

WATER TREATMENT AND ANALYSIS

UNIT-II

2.1 Water Softening Methods - Clark's process - Lime soda process - Modified lime soda process - Permutit or Zeolite process - Ion exchange process - Demineralization of water.

2.2 Determination of Hardness of water - Titration method - Complexometric method using EDTA - Expressing Hardness.

2.3 Equivalents of Calcium Carbonate - Problems to determine Temporary and Permanent Hardness.

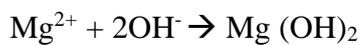
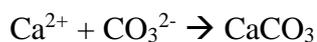
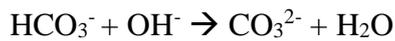
WATER SOFTENING METHODS

Softening of Water

Water used for industrial purposes should be pure. i.e., It should be free from hardness, scale forming substances and corrosive agents like dissolved O₂ etc., The process of removing hardness producing salts from water is known as **softening of water**.

CLARK 'S PROCESS

It is the process of liming hard water. It is used to decrease the alkalinity of water. During lime treatment the following reactions occur.



Softening of Water can be done by the following two ways

1. External conditioning or External treatment
2. Internal conditioning or Internal treatment.

EXTERNAL CONDITIONING

It involves the removal of hardness producing salts from the water before feeding into the boiler. The external treatment can be done by the following methods.

- a) Lime soda process
- b) Zeolite (or Permutit process
- c) Demineralisation (or) Deionization.

The above said processes are the examples of **ionexchange process** of water softening.

In an ion-exchange process, a reversible exchange of ions taking place between a stationary solid phase and an external liquid mobile phase.

a) Lime-Soda Process

Lime-Soda process is a very important method used for the softening of water.

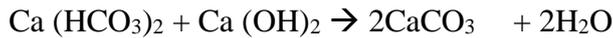
[i] Principle

The lime-soda process involves the chemical conversion of all the soluble hardness-causing salts by the addition of soda and lime into insoluble precipitates which could easily be removed by settling and filtration.

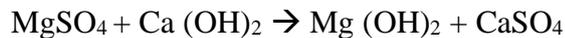
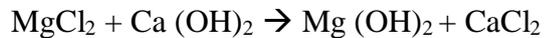
In this process, water to be softened is treated with calculated amounts of lime Ca(OH)_2 and soda Na_2CO_3 . For quick completion of reactions, the reagents may be used in 10 % excess. The functions of lime and soda are as follows.

Functions of lime

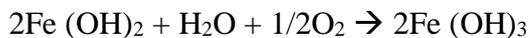
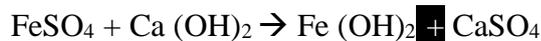
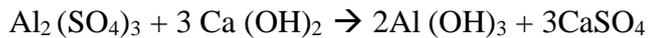
Lime removes temporary hardness, permanent magnesium hardness, dissolved iron and aluminium salts, dissolved CO_2 and H_2S gases and free mineral acids present in water. The reactions involved are as follows



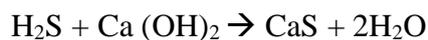
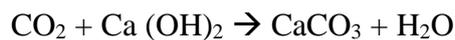
Removal of permanent magnesium hardness



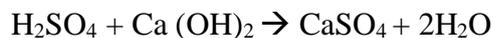
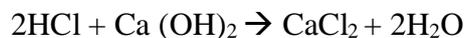
Removal of dissolved iron and magnesium salts



Removal of dissolved CO_2 and H_2S

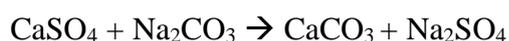
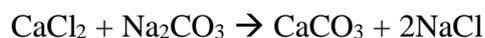


Removal of free mineral acid



Functions of soda

During the removal of Mg^{2+} , Fe^{2+} , Al^{3+} , HCl and H_2SO_4 by lime, permanent calcium hardness is introduced in the water due to formation of calcium salts. The permanent calcium hardness thus introduced on account of the treatment of water with lime and the permanent calcium hardness already present in water before lime treatment are removed by soda. The reactions involved are as follows,



The chemical reactions involved in the lime-soda process are quite slow. Moreover, the precipitates formed [particularly of CaCO_3 and $\text{Mg}(\text{OH})_2$] are fine and have a tendency to form super-saturated solutions. This results in after deposition of these precipitates later in the pipes and boiler tubes leading to their clogging and corrosion. These drawbacks of the process can be overcome by

- thorough mixing of chemicals and water.
- allowing proper time for the completion of reactions.
- the use of accelerators such as active charcoal and
- the use of coagulants such as alum or NaAlO_2 .

