Water chemistry

Imp

Hardness :

The soap Consuming power of Capacity is known as Hardness of water. This is due to Present in water of certain salt calcium and magnesium and other metal Like Al^{3+}, Fe^{3+}, Mn^{3+} dissolve in it.

Generally soap consist of sodium salt of oleic acid Palimitic acid and steric acid. when sodium and potassium salt of oleic acid Palimitic acid is dissolve in water then it does not allow leather to be formed due to insolubility.

The Leather does not form due to the reason that CO_2 Present in water break Sodium and potassium into three thirty acid. generally the measurement of Calcium contains in water is the main reason of hardness the hardwater Produced insoluble salts of in calcium and Magnesium.

$2C_{17}H_{35}COONa \rightarrow$ sodium stearate

$2C_{17}H_{35}COONa + CaCl_2 \rightarrow (C_{17}H_{35}COO)_2Ca$

Calcium Stearate

(Insoluble [illegible])

$2C_{17}H_{35}COONa + Ca(HCO_3)_2 \rightarrow$
sodium stearate $(C_{17}H_{35}COO)_2Ca$

+ Types of hardness :-

Imp (i) Tempoary hardness ;

due to HCO_3^- of Ca^{++} & Mg^{++}

due to $Ca(HCO_3)_2$ & $Mg(HCO_3)_2$

Imp (ii) Parmanent hardness : Cl_2, SO_4, NO_3

due to the formation of
Calcium chloride, $MgCl_2$, $CaSO_4$, $MgSO_4$, $Ca(NO_3)_2$, $Mg(NO_3)_2$

Chloride
Nitrate
Sulphate

(i) This is due to the Pracent of Calcium and Mg of bycarbonate, This type of hardness easily be removed by boiling when by carbonate decompose into insoluble Carbonates

$$Ca(HCO_3)_2 \longrightarrow \underset{\text{ppt insoluble}}{CaCO_3\downarrow} + CO_2\uparrow + H_2O\uparrow$$

DATE: / 20
PAGE No

The insoluble of magnesium carbonate can easily removed by filteration

☆ (ii) This type of hardness is Present due to the Presence of sulphates, chloride and nitrate of calcium and magnesium and other metals.

Permanent can't be removed by boiling of water.

The classification of hardness is based on alkalinity. The alkline hardness is due to the Presence of ~~by~~ bycarbonate, carbonate & hydroxide of metals, while non-alkline hardness due to the Presence of chloride, sulphate, nitrate of metals

✓ Determination of hardness of water

(i) Soap Solution method
(ii) EDTA method (ethyline diamine tetra acetic acid)

~~units~~ :

Units of hardness

(i) PPm
(ii) mg/lit
(iii) Degree of Clarke (°cl)
(iv) Degree of french (°fr)

Inter relation between various units of hardness :

1PPm = 1m/l = 0.1°fr = 0.07°cl

* Degree of hardness :

(i) Soap Solution method : Soluble soaps consist of sodium or potassium salts of higher fatty acids. when soaps solution is added to hard water, the hardness causing ions first react to form precipitated of calcium and magnesium soap which are insoluble of water.

Thus after all the hardness causing metal ions presents in the hard water sample are precipitated the further addition of soap give lather.

Properties of hard water and Soft water.

DATE: / 20
PAGE No

The total hardness of water sample can be determined by titrating an aliquate of the sample against a standard soap solution in alcohol. The appearance of a stable lather persisting even after shaking for about ~~2min~~ 2min marks end point the water sample is boiled for 30 min to remove temporary hardness and then it is titrated with standard soap solution, the titre value correspond to permanent hardness of sample.

The difference b/w the two measurements Corresponds to the temporary hardness.

(ii) EDTA Method:

EDTA means (Ethylene diamine tetraacetic acid). This EDTA reagent can be forming EDTA - metal complexes by the reaction with metal ions except alkali metals ions. this reagent can form a stable complex with the alkaline earth metal like calcium ion and magnesium in alkaline condition PH above 9.0

∴ The total hardness of water can be determination by edta titration method.

In this method buffer Solution is used for attain suitable Condition PH level about 9 for the titration Buffer Solution present PH at a Balance position.

$H_2Y^{2-} + M^{2+} \longrightarrow MY^{2-} + 2H^{+}$

During titration Eriochrome Black T is used as indicator. The indicator is red in Colour while it is forms complexes with metal ions and blue in colour with it is free.

$MIn^{-} + H_2Y^{2-} \longrightarrow HIn^{2-} + MY^{2-} + H^{+}$

but metal indicator Complex is unstable, then EDTA Reacts with metal indicator to get blue colour.

$H_2Y^{2-} + MIn^{-} \longrightarrow MY^{2-} + In^{3-} + 2H^{+} \Rightarrow$

$MY^{2-} + \underset{\text{Blue in Colour}}{\underset{\downarrow}{HIn^{-}}} + H^{+}$

* Degree of hardness :

Hardness of water generally expressed in terms of equivalent amount of calcium Carbonate the reason for choosing calcium Carbonate the standard for reporting hardness in calculation its molecular weight 100 more ever, it is the most insoluble salt that can be precipitated in water treatment.

Equivalent of Calcium Carbonate equal to

$$= \frac{\text{Strength of hardness producing substance} \times 50 \text{ (eq. wt of } CaCO_3)}{\text{Eq. wt of hardness producing substance}}$$

Eq. of $CaCO_3$ ⇒ strength of the Hardness Producing substance × multiplication factor

multiplication factor =

$$= \frac{\text{molecular wt of } CaCO_3}{\text{molecular wt of hardness Producing substance}}$$

Note: Molecular wt of some imp. salt are -

$CaCO_3 = 100$ → $MgCO_3 = 84$

$CaCl_2 = 111$

$Ca(HCO_3)_2 = 162$

$CaSO_4 = 136$

$MgCl_2 = 95$

$Mg(HCO_3)_2 = 146$

$MgSO_4 = 120$

$Mg(NO_3)_2 = 148$

$HCO_3^- = 61$

Soap consuming tendency of water is called hardness

causes scum

27/3/19

* Treatment or softening of water:

(1) Zeolite method:

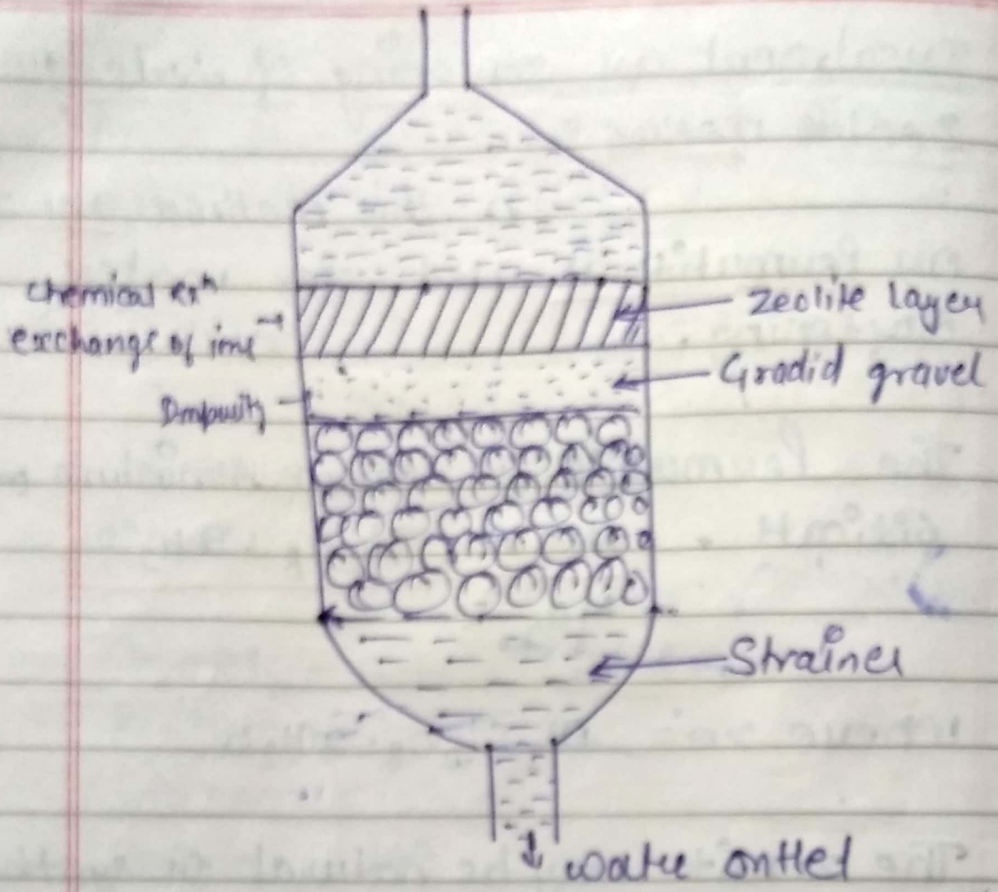
In this method, the zeolite or Permutite is used for water softening.

The Permutite is sodium Aluminium ortho-silicate. $Na_2Al_2Si_2O_8 \cdot xH_2O$
Na_2Ze

where $Ze = Al_2Si_2O_8 \cdot xH_2O$.

The zeolite may be natural or synthetic the zeolite have the property of exchanging their sodium ions easily with calcium or magnisium ions. when they come in contact with hard water

The zeolite softner consist of a steel tank packed with a thick layer of Permutited. the water enters at the top and passes through the bed of zeolite where the chemical Rx^n occurs as follows.



$Ca(HCO_3)_2 + Na_2Ze \rightarrow \overbrace{CaZe}^{\text{exestive zeolite}} + 2NaHCO_3$

$Mg(HCO_3)_2 + Na_2Ze \rightarrow MgZe + 2NaHCO_3$

$CaCl_2 + Na_2Ze \rightarrow CaZe + 2NaCl$

$MgCl_2 + Na_2Ze \rightarrow MgZe + 2NaCl$

$CaSO_4 + Na_2Ze \rightarrow CaZe + Na_2SO_4$

$MgSO_4 + Na_2Ze \rightarrow MgZe + Na_2SO_4$

The Process remove both temp. as well as Parmanent hardness when the ~~mg~~ zeolite Permutite Completely converted into caze and mgze then it get Exhausted and it ceases to soften water

The Permutite can be made active by Passing 10% solution NaCl and brine Solution

$$2NaCl + CaZe \rightarrow Na_2Ze + CaCl_2$$
$$2NaCl + MgZe \rightarrow Na_2Ze + MgCl_2$$

The soluble salt of calcium and magnesium be removed.

* Limitations of zeolite Process :-
There are certain limitations for this process

(i) The water must be free from suspended matter otherwise Permuted get clogged.

(ii) if water contains some acids, it must be neutrilised with base, because the minerals acids destroid the gealite

(iii) This method can not remove lead because it can not be converted into lead of zeolite.

(iv) Coloured ions should be removed by pre treatement because the ca and mg zeolite can not be easily converted into zeolite

* Advantages of zeolite process:

① this method can produce zero hardness
2) The equipment occupied small space and is easy to operate.
3) No slubge formation occurs during the process
4) this process can automatically adjusted itself for different types of hardness of water.
5) this method is very chelp because the regenerated permuitete can again reuse.

* Disadvantages of zeolite process:
1) After treatment water contains more Na salt.

2) this method needs all the acidic ions such as CO_3^{2-} and HCO_3^- in the softened water

3) High turbidity in water can not easily be treated by this method.

4) when such water is boil in boiler, then CO_2 is liberated. free CO_2 is weakly acidic in nature and highly corrosive to boiler material.

$Ca(OH)_2$ $\rightarrow$ Na_2CO_3

$\boxed{Na_2CO_3 \rightarrow soda}$
$Ca(OH)_2 \rightarrow lime$

(2) Lime soda method:

The Principle of the Process is to chemically convert all the soluble hardness causing impurties insoluble ppt which may be removed by setting and filteration. this is done by adding a suspension of milk of lime, $Ca(OH)_2$, together with a calculated amount of sodium carbonate Na_2CO_3 (soda);
the method is based on following facts.

a) Lime removes the temperory hardness and mg, Al and Iron Salts remove Parmanent hardness.

Temp. + Parm. of mg

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow \underline{2CaCO_3} + 2H_2O$

most Insoluble salt.

$Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow CaCO_3 + 2Mg(OH)_2 + 2H_2O$

$(MgCl_2 \text{ or } MgSO_4) + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2 \text{ or } CaSO_4$

$CaSO_4 + Na_2CO_3 \rightarrow Na_2SO_4 + 2CaCO_3$

$FeSO_4 + Ca(OH)_2 \rightarrow Fe(OH)_2 + CaSO_4$

$2Fe(OH)_2 + H_2O + [O] \rightarrow 2Fe(OH)_3$

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

(b) Lime Removes free minerals acids as well as gases like H_2S

$\underset{\text{mineral Acid.}}{2HCl} + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$

Lime ⇒ temp. Hardness + Perm. of mg, $MgCl_2$ + $MgSO_4$
Soda ⇒ Calcium ⇒ $CaSO_4$, $CaCl_2$ Permanent of mg

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

(c) Soda Removes all the calcium Permonent hardness which is soluble in water

$$CaCl_2 + Na_2CO_3 \rightarrow \underset{ppt.}{CaCO_3} + 2NaCl$$

$$CaSO_4 + Na_2CO_3 \rightarrow \underset{ppt}{CaCO_3 (\downarrow)} + Na_2SO_4$$

The lime soda washes may be broadely classified into two catogories.

(1) Cold-lime soda method
(2) hot lime soda method.

(fine ppt mix coagualant for ppt)

(1) Cold lime soda method :-
In this Process calculated Quantities of chemical are mixed with water at room temp. The ppt formed at room temp. is finely divided and does not settel down easily. These can not be easily filtered. So, it is essential to add a small quantity of Coagualant which hydrolysis to give geletenius ppt of ~~Alm~~ Al hydroxide and show it entrepes the fine ppt.

(use soda ⟹ NaOH → age Rxn

② hot lime soda method!

