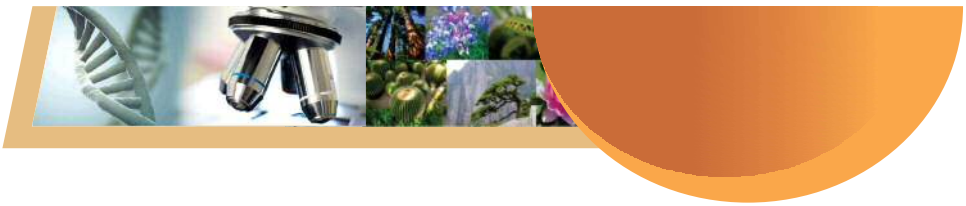
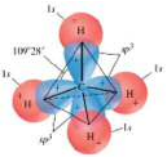




Chapter - 4

Chemical Bonding And Molecular Structure

1. The interaction between two atoms which holds them together within a molecule or ions in known as chemical bond.
2. The elements with one, two, three, four, five, six or seven electrons is outer shell, use these electrons to complete octet. The electrons which take part in two or more atoms to complete octet is known as electrovalency.
3. Lewis symbols or electron dot symbols involve the presentation of valence electrons (outer electrons) in an atom $\dot{N}a$, $Mg\dot{:}$, $\dot{A}l\cdot$, $\dot{S}\dot{i}\cdot$ etc.
4. Electrovalent bond or ionic Bond : The bond (chemical interaction) between two atoms formed by complete transference of electron from valence shell (outer shell) of an atom to another to complete octet (noble gas configuration) [$2e^-$ in H, Li] is known as ionic bond.
5. This ionic bond is favoured by low ionization enthalpy of metal high electron gain enthalpy of non-metal atom and in the resulting ionic compound more lattice energy.
6. Characteristics of ionic compound : They are solids, a definite arrangement/ pattern of ion (to give crystalline solids), high MP and BP, conductors in fused state and in aqueous medium, soluble in H_2O [Hydration].
7. **Lattice enthalpy :** The energy released when one more of ionic compound is formed from its ions in their gaseous state. Lattice energy is directly proportional to charge of ion nd inversely proportions to size of ions *i.e.*, more is change density more is lattice energy.
8. *e.g.*, $Mg \longrightarrow Mg^{2+} + 2e^-$ $\quad O + 2e^- \longrightarrow O^{2-}$

   (2, 8, 2) $\quad$ (2, 6)

   $Mg^{2+} + O^{2-} \longrightarrow MgO$ Ionic compound [A crystalline lattice].

9. (a) Born Haber Cycle : For formation of ionic compound *e.g.*, Na^+Cl^-.

$$\left.\begin{array}{l} Na_{(S)} \xrightarrow{\text{'S'}} Na_{(g)} \xrightarrow{IE} Na^+_{(g)} \\ \frac{1}{2}Cl \xrightarrow{\frac{1}{2}D} Cl_{(g)} + \xrightarrow[EA]{electron} Cl^-_{(g)} \end{array}\right\} \xrightarrow{LE} Na^+Cl^-_{(S)}$$

$$\Delta H \text{ formation of } NaCl = S + IE + \frac{1}{2}D + EA + Cl$$

[All Energies per mole]

S = Sublimation Energy
IE = Ionization Enthalpy
D = Dissociation Energy
EA = Electron Affinity
LE = Lattice Energy

(b) Ionic bonds are **Non directional** in nature.

10. Fajan's Rule : Polarizability and polorizing power. The power of an ion to distart the other ion is polarising power and the tendency of an ion to get distorted is known as polarizability. Factors affection polarizing power and polarizability.

(a) High charge and small size of C^+.

(b) High charge and large size of A^-.

11. Covalent Bond : Lewis Langmuir Concept

The (chemical interaction) bond formed between two atoms say mutual sharing of electrons between them so. as to complete their octets is known as covalence bond and no. of electrons involved is covalency.

12. Formal charge : Electron of an atom in a molecule/ion

FC = [Total no. of valence in free atom] – [Total no. of non bonding electrons] – $\frac{1}{2}$ [Total no. of stored electrons]

13. The valence bond approach : (a) The two atomic orbitals with one electron each, overlap to give maximum electron density region common to both atoms is known as single covelent bond

e.g., S + S → (i) + → (ii)

(b) The strength of covalent bond is proportional to extent of overlapping between the atomic orbitals of valence shell.

