SNS COLLEGE OF TECHNOLOGY
Vazhiampalayam, Coimbatore-35
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Engineering Chemistry
CY8151

UNIT I

Water and its Treatment

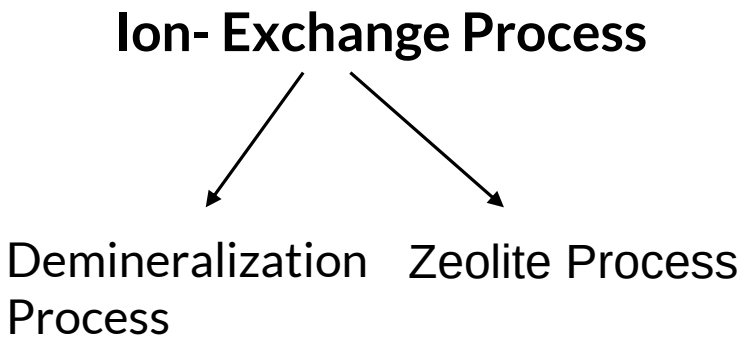
Contents

- EXTERNAL CONDITIONING PROCESS
- LIME SODA PROCESS
- ION-EXCHANGE PROCESS
  - DEMINERALIZATION
  - ZEOLITE PROCESS
    - DESALINATION OF BRACKISH WATER
    - REVERSE OSMOSIS

- It involves the removal of hardness producing salts from the water before feeding into the boiler

- The external treatment can be done by the demineralization or Ion-exchange process

1. **Lime soda process**
2. **Ion-exchange process**



Definition

- Anions and Cations are removed from the hard water is called **demineralization process (or) de-ionization Process**

- The soft water, produced by lime-soda and zeolite processes, does not contain hardness producing Ca^{2+} and Mg^{2+} ions, but it will contain other ions like Na^{+}, K^{+}, SO_4^{2-}, Cl^{-} etc.,

- Demineralized water does not contain both anions and cations

- Thus a soft water is not demineralized water whereas a demineralized water is soft water

- This process is carried out by using ion exchange resins, which are long chain, cross linked, insoluble organic polymers

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- Demineralization process, the ions present in water are removed by ion exchangers process

Ion exchange Resins

❖ These are long chain, cross linked, insoluble organic polymers with micro porous structure and having replaceable functional group.

➢ Resins are classified into two types,

1. **Cationic Exchange Resin**

2. **Anionic Exchange Resin**

1. Cation Exchanger:

They contain acidic functional groups (-COOH, $-SO_3H$) and are capable of exchanging their H^+ ions with cations of hard water.

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- They are represented by RH^+
- E.g. sulphonated coals,
- sulphonated polystyrene
- **$R - SO_3H$; $R - COOH \equiv RH_2$** etc.,

- Hard water is first passed through a cation exchange column.
- All the cations like Ca^{2+} , Mg^{2+} , Na^+ , K^+ etc., exchange with H^+ ions.
- $2RH^+ + Ca^{2+} \longrightarrow R_2Ca^{2+} + 2H^+$
- $2RH^+ + Mg^{2+}$ $R2Mg^{2+} + 2H^+$

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2. Anion Exchanger

- They contain basic functional groups (-OH) are capable of exchanging their OH^- ions with anions of hard water.
- They are represented by $R'OH^-$.

