Resistance ⇒ Resistance is defined as obstruction to the flow of current in any conduct

→ It is denoted by R.

→ It's unit is ohm (Ω).

→ In any cell it is directly proportion to the length between electrode and inversely proportional to the area of cross-section

$$R \propto l \quad \text{--- (i)}$$

$$R \propto \frac{1}{A} \quad \text{--- (ii)}$$

From eq. (i) and (ii)

$$R \propto \frac{l}{A}$$

$$R = \rho \frac{l}{A}$$

ρ = Specific resistance or resistivity.

Conductance ⇒ Reciprocal of resistance is called conductance.

⇒ It is denoted by G.

$$\text{conductance} = \frac{1}{\text{Resistance}}$$

$$\boxed{G = \frac{1}{R}}$$

→ Unit of conductance is per ohm or mho o Siemen.

Specific conductance ⇒ Reciprocal of specific resistance is called specific conductance.

→ It is denoted by Kappa (K).

$$\text{Specific conductance} = \frac{1}{\text{Specific resistance}}$$

$$\boxed{G = \frac{1}{\rho}}$$

$$G = \frac{1}{\frac{RA}{l}} = \frac{l}{RA} \quad \left(R = \rho \frac{l}{A}\right)$$

If $l = 1\,cm$, $A = 1\,cm^2$, $V = 1\,cm^3$

$$G = \frac{l}{RA} = \frac{1}{R \times 1} = \frac{1}{R}$$

V.V.I → Specific conductance of the solution is the conductance of $1\,cm^3$ solution of electrolyte.

Unit of specific conductance

$$G = \frac{l}{RA} = \frac{cm}{\Omega \times cm^2} = \Omega^{-1}\,cm^{-1} \text{ OR } = S\,cm^{-1}$$

Equivalent conductance

→ Equivalent conductance is defined as the conductance of a solution containing one gram equivalent of electrolyte placed between two electrodes one centimeter apart in a cell.

It is denoted by lambda ($\Lambda_{eq.}$).

→ Let $V\,cm^3$ of the solution containing one gram equivalent of electrolyte placed between two electrode one centimeter apart.

Let measured conductance of $V\,cm^3$ solution $= \Lambda_{eq.}$

" " $1\,cm^3$ $= \frac{\Lambda_{eq.}}{V}$

specific conductance $= \frac{\Lambda_{eq}}{V}$

or $\boxed{\Lambda_{eq} = K \times V}$

→ Let $V\,cm^3$ of the solution containing one mole of electrolyte placed between two electrode one centimeter apart.

~~Let~~ Measured conductance of $V\,cm^3$ solution $= \Lambda_m$

" " $1\,cm^3$ " $= \frac{\Lambda_m}{V}$

$$\text{Specific conductance} = \frac{\text{Molar conductance}}{\text{Volume}}$$

Molar conductance = Specific conductance × volume

$$\boxed{\Lambda_m = K \times V}$$

$$\text{Molarity } (M) = n \times \frac{1000}{V}$$

For one mole electrolyte –

$$M = 1 \times \frac{1000}{V}$$

$$V = \frac{1000}{M}$$

Now

$$\Lambda_m = K \times V$$

$$\boxed{\Lambda_m = K \times \frac{1000}{M}}$$

M → Molarity

Unit of molar conductance $= \Omega^{-1}\,cm^2\,mol^{-1}$

$$\Lambda_m = K \times \frac{1000}{n/V}$$

$$= \Omega^{-1}\,cm^{-1} \times \frac{1000 \times V}{n}$$

$$= \Omega^{-1}\,\cancel{cm^{-1}} \times \frac{1000 \times cm^3}{mol}$$

$$= \Omega^{-1}\,cm^2\,mol^{-1}$$

Equivalent conductance = Specific conductance × volume

Normality (N) = $n_e \times \frac{1000}{V}$

For one gram equivalent -

$$N = \frac{1000}{V}$$

$$V = \frac{1000}{N}$$

Now

$$\Lambda_{eq} = K \times V$$

$$\Lambda_{eq} = K \times \frac{1000}{N}$$

N = Normality

K = Specific conductance.

Unit of equivalent conductance $= K \times \frac{1000}{N}$.

$$= \Omega^{-1} cm^{-1} \times \frac{1000}{\frac{n_e}{V}}$$

$$= \Omega^{-1} cm^{-1} \times \frac{1000 \times V}{n_e}$$

$$= \Omega^{-1} cm^{-1} \times \frac{1000 \times cm^3}{n_e}$$

$$= \Omega^{-1} cm^2 \, equivalent^{-1}$$

Molar conductance

→ Molar conductance is defined as the conductance of solution containing one mole of the electrolyte placed between two electrode one centimeter part. It is denoted by lambda (Λ_m).

Electrochemistry (Lecture -12)

N.C.ERT 3.8

Ques ⇒ The conductivity of 0.20M solution of KCl at 298K is 0.0248 $S\,cm^{-1}$. Calculate its molar conductivity.

Given data

$c = 0.20M$

$T = 298K$

$K = 0.0248\ S\,cm^{-1}$

$\Lambda_m = ?$

$$\Lambda_m = K \times \frac{1000}{c} = \frac{0.0248 \times 1000}{0.20} = 124\ S\,cm^2\,mol^{-1}$$

Ques ⇒ The Specific resistance of 0.4M solution of electrolyte is $2\times10^{-2}\ \Omega\,cm$. Calculate its molar conductivity.

Given data

$\rho = 2\times10^{-2}\ \Omega\,cm$

$c = 0.4M$

$\Lambda_m = ?$

$$K = \frac{1}{\rho} = \frac{1}{2\times10^{-2}} = \frac{100}{2} = 50\ S\,cm^{-1}$$

$$\Lambda_m = K \times \frac{1000}{c} = \frac{50 \times 1000 \times 10}{4}$$

$$= 5\times10^{3} \times \frac{100}{4}$$

$$= 125\times10^{3}\ S\,cm^{2}\,mol^{-1}$$

Ques :- The resistance of decinormal solution of a salt occupying a volume between two platinum electrode is 1.80 cm apart and 5.4 cm^2 area was found to be 32 Ω. Calculate K and Λ_{eq}.

Given

$R = 32\ \Omega,\quad l = 1.80\ \Omega \quad a = 5.4\ cm^2$

$$K = \frac{1}{R} \times \frac{l}{a} = \frac{1}{32} \times \frac{1.8}{5.4} = 0.01\ S\,cm^{-1}$$

$$\Lambda_{eq} = K \times \frac{1000}{N} = \frac{0.01 \times 1000}{0.1}$$

$$= 100\ S\,cm^2\,eq^{-1}$$

Cell constant

→ Cell constant is a ratio taken between length between two electrode and area of cross-section. It is denoted by G^*.

→ It's unit is cm^{-1}.

$$\text{cell constant } (G^*) = \frac{l}{A}$$

→ Measurement of l and A is not only inconvenient but also unreliable hence it can be calculated as follow :-

$$G^* = \frac{l}{A} = \frac{R}{\rho} \quad \left(R = \rho \cdot \frac{l}{A}\right)$$

$$G^* = \frac{1}{\rho} \times R$$

~~Cell constant G^* = Specific resistance × R~~ (conductor)

cell constant = specific conductance × resistance

$$G^* = \frac{\frac{1}{\rho}}{1/R}$$

$$\text{cell constant} = \frac{\text{specific conductance}}{\text{conductance}}$$