14. Characteristics of covalent compounds—(a) They are in all three physical states solid, liquid, or gas depending upon factors like molecular mass, Vander-wall force, covalency, (S_8), Hydrogen bonding, polarity etc.

(b) These are directional soluble in less polar or non-polar solvents, less

MP and BP [than ionic compounds] Due to weak Vander-Waal forces, bad conductor of electricity (no. free electrons)

15. Hybridization : (a) Phenomenon of intermixing of atomic orbitals with slightly different energies to form new orbitals of equal energy and identical shape. The new orbitals are knows as **hybrid orbitals.**

(b) The number of hybrid orbitals is equal to no. of orbitals mizing.

(c) As the '*s*' character in hybrid orbital inc. electronegativity and size of hybrid orbital inc.

(d) The hybrid orbital can have period e^- as well as unpaired e^-.

16. VSEPR (Valence shell electron pair repulsion theory)

(a) There are three types of repulsion in a covalent molecule *lp - lp* > *lp - bp* > *bp - bp*.

(b) These repulsion depend upon difference in electronegativity between A and B.

(c) The hybridization of central atom decides geometry and VSEPR theory the shape of molecule.

17. Sigma and Pi π bond : (a) The bond formed by overlap of two atomic orbitals along the internuclear axis of two atoms is Sigma bonds.

Degree of overlap is **large therefore strong bond.**

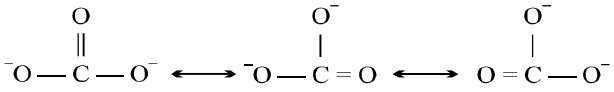
(b) **π bond :** The bond formed by sideways overlap of two atomic orbitals degree of overlap is not along the nuclear axis therefore a weak bond.

(c) A single bond is σ bond; A double bond is one σ one one π bond a triple covalent bond is one σ and 2π bonds.

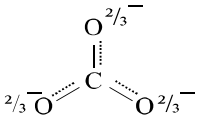
18. Resonance : (a) The delocalization of $2e^-$ in a molecule/ion which results in observed bond length, bond order, bond energy different from normal covalent bond. Data is known as resonance. Various resonating structures have nearly same energy and interconvertible to each other.

(b) It gives stability to the molecule/ion. Atom do not shift their position in any of the resonating structure. The structure which is near to all resonting structure and nearly explain the property of that molecule/ion is known

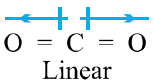
as **resonating hybrid.**



Resonating Hybrid



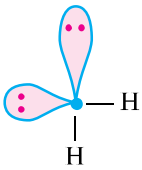
19. Dipole moment : (a) For polar covalent molecules (atoms with difference in electronegativity] the product of charge separation and distance b/w charges is known as dipole moment. (b) Being vector, if net resultant of all vector is zero the molecule has zero DM and known as non **polar otherwise.**



Linear

DM = 0

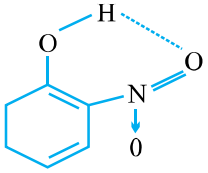
Nonpolar



DM ≠ 0

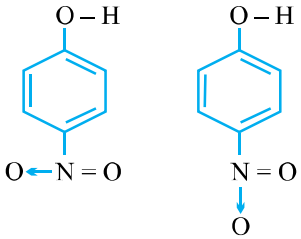
Polar

20. Hydrogen bonding : The dipole interaction b/w molecules when H is bounded wih highly electronegtive atoms (F, O, N only).



(a) **Intramolecular HB :** When hydrogen bonding is in between the same molecule. Hence molecules are independent and with less MP, BP. Due to within hydrogen bonding notable to make hydrogen bonding with H_2O therefore less soluble in water.

(b) **Intermolecular hydrogen bonding :** When hydrogen bonding in between the different molecules therefore close packing of molecules therefore more MP and BP and more solube in water.



21. Molecular orbital theory : (a) The overlap of atomic orbitals of same symmetry of two homonuclear atoms to give addition or subtraction of wave functions and form bonding MO and antibonding MO respectively is known as MO theory.