[ii] Process

The lime-soda process can be carried out both at room temperature as well as at higher temperatures. The process carried out at room temperature is called **cold lime –soda process** and that carried out at $94^\circ\text{-}100^\circ\text{C}$ is called **hot lime-soda process**.

1. Cold Lime-Soda Process

In this method, water to be softened is treated with calculated quantities of lime and soda at room temperature. Small amounts of a coagulant such as alum, aluminium sulphate, sodium aluminate etc., are also added.

The coagulant helps the finely divided precipitate formed in the process to flocculate. Sodium aluminate also helps in the removal of silica and oil present in water.

Method

The mixture of water, calculated quantities of lime and soda and a small amount of a coagulant is fed from the top into inner chamber of a vertical circular tank (Fig.1).

The chamber is provided with a vertical rotating shaft carrying a number of paddles to ensure vigorous stirring and continuous mixing of water with the chemicals added.

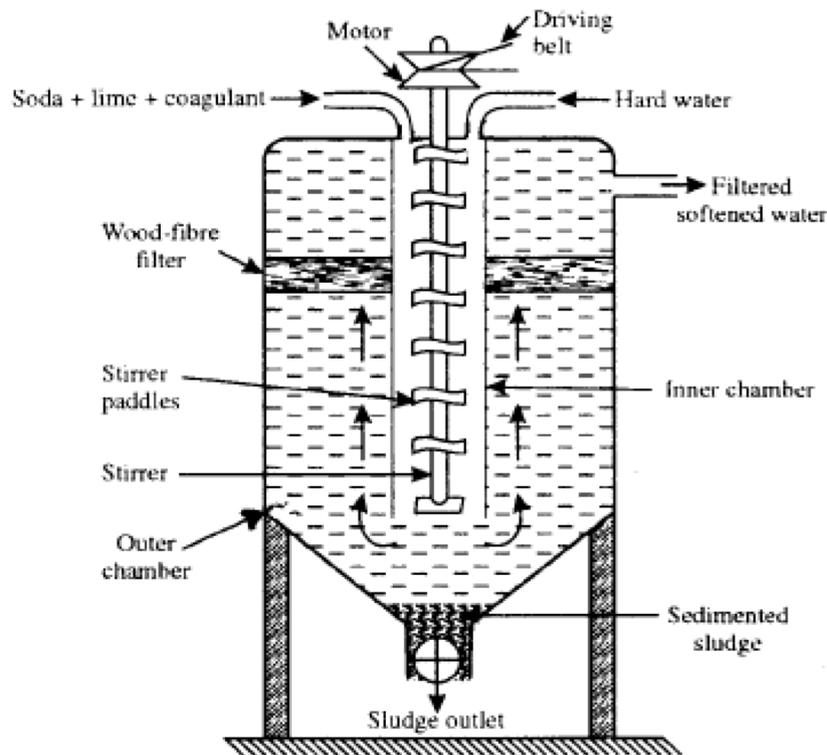


Fig. 4.3. Cold-lime-soda softener.

Fig 1 Cold Lime-Soda Process

The chemical reactions take place and the hardness producing salts get converted into insoluble precipitates which accumulate in the form of a heavy sludge.

As the softened water reaches the outer coaxial chamber, it rises upwards and is filtered by a wood-fibre filter and finally taken out from an outlet provided at the top of the outer cylinder.

The heavy sludge settles down at the bottom of the outer chamber and is taken out through an outlet. The softened water obtained from this process contains a residual hardness of about 50-60 ppm.

2. Hot Lime-Soda Process

In this process, water is treated with the softening chemicals at a temperature of 94°-100°C. Since the process is carried out at a temperature close to the boiling point of the solution, the reaction proceeds faster and the softening capacity of the process increases several times.

