Chemical Bonding

Ionic bond

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Ionic bond

Factors favoring the format of ionic bonds (or) conditions for the formation of ionic bonds:

1) Ionisation energy:

The lesser the ionization energy the greater in the ease of the formation of a cation.

Alkali metals and alkali earth metals have low ionization energy and the form metal cations very easily

$A_{(g)+}$ energy required ⟶ $A^{+}_{(g)} + e^{-}$

gaseous (ionization cation

metal atom energy)

2) **Electron affinity:**

The higher the valence of electron affinity, the greater will be the ease of formation of the anion. Thus high electron affinity of a non-Metal favors the formation of an anion.

- $B_{(s)}$ +e- ⟶ $B^{-}_{(g)}$+energy released
- Gaseous anion (electron affinity)

Non-metal

3) Lattice energy

The energy released when the requisite number of positive ions and negative ions are condensed into ionic crystal to form one mole of the compound is called Lattice energy. The higher the value of lattice energy of the resulting ionic compound the greater its case of formation.

- $A^{+}_{(g)} + B^{-}_{(g)}$ ⟶ A-B(crystal)+energy released

1mole 1mole 1mole (lattice energy)

Lattice energy of ionic compound:

- Lattice energy is defined as the amount of energy released when one gram mole of a crystal is formed from its gaseous ions of the crystal.
- Thus
- $A^+_{(g)} + B^-_{(g)} \longrightarrow$ A-B(crystal)+energy released

  1mole 1mole 1mole (lattice energy)
- Born –lande equation:
- The lattice energy of an ionic crystal can calculated from Born –lande equation.
- $U = -z^+z^-e^2AN/r_0(1-1/n)$ per mole
- Where z^+z^-= charge of cations and anions
- e= electronic charge
- N=Avogadro number
- r_0=Inter ionic exponent.

Solvation enthalpy and solubility of ionic compound

Ionic solids are freely soluble in polar solvents like H_2O and liq NH_3. The dissolution of an ionic compound in a polar solvent can be explained on the basis of relative values of hydration energy and lattice energy.

The dissolution of an ionic compound in a polar solvent take place through the following two steps:

Step:1 when an ionic solid ,MX(s) is dissolved in a polar solvent , the ionic solid is broken into its isolated gaseous ions.

$MX(s) \longrightarrow M^+_{(g)} + X^-_{(g)}$

In this process of breaking some amount of energy in required.

- This is called lattice energy of MX(s) ionic crystal .Thus

- $MX_{(s)}$+ Energy required ⟶ $M^+_{(g)}+X^-_{(g)}$
- Ionic crystal (lattice energy) isolated gaseous ion

Step2: In this step the isolated gaseous ions formed is step (1) go into the solvent and interact with their molecules so that they get surrounded by a definite number of solvent molecules and are converted into solvated ions which are represented as

- $[M(solv)_x]^+$ and $[X(solv)_y]^-$
- If water is used as a solvent, the gaseous ions are said to be converted in to hydrated ions which are represented as $[M(H_2O)_x]^-$ (or)$[M(aq)]^+$ and $[X(H2O)_x]^+$ (or)$[X(aq)]^+$.
- The process of solvation (or) hydration is accompanied by the release of a certain amount of energy is called solvation (or) hydration energy.

- $M^+_{(g)}+X_{(solve)}$ ⟶ $[M(solv)_x]^+$+Energy released
  solvated cation   solvation energy

$X^-_{(g)}+y_{(solv)}$ ⟶ $[X(solv)_y]^-$+ Energy released
solvated anion   solvation energy

Obviously the process of solvation (or) hydration is an exothermic process.

Born-Haber cycle:

The lattice energy of an ionic solid can be determined experimentally by a process known as Born-Haber cycle.

Consider the determination of the lattice energy of NaCl.

The various steps involved in the formation of $NaCl_{(s)}$ in crystalline state are as follows.

1) Conversion of metallic sodium into gaseous sodium atoms. The energy required for the conversion of 1 mole of metallic sodium into gaseous sodium atoms is called sublimation energy. It is represented by S.

$$Na_{(s)} + S \longrightarrow Na_{(g)}$$

S= sublimation energy

2) Dissociation of gaseous chlorine molecules into gaseous chlorine atoms. This step involves the dissociation of gaseous Cl_2 molecules into Cl atoms

The amount of energy required to dissociate one mole of gaseous Cl_2 molecules into gaseous atoms is called dissociation energy. It's represented by D

$$Cl_{2(g)} + D \longrightarrow 2Cl_{(g)}$$

1mole D= dissociation energy

Evidently the energy required to produce 1mole of gaseous Cl atom would be D/2.