➢ E.g. Cross linked quaternary ammonium salts,

➢ Urea formaldehyde resins etc.,

➢ $R - NR_3OH$; $R-OH$; $R-NH_2 \equiv R(OH)_2$

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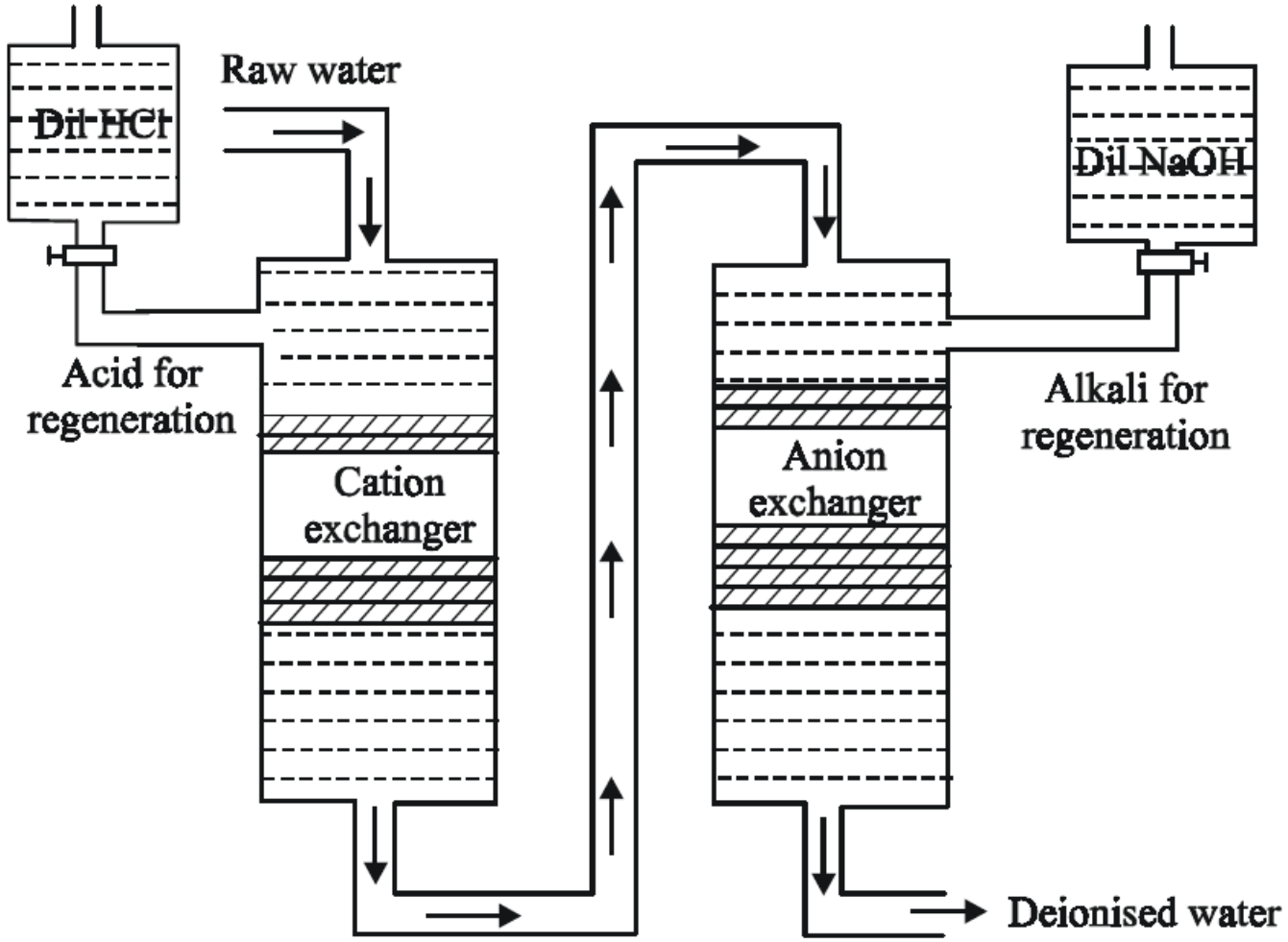
- The cation free water is then passed through anion exchange column.
- These exchange all the anions like SO_4^{2-} , Cl^- , CO_3^{2-} , HCO_3^- - etc., present in the water with OH ions.
- $2R'OH^- + SO_4^{2-} \longrightarrow R'2\ SO_4^{2-} + 2OH^-$
- $R'OH^- + Cl^- \longrightarrow R'Cl^- + OH^-$

Demineralization Process



- The water coming out of the anion exchanger is completely free from cations and anions.

- This water is known as demineralized water or deionized water.

Regeneration

a) The cation exchanger resin can be regenerated with dilute acid.

$$R_2Ca^{2+} + 2H^{+} \longrightarrow 2RH^{+} + Ca^{2+}$$

$$R_2Mg^{2+} + 2H^{+} \longrightarrow 2RH^{+} + Mg^{2+}$$

b) The anion exchanger resin can be regenerated with dilute NaOH.

$$R'_2SO4^{2-} + 2OH^{-} \longrightarrow 2R'OH^{-} + SO4^{2-}$$

$$R'Cl^{-} + OH^{-} \longrightarrow R'OH^{-} + Cl$$

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Advantages

(i) Highly alkaline and acidic water can be treated.

(i) Produces water with very low hardness (0 – 2 ppm)

Disadvantages

(i) Equipment is costly.
(ii) Chemicals are expensive.
(iii) Fe, Mn containing water cannot be treated (because the regeneration is very difficult)

Zeolite (permutit) process

- Zeolites are naturally occurring hydrated sodium aluminosilicates.
- Its general formula is $Na_2O.Al_2O_3.xSiO_2.yH_2O$.
- **Natural zeolites** are green sands which are non-porous.
- **Synthetic zeolites** is known as permutit.
- It is porous and has gel like structure.
- 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.

