own electron i.e., $H_A - e_A$ and $H_B - e_B$.

(b) Nucleus of one atom and electron of another atom i.e., $H_A - e_B$ and $H_B - e_A$.

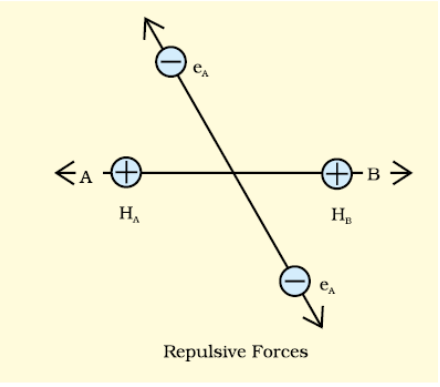
Repulsive force arises between:

(a) Electrons of two atoms i.e., $e_A - e_B$.

(b) Nuclei of two atoms i.e., $H_A - H_B$. The force of attraction brings the two atoms together, whereas the force of repulsion tends to push them apart.



Attractive Forces



Repulsive Forces

The magnitude of the attractive forces is more than that of the repulsive forces. Hence, the two atoms approach each other. As a result, the potential energy decreases. Finally, a state is reached when the attractive forces balance the repulsive forces and the system acquires minimum energy. This leads to the formation of a dihydrogen molecule.

Que 12. Write the important conditions required for the linear combination of atomic orbitals to form molecular orbitals.

Ans 12: The given conditions should be satisfied by atomic orbitals to form molecular orbitals:

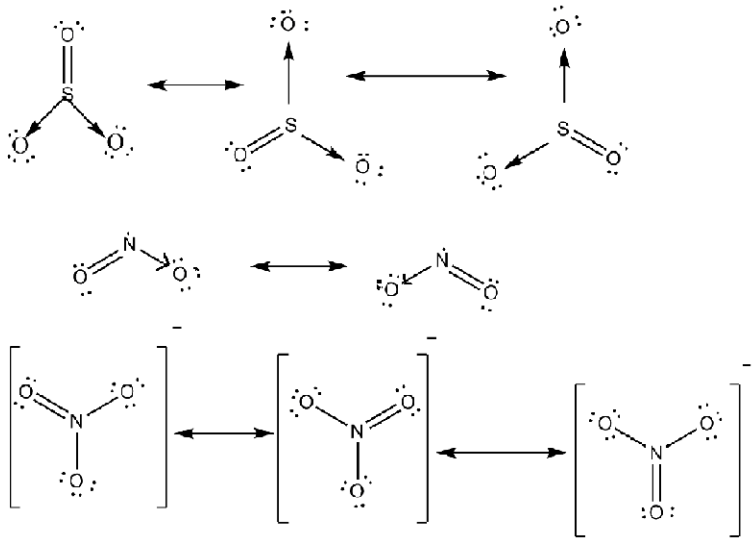
(a) The combining atomic orbitals must have the same or nearly the same energy. This means that in a homonuclear molecule, the 1s-atomic orbital of an atom can combine with the 1s-atomic orbital of another atom, and not with the 2s-orbital.

(b) The combining atomic orbitals must have proper orientations to ensure that the overlap is maximum.

(c) The extent of overlapping should be large.

Que 13. Write the resonance structures for SO_3, NO_2 and NO_3^-.

Ans 13.



Que 14. Compare the relative stability of the following species and indicate their magnetic properties; O_2, O_2^+, O_2^- (superoxide), O_2^{2-} (peroxide).

Ans 14:

$$O_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2$$
$$= \pi 2p_y^2, \pi^* 2p_x^1 = \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{10-6}{2} = \frac{4}{2} = 2.0$$

$$O_2^- = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2$$
$$= \pi 2p_y^2, \pi^* 2p_x^2 = \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{10-7}{2} = \frac{3}{2} = 1.5$$

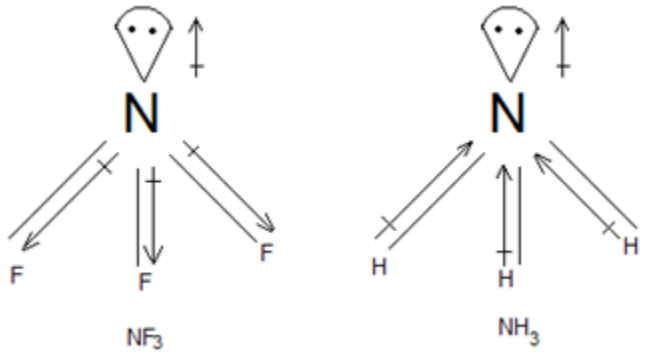
$$O_2^{2-} = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2p_z^2, \pi 2p_x^2$$
$$= \pi 2p_y^2, \pi^* 2p_x^2 = \pi^* 2p_y^2$$

$$\text{Bond order} = \frac{10-8}{2} = \frac{2}{2} = 1.0$$

$$O_2^+ = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2$$
$$= \pi 2p_y^2, \pi^* 2p_x^1 = \pi^* 2p_y^0$$

