Potentiometry

Potentiometry

Definition

- Potentiometry is an electroanalytical method used to measure the voltage or potential difference between two electrodes in a solution.
- It helps to find the concentration of ions in a sample.
- It is commonly used in pharmaceutical analysis, water testing, clinical testing, and chemistry labs.
- Very little current flows during the measurement.

Principle

- Potentiometry works when two electrodes are placed in a solution and a potential difference is produced.
- One electrode is a **reference electrode** with constant potential, and the other is an **indicator electrode** whose potential changes with ion concentration.
- The relation between electrode potential and ion concentration is given by the **Nernst equation**:

$$E = E^0 + \frac{0.0591}{n} \log C$$

- **Where:**
  - **E** = Electrode potential
  - **E^0** = Standard electrode potential
  - **n** = Number of electrons involved
  - **C** = Ion concentration
- Potentiometry is mainly used for measuring **pH, ion concentration, and end points in titrations**.

Important Points

- Electrode potential changes with ion concentration.
- The measured voltage depends on ion activity.
- Very little current flows, so the solution does not change.
- It can be used for acid-base, redox, and ion-selective measurements.

Advantages

- Simple and easy method.
- Gives quick and accurate results.

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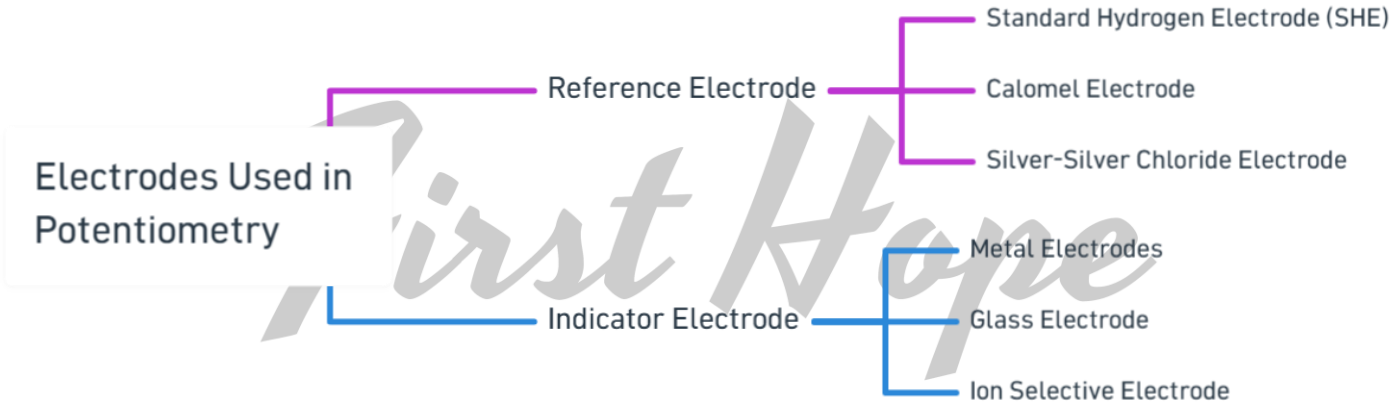
- Needs small sample quantity.
- Useful for colored and turbid solutions.
- Can be automated easily.
- Ion-selective electrodes help detect specific ions.

Limitations

- Electrodes need regular calibration.
- Temperature can affect results.
- Interfering ions may cause errors.
- Electrodes may get damaged or contaminated.
- Proper maintenance is needed for accurate results.

Electrodes Used in Potentiometry

There are mainly two types of electrodes used in potentiometry:



1. Reference Electrode

- A reference electrode gives a **constant and stable potential**.
- Its potential does not change with the test solution.

