Formula

- Hardness per mL of EDTA = $(50/V_1)$
- Total hardness of sample hard water = $\left(\frac{V_2}{V_1}\right) \times 1000$ mg/L
- Permanent hardness = $\left(\frac{V_3}{V_1}\right) \times 1000$ mg/L
- Temporary Hardness = Total Hardness – Permanent hardness

Provided the volume of standard hard water, sample hard water and boiled & filtered sample hard water are same

Numerical problems in hardness determination by EDTA

(1) The standard hard water is prepared by dissolving 1 g of $CaCO_3$ in HCl and the solution is made up to 1000 mL with deionized water. 50 mL of the prepared solution requires 20 mL of EDTA solution for titration. 50 mL of sample water requires 15 mL of EDTA solution and after boiling and filtering 50 mL of the solution requires 10 mL of EDTA. Calculate the total, carbonate and non-carbonate hardness of the water sample.

Numerical problems in hardness determination by EDTA

Solution

V_1 = **20 mL** (volume of standard hard water = **50 mL**)
V_2 = **15 mL** (volume of sample hard water = **50 mL**)
V_3 = **10 mL** (volume of boiled sample hard water = **50 mL**)

Total hardness of sample hard water = $\left(\frac{V_2}{V_1}\right) \times 1000$ mg/L

= (15/20) x 1000 = 750 ppm

Permanent hardness = $\left(\frac{V_3}{V_1}\right) \times 1000$ mg/L

= (10/20) x 1000 = 500 ppm

Temporary Hardness = Total Hardness – Permanent hardness

= 750 - 500 = 250 ppm

Formula

- Total hardness of sample hard water = $\left(\frac{x}{V_1}\right) \times \left(\frac{V_2}{y}\right) \times 1000$ mg/L
- Permanent hardness = $\left(\frac{x}{V_1}\right) \times \left(\frac{V_3}{z}\right) \times 1000$ mg/L
- Temporary Hardness = Total Hardness – Permanent hardness

- x = Volume of standard hard water used for EDTA standardisation
- y = Volume of sample hard water used
- z = Volume of boiled & filtered sample hard water used

If the volume of standard hard water, sample hard water and boiled & filtered sample hard water are different

Numerical problems in hardness determination by EDTA

(2) 20 ml of std water containing 1 g/L of pure $CaCO_3$ per liter consumed 25 ml of EDTA. 100 ml of water sample consumed 18 ml of EDTA using EBT as indicator. While same water sample after boiling requires 12 ml of EDTA for 100 mL boiled water. Calculate carbonate and non-carbonate hardness of water.

Numerical problems in hardness determination by EDTA

Solution

V_1 = **25 mL** (volume of standard hard water = **20 mL**)
V_2 = **18 mL** (volume of sample hard water = **100 mL**)
V_3 = **12 mL** (volume of boiled sample hard water = **100 mL**)

Total hardness of sample hard water $= \left(\frac{20}{V_1}\right) \text{x} \left(\frac{V_2}{100}\right) \text{x } 1000 \text{ mg/L}$

$= \left(\frac{20}{25}\right) \text{x} \left(\frac{18}{100}\right) \text{x } 1000 = 144 \text{ ppm}$

Permanent hardness $= \left(\frac{20}{V_1}\right) \text{x} \left(\frac{V_3}{100}\right) \text{x } 1000 \text{ mg/L}$

$= \left(\frac{20}{25}\right) \text{x} \left(\frac{12}{100}\right) \text{x } 1000 = 96 \text{ ppm}$

Temporary Hardness = Total Hardness – Permanent hardness

= 144 - 96 = 48 ppm

Numerical problems in hardness determination by EDTA

(3) 50 ml of std water containing 1 g/L of pure $CaCO_3$ per liter consumed 20 ml of EDTA. 20 ml of water sample consumed 18 ml of EDTA. While same water sample after boiling requires 12 ml of EDTA for 40 mL boiled water. Calculate carbonate and non-carbonate hardness of water

Numerical problems in hardness determination by EDTA

Solution

V_1 = **20 mL** (volume of standard hard water = **50 mL**)
V_2 = **18 mL** (volume of sample hard water = **20 mL**)
V_3 = **12 mL** (volume of boiled hard water = **40 mL**)

Total hardness of sample hard water $= \left(\frac{50}{V_1}\right) \times \left(\frac{V_2}{20}\right) \times 1000$ mg/L

$= \left(\frac{50}{20}\right) \times \left(\frac{18}{20}\right) \times 1000 = 2250$ ppm

Permanent hardness $= \left(\frac{50}{V_1}\right) \times \left(\frac{V_3}{40}\right) \times 1000$ mg/L

$= \left(\frac{50}{20}\right) \times \left(\frac{12}{40}\right) \times 1000 = 750$ ppm

Temporary Hardness = Total Hardness – Permanent hardness

= 2250 - 750 = 1500 ppm

Numerical problems in hardness determination by EDTA

(4) 0.5 g of $CaCO_3$ was dissolved in HCl and the solution made up to 1000 mL with distilled water. 50 mL of the solution required 50 mL of EDTA solution for titration. 50 mL of hard water sample required 18 mL of EDTA and after boiling and filtering required 10 mL of EDTA solution. Calculate each type of hardness of water.