3) Conversion of sodium atom into sodium ions. The amount of energy required to convert 1mole of gaseous sodium atoms into sodium ions in the gaseous state is called ionization energy. This may be represented by ionization energy.

$$Na + I.E \longrightarrow Na^+ + e^-$$ I.E= ionization energy

4) Conversion of gaseous Cl_2 atoms into chloride ions. The amount of energy released when one mole of gaseous chlorine atoms are converted into chloride ions in the gaseous state is called electron affinity. It is represented by E.A.

$$Cl_{(g)} + e^- \longrightarrow Cl^-_{(g)} + E.A$$

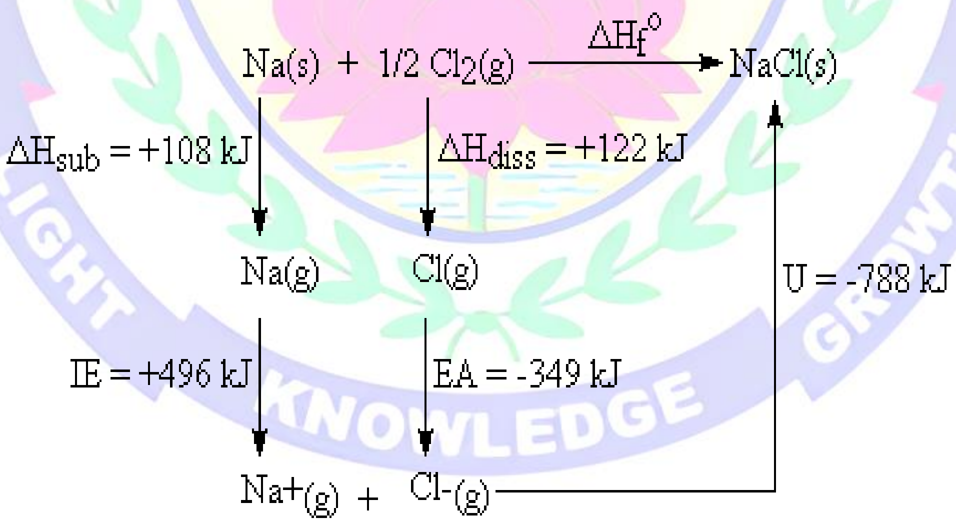
5) Combination of gaseous ions to from a solid crystal. This step involves the combination of gaseous Na^+ and Cl^- ions to give 1mole of NaCl crystal. The amount of energy released when 1 mole of solid NaCl is formed from Na^+ and Cl^- ions is called lattice energy. It is denoted by U.

$$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)} + U$$

The overall charge may be represented as

$$Na_{(s)} + 1/2Cl_{2(g)} \longrightarrow NaCl_{(s)}$$

- The enthalpy change for this reaction is called enthalpy of formation of NaCl and may be denoted ΔHf.
- The various steps may be represented in the form of Born-Haber cycle as shown in figure
- According to Hess's law, the enthalpy of formation of NaCl should be the same whether it takes place directly in one step (or) through a number of steps as illustrated above. Hence
- $-\Delta H_f = S + 1/2D + I.E - E.A - U$



$$\Delta H_f^o = \Delta H_{sub} + IE + \Delta H_{diss} + EA + U$$

$$\Delta H_f^o = 108 + 496 + 122 - 349 - 788 = -411 \text{ kJ/mole}$$

Properties of ionic compounds:

1) physical state:

- Ionic compounds consist of three dimensional solid aggregates of cations and anions which are arranged in a well defined geometrical pattern.
- Thus ionic compounds are crystalline solids at room temperature.

2) Electrical conductivity:

- Ionic compounds do not conduct electricity when they are in the solid state.
- However the ionic solids conduct electricity when they are in water solution (or) in fused (molten) state.
- 3) They are hard have low volatility and high melting and boiling points.

4)Solubility in polar and non polar solvents:

- Ionic solids are freely soluble in polar solvents like H_2O and liq NH_3 but ionic solids are insoluble (or) slightly soluble in Non polar solvents (organic solvents) such as alcohol, benzene and ccl_4

Polarization of ions:

- when a cation , C^+ of an ionic molecules C^+A^-approaches closely the anion A^- if with draws the electrons (i.e., cloud) of the anion towards itself and the electrons cloud of the anion gets distorted from its symmetrical shape.
- Thus the electron cloud of the anion is elongated towards the cation.
- In other wards we says that the A^- anion is distorted (or) deformed (or) polarized by C^+ cations and this phenomenon is called distortion (or) deformation (or) polarization of A^- anions by C^+ cation.

- The ability of a cation to polarize a near by anion is called its polarizing power (or) polarizing ability and the tendency of an anion to get distorted (or) polarized by a cation is called its polarisibility.