HINTS & SOLUTIONS

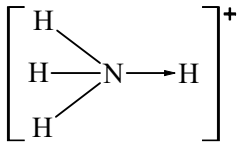
Chemical bonding and Molecular Structure

[Set-2]

SECTION-A

1. (i): In BF_3, B has only six electrons in its valence shell. Also, in $AlCl_3$, Al has six electron in its valence shell. Both are hypovalent molecules.

2. (i) NH_4^+



3. (i): SO_2 $S \rightarrow sp^2$

CO_2 $C \rightarrow sp$

OH_2 $O \rightarrow sp^3$

Cl_2O $O \rightarrow sp^3$

4. (iv): $O_2 : \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2 \left[\begin{matrix}\pi 2p_x^2 \\ \pi 2p_y^2\end{matrix}\right] \left[\begin{matrix}\pi^* 2p_x^1 \\ \pi^* 2p_y^1\end{matrix}\right]$

two unpaired electrons

O_2^+ has only one, F_2 and N_2 do not have any unpaired electron present.

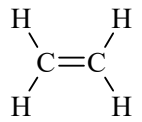
5. (ii): SO_3 $AX_3 \rightarrow$ trigional planar

XeO_3 $AX_3E \rightarrow$ trigonal pyramidal

BF_3 $AX_3 \rightarrow$ trigonal planar

ClF_3 $AX_3E_2 \rightarrow$ distorted T-shape

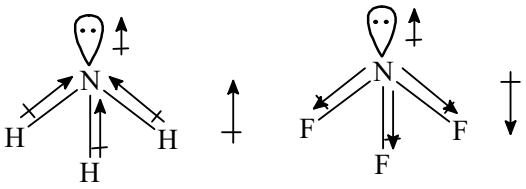
6. (ii):



ethene (one pi boond)
$C \rightarrow sp^2$

ethyne (two pi bonds)
$C \rightarrow sp$

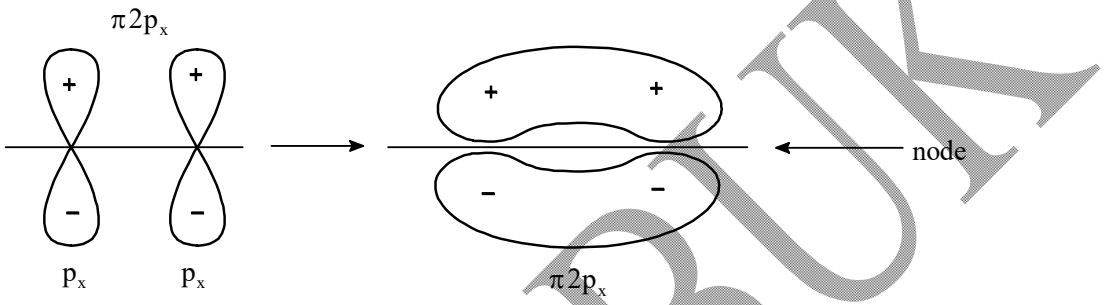
7. (iii): NH_3 has a higher value of dipole moment because the orbital dipole and the resultant of the three bond dipoles are in the same direction.



$\mu_1 \neq 0$ $\mu_2 \neq 0$

But $\mu_1 > \mu_2$

8. (ii):



9. (i): O_2 and N_2^{2-} both are isoelectronic (16 electrons each), and both have same bond order of 2.0.

10. (iv): O_2: $\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2 \begin{bmatrix} \pi 2p_x^2 \\ \pi 2p_y^2 \end{bmatrix} \begin{bmatrix} \pi^* 2p_x^1 \\ \pi^* 2p_y^1 \end{bmatrix}$

Number of bonding electrons = 10.

11. (i) Sigma bond is stronger than pi bond as it is formed by overlapping of atomic orbitals along the internuclear axis.