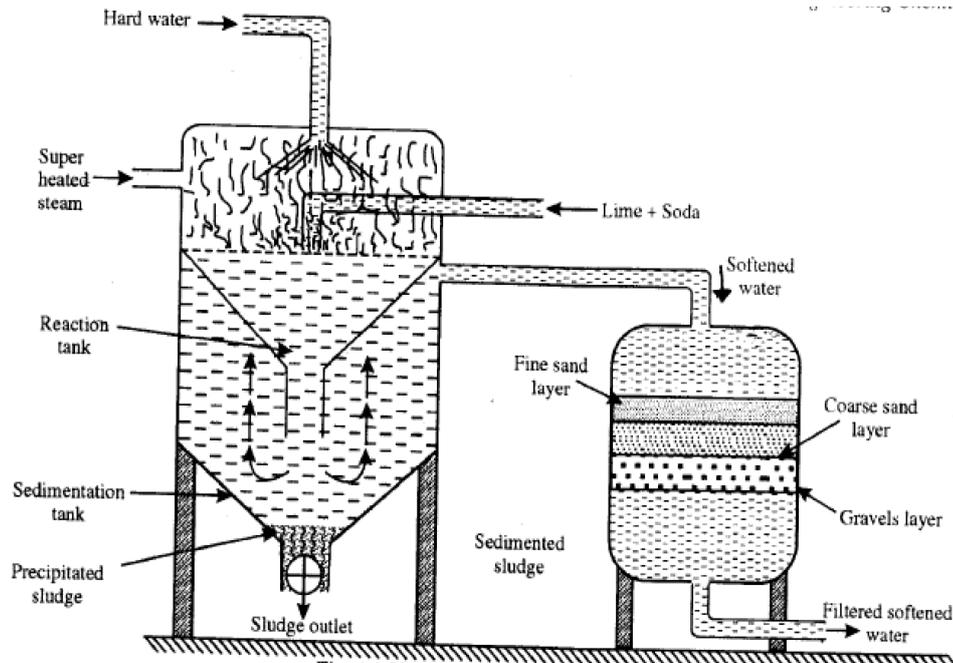


Fig.2 Hot Lime-Soda Process

At this temperature, the viscosity of water is much less than that at room temperature. Hence, rate of aggregation of particles increases and there is hardly any need of adding any coagulant. Moreover, the dissolved gases also escape to some extent at the temperature of the process.

Method

A typical hot lime-soda water softening plant is shown in

Fig.2. It consists of

- a reaction tank
- a conical sedimentation vessel and
- a sand filter.

Raw water is fed from the top into the reaction tank where it is thoroughly mixed with calculated quantities of softening chemicals and is agitated with superheated steam. The reactions take place and water gets softened. The softened water containing sludge then enters into the sedimentation vessel where sludge settles down.

The softened water rises up in the vessel, while precipitated sludge is taken out through an outlet provided at the bottom of the vessel. The softened water is then taken to a sand filter which ensures the complete removal of the sludge from softened water.

The softened water obtained from this process contains a residual hardness of 15-30 ppm.

Advantages of the process

The hot lime-soda process has the following advantages.

- The process is much faster as compared to the cold sodalime process.
- It is very economical.
- Lesser amounts of coagulants are needed.
- The process increases the pH value of the treated water, thereby reducing the corrosion of distribution pipes.
- To certain extent, iron and manganese are also removed from water.
- Much of dissolved gases in water are also removed.
- Due to an increase in the pH, the amount of pathogenic bacteria in treated water also gets reduced.

Disadvantages of the process

- The hot lime-soda process has the following disadvantages.
- Disposal of large amounts of sludge formed in the process poses problems.
- The treated water obtained by this process is not completely softened. It still contains a residual hardness of about 15-30 ppm, which is not good for boilers.

Table 1.4 Difference between cold and hot lime soda process

Cold L-S Process	Hot L-S Process
Done at room temperature.	Done near the boiling point of water.
Reactions are slow and takes hours to complete.	Fast and takes only 15 minutes.
Precipitate is finely divided and therefore coagulants are needed.	Coarse precipitate coagulants not needed.
Tank size is large.	Small and compact.
Residual hardness 50 to 60 ppm.	15 to 30 ppm
Chemicals are consumed by dissolved gas, CO ₂ etc.,	CO ₂ and temporary hardness are automatically removed.

b) Zeolite (or) Permutit Process

Zeolites are naturally occurring hydrated sodium aluminium silicate, $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$ where $x = 2$ to 10 and $y = 2$ to 6 . The synthetic form of zeolite is known as **permutit**. Synthetic zeolite is represented by Na_2Ze . The sodium ions which are loosely held in Na_2Ze are replaced by Ca^{2+} and Mg^{2+} ions present in the water. Natural zeolites are non-porous.

Synthetic zeolites are porous and gelly structure. They are prepared by heating together china clay, feldspar and soda ash. These zeolites are higher exchange capacity per unit weight than natural zeolites.

Process

In this process, the hard water is passed through a bed of sodium zeolite (Na_2Ze). The hardness causing ions (Ca^{2+} , Mg^{2+}) in hard water is replaced by loosely held sodium ions in zeolite bed (Fig.3.7). The outgoing soft water contains only sodium ions.

