Electrical conductance

The measurement of the conductivity in solution is carried out in vessels provided with electrodes that surface area (A) and distance (l) between two electrodes must be known.

In general, electrolytes, that conductivity is well known are used to calibrate the cell.

For example KCl solution.

The equation below which gives the resistance

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

$$R = \rho \, \frac{l}{A} \quad \text{..............................(1)}$$

$$\rho = R \, x \, \frac{A}{l} \quad \text{............................ (2)}$$

Where

R is the resistance (Ω, ohm)
A is the electrode's area (cm^2)
l is the distance between two electrods (cm)
ρ is the specific resistance (Ω.cm)

$$G = \frac{1}{R} \quad \text{..................................(3)}$$

G is the conductance (Ω^{-1}or S or mho)

$$L = \frac{1}{\rho} \quad \text{..................................(4)}$$

$$L = \frac{1}{\rho} = \frac{1}{R \, X \, \frac{A}{l}} \text{........................(5)}$$

$$L = \frac{1}{\rho} = \frac{1}{R} \text{ x } \frac{l}{A} \quad \text{......................(6)}$$

L = Specific conductance(conductivity)

(Ω^{-1}. cm^{-1}) or (S. cm^{-1})or(mho. cm^{-1})

So

$$L = G \times \frac{l}{A} \quad \text{.......................}(7)$$

$$R = \frac{E}{I} \text{ (from ohm law) ....}(8)$$

Where **E** = potential

I = Current

After Instead of equation 8 in equation 6

$$L = \frac{I}{E} \times \frac{l}{A} \rightarrow L = \frac{I}{A} \times \frac{l}{E} \quad \text{.........}(9)$$

$$L = \frac{I/A}{E/l}$$

As

$$i = \frac{I}{A} \quad \text{and} \quad E_i = \frac{E}{l}$$

So

$$L = \frac{i}{E_i} \text{............................(9)}$$

where i is the current density

E_i is the potential energy.

Cell constant

$$L = G.\frac{l}{A} \quad ....(1)$$

$$K = \frac{l}{A}$$ (K= cell constant (cm^{-1}))

So

$$L = G.K \quad ....(2)$$

Equivalent Conductance and Molar Conductance

$$\lambda = \frac{1000\, L\,(S.\,cm^{-1})}{N\,(eq.\,cm^{-3})}$$ (Equivalent conductance) ($S.cm^2.eq^{-1}$).....(1)

where N = normality

$$\lambda = \frac{1000L\,(S.\,cm^{-1})}{M\,(mol.\,cm^{-3})}$$ (Molar conductance) ($S.cm^2.mole^{-1}$) .... (2)

where M= Molarity

Equivalent conductance = (Molar conductance)/n ....(3)

n = (M.Wt (g/mol)/(Eq.wt (g/eq)= $eq.mol^{-1}$

Q/ Why use KCl solution when the measured conductivity?

KCl solution has physical properties are

1. It is easily dissolve
2. It is stable at high temperature
3. It has high molecular weight
4. It is non-hygroscopic

Solvent Correction

Solution = Solute + Solvent

R Solution = R Solute + R Solvent

G Solution = G Solute + G Solvent

$$\frac{1}{\text{R Solution}} = \frac{1}{\text{R Solute}} + \frac{1}{\text{R Solvent}}$$

$$\frac{1}{\text{R Solute}} = \frac{1}{\text{R Solution}} - \frac{1}{\text{R Solvent}}$$ **(Correction equation)**

The equation is used when the diluted solution, weak solution, and contamination solution.

$$CH3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$$

$$2H_2O \leftrightarrow OH^- + H_3O^+$$

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Note/

Correction process is carried out for solvent when the question has G or L also when mentioned distilled water.

Q/ The specific resistance (ρ) of metal is 2.8×10^{-8} Ω.cm. calculate the voltage across metal wire if length is 1m and diameter 2mm, the current pass its wire is 1.25A.

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