

Hardness of Water

Hardness of water is due to presence of soluble salts of calcium, magnesium and other heavier metals in water. Hard water does not give lather easily with soap, but produces a white scum or precipitate with soap. The scum or precipitate is due to the formation of insoluble soaps of calcium and magnesium ions react with soap. Hardness of water can be classified as temporary hardness and permanent hardness.

Types of hardness: Temporary hardness: Temporary hardness is caused by the presence of dissolved bicarbonates of calcium and magnesium. This can be removed by boiling.

Permanent hardness: Permanent hardness is due to presence of chlorides & sulfates of dissolved calcium, magnesium, iron & other heavy metals. The salts responsible for permanent hardening are CaCl_2 , MgCl_2 , CaSO_4 , MgSO_4 , FeSO_4 , $\text{Al}_2(\text{SO}_4)_3$. Permanent hardness cannot be removed by boiling. This is also known as non-carbonate or non-alkaline hardness. The sum of temporary and permanent hardness is referred as total hardness of water. Although hardness of water is never present in the form of CaCO_3 as it is insoluble in water hardness of water is conveniently expressed in terms of equivalents of CaCO_3 . The hardness is expressed in terms of equivalent calcium carbonate. The reason for choosing CaCO_3 as standard for report in hardness is ease in calculations on its molecular weight is exactly 100.

Units of Hardness: 1. Parts Per Million: Parts of CaCO_3 equivalent hardness per 10⁶ parts of water. 1 ppm = 1 part of CaCO_3 equivalent hardness in 10⁶ parts of water.

Estimation of hardness of water by EDTA Method:

This is a complexometric method. Ethylene diamine tetraacetic acid (EDTA) in the form of its sodium yields the anion. Principle of EDTA titrations: The quick, complete and 1:1 interaction of metal ions with EDTA leading to the formation of stable complex is the basis for complexometric titrations. Theory: The hard water is buffer to a pH value of ~10 using $\text{NH}_4\text{OH}-\text{NH}_4\text{Cl}$ buffer and few drops of EBT indicator solution are added. EBT forms a weak complex with metal ions that has a wine-red colour.

During the course of titration of water sample against EDTA, first EDTA combines with free Ca^{2+} or Mg^{2+} ions to give very stable and colourless metal-EDTA complex. After all the free metal ions are consumed, the next drop of added EDTA solution displaces the indicator to form Metal-EBT complex. $\text{Metal} - \text{EBT} + \text{EDTA} \rightarrow \text{Metal} - \text{EDTA} + \text{EBT}$ Wine red blue
At the equivalence point, there is change in colour from wine-red to blue.

Procedure: Step – 1: Standardisation of EDTA solution: The burette is filled with EDTA solution after washing and rinsing. Pipette out 50 mL of standard hard water (1 mL of it must contain 1 mg of CaCO_3) into a 250 mL conical flask, 10 mL of buffer solution and 2-3 drops of EBT indicator are added and titrated against EDTA solution until the wine-red colour changes to blue. Let the volume of EDTA solution consumed be V_1 mL.

Step – 2:

Determination of total hardness of water: As per the same procedure (Step-1), 50mL of the unknown water sample is titrated against EDTA. Let the volume of EDTA solution consumed be V_2 mL

Step -3:

Determination of permanent hardness of water: 250mL of the water sample is taken in a 500mL beaker and boiled it till the volume is reduced to about 50mL. [The step causes all the bicarbonates to decompose respectively into insoluble CaCO_3 and Mg(OH)_2]. Filter and wash the precipitate with distilled water and quantitatively collect the filtrate and washings in a 250mL conical flask and made up the volume to 250mL with distilled water. 50mL of this water sample is titrated against EDTA solution as in Step-1. Let the volume of EDTA solution consumed be V_3 mL.