MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY & MANAGEMENT
(Affiliated to JNTU, Hyderabad, Approved by AICTE, New Delhi)
Accredited by NBA, Accredited by NAAC with 'A' Grade & Recognized Under section 2(f) & 12(B) of the UGC act, 1956
Dundigal (Vill .& Mandal), Medchal District, Hyderabad - 500043, Telangana.

UNIT-II

WATER AND ITS TREATMENT

CH102BS/CH202BS: CHEMISTRY

B.Tech. I Year II Sem.

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Course Objectives:

- To bring adaptability to the concepts of chemistry and to acquire the required skills to become a perfect engineer.
- To impart the basic knowledge of atomic, molecular and electronic modifications which makes the student to understand the technology based on them.
- To acquire the knowledge of electrochemistry, corrosion and water treatment which are essential for the Engineers and in industry.
- To acquire the skills pertaining to spectroscopy and to apply them for medical and other fields.
- To impart the knowledge of stereochemistry and synthetic aspects useful for understanding reaction pathways

Course Outcomes: The basic concepts included in this course will help the student to gain:

- The knowledge of atomic, molecular and electronic changes, band theory related to conductivity.
- The required principles and concepts of electrochemistry, corrosion and in understanding the problem of water and its treatments.
- The required skills to get clear concepts on basic spectroscopy and application to medical and other fields.
- The knowledge of configurational and conformational analysis of molecules and reaction mechanisms.

Unit - I:

Molecular structure and Theories of Bonding: Atomic and Molecular orbitals. Linear Combination of Atomic Orbitals (LCAO), molecular orbitals of diatomic molecules, molecular orbital energy level diagrams of N_2, O_2 and F_2 molecules. π molecular orbitals of butadiene and benzene.

Crystal Field Theory (CFT): Salient Features of CFT – Crystal Field Splitting of transition metal ion d- orbitals in Tetrahedral, Octahedral and square planar geometries. Band structure of solids and effect of doping on conductance.

Unit - II:

Water and its treatment: Introduction – hardness of water – Causes of hardness - Types of hardness: temporary and permanent – expression and units of hardness – Estimation of hardness of water by complexometric method. Potable water and its specifications. Steps involved in treatment of water – Disinfection of water by chlorination and ozonization. Boiler feed water and its treatment – Calgon conditioning, Phosphate conditioning and Colloidal conditioning. External treatment of water – Ion exchange process. Desalination of water – Reverse osmosis. Numerical problems.

Unit - III:

Electrochemistry and corrosion: Electro chemical cells – electrode potential, standard electrode potential, types of electrodes – calomel, Quinhydrone and glass electrode. Nernst equation Determination of pH of a solution by using quinhydrone and glass electrode. Electrochemical series and its applications. Numerical problems. Potentiometric titrations. Batteries – Primary (Lithium cell) and secondary batteries (Lead – acid storage battery and Lithium ion battery).

Causes and effects of corrosion – theories of chemical and electrochemical corrosion – mechanism of electrochemical corrosion, Types of corrosion: Galvanic, water-line and pitting corrosion. Factors affecting rate of corrosion, Corrosion control methods- Cathodic protection – Sacrificial anode and impressed current cathodic methods. Surface coatings – metallic coatings – methods of application. Electroless plating of Nickel.

Unit - IV:

Stereochemistry, Reaction Mechanism and synthesis of drug molecules: Introduction to representation of 3-dimensional structures, Structural and stereoisomers, configurations, symmetry and chirality. Enantiomers, diastereomers, optical activity and Absolute configuration. Conformation alanalysis of n- butane.

Substitution reactions: Nucleophilic substitution reactions: Mechanism of S_N1, S_N2 reactions. Electrophilic and nucleophilic addition reactions: Addition of HBr to propene. Markownikoff and anti Markownikoff's additions. Grignard additions on carbonyl compounds. Elimination reactions: Dehydro halogenation of alkylhalides. Saytzeff rule. Oxidation reactions: Oxidation of alcohols using $KMnO_4$ and chromic acid.

Reduction reactions: reduction of carbonyl compounds using $LiAlH_4$ & $NaBH_4$. Hydroboration of olefins. Structure, synthesis and pharmaceutical applications of Paracetamol and Aspirin.

Unit - V:

Spectroscopic techniques and applications: Principles of spectroscopy, selection rules and applications of electronic spectroscopy, vibrational and rotational spectroscopy. Basic concepts of Nuclear magnetic resonance Spectroscopy, chemical shift. Introduction to Magnetic resonance imaging.

Suggested Text Books:

1. Physical Chemistry, by P.W. Atkins
2. Engineering Chemistry by P.C.Jain & M.Jain; Dhanpat Rai Publishing Company (P) Ltd., New Delhi.
3. Fundamentals of Molecular Spectroscopy, by C.N. Banwell
4. Organic Chemistry: Structure and Function by K.P.C. Volhardt and N.E.Schore, 5th Edition.
5. University Chemistry, by B.M. Mahan, Pearson IV Edition.
6. Engineering Chemistry (NPTEL Web-book), by B.L. Tembe, Kamaluddin and M.S. Krishnan

CLASS NOTES	UNIT NO: II LECTURE NO: LH 11
SUB: NAME OF THE FACULTY: K.V. Swamy. TOPIC:	DATE PLANNED: DATE CONDUCTED: Page No:

Introduction & Scope

Water is the most important compound for the existence (or) surviving of human beings, animals and plants. Water has great applications in industries. Water is mainly used in power generation industry by the production of electrical current through steam generation. It is also largely used in agricultural perpose and fire fighting.

Sources of water

It can be classified into 2 types. They are

1) Surface water
2) underground water.

Surface water can be further classified into 4 major sources. They are

i) Rain water
ii) River water
iii) Lake water
IV) Sea water.

uses of water:

Water is essential for the sustenance and continuation of life both animals and vegetable kingdom. The various other uses of water are as follows.

(i) Domestic purposes [cooking, bathing, drinking etc]
(ii) Industrial purposes.

(iii) Municipal purposes

(IV) Agricultural purposes

(V) Fire fighting purposes.

IMPURITIES of WATER

Chemically pure water is composed of two parts of hydrogen and one part of oxygen by volume and dissolves many substances.

The various impurities present in natural water may be broadly categorised as follows. They are

i) Suspended matter:

River water mainly contains suspended matter, which is responsible for turbidity of water.

ii) Dissolved substances:

Inorganic salts like carbonates, chlorides, sulphates, nitrates of Ca and Mg in the dissolved form causes hardness to water.

HARD AND SOFT WATER:

Those waters which doesn't produce lather with soap is called Hard water. Soap is sodium (Na) (or) K salts of higher fatty acids like stearic, oleaic acid, palmatic acids.