In this process only sodium carbonate is used for softnece. The excess of sodium carbonate is carried out into the boiler which decomposes into sodium hydroxide at high pressure and temperature.

$$\underset{\text{Soda}}{Na_2CO_3} + H_2O \longrightarrow 2NaOH + CO_2$$

Sodium hydroxide soap produced goes into the softner and reacts with known alklyn hardness of sodium and calcium carbonate.

$$Ca(HCO_3)_2 + 2NaOH \longrightarrow CaCO_3 + Na_2CO_3 + 2H_2O$$

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$$

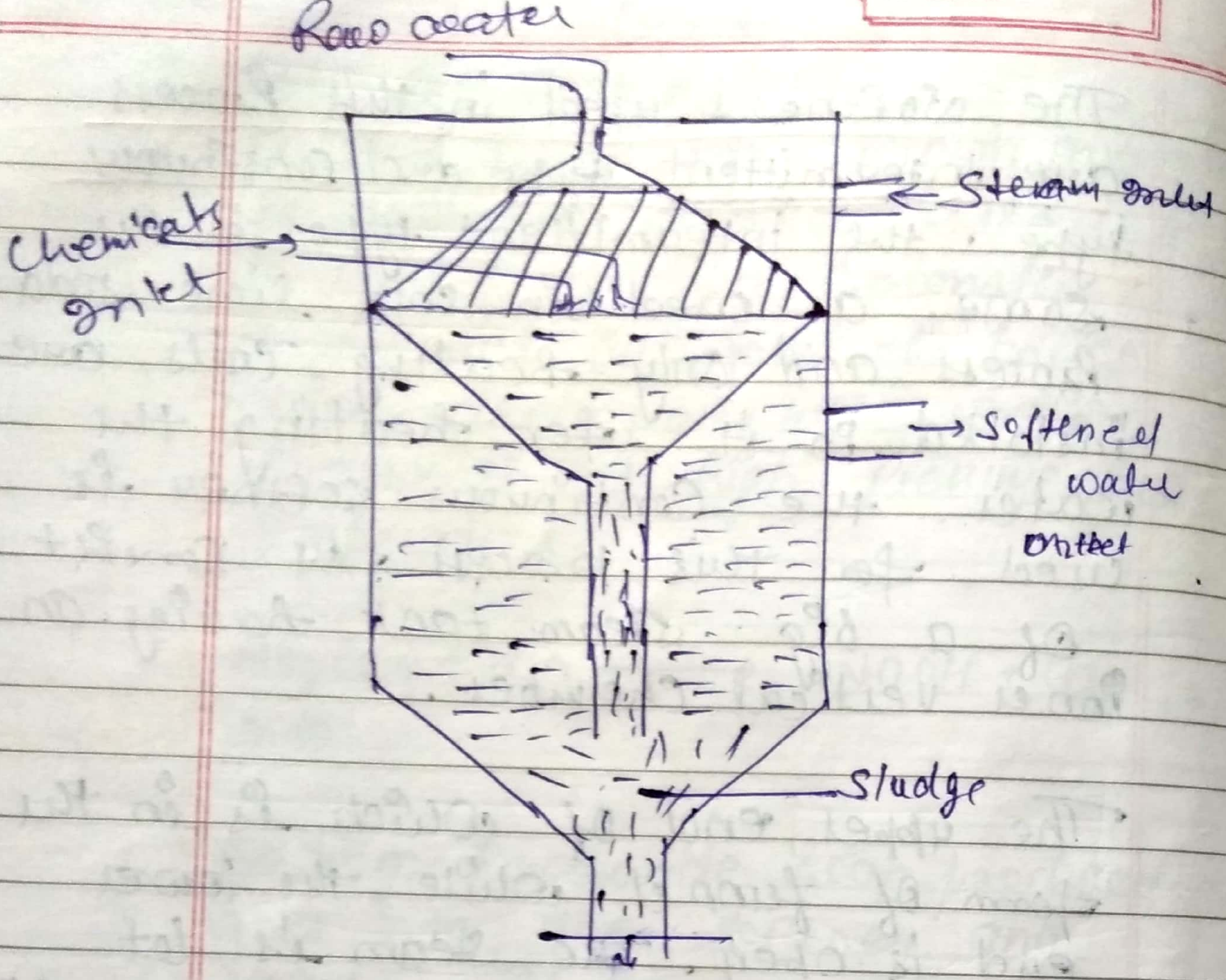
$$Mg(HCO_3)_2 + 4NaOH \rightarrow Mg(OH)_2 + 2Na_2CO_3 + 2H_2O$$

$$MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 + 2NaCl$$

Silicates can also be removed from water by this process.

The softners used in this Process are intermittent type and continuous type. the intermittent type is the same as used in cold lime soda Process and only heating coils are installed in it for heating the water. the Continuous softner is used for this process. It consist of a big steam tank having an inner vertical chamber.

The upper end of which is in the form of funnel while the lower end is open. The steam is let when the mixture goes down the Rx^n is completed and water rises up the slag settel down, in this Process the residual hardness is far less as compare to lime soda method.



* Advantages:-

hot lime soda Process have the following Advantages

1) there is saving of Coals as the preheating of water is completed through hot exhaust gases of the boiler

2) the use of lime is avoided

3) The chemical action is accelerated at high temp.

4. The quantities of chemicals for softenic purpose is reduced.

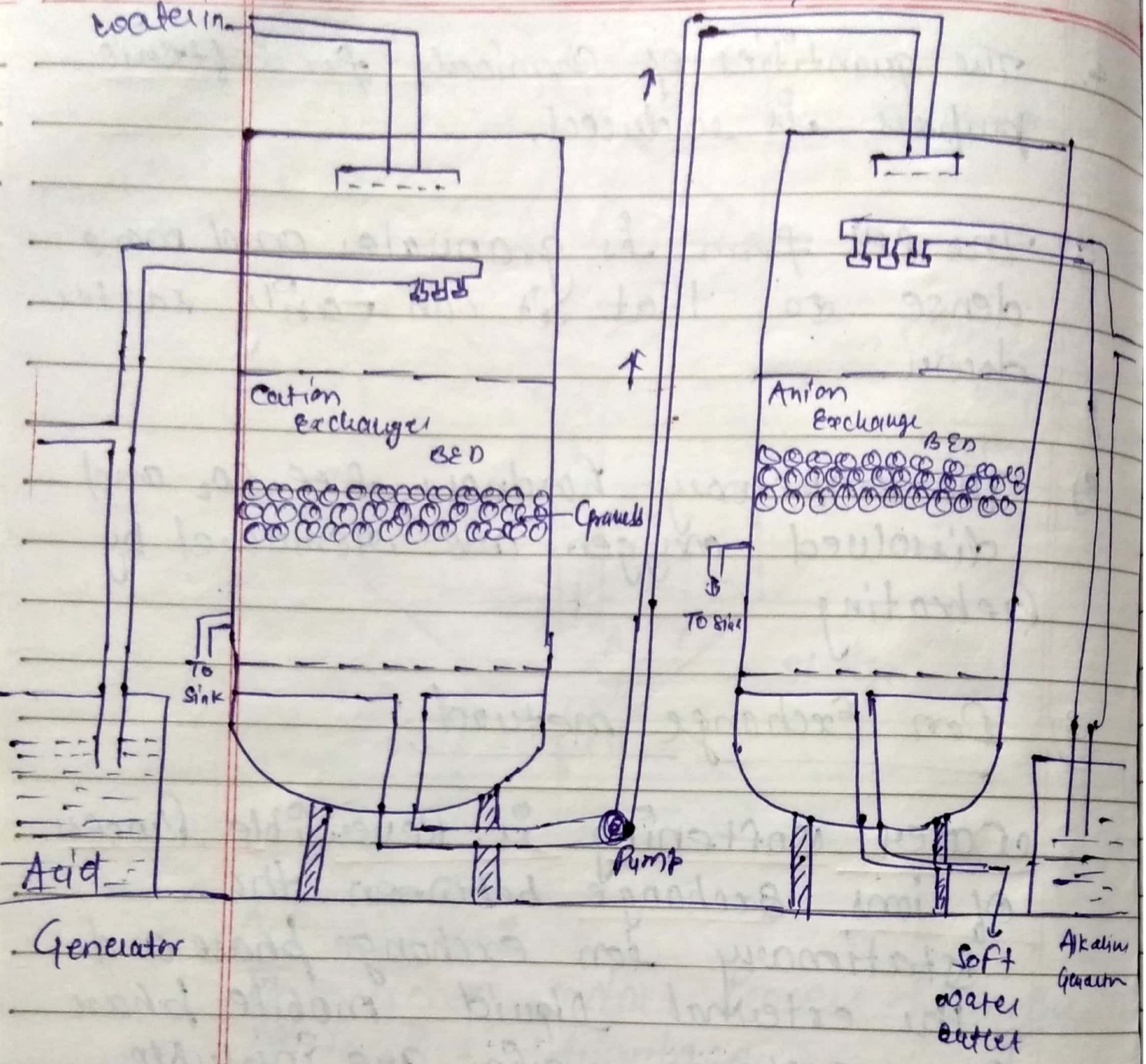
5. The ppt form is granualer and more dense. so, that it can easily setter down.