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- Process When hard water is passed through sodium zeolite (Na_2Ze), kept in a cylinder, it exchanges its sodium ions with Ca^{2+} and Mg^{2+} ions present in the hard water to form calcium and magnesium zeolites.

$$CaSO_4 + Na_2Ze \text{ ----------> } CaZe + Na_2SO_4$$

$$MgSO_4 + Na_2Ze \text{ ----------> } MgZe + Na_2SO_4$$

$$CaCl_2 + Na_2Ze \text{ ---------> } CaZe + 2NaCl$$

$$MgCl_2 + Na_2Ze \text{ ----------> } MgZe + 2NaCl$$

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- The softened water contains a large amount of sodium salts, which do not cause any hardness, but cannot be used in boilers.

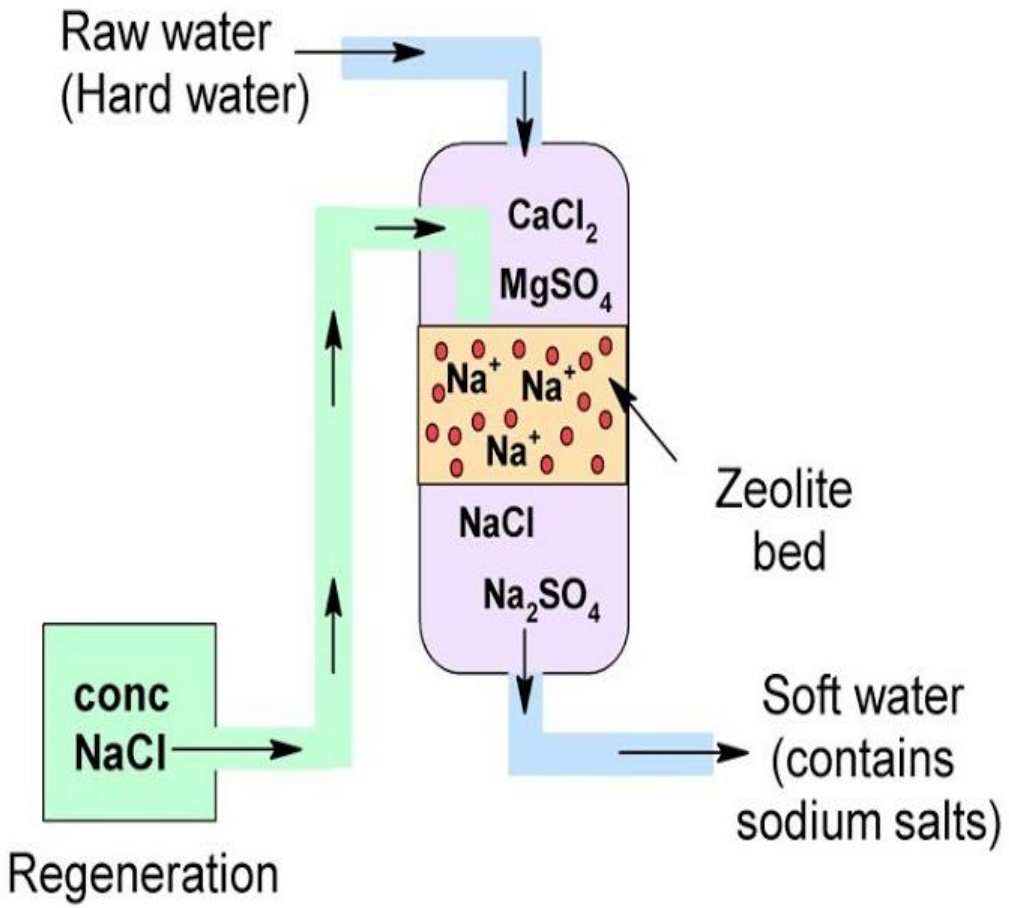
Regeneration

- After some time the zeolite gets exhausted.
- Regeneration is done by using 10% solution of NaCl.

$$CaZe + 2NaCl \text{ ----------} > Na_2Ze + CaCl_2$$

$$MgZe + 2NaCl \text{ ---------} > Na_2Ze + MgCl_2$$

D ZEOLITE PROCESS (WATER SOFTENING)



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- The softened water will contain large amount of sodium salts.
- But they do not cause any hardness.
- Soft water obtained by this process is mostly used for laundry purposes.
- Water softened by this method cannot be used in boilers, because it contains large amount of dissolved salts (sodium salts)

❖ **Advantages**

- ➢ Water obtained by this process will have hardness of 1 to 10 ppm only
- ➢ The equipment used is compact

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- No sludge is formed.
- Its operation is easy
- The process is cheap.

