Determination of Total Hardness of Water by Complexometric Titration [EDTA Method]

Aim

To determine the total hardness of a given water sample by complexometric titration (EDTA method)

Theory

Water which does not give ready and permanent lather with soap is called hard water. Presence of calcium and magnesium salts in the form of bicarbonate, chloride and sulphate in water makes water 'hard'. Water free from soluble salts of calcium and magnesium is called soft water. It gives lather with soap easily.

The property of water which restricts the lather formation with soap is called hardness. It is of two types: (a) temporary hardness and (b) permanent hardness

Temporary Hardness: It is due to the presence of magnesium and calcium bicarbonates [$Ca(HCO_3)_2$ and $Mg(HCO_3)_2$].

Permanent Hardness: It is due to the presence of soluble salts of magnesium and calcium in the form of chlorides and sulphates in water ($CaCl_2$, $CaSO_4$, $MgCl_2$ and $MgSO_4$).

The unit used for expressing the hardness of water is parts per million (ppm). It is the number of parts of calcium carbonate ($CaCO_3$) equivalent hardness present in one million parts of water.

Eriochrome Black-T [EBT] is the indicator used in the determination of hardness by complexometric titration with EDTA. Here, Eriochrome Black-T is a complex organic compound [sodium-1-(1-hydroxy 2-naphthylato)-6-nitro-2-naphthol-4-sulphonate] and EDTA is a hexadentate ligand [disodium salt of ethylenediamine tetraacetic acid].

Eriochrome Black-T [EBT]

EDTA
[Disodium salt of ethylenediamine tetraacetic acid]
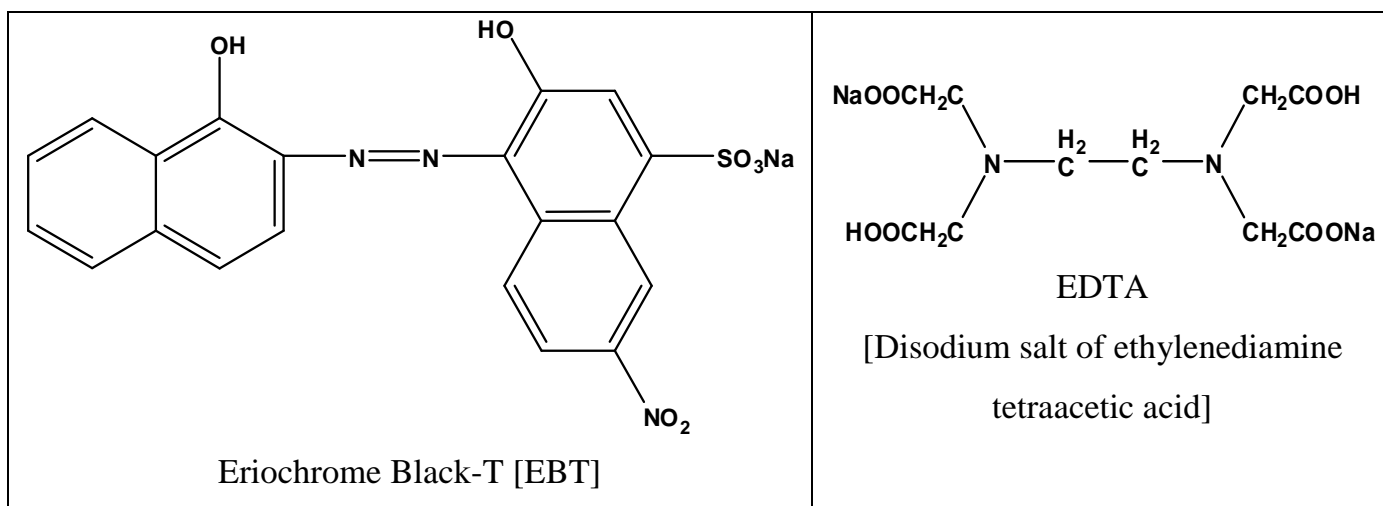
Observations and Calculations

(a) <u>Standardisation of EDTA solution with standard hard water</u>

S.No	Volume of standard hard water in ml	Burette Readings in ml		Volume of EDTA solution in ml
		Initial	Final	
1				
2				
3				
4				

Concordant Volume of EDTA solution, V_1 =………ml

| 1 ml of Standard hard water	=	1 mg $CaCO_3$
V_1 ml of EDTA solution	=	20 ml of Standard hard water
	=	20 mg $CaCO_3$
1 ml of EDTA solution,	=	$\dfrac{20}{V_1}$ mg $CaCO_3$
	=	…………..mg $CaCO_3$

