Experiment no: 2
Determination of total hardness of water using EDTA titration

Theory

Water samples that do not readily form lather with soap or deposit scales on the walls of the container when there is appreciable change in temperature are called hard water. Hardness is caused by the presence of some metallic ions *viz*. Ca^{2+}, Mg^{2+} and some other metallic ions- Fe^{2+}, Mn^{2+} and Sr^{2+}. But these are usually present in small quantities. The portion of hardness that can be removed by boiling is known as temporary hardness. Boiling converts the soluble bicarbonates present into insoluble carbonates and hydroxides which can be removed by filtration. The portion of hardness that cannot be removed by boiling is termed as permanent hardness. Hardness is generally reported in terms of $CaCO_3$ equivalent and is calculated by general formula:

Hardness (in mg/l) = M^{2+} (in mg/l) × (50/Equivalent wt of M^{2+})
50 being the equivalent weight of $CaCO_3$ and M^{2+} is any divalent metallic ion.

Unit of Hardness

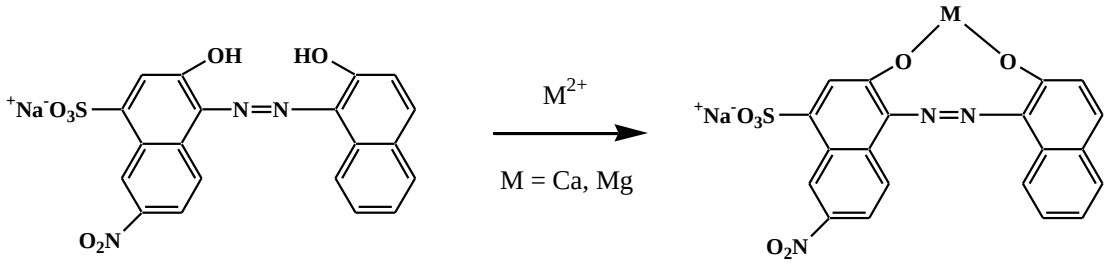
Parts per million (ppm) is the most commonly used unit of hardness.
1 ppm = 1 part $CaCO_3$ equivalent in 10^6 parts of water

Degree of hardness

Very soft: 0-70 ppm; Soft: 70-140 ppm
Slightly hard: 140-210 ppm; Moderately hard: 210-320 ppm
Hard: 320-530 ppm; Very hard> 530 ppm

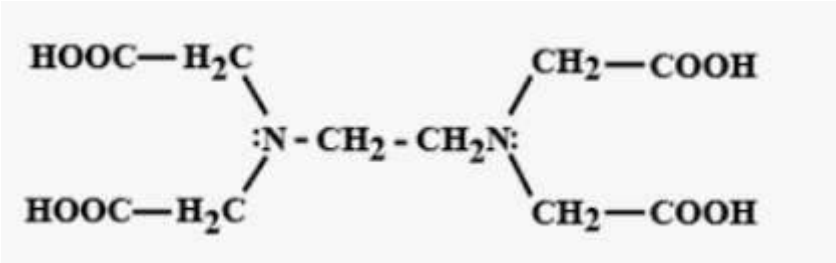
Equation

Between pH 7 to 11, Erichrome Black-T (**EBT**) indicator is blue in colour. Addition of metallic salt in this pH range results in a brilliant change in colour from blue to wine red due to formation of metal ion-EBT complex (**C1**). When the wine red complex **C1** is treated with the disodium salt of EDTA, the colourless metal ion-EDTA complex (**C2**) is formed rapidly. This is indicated by the change of the wine-red color of the metal ion-EBT complex (**C1**) to the blue colour of the free indicator **EBT**. The Full form of $EDTA^{2-}$ is ethylene diamine tetracetate ion.



EBT(In) **C1**

C1 + $EDTA^{2-}$ = MEDTA + In
(wine red) (**C2**) (Free Indicator)
(Metal-EDTA complex) (blue)



Structure of ethylenediaminetetraacetic acid

Chemicals required

1. EDTA (N/50) Solution
2. Buffer ($NH_4Cl + NH_4OH$) [pH 10]
3. Erichrome Black T indicator

Apparatus

1. Burette
2. Pipette
3. Conical flask
4. Measuring Cylinder

Procedure

50 ml of hard water sample is pipetted out and transferred to a conical flask. 2 mL of buffer solution and 2 drops of EBT indicator are added to it. The solution is then titrated against standard EDTA solution running from a burette till the wine red colour of the solution is turned to blue. Three such titrations are performed and the average value is recorded. The buffer solution is used to maintain the pH of the solution. Ammonium hydroxide-Ammonium chloride buffer is used for the reaction.

No. of observations	Burette Reading (ml)		Volume of EDTA used (ml)	Average Volume of EDTA (ml)	Strength of EDTA Solution	Volume of water sample taken (ml)
	Initial	Final				
1	0	2.6	2.6	2.53	(N/50)	50
2	3	5.5	2.5			
3	0	2.5	2.5			

Calculation

1000 ml of 1(M) EDTA ≡ 100 gm $CaCO_3$
1 ml of 1(M) EDTA ≡ (100/1000) gm $CaCO_3$
1 ml of 1(M/50) EDTA ≡ (100/1000) × (1/50) gm $CaCO_3$
≡ (100/1000) × (1/50) × 1000 mg $CaCO_3$
≡ 2 mg $CaCO_3$

2.53 ml of EDTA required for titration
So, 2.53 ml (M/50) EDTA ≡ 2 × 2.53 = 5.06 mg $CaCO_3$
Now Volume of water taken = 50 ml
So,
50 ml water contains = 5.06 mg $CaCO_3$
1000 ml water contains = [5.06/50 × 1000] mg $CaCO_3$ = 101.2 ppm or mg/l

Precautions

1. Distilled water was used for washing and rinsing of glass apparatus
2. Same amount of indicator was added each time
3. pH 10 was maintained during the titration by adding buffer
4. End point was observed carefully