

Engineering Chemistry Unit-1

Water – Analysis, Treatments and Industrial Applications

1. Introduction to Water

Water is one of the most important natural resources required for domestic, industrial and agricultural purposes. In industries, water is used in: Steam generation Cooling systems Boilers Chemical manufacturing Power plants Pure water is colorless, odorless and tasteless. However natural water contains many impurities.

2. Sources of Water

Water is mainly obtained from the following sources: **(i) Rain Water**

Rain water is considered the purest natural form of water. It contains dissolved gases like oxygen, nitrogen and carbon dioxide. **(ii) Surface Water**

Includes: Rivers Lakes Ponds Sea water Surface water contains suspended impurities and microorganisms. **(iii) Underground Water**

Obtained from: Wells Tube wells Springs Groundwater contains dissolved salts and minerals.

3. Impurities in Water

Impurities present in water are classified into: **(i) Suspended Impurities** Sand Mud Clay **(ii) Dissolved Impurities** Calcium salts Magnesium salts Sodium chloride **(iii) Biological Impurities** Bacteria Viruses Fungi **(iv) Dissolved Gases** CO₂ H₂S NH₃

4. Hardness of Water

Hardness of water is the property due to which water does not produce lather easily with soap. Hardness is caused by dissolved calcium and magnesium salts. Types of hardness: **(i)**

Temporary Hardness

Caused by bicarbonates of calcium and magnesium. Examples: $\text{Ca}(\text{HCO}_3)_2$ $\text{Mg}(\text{HCO}_3)_2$
Temporary hardness can be removed by boiling. **(ii) Permanent Hardness**

Caused by chlorides and sulphates of calcium and magnesium. Examples: CaSO_4 MgCl_2
Permanent hardness cannot be removed by boiling.

5. Units of Hardness

Hardness is expressed in terms of CaCO_3 equivalents. Common units: ppm (parts per million) mg/L Degree Clarke Degree French 1 ppm = 1 mg of CaCO_3 per liter of water.

6. Determination of Hardness by EDTA Method

EDTA method is the most common method used for determination of hardness. **Principle:**

EDTA forms stable complexes with calcium and magnesium ions. Indicator used: Eriochrome Black-T (EBT) Buffer solution maintains pH around 10. **Procedure:** Take sample water Add buffer solution Add EBT indicator Titrate with EDTA solution Color changes: Wine red → Blue **Formula:**

Hardness = (Volume of EDTA × Normality × 50,000) / Volume of sample

7. Numerical Example on Hardness

Question:

50 mL water sample requires 10 mL EDTA solution for titration. Calculate hardness if EDTA normality is 0.01N. **Solution:**

Formula: Hardness = $(V \times N \times 50,000) / \text{Sample Volume}$ Substitute values: = $(10 \times 0.01 \times 50,000) / 50 = 100$ ppm Therefore hardness = 100 ppm.

8. Alkalinity of Water

Alkalinity is the capacity of water to neutralize acids. It is caused due to: Hydroxides Carbonates Bicarbonates Excess alkalinity causes: Boiler problems Scale formation Corrosion

9. Determination of Alkalinity

Alkalinity is determined by acid-base titration. Indicators used: Phenolphthalein Methyl Orange **Procedure:** Take water sample Add indicator Titrate with standard acid End point is indicated by color change.

10. Numerical on Alkalinity

Question:

100 mL water sample requires 20 mL of 0.02N HCl. Calculate alkalinity. **Solution:**

Formula: Alkalinity = $(V \times N \times 50,000) / \text{Sample Volume}$ = $(20 \times 0.02 \times 50,000) / 100 = 200$ ppm
Therefore alkalinity = 200 ppm.

11. Industrial Applications of Water

Water is used in industries for: Boiler feed water Cooling water Steam production Textile industry Food processing Chemical industries For industrial use, water should be soft and free from impurities.

12. Most Important PYQs

Repeated Questions: Define hardness of water Differentiate temporary and permanent hardness Explain EDTA method Determine alkalinity of water Write industrial applications of water Numericals based on hardness and alkalinity Most Important 7 Marks Questions: Explain EDTA method with diagram Differentiate temporary and permanent hardness Numericals on hardness and alkalinity