When soap reacts with hard water, sodium stearate will react with dissolved Ca & Mg salts and produce Ca- stearate (or) Mg- stearate which is white ppt

$$\underset{\text{(Soap)}}{2Na\text{-Stearate}} + \underset{\text{(H. water)}}{Ca^{+2}/Mg^{+2}} \longrightarrow \underset{\text{(white ppt)}}{Ca\text{-stearate}} + 2Na^{+}$$

When soap reacts with unders those waters which readily gives the lather such type of water is called soft water.

Soap is mixed with soft water lather produced due to Stearic acid and Na- Stearate.

Na- Stearate + H_2O (Soft) $\longrightarrow$ NaOH + Stearic acid.

Stearic acid + Na- Stearate $\longrightarrow$ formation of lather.

$\rightarrow$ Different types of water have different degrees of hardness.

Hardness	Name of water.
0-70 mg/lit	Soft water
70-150 mg/lit	Moderate hard water
150 - 300 mg/lit	Hard water
300 mg/lit & above	Very Hard water.

Types of Hardness of water:

The hardness of water is two types, they are

(i) Temporary Hardness (or) Carbonate hardness

(ii) permanent hardness (or) non- carbonate hardness.

i) Temporary Hardness of water:

Temporary hardness of water is caused by two dissolved bicarbonates of Ca & Mg [i.e $Ca(HCO_3)_2$ & $Mg(HCO_3)_2$ the hardness called temporary hardness because it can be easily removed by boiling.

$$Ca(HCO_3)_2 \xrightarrow{\text{heating}} CaCO_3\downarrow + H_2O + CO_2\uparrow$$

$$Mg(HCO_3)_2 \xrightarrow{\text{heating}} MgCO_3\downarrow + H_2O + CO_2\uparrow$$

permanent hardness of water:

permanent hardness of water is due to the dissolved chlorides, sulphates, Nitrates of Ca & Mg i.e $CaCl_2$, $MgCl_2$, $CaSO_4$, $MgSO_4$, $Ca(NO_3)_2$, $Mg(NO_3)_2$. This hardness can't

removed by boiling hence it is called permanent hardness of water.

Total Hardness of water = Temporary hardness + permanent hardness of water.

Units of Hardness:

The following common units are used in hardness measurements.

(i) **PPM** (Parts per millian)

ppm is the number of parts by wt of $CaCO_3$ equivalents of hardness causing salts present in one millian of parts of water.

(ii) **Mg/lit** (milligrams per lit)

The amount of the $CaCO_3$ equivalents hardness causing salts in mg present in 1 litre of water.

(iii) **°cl** (Degree clark)

It is expressed in terms of grains $\left[1\ gr = \frac{1}{7000\ lb}\right]$

(IV) **°Fr** (Degree French)

It is expressed as number of parts of $CaCO_3$ equivalents hardness causing substance in 10^5 parts of water

(V) Equivalent per millian (EPm)

The following inter conversions of 4 different units.

$$1\ ppm = 1\ mg/lit = 0.07°cl = 0.1°Fr = 0.02\ epm$$
$$1°cl = 1.43°Fr = 14.3\ ppm = 14.3\ mg/lit$$

→ For finding the hardness of water in ppm (or) mg/lit it is necessary that the hard salts should be represented as equivalents of $CaCO_3$

The choice of $CaCO_3$ in particular is due to it's m.wt is 100 and eq.wt is 50 which is found to be a convenient number and it is in soluble salt."

The conversion of hardness salts into $CaCO_3$ equivalent can be achieved by using the following formula; i.e.

$$\text{hardness of water (or) Equivalent of } CaCO_3 = \frac{\text{wt of hardness causing salt in mg}}{\text{M.wt of hardness causing salt}} \times 100$$

Problem

A sample of water gives an analysis 13.6 mg/lit of $CaSO_4$, 7.3 mg/lit of $Mg(HCO_3)_2$. Calculate the total hardness & permanent hardness of water.

Solution

$CaSO_4$, it is permanent hardness causing salt which gives the 13.6 mg/lit hardness. so

$$\therefore \text{permanent hardness of water} = \frac{13.6}{\text{M.wt of } CaSO_4} \times 100$$

$$= \frac{13.6}{136} \times 100$$

$$= 10 \text{ ppm.}$$

Ca - 20 → 40
S - 16 - 32
O - 16 - 64
136

$Mg(HCO_3)_2$, It is Temporary hardness causing salt which gives the 7.3 mg/lit hardness. so.

$$\text{Temporary hardness of water} = \frac{7.3}{\text{M.wt of } Mg(HCO_3)_2} \times 100$$

$$= \frac{7.3}{146} \times 100$$

$$= 5 \text{ ppm.}$$

∴ Total hardness of water = Temp + perm. hardness of water

= 5 + 10

= 15 ppm.

Estimation of hardness of water by Complexometric Method

The estimation of hardness of water is very essential for it's use in boilers for steam generation as well as Industrial uses.

Three methods are generally employed for the estimation of hardness of water. They are.

(i) EDTA Method (or) Complexometric method.

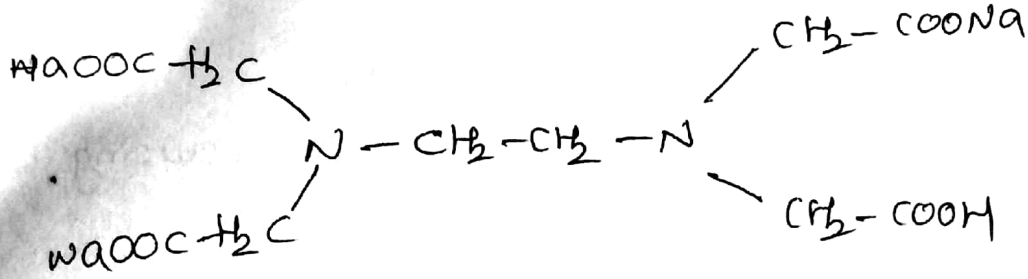
(ii) Soap titration method

(iii) Alkalinity method.

EDTA (or) Complexometric method:

Di-sodium salt of Ethylene diamine Tetra acetic acid is used as permanent complexing agent with hard water.

The structure of the EDTA is.



Before starting the titration we have to add the buffer solution and EBT indicator to the hard water which forms unstable wine red colour complex with EBT Indicator.

Ca^{+2}/Mg^{+2} + EBT (Indicator) $\longrightarrow$ $\left[\begin{matrix} Ca-EBT \\ /Mg-EBT \end{matrix}\right]$

(Hard water) (pH. 9 to 10)

Unstable wine red colour complex.

The wine red unstable colour complex is titrated with EDTA, where EDTA replaces the EBT & form stable complex & releasing the blue coloured indicator EBT into water hence the colour changes at the end point i.e wine red into blue colour the titration carried out in the following step.