(b) <u>Estimation of Total Hardness of given water sample</u>

S.No	Volume of given water sample in ml	Burette Readings in ml		Volume of EDTA solution in ml
		Initial	Final	
1				
2				
3				
4				

Concordant Volume of EDTA solution, V_2 =………ml

$$20 \text{ ml of given water sample} = \textbf{V}_2 \textbf{ ml of EDTA solution}$$

$$= V_2 \times \left[\frac{20}{V_1}\text{ mg } CaCO_3\right]$$

$$1 \text{ ml of given water sample} = V_2 \times \left[\frac{20}{V_1}\text{ mg } CaCO_3\right] \times \frac{1}{20}$$

$$1000 \text{ ml of given water sample} = V_2 \times \left[\frac{20}{V_1}\text{ mg } CaCO_3\right] \times \frac{1}{20} \times 1000$$

$$= \frac{V_2}{V_1} \times \frac{20}{20} \times 1000 \text{ mg } CaCO_3$$

$$= \frac{V_2}{V_1} \times 1000 \text{ mg } CaCO_3$$

$$\text{Total Hardness of given water sample} = \frac{V_2}{V_1} \times 1000 \text{ ppm} = \cdots\ldots\ldots\ldots. \textbf{ppm}$$

When Eriochrome Black-T is added to the hard water at pH around 10, it gives wine red coloured unstable complex with Ca^{2+} and Mg^{2+} ions of the sample water.

$$Ca^{2+}/Mg^{2+} + EBT \rightarrow [Ca^{2+}/Mg^{2+}EBT]$$

from hard water   Wine red coloured unstable complex
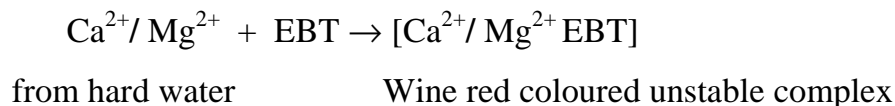
Now when this wine red-coloured solution is titrated against EDTA solution, EBT in the unstable complex is replaced by EDTA to form a stable metal-EDTA complex and liberates the free Eriochrome Black-T. At this point, the colour of the solution changes from wine red to original blue colour which showing the end point of the titration.

$$[Ca^{2+}/Mg^{2+}EBT] + EDTA \rightarrow [Ca^{2+}/Mg^{2+}EDTA] + \text{free EBT}$$

Wine red coloured   Stable metal-EDTA complex   Blue colour
unstable complex   (Colourless)
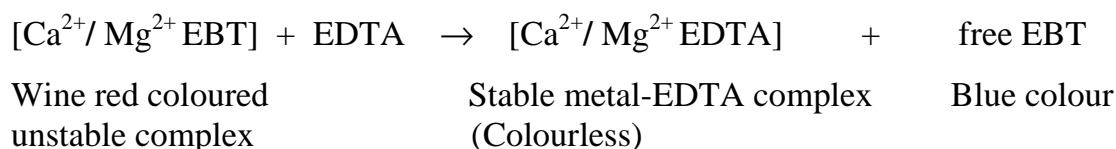
Apparatus:

Conical flask, Burette, Pipette, Beaker, Measuring flask

Reagents:

0.1M EDTA solution, Eriochrome Black-T indicator, Basic buffer solution (NH_4OH and NH_4Cl), Standard hard water, Given water sample

Procedure:

(a) Standardisation of EDTA solution with standard hard water

Pipette out 20 ml of standard hard water in a washed conical flask. Add 5ml basic buffer solution and 2-3 drops of Eriochrome Black-T indicator, the colour of the solution turns wine red. Titrate this solution against EDTA solution taken in the burette until the colour changes from wine red to clear blue at the end. The final reading of the burette is noted and the titration is repeated to get concordant value.

(b) Estimation of Total Hardness of given water sample

Pipette out 20 ml of given hard water in a washed conical flask. Add 5ml basic buffer solution and 2-3 drops of Eriochrome Black-T indicator, the colour of the solution turns wine red. Titrate this solution against EDTA solution taken in the burette until the colour changes from wine red to clear blue at the end. The final reading of the burette is noted and the titration is repeated to get concordant value.

Result:

The total hardness of given water sample is………..ppm