Ion selective electrode (ISE)

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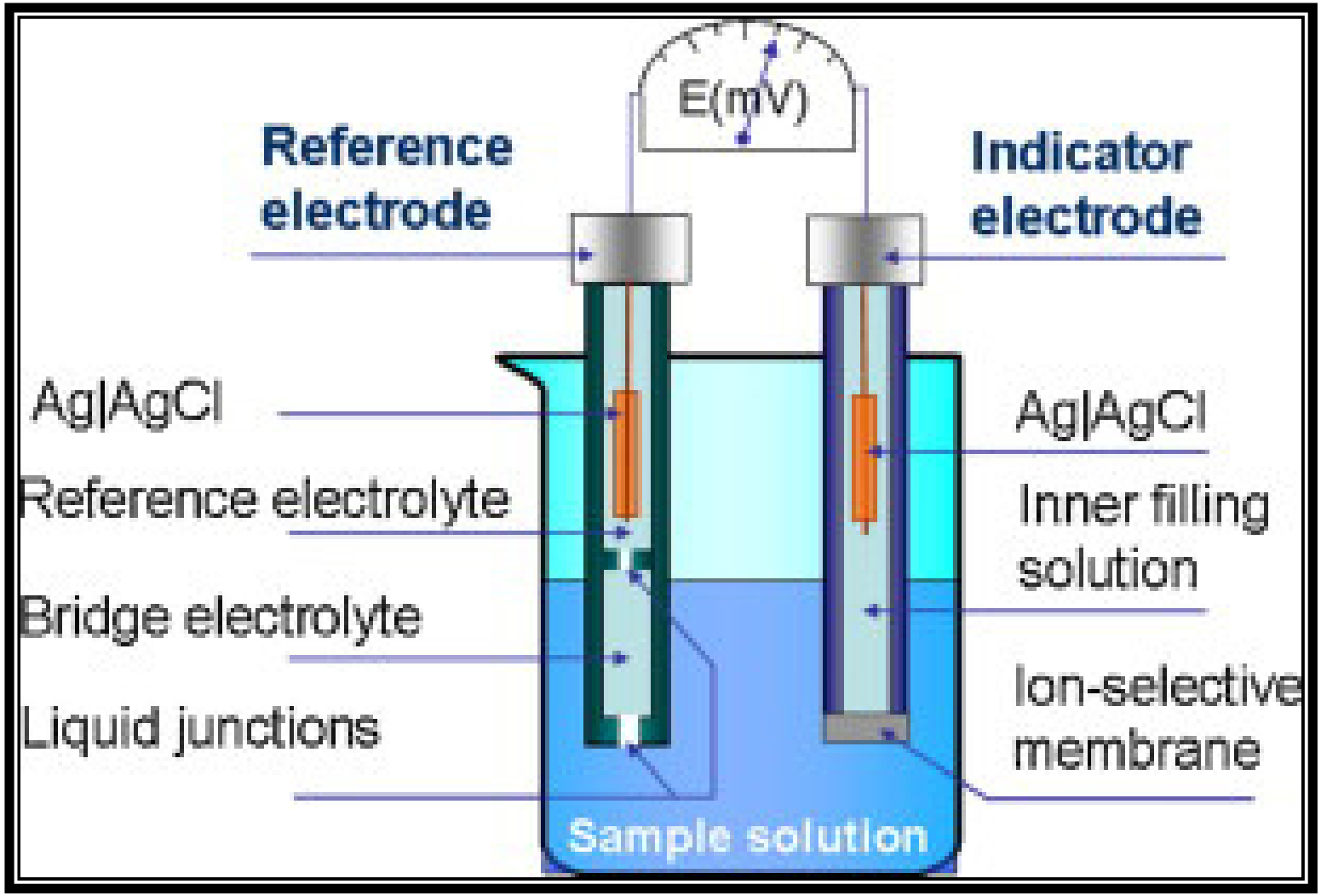
Introduction

- Ion selective electrode (ISE) is an analytical technique used to determine the activity of ions in aqueous solution by measuring the electrical potential.
- Specific ion dissolved in a solution create an electrical potential, which can be measured by a voltmeter or pH meter.
- The strength of this charge is directly proportional to the concentration of the selected ion.


E(mV)
Reference electrode
Indicator electrode
Ag|AgCl
Reference electrolyte
Bridge electrolyte
Liquid junctions
Ag|AgCl
Inner filling solution
Ion-selective membrane
Sample solution

Principle

- ISE consists of a thin membrane
- Only specific ion can be diffuse.
- By measuring the electric potential generated across a membrane by "selected" ions, and comparing it with reference electrode.
- And net charge is determined.

Potentiometry

- Potentiometry
  - Use of Electrodes to Measure Voltages that Provide Chemical concentration

  - Indicator Electrode:
  - Electrode that responds to analyte

  - Reference Electrode:
  - Second ½ cell at a constant potential

  - Cell voltage is difference between the indicator and reference electrode

Reference Electrode

Silver-Silver Chloride Reference Electrode

$$AgCl(s) + e^- \rightleftharpoons Ag(s) + Cl^-$$

Types of ISE

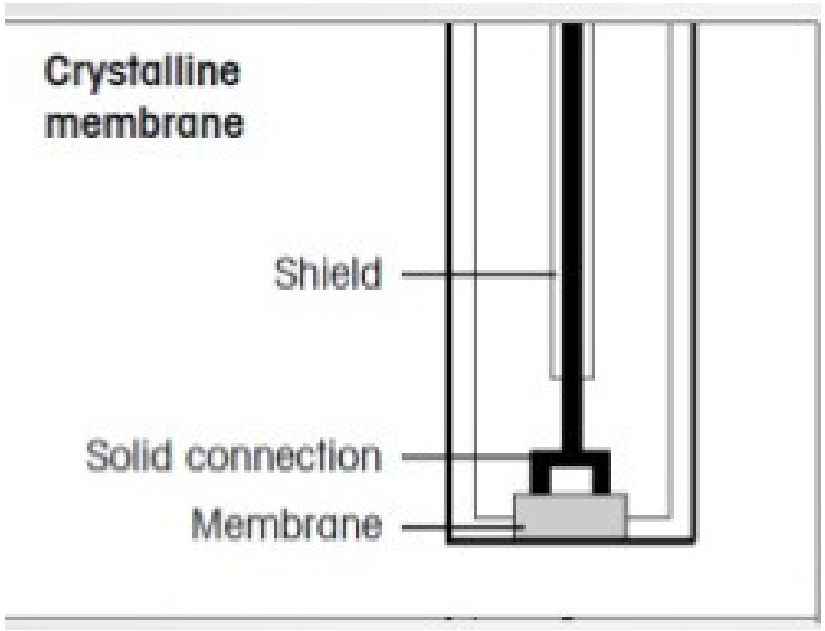
- Glass membrane
- Solid state electrode
- Liquid based electrode
- Compound electrode

Glass Membrane Electrode

- This method uses the electrical potential of pH-sensitive **electrodes** as a measurement signal.
- The **glass electrode** is the most commonly used sensor.
- Not having the **disadvantages** of the optical methods, it can be used almost universally.

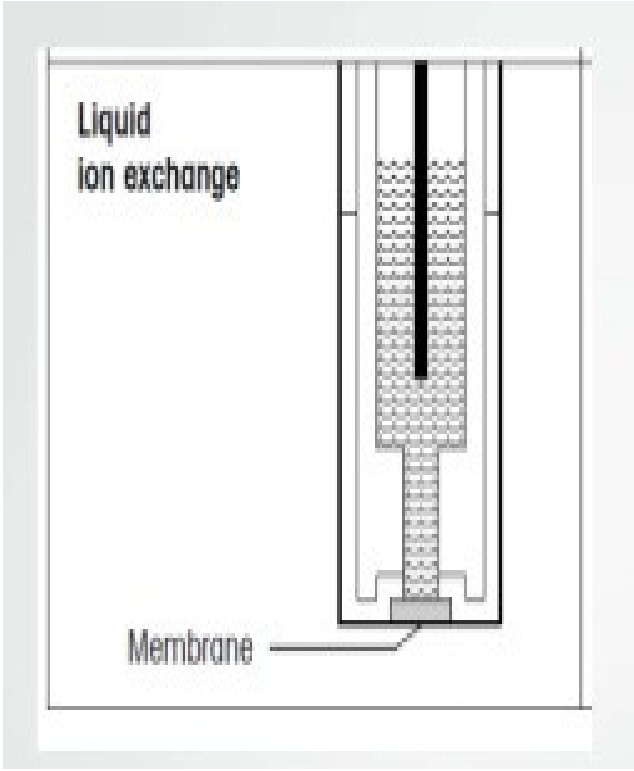
Solid State Electrode

- Electrode body of Inorganic crystalline polymer.
- E.g. Special Epoxide Resin with excellent mechanical properties.
- High temperature stability.



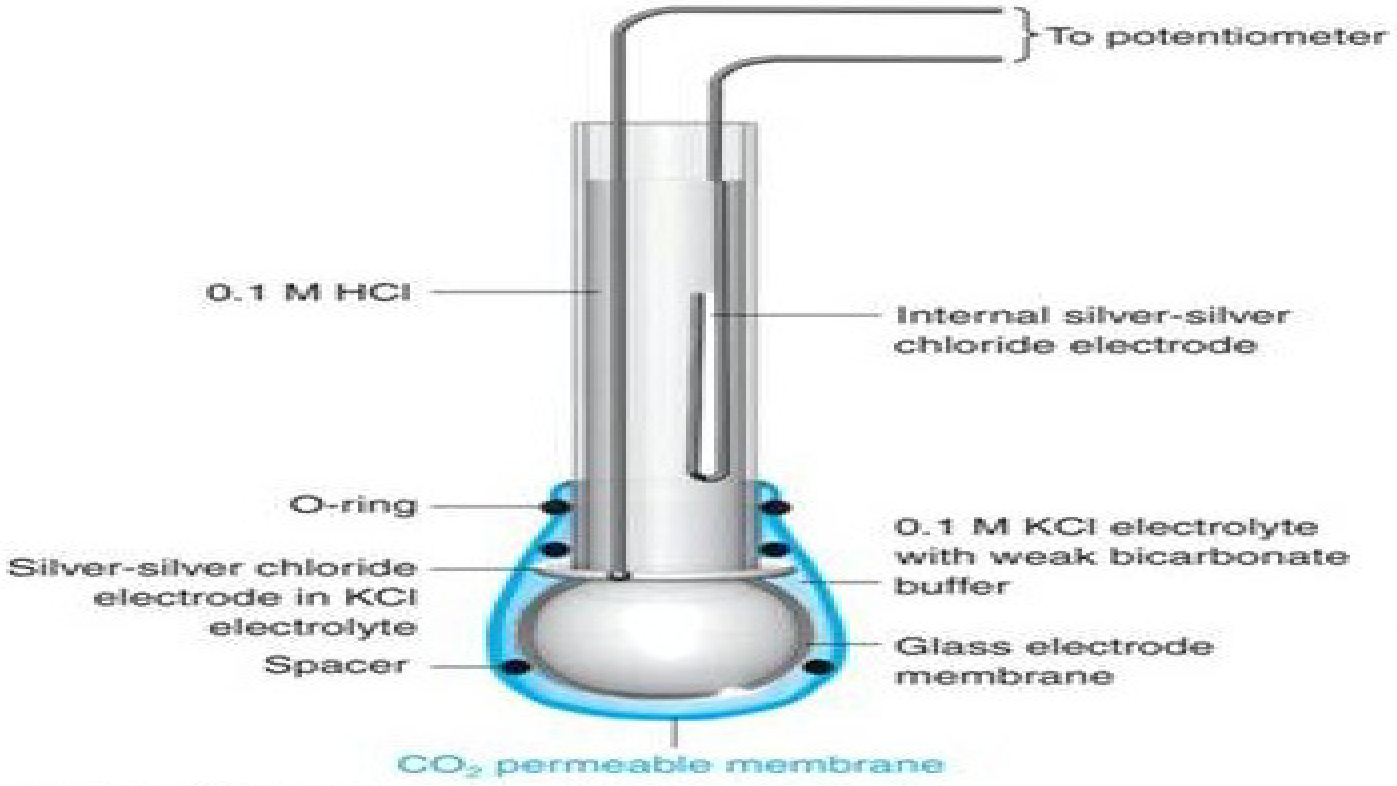
Liquid based electrode

- Formed by a very thin layer of an organic liquid.
- Membrane is like jelly
- Impermeable to water
- only to allow to pass certain ion.
- Organic material
    - Carbon tetrachloride
    - Benzene
    - Mesitylene



Compound electrode

- Electrode have membrane of multiple type



Electrolytes

- Type of ions
  - Cations – Positive charge
    - move toward the cathode
      - Na+ = Extracellular – Brain Activity
      - K+ = Intracellular – Heart & Muscle
      - Ca+ = Extracellular – Heart & Muscle
      - H+ = Extracellular - Acidic
  - Anions – Negative charge
    - move toward the anode
      - Cl – Extracellular
      - HCO–3 – Extracellular - Basic