6) The temporary hardness, free CO_2 and dissolved oxygen are removed by preheating

3) Ion Exchange method:

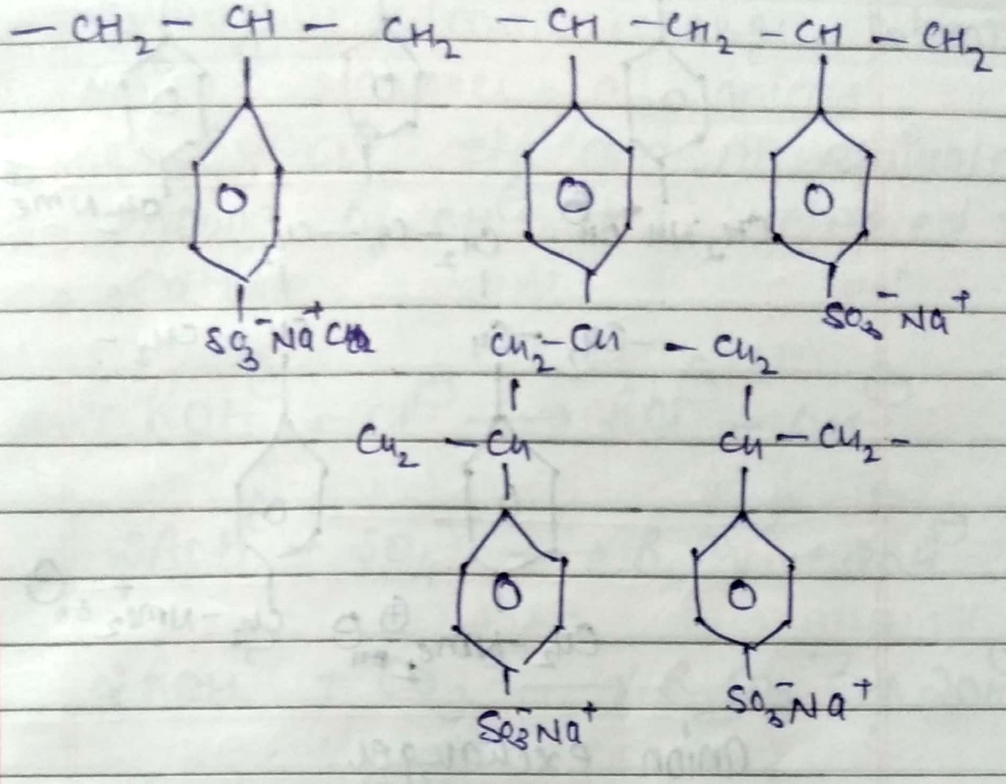
Water softening is Reversible Process of ions exchange between the stationary ion exchange phase and the external liquid mobile phase Ion exchange resin are insoluble Crossely long chain Organic Polymers, these have microporous structure. ~~the~~ function group atteched to them are ~~respec~~ responsible for ion exchange properties these are classified into two catogries.

i) Cation exchanger resin
ii) Anion exchanger resin.



* Cation Exchange resin:

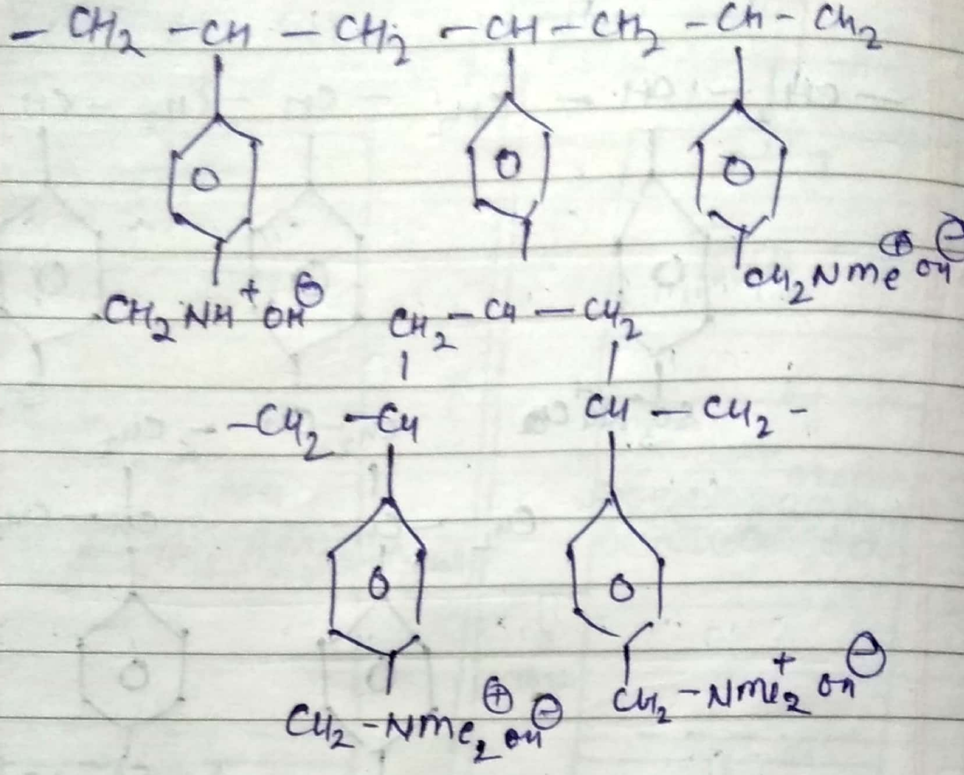
These are Polymer having sulphate group attached to them and equal no. of replacable Na^+ ions near them



Cation exchange resins.

