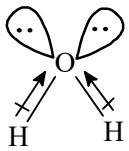
HINTS & SOLUTIONS

Chemical bonding and Molecular Structure

[Set-1]

SECTION-A

1. (iv): H_2O has a highest value of dipole moment due to its bent structure and two lone pair of electron on the electronegative oxygen atom.



2. (iii): $NF_3 : AX_3E$

   $SO_3: AX_3$

   $XeF_2 : AX_2E_3$

   $ClF_3 : AX_3E_2$

3. (i): H_2 has no unpaired electron present. Other molecule/molecule ions have one or more unpaired electron parent.

4. (iii): NH_2^- $N \rightarrow sp^3$ AX_2E_2

   H_3O^+ $O \rightarrow sp^3$ AX_3E

   CO_3^{2-} $C \rightarrow sp^2$ AX_3

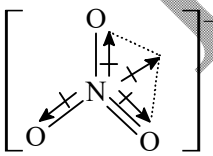
5. (ii) $I_3^- \rightarrow AX_2E_3 \rightarrow$ linear

   $PH_4^+ \rightarrow AX_4 \rightarrow$ tetrahedral

   $CS_2 \rightarrow AX_2 \rightarrow$ linear

   $SF_4 \rightarrow AX_4E \rightarrow$ sea – saw

6. (i):

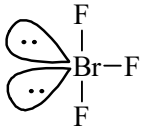


   $N - sp^2 \rightarrow$ trigonal planer

   $\mu = 0$

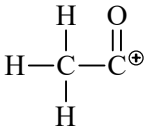
7. (ii): $H_3N: + H^+ \rightarrow \left[H-\underset{H}{\overset{H}{N}}-H \right]^+$ $N \rightarrow sp^3$

$H_2\ddot{O}: + H^+ \rightarrow \left[\underset{H}{\overset{H}{\ddot{O}}}-H \right]^+$ $O \rightarrow sp^3$

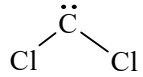
8. (ii): 

Br has 10 electrons in its valence shell, has an expanded octet.

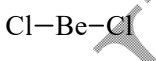
9. (ii): Because positively charged carbon has an incomplete octet with only six electron.



10. (iv): In all three molecules central atom has less than eight electrons. All three are hypovalent molecules.



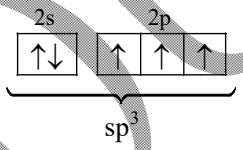
(six electrons)



(four electrons)

(six electrons)

11. NH_3 (Ammonia)

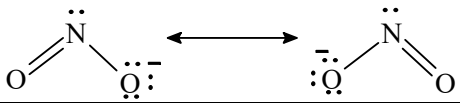
$_7N$ (ground state): (He) 

There are four sp^3 hybrid orbitals aligned in tetrahedral fashion at an angle of 109°. Each sp^3 hybrid then overlap with 1s orbital of hydrogen to form sigma bond. One of the sp^3 orbital contain lone pair of electron.

Due to lone pair-bond pair repulsions, NH_3 is trigonal pyramidal with a bond angle of 107°. The hybridization of N remain same (sp^3) where NH_3 changes to NH_4^+.

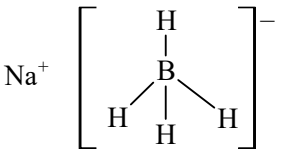
12. Resonance is defined as the phenomenon in which the molecule/ion can be represented by more than one Lewis dot structure. Resonance involves the delocalization of pi bond.

Nitrite ion, NO_2^-



OR

$NaBH_4 \rightarrow$ sodium borohydride, its structure is



B is sp^3 hybridised.