❖ **Disadvantages**

- Turbid water cannot be treated (because it blocks the pores of zeolite bed)
- Water softened by this method cannot be used in boilers, because it contains large amount of dissolved salts (sodium salts).
- Acidic water cannot be treated (because it affects zeolite bed)
- Fe, Mn containing water cannot be treated (because the regeneration is very difficult)
- This process cannot be used for softening brackish water

Comparison of zeolite process with demineralization process

S No	Zeolite process	Demineralization process
1	It removes only cations	It removes both cations and anions completely
2	Soft water is produced by this process	Demineralized water is produced by this process
3	This method cannot be used to treat acidic water	This method can be used to treat highly acidic or alkaline water
4	Water obtained from this treatment cannot be used in boilers. It contains large amount of sodium salts	Water obtained from this treatment can be used in high pressure boilers

- The process used for the removal of total dissolved salts from the brackish or saline water is called desalination.

- The water containing dissolved salts with a peculiar salty or brackish taste is called **brackish water**

Different techniques of desalination are

1. Distillation
2. Electro dialysis
3. Reverse osmosis

Let us discuss the reverse osmosis.

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(i)Fresh Water – Contains < 1000 ppm of dissolved solids.

(ii) Brackish water – Contains > 1000 but < 35,000 ppm of dissolved solids.

(iii) Sea water – Contains > 35,000 ppm of dissolved solids.

OSMOSIS

- When two solutions of different concentrations are separated by a semi-permeable membrane, solvent (water) flows from a region of lower concentration to higher concentration.

- This process is called osmosis.

- The driving force in this phenomenon is called osmotic pressure

❖ **Reverse Osmosis**

- If a hydrostatic pressure in excess of osmotic pressure is applied on the higher concentration side, the solvent flow is reversed.

- i. e Solvent flows from higher concentration to lower concentration.

- This process is called reverse osmosis.

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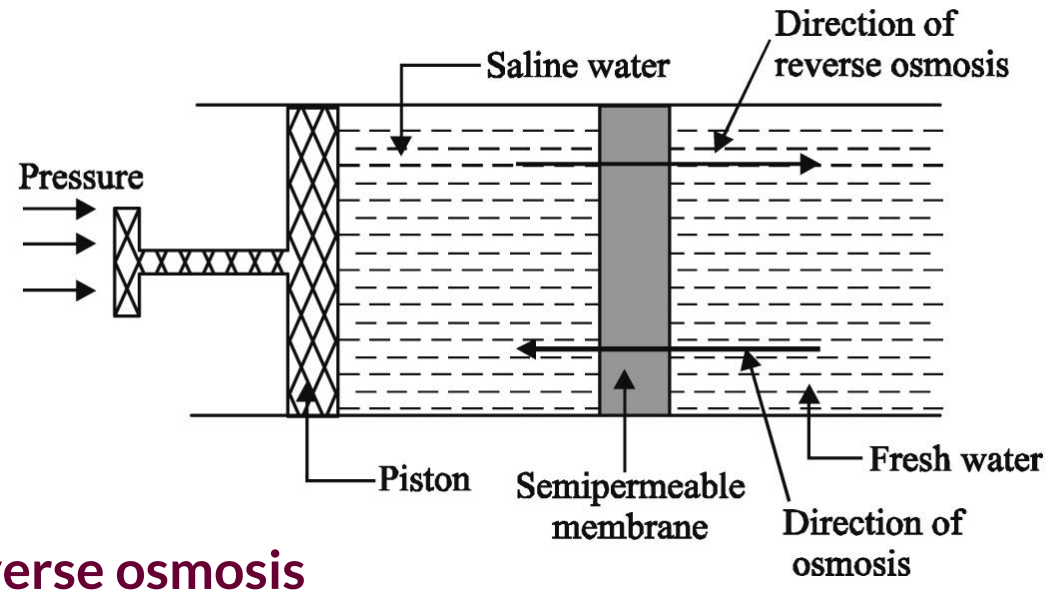
- Thus, in the process of reverse osmosis pure water is separated from salt water.
- This process is also known as super –filtration.
- The membranes used are cellulose acetate, cellulose butyrate, aromatic polyamide and a thin film of polymer composites etc.,



Reverse osmosis

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❖ **Advantages**

1. The lifetime of the membrane is high (2 years).
2. Water obtained by this process can be used in high pressure boilers.
3. Low capital and operating cost.
4. Low energy consumption.
5. Removes all types of impurities like ionic, non-ionic and colloidal impurities.

Disadvantages

1. The membrane is costly.
2. The membrane must be capable of withstanding pressure of the order of 20-100 atm.

THANK YOU