- Anion Exchange resin:

Anion Exchange resins are Polymer which ~~contain an~~ Contain amine or quaternary ammonia group as integral Part of the resins and an equivalent amount of anions, such as $OH^{\ominus}$ ions as counter ion.



anion exchanger

* Process of softning by exchange Resin:

The hardwater is first passed through cation exchanger Column which removes all the cation like ca^{+2}, mg^{+2} from it and an equivalent amount of H$^{\oplus}$ ions are released from this Column to water

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

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

Remove

After that water is passed through anion exchange column which removes all anions SO_4^{-2}, $Cl^{\ominus}$ etc and an equivalent amount of $OH^{\ominus}$ ions released to water

$$ROH^{\ominus} + Cl^{\ominus} \longrightarrow RCl^{\ominus} + OH^{\ominus}$$

$$2ROH^{\ominus} + SO_4^{2-} \longrightarrow R_2SO_4^{-2} + 2OH^{\ominus}$$

$$2ROH^{\ominus} + CO_3^{-2} \longrightarrow R_2CO_3^{-2} + 2OH^{\ominus}$$

$H^{\oplus}$ and $OH^{\ominus}$ ions are Released from Cation and anion exchange column get Combine to Produce water molecules.

$$H^{+} + OH^{\ominus} \longrightarrow H_2O$$

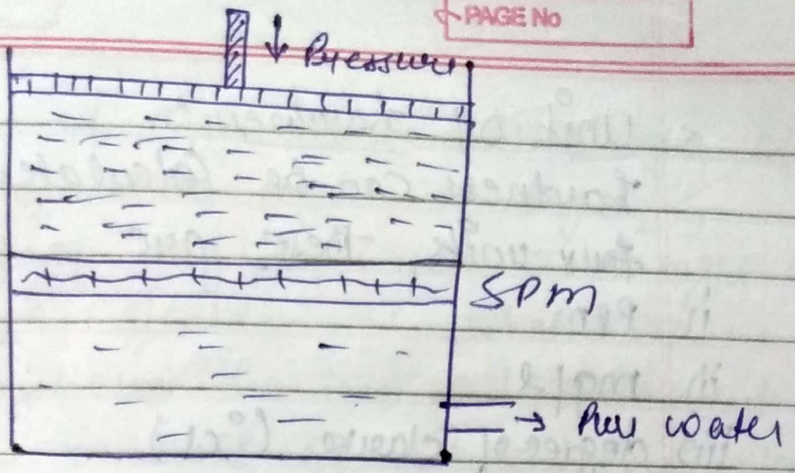
The Water Coming Out from the exchanger is free from Cation as well as anion and such water is known as demineralised or deionised water.

DATE : / 20
PAGE No

- Reverse osmosis (RO) :- Hyper filteration or Super filteration

When two solution of different Conc^n. are seperated by a semi permeable membrane SPM (which selectevely does not permits the passage of dissolved solute particles) flow of solvent takes place from dilute to concentration sides due to Osmosis. If however a hydrostatic pressure in excess of osmotic pressure is applied on the concentration side the solvent flow reverse i.e solvent is force to move from Conc^n side to dilute side across the membrane. this is the principle of reverse osmosis.

Therefore. In reverse osmosis method, pure solvent, water is seperated from it contaminants rather than removing contamenants from the water. This membrane filteration sometimes also called super filteration or hyper filteration.



Imp

* **Degree of hardness:**

hardness of water is generally expressed in terms of equivalent amount of $CaCO_3$ (equivalents of $CaCO_3$). The region for choosing $CaCO_3$ as the standard for reporting the hardness of water is the ease in calculation as it m.wt is 100. ~~Moreover~~ forever, it is the most insoluble salt that can be ppt in water treatment.

equivalents of ~~$Ca(HCO_3)_2$~~ $CaCO_3$ ($CaCO_3$ eq^{y}) =

$$= \frac{\text{strength of the hardness producing substance} \times 50 \text{ (eq. wt of } CaCO_3)}{\text{Eq. wt of hardness producing substance}}$$

$$\text{Eq. } CaCO_3 = \text{strength of the hardness producing substance} \times \text{multiplication factor}$$

$$\text{multiplication factor} = \frac{\text{m.wt of } CaCO_3}{\text{m.wt of hardness producing substance}}$$

units of hardness:

hardness can be calculated in terms of four units, these are

i) PPm
ii) mg/l
iii) degree of clarke (°cl)
(iv) degree of french (°fr)

Inter relation b/w various units of hardness

1 PPm = 0.07 Degree of Clarke
= 0.1 Degree of french
= 1 m.g/l

Que! Note:

The m.wt of some compounds are given below

$CaCO_3$ ⇒ 100.
$CaSO_4$ = 136
$MgCl_2$ = 95
$MgSO_4$ = 120
$Mg(HCO_3)_2$ = 146
$Mg(NO_3)_2$ = 148
$Ca(HCO_3)_2$ = 162
$CaCl_2$ = 111
e $(HCO_3)^1$ = 122

D.O.N
2

Que A sample of water contain 16.8 mg/l of $Mg(HCO_3)_2$, 19.0 mg/l of $MgCl_2$, 24.0 mg/l of $MgSO_4$, and 22.2 mg/l of $CaCl_2$. Calculate the total hardness of water, tempeory hardness and Parmanent hardness in terms of $CaCO_3$ equivalent.

Hardness

Substance	Mass of the Substance (mg/l)	multiplication factor	~~H Ca~~ $CaCO_3$ equ.
$Mg(HCO_3)_2$	16.8 mg/l	$\frac{100}{146}$	$\frac{16.8 \times 100}{146} = 11.51$
$MgCl_2$	19.0	$\frac{100}{95}$	$\frac{19.0 \times 100}{95} = 20$
$MgSO_4$	24.0	$\frac{100}{120}$	$\frac{24.0 \times 100}{120} = 20$
$CaCl_2$	22.2	$\frac{100}{111}$	$\frac{22.2 \times 100}{111} = 20$

tempeory hardness = $\frac{16.8 \times 100}{146} = 11.51$

Parmanent hardness = 60

Total hardness = 71.51 mg/l.

Q. Calculate the Alklyine, non-~~Al~~klyne and total hardness of water containing the following salts- in mg/l

$Ca(HCO_3)_2$ = 16.2
$MgSO_4$ = 15.0
$Mg(HCO_3)_2$ = 17.3
$CaSO_4$ = 6.8
$MgCl_2$ = 19.0 and
$NaCl$ = 12.0 × neglect

~~$Ca(HCO_3)$~~

Substance	Mass of the Substance	m.f	$CaCO_3$ eq.
$Ca(HCO_3)_2$	16.2	[illegible] × $\frac{100}{162}$	$16.2 \times \frac{100}{162} = 10$
$MgSO_4$	15.0	[illegible] × $\frac{100}{120}$	$15 \times \frac{100}{120} = 12.5$
$Mg(HCO_3)_2$	17.3	[illegible] × $\frac{100}{146}$	$17.3 \times \frac{100}{146} = 11.8$
$CaSO_4$	6.8	[illegible] × $\frac{100}{136}$	$6.8 \times \frac{100}{136} = 5.0$
$MgCl_2$	19.0	[illegible] × $\frac{100}{95}$	$19.0 \times \frac{100}{95} = 20.0$
NaCl	NaCl does not ~~[illegible]~~ cause of any hardness		

Alkyl hardness:
due to carbonate, bycarbonate and hydroxides

Total hardness = ~~2028~~ 59.3

Alklyne hardness = (~~add~~ due to carbonate, bicarbonate and hydroxide).