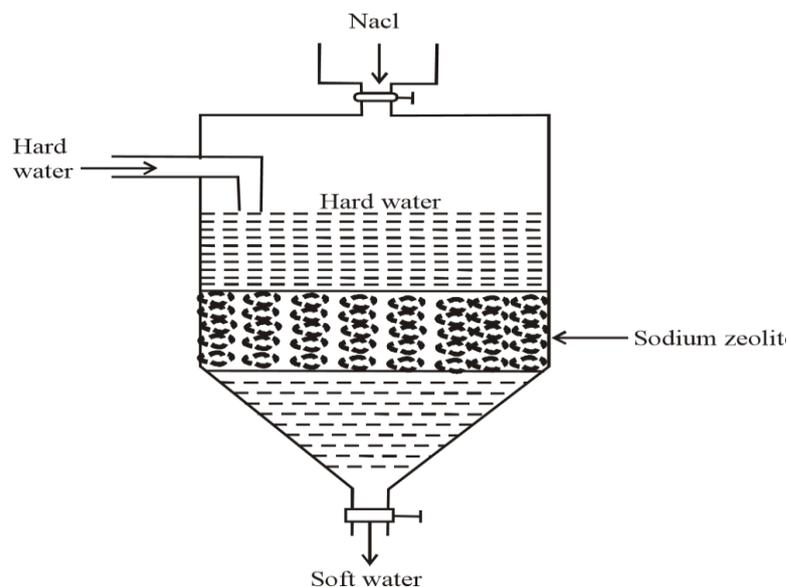
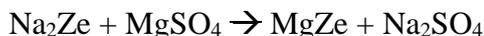
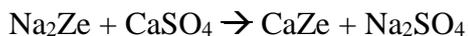
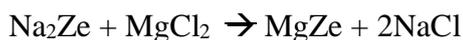
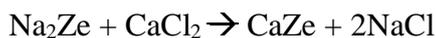
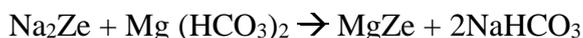
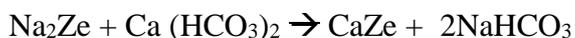


Fig. 3 Zeolite process

Regeneration

After the softening process, the zeolite is completely converted into calcium and magnesium zeolites and it gets exhausted. At this stage the hard water supply is stopped and the exhausted bed is regenerated by treating with a concentrated 10% brine (NaCl) solution.



Exhausted	Regenerated
Zeolite	Zeolite

Advantages of the process

- This process removes hardness upto 10ppm.
- Operational cost is less
- The equipment used is compact No sludge formation.
- The plant can be connected to water supply line as it avoids double pumping. Requires less time for softening
- Maintenance and operation is easy
- The process automatically adjusts itself to waters of different hardness.

Limitations of the process

- The process exchanges only Ca^{2+} and Mg^{2+} ions with Na^+ ions. It does not remove the acidic ions like HCO_3^- , CO_3^{2-} .
- Water containing such ions is not much suitable for boilers as it may cause corrosion of boilers. Turbid water, if used clogs the pores of the Zeolite bed, making it inactive.
- Highly acidic or alkaline water will destroy the Zeolite bed.
- Coloured ions (Fe^{2+} and Mn^{2+}) if present in water should be removed first and then the water is sent to the bed, as these ions convert sodium Zeolite into their respective Zeolites (FeZe , MnZe) which are difficult to be regenerated.
- High capital cost

c) Demineralization (or) Deionization Process

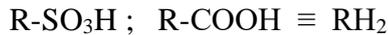
In this method ion exchange resins are used as softening material. In this process cations like Ca^{2+} , Mg^{2+} and anions like Cl^- , SO_4^{2-} which are responsible for hardness are removed respectively by cation exchange resins and anion exchange resins. Ion exchange resins are insoluble, cross linked, long chain organic polymers with a micro porous structure. The functional groups attached to the chains are responsible for the ionexchanging properties.

Cation exchange resins (RH+)

Resin containing acidic functional groups ($-\text{COOH}$, $-\text{SO}_3\text{H}$) are capable of exchanging their H^+ ions with cations of hard water.

Example: (i) Sulphonated coals.

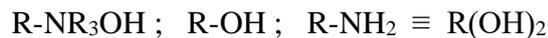
(ii) Sulphonated polystyrene.



Anion exchange resins (ROH^-)

Resins containing basic functional groups ($-\text{NH}_2$, $-\text{OH}$) are capable of exchanging their OH^- ions with the anions of hard water.