Types of Reference Electrodes

a) **Standard Hydrogen Electrode (SHE)**

- It is the primary reference electrode.
- It has a platinum electrode in acidic solution.
- Hydrogen gas is passed over it.
- Its potential is taken as **zero volt**.

b) **b. Calomel Electrode**

- It contains mercury and mercurous chloride.
- It is commonly used because it is stable and easy to handle.

c) **c. Silver-Silver Chloride Electrode**

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- It has a silver wire coated with silver chloride.
- It is widely used in pH measurement.

2. Indicator Electrode

- An indicator electrode responds to changes in ion concentration.
- Its potential changes according to the activity of ions in the solution.

Types of Indicator Electrodes

a) Metal Electrodes

- Made of metals like silver, copper, or zinc.
- Used for measuring metal ions.

b) Glass Electrode

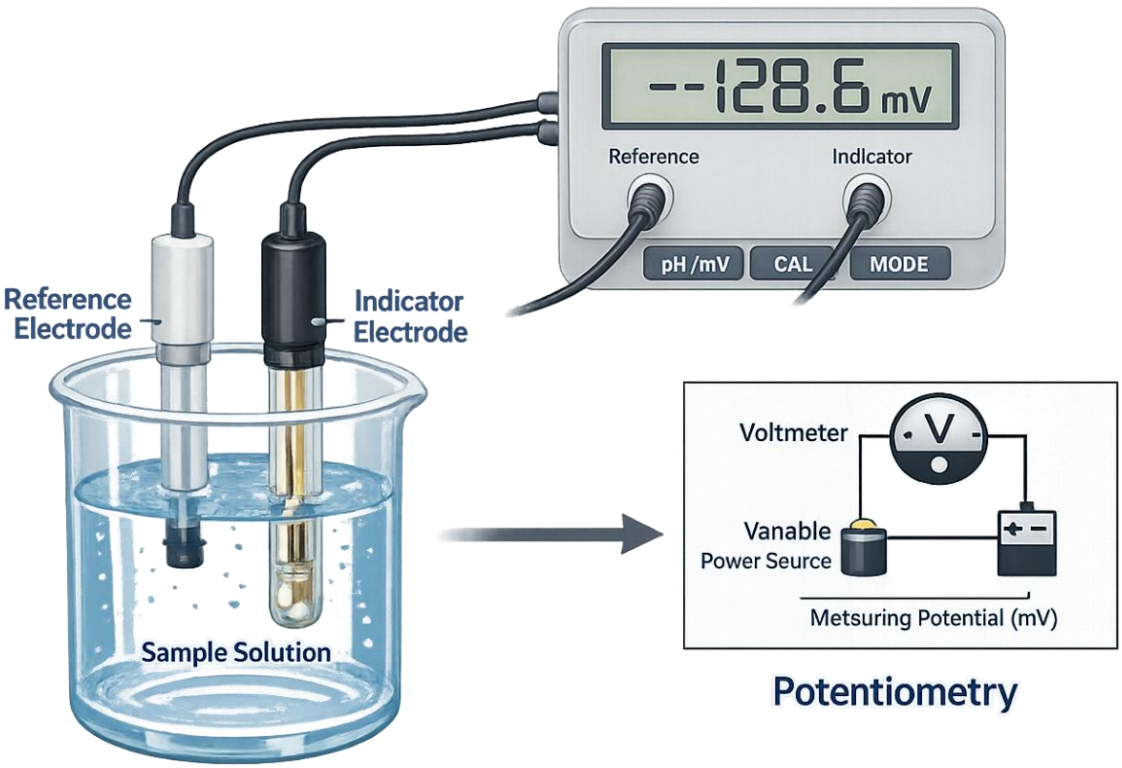
- Mainly used for pH measurement.
- Sensitive to hydrogen ions.

c) Ion Selective Electrode

- Responds selectively to a particular ion.
- Commonly used in analytical chemistry.

Working of Potentiometry

Basic Working



- In potentiometry, two electrodes are placed in the test solution.