= 21.8

Non Alklyne = 37.5

Que Calculate the temp. and permanent hardness by using following analysis of water.

Substance	Mass of sub.	M.F	$CaCO_3$ eq^n.
$Ca(HCO_3)_2$	55 PPm	$\frac{100}{162}$	$\frac{55 \times 100}{162} =$
$MgCl_2$	20 PPm	$\frac{100}{95}$	$\frac{20 \times 100}{95} =$
$CaSO_4$	32 PPm	$\frac{100}{136}$	$\frac{32 \times 100}{136} =$
$Mg(NO_3)_2$	10 PPm	$\frac{100}{148}$	$\frac{10 \times 100}{148} =$
$Mg(HCO_3)_2$	25 PPm	$\frac{100}{146}$	$\frac{25 \times 100}{146} =$

temp. hardness = 51.07

Permanent hardness = 51.335

Total = 102.405

% factor => Lime 100% or [illegible]
= Purity factor

DATE : / 20
PAGE No

* Calculation of amount of soda and Lime Required

Calcula

(i) Total Lime Req. = $\frac{74}{100}$ [2x temp. of mg + Temp. of Ca + Perm. of mg + Salt of Fe & Al + + CO_2 + HCl + H_2SO_4 + HCO_3^- − NaAl

All in terms of $CaCO_3$ eq.] × volume of water × % factor

% factor is given = 74%
= $\frac{100}{74}$

(ii) Total Soda Req. = $\frac{106}{100}$ [Perm. of mg + Perm. of Ca + Perm of Salt of Fe + Salt of Al + HCl + H_2SO_4 − − HCO_3^{1-} All in terms of $CaCO_3$ eq.]

× volume of water × % factor.

Imp

Que. Calculate the amount of Lime (95% Pure) and soda (98% Pure) required for the treatement of 50,000 liter of water whose analysis as follows

(i) $Ca(HCO_3)_2$ = 45.5 Ppm,
$Mg(HCO_3)_2$ = 38.0 Ppm,
$MgSO_4$ = 25.0 Ppm,
$CaSO_4$ = 32.0 Ppm,
$CaCl_2$ = 28.0 Ppm,
× NaCl = 10.0 Ppm,

Parmanent ⇒ mg. both

Lime ⇒ temp + Parm (mg)

Soda ⇒ Ca, Par. mg

$\frac{32}{\times 4}$ c 12

DATE : / 20

PAGE No

$MgCl_2$ = 95.0 ppm

substance	mass of the substance	M.F	$CaCO_3$ eq^n.
$Ca(HCO_3)_2$	48.5 L)	$\frac{100}{162}$	$\frac{48.5 \times 100}{162} = 28.08$ L
$Mg(HCO_3)_2$	38.0	$\frac{100}{146}$	$\frac{38.0 \times 100}{146} = 26.63$ 2L
$MgSO_4$	25.0	$\frac{100}{120}$	$\frac{25.0 \times 100}{120} = 20.83$ L+S
$CaSO_4$	32.0	$\frac{100}{136}$	$\frac{32.0 \times 100}{136} = 23.53$ S.
$CaCl_2$	28.0	$\frac{100}{111}$	$\frac{28.0 \times 100}{111} = 25.23$ S
$MgCl_2$	95.0	$= \frac{100}{95}$	$\frac{95.0 \times 100}{95} = 100$ L+S.
NaCl	does not cause of any hardness		

~~Req. of~~

$$\text{Requirement of Lime} = \frac{74}{100}\left[28.08 + (2 \times 26.63) + 20.83 + +100\right]$$

$$\times \frac{100}{95} \times 50{,}000 = 7827.2 \text{ gm}$$

7.8 Kg

$$\text{Req. of Soda} = \frac{106}{100}\left[20.83 + 28.53 + 25.23 + 100\right]$$

$$\times \frac{100}{98} \times 50000$$

$$= 9171.70 \text{ gm} = 9.17 \text{ Kg}.$$

01/4/17

Que How many gm of $MgCO_3$ dissolved per liter gives 70ppm hardness

~~70~~ =

hardness = $x \times \frac{100}{}$

$70 = x \times \frac{100}{}$

$CaCO_3$ eq^u = strength of the hardness producing substance × multiplication factor

$70 = x \times \frac{100}{84} = \frac{560}{10} = x$

$= 56$

$x = \frac{5880}{10} = 58.8$ mg

Q. A water sample contains 4.08 gm of $CaSO_4$ per 1000ml. Calculate the hardness in terms of $CaCO_3$ eq^u.

$CaCO_3$ eq^u $= 4.08 \times \frac{100}{136}$

$= \frac{408}{136} = 3$ gm/l

$$\begin{array}{r} 136 \\ \times 3 \\ \hline 408 \end{array}$$

Que Calculate Amount of lime and soda require for the treatement of 20,000 litres of water whose analysis is as follows

			M.f	
L	$Ca(HCO_3)_2$ =	40.5 ppm	$\frac{100}{162}$	$\frac{40.5 \times 100}{162} = 25$
2L	$Mg(HCO_3)_2$ =	36.5 ppm	$\frac{100}{146}$	$\frac{36.5 \times 100}{146} = 25$
S	$CaSO_4$ =	34.4 ppm	$= \frac{100}{136}$	$\frac{34.4 \times 100}{136} = 25$
L+S	$MgSO_4$ =	30 ppm	$\frac{100}{120}$	$\frac{30 \times 100}{120} = 25$
S	$CaCl_2$ =	27.75 ppm	$= \frac{100}{111}$	$\frac{27.75 \times 100}{111} = 25$

Lime Req $= \frac{74}{100}\left[2 \times 25 + 25 + 25\right] \times 20{,}000 =$ ~~7144~~ 2881000 1.48 kg

Soda Req $= \frac{106}{100} \times \left[25 + 25 + 25\right] \times 20{,}000 = \frac{\overset{2}{106}}{\underset{4}{\cancel{100}}} \times \overset{3}{\cancel{75}}$

$= 1.59$ kg

eqᵗ wt of $CaCO_3 = 50$

Q The hardness of 1,000 L of water sample was completely removed by passing it through a zeolite condensor. The soffner then Required 30L of NaCl solⁿ Containing 1.5g/l of NaCl for Regeneration. Calculate the hardness of water sample of water.

Solⁿ: NaCl Contained in 30 li of NaCl solution
$= 1.5 g/l \times 30$
$= 45$ gm

11
17
28

$$\text{gm.eq}^{t} = \frac{45 \times 50}{58.5} = \frac{2250}{58.5} = 38.46 \text{ gm eq}^{t}\ CaCO_3$$

1000 L of water $= 38.46$ gm eqᵗ of $CaCO_3$

1 L of ~~1000~~ Water $= \frac{38.46}{1000} \times 1000 = 38.46$ mg/l

23.3
3.2
9

effect, prevention

* Corrosion :

Certain metals are slowely eaten up on long exposer to atmosphere, Such metals reacts with the gases or moisture present in envirnment to form compounds. Generally oxides are formed and depending upon the presence of Carbonates, sulphide, sulphates etc may also be formed and this particular process is refered to as corrosion.