Types of bonds present are:

(i) Ionic

(ii) Covalent

(iii) Coordinate covalent

13. Bond order is defined as the half of the difference of bonding electrons and anti bonding electrons.

$$\text{Bond order} = \frac{1}{2}(N_B - N_A)$$

(i) $\underset{\text{B.O = 3.0}}{N_2} \longrightarrow \underset{\text{B.O = 2.5}}{N_2^+} + e^-$

Bond order decreases by 0.5 because the electron has been removed from $\sigma 2p_z$ bonding molecular orbital

$$\underset{\text{B.O = 2.0}}{O_2} \longrightarrow \underset{\text{B.O = 2.5}}{O_2^+} + e^-$$

Bond order increases by 0.5 because the electron has been removed from $\pi^* 2p_x$ (or $\pi^* 2p_y$) anti bonding molecular orbital.

14. (i) $\underset{\text{(no unpaired electron)}}{C_2} < \underset{\text{(one unpaired elecrtron)}}{F_2^-} < \underset{\text{(two unpaired electrons)}}{O_2}$

(ii) $\underset{\text{(less than 90°)}}{ClF_3} < \underset{\text{(102°)}}{NF_3} < \underset{\text{(120°)}}{BF_3}$

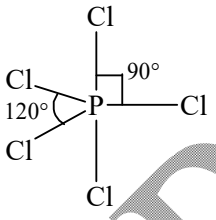
(iii) $\underset{\text{(linear)}}{CO_2} < \underset{\text{(linear but O and S have different electronegativity)}}{OCS} < \underset{\text{(bent)}}{SO_2}$

OR

(i)

	Sigma bond		Pi bond
(a)	Sigma bond is formed by end to end overlapping of atomic orbital	(a)	Pi bond is formed by lateral or sideways overlapping of atomic orbitals.
(b)	Sigma bond is a strong bond.	(b)	Pi bond is weaker than sigma bond.
(c)	Sigma bond is formed first.	(c)	Pi bond is formed after the formation of sigma bond.
(d)	Sigma bond allows free rotation about the bond.	(d)	Pi bond restricts free rotation, it makes the molecule rigid.

(ii)



Cl atoms at 90° bond angle repel each other more strongly than Cl atom at 120°. As a result, axial P – Cl bonds are longer than the equatorial P – Cl bonds. Hence, PCl_5 is highly reactive.

15. (i) Melting point increases as charge to size ratio of metal ion increases lattice enthalpy increases. The increasing melting point order is

$NaCl < MgCl_2 < AlCl_3$

(ii) (a) NO is an odd electron molecule with a bond order of 2.5 Removal of electron from NO increases the bond order to 3.0 in NO^+. Hence, NO^+ is more stable than NO.

(b) H_2O has a higher boiling point than HF because H_2O is more highly associated via intermolecular hydrogen bonding than HF.

(iii) $\overset{\cdot\cdot}{\underset{(1)}{O}}\equiv C-\overset{\cdot\cdot}{\underset{(2)}{O}}:$

Formal charge = valence electrons – number of non-bonding electrons – ½ × (number of bonding electrons).

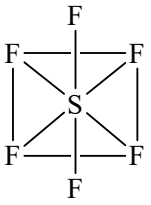
Formal charge on carbon $= 4 - 0 - \frac{1}{2} \times 8 = 0$

Formal charge on oxygen (1) = 6 – 2 – ½ × 6 = + 1

Formal charge on oxygen (2) = 6 – 6 – ½ × 2 = – 1

OR

(i) $S \rightarrow sp^3d^2$ hybrdised



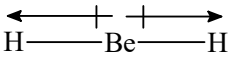
(ii) (a) Be_2 molecule does not exist because it has a bond order equals to zero

Be_2 (number of electron = 8)

$\sigma 1s^2 \quad \sigma^* 1s^2 \quad \sigma 2s^2 \quad \sigma^* 2s^2$

$$\text{Bond order} = \frac{N_B - N_A}{2} = \frac{4-4}{2} = 0$$

(b) BeH_2 is a linear molecule



$\mu = 0$

(iii) According to Fajan's rules, covalent character increases with

(1) Small size of cation

(2) large size of anion

(3) High charge on both the ions

(a) $FeCl_3$ is more covalent than $FeCl_2$

(b) Al_2O_3 is more covalent than MgO.

