

Applied Science (chemistry)

22211 /EE /AO

ELECTROCHEMISTRY AND BATTERIES

Teaching Hours :12

Marks :14

SYLLABUS

5.1 Electrical conductance in metals and electrolytes, specific conductance, equivalent conductance, cell constant.

5.2 Conductance: Nature of solute, nature of solvent, temperature, concentration or dilution.

5.3 Electrode - Hydrogen electrode, calomel electrode & glass electrode

5.4 Conductometric titration

5.5 Batteries- Dry cell, Lead -acid cell, Ni-Cd battery, H₂-O₂ fuel cell, lithium ion battery

ELECTROCHEMISTRY AND BATTERIES

Conductors - The materials which allow the passage of heat or electricity.

Metallic Conductor – All metals conduct electricity. Due to the presence of free electrons.

Electrolytic Conductor - All Salt solution, basic solutions and acid solution, Conduct electricity, due to the presence of free ions.

Ionisation : The process of splitting of molecules of a substance into charged ions in aqueous or fused state.

Strong electrolyte: The substance which solutions ionizes completely in their aqueous or fused state. eg Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric Acid (HNO_3), Sodium Hydroxide (NaOH) solution.

Weak electrolyte: The substance which partially ionize in their aqueous solution
eg. : Acetic Acid (CH_3COOH), Ammonium Hydroxide (NH_4OH)

Ohm's law :

$$I = E/R$$

Where

I= Current in amperes

E=Potential difference in volt

R= Resistance in ohms

Conductance : The ease of flow of charge.

It is the reciprocal of Resistance

Unit : ohm⁻¹ or mhos or Siemens (S)

Resistance: The Obstruction to flow of charge.

Unit - ohms.

Specific conductance ($\kappa = \text{kappa}$): The conductance offered by a conducting wire of length 1cm and cross section area 1 cm sq.

$$\kappa = 1/\rho$$

$$\text{Unit} = \text{ohm}^{-1} \text{cm}^{-1}$$

Specific Resistance ($\rho = \text{rho}$): The resistance offered by a conducting wire of length 1cm and cross section area 1 cm sq.

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

$$\text{Unit} = \text{ohm cm}$$

Equivalent conductance (Λ_{eq}): The conductance due to all the ions

produced by dissociation of 1gram equivalent of an electrolyte dissolved in V ml of Solution.

$$\text{Unit} = \text{ohm}^{-1} \text{cm}^2 \text{eq}^{-1}$$

Molar conductivity (Λ_m): The conductance due to all the ions

produced by dissociation of 1gram mole of an electrolyte dissolved in V ml of Solution.

$$\text{Unit} = \text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$$

Molar conductivity and specific conductivity are related to each other by the given equation.

$$\Lambda_m = \kappa \cdot C / 1000$$

Where,

Λ_m = Molar conductivity

κ = Specific conductivity

C = Molar concentration.

Conductance: The conductance of Electrolyte depends upon the Dissociation of molecules .

Degree of Dissociation : The fraction of the number of molecules Dissociated to the total number of molecules taken.

Factors affecting the Degree of Dissociation::

Nature of solute: Electrovalent molecules dissociate readily.

Nature of solvent : Polar Solvent like water helps in dissociation of molecules.

Temperature : Rate of Dissociation increases with increase in temperature .or Degree of dissociation is directly proportional to temperature.

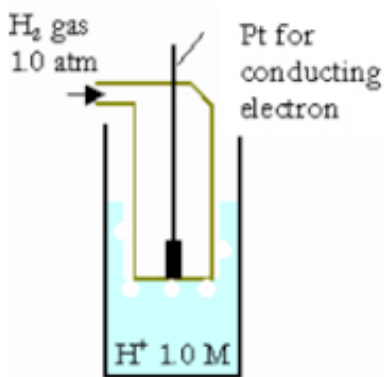
Concentration or dilution : Rate of Dissociation Increases with Dilution and Decreases with increase in Concentration. Or Degree of dissociation is inversely proportional to concentration.

