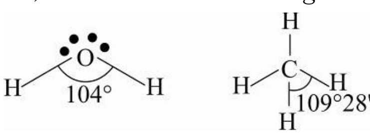
Solutions to Workbook-1 [Chemistry] | Chemical Bonding-I & II

Daily Tutorial Sheet	Level - 0

Short Answer Type-I (2 Marks)

1. Bond length is defined as the equilibrium distance between the nuclei of two bonded atoms in a molecule.
Yes, double bonds are stronger than single bond.

2. 

Both H_2O and CH_4 are sp^3 hybridized-Bond angle of water is less than CH_4 because of lone pair-bond pair repulsion.

3. Bond order is given by number of bonds between the two atoms in a molecule.

Bond order $\propto$ Bond Energy $\propto \dfrac{1}{\text{Bond length}}$.

$\therefore$ As bond order increases, bond length decreases.

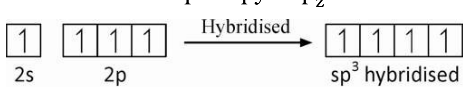
4. **(a)** SF_6 **(b)** PF_5 **(c)** ClF_3

5. NH_4^+ : Tetrahedral N_3^- : Linear CO_3^{2-} : Trigonal Planar SO_2 : Angular

6. Methane i.e. CH_4 is sp^3 hybridised.

C in ground state : $2s^2 2px^1 2py^1$

C in excited state : $2s^1\ 2px^1\ 2py^1\ 2p_z^1$



7. Example of molecule exhibiting sp^3d^2 hybridisation : SF_6, it is possible for d-orbitals to mix with lower energy s and p orbital due to d-orbital contraction caused by electronegative atom.

8. Due to polar nature of water, there is association of water molecules giving a liquid state of abnormally high Boiling Point.

9. Yes, can participate in hydrogen-Bonding. It acts as hydrogen acceptor $(H_3C)_2C=O\cdots H-O-H$

10. MgO has higher lattice energy because each ion carries two unit charge whereas in NaCl each ion carries one unit charge.

11. NaCl is an ionic compound and hence gives Cl^- ions in the solution which combine with Ag^+ ions given by $AgNO_3$ to form a white precipitate of AgCl but CCl_4 is a covalent compound and does not give Cl^- ions.

12. $\sigma-$bond is stronger. This is because $\sigma-$ bond is formed by head-on overlapping of atomic orbitals and, therefore, the overlapping is large. $\pi-$ bond is formed by sidewise overlapping which is small.

13. C–H (C_2H_6) > C–H (C_2H_4) > C–H(C_2H_2). This is because hybrid orbitals of carbon involved in overlapping with $1s$ orbital of hydrogen are sp^3, sp^2 and sp respectively and their sizes are in the order $sp^3 > sp^2 > sp$.

Short Answer Type-II (3 Marks)

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

Bond energy – it is defined as the amount of energy required to break one mole of bond of a particular type in gaseous state Bond energy $\propto \frac{1}{\text{Bond length}}$.

15. E.C of F_2 : $(\sigma 1s)^2 (\sigma * 1s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2px)^2 (\pi 2py)^2 (\pi * 2px)^2 (\pi * 2py)^2$

E.C. of F_2^+: $(\sigma 1s)^2 (\sigma * 1s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2px)^2 (\pi 2py)^2 (\pi * 2px)^2 (\pi * 2py)^1$

E.C. of F_2^- : $(\sigma 1s)^2 (\sigma * 1s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2px)^2 (\pi 2py)^2 (\pi * 2px)^2 (\pi * 2py)^2 (\sigma * 2p_z)^1$

Bond Order of $F_2 = \frac{10 - 8}{2} = 1$

Bond Order of F_2^+ : $\frac{10 - 7}{2} = 1.5$

Bond Order of $F_2^- = \frac{10 - 9}{2} = 0.5$

Bond Energy Order : $F_2^+ > F_2 > F_2^-$ [Bond energy $\propto$ Bond order]

16. E.C. of O_2 : $(\sigma 1s)^2 (\sigma 1^* s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2px)^2 (\pi 2py)^2 (\pi * 2px)^1 (\pi * 2py)^1$

E.C. of O_2^+ : $(\sigma 1s)^2 (\sigma * 1s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2px)^2 (\pi 2py)^2 (\pi * 2px)^1$

E.C. of O_2^- : $(\sigma 1s)^2 (\sigma * 1s)^2 (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\pi * 2p_x)^2 (\pi * 2p_y)^1$

	B.O.	**Number of Unpaired** e^-	**Magnetic character**
O_2	$\frac{10-2}{2} = 2$	2	Paramagnetic
O_2^+	$\frac{10-5}{2} = 2.5$	1	Paramagnetic
O_2^-	$\frac{10-7}{2} = 1.5$	1	Paramagnetic

17. E.C. of N_2 : $(\sigma_{1s})^2 (\sigma_{1s}^*)^2 (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi 2px)^2 (\pi 2py)^2 (\sigma 2p_z)^1$

E.C. of N_2^+ : $(\sigma_{1s})^2 (\sigma_{1s}^*)^2 (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\sigma 2p_z)^1$

Bond Order of $N_2 = \frac{10 - 4}{2} = 3$

Bond Order of $N_2^+ = \frac{9 - 4}{2} = 2.5$

Bond energy $\propto$ bond order

Bond energy of $N_2^+ < N_2$ $\therefore$ Bond dissociation energy of N_2^+ is less than N_2

18. Ne_2 do not exist

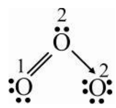
$He_2 : (\sigma_{1s})^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\pi^* 2p_x)^2 (\pi^* 2p_y)^2 (\sigma^* 2p_z)^2$

Bond Order of $Ne_2 = \frac{10 - 10}{2} = 0$

F_2^- : Refer Ans. 10

Bond Order = 0.5.

