Hardness

I.   Purpose:

To become familiar with the concept of hardness and its measurement in water.

II.   Definition:

Hardness of water is a measure of its capacity to precipitate soap and is caused by the presence of divalent cations of calcium and magnesium.

III.   Reference:

Standard Methods of the Examination of Water and Wastewater (1980) 15th Ed. p.200.

IV.   Materials :

Burette, 25 ml
Porcelain dish
Magnetic stirrer and rod
Pipette
Measuring cylinder, 100 ml
Ammonia buffer solution
Sodium hydroxide solution
Eriochrome black T indicator
Murexide (Ammonium purpurite)
0.01MEDTA (Ethylene Diamine Tetra Acetate, Sodium Salt)
Raw water sample
Treated water sample

V.   Procedure :   EDTA Titrinetric Method

1) Analysis for hardness is performed in two stages by estimating Total and Calcium Hardness separately and the Magnesium Hardness is calculated from the difference between the two.
2) Pipette exactly 25 ml of raw water sample into a porcelain dish and drop in a magnetic rod.
3) Mount of 50 ml burette and fill it to the mark with 0.01M EDTA solution.
4) Add 1-2 ml of Ammonia buffer, 0.2 g Eriochrome Black T indicator and add slowly 0.01M EDTA solution until the color of the solution changes from wine red to blue. Record the volume of EDTA solution and calculate Total Hardness.
5) Add 1-2 ml sodium hydroxide buffer and 0.2 g Murexide indicator into 25 ml of raw water sample and add 0.01M EDTA solution slowly till the color of the solution changes from purple to violet. Record the volume of EDTA solution and calculate Calcium Hardness.

6) Repeat titration for the treated water and calculate the hardness.

VI.   Calculations :

Total hardness and calcium hardness are both calculated using the following equation:

$$\text{Hardness (EDTA) as mg/l CaCO}_3 = \frac{A \times B \times 1000}{\text{ml sample}}$$

A = ml EDTA solution used
B = mg $CaCO_3$ equivalent to 1 ml EDTA titrant

Magnesium Hardness as mg/l $CaCO_3$ = total Hardness - Calcium Hardness

VII.   Problems :

1.   What are other cations besides calcium and magnesium that can cause hardness?

2.   A sample of water has 190 mg/l alkalinity, 310 mg/l total hardness and 270 mg/l calcium hardness. Find out the following?

       a)   Magnesium hardness
       b)   Carbonate hardness
       c)   Noncarbonate hardness.

3.   What is the public health significance of hardness?

4.   How does calcium hardness cause scale inside water pipes?

5.   What would be the effect of performing the test at pH 9 instead of pH 10?

6.   Mark the following statements as True or False

       a)   Hardness of natural water is caused by Calcium and Carbonate.
       b)   Ammonia buffer used in hardness analysis helps to prevent precipitation of the actual ions being analyzed.
       c)   With the advent of synthetic detergents, many of the disadvantages of hard waters for household use have been diminished.
       d)   In general surface waters are softer than ground waters.
       e)   Hard waters originate in the area where the top soil is thick and lime stone formations are absent.
       f)   Hard waters are as satisfactory for human consumption as soft waters.
       g)   Hardness associated with bicarbonate and carbonate ions can be precipitated by elevated temperature.

h)   The amount of hardness which is in excess of the carbonate hardness is called carbonate hardness.

7.   Circle the correct answer:

a)   In hardness analysis EDTA is used as

   1. Oxidizing agent
   2. Chelating agent
   3. Reducing agent
   4. Neutralizing agent

b)   hardness of water is classified

   1. With respect to the metallic ions
   2. With respect to the anions associated with the metallic ion
   3. With respect to both
   4. With respect to none.

c)   A moderately hard water contains - hardness as $CaCO_3$

   1. Above 300 mgl/l
   2. 75-150 mg/l
   3. 0-75 mg/l
   4. 150-300 mg/l

d)   Hardness of water is removed by

   1. Aeration
   2. Filtration
   3. Coagulation
   4. Evaporation

c)   Non-carbonate hardness is removed by the addition of

   1. Alum
   2. Soda ash
   3. Lime
   4. Ferric chloride