Corrosion can be defined as the degradation of deterioration of the metal by chemical or electrochemical $R x^n$ with its environment.

OR

Corrosion is a process of slow conversion of metals into their undesirable compounds by $R x^n$ with moisture and other gases present in the environment.

Some examples of corrosions are as follows

1. Rusting of iron
when exposed to the atm. condition a layer of raddish scale and powder of Fe_3O_4 is formed on the surface

2. formation of green film on the surface of copper
A green layer of basic carbonate consisting of $CuCO_3 + Cu(OH)_2$ is formed on the surface of copper when exposed to moist air.

3. Tarnishing of silver:
When silver is exposed to the atmosphere, a black coating is formed.

* Types of corrosion:
Corrosion is classified as-
i) dry corrosion or direct chemical corr.
ii) wet corrosion or immersed corrosion or electrochemical corrosion

(1) Dry corrosion or direct chemical corrosion:
Dry corrosion occurs may be through the direct chemical attack of gases such as oxygen, hydrogen, H_2S, SO_2, N_2 or certain anhydrous (not water) in organic liquid with metal surface in intermediate contact. Three types of chemical corrosions.
a) Oxidation corrosion
b) Corrosion by other gases
c) Liquid metal corrosion

always in Pure
↑ (loss of $e^{\ominus}$).

g) oxidation Corrosion :

This types of corrosion brought by the direct attack of oxygen on metal surface at low or high temp, usually in the absence of mosture. alkali metals (li, Na, K, Rb, etc) and alkline earth metal (P, mg, ca, Sr etc), are highly prone for oxidation even at low temperature, while at high temperature, almost all metals except noble metals (Ag, Au, Pt) are oxidisied

The Chemical Rx

$$\underset{\text{metal}}{2M} \longrightarrow \underset{\text{metal ion}}{2M^{n+}} + \cancel{2n}e^{\ominus}$$

(oxidation)

$$\underset{\text{oxygen}}{nO_2} + \cancel{2ne^{\ominus}} \longrightarrow \underset{\text{Oxide ion}}{2nO^{2-}}$$

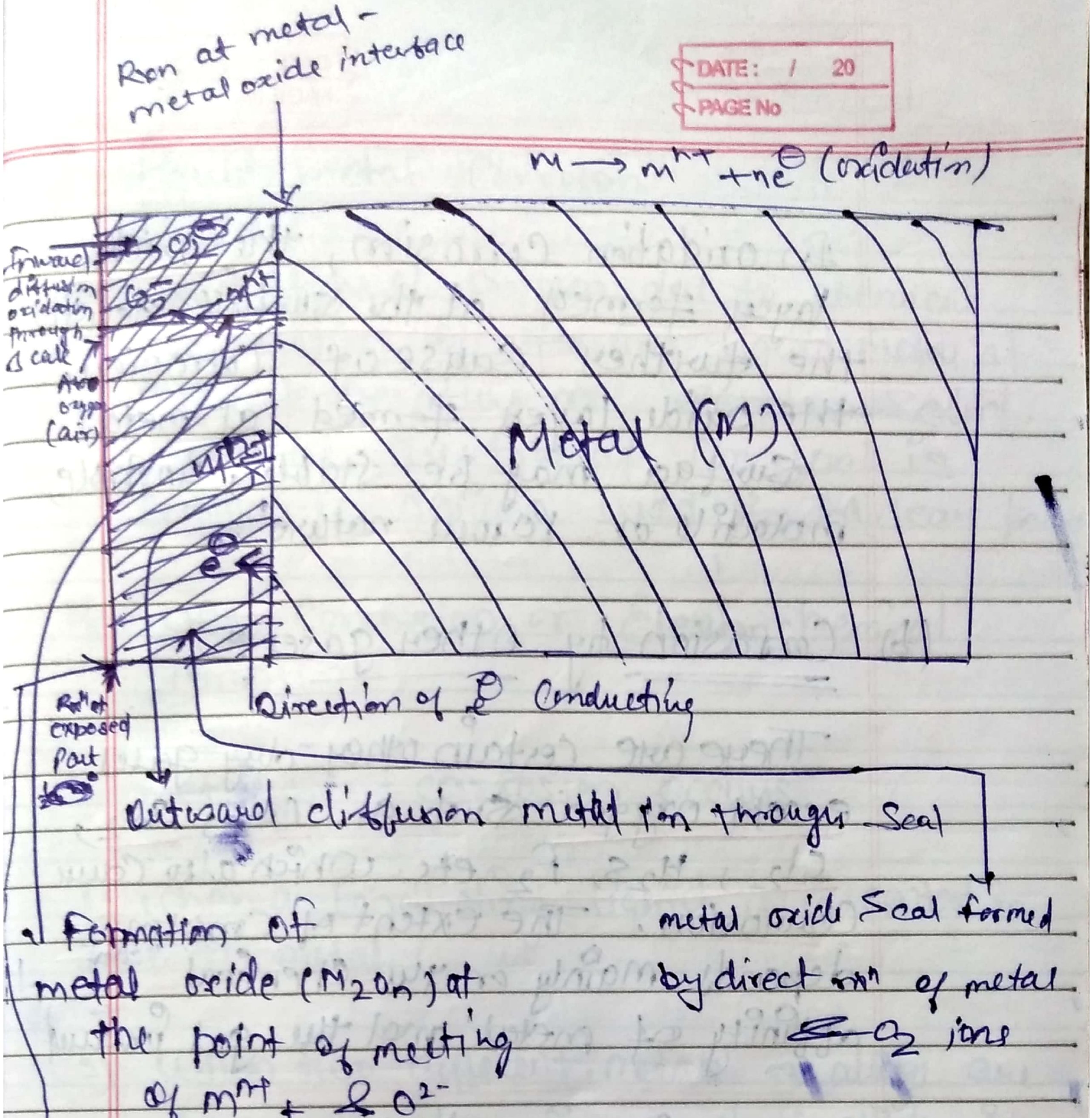
$$\underset{\text{metal}}{2M} + \underset{\text{oxygen}}{nO_2} \longrightarrow \underset{\text{metal ion}}{2M^{n+}} + \underset{\text{oxide ion}}{2nO^{2-}}$$

Mech^{n}:-

First oxidation occurs at the surface of the metal and the formed metal oxide scale forms a barrier which restrict further oxidation of metal surface. All the gas molecules are adsorbe rapidely by the surface of the metal as atoms, ions or molecules. this is followed by diffusion by gas in metal.

For oxidation to continue, eithe the metal must diffuse outwards to the scale to the surface or the oxygen must diffuse inwards through the scale underline metal.

The outward diffusion of metal is generally much more rapid then the inward refusion of oxygen. Since the metal ion is small in size than the oxygen ion.