Example: (i) Cross-linked quaternary ammonium salts. (ii) Urea-formaldehyde resin



Process

The hard water first passed through a cation exchange column (Fig.1.8) which absorbs all the cations like Ca^{2+} , Mg^{2+} , Na^+ , K^+ etc., present in the hard water.

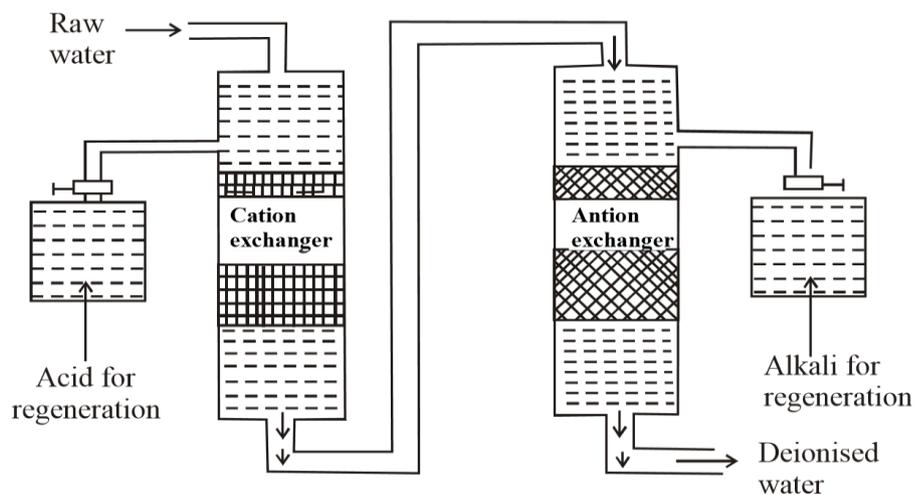
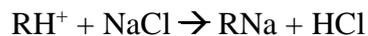
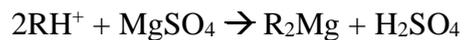
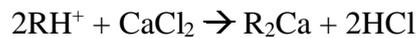
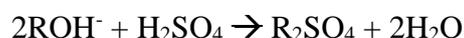
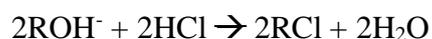


Fig.4 Demineralisation process

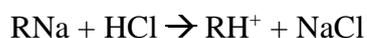
The cation free water is then passed through an anion exchange column, which absorbs all the anions like Cl^- , SO_4^{2-} etc., present in the water.



Thus the water coming out from the anion exchange is free from both cations and anions. This water is known as ionfree water (or) deionised (or) demineralised water.

Regeneration

When the cation exchange column is exhausted, it can be regenerated by passing a solution of dil.HCl (or) dil.H₂ SO₄.



When the anion exchange column is exhausted, it can be regenerated by passing a solution of dil. NaOH.



Advantages

- The process can be used to soften highly acidic (or) alkaline water.
- It produces water of very low hardness (2ppm).

Disadvantages:

- The equipment is costly and more expensive chemicals are needed.
- If the water contains turbidity, the output is low due to clogging.

MIXED BED DEIONIZER

This comprises of a single cylinder. This contains a bed of intimate mixture of cation exchanger resin and anion exchanger resin. When water is passed through this bed it comes in contact many times with both cation and anion exchangers alternatively. The effect of mixed bed exchanger is equivalent to passing through a series of several cation and anion exchangers (multiple cycle). The outgoing water from the mixed bed contains even less than 1ppm of dissolved salts.

Regeneration

When the resins are exhausted, the mixed bed is back washed by forcing water in the upward direction. The lighter anion exchanger gets displaced to form an upper layer. The heavier cation exchanger forms the lower layer. There after the anion exchanger is regenerated by passing caustic soda solution from the top and then rinsed and reused. The lower cation exchanger bed is then regenerated by passing sulphuric acid solution and rinsed and then reused. The two beds are then mixed again by forcing compressed air. The bed is then reused.

Table 1.5 Comparison of Zeolite & Demineralization process

Zeolite (or) Permutit Process	Demineralization (or) Deionization Process
It exchanges only cations.	Both the cation and anion exchanges are available.
Residual hardness 1-5 ppm.	Residual hardness 0-2 ppm.
Cost of plant and material high.	Cost higher.
Operating expenses are low.	Operating expenses high.
Acidic water cannot be treated.	Even highly acidic or highly alkaline water can be treated.
Treated water contains more dissolved solids	No dissolved solids.

