The Chemical Bond - I

INTRODUCTION Section - 1

We have come across the terms *molecules and compounds.* Molecule can be defined as an uncharged entity in which atoms of same kind or of different kinds are held together by some forces. Compound is the collective name of a set of molecules of same kind.

For example : Sulphur dioxide is a compound which contains the molecules of SO_2, which is made up of atoms of S and O. Cane sugar consists the molecules of $C_{12}H_{22}O_{11}$, which is made up of atoms of C, H and O.

The forces that hold together the atoms in a molecule are known as *Chemical forces* or *Valence forces.* The association between atoms in a molecule by valence forces is called as *Chemical Bond.*

An atom possesses its greatest stability when its valence electron shell (outer shell) is complete. The K shell (n = 1) is complete when it contains two electrons, while the remaining shells are complete when they contain eight electrons. This is referred to as *Lewis Octet Rule.*

Note : The arrangement of electrons in Noble Gases is the criteria of stability, i.e., fully filled sub-shells (ns^2np^6). The atoms of these elements are in a state of great stability and hence do not form compounds and in general are chemically inert.

So it is the valence electrons that determine the chemical behavior of an atom. In a compound, a definite number of valence electrons are involved in the bonding process. The chemical association among atoms can be achieved by many ways depending upon number of valence electrons contained in the atoms. Three major types of chemical bonding are as follows:

Ionic Bonding	:	*Stability through transfer of electrons.*
Covalent Bonding	:	*Stability through mutual sharing of electrons.*
Coordinate Bonding	:	*Stability through partial transfer and partial sharing of electrons.*

1. Kossel – Lewis's Electronic Theory of Chemical Bonding :

Lewis pictured the atom in terms of :

(a) A positively charged 'Kernel' (the nucleus plus the inner electrons) and

(b) The outer shell that could accommodate a maximum of eight electrons. He, further assumed that these eight electrons occupy the corners of a cube which surround the 'Kernel'.

When all the eight corners of the cube are occupied then an atom is said to have stable electronic configuration. Clearly noble gases which have 8 outer most electrons already have stable configuration while all other atomic achieve stable octet of electrons (set of 8) when they are linked by chemical bonds.

Note :

- **Valence electrons :** It refers to the outer shell electrons (of an atom) that take part in chemical combination in the formation of a molecule.
- The inner shell electrons are well protected and are generally not involved in the combination process.
- **Common or group valence of an element :** It generally refers to no of valence electrons or 8 minus the number of valence electrons.
- Atoms can combine either by transfer of valence electrons from one atom to another (gaining or losing) or by sharing of valence electrons in order to have an octet in their in their valence shells. This is known as octet rule.

IONIC OR ELECTROVALENT BONDING Section - 2

The chemical bond formed due to electrostatic attraction between cations and anions (which are formed by the complete transfer of electron(s) from one atom to the other atom) is called as Electrovalent or Ionic Bond. The Ionic valency or Electrovalence is referred to as the number of electrons that an atom can give up or gain. In other words it is equal to the number of unit charge(s) on the ion, eg. In NaCl, sodium is assigned a positive electrovalence of one, while chlorine a negative electrovalence of one.

The formation of a positive ion involves ionization, i.e., removal of electron(s) from the neutral atom and that of the negative ion involves the addition of electron(s) to the neutral atom.

$$M(g) \longrightarrow M^+(g) + e^- \; ; \quad \text{Ionization enthalpy}$$

$$X(g) + e^- \longrightarrow X^-(g) \; ; \quad \text{Electron gain enthalpy}$$

$$M^+(g) + X^-(g) \longrightarrow MX(s) \; ; \quad \text{Lattice energy}$$

Formation of Lattice :

The compounds which are formed by ionic bonds are mostly solids. These compounds crystallize in different crystal structures determined by factors such as size of the ions, their packing arrangements etc. In the crystalline state, these compounds consist of orderly three-dimensional arrangements of cations and anions (*which is called* lattice) held together by coulombic interaction energies. The energy released when such an arrangement is formed (due to electrostatic attraction) is known as Lattice Energy.

The lattice is a highly stable arrangement and hence all ionic compounds have high melting and boiling points. The higher is the lattice energy, the more stable is the ionic bond.

Factors affecting lattice energy :

Magnitude of charge : More is the magnitude of charge on cation or anion, the more is the lattice energy. For example, the lattice energy of $MgCl_2$ is higher than that of NaCl.

Size of ions **:** For higher lattice energy, the cations should be smaller and anion should be larger. The smaller is the cation, the more effective is the nucleus in pulling the neighbouring anions towards it. As a result, the lattice formed is highly stable or we can say that the lattice energy is high. Eg : Lattice energy of NaCl is greater than that of CsCl, as Na^+ cation is smaller than Cs^+ cation though the ionisation energy of Cs is much lower than that of Na.