Rxn at exposed part

$$\frac{1}{2}O_2 + 2e^{\ominus} \xrightarrow[\text{Reduction}]{} O^{2-}$$

In oxidation corrosion, the oxide layer formed at the surface decides the further cause of corrosion. the oxide layer formed at metal surface may be stable, unstable, molatile or porous nature

(b) Corrosion by other gases :

There are certain other dry gases except oxygen such as CO_2, SO_2, Cl_2, H_2S, F_2 etc. which also cause corrosion. The extent of corrosion depends mainly on the chemical affinity of metal and the gas involved

If the film formed is proctective or non porous, the extent of attack decreases because the film formed protects the metal from further attack

If film formed is not protective or porous, the surface of the hole metal is gradualy destroy

9) **Liquid metal Corrosion:**

Such type of Corrosion due to chemical action of flowing Liquid metal at high temperature ~~on~~ ~~Salt in~~ Solid metal. This type of Corroson is common in devices used for nuclear power

* **Wet Corrosion or Electrochemical Corrosion:**

Wet type of corrosion occurs.

1) when a Conducting Liquid is in contact in with metal

2) When two different metals or alloys are either dipped or immersed partially in a solution

In this type of Corrosion Impure metal surface behaves like a small electrochemical cell and called as Corrosion cell. ~~on~~ these miniature cells, Pure metal act as anode and impure surface act as cathode at anode oxidation of metal takes place. metal atom pass into solution as metal ions, leaving behind electrons in the metal which are pushed into cathodic area.

Reduct

~~$M^{n+} + ne^{\ominus}$~~

$$M \longrightarrow M^{n+} + ne^{\ominus}$$

metal

metal ion

$\ominus$

↓ dissolved in soln

↓ forms oxide

at cathode, reduction Rxn takes place. usually, at cathode, dissolved constituents in the conducting medium ~~accept to~~ ele accept $e^{\ominus}$ to from O^{2-} ions.

The metallic ion at anode and some other ions formed at cathode diffused towards each other. Through conducting medium and formed a corrosion b/w anode and cathode.

Dnyl: Dnyl

* Electrochemical theory of corrosion.

according to this theory the chemical unwen s of metals behave like small electric cells in presence of water containing dissolved O_2 and CO_2. therefore, corrosion takes place as a result of Local action, the main features are

a) the Covered part of the metal surface act as the anode where iron changes to Fe^{2+} ions by giving electrons.

$$Fe \longrightarrow Fe^{2+} + 2e^{\ominus}$$

b) A less electropositive metal like copper which is present as impurity takes away the electrons and develops the cathode where $OH^{\ominus}$ ions are formed.

$$Cu^{2+}_{(aq)} + 2e^{\ominus} \longrightarrow Cu_{(s)}$$

$$2H_2O + 2e^{\ominus} \longrightarrow H_2 + 2OH^{-}$$

The evolved hydrogen make a accumulated at the cathode and cause Polarisation, but it is depolarised by atmospheric O_2.

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$

c) Due to the presence of two oppositely charged ions at the surface of metal, a galvanic flow of ions may take plac and them these two ions combine to form a compound.

$$Fe^{2+} + 2OH^{\ominus} \longrightarrow Fe(OH)_2$$

finally, $Fe(OH)_2$ is converted to basic carbonate by the atmospheric CO_2 and O_2

$$4Fe(OH)_2 + 2H_2O + O_2 \longrightarrow 4Fe(OH)_3$$

$$Fe(OH)_2 + CO_2 \longrightarrow Fe(OH).HCO_3)$$

$$Fe(OH)_3 + CO_2 \longrightarrow Fe(OH)_2(HCO_3)$$

Any corrosion process can be termed as an electrochemical process in which cathode and anode are formed on the metal surface and an electrolyte (water or salt) must be permits to ionic flow to form corrosion products.

* factors which affect the Corrosion:

1) Position of metal in electrochemical series:
the reactivity of metal depends upon the Position in the electrochemical series. more the reactive, the more will be the Possibility of geting corrose.

2) Presence of impurities in metal!
The impurities Help in Boltic cell, which increase speed of corrosion

3) Presence of electrolyte:
Presence of water, increasing the rusting of iron.

4) Presence of CO_2 in water:
increase the dissosiation of H_2O readily.

5) Presence of Procting coating:
When the Iron surface is coated with layer a more active than iron then the rate of corrosion decrease.

Dmk

* Prevention of Corrosion:

the corrosion can be prevented by method given below

1) Barrier Protection

In this method a barrier is placed b/w metal and environment. the Barrier Protection can be achieved by the following methods

a) the surface is coated with Paint
b) " " " Protected by applying a thin layer of oil or grease
c) The metal is electro with metal like tin, Zn, Ni etc

2) Sacrificial Protection:

In this method the metal is protected by corrosion by covering it with a layer of other metal which is more reactive the parent metal.

This prevent Loss of electrons from the parent metal. The active metal losses electrons in preference to parent metal and goes into ionic state.

Therefore the covering metal consume with time as long as it is present on the surface of parent metal, the parent metal is protective and this is known as Sacrificial Protection.
For Ex. Zn is commonly used for covering iron surfaces. thus the process of covering iron with Zn is called Galvanisation

2] Electrical Protection:

This method is used for protecting iron articals which are in contact with ~~Sa~~ water such as underground pipe. the artical of irons are connected more active metals like Mg or Zn.
The active metal has lower reduction potential than iron and will loss electrons in presence of iron.
For Ex- Mg has lower reduction potential then iron. then Mg will be oxidised in ~~Reference~~ presence to iron and it will protect iron being rusted

4.) Using antirust Solution:

To retard the Corrosion of metal, certain antirust solution are used. For ex- alklyne solution of phosphate and chromates are used as antirust Solution

Que: A sample of water on analysis was found to contain following in mg/L

$CaSO_4$	= 0.4,	32.0
$MgCO_3$	= 0.44	80.
$CaCO_3$	= 2.00	100
$MgSO_4$	= 0.80	120
$MgCl_2$	= 0.78	84
SiO_2	= 2.40	
NaCl	= 2.50	

Calculate the amount of Lime Required to Softine the 20,000 Litre of water Per day of a Year, if Purity of Lime and soda is 90%.

$CaSO_4$	0.4	100/32	0.29	S
$MgCO_3$	0.44	100/80	0.52	2L
$CaCO_3$	2.00	100/100	2	L
$MgSO_4$	0.80	100/120	0.66	L+S
$MgCl_2$	0.78	100/95	0.82	
SiO_2	2.40			
NaCl	2.50			

Lime Req. $= \frac{74}{100}\left(2 \times 0.52 + 2 + 0.66 + 0.82\right) \times \frac{100}{90} \times 20000$

$= \frac{74}{100}\left[1.04 + 2 + 0.66 + 0.82\right] \times \frac{100}{90} \times 20000$

$= 74222.2\ mg = 74.22\ g = 0.0742\ kg/day$

Req. of Soda $= \frac{106}{100}\left[0.29 + 0.66 + 0.82\right] \times \frac{100}{90} \times 20000$

$= \frac{106}{100}\left[1.77\right] \times \frac{100}{90} \times 20000 = 4169\ mg$

$= 41.69\ g = 0.0415\ kg/day$

Lime Req. for 1 Yr ⇒ 0.072 × 365 = 27.08 kg

Soda Req. for 1 Yr = 0.0415 × 365 = 15.14 kg