Characteristics of Soft, Deionised and Distilled Water

Soft Water

- ★ It does not contain hardness producing ions like Ca^{2+} , Mg^{2+}
- ★ It may contain Na^+ , K^+ , SO_4^{2-} , Cl^- ions and microorganisms.

Deionised water (mineral water)

- ★ It does not contain any ions including hardness producing cations.
- ★ It may contain some amount of micro-organisms.

Distilled Water

It does not contain any ions and micro-organisms, because it is prepared by condensing the vapour of boiling water.

Hard Water

It contains all hardness producing ions.

Specification for Drinking water

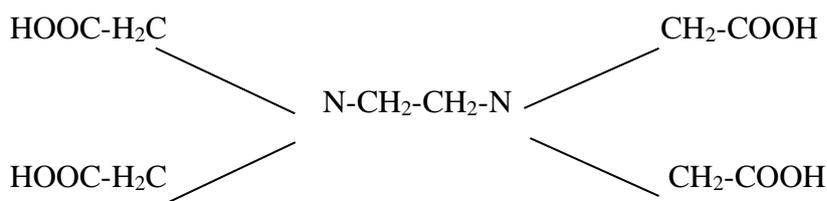
- ★ The common specifications recommended by the US Public health for Drinking water are given below.
- ★ Water should be clear and odourless.

- ★ It should be cool.
- ★ It should be pleasant to taste.
- ★ Turbidity of water should not exceed 10 ppm.
- ★ pH of the water should be in the range of 7.0 – 8.5.
- ★ Chloride and sulphate contents should be less than 250 ppm.
- ★ Total hardness of the water should be less than 500 ppm.
- ★ Total dissolved solids should be less than 500 ppm.
- ★ Fluoride content of the water should be less than 1.5 ppm.
- ★ The water must be free from disease producing bacteria.
- ★ Water should be free from objectionable dissolved gases like H₂S.
- ★ Water should be free from objectionable minerals such as lead, chromium, manganese and arsenic salts.

Estimation of Hardness of Water by EDTA Method

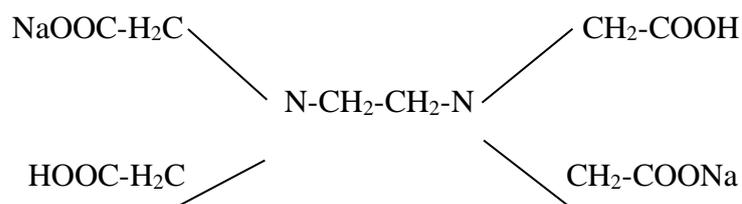
The hardness of water can be estimated by EDTA method. This is a reliable method because of its greater accuracy. In this method hardness is estimated by forming complexes. EDTA is Ethylene diamine tetra acetic acid.

Molecular structure of EDTA



In this complexometric method, disodium salt of ethylene diamine tetra acetic acid is actually used.

Structure of disodium salt of EDTA



Principle

1. Disodium salt of EDTA forms complex with calcium and magnesium ions present in water.
2. The indicator used in this titration is Eriochrome Black-T (EBT) which also forms an unstable complex with calcium and magnesium ions present in water, at pH value about 8-10.
3. In order to maintain the pH, buffer solution [NH₄Cl-NH₄OH] mixture is added. Only at this pH such a complexation is possible.
4. pH=8-10



Indicator Unstable complex (Blue colour)
(Wine red)

This wine red colour solution is titrated against EDTA, EDTA replaces EBT indicator from [Ca / Mg - EBT] complex. The colour of the solution changes from wine red to steel blue at the end point.

pH=8-10



Unstable complex Stable complex (Steel blue)
(Wine red) (Colorless)

Reagents Required :

1) EDTA solution

It is prepared by dissolving 4 gms of EDTA in 1000 ml of distilled water.

Standard hardwater

1 gm of pure CaCO₃ is dissolved in minimum quantity of HCl and then made up to 1000 ml using distilled water.

1 ml of standard hardwater = 1 mg of CaCO₃ equivalent hardness.

EBT indicator

0.5 gms of EBT is dissolved in 100 ml of alcohol.

Buffer solution:

67.5 gms of NH₄Cl and 570 ml of NH₃ are dissolved and the solution is made up to 1000 ml using distilled water.

Procedure

1) Standardisation of EDTA solution

20ml of Std.hard water is taken in a conical flask. 5 ml of buffer solution and a few drop of EBT indicator are added. The solution is titrated against EDTA taken in burette. The endpoint is the colour change from wine red to steel blue colour. Let the volume of EDTA consumed be V_1 ml.