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- One is the **reference electrode**, which gives a constant potential, and the other is the **indicator electrode**, which responds to ion concentration.
- A potentiometer or pH meter measures the potential difference between them.
- This voltage is then used to find the concentration or pH of the solution.

Basic Components

1. Indicator Electrode

- Responds to a specific ion in the solution.
- Its potential changes with ion concentration.
- Examples: glass electrode, metal electrode, ion-selective electrode.

2. Reference Electrode

- Gives a stable and constant potential.
- Its potential does not change during the experiment.
- Examples: calomel electrode and silver-silver chloride electrode.

3. Salt Bridge

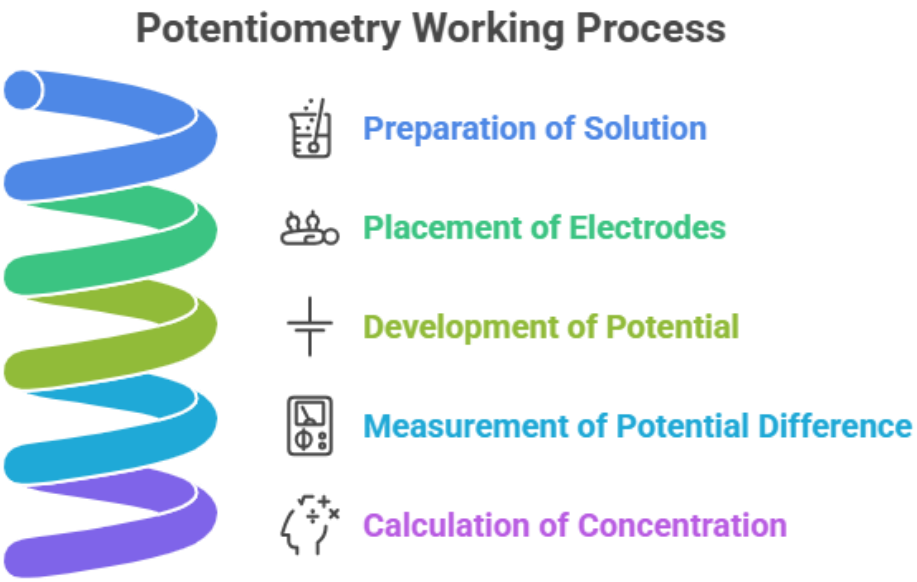
- Completes the electrical circuit.
- Helps maintain electrical neutrality of the solution.

4. Potentiometer or pH Meter

- Measures the potential difference between the electrodes.
- Digital pH meters work on this principle.

First Hope

Stepwise Working of Potentiometry



Step 1: Preparation of Solution

- The test solution containing ions is prepared in a beaker.

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Step 2: Placement of Electrodes

- The indicator electrode and reference electrode are immersed in the solution.

Step 3: Development of Potential

- The indicator electrode develops a potential depending on ion concentration.
- The reference electrode maintains a constant potential.

Step 4: Measurement of Potential Difference

- The potentiometer measures the voltage difference between the two electrodes.

Step 5: Calculation of Concentration

- The measured potential is used to calculate ion concentration using calibration graphs or the Nernst equation.

Ion Selective Electrodes (ISE)

Definition

- Ion selective electrodes are special electrodes that respond selectively to a specific ion present in a solution.
- These electrodes develop a potential depending on the concentration of a particular ion.
- They are highly sensitive and provide rapid analysis.

Principle of Ion Selective Electrodes

- Ion selective electrodes work on the principle of selective ion exchange across a membrane.
- The membrane allows only specific ions to interact and generate electrical potential.
- The potential developed is directly related to the concentration of the selected ion.

Construction of Ion Selective Electrode

Main Parts

1. **Selective Membrane**
   - The membrane is the most important part of the electrode.
   - It selectively interacts with a particular ion.
   - Different membranes are used for different ions.
2. **Internal Reference Solution**
   - The electrode contains an internal solution with fixed ion concentration.
   - This helps maintain stable electrode potential.

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