Ne_2 do not exist but F_2^- exist.

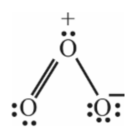
19. Lewis structure of O_3 is : 

The atom have been numbered as 1, 2, 3

Formal charge on end O-atom numbered 1 = $6 - 4 - \frac{1}{2}(4) = 0$

Formal charge on central O-atom numbered 2 = $6 - 2 - \frac{1}{2}(6) = +1$

Formal charge on end O-atom numbered 3 = $6 - 6 - \frac{1}{2}(2) = -1$

Hence, we represent O_3 along with formal charges as : 

20. If HCl were 100% ionic, each end would carry charge equal to one unit, viz, 4.8×10^{-10} esu. As bond length of HCl is 1.275 Å , its dipole moment for 100% ionic character would be

$\mu_{ionic} = q \times d = 4.8 \times 10^{-10} esu \times 1.275 \times 10^{-8} cm = 6.12 \times 10^{-18} esu\,cm = 6.12D$

$\mu_{observed} = 1.03D(\text{given})$ $\therefore$ % ionic character $= \frac{\mu_{observed}}{\mu_{ionic}} \times 100 = \frac{1.03}{6.12} \times 100 = 16.83\%$

21. **(i)** C_2H_2 : sp hybridised H_2O : sp^3 hybridised

BF_3 : sp^2 hybridised

CH_4 : sp^3 hybridised

NH_3 : sp^3 hybridised

$C_2H_2(180°) > BF_3(120°) > CH_4(109°28') > NH_3(107°) > H_2O(104.5°)$

(ii) $NH_4^+ > NH_3 > NH_2^-$

This is because all of them involve *sp^3* hybridization. The number of lone pair of electrons present on N-atom are 0,1 and 2 respectively. Greater the number of lone pairs, greater is the $(\ell \cdot p - b \cdot p)$ repulsions and hence smaller is the angle.

Long Answer Type (5 Marks)

22. Phenomenon that results from hydrogen – Bonding :

(a) Higher Boiling point of NH_3, H_2O and HF compared to PH_3, H_2S and HCl

(b) Dimer formation in carboxylic acid

(c) High water solubility of many compounds such as ammonia is explained by hydrogen – bonding with water molecules.

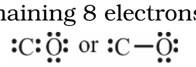
(d) Ice is less dense than liquid water due to a crystal structure stabilized by hydrogen-bonding

(e) Hydrogen Bonding also plays an important role in determining the three-dimensional structure adopted by proteins and nucleic bases.

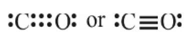
23. Step 1 : Total number of valence electrons in CO = 4 + 6 = 10.

Step 2 : Skeletal structure is C – O

Step 3 : Putting a single bond between C and O, i.e., one shared pair of electrons between C and O, and the remaining 8 electrons as 3 lone pairs on O to complete its octet and 1 lone pair on C, we have



Step: 4 As in this structure, octet of C is not complete, multiple bonding is required between C and O. To complete the octet of C, triple bond is required between C and O. We should, therefore, shift two lone pairs on O as shared pairs between C and O so that octet of both C and O remains complete. Thus, the structure should be

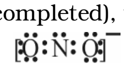


24. Step 1: N = 2,5, O = 2, 6, –ve charge = 1 $\therefore$ Total no. of valence electrons in NO_2^- = 5 + 2 × 6 + 1= 18 = 9 pairs.

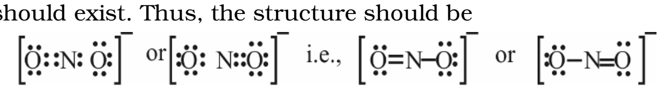
Step 2: Skeletal structure of NO_2^- will be O N O

Step 3: Putting a single bond (one shared pair) between O and N and N and O, we have

Step 4: Putting the remaining 7 pairs of electrons as lone pairs, 3 on each O and 1 on N (so that octets of O are completed), we have



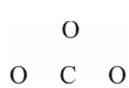
Step 5: As octet of N is not complete, multiple bonding is required. As N is short of only one pair of electrons, one pair from O should be shifted as shared pair between O and N or N and O, i.e., a double bond should exist. Thus, the structure should be



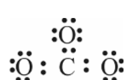
25. Step 1: Total number of valence electrons of CO_3^{2-} = 4 + 3 × 6 = 22

Step 2 : total number of electrons to be distributed in CO_3^{2-} = 22 + 2

Step 3 : The skeletal structure of CO_3 is



Step 4 : Putting one shared pair of electrons between each C and O and completing the octets of oxygen, we have



In this structure, octet of C is not complete. Hence, multiple bonding is required between C and one of the O-atoms. Drawing a double bond between C and one O-atom serves the purpose: