

24 Jan, 2023

Date \_\_\_\_\_  
Page No. \_\_\_\_\_  
Tuesday

## CHAPTER:

# WATER & ITS TREATMENT:

- Introduction
- Hardness of water
- Estimation of hardness
- Removal of Hardness
- Treatment of water.

## → HARDNESS:

Water which does not allow water to make foam, that water is known as hard water.

Hardness of water is due to presence of soluble salts of Ca and Mg

→ Temporary hardness

- Calcium Bicarbonates
- Calcium chlorides
- Calcium Sulphates  
(Permanent hardness)

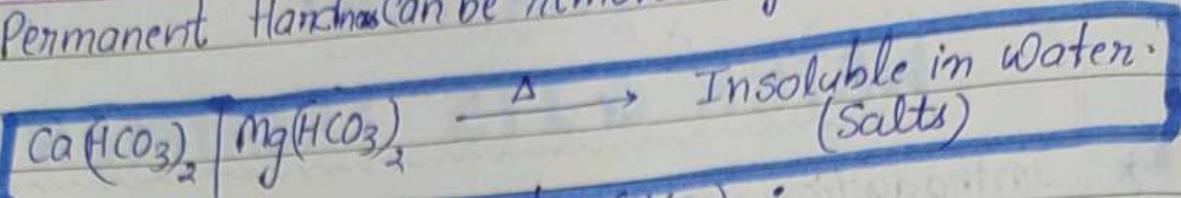
- Magnesium Bicarbonates
- Magnesium chlorides
- Magnesium Sulphates

→ Temporary Hard. : Temporary Hardness is due to  $\text{Ca}(\text{HCO}_3)_2$ ,  $\text{Mg}(\text{HCO}_3)_2$ .

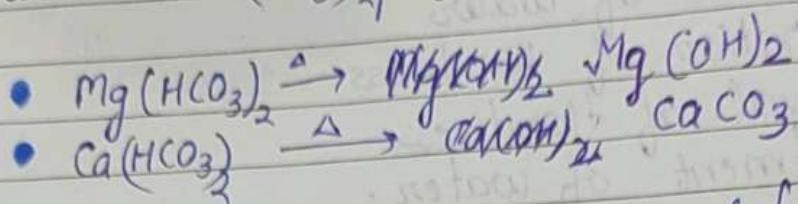
→ Permanent Hard. Permanent Hardness is due to  $\text{CaCl}_2$ ,  $\text{MgCl}_2$ ,  $\text{CaSO}_4$  &  $\text{MgSO}_4$ .

→ Temporary Hardness can be removed by heating

Permanent Hardness can be removed by chemical methods



when we heat  $\text{Ca}(\text{HCO}_3)_2 \mid \text{Mg}(\text{HCO}_3)_2$ ;



Then we will filter that, then Insoluble particles will be Removed easily.

⇒ **TOTAL HARDNESS**: Temporary Hardness + Permanent Hardness

## ⇒ ESTIMATION OF HARDNESS:

• EDTA Method

or

• complexometric Method

units: mg/L

ppm

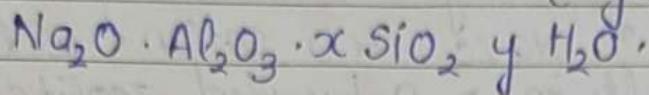
$1\text{mg/L} = \text{ppm}$

## ⇒ SOFTENING OF WATER:

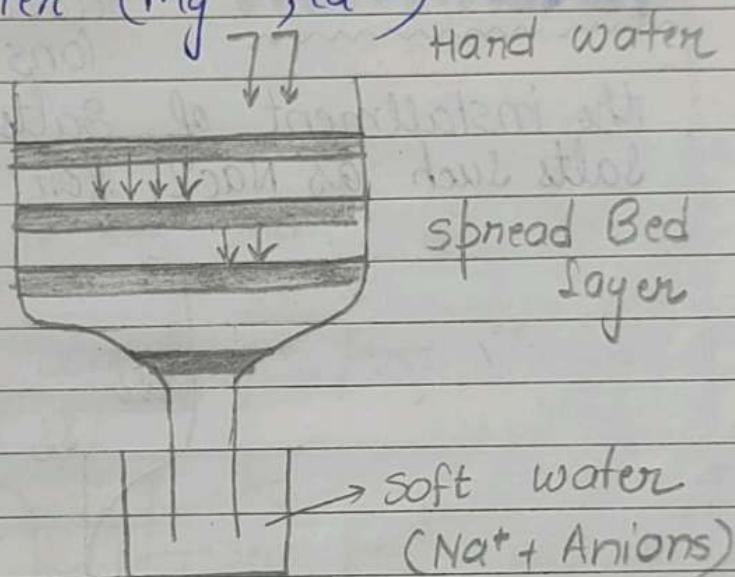
The process which involves the removal of hardness of water - Softening of water,

- \* Lime Soda Method
- \* Ion-Exchange method
- \* Zeolite Method

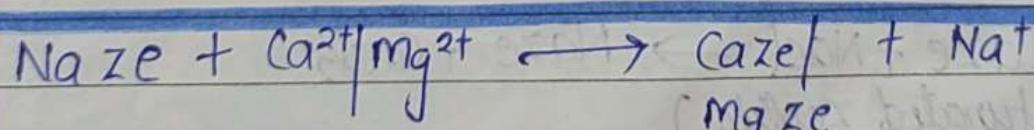
⇒ **ZEOLITE METHOD:** sodium almino silicate  
(hydrated)



- Inorganic in Nature
- Sodium Zeolite (Na ze)
- Na ze is capable of exchanging its cations with water ( $\text{Na}^+$ ) cations
- It will give positive Ion ( $\text{Na}^+$ ) & take positive ion from water ( $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ )



Hard water (cations) :  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$



Calcium & (zeolite) (water)  
Magnesium

Anions at the outlets -  $\text{Na}^+$        $\text{SO}_4^{2-}$   
      $\text{HCO}_3^-$        $\text{Cl}^-$

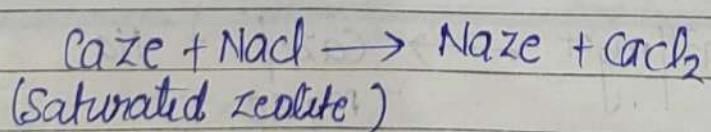
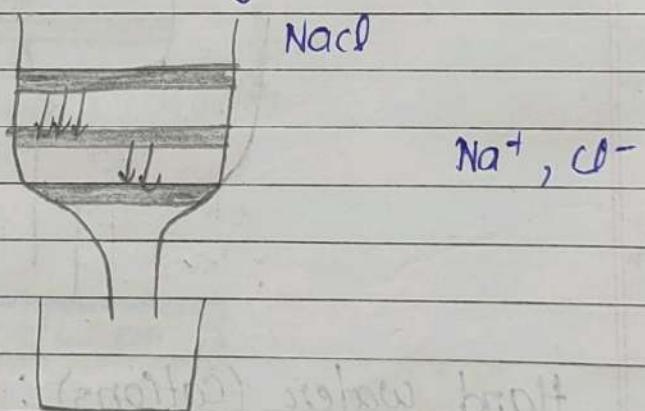
At the end, we get impure water, but it will be soft.

If we use zeolite layer continuously then a pt. will come when in Nazc no cation will be there. This pt results in  $\rightarrow$  saturated zeolite.

## → INSTALLATION OF NEW LAYERS:

firstly, we can install new layers in the spread bed. But this will be very expensive method.

→ GENERATION : Secondly, we can generate  $\text{Na}^+$  ions. We will use this with the installment of salts. We will use cheap salts such as  $\text{NaCl}$ , for regeneration.



Now, we will again use this for the softening of water.

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## DESALINATION OF WATER:

Saline water → Sea water → NaCl

(But this is not useful)

How can we remove NaCl from sea water <sup>make</sup> useful.

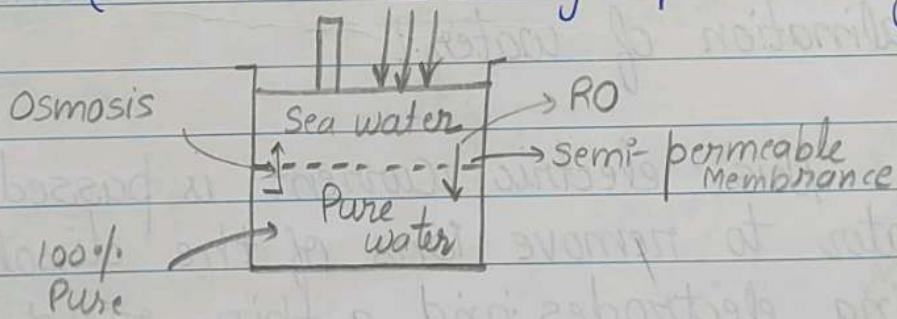
The process by which we remove NaCl from sea water to make it useful is known as salination of water.

Water → Boiler  $\xrightarrow{\text{Industry}}$  Steam  $\xrightarrow{\text{run}}$  turbine  
↳ Industrial use.

## ⇒ REVERSE OSMOSIS:

Osmosis: Movement of water from its high concentration to low concentration through semi-permeable membrane.

↳ (which allow something to pass through it)



But when water moves from its low concentration to high concentration through Semi-permeable Membrane then it is known as RO (Reverse osmosis)

When Reverse osmosis take place then salt lefts behind and water moves through semi-permeable membrane.

To get Reverse osmosis, we will apply pressure then the firstly osmosis will take place. When we apply even more pressure then also the same process will be carried out then a pt will come when the osmosis stops, at this pt the pressure is known as osmotic pressure

If we apply further more pressure than the OP then the process of reverse osmosis takes place.

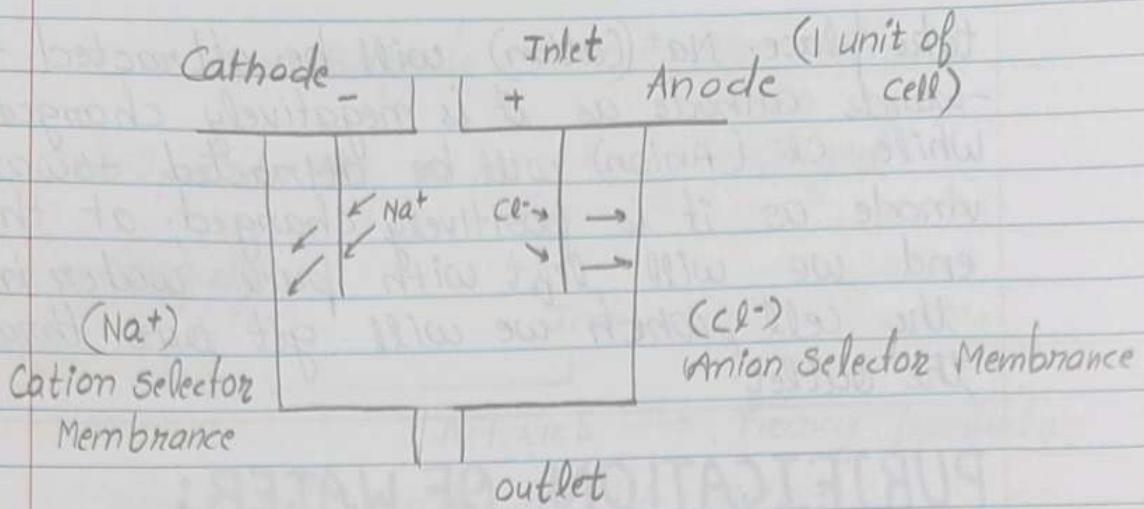
$$P > OP$$

→ Reverse Osmosis

⇒ **ELECTRO DIALYSIS:** Electro dialysis is another method for desalination of water.

In this electric current is passed through water to remove ions of the dissolved salts using electrodes and a thin rigid membrane pair.

following is the working for desalination of water.



Inlet → Salty water

Outlet → Pure water

When water passed through this cell, current will pass through it and Ionization take place.

It left behind water inside the cell &  $\text{Na}^+$ ,  $\text{Cl}^-$  will be removed. There might be another option such as crystallization of water followed by filtration, distillation also for desalination of water.

Brackish water → Salty water.

On the Left side = Cation-selective Membrane  
 $(\text{Na}^+)$

on the Right side = Anion Selective Membrane  
 $(\text{Cl}^-)$

When we will put water through inlet then when current flows through it then ionization

take place.  $\text{Na}^+$  (cation) will be attracted towards cathode as it is negatively charged while  $\text{Cl}^-$  (Anion) will be attracted towards anode as it is positively charged; at the end we will be left with pure water in the cell, which we will get out through the outlet.

## PURIFICATION OF WATER:

Water which can be used for domestic purpose  
Impure  $\rightarrow$  Solid particles  
water              Bacteria/Micro-organisms.

Purification of water can be done in two steps which includes: filtration and disinfection, which are explained below:

Impure water  $\rightarrow$  filtration + Disinfection  $\rightarrow$  Pure water

1. FILTRATION: To get rid of suspended particles and non-suspended particles.  
Solid particles - dust, sand, soil etc.

Suspended Particles  $\rightarrow$  Light particles - coagulation & sedimentation

Coagulation is process of addition of coagulants  $\text{Al}_2(\text{SO}_4)_3$ , potash alum, Iron sulphate

Iron Sulphate → cation (release)

Iron

Soil, dust, clay → Negatively charged.

Coagulant  
(+ve)

(-)

Impurity

Attract → heavy particle

and will sink in the water.

After coagulation;

When we ~~won't~~ not disturb the water, then the particles get set settled at the bottom → this is known as coagulation & sedimentation.

firstly unsuspended particles will be removed, after then suspended particle will be removed after the process of coagulation and sedimentation. In this way, the suspended & unsuspended particles will be removed.

⇒ **DISINFECTION:** Removal of Microbes from the water.

• **Boiling:**

Bacteria → growth → ambient temperature require.

If Temperature ↑ than AT, then growth will be stopped.

gno Disinfection will be there.

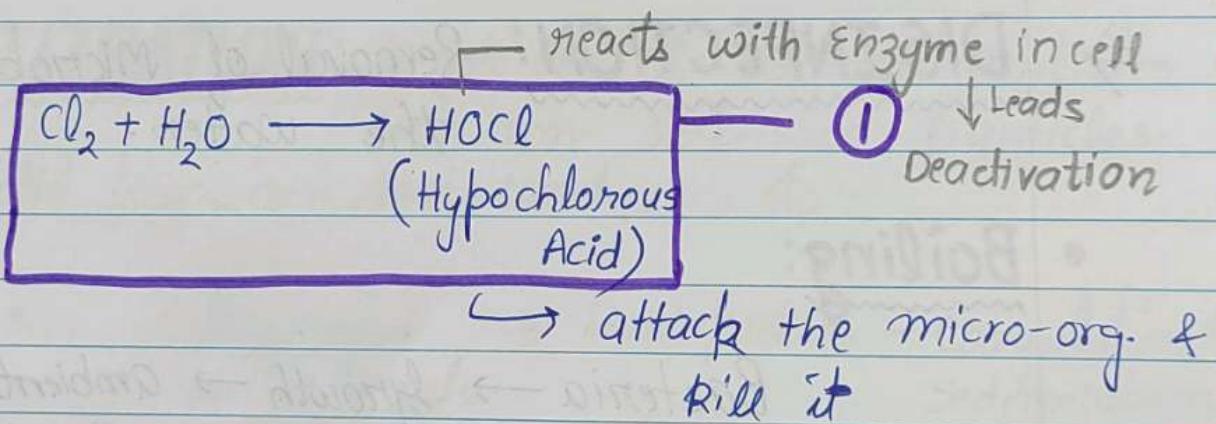
If we boil water for 10-15 minutes, then bacteria will be killed. But if we want to do chlorination at large scale, then it will be very expensive method, then we will use CM.

## ⇒ CHEMICAL METHODS:

- UV Rays
- chlorination
- calcium chloramines
- Bleaching Powder  
(calcium oxychloride) →  $\text{CaOCl}_2$
- Ozone

Apparatus used for this purpose - chlorinator.

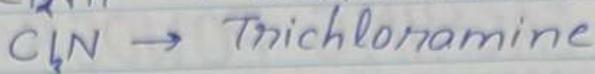
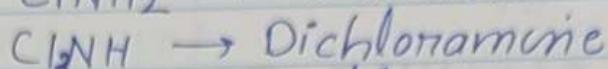
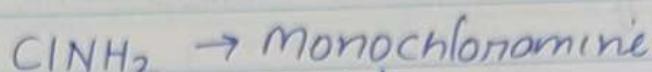
⇒ chlorination: It is very effective Method for purification.



As here chlorine is both its state free state/form and combined form of chlorine.

Excess Amount of  $\text{Cl}_2 \rightarrow$  unpleasant taste & odour  
Actual concentration  $\rightarrow 1.0 - 2.0 \text{ ppm}$

$\Rightarrow$  Chloramines: Chloramine is ammonical salt of chlorine

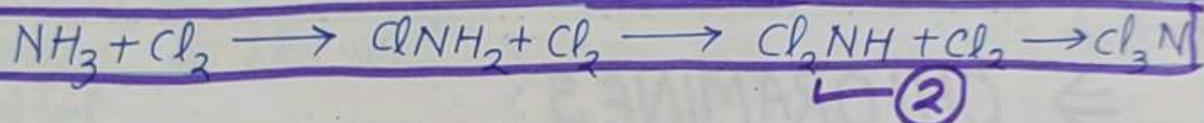


The Process of chlorination is as follows-

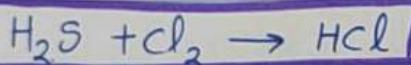
$\text{Cl}_2$  — oxidizing Agent, so it does not react immediately.

React  $\downarrow$   $\text{NH}_3, \text{H}_2\text{S} \rightarrow$  there might be Reducing Agent in the unpurified water

$\downarrow$  Temperature ↑  
 $\downarrow$  Metabolism of Bacteria pH Level ↓



②



when eqn ① reaction starts  $\rightarrow$  Break pt. chlorination.

It is pt. where disinfection starts.

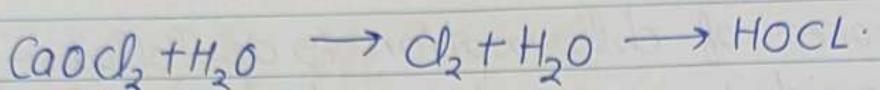
Addition of chlorination  $\rightarrow$  corresponding to Break pt. chlorination

In Eqn ② is known as combined form of chlorine  
( $\text{CINH}_2, \text{Cl}_2\text{NH}_2, \text{Cl}_3\text{N}$ )

free chlorine -  $\text{Cl}_2$

free chlorine reacts with RA  $\rightarrow$  combined chlorines

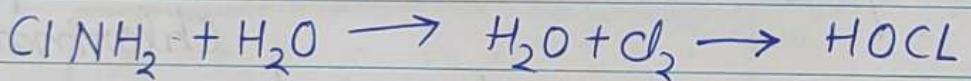
## $\Rightarrow$ BLEACHING POWDER:



In this rxn, bleaching powder reacts with water to form chlorine, which further reacts with water to form hypochlorous Acid; which kills the germs present in water.

But it introduces Ca in water, which makes it hard water.

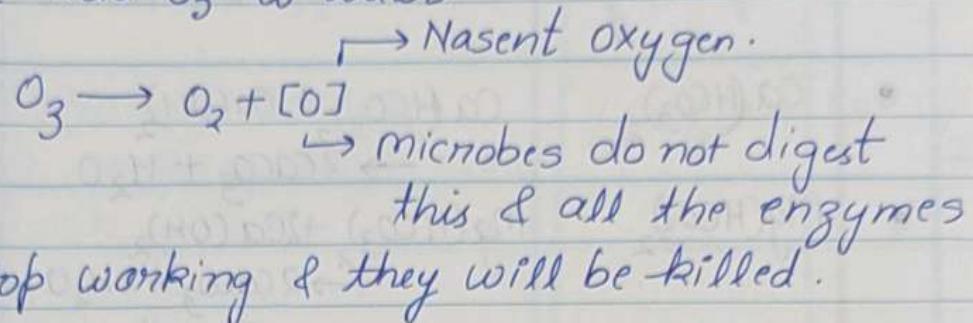
## $\Rightarrow$ CHLORAMINES:



Chloramines has lasting effect than chlorine alone. Now-a-days this is a better used disinfectant because its excess does not give any odour & it imparts good taste to water. chlorine tablets are used these days.

## ⇒ OZONE :

When we add  $O_3$  to water



It is very Expensive Method for the purification of water

## ⇒ UV RAYS:

UV rays are very useful in killing Bacteria. This method is very useful for swimming pools because it does not require any chemical to be added.

Water is simply exposed to UV Rays.

## ⇒ BOILER FEED WATER:

↓  
A Big vessel / container

Boiler feed water is basically used to boil the water → which in turn will produce steam and the steam will run the turbine. But if we use hard water in Boiler then → It has disadvantages.

What will we do if we use hard water and impure water in the Boiler.

### • Disadvantages of Hard water:

1. ⇒ Scale & SLUDGE: Deposit Inside the boiler. which decrease the BP increase the BP  
- ease the BP of the water, as there are solid Impurities present in Hard water. wastage of fuel, time & money; will be lead by Scale & sludge.

### (Hot water)

- Salts (Ca & Mg) → Scale deposit → which are less soluble / Insoluble in water.

Scale basically present in the high temperature.

- Sludge → Standing water → Room Temp. → Salts (Ca & Mg) → less soluble salts

### (in cold water)

Cause

- ⇒ for the Removal of Scale - • Diluted Acid  
• Scratch with wire brush

- ⇒ for the Removal of Sludge - • Simply scrub

Scale is difficult to Remove, while sludge is easy to Remove.

Boiler  $\rightarrow$  Steel/Iron  $\rightarrow$  Overheat  $\xrightarrow{\text{leads}}$  Damage.

## $\Rightarrow$ Prevention: (Imp.)

Prevention is also known as conditioning.

- colloidal conditioning. (agar-agar sol.)
- Phosphate conditioning. ( $\text{Na}_2\text{PO}_4$ )
- carbonate conditioning. ( $\text{Na}_2\text{CO}_3$ )
- calgon conditioning  $\rightarrow$  (sodium hexameta phosphate)

$\hookrightarrow$  Internal Treatment A.

## B. External Treatment:

- Zeolite Method
- Lime Soda method
- Ion Exchange Method

## $\Rightarrow$ Conditioning:

We add  $\rightarrow$  chemicals  $\rightarrow$  React with  $\xrightarrow{\text{so that}}$   $\text{Ca}$  &  $\text{Mg}$   
 $\text{Ca}$  &  $\text{Mg}$   $\xrightarrow{\text{do not}}$  get deposit.

Moreover the formed product will not produce any harm  $\rightarrow$  Boiler.

In conditioning, we basically add chemicals to the hard water, which acts as a conditioner. It reacts with  $\text{Ca}$  and  $\text{Mg}$ , ~~rea~~ so that they do not get deposit on the surface of contain-

- ner.

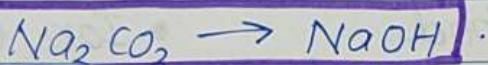
The product formed after the rxn  $\rightarrow$  will not be harmful.

$\rightarrow$  (Alkaline water)

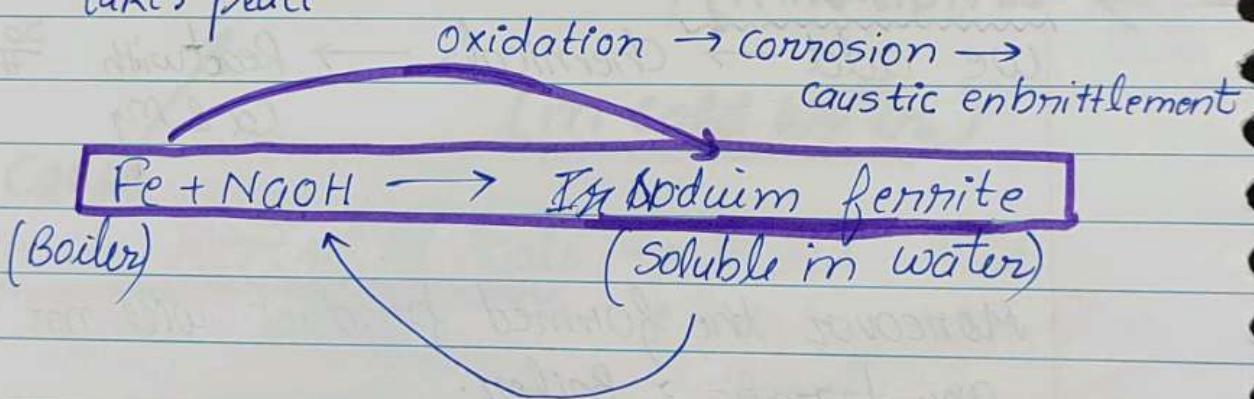
## 2. CAUSTIC ENBRITTLEMENT

Cause -

corrosion of Boiler by Alkaline water (NaOH)  
 $\rightarrow$  (Oxidation of metal)



we get this ~~from~~  $\leftarrow$  when the softening of hard water, as shown the rxn above; takes place

