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

**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.

# 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- Ca2+/Mg2+ wine red coloured complex with Ca2+/Mg2+ ions present in the hard water. On addition of EDTA solution, Ca2+/Mg2+ ions preferably forms a stable EDTA- Ca2+/Mg2+ 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).

Eriochrome Black-T + Ca2+/Mg2+ Eriochrome Black-T-Ca2+/Mg2+

(Wine red)

Eriochrome Black-T-Ca2+/Mg2+ + EDTA EDTA-Ca2+/Mg2+ + Eriochrome Black-T

(Wine red) (Steel blue)

# 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)

Eriochrome Black-T + Ca2+/Mg2+ Eriochrome Black-T-Ca2+/Mg2+

(Wine red)

Eriochrome Black-T-Ca2+/Mg2+ + EDTA EDTA-Ca2+/Mg2+ + Eriochrome Black-T

(Wine red) (Steel blue)

# 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.

# 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.

# 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.

# Temporary Hardness

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

Temporary Hardness = Total Hardness  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** |  | |
| 1 ml of 0.01 M EDTA | ≡ | 1 mg of CaCO3 |
| V1 ml of EDTA | ≡ | V1 mg of CaCO3 |

**Calculation of total hardness**

Volume of EDTA solution consumed = ml

Volume of hard water taken = ml

Total hardness = Volume of EDTA solution consumed X1000 ppm

Volume of the hard water taken

= ppm

# Calculation of permanent hardness

Volume of EDTA solution consumed = ml

Volume of boiled water taken = ml

Permanent Hardness = Volume of EDTA solution consumed X1000 ppm

Volume of the boiled water taken

= ppm

# Calculation of temporary hardness

Temporary hardness of the given sample of water = Total hardness - Permanent hardness

= ppm

# 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?