

Estimation of total, permanent and temporary hardness of water (EDTA method)

Expt. No.:

Date:

Aim:

To estimate the amount of total, permanent and temporary hardness in the collected sample of water. A standard solution of EDTA is provided.

Principle:

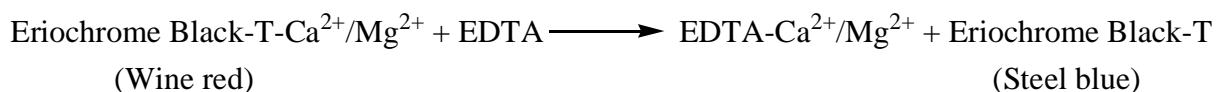
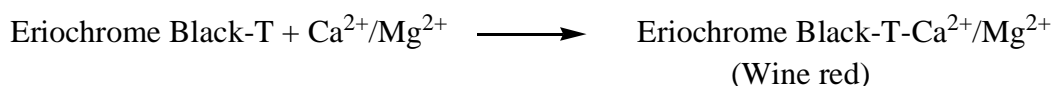
Hardness in water is due to the presence of dissolved salts of calcium and magnesium. It is unfit for drinking, bathing, washing and it also forms scales in boilers. Hence it is necessary to estimate the amount of hardness producing substances present in the water sample. Once it is estimated, the amount of chemicals required for the treatment of water can be calculated.

The estimation of hardness is based on complexometric titration. Hardness of water is determined by titrating with a standard solution of ethylene diamine tetra acetic acid (EDTA) which is a complexing agent. Since EDTA is insoluble in water, the disodium salt of EDTA is taken for this experiment. EDTA can form four or six coordination bonds with a metal ion.

1. Total hardness

Total hardness is due to the presence of bicarbonates, chlorides and sulphates of calcium and magnesium ions.

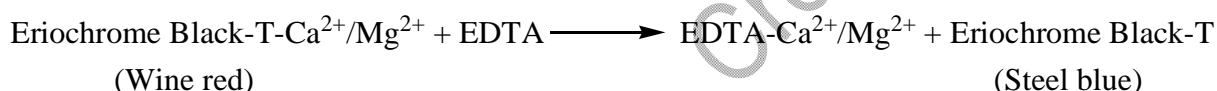
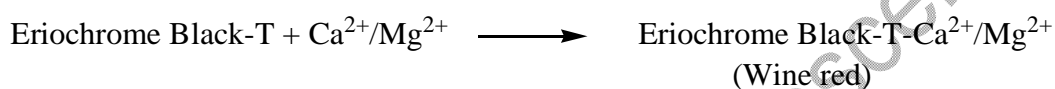
The total hardness of water is estimated by titrating the water sample against EDTA using Eriochrome Black-T (EBT) indicator. Initially EBT forms a weak EBT- $\text{Ca}^{2+}/\text{Mg}^{2+}$ wine red coloured complex with $\text{Ca}^{2+}/\text{Mg}^{2+}$ ions present in the hard water. On addition of EDTA solution, $\text{Ca}^{2+}/\text{Mg}^{2+}$ ions preferably forms a stable EDTA- $\text{Ca}^{2+}/\text{Mg}^{2+}$ complex with EDTA leaving the free EBT indicator in solution which is steel blue in colour in the presence of ammonia buffer (mixture of ammonium chloride and ammonium hydroxide, pH 10).



2. Temporary hardness

Temporary hardness is due to the presence of bicarbonates of calcium and magnesium ions. It can be easily removed by boiling.

When water is boiled, temporary hardness producing substances (bicarbonates) are precipitated as insoluble carbonates or hydroxides. This precipitate can be removed by filtration. (The filtrate is used in the next step)



3. Permanent hardness

Permanent hardness is due to the presence of chlorides and sulphates of calcium and magnesium ions. This type of hardness cannot be removed by boiling. The filtrate obtained from the above step contains permanent hardness producing substances and is estimated against EDTA using EBT indicator.

Procedure:

The burette is filled with standard EDTA solution to the zero level, following usual precautions.