1) preparation of $MgSO_4$ solution
2) standardisation of EDTA solution.
3) Determination of Total hardness of water.
4) Determination of permanent hardness of water.

Preparation of $MgSO_4$ solution:

Weight 0.25 gm of $MgSO_4$ & transfer into 100ml of standard flask through the funnel & dissolve in minimum quantity of dissolved water, make up the solution upto the mark with distilled water, & shake the flask well for uniform concentration then calculate the molarity of $MgSO_4$

$$\text{Molarity of } MgSO_4 = \frac{\text{wt of Solute}}{\text{Mol. wt of Solute}} \times \frac{1000}{V}$$

Standardisation of EDTA solution:

Pippet out 20ml of the prepared $MgSO_4$ solution into a conical flask, add 2 ml of the buffer solution & add 2 to 3 drops of EBT indicator, it get wine red colour complex then titrate it with EDTA solution taken in burette until wine red colour changes to blue colour solution. Repeat the titration

to get concurrent values. Calculate the molarity of EDTA solution.

$$M_1V_1 = M_2V_2$$

$$\Rightarrow \boxed{M_2 = \frac{M_1V_1}{V_2}}$$

Determination of Total Hardness of water

Pipette out 20ml of tap water into a clean conical flask, add 2ml of buffer solution & add 2 to 3 drops of EBT Indicator, it gets wine red colour then titrate it with EDTA solution until blue colour appeared. Repeat the titration to get concurrent values. Calculate the molarity of tap water then calculate the total hardness of water.

$$M_2V_2 = M_3V_3$$

$$\boxed{M_3 = \frac{M_2V_2}{V_3}}$$

∴ Total Hardness of water = $M_3 \times 10^5$ ppm.

Determination of permanent hardness of water.

Take 100ml of hard water into a beaker (500ml) and heat it till volume reduce to 50ml. Cool the solution & filter the water into another beaker. pipette out 20ml of this water sample into 250ml of conical flask & add 2ml of buffer solution & add 2 to 3 drops of EBT Indicator. Titrate the wine red coloured solution with EDTA till blue colour appeared. Repeat the titration to get concurrent values.

$$M_2V_2 = M_4V_4$$

$$\boxed{M_4 = \frac{M_2V_2}{V_4}}$$

∴ permanent Hardness of water = $M_4 \times 10^5$ ppm.

∴ Total Hardness of water = Temp + permanent H. water

Temp. Hardness of water = Total Hardness of water
— permanent Hardness of water.

Potable Water:

Drinking water, also known as potable water, is water that is safe to drink (or) to use for food preparation.

Specifications

The following are the specifications of water for drinking purpose.

1) The water should be clear, colourless & odourless
2) The water must be free from pathogenic bacteria & dissolved gases like H_2S.
3) The optimum hardness of water must be 125 ppm & pH must be 7.0 to 8.5
4) The turbidity in drinking water should not exceed 25 ppm.

Treatment of Potable water:

The treatment of potable water for drinking purposes mainly includes the removal of suspended impurities colloidal impurities & harmful pathogenic bacteria.

The following steps are involved in treatment of potable water.

Source of water → screening → aeration → sedimentation → filtration → Sterilisation & Disinfectation → storage & distribution

Screening:

The water is passed through screens having large number of holes in it, to remove floating impurities.

Aeration:

The water is then subjected to aeration which

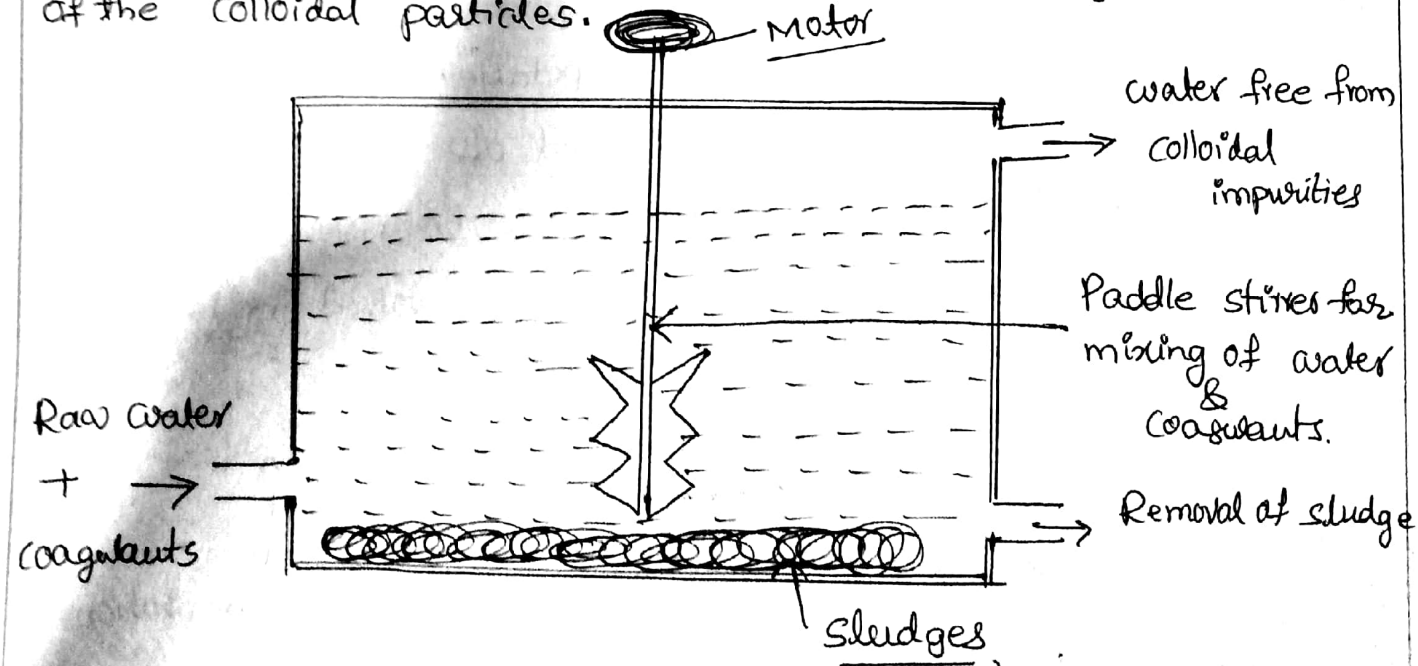
(i) helps in exchange of gases between water & air

(ii) Increases the oxygen content of water.

(iii) Removes the impurities like Fe & Mn by precipitating as their hydroxides.