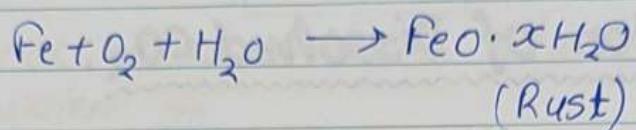


It is continuous process. In this (fe) of the Boiler reacts with NaOH to form sodium ferrite, which is soluble in water. As (fe) is oxidising, so corrosion will take place  $\rightarrow$  Caustic embrittlement.

## PREVENTION:

- Neutralize the water having NaOH
- we should add calculated amount of  $\text{Na}_2\text{CO}_3$ . As when we add calculated amount of  $\text{Na}_2\text{CO}_3$  then all the amount will be consumed by impurities

## 3. BOILER CORROSION:



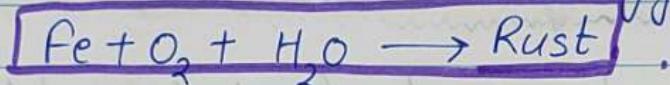
Corrosion  $\rightarrow$  Boiler  $\rightarrow$  Iron.

Cause: Dissolved Oxygen

Dissolved Carbon-Dioxide

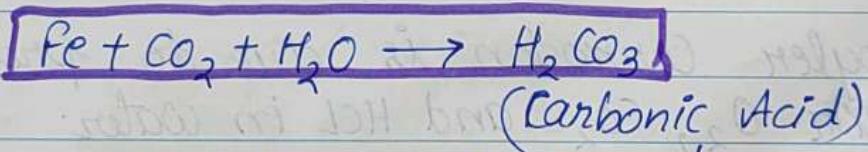
Acid  $\rightarrow$  (HCl)

$\Rightarrow$  When Iron Reacts with most oxygen (diss.)



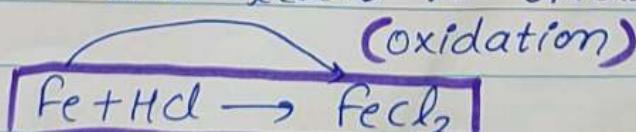
$\hookrightarrow$  Rusting of Iron.

$\Rightarrow$   $\text{CO}_2$ :



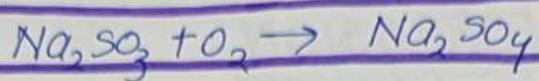
Corrosive in Nature  $\leftarrow$

$\Rightarrow$  HCl: Being an acid, It is corrosive in Nature.  
It will leads to oxidation of metal (Fe).



## 1. Prevention of Dissolved oxygen:

- Removal of (deaeration) air → Because if O<sub>2</sub> will not be there then → no Rusting.
- Addition of sodium sulphide → absorb O<sub>2</sub> from H<sub>2</sub>O



## 2. Prevention of Dissolved CO<sub>2</sub>:

- Deaeration → with help of vacuum pump air will be removed.
- Addition of NH<sub>3</sub> to water → absorb CO<sub>2</sub> → No CO<sub>2</sub> → No carbonic Acid → No corrosion

## 3. Prevention from Acid (HCl) -

- Acid can be neutralized by adding → Base (NaOH)

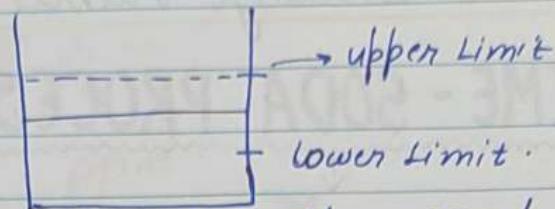
Boyle's corrosion is due to presence of

air O<sub>2</sub>, CO<sub>2</sub> and HCl in water.

## ⇒ PRIMING & FOAMING:

→ Formation of Foam on the surface

⇒ Foam → due to heating of oil Impurities  
Foaming is a disadvantage to Boiler.



we do not find out the exact level of the water, as formation of foams & bubbles continuously - Foaming

Priming and foaming Basically occurs together.

⇒ PREVENTION: By adding Anti-foaming agents to the water

⇒ Priming: formation of wet steam.