(b) The e^- are filled in molecule increasing energy order of MO.

(c) **Bond order :** Bond order of molecule/ion

$$= \frac{\text{No. of electron in BMO} - \text{No. of electrons in ABMO}}{2}$$

(d) More is bond order more is bond energy lesser is the bond length. Bond order zero means no. possibility of that molecule.

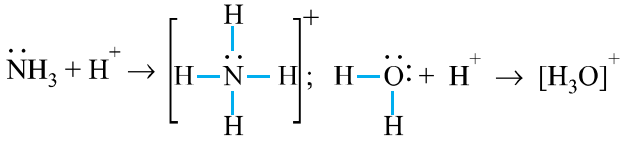
(e) Increasing order of energy of MO for upto $14e^-$.

$$\sigma_{1s}, \overset{*}{\sigma}_{1s}, \sigma_{2s}, \overset{*}{\sigma}_{2s}, \pi_{2px} = \pi_{2py}, \sigma_{2pz}$$

for more than $14e^- \rightarrow \sigma_{1s}, \overset{*}{\sigma}_{1s}, \sigma_{2s}, \overset{*}{\sigma}_{2s}, \sigma_{2pz}, \pi_{2px} = \pi_{2py}, \overset{*}{\pi}_{2px} = \overset{*}{\pi}_{2py}, \sigma_{2pz}$

(d) This theory decides the magnetic behaviour also. [Equal energy orbitals]

22. Coordinate covalent bond : The sigma bond formed by donation of lp into vacant by drized orbital of other atom (acception atom) is known as coordinte covalent bond or **donor acceptor** or **daive bond.**



$$F_3B: \leftarrow NH_3 \rightarrow H_3N \rightarrow BF_3$$

23. Bond strength; Bond energy; Bond length :

For covalent molecule BE $A \equiv A > B = B > C — C$

BL $A \equiv A < B = B < C — C$

Bond angles : (a) As the no. of *lp* increase; *bp – lp, lp – lp* repulsion increase therefore bond angles decrease.

(b) As lp decreases bond angle increases.

Important Points :

24. (a) Max. density of H_2O at 4°C due to strongest.

Intermolecular hydrogen bonding.

(b) H_2O to H_2S bond angle decrease

(c) **NH_3** more DM than NF_3.

(d) NCl_3 more DM than NF_3.

25. Vander wall forces weak intermolecular force of attraction.

(a) Dipole interactions NH_3, HCl, HF.

(b) Dipole induced dipole interactions. Noble gas in H_2O, HCl; F_2

(c) Induced dipole induced dipole interaction (london force) Halogens noble gases.

(d) Ion reduced dipole interaction [NO_3^- Br_2].

Chemical Bonding and Molecular Structure

1-Mark Questions

1. What is the covalence of Al in $AlCl_3$? [**Ans.** 3]

2. $MgCl_2$ is covalent or ionic compounds. [**Ans.** Both]

3. CCl_4 $CHCl_3$ CH_2Cl_2 which is covalent. [**Ans.** All]

4. Al_2O_3 has ionic or covalent bond. [**Ans.** Ionic]

5. AlF_3 or $AlCl_3$ which is covalent ? [**Ans.** $AlCl_3$]

6. The $[BF_4]^{1-}$ has what covalence ? [**Ans.** Four]

7. Ionic bonds are formed by metal with non-metals ? (True/False) [**Ans.** True]

8. NH_3 and $\overset{+}{N}H_4$ have what cordencies. [**Ans.** 3, 4]

9. Covalency can be mutual sharing or one sided donation of electrons (True/False) [**Ans.** True]

10. N_2, O_2, H_2 have what covalencies. [**Ans.** 3, 2, 1]

11. I_2, Cl_2, Br_2, F_2 all have single covalent bond. (True/False) [**Ans.** True]

12. $AlCl_3$ and $AlCl_4^{-1}$ Al_2Cl_6 have what covalencies. [**Ans.** 3, 4, 4]

13. C_2H_6 has 'C' with what covalencies between C and C. [**Ans.** 2]

14. N_2H_4 (Hydrazine) has what covalency of N—N. [**Ans.** 1]

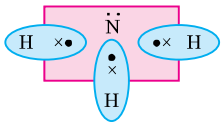
15. HF HCl HBr all polar covalent or pure covalent. [**Ans.** Polar]