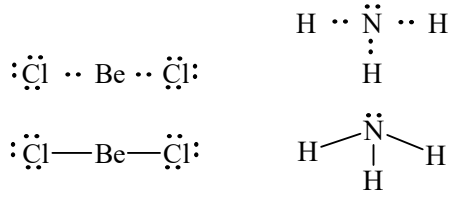
(ii) OCS has a higher value of the dipole moment than CS_2 although both are linear. This is due to higher polar nature of carbon, oxygen bond.

O═C═S S═C═S
$\mu \neq 0$ $\mu \neq 0$

12. (i)

H_2O	<	SO_2	<	CO_2
105°		118°		180°
due to LP – LP repulsion		due to LP – BP repulsion		linear

(ii) (a)



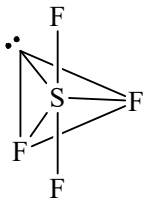
OR

(i) SF_4

AX_4E

Distorted trigonal bipyramid

$S \rightarrow sp^3d$

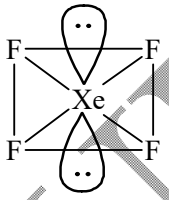


(ii) XeF_4

AX_4E_2

Square planar

$Xe \rightarrow sp^3d^2$



13. (i) H_2^+ has more stability due to absence of any electron in the higher energy antibonding molecular orbital.

H_2^- has one electron in the antibonding molecular orbital.

$H_2^+ : \sigma 1s^1$

$H_2^- : \sigma 1s^2 \ \sigma^* 1s^1$

(ii) N_2^+ (no of electrons = 13)

$$\sigma 1s^2 \ \sigma^* 1s^2 \ \sigma 2s^2 \ \sigma^* 2s^2 \begin{bmatrix} \pi 2p_x^2 \\ \pi 2p_y^2 \end{bmatrix} \sigma 2p_z^1$$

$$B.O = \frac{9-4}{2} = 2.5$$

N_2^- (no. of electron = 15)

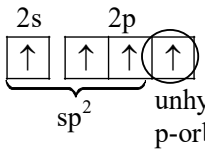
$$\sigma 1s^2 \ \sigma^* 1s^2 \ \sigma 2s^2 \ \sigma^* 2s^2 \begin{bmatrix} \pi 2p_x^2 \\ \pi 2p_y^2 \end{bmatrix} \sigma 2p_z^2 \begin{bmatrix} \pi^* 2p_x^1 \\ \pi^* 2p_y^0 \end{bmatrix}$$

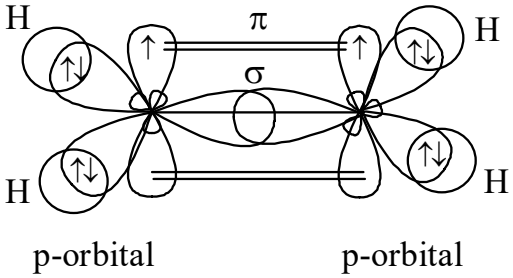
$$B.O = \frac{10-5}{2} = 2.5$$

(iii) HF has a higher boiling point than HCl, due high electronegativity of F, H – F bond is highly polar and HF is highly associated via intermolecular hydrogen bonding.

14. In ethene, each carbon atom is sp^2 hybridised and one unhybridised p-atomic orbital is used in pi bond formation.

Each C atom has C(ex. States) [He]

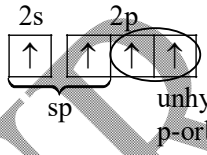


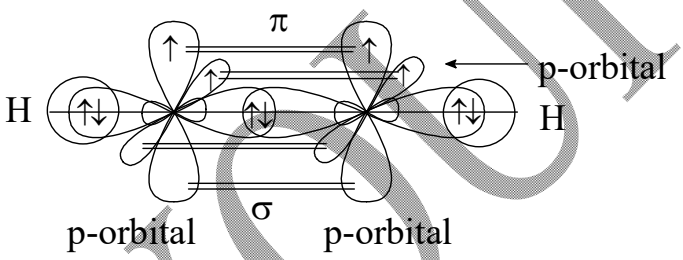


OR

In ethyne, each carbon atom is sp hybridized and two unhybridised p-atomic orbitals are used in pi bond formation, which are perpendicular to each other, as well as perpendicular to carbon-carbon sigma bond.