Que 15: Which out of NH_3 and NF_3 has higher dipole moment and why?

Ans 15: 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.

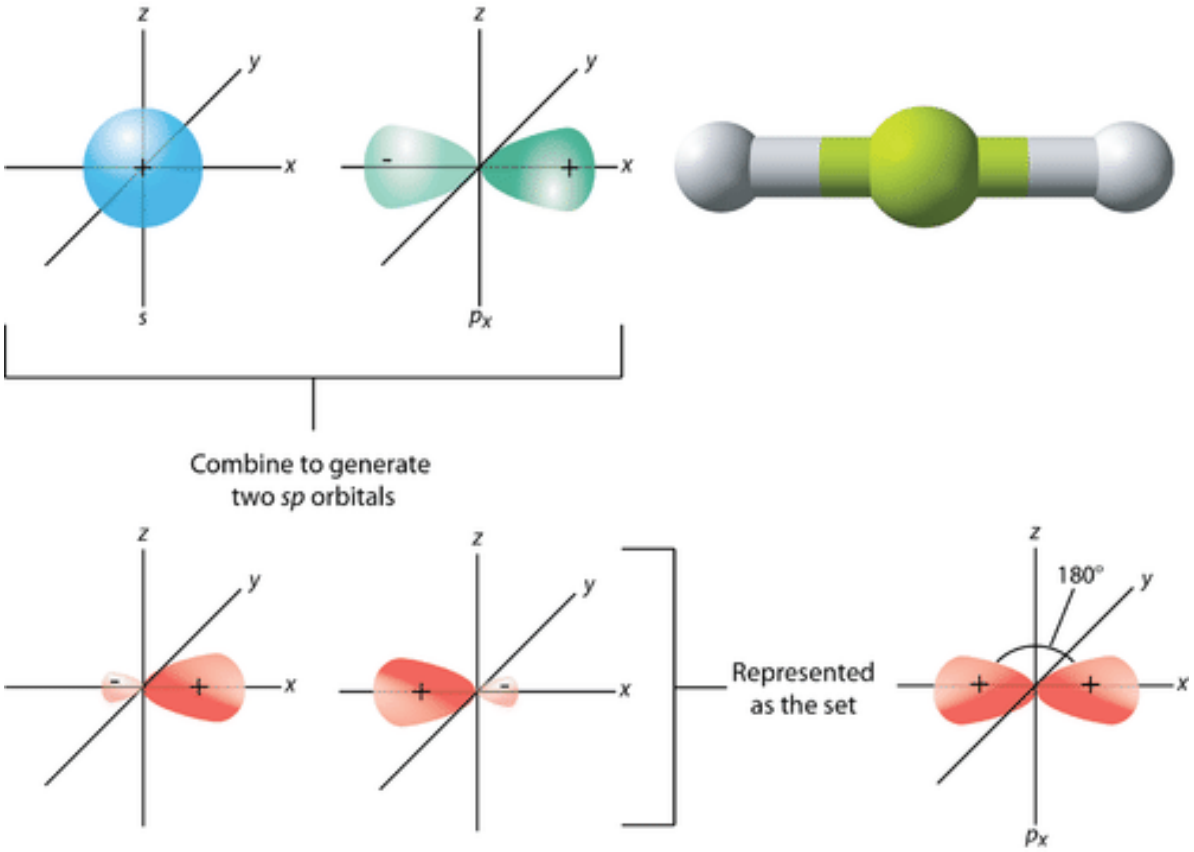
Que 16. What is meant by hybridisation of atomic orbitals? Describe the shapes of sp, sp^2, sp^3 hybrid orbitals.

Ans 16: 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 2s-orbital hybridizes with two 2p-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.