0.5 g of $CaCO_3$ was dissolved in HCl and the solution made up to 1 L with distilled water.

1 L of standard hard water contains 0.5 g of $CaCO_3$

1000 mL of standard hard water contains 500 mg of $CaCO_3$

1 mL of standard hard water contains 0.5 mg of $CaCO_3$

Titration - I

50 mL of the solution required 50 mL of EDTA solution for titration. (V_1 = 50 mL)

50 mL of EDTA = 50 mL of standard hard water

= 50 x 0.5 mg of $CaCO_3$

= 25 mg of $CaCO_3$

1 mL of EDTA = 25/50 = **0.5 mg of $CaCO_3$**

Titration - II

50 mL of hard water sample required 18 mL of EDTA (V_2 = 18 mL)

1000 mL of sample hard water = $0.5 \times \left(\frac{V_2}{50}\right) \times 1000$ mg/L

= $0.5 \times \left(\frac{18}{50}\right) \times 1000$ mg/L

Total hardness = **180 ppm $CaCO_3$ eq.**

Titration - III

50 mL of hard water sample after boiling and filtering required 10 mL of EDTA solution (V_3 = 10 mL)

1000 mL of sample hard water = $0.5 \times \left(\frac{V_3}{50}\right) \times 1000$ mg/L

= $0.5 \times \left(\frac{10}{50}\right) \times 1000$ mg/L

Permanent hardness = **100 ppm $CaCO_3$ eq.**

Temporary hardness = Total hardness – Permanent hardness

= 180 – 100 = **80 ppm $CaCO_3$ eq.**

Numerical problems in hardness determination by EDTA

(5) A std hard water contains 15 g of $CaCO_3$ /1 L. 20 mL of this required 25 mL of EDTA. 100 mL of Sample water required 18 mL of EDTA solution the same sample after boiling required 12 mL of EDTA solution calculate the temporary hardness of the given sample of water in terms of ppm.

15 g of $CaCO_3$ was dissolved in HCl and the solution made up to 1 L with distilled water.

1 L of standard hard water contains 15 g of $CaCO_3$

1000 mL of standard hard water contains 15000 mg of $CaCO_3$

1 mL of standard hard water contains 15 mg of $CaCO_3$

Titration - I

20 mL of the solution required 25 mL of EDTA solution for titration. (V_1 = 25 mL)

25 mL of EDTA = 20 mL of standard hard water

= 20 x 15 mg of $CaCO_3$

= 300 mg of $CaCO_3$

1 mL of EDTA = 300/25 = **12 mg of $CaCO_3$**

Titration - II

100 mL of hard water sample required 18 mL of EDTA (V_2 = 18 mL)

1000 mL of sample hard water = $12 \times \left(\frac{V_2}{100}\right) \times 1000$ mg/L

= $12 \times \left(\frac{18}{100}\right) \times 1000$ mg/L

Total hardness = **2160 ppm $CaCO_3$ eq.**

Titration - III

100 mL of hard water sample after boiling and filtering required 12 mL of EDTA solution (V_3 = 12 mL)

1000 mL of sample hard water = $12 \times \left(\frac{V_3}{100}\right) \times 1000$ mg/L

= $12 \times \left(\frac{12}{100}\right) \times 1000$ mg/L

Permanent hardness = **1440 ppm $CaCO_3$ eq.**

Temporary hardness = Total hardness – Permanent hardness

= 2160 – 1440 = **720 ppm $CaCO_3$ eq.**

Numerical problems in hardness determination by EDTA

(6) 0.25 gm of $CaCO_3$ was dissolved in HCI and the solution made up to 250 mL with distilled water. 50 mL of the solution required 20 mL of EDTA solution for titration. 50 mL of hard water sample required 18 mL of EDTA and after boiling and filtering required 10 mL of EDTA solution. Calculate temporary hardness of water

Numerical problems in hardness determination by EDTA

(7) 0.45 gm of $CaCO_3$ was dissolved in HCI and the solution made up to 500 mL with distilled water. 50 mL of the solution required 50 mL of EDTA solution for titration. 50 mL of hard water sample required 20 mL of EDTA and after boiling and filtering required 8 mL of EDTA solution. Calculate each type of hardness of water.

Pros and Cons of EDTA Titration

Advantages

- ✓ It is very simple and fairly accurate method
- ✓ It also very cost efficient
- ✓ It also very quick and time efficient process when compared to gravimetric analysis

Disadvantages

- Possible human error during the preparation of solution and the titration.
- EDTA grabs all the metal ions in the water, not just the Ca^{2+} ions. This gives us a value that is not truly the concentration of Ca^{2+} ions. This causes an experimental error of about 1%, but that is acceptable.