Chapter 6

Chemical Bonding

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Types of Chemical Bonds -

(A) Strong bond (Bond Energy↓)

- **(i)** Ionic Bond
- **(ii)** Covalent
- **(iii)** Co-ordination Bond
- **(iv)** Metallic bond

(B) Weak bond (Bond Energy↑)

- **(i)** Vander-Wal Bond
- **(ii)** Hydrogen Bond

Electrovalent/Ionic Bond :

- The electrostatic attraction between oppositely charged ions in a chemical compound. Such a bond forms when the valence (**outermost**) electrons of one atom are transferred permanently to another atom. The atom that loses the electrons becomes a positively charged ion (**cation**), while the one that gains them becomes a negatively charged ion (**anion**). Ionic bonding results in compounds known as **ionic**, or **electrovalent** compounds,
- It is formed by complete transfer of electron from one to another atom, so as to complete their octet by acquiring 8 electrons or duplet in case of **H2, Li2** etc. and hence acquire the nearest stable noble gas configuration.
- Electro-rich atoms lose electrons. (**group IA to IIIA**)
- Electronegative atoms gain electrons. (**group VA to VIIA**)
- The total number of electrons lost or accepted is called **electrovalency.**
- Electrostatic attraction force is same in all directions, therefore ionic bonds are **non-directional**. Ionic compounds form a definite three **dimensional** structure which is called **crystal lattice**.
- The energy emitted during the formation of one mole of crystal lattice is called **lattice energy.**
- Ionic or Electovalent Bond According to Kossel's theory, in the process of formation of ionic bond the atoms acquire the noble gas electronic configuration by the gain or loss of electrons.

Example: NaCl, MgO_2, $CaCl_2$ etc.

The electronic configuration of **sodium (Na)** atom (atomic number 11) is 2,8,1. Since it is highly electropositive, it readily loses an electron to attain the stable configuration of the nearest **noble gas (neon)** atom. It becomes a positively charged sodium cation **(Na+)** in the process.

Na ➞ $Na^+ + e^-$; ΔH = 493.8 kJ mol−1
2,8,1 2,8 (□ΔH is enthalpy change)

On the other hand, a chlorine atom (electronic configuration: 2,8,7) requires one electron to acquire the stable electronic arrangement of an argon atom. It becomes a negatively charged **chloride anion (Cl–) i**n the process.

Cl + e− ➞ Cl^-: ΔH = −379.5 kJ mol−1

2,8,7 2,8,8

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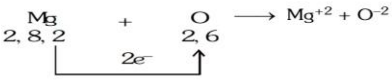
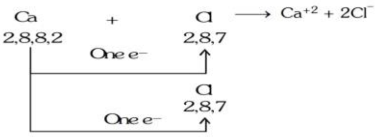
According to Kossel's theory, there is a **transfer** of one electron from sodium atom to chlorine atom and both the atoms attain noble gas configuration.

The positively charged sodium ion and the negatively charged chloride ion are held together by electrostatic attractions. The bond so formed is called an **electrovalent** or an **ionic bond**. Thus the ionic bond can be visualised as the electrostatic force of attraction that holds the cation and anion together. The compounds so formed are termed as ionic or electrovalent compounds.



Electrovalency of Mg = 2

Electrovalency of O = 2



Electrovalency of Ca = 2

Electrovalency of Cl = 1

Energetics of Ionic Compound Formation :

We have just described the formation of an ionic compound **(NaCl)** as a result of transfer of electrons as proposed by Kossel. You may raise a question here that when more energy is required **(ionisation energy)** to form a sodium ion from sodium atom, **than that released (electron affinity)** in the formation of chloride ion from chlorine atom then how do we say that the formation of NaCl is accompanied by a decrease in energy? Your question is quite justified but let us assure you that there is no anomaly. Let us look at the whole process somewhat closely to clarify your doubts.

The formation of NaCl from sodium and chlorine can be broken down into a number of
steps as :

a) Sublimation Energy of solid sodium to gaseous sodium atoms.

$Na(s) \rightarrow Na(g)$; $\Delta H = 108.7$ kJ mol−1

b) Ionization Energy of gaseous sodium atom to give sodium ion.

$Na(g) \rightarrow Na^{+}(g) + e^{-}$; $\Delta H = 493.8$ kJ mol−1

c) Dissociation Energy of gaseous chlorine molecule into chlorine atoms.

$\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$; $\Delta H = -120.9$ kJ mol−1

d) Electron affinity Conversion of gaseous chlorine atom to chloride ion **(addition of electron).**

$Cl(g) + e^{-} \rightarrow Cl^{-}(g)$; $\Delta H = -379.5$ kJ mol−1

e) Formation of NaCl from sodium and chloride ions.**(Crystal or lattice formation).**

$Na^{+}(g) + Cl^{-}(g) \rightarrow Na^{+}Cl^{-}(s)$; $\Delta H = -754.8$ kJ mol−1

The energy released in this step is **lattice energy**.

The net reaction would be

$$Na(s) + \tfrac{1}{2}Cl2(g) \xrightarrow{\Delta H = -410.9 \text{ kJ mol}^{-1}} Na^{+}Cl^{-}(s) \;;$$

The overall energy change can be computed by taking the sum of all the energy changes:

$\Delta H = (180.7+493.8+120.9-379.5-754.8) = -410.9$ kJ mol−1

Thus we see that the net process of formation of NaCl from sodium and chlorine is accompanied by a large decrease in the energy. The approach we have just followed is based on the law of conservation of energy and is known as **Born-Haber cycle.**

ΔH (formation) = S.E. + I.E. + D.E./2 + EGE + L.E.;

(Born-Haber Cycle)

Of the five different types of energies involved, two (**sublimation** and **dissociation energies**) are generally have low values than the rest. Therefore, the three energy terms i.e., **ionization energy**, **electron affinity** and lattice energy are important in determining the formation of an ionic compound. On the basis of the above discussion we can say that the formation of an ionic compound is favoured by

i. Low ionisation energy of the metal,
ii. High electron affinity of the other element (non-metal), and
iii. High lattice energy

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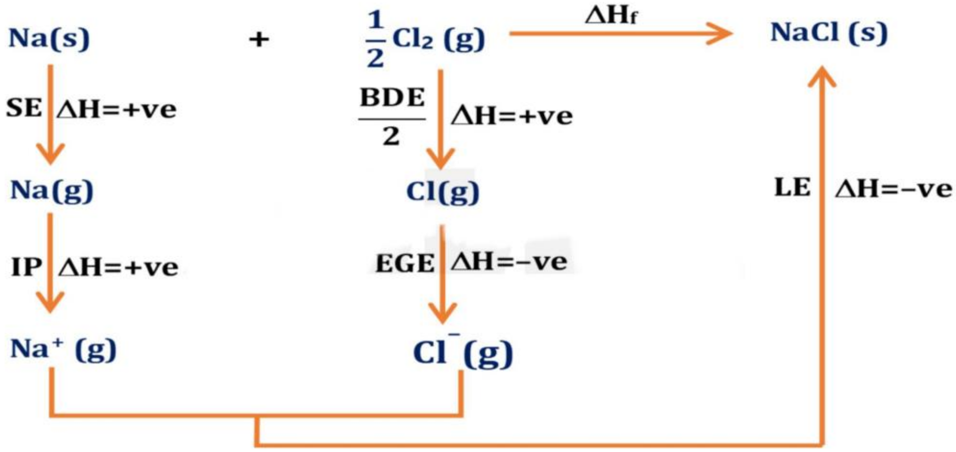

Born-Haber Cycle

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