Calculation

$$1 \text{ ml of std.hard water} = 1 \text{ mg of CaCO}_3$$

$$20 \text{ ml of std. hard water} = 20 \text{ mgs of CaCO}_3$$

20 ml of std. hard water consumes = V_1 ml of EDTA
 V_1 ml of EDTA consumes = 20 ml of Std hardwater.

$$= 20 \times 1 \text{ mg of CaCO}_3 \text{ eq. hardness}$$

$$1 \text{ ml of EDTA} = 20 / v_1 \quad \text{mg / L CaCO}_3 \text{ eq. hardness}$$

2) Estimation of Total Hardness

20ml of sample hard water is pipetted out into a conical flask and titrated against EDTA taken in burette by adding the buffer and the indicator to get the end point. Let the volume of EDTA consumed be V_2 ml.

Calculation

$$20 \text{ ml of sample hardwater} = V_2 \text{ ml of EDTA}$$

$$= V_2 \times 20 / V_1 \text{ mg of CaCO}_3 \text{ eq. Hardness}$$

$$\text{In 1000 ml of water sample} = V_2 \times 20 / V_1 \times 1000 / 20 \text{ mg of CaCO}_3 \text{ eq.hardness}$$

$$\text{Total hardness} = 1000 \times V_2 / V_1 \text{ mg / L (or) ppm.}$$

3) Estimation of Permanent Hardness

250ml of water sample is boiled off to a volume of 50 ml in a beaker to remove temporary hardness. The temporary hard salts settle down. Filter and wash thoroughly and make up the solution again to 250 ml. 20 ml of this solution which is free from carbonate hardness is titrated against the EDTA as done before. Let the volume of EDTA consumed be V_3 ml.

Calculation

$$20 \text{ ml of boiled sample hard water consumes} = V_3 \text{ ml of EDTA}$$

$$= V_3 \times 20 / V_1 \text{ mg of CaCO}_3 \text{ eq. hardness}$$

$$\text{In 1000 ml of water sample}$$

$$= V_3 \times 20 / V_1 \times 1000 / 20 \text{ mg of CaCO}_3 \text{ eq. hardness}$$

$$= 1000 \times V_3 / V_1 \text{ mg/L (or) ppm.}$$

$$\text{Permanent hardness} = 1000 \times V_3 / V_1 \text{ mg/L (or) ppm.}$$

Estimation of Temporary Hardness

This can be calculated by using the following methods.

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

$$\text{Temporary Hardness} = 1000 \times (V_2 - V_3) / V_1 \text{ mg/L (or) ppm.}$$

Advantages of EDTA method

- ★ This method is more accurate in the estimation of hardness of water than other methods rapid process.
- ★ It is convenient and more rapid process.

Problem

1. While titrating a sample of hard water, 50 ml of the sample consumed 10 ml of 0.01 M EDTA to attain the end point. Calculate the total hardness of the sample in terms of mg equivalent of CaCO₃ per liter.

Solution:

Number of gram moles of EDTA consumed by 50 ml of sample

$$= M \times V / 1000 = 0.01 \times 10 / 1000 = 1 \times 10^{-4}$$

1 gm mole of EDTA = 100g of CaCO₃

$$= 1 \times 10^5 \text{ mg of CaCO}_3$$

Total hardness in 50 ml sample = $1 \times 10^{-4} \times 1 \times 10^5$

$$= 10 \text{ mg of CaCO}_3$$

Hence total hardness of the given sample

$$= 10 / 50 \times 1000 = 200 \text{ mg /L of CaCO}_3$$

2. 100 ml of water sample require 20 ml N/ 100 EDTA when titrated using NH₄Cl _NH₄OH buffer and EBT indicator. Calculate the hardness of the sample.