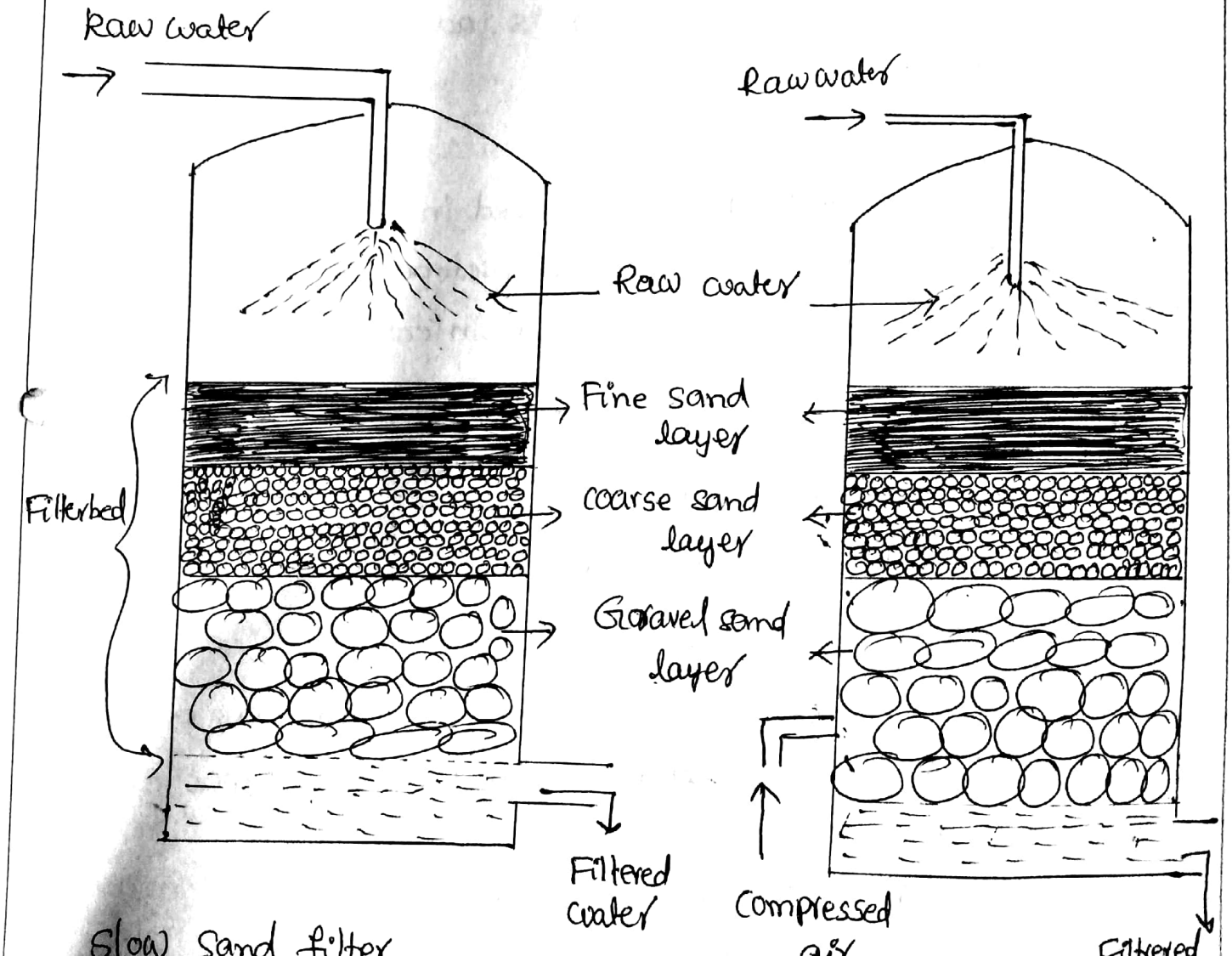
Sedimentation:

The Suspended & colloidal impurities are allowed to settle under gravitation. The basic principle of this treatment is to allow water to flow at a very slow velocity. So that the heavier particles settle under gravitation for setting of fine particles, coagulants like alums, sodium aluminates & salts of iron are added, which produces gelatinous ppts called flocculants, floc attracts & helps accumulations of the colloidal particles resulting in setting of the colloidal particles.



Filtration

Filtration helps in removal of the colloidal & suspended impurities not removed by sedimentation. usually sand filters are employed. There are two types of sand filtres are, slow sand filtre & rapid sand filtre @r pressure filtre. In slow sand filtre the filtre bed consists of three layers of sand of different particles size. A fine sand layer on the top supported by coarse sand layer, which is supported by gravel the colloidal impurities are retained by the fine sand layer resulting the very slow filtration of water. The top layers of the fine sand layer is scrafted off washed, dried & introduced into the filtre bed for reuse.



Disinfection of water

Destruction of harmful pathogenic bacteria from drinking water is carried out by sterilisation & disinfectation. The following methods adopted for sterilisation & disinfectation. They are.

1) Boiling
2) passing ozone
3) chlorination.

Boiling:

By boiling water for 15-20 min, harmful bacteria are killed. This is not possible for the muncipal supply of water. This method of sterilisation is adopted for domestic purpase.

Passing ozone:

Ozone (O_3) when passed into water acts as disinfectant. ozone is an unstable isotope of oxygen produces nascent oxygen which is powerful disinfectant.

$$O_3 \longrightarrow O_2 + [O]$$

nascent oxygen.

This treatment is costly & ozone (O_3) is unstable & can't be stored for a long time.

chlorination'

The process of utilising chlorine as a powerful disinfectant is called chlorination. There are 3 types of chlorinating reagents.

1) By passing chloramines
2) By adding bleaching powder
3) Chlorination

1) By passing Chloramines:

Chlorine is mixed with "ammonia" in the ratio 2:1 by volume to form a stable chloramine which generates hypochlorous acid. It is a powerful disinfectant.

$$Cl_2 + NH_3 \longrightarrow Cl-NH_2 + HCl$$

(Chloramine)

$$Cl-NH_2 + H_2O \longrightarrow HOCl + NH_3$$

(Hypochlorous acid)

HOCl is inactivates the enzymes of bacteria & kills bacteria. Chloramine is useful for disinfecting swimming Pools.

2) By bleaching powder

Bleaching powder contains 30% Chlorine(Cl_2) when bleaching powder is used as disinfectant, it is called hypo-chlorination because the disinfectation is due to HOCl.

$$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

(Bleaching powder)

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

(disinfectant)

3) Chlorination

The process of applying calculated amount of chlorine to water in order to kill the pathogenic bacteria is called "chlorination"

Cl_2 is also reacts with the water & generates HOCl which kills bacteria. Cl_2 is a powerful disinfectant than Chloramine & bleaching powder ($CaOCl_2$)

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

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Calculated amount of Cl_2 must be added to water because Cl_2 after reacts with bacteria & organic impurities ammonia, remains in water as residual chlorine which gives bad taste, odour & toxic to human beings.