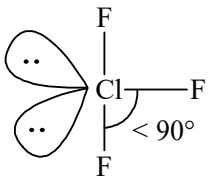
Each C atom has C(ex.state) (He)



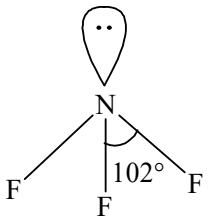


15. (a) ClF_3 and NF_3 are not isostructural because they have different number of lone pair of electrons

$ClF_3 \rightarrow AX_3E_2 \rightarrow$ distorted T-shaped



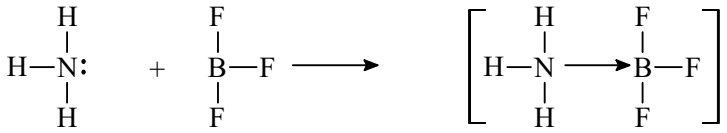
$NF_3 \rightarrow AX_3E \rightarrow$ trigonal pyramidal



(b) In PCl_5, P is sp^3d hybridized and shape is trigonal bipyramid. The Cl atoms at 90° bond angle repel each other more strongly then Cl atoms at 120°. As a result, axial P – Cl bonds are slightly longer than the equatorial P – Cl bonds. Hence, all five P – Cl bonds in PCl_5 are not equal in length.

(c) $C_6H_{12}O_6$ contain five polar O – H groups, through which it can form hydrogen bonds with water. Hence, glucose is soluble in water

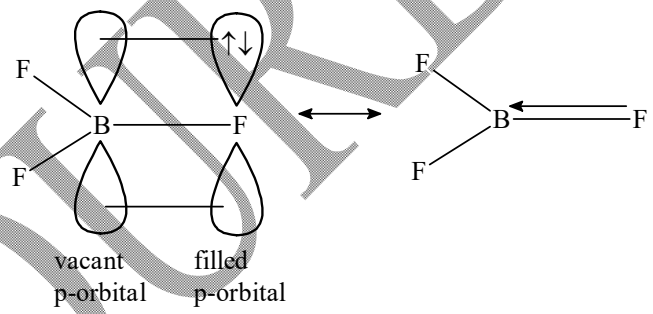
(ii)



$N \rightarrow sp^3$	$B \rightarrow sp^2$	$N \rightarrow sp^3$	$B \rightarrow sp^3$
AX_3E	AX_3	AX_4	AX_4
trigonal pyramidal	trigonal planar	tetrahedral	tetrahedral
107°	120°	109°	109°

OR

(i) (a) B – F bond in BF_3 is slightly shorter than the B – F bond in BF_4^-. This is due to the dative pi bond and double bond character.



(b) H_2O is highly associated via intermolecular hydrogen tending. That's why water is a liquid at room temperature. In H_2S, due to large size and less electronegativity of S, S – H bond is less polar. There is no hydrogen bonding in H_2S. H_2S is a discrete molecule and has weak vander Waal's forces. Hence, H_2S is a gas.

(c) C_2 molecule has a bond order of two. It means there is a double bond in C_2 molecule and is consists of two pi bonds because of the presence of four electrons is two pi molecular orbitals.

(ii) F_2 (total number of electron = 18)

Its molecular orbital electronic configuration is

$$\sigma 1s^2 \ \sigma^* 1s^2 \ \sigma 2s^2 \ \sigma^* 2s^2 \ \sigma 2p_z^2 \begin{bmatrix} \pi 2p_x^2 \\ \pi 2p_y^2 \end{bmatrix} \begin{bmatrix} \pi^* 2p_x^2 \\ \pi^* 2p_y^2 \end{bmatrix}$$

$N_B = 10$ $N_A = 8$

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

Since, there is no unpaired electron present, F_2 molecule is diamagnetic.

Molecular orbital energy level diagram of F_2 is