Electrodes

- ❖ *Hydrogen electrode*
- ❖ *Calomel electrode*
- ❖ *Glass electrode*

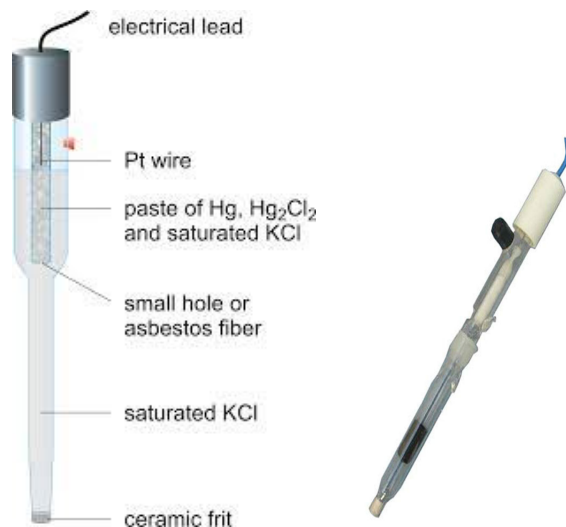
Construction of Electrodes

Hydrogen electrode



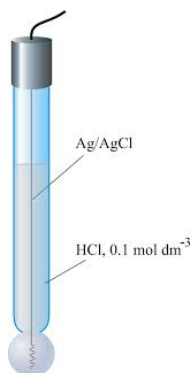
- ❖ **Standard Hydrogen Electrode (SHE)**
- ❖ Consists of -pt wire, and H₂ gas is passed.
- ❖ This is also known as standard Hydrogen Electrode (SHE)

Calomel electrode



- ❖ Consist of - Mercury-mercurous chloride
- ❖ It is filled with Potassium Chloride Solution.

Glass electrode



- ❖ Consist of Ag (Silver) electrode Coated with AgCl
- ❖ This electrode is also used as an Internal reference electrode .

Conductometric titrations

- ❖ This is a analysis (Titration) based on change of conductance of solution
- ❖ Conductance in electrolyte depends on the number and mobility of free ions

Types of conductometric titrations

- ❖ Acid -Base Titration
- ❖ Precipitation Titration

In acid base -titration strong acid reacts with strong base.

- ❖ The nature of graph is V' shaped
- ❖ Conductivity of electrolyte decrease and then increase again

In weak acid and strong base titration

- ❖ the graph is 'S' shaped, the conductance slowly increases and at equivalence point rises sharply.

Battery :

- ❖ A battery is a storehouse of energy
- ❖ Primary Battery is non rechargeable
- ❖ Secondary battery is rechargeable

Electrolytic Cell: A device in which electrolytes decompose by passing electricity.

Electrochemical Cell : A device in which electricity is generated by Spontaneous Redox reaction

Charging - when current from the external source reverse the chemical reaction of battery and restores it.

Discharging - when the battery gives current to the external source.

Primary battery

Dry Cell:

- ❖ (Oxidation) Anode - Zinc vessel
- ❖ (Reduction) Cathode - Graphite rod surrounded by paste of Carbon powder and Magnesium dioxide ($C + MnO_2$)
- ❖ Electrolyte - Paste of Zinc Chloride and Ammonium Chloride ($ZnCl_2 + NH_4Cl$)
- ❖ Separator - Muslin cloth.
- ❖ The cell reaction is irreversible as an ammonium complex is formed during the reaction.
- ❖ E.M.F =1.5V
- ❖ Use in torches, door bells, transistors etc

Secondary battery

Ni-Cd (Alkaline batteries)

- ❖ (Oxidation) Anode -Cadmium Oxide
- ❖ (Reduction) Cathode - Nickel Oxide mixed with Nickel (Ni_2O_3/NiO)

- ❖ Electrolyte - 20 to 25% KOH solution
- ❖ Use in power tools , computer power supply & also Space application

Lead acid Storage Cell

- ❖ (Oxidation] Anode - Lead Rod
- ❖ (Reduction) Cathode - Lead + Lead oxide.
- ❖ Electrolyte- 20% dil Sulphuric Acid
- ❖ EMF = 2 to 12 volts
- ❖ Use in gas engines, Telephone exchange, mines , laboratories, hospitals, automobiles.

Lithium ion battery

- ❖ (Oxidation) Anode - Metal oxide (Lithium - Cobalt oxide)
- ❖ (Reduction) Cathode - Carbon Rod
- ❖ Electrolyte - lithium salt in organic solvent.
- ❖ Use in mobile phones, Laptops, tablete, cameras etc

Fuel cell

The cell which converts the chemical energy of fuel directly into Electrical energy.

Eg Hydrogen - Oxygen fuel cell ($H_2 - O_2$)

Advantage of fuel cell.

- ❖ High energy efficiency
- ❖ No Air pollution
- ❖ Efficient use of fuel.
- ❖ No noise pollution
- ❖ low maintenance