NOTE: The amount of chlorine required to kill the bacteria & to remove organic matter is called "break point Chlorination"

Boiler feed water and its treatment:

In several industries, boilers are used to make steam, when water is continuously evaporated to generate steam, the concentration of the dissolved salts are increases progressively causing bad effects for boilers.

The following are boiler troubles that arise due to

1) Scale & sludge formation
2) Boiler corrosion
3) Caustic embrittlement
4) priming & foaming

The above problems (or) trouble can be prevented by "softening" water which is discussed separately in treatment of water.

Treatment of boiler feed water

- Internal treatment
- External treatment

→ The treatment given to water for the removal of hardness causing salts after taken in to the boiler is called Internal treatment of boiler feed water.

→ The treatment given to water for the removal of hardness causing salts before it is taken into the boiler is called external treatment.

"The process of removing the hardness causing salts from water is called "Softening of water"

Internal treatment of boiler feed water methods

Internal treatment methods are generally followed by blow-down operation. They are.

1) Calgon conditioning
2) phosphate conditioning
3) Colloidal conditioning.

Calgon conditioning:

It involves adding of calgon [ie Sodium Hexa meta phosphate $[(NaPO_3)_6]$ to boiler water. It prevents the scale & sludge formation by forming Soluble complex compound with $CaSO_4$.

$$[NaPO_3]_6 \text{ (or) } Na_6(PO_3)_6 \text{ (or) } Na_2[Na_4(PO_3)_6]$$

$$Na_2[Na_4(PO_3)_6] \rightleftharpoons 2Na^{\oplus} + [Na_4(PO_3)_6]^{-2} \text{ (or) } [Na_4P_6O_{18}]^{-2}$$

$$2CaSO_4 + [Na_4P_6O_{18}]^{-2} \longrightarrow [Ca_2P_6O_{18}]^{-2} + 2Na_2SO_4$$

"Soluble Complex"

phosphate conditioning:

The scale formation due to permanent hardness causing salts are avoided by reacting with sodium phosphate in high pressure boilers.

$3CaSO_4 / 3CaCl_2 + 2Na_3PO_4 \longrightarrow \underline{Ca_3(PO_4)_2} + 6NaCl$

$3MgCl_2 + 2Na_3PO_4 \longrightarrow \underline{Mg_3(PO_4)_2} + 6NaCl.$

The above products Calcium phosphate and Magnesium phosphate were removed by blow-down operation.

The different phosphates are used. They are

(1) Na_3PO_4 [Tri sodium phosphate used for acidic water]

(2) Na_2HPO_4 [Di sodium hydrogen phosphate used for weakly alkaline]

(3) NaH_2PO_4 [Mono sodium di hydrogen phosphate used for alkaline water]

Colloidal Conditioning:

In low pressure boilers, scale formation can be avoided by adding organic substances like kerosene, tannin, agar-agar etc. which get coated over the scale forming precipitates there by yeilding non-sticky & loose deposits which can easily be removed by blow-down operation.

EXTERNAL TREATMENT OF WATER

The treatment given to water for the removal of hardness causing salts before it is taken into the boiler is called external treatment of water.

There are three main methods employed for softening of water they are

1) Lime-soda process
2) Zeolite process
3) Ion-Exchange process.

Ion-Exchange process (or) deionisation process

The process of complete removal of all ions present in water is called deionisation process.

Ion-Exchange process includes the exchange of the cations & Anions of dissolved salts with H^+ & OH^- ions respectively. For this purpose two types of ion-exchange resins are used, which are insoluble, cross-linked long chain organic polymers with microporous structure.

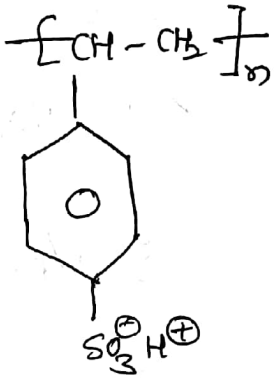
The property of Ion-Exchange resin is obtained due to the presence of functional groups. These functional groups may be acidic (or) basic. Based on these ion-exchange resins are classified into two types, they are

1) Cation-Exchange resin
2) Anion-Exchange resin.

Cation-Exchange resin:

The cation exchange resins are polystyrene polymer with attaching of sulphonic group (or) carboxyllate group

The acidic (H^+) functional group have the capability to exchange their H^+ ions with cations which are presents in the water.

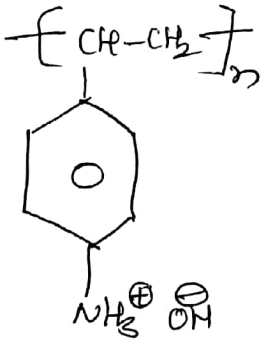


"Cation- Exchange resin"

→ It is represented by "R-H" [∵ R = Resin]

Anion exchange resin:

The anion Exchange resins are poly styrene polymer with attaching of ammonium group at para position the basic ($\ominus OH$) group have the capability to exchange their $\ominus OH$ ions with anions which are present in the water.



Anion- Exchange resin

→ It is represented by R'-OH

Process

In this Ion- Exchange process it consists of two tanks containing the cation exchange resin & anion exchange resin which are kept alternatively. so that the hard water is passed through the Ist cation- exchange resin where

all the cations are exchanged with the $H^{\oplus}$ ion of the resin.

$$2RH + Ca(HCO_3)_2/Mg(HCO_3)_2 \longrightarrow R_2\text{-}Ca + 2H_2CO_3$$

$$2RH + CaCl_2/MgCl_2 \longrightarrow R_2\text{-}Ca/R_2\text{-}Mg + 2HCl$$
(Ca^{+2}/Mg^{+2}) (Hydrochloric acid)

$$2RH + CaSO_4/MgSO_4 \longrightarrow R_2\text{-}Ca/R_2\text{-}Mg + H_2SO_4$$
(Sulphuric acid)

$$2R\text{-}H + Ca(NO_3)_2/Mg(NO_3)_2 \longrightarrow R_2\text{-}Ca/R_2\text{-}Mg + 2H\text{-}NO_3$$
(Nitric acid)

The Ca^{+2} & Mg^{+2} are retained by the cation-exchanges as R_2-Ca / R_2-Mg releasing H^{+} ions into water. Thus the water coming out of the resin is highly acidic in nature.

Then the water is passed through anion exchanges where the anions of the acids present in water are removed by the anionic exchangers & releasing $\overset{\ominus}{OH}$ ions into water.