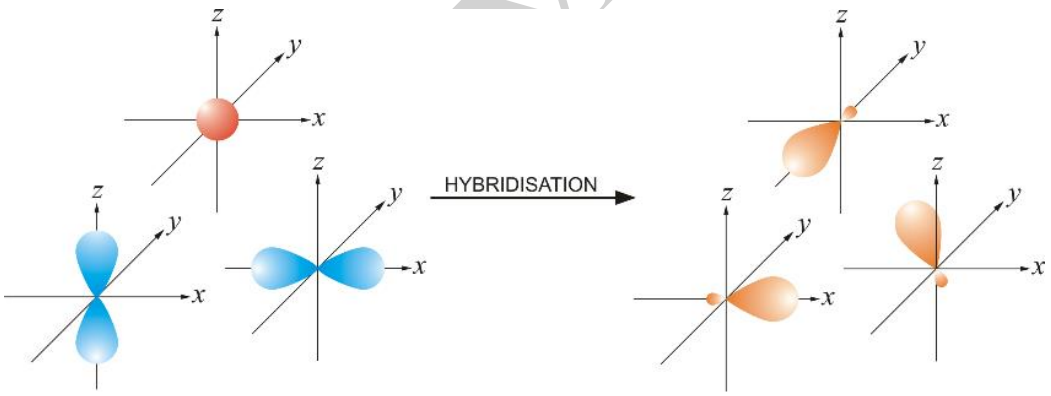
Shape of sp hybrid orbitals:

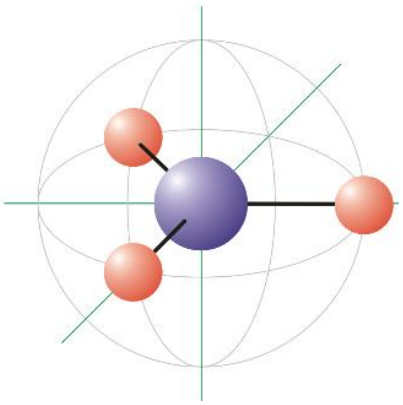
sp hybrid orbitals have a linear shape. They are formed by the intermixing of s and p orbitals as:



Shape of sp^2 hybrid orbitals:

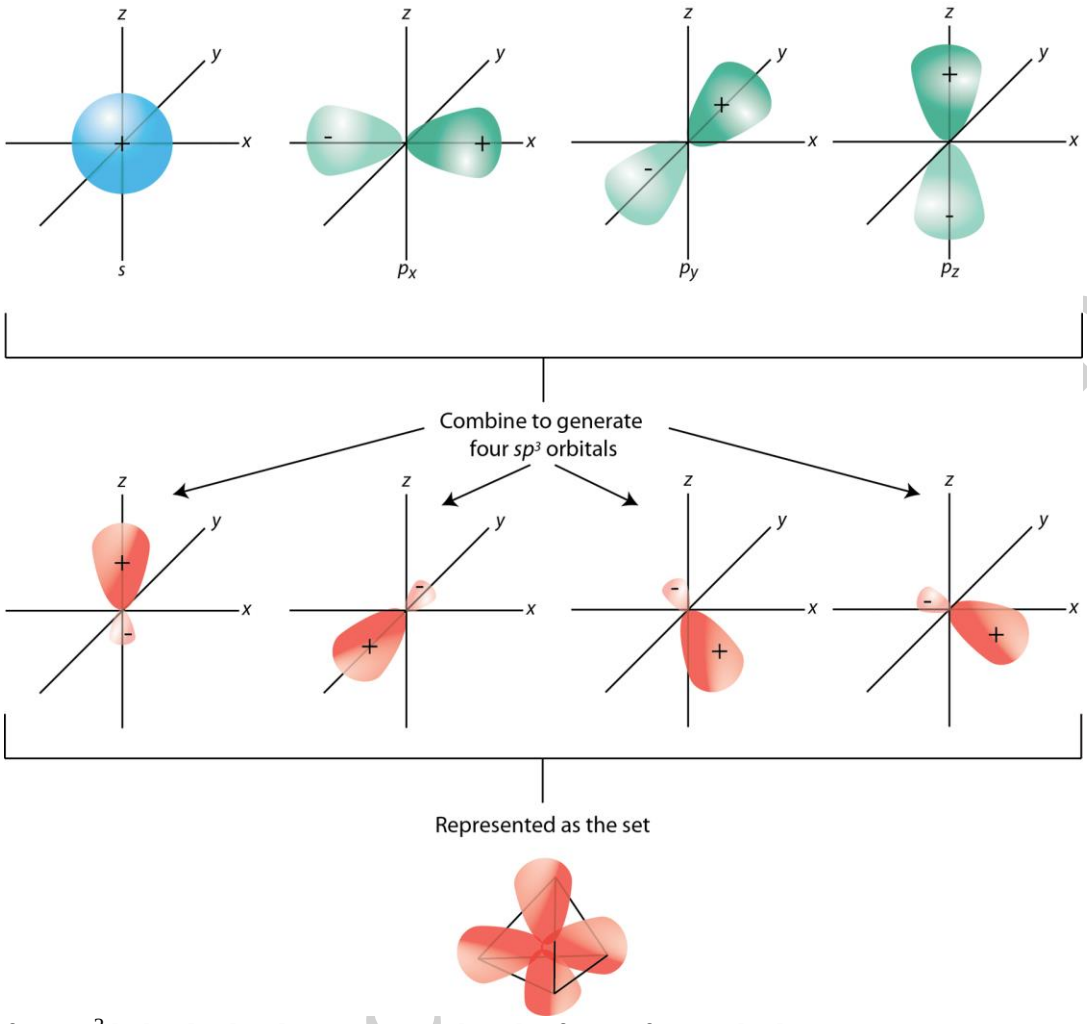
sp^2 hybrid orbitals are formed as a result of the intermixing of one s-orbital and two 2p-orbitals. The hybrid orbitals are oriented in a trigonal planar arrangement as:





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:

Que 17: How is VB theory different from Lewis's concept in regard to the formation of covalent bond?

Ans 17. (i) Lewis's concept considers the formation of covalent bond by mutual sharing of electrons. VB theory considers the formation of covalent bond by overlap of half-filled atomic orbitals.

(ii) Lewis's concept does not provide explanation for different shapes of molecules but VB theory does explain molecular shapes.

(iii) Lewis's concept does not explain the bond strength but VB theory is able to explain it

Que 18. Explain:

(i) Why melting point of MgO (2800°C) is much higher than that of BaO (1920°C)?

(ii) Why solubility of $MgCl_2$ much greater than that of MgF_2?

(iii) Why AlF_3 is a high melting solid whereas SiF4 is a gas?

Ans 18. (i) Lattice enthalpy of MgO is higher than that of BaO due to relatively larger size of Ba^{2+} ion.

(ii) Size of Cl^- ions are larger than F^- ions consequently, Lattice enthalpy of $MgCl_2$ is smaller than that of MgF_2. Due to smaller value of $\Delta_L H°$ of $MgCl_2$, its solubility in water is relatively more.

(iii) AlF_3 is ionic compound while SiF_4 is a non-polar covalent compound. Hence interparticle forces in AlF_3 are quite strong.

Que 19. What do you understand by dipole moment? Give its SI units.

Ans 19. A dipole consists of a positive and negative charge (equal in magnitude) separated by a distance within a molecule. Dipole moment is defined as the product of the magnitude of charge on any one of the atoms and the distance between them. Dipole moment is represented by μ (mu).

μ = charge (q) × distance of separation (r)

Dipole moment is usually expressed in debye units (D).

The conversion factor is $1D = 3.34 \times 10^{-30}$ Cm

where C is coulomb and m is metre. Dipole moment is a vector quantity and is depicted by a small arrow with tail on the positive centre and head pointing towards the negative centre.

The shift in electron density is symbolised by crossed arrow () above the Lewis structure to indicate the direction of the shift.

Que 20. Explain the following:

(i) CCl_4 and $SiCl_4$ both are tetrahedral.

(ii) BF_3 and NF_3 are not isostructural.

(iii) The HSH angle in H_2S is close to 90° while HOH angle in H_2O is 104.5°.

Ans 20. (i) In both CCl_4 and $SiCl_4$, the central atom is sp3 hybridised. Both are AX_4 type molecules without any lone pair of electrons present on the central atom. Hence CCl_4 and $SiCl_4$, both are tetrahedral is shape.

(ii) In BF_3, the B atom is sp^2 hybridised (AX_3). The shape is trigonal planar. In NF_3, N atom is sp^3 hybridised due to the presence of one lone pair of electrons on N atom, the shape is reduced from tetrahedral to trigonal pyramidal.

(iii) In H_2O, O atom is sp^3 hybridised. But due to the repulsion between lone pair-lone pair of electrons on O-atom, the angle is reduced to 104.5° from 109°. In H_2S, S is less electronegative than O atom, so bond pair-bond pair repulsion is less than H_2O.