Chemical Bonding and Molecular Structure

1. What is Chemical Bonding?

Chemical bonding refers to the attractive force that holds various constituents (atoms, ions, etc.) together in different chemical species.

It arises due to the tendency of atoms to attain a stable configuration (like noble gases) through electron transfer or sharing.

2. Theories of Chemical Bonding

There are several theories to explain chemical bonding and molecular structure:

- Kossel-Lewis Approach: Suggests atoms bond to achieve noble gas configuration through electron transfer (ionic) or sharing (covalent).

- VSEPR Theory: Predicts the shape of molecules based on electron pair repulsions in the valence shell.

- Valence Bond Theory (VBT): Explains bond formation via orbital overlap, distinguishing between sigma (σ) and pi (π) bonds.

- Molecular Orbital Theory (MOT): Describes bonding using molecular orbitals formed by the combination of atomic orbitals.

3. Kossel-Lewis Approach to Bonding

Introduced concepts of electrovalent (ionic) and covalent bonds.

Ionic bonds form by complete transfer of electrons (e.g., NaCl), while covalent bonds form via electron sharing (e.g., Cl_2).

Lewis dot structures represent the arrangement of valence electrons.

4. VSEPR Theory

Valence Shell Electron Pair Repulsion (VSEPR) theory is used to predict molecular geometries.

Based on repulsion between electron pairs (bonded and lone pairs) around the central atom.

Examples: CH_4 (tetrahedral), NH_3 (trigonal pyramidal), H_2O (bent).

5. Valence Bond Theory (VBT)

VBT explains bonding via the overlap of atomic orbitals.

Two types of overlaps: head-on (sigma bonds) and sidewise (pi bonds).

Hybridization concept explains geometry: sp (linear), sp^2 (trigonal planar), sp^3 (tetrahedral).

6. Molecular Orbital Theory (MOT)

MOT considers molecular orbitals formed from the combination of atomic orbitals.

Bond order = (Number of bonding electrons - Number of antibonding electrons)/2.

Predicts magnetic and bonding properties, e.g., O_2 is paramagnetic due to unpaired electrons.

7. Types of Chemical Bonds

- Ionic Bond: Formed via complete electron transfer.

- Covalent Bond: Electron sharing between atoms.

- Coordinate Bond: One atom donates both bonding electrons.

- Metallic Bond: Delocalized electrons among metal ions.

- Hydrogen Bond: Weak bond between hydrogen and electronegative atom (e.g., O, N).

8. Bond Parameters

- Bond Length: Distance between nuclei of bonded atoms.

- Bond Angle: Angle between two bonds at an atom.

- Bond Enthalpy: Energy needed to break one mole of bonds.

- Bond Order: Number of bonds between two atoms.

- Dipole Moment: Measure of polarity in a bond.