→ The $H^{\oplus}$ ions & $\overset{\ominus}{OH}$ released from exchangers get combined & produce water (H_2O)

$$R^1\text{-}OH + H_2CO_3 \longrightarrow R^1\text{-}HCO_3 + H_2O$$

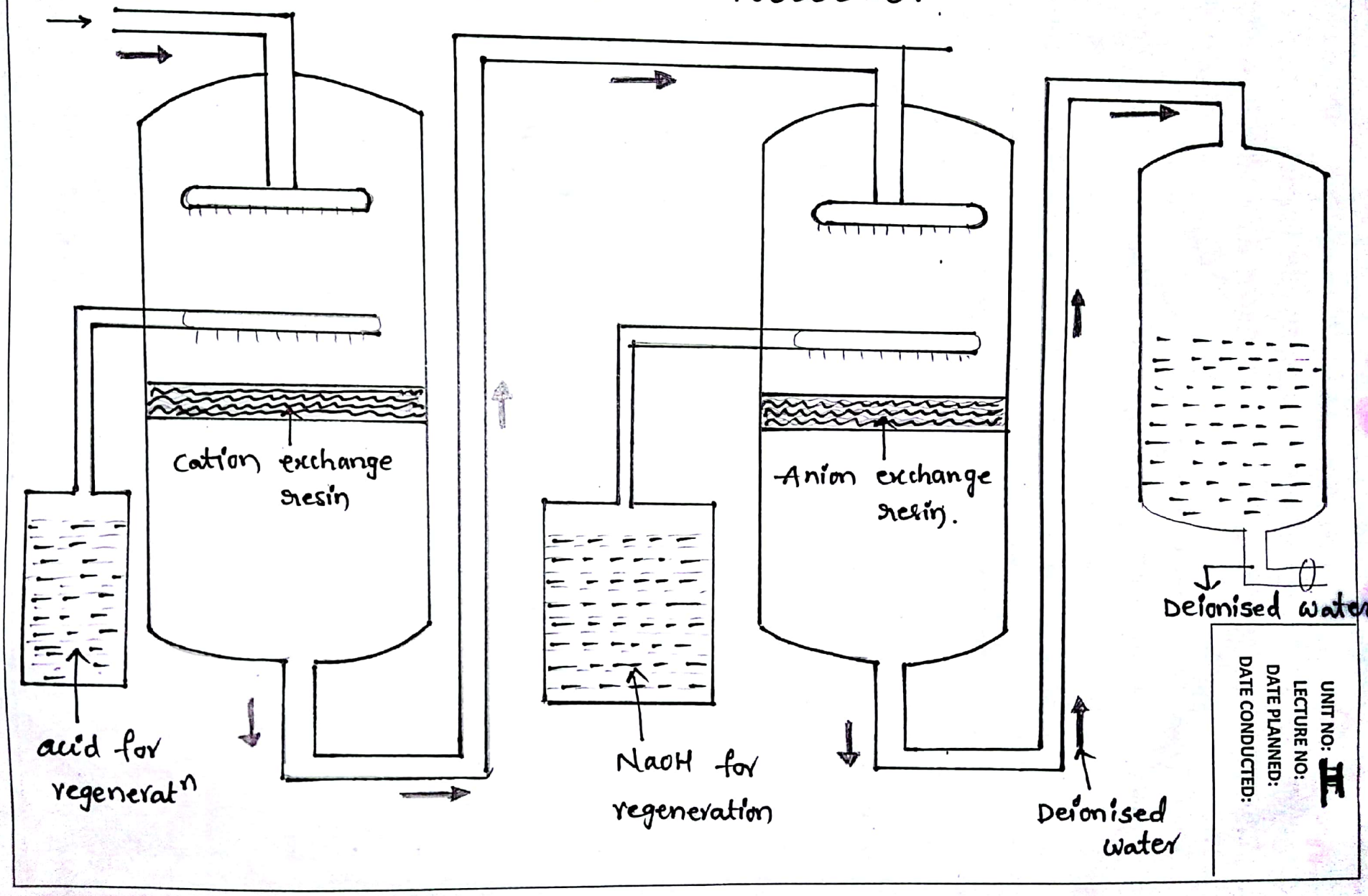
$$R^1\text{-}OH + HCl \longrightarrow R^1\text{-}Cl + H_2O$$

$$2R^1\text{-}OH + H_2SO_4 \longrightarrow R^1_2\text{-}SO_4 + 2H_2O.$$

$$R^1\text{-}OH + HNO_3 \longrightarrow R^1\text{-}NO_3 + H_2O.$$

Thus the waters coming out from exchangers free from all ions known as deionised water (or) demineralised water.

Deionisation of water.



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Regeneration of resins

After the deionisation of certain amount of raw water the cation & anion exchangers will be exhausted regeneration of cation exchangers is carried out by passing dil HCl (or) H_2SO_4 solution into the bed. The $H^{\oplus}$ ions of the acid are exchanged with the cations (Ca^{+2} / Mg^{+2}) present in the cation exchanger.

$$R_2\text{-}Ca + 2HCl \longrightarrow 2R\text{-}H + CaCl_2$$

$$R_2\text{-}Mg + 2HCl \longrightarrow 2R\text{-}H + MgCl_2$$

→ The exhausted anion exchangers is treated with the dil NaOH solution.

$$R^1\text{-}SO_4 + 2NaOH \longrightarrow Na_2SO_4 + R^1\text{-}OH$$

$$R^1\text{-}Cl + NaOH \longrightarrow NaCl + R^1\text{-}OH$$

$$R^1\text{-}NO_3 + NaOH \longrightarrow R^1\text{-}OH + NaNO_3.$$

Advantages:

1) Very low hardness of water (0-2 ppm) is obtained
2) Demineralized water can be used for industrial purposes & domestic purposes.

Disadvantages:

→ The ion-exchange resins are very expensive, hence the cost of purification is high.

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Desalination of water

The process of removing common salt (NaCl) from the water is known as desalination of water. The water containing dissolved salts with a peculiar salty (or) brackish taste is called brackish water

Depending upon the quantity of dissolved salts, solids, water is graded as.

(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.

Sea water & brackish water can be made available as drinking water through desalination process. desalination is carried out either by reverse osmosis (or) electrodialysis.