1. Estimation of Total Hardness

20 ml of the given water sample is pipetted out into a clean conical flask. 5 ml ammonia buffer and 2 drops of EBT indicator are added and titrated against EDTA from the burette. The end point is the change of colour from wine red to steel blue. The titration is repeated to get concordant titre value.

2. Estimation of Permanent Hardness

100 ml of the given sample of water is pipetted out into a clean beaker and boiled for 20 minutes. It is then filtered to remove the precipitate formed due to the decomposition of temporary hardness producing salts. The filtrate is made up to 100 ml in standard measuring flask (SMF) using distilled water.

20 ml of the made up solution is pipetted out into a conical flask, 5 ml ammonia buffer and 2 drops of EBT indicator are added and titrated against the EDTA. The end point is the change of colour from wine red to steel blue. The titration is repeated to get concordant titre value.

3. Temporary Hardness

The temporary hardness is calculated from the total and permanent hardness.

$$\text{Temporary Hardness} = \text{Total Hardness} - \text{Permanent Hardness}$$

Result:

The collected water sample contains

Total hardness	=	ppm
Permanent hardness	=	ppm
Temporary hardness	=	ppm

Titration-1 Estimation of Total Hardness

Standard EDTA vs Water sample

Volume of hard water sample (ml)	Burette Reading		Volume of EDTA solution (ml)	Indicator
	Initial	Final		

Titration-2 Estimation of Permanent Hardness

Standard EDTA X Boiled water sample

Volume of boiled water sample (ml)	Burette Reading		Volume of EDTA solution (ml)	Indicator
	Initial	Final		

Calculation

$$\begin{aligned} 1 \text{ ml of } 0.01 \text{ M EDTA} &\equiv 1 \text{ mg of CaCO}_3 \\ V_1 \text{ ml of EDTA} &\equiv V_1 \text{ mg of CaCO}_3 \end{aligned}$$

Calculation of total hardness

$$\begin{aligned} \text{Volume of EDTA solution consumed} &= \dots\dots\dots \text{ ml} \\ \text{Volume of hard water taken} &= \dots\dots\dots \text{ ml} \end{aligned}$$

$$\begin{aligned} \text{Total hardness} &= \frac{\text{Volume of EDTA solution consumed} \times 1000}{\text{Volume of the hard water taken}} \text{ ppm} \\ &= \dots\dots\dots \text{ ppm} \end{aligned}$$

Calculation of permanent hardness

$$\begin{aligned} \text{Volume of EDTA solution consumed} &= \dots\dots\dots \text{ ml} \\ \text{Volume of boiled water taken} &= \dots\dots\dots \text{ ml} \end{aligned}$$

$$\begin{aligned} \text{Permanent Hardness} &= \frac{\text{Volume of EDTA solution consumed} \times 1000}{\text{Volume of the boiled water taken}} \text{ ppm} \\ &= \dots\dots\dots \text{ ppm} \end{aligned}$$

Calculation of temporary hardness

$$\begin{aligned} \text{Temporary hardness of the given sample of water} &= \text{Total hardness} - \text{Permanent hardness} \\ &= \dots\dots\dots \text{ ppm} \end{aligned}$$

Viva Questions

1. What is hard water?
2. What is saline water?
3. Saline water is not hard water. Why?
4. Which causes hardness to water?
5. How is water classified based on the degree of hardness?
6. List the types of hardness present in water
7. State the salts responsible for temporary and permanent hardness of water
8. How is temporary hardness removed?
9. How is permanent hardness removed?
10. What is meant by softening of water?
11. How do you express the total hardness of water?
12. What is EDTA?
13. Why is disodium salt of EDTA preferred to EDTA for estimation of hardness?
14. What is a buffer solution? Give an example.
15. Why is ammonium hydroxide-ammonium chloride buffer added during the determination of hardness of water?
16. Why is the colour of solution wine red before titration and blue colour at the end of titration?
17. What is ppm?
18. Why is hardness of water expressed in terms of calcium carbonate equivalent?
19. Mention the disadvantages of hard water for industrial purpose.
20. List the methods of determining hardness of water.
21. What is the significance of this experiment?