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PHARMACEUTICAL ANALYSIS I

UNIT 5

TOPIC :

- **Electrochemical methods of analysis**
- **Conductometry –** Introduction, Conductivity cell, Conductometric titrations, applications

Conductometry

- Conductometry is the branch of electrochemistry that deals with the measurement of the electrical conductivity of an electrolyte solution to study chemical reactions, particularly titrations.
- It is based on the principle that ions in a solution conduct electric current, and any chemical reaction that changes the ionic concentration will affect the conductivity of the solution.

Principle:

- In an electrolyte solution, positive (cations) and negative (anions) move and carry electric current.
- The conductivity of the solution depends on:
  - Number of ions
  - Mobility of ions
  - Temperature
  - Nature of the electrolyte
- During a chemical reaction (e.g., neutralization), ions are either produced or consumed.
- This results in a measurable change in conductivity, which can be used to determine the endpoint of the reaction.

Instruments Used in Conductometry:

- Conductivity Cell: Consists of two platinum electrodes, often platinized, fixed at a known distance.
- Conductometer (or conductivity meter): Measures and displays the conductance or conductivity of the solution.
- AC Source: An alternating current is used to avoid electrolysis and polarization.

Applications of Conductometry:

In Analytical Chemistry:

- Detection of end point in titrations without using indicators.

- Useful in colored or turbid solutions where visual detection is hard.
- Estimation of acids, bases, salts, and precipitation reactions.

In Industry:

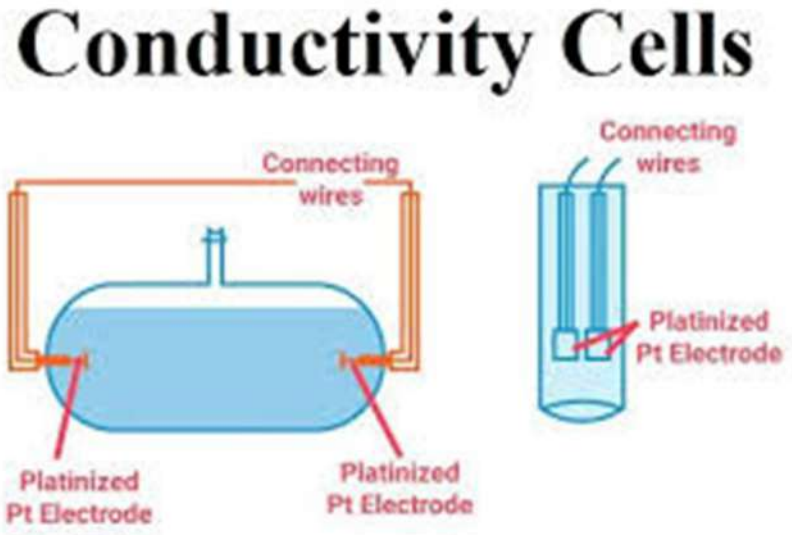
- Monitoring water purity (e.g., in pharmaceutical and power plants).
- Measuring dissolved salts in water treatment.

In Research:

- Studying ionic reactions, complex formation, and salt hydrolysis.

Conductivity Cell

- A conductivity cell is a device used to measure the electrical conductivity of an electrolyte solution by allowing an electric current to pass between two electrodes immersed in the solution.
- It is used along with a conductometer to detect changes in ionic concentration during chemical reactions, especially in conductometric titrations.



Construction of Conductivity Cell:

- It consists of two platinized platinum electrodes that are:
  - Chemically inert
  - Parallel to each other
  - Mounted at a fixed distance
  - Usually 1 cm^2 surface area
- The electrodes are enclosed in a glass or plastic body.
- Platinized platinum means the electrodes are coated with platinum black to increase surface area and reduce polarization.

Working Principle:

- When an alternating current (AC) is applied between the two electrodes, ions in the solution conduct electricity.
- The resistance of the solution is measured, and the conductance is calculated as:

$$G = 1 / R$$

- This conductance is then converted to specific conductivity (κ) using the cell constant (K):

$$K = G \times K$$

Applications of Conductivity Cell:

- Used in conductometric titrations (acid-base, precipitation, redox).
- Determination of water purity in pharmaceutical and industrial labs.
- Study of ionic mobility and dissociation in electrolytes.

Conductometric Titrations

- A conductometric titration is a titration method where the conductance of the solution is continuously measured as a titrant is added, and the end point is determined from the change in electrical conductivity.
- It is used when visual indicators are not effective — especially in colored, turbid, or weak acid/base solutions.

Principle of Conductometric Titration:

- Ions conduct electricity in solution.
- As titrant is added, the ionic composition changes due to neutralization or precipitation.
- This results in a change in conductance, which is recorded after each addition.
- A graph of conductance vs. volume of titrant is plotted.
- The end point is identified at the intersection of two linear segments.

Types of Conductometric Titrations

1. Strong Acid vs Strong Base

- Titration between a strong acid (e.g., HCl) and a strong base (e.g., NaOH), both of which ionize completely in solution.

2. Weak Acid vs Strong Base

- Titration between a weak acid (e.g., CH_3COOH) and a strong base (e.g., NaOH), where the acid only partially ionizes.

3. Strong Acid vs Weak Base

- Titration between a strong acid (e.g., HCl) and a weak base (e.g., NH_4OH), where the base is partially ionized.

4. Weak Acid vs Weak Base

- Titration between a weak acid (e.g., CH_3COOH) and a weak base (e.g., NH_4OH), both weak electrolytes.

5. Precipitation Titration

- A titration where the reaction forms an **insoluble precipitate**, removing ions from solution and changing conductivity.

6. Redox Titration

- A titration based on oxidation-reduction reactions, where ions are consumed or produced.

Applications of Conductometry

1. In Titrations

- Used to determine end points in:
  - Acid–base titrations (e.g., HCl vs NaOH)
  - Weak acid–weak base titrations (e.g., CH_3COOH vs NH_4OH)
  - Precipitation titrations (e.g., $AgNO_3$ vs NaCl)
  - Redox titrations (e.g., $KMnO_4$ vs H_2O_2)

2. In Pharmaceutical Analysis

- Estimation of drug concentration (e.g., aspirin, salicylic acid)
- Suitable for colored or turbid drug solutions
- Used in non-aqueous titrations for weakly basic drugs

3. In Water Quality Testing

- Measures total dissolved salts (TDS) in water
- Used to check purity of distilled/deionized water
- Monitoring of boiler feedwater and cooling systems

4. In Industrial Applications

- Monitoring neutralization reactions in chemical processes
- Estimation of alkalinity in soaps and detergents
- Quality control in electroplating and dye industries

5. In Chemical and Physical Research

- Study of ionic mobility and electrolyte behavior
- Determination of dissociation constants (Ka)
- Investigation of salt hydrolysis and ion pairing

6. In Education and Training

- Used in labs to teach instrumental analysis
- Helps students understand ionic conduction and titration curves