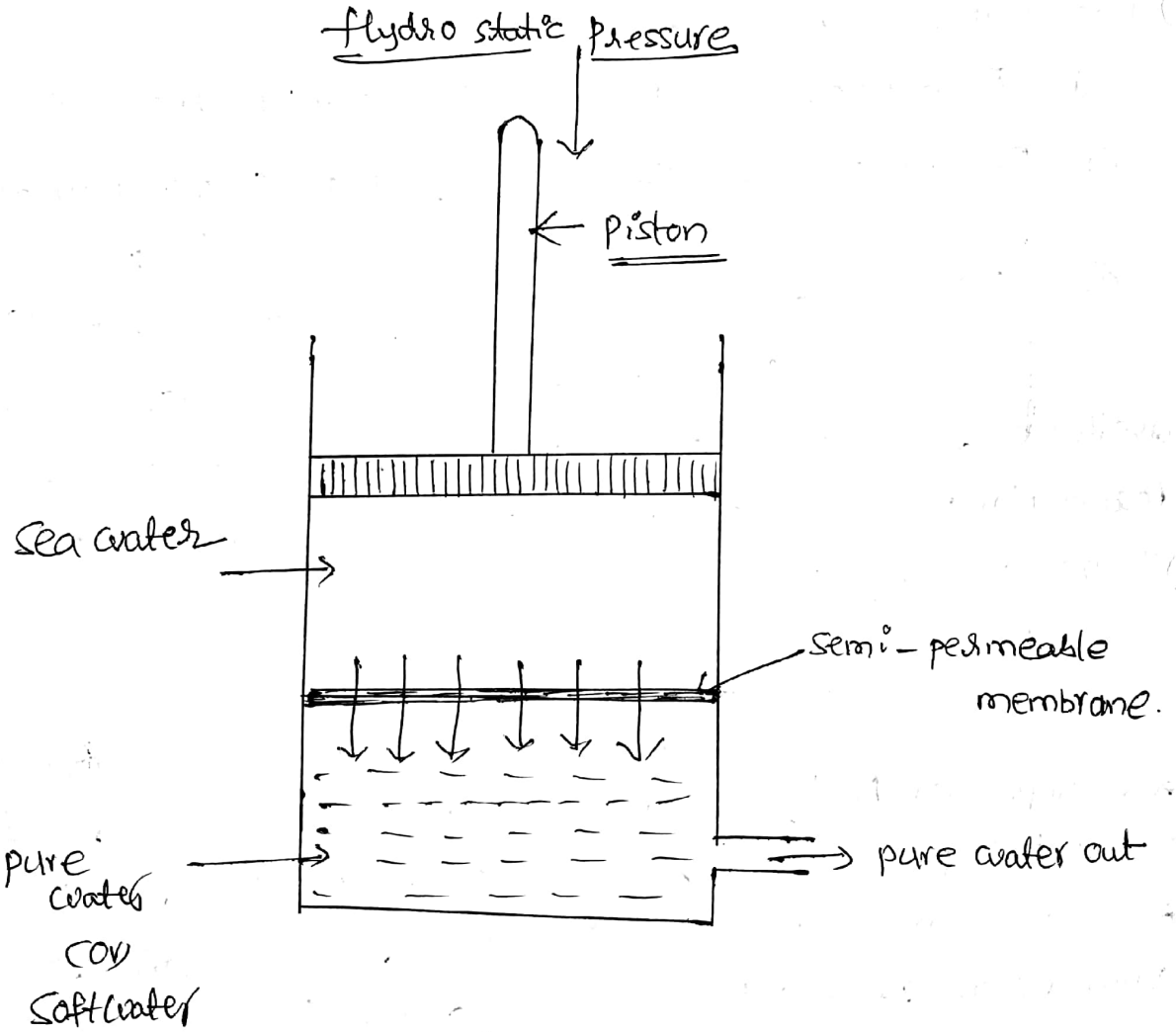
Reverse osmosis

When two solutions of unequal concentration are separated by a semipermeable membrane which doesn't permit the passage of dissolved solute particles (molecules & ions) flow of solvent takes place from the dilute solution to concentration solution this is called osmosis.

If a hydrostatic pressure in excess of osmatic pressure is applied on the concentrated side of the solvent

The solvent is forced to move from higher concentration to lower concentrated side across. Thus the solvent flow is reversed hence this method is called "reverse osmosis". thus in reverse osmosis method, pure solvent (water) is separated from its contaminates, rather than removing contaminates from the water.

This membrane filtration is sometimes also called super-filtration (or) Hyper filtration.



Reverse osmosis process

UNIT-II

QUESTION BANK

UNIT-II
WATER AND ITS TREATMENT

JNTUH PREVIOUS QUESTIONS:

1. What do you understand by the priming and foaming problems in boilers? **(DEC-2010)**
2. Differentiate between scale and sludge formation in boliers. What are their disadvantages? **(DEC-2010)**
3. Write the structure of EDTA and the complex formed between Mg+2 and EDTA. **(DEC-2010)**
4. What are boiler-troubles? Explain the scale and sludge formation in boilers. **(DEC-2010)**
5. What are scales? How are they formed in boilers? What are their disadvantages? **(DEC-2010)**
6. What are the prevention methods for scale formation in boilers. **(DEC-2010)**
7. Describe the zeolite process for softening of hard water. **(DEC-2010)**
8. Discuss the methods for disinfectaion of water. **(DEC-2010)**
    1. Alums are used for the treatment of water supplied by municipalities.
9. Why is hard water harmful to boilers? **(JUNE-2010)**
10. Describe the causes and harmful effects of scale formation. **(JUNE-2010)**
11. One liter of water from Khammam Dist. in Andhra Pradesh showed the following analysis: $Mg(HCO3)2 = 0.0256$ gms, $Ca(HCO3)2 = 0.0156$ gms, $NaCl = 0.0167$ gms, $CaSO4 = 0.0065$ gms, and $MgSO4 = 0.0054$ gms. Calculate the lime & soda required for softening of 10,000 litres of water **(JUNE-2010)**
12. Differentiate between lime-soda and zeolite processes for softening of water **(JUNE-2010)**
13. How is the hardness of water expressed? What are the various units employed? Explain their interconversion. **(JUNE-2010)**
14. Write a note on complex metric titrations used for estimation of hardness of Water by EDTA. **(JUNE-2010)**
15. Explain the process of electro dialysis. **(JUNE-2010)**

16. What is the principle involved in internal treatment of boiler few water? **(JUNE-2010)**

17. Write short notes on following:
    1. Calgon treatment
    2. Phosphate conditioning

18. Ion-exchange process. **(JUNE-2010)**

19. (a) What is desalination? **(JUNE-2011)**
    (b) Describe the different methods used for desalination of water.

