CONDUCTANCE OF ELECTROLYTIC SOLUTIONS

Electrolytic Conductance

(a) **Resistance (R):** Metallic and electrolytic conductors obey ohm's law according to which the resistance of a conductor is the ratio of the applied potential difference (V) to the current following(I).

$$R = \frac{V}{I}$$

- R is expressed in ohms.

(b) **Conductance (C):** The conductance of a conductor is equal to reciprocal of resistance

$$C = \frac{1}{R}$$

- C is expressed in mho.

(c) **Specific resistance (ρ):** The resistance (R) of a conductor of uniform cross section is directly proportional to its length(λ) and inversely proportional to its area of cross section (A)

$$R \propto \frac{\ell}{A} \qquad R = \rho\frac{\ell}{A}$$

where ρ is a constant and called resistivity or specific resistance.

When $\lambda = 1$, $A = 1$, then $\rho = R$ thus the specific resistance may be defined as the resistance of a conductor of unit length and unit area of cross section.

- Unit of $\rho \rightarrow$ ohm .cm

(d) **Specific conductance (k):** It is defined as the reciprocal of specific resistance $k = \frac{1}{\rho}$

The above definitions apply to metallic conductors and electrolytes.

- In the case of solution of electrolytes, the resistance offered by the solution to the flow of current is –
- Directly proportional to the distance between the electrodes

$$R \propto \lambda$$

- Inversely proportional to the area of cross section of the electrodes

$$R \propto \frac{1}{A} \quad R = \rho\frac{\ell}{A}$$

The conductance $C = \frac{A}{\rho\ell}$

∵ $\frac{1}{\rho} = k$

so, $\kappa = \frac{C\ell}{A}$

If $\ell = 1$ cm and $A = 1\ cm^2$ then

$$k = C$$

Hence specific conductivity of a solution is defined as the conductance of one centimeter cube of the solution of the electrolyte.

- $k = \frac{C\ell}{A}$

Where $\frac{\ell}{A}$ = cell constant

- Cell constant (x) is a fixed quantity for a particular cell and is defined as the distance between two parallel electrodes of a cell divided by the area of cross section of the electrodes.

$$k = C \times \text{cell constant}$$

$$\text{cell constant} = \frac{K}{C} = kR = \text{Specific conductivity} \times \text{resistance}$$

- Unit of $k \rightarrow ohm^{-1}\ cm^{-1}$

(e) **Equivalent Conductance (λeq) :** It is defined as the product of specific conductance (k) and the volume (V in mL) of the solution which contain one gram equivalent of the electrolyte.

$\therefore$ $$\lambda eq = k \times V$$

If concentration of solution is C - gram equivalent per liter then $\lambda eq = \frac{K}{C} \times 1000$

- Unit $ohm^{-1}\ cm^2$ per gram equivalent

Classification of Conductivity

Depending on the magnitude of their (material) conductivity, they

1. conductors
2. Insulators
3. Semi-conductors

1. Conductors

- Metals and their alloys have large conductivity and are known as conductors.
- Their conductivity ranges from 104 to 107 $ohm^1\ m^1$

Ex:

All metals, alloys of metals, certain non-metals like carbon-black, graphite and some organic polymers like polyaniline, polypyrene and polythiophene etc.

2. Insulators

- Substances like glass, ceramics etc having very low conductivity are known as insulators.
- Their conductivity ranges from 10^{-20} to 10^{-10} $ohm^{-1}\ m^{-1}$

3. Semi-conductors

- Substance like silicon, doped silicon and gallium arsenide having resistivity in the range 1-106 conductors. ohm.cm are called semi
- These are very important materials used in electronic industry.

Superconductors

- The substance having zero resistivity or infinite conductivity are superconductors.

Ex: A number of ceramic materials and mixed metal oxide conductors act as Superconductors at 150k.

Types of Conductance

Conductor: Substances which allow electric current to flow through them are called conductors.

Examples - Metals, Aqueous solution of acids, bases and salts, fused salts and impure water etc.

Conductors Are of Two Types

(i) Metallic conductors

(ii) Electrolytic conductors or electrolytes.

(i) Metallic conductors

Metallic conductors are those that facilitate the flow of electric current through the movement of electrons without experiencing any chemical alteration. Examples of metallic conductors include metals such as copper, silver, iron, and aluminum, non-metals like graphite, as well as various alloys and minerals.

(ii) Electrolytic conductors

Electrolytes are substances whose aqueous solution conducts electric current and undergo decomposition when a current passes through them. In such cases, conduction occurs through the movement of ions. Electrolytes also conduct electricity in their fused state and experience decomposition with the passage of electric current. Substances whose aqueous solution does not conduct electric current are termed non-electrolytes. Additionally, non-electrolytes do not conduct electricity in their fused state.
Examples of non-electrolytes include solutions of cane sugar, glycerin, glucose, urea, etc.

- **Strong electrolyte:** Strong electrolytes are those that undergo complete ionization in an aqueous solution or in their molten state.

Example – all salts, strong acid and strong base

- **Weak electrolyte:** Weak electrolytes are those that do not undergo complete ionization in an aqueous solution or in their molten state.

Examples: - All carbonic acids (except sulphonic acid), CH_3COOH, HCN, NH_3, amine, etc.