Solution:

No. of gm eq. of EDTA used by 100 ml sample = $N \times V / 1000 = (1/100) \times 20 / 1000 = 2.0 \times 10^{-4}$

no of gm moles of EDTA consumed

$$= 2.0 \times 10^{-4} / 2 = 1.0 \times 10^{-4}$$

$$1 \text{ gm of mole of EDTA} = 10^5 \text{ mg of CaCO}_3$$

$$1 \times 10^4 \text{ gm of mole of EDTA} = 10^5 \times 1.0 \times 10^4$$

$$= 10 \text{ mg of CaCO}_3$$

$$\text{Hence total hardness of the sample} = 10 / 100 \times 1000$$

$$= 100 \text{ mg /L of CaCO}_3$$

- 3. 100 ml of a hard water sample require 25 ml of 0.01 M EDTA with NH₄Cl-NH₄OH buffer and EBT indicator. Another 100ml of the sample is boiled for about half an hour and after filtering the precipitate, the volume of the filtrate is made to 100 ml again by the addition of distilled water. 20ml of this boiled sample require only 4 ml of 0.01 M EDTA following the same procedure. Calculate the temporary and permanent hardness of the sample.**

Solution:

i) Calculation of total hardness of the sample:

100 ml of the sample requires 25 ml of 0.01 M EDTA.

$$\text{No. of gram moles of EDTA consumed} = 0.01 \times 25 / 1000 = 2.5 \times 10^{-4}$$

$$1 \text{ gm moles of EDTA} = 10^5 \text{ mg of CaCO}_3$$

$$2.5 \times 10^{-4} \text{ gm moles of EDTA} = 10^5 \times 2.5 \times 10^{-4}$$

$$= 25 \text{ mg of CaCO}_3$$

Hence total hardness of the given sample

$$= 25 / 100 \times 1000 = 250 \text{ mg /L of CaCO}_3$$

ii) Calculation of permanent hardness

the boiled sample will contain only permanent hardness 20 ml of boiled sample consumes 4 ml of 0.01 M EDTA. No. of gm moles of EDTA consumed.

$$= 0.01 \times 4 / 1000 = 4 \times 10^{-5}$$

$$1 \text{ gm mole of EDTA} = 10^5 \text{ mg of CaCO}_3$$

$$4 \times 10^{-5} \text{ gm moles of EDTA} = 10^5 \times 4 \times 10^{-5}$$

$$= 4 \text{ mg of CaCO}_3$$

Hence permanent hardness of the given sample

$$= 4 / 20 \times 1000 = 200 \text{ mg /L of CaCO}_3$$

iii) Calculation of temporary hardness

$$\begin{aligned}\text{temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= (250 - 200) \text{ mg / L of CaCO}_3 \\ &= 50 \text{ mg / L of CaCO}_3.\text{CaCO}\end{aligned}$$

Reference

1. Engineering Chemistry II, Dr. Syed Shabudeen. P. S. Professor chemistry and Environmental science, pp. 1.1 to 1.95, October 2010, Kumaraguru College of Technology.
2. Water Treatment & Analysis, Kanwaljit Kaur.
3. <https://www.scribd.com/document/23180395/Engineering-Chemistry-Unit-I-Water-Treatment>

Question

Section - A

1. What is meant by softening of water?
2. What is clarks process?
3. What are zeolites mention its general formulas?
4. What are advantages of ion-exchange process?
5. Draw EDTA structure.

Section – B

1. What is lime soda process? Explain the functions of lime and soda.
2. Explain the zeolite process of water softening with neat diagram.
3. How will you determine the temporary & permanent by titration method?
4. Explain the modified lime soda process of softening of water.

Section - C

1. Explain the detail the cold & hot lime soda process with neat diagram.
2. Explain the ion-exchange process in detail with neat diagram.
3. Explain the various steps involved in EDTA method?
4. 100 ml of hard water requires 20 ml of EDTA solution for titration. 22 ml of the same EDTA solution was required for the titration of 100 ml of standard hardwater containing 1gm CaCO₃per litre. Determine the hardness of water sample in ppm.
5. 250 ml of hard water required 17 ml of 0.025 M EDTA solution to attain the end point. Calculate the hardness of water.

6. 100 ml of water sample requires 18ml of EDTA solution for titration. 1 ml of EDTA solution is equivalent to 1.1 mgs of CaCO_3 . Determine the hardness in ppm.
7. 100ml of a sample of water required 18 ml of 0.01M EDTA for titration using Erio-chrome Black-T indicator. In another experiment, 100ml of the same sample was boiled to remove the CH, the precipitate was removed and the cold solution required 10 ml of 0.01 M EDTA using Erio-chrome Black- T indicator. Calculate i) the total hardness, ii) permanent hardness or NCH iii) carbonate hardness CH, in terms of mg/lit of CaCO_3 .
8. 500 ml of a water sample is boiled for 1hr. It is then cooled and filtered. The filtrate is made upto 500ml again with distilled water. 50ml of this solution requires 12 ml of N/50 EDTA with EBT-indicator and $\text{NH}_4\text{Cl-NH}_4\text{OH}$ buffer. Determine the permanent hardness of the water sample