Steam → More specific heat.

Because if water reaches to the blade of the turbine → corrosion.

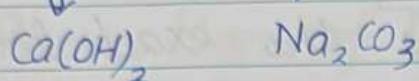
Solid Impurities → No homogeneity in Boiling → Bumping of Water

→ Splash of water → Steam (wet)

⇒ Cause: Presence of different - different salts.

⇒ Prevention: we must use soft water and  
if water is hard → we do →  
Softening of water by zeolite, lime soda &  
ion - exchange method.

## ⇒ LIME-SODA PROCESS:



use →

Principle:  
to make water  
soft.

Soluble salts of Ca and Mg

- $\text{Ca}(\text{HCO}_3)_2$
- $\text{CaCl}_2$
- $\text{CaSO}_4$
- $\text{MgHCO}_3$
- $\text{MgCl}_2$
- $\text{MgSO}_4$

⇒  $\text{Ca}(\text{HCO}_3)_2, \text{CaCl}_2, \text{CaSO}_4 \xrightarrow[\text{L and S}]{\text{L or S}} \text{CaCO}_3 \downarrow$  (Insoluble)

By using  $(\text{Ca(OH)}_2 \& \text{Na}_2\text{CO}_3)$  chemicals

Lime → L

Soda → S

$\text{Mg}(\text{HCO}_3)_2, \text{MgCl}_2, \text{MgSO}_4 \xrightarrow[\text{L & S}]{\text{L or S}}$   $\text{Mg(OH)}_2 \downarrow$  Insoluble

## LIME SODA METHOD:

Impurity	Reaction Involved	Req.	$\text{CaCO}_3$ Eq'l.
• $\text{Ca}(\text{HCO}_3)_2$	$\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \rightarrow 2\text{CaCO}_3 + \text{H}_2\text{O}$	L	$\frac{100}{162} \times 1$
• $\text{Mg}(\text{HCO}_3)_2$	$\text{Mg}(\text{HCO}_3)_2 + 2\text{Ca}(\text{OH})_2 \rightarrow 2\text{CaCO}_3 + 2\text{H}_2\text{O} + \text{Mg}(\text{OH})_2$	2L	$\frac{100}{140} \times 2$
• $\text{CaCl}_2$	$\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NaCl}$	S	$\frac{100}{110} \times 1$
• $\text{CaSO}_4$	$\text{CaSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + \text{Na}_2\text{SO}_4$	S	$\frac{100}{136} \times 1$
• $\text{MgCl}_2$	$\text{MgCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{MgCO}_3 + 2\text{NaCl}$ $\text{MgCO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{Mg}(\text{OH})_2 + \text{CaCO}_3$	L+S	$\frac{100}{95}$
• $\text{MgSO}_4$	$\text{MgSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{MgCO}_3 + \text{Na}_2\text{SO}_4$ $\text{MgCO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{Mg}(\text{OH})_2 + \text{CaCO}_3$	L+S	$\frac{100}{120}$
• $\text{Al}_2(\text{SO}_4)_3$	$\text{Al}_2(\text{SO}_4)_3 + 3\text{Ca}(\text{OH})_2 \rightarrow$ $3\text{CaSO}_4 + 2\text{Al}(\text{OH})_3$ $3\text{CaSO}_4 + 3\text{Na}_2\text{CO}_3 \rightarrow$ $3\text{CaCO}_3 + 3\text{Na}_2\text{SO}_4$	3L+3S	$\frac{100}{342} \times 3$
• $\text{H}^+(\text{HCl}, \text{H}_2\text{SO}_4)$	$2\text{H}^+ + \text{Ca}(\text{OH})_2 \rightarrow \text{Ca}^{2+} + \text{H}_2\text{O}$ $\text{Ca}^{2+} + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{Na}^+$	$\frac{1}{2}\text{L} + \frac{1}{2}\text{S}$	$\frac{100}{1} \times \frac{1}{2}$

•	$\text{CO}_2$	$\text{CO}_2 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$	L	$\frac{100}{44}$
•	$\text{H}_2\text{S}$	$\text{H}_2\text{S} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaS} \downarrow + 2\text{H}_2\text{O}$	L	$\frac{100}{34}$
•	$\text{NaHCO}_3$ or $\text{HCO}_3^-$	