16. Lewis dot structure of $:\ddot{N} + 3e^- \longrightarrow$ ..... **Ans.** $\left[:\ddot{\underset{\times}{\underset{\times}{N}}}\times\right]^{3-}$

17. Lewis dot structure of AlN is $\longrightarrow$ ..... [**Ans.** Al^3 $\left[:\ddot{\underset{\times}{\underset{\times}{N}}}\times\right]^{3-}$]

18. Pure covalent diatomic molecule is H_2, C_2, N_2, all. [**Ans.** All]

19. Lewis dot structure of NH_3 is ⟶ .....



20. C_6H_6 has C with covalency of 4, 3, 2.

Resonance; MO theory; Dipole moment

1-Mark Questions

1. More is the no. of resonating structures more is the stability of that molecule/ion. (True/False) [**Ans.** True]

2. Resonance involves shifting of π electrons with lp, negative charge, positive charge or all. [**Ans.** All]

3. N_2 to N_2^+ bond length increases. (True/False) [**Ans.** True]

4. O_2, O_2^+, O_2^- what is decreasing bond order. [**Ans.** ($O_2^+ > O_2 > O_2^-$]

5. H_2^+ H_2 which is more stable. [**Ans.** H_2]

6. More is the bond order more is the bond length between atoms. (True/False) [**Ans.** False]

7. Dipole moment of $BeCl_2$ = O. (True/False) [**Ans.** True]

8. All linear molecules have zero diple moment. (True/False) [**Ans.** False]

9. Dipole moment of a molecule/ion decides the polarity of that molecule/ion. (True/False) [**Ans.** True]

10. CO_2, $BeCl_2$, ICl_4^-, SF_6 which has zero DM ? [**Ans.** All]

11. No. of antibonding electrons in O_2^+ is 1, 2 or 3. [**Ans.** 1]

12. N_2, O_2, F_2 arrange in decreasing order of stability. [**Ans.** $N_2 > O_2 > F_2$]

13. SO_2, CO_2 which has zero dipole moment. [**Ans.** CO_2]

14. Dipole moment of hydrogen halides from HF to HI. Why ?

[**Ans.** At radius increases EN Dec.]

15. Which does not show resonance CO_3^{2-}, BO_3^{3-}, SO_4^{2-} ? [**Ans.** BO_3^{3-}]

VSEPR, Shape, Bond Angle, Bond Energy, Hybridization

2-Mark Questions

1. Which are isostructural species [same shape] $\overset{+}{N}O_2$, CO_2, $BeCl_2$, BCl_3 ?

[**Ans.** NO_2; CO_2, $BeCl_2$ all linear]

2. BCl_3, H_2O, NO_3^- which have same type of hybridization. [**Ans.** BCl_3 NO_3^-]

3. Which is angular or bent XeF_2, H_2O, NO_2 ? [**Ans.** XeF_2, NO_2]

4. Which is not linear XeF_2, $\overset{+}{N}O_2$, CO_3^{2-}, ICl_2^- ? [**Ans.** ICl_2^- XeF_2, $\overset{+}{N}O_2$]

5. Which has more EN of carbon ?

   (a) CH ≡ CH (b) $CH_2 \equiv CH_2$ (c) CH_3—CH_3.

   [**Ans.** *a* > *b* > *c* as '*s*' character increase EN increases]

6. $N(SiH_3)_3$ $N(CH_3)_3$ are not isostructural why ?

   [**Ans.** Si has vacant '*d*' orbital 'C' does not]

7. Which has maximum bond angle ?

   CH_4, $BeCl_2$, NH_3 arrange in decreasing order. [**Ans.** $BeCl_2 > CH_4 > NH_3$]

8. Hydrogen bond is shorter than H—H bond. (True/False) [**Ans.** True]

9. Which has nearly same bond angle ?

   $\overset{+}{N}H_4$, CCl_4, $\overset{+}{C}H_3$ [**Ans.** $\overset{+}{N}H_4$, CCl_4]

10. Which has different hybridization ?

    (a) $AlCl_3$; $[AlCl_4]^-$ (b) $BF_3[BF_4^-]$

    (c) $[NH_3\overset{+}{N}H_4]$ (d) $\overset{+}{N}O_2$ $(\bar{N}O_2)$ [**Ans.** (c)]

11. KHF_2 exist but $KHCl_2$ $KHBr_2$ does not why ?

    [**Ans.** (HF .... HF) Hydrogen bonding]

12. As EN increases polarity increases but still chlorine does not show hydrogen bonding but nitrogen shows (EN of Cl 3.2; N 3.0).