Sample Collection

- Serum
  - Collected in heparin bulb
  - Plain
  - EDTA can not be use for doing electrolyte
    - EDTA is chelating agent & anti-coagulant.
    - It chelat with all ions of blood
    - So interfere with concentration of ions
- Urine
  - Collected in plain vacuette

Types of Heparin vacuette

- Ammonium
- Lithium = Lithium+ heparin
- Sodium=Sodium+ heparin

For measure the sodium

- lithium heparin vacuette
- ammonium heparin vacuette

Use of sodium vacuette gives false high sodium concentration.

Routinely measured electrolytes

Sodium

- (90%)Major cation
- Extracellular fluid **outside cells**

Normal values

- Serum = 135-145 mEq/L
- Urine (24 hr) = 40-220 mEq/L

Functions

- Influence on regulation of body water
- Osmotic activity
- Central - Neuromuscular activity

Hyponatremia

- **Hyponatremia <135 mEq/L**
  - Increased Na+ loss
  - Causes
    - Diabetes mellitus
    - Diabetic Ketoacidosis
      - Because of diuresis
    - Severe diarrhea & Severe Vomiting

Hypernatremia

- Excess water loss resulting in dehydration (relative increase)
  - Dehydration from inadequate water intake
  - Dehydration due severe diarrhea
  - Diabetes insipidus
  - Burns

Potassium (K)

- (2%)major cation
- Intracellular fluid **inside cell**

Normal value

- Serum- 3.5-5.3 mEq/L
- Urine- 25-125 mEq/L

Function

Heart muscle contraction

Increase or Decrease K+ = Arrhythmiasis

Hypokalemia

- **Hypokalemia** = a low level of potassium (K^+) in the blood serum.
- Diarrhea
- Medications like furosemide (diuretic)
- Dialysis
- Diabetes insipidus
- Hyperaldosteronism

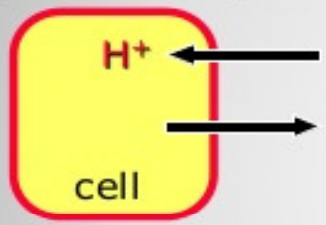
Hyperkalemia

- Increased K concentration
- Causes
  - Acute Renal failure
  - Chronic Renal failure
  - Acidosis (Diabetes mellitus)
    - H+ competes with K+ to get into cells & to be excreted by kidneys
    - Decreased insulin promotes cellular K loss
    - Hyperosomolar plasma (from ↑ glucose) pulls H_2O and potassium into the plasma .

ELECTROLYTE SHIFTS

Acidosis

Compensatory Response

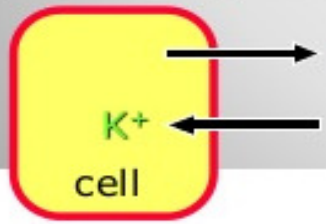


Result

- H^+ buffered intracellularly
- Hyperkalemia

Alkalosis

Compensatory Response



Result

- Tendency to correct alkalosis
- Hypokalemia

Chloride (Cl^-)

Chloride

Major cation

Extracellular fluid

Normal value

- Serum – 100 -110 mEq/L
- 24 hour urine – 110-250 mEq/L

  varies with intake
- CSF – 120-132 mEq/L

Hypochloremia

Same as Hyponatremia

- congestive heart failure
- Severe diarrhea
- Severe vomiting
- drugs such as
  - Laxatives
  - diuretics
  - corticosteroids
  - Bicarbonates.

Hyperchloremia

- Same as Hypernatremia
- Increased serum Cl
  - dehydration
  - renal tubular disease
  - metabolic acidosis

Advantages

1. Good Linearity
2. Good precision
3. Less chance of damage
4. No consumption require
5. Non-contaminating.
6. Fast analysis.
7. Less interference from serum color & turbidity.

Limitations

1. Electrodes can be block by proteins.
2. Interference by other ions.
3. Electrodes are fragile
4. Limited electrode life – 3 to 4 months.

Application of ISE

- Electrolyte
  - Sodium
  - Potassium
  - Calcium
  - Lithium
  - Iodine
  - Magnesium
  - Chloride
  - Fluoride
- Glucose
- Urea
- Arterial Blood Gas Analysis
  - pO2
  - pCO2
  - pH
  - HCO3-