20. What is caustic embrittlement? **(JUNE-2011)**

21. Explain the priming and foaming in boilers. **(JUNE-2011)**

22. Write a note on phosphate and carbonate conditioning of water.

23. Write a short note on the following:-
    1. Electro dialysis
    2. Break-point Chlorination. **(DEC-2011)**

24. What are the specifications of potable water? **(DEC-2011)**

25. Write short notes of break-point chlorination. **(DEC-2011)**

26. Discuss the process of priming and foaming. **(DEC-2011)**

27. Describe the zeolite process for softening of hard water. **(DEC-2011)**

28. Explain carbonate and non-carbonate hardness of water. List the various

29. Disadvantages of hard water for domestic use. **(DEC-2011)**

30. Explain about the reverse osmosis

NEWLY ADDED QUESTION (2014-2015)

31. Explain about the disinfectation of water by chlorination and ozonization

32. Why is ion exchange process preferred over zeolite process for the boiler corrosion

33. Explain about the boiler corrosion

34. Explain about the process of phosphate conditioning of boiler feed water

35. How is exhausted ion exchange resins regenerated

36. How Calgon treatment prevents scale formation in boilers

37. Discuss the ion exchange process for softening of water.

38. Write a note on scale and sludges

39. What is Break point of chlorination ? Explain
40. What is Hardness of water?Give the causes of hardness

NEWLY ADDED QUESTIONS (2016-2017)

41. Calgon treatment prevents scale formation in boilers give reason
42. Explain the principle involved in complexometric method for the determination of hardness of water
43. What is Zeolite? Explain the method for softening of water
44. Explain about the disinfectation by chlorination
45. Explain about the principal of Lime Soda Process for softening of hard water
46. What is Caustic embrittlement? Explain and also write its prevention

NEWLY ADDED QUESTIONS (2017-2018)

47. What is hard water ? What are the salts that causes hardness to water
48. How are the salts from sea water removed
49. Explain about the ion exchange method of softening of water
50. What is disinfection of water ? Explain about the chlorination method
51. Explain the steps involved in sewage treatment

NEWLY ADDED QUESTIONS (2017-2018)

52. Write various units of hardness and the relationship between them
53. Write short notes on caustic embrittlement
54. What is mean by defouridation of water give an account about nalgonda technique
55. Write a brief note on Reverse osmosis
56. What are the steps involved in the treatment of potable water? Explain
57.

39. What is Break point of chlorination ? Explain
40. What is Hardness of water?Give the causes of hardness

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Newly added Questions (2018-2019)

[April/May-2018 II sem A.P]

1. What is deflouridation? Mention a technique of it
2. Discuss the principle of reverse osmosis. How is it useful in softening of waters?
3. Explain about the estimation of hardness of water by complexometric titration using EDTA.
4. Discuss the steps involved in the treatment of sewage water.

MARRI EDUCATIONAL SOCIETY'S GROUP OF INSTITUTIONS

MARRI LAXMAN REDDYINSTITUTE OF TECHNOLOGY & MANAGEMENT

(Approved by AICTE, New Delhi & ADundigal, Quthbullapur, Hyderabad – 430)

UNIT-II

OBJECTIVE QUESTIONS

: WATER - IV :

VIVA VOICE

1. Temporary hardness in water is removed by "Boiling"
2. Blow-down operation causes the removal of sludges
3. Solubility of $CaSO_4$ in water "decreases with ↑cing Temp"
4. Hard water is unfit for use in boilers for generating steam because "It produces scales inside the boiler"
5. Estimation of Hardness of water by EDTA method is used to determine
   (a) alkaline hardness b) Temporary hardness only
   (c) permanent hardness only (d) All the above
6. Hard water can be softened by passing it through "Ion-exchange Resin"
7. "calgon" is Sodium Hexa meta phosphate $[Na(PO_3)]_6$
8. Brackish water mostly contains dissolved "NaCl"
9. The purification of brackish water by reverse osmosis is also called as "super-filtration"
10. One part of $CaCO_3$ equivalent hardness per 10^5 parts of water is called "ppm"
11. Boiler corrosion caused by using highly alkaline (NaOH) water in a boiler is called "caustic embrittlement"
12. Caustic embrittlement can be avoided by using "Na_2SO_4"
13. Caustic embrittlement is a type of "boiler corrosion"
14. The soft, loose, slimmy ppt formed within the boiler is called "sludge"
15. Sodium meta aluminate $[NaAlO_2]$ used in internal treatment of boiler water produces the flocculant ppts of "NaOH & $Al(OH)_3$"

* 16. In low pressure boilers carbonate conditioning of boiler feed water is carried out to remove "$CaSO_4$"

* 17. The process of allowing water to stand undisturbed in big tanks for settling of the suspended particles due to force of gravity called "sedimentation"

* 18. The composition of alum is "$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$"

* 19. Ferrous sulphate ($FeSO_4$) is commonly used in the treatment of municipal water for "flocculation"

* 20. Liquid chlorine is a most effective "disinfectant" in chlorination process.

21. Disinfection by ozone (O_3) is due to liberation of "nascent O_2"

22. The formula of chloramine is "$Cl-NH_2$"

23. phosphate conditioning of boiler feed is carried out by "Na_3PO_4" "sodium phasphate"

24. Tannins & agar-agar are used for "colloidal conditioning"

25. The external treatment of boiler water feed done by

(a) Lime-soda process
(b) Na_2SO_4
(c) Calgon process
d) $NaAlO_2$

26. The process of wet-steam formation is called "priming"

27. Mechanical steam purifiers avoid "scale formation"

28. castor oil is a "antifoaming agent"

29. on addition of chlorine to water "HOCl (Hypochlorous)" acid is produced which is powerful germicide.

30. The chemical which removes dissolved O_2 of water Hydrazeen(NH_2-NH_2), sodium sulphite (Na_2SO_3) & Na_2S

31. Hardness of water is expressed in equivalents of "$CaCO_3$"

*32. In lime-soda [$Ca(OH)_2$ & Na_2CO_3] process of softening, calcium & magnesium ions are ppted as "$CaCO_3$ & $Mg(OH)_2$"

33. Sodium aluminate ($NaAlO_2$) is used as "coagulant" during purificatn of water.

*34. Anion exchange resins are regenerated by using "NaOH"

*35. Best method of removing hardness of water is "Ion-exchange process"

36. "Osmosis" causes the flow of solvent from lower concentratn to higher concentratn, which is separated by a semi permeable membrane

*37. In lime-soda process the addition of lime cannot remove "Ca-hardness (permanent)"

*38. priming & foaming in boilers produce "wet" steam.

39. Cation exchange resin contains H^+ mobile ions

*40. Calgon treatment is used for the removal of dissolved "$CaSO_4$"

**41. The chemical structure of Zeolite is $Na_2O\ Al_2O_3\ xSiO_2\ yH_2O$ (sodium alumino silicates)

42. Natrolite is a "Natural" zeolite

*43 Ion free water is known as "deionised water"

*44 The exhausted zeolite is regenerated by "NaCl"

*45. "Ion-selective membranes" are selected for efficient separation of ions.

46. $Al_2(SO_4)_3$ dium produce "$Al(OH)_3$" as flocculant ppts during softening of water.

47. The method by which the ions are pulled out of salt water by direct current & employing thin, rigid membrane pair is called "Electrodialysis"

48. Bleaching powder is "$CaOCl_2$" (Calcium oxy chlorides) (80% Cl_2)

49. Sodium aluminium silicates ($Na_2O\ Al_2O_3\ xSiO_2, yH_2O$) is synthetic zeolite

& Natural zeolite is "Natrolite"

50. Blowdown operation is removal of water, concentrated with dissolved salts and feeding the boiler with fresh soft water

All the Best .....