    [**Ans.** ∵ Cl has large size H—Cl is less polar]

13. Which is sp^3 hybridized Be atom ?

    (a) $BeCl_2(g)$ (b) $BeCl_2$ (solid) (c) $BeCl_4^{2-}$. [**Ans.** $BeCl_2$ solid $[BeCl_4^{2-}]$]

14. $[AlF_6]^{3-}$ $[Al_2O_3]$ which have both covalent and ionic bond ? [**Ans.** $AlF_6]^{3-}$

15. The shortest carbon-carbon bond distance is found In :

    (a) Diamond (b) Benzene (c) Ethane (d) Cyclopropane [**Ans.** (d)]

16. HF, H_2O, HCl, CCl_4 which is not liquid and why ?

17. Which is not see saw shaped ?

    (a) SF_4 (b) XeO_2F_2(c) $XeOF_2$ (d) $SiCl_4$. [**Ans.** $XeOF_2$]

18. H_2^+ H_2^- have same bond order which is more stable ? [**Ans.** H_2^+]

19. B_2 has ten electrons but paramagnetic why ?

20. Draw the resonating structure of $\bar{N}O_2$.

21. ClF_3 is T shaped but BF_3 is planar. Explain.

22. Density of ice is less than water. Why ?

23. O nitrophenol has less B.P. than *p*-nitrophenol. What is decreasing solubility in water ?

24. $H_2O + H^+ \rightarrow H_3O^+$ $NH_3 + H^+ \rightarrow \overset{+}{N}H_4$. Explain the type of bond.

25. Why do noble gas Ne_2 does not exist but Ne_2^+ exists ?

26. H_2O is liquid at room temperature but H_2S is gas why ?

27. O_2 is paramagnetic but O_2^{2-} (peroxide ion) is diamagnetic why ?

28. What is the difference b/w σ (sigma) and π (pi) bond explain diagrammatically ?

29. (a) F_2 and Cl_2 which has less bond dissocition energy and why ?

(b) O_2^+ O_2^- which is more stable and why ?

30. What is difference bond enthalpy and bond dissociation enthalpy ?

3-Mark Questions

1. Arrange in decreasing order of bond angle :

(a) H_2O, H_2S, H_2Se [**Ans.** $H_2O > H_2S > H_2Se$]

(b) NO_2^+, NO_2, NO_2^- [**Ans.** $\underset{(sp)}{\overset{+}{N}O_2} > \underset{(sp^2)}{NO_2} > \underset{(sp^2)}{NO_2^-}$]

(c) PF_3, PH_3, PCl_3 [**Ans.** $PCl_3 > PF_3 > PH_3$]

2. C_2 exists; Be_2 does not why ? [**Ans.** BO $\begin{bmatrix} Be_2 = 0 \\ C_2 = 2 \end{bmatrix}$]

3. C_2H_4, C_2H_2, C_2H_6 arrange in decreasing :

(a) Bond length C—C bond.

(b) Bond energy of C—C bond.

4. (a) C_2H_2 'C' is acidic.

(b) C_2H_6 'C' is electron donating.

5. What is the (a) formula of compound.

(b) Nature of bond formed beween element 'X' atomic no. 31 and element '*y*' atomic number 8. Draw the Lewis dot structure. [**Ans.** X_2O_3]

6. Which are add electron molecules/ions : PCl_3, NO $\bar{N}O_2$ O_2^+ O_2^-, O_2 ?

7. Write the bond angle in each :

SO_4^{2-} CO_3^{2-} $[H_3O]^+$ $\bar{N}O_3$ PCl_5 SF_4

8. Write the no. of e^- in valence shell of 'S' in (a) SF_6 (b) SO_2 (c) SO_3.

[**Ans.** 12, 10, 8]

9. Arrange from strongest hydrogen bond to weakest hydrogen bond.

H—F .... H—N H—F ..... H—O

H—O ... N—H H—F ..... H—F

10. $[Ni(CN)_4]^{2-}$, SF_4, SiF_4, XeF_4, BF_4^-. Give hybridization in each case.

11. NH_3 PH_3 BH_3 BeH_2 CO_2 IO_2^-. Give shape of each of the above ?

12. IO^- IO_2^- IO_3^- IO_4^-. Which has maximum bond angle and why ? Arrange in decreasing order of bond angle ?

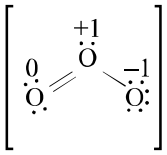
13. (a) PH_3 is non polar PCl_3 is polar why ?

(b) PCl_5 is non polar BF_4 is polar why ?

(c) BCl_3 is non polar NCl_3 is polar why ?

14. Five moles of σ bonds is present in simple hydrocarbon with sp^2 hybridization. Give formula of the compound.

15. O_3 has what formal charge of each 'O' atom.



5-Mark Questions

1. Arrange in increasing order as indicated :

(a) H_2O, NH_3, H_2S, HF (Polar character)

(b) HF, HCl, HBr, HI (Dipole moment)

(c) O_2, O_2^+, O_2^- (Stability)

(d) NO_3^-, $\overline{N}O_2$, NO ('S' character of hybridization)

(e) $BeCl_2$, BCl_3, CCl_4, PCl_3 (Bond angle)

2. Which has (a) zero dipole moment CO_2; SO_2.

(b) *sp* hybridization SO_2, SO_3, None.

(c) No octet rule OF_2, BCl_3, H_2Se.

(d) Zero bond order Ne_2, He_2 Both

(e) Paramagnetic character Cl^-, Br, I^-

3. Which has both (a) Polar and nonpolar bond H_2O_2 BCl_3.

(b) *sp* and sp^3 hybridization Propyne Ethyne

(c) σ and π bonds and *sp* hybridization $CH_2 = CH = CH_2$

$CH_2 = CH—CH_3$

(d) Ionic and covalent bond, coordinate bonds as well $AgNO_3$ AgF Ag_2SO_4.

(e) Coordinate and only σ bond H_3O^+; $\overset{+}{N}H_4$; $\overset{+}{P}H_4$]

4. (a) In dsp^2 hybridization — '*d*' orbital is $dx^2 - y^2$ or dz^2

(b) sp^3d Hyb. — '*d*' orbital is $dx^2 - y^2$ or dz^2

(c) sp^3d^2 Hyb. [XeF_4] — Geometry is octahedral or square planar.

(d) CO has — (a) *sp* (b) sp^2 (c) *sp* with back bonding

(e) PCl_5 has bond angles — (i) Bond 90° and 120° (ii) Only 90° (iii) Only 120°.

5. Why (a) $BaSO_4$ is insoluble although ionic in nature.

(b) ClF_3 has only 90° bond angles.

(c) SO_2 is angulr but SO_3 is planar.

(d) NH, PH_3 have same hybridization but different bond angle.

(e) $CuSO_4.5H_2O$ looses $4H_2O$ on heating but not fifth H_2O.

6. Explain the scheme of Hybridization in C_2H_4, C_2H_6, C_2H_2.

7. CO_3^{2-} NO_3^- $\overline{N}O_2$ SO_4^{2-} PO_4^{3-}. Draw their resonating structures and resonating hybrid structure ? Why all bond angles in CO_3^{2-} are equal ?

8. Draw the Lewis dot structure of (a) Al_2O_3 (b) Mg_3N_2 (c) CCl_4 (d) Na_2O_2

(e) NCl_3.

9. Draw the shapes (VSEPR) and geometries of :

SO_3^{2-}, I_3^-, XeO_3, $XeOF_4$ and $\bar{N}O_2$.

10. Arrange in properties as shown :

(a) HF, HCl, HBr, HI thermal stability

(b) LiF, LiCl, LiBr, LiI decreasing ionic character.

(c) PH_3 PCl_3 more covalent character.

(d) $O_2 \rightarrow O_2^+$ bond length

$N_2 \rightarrow N_2^+$ bond length

In which case bond length decrease and why ?

(e) Why CCl_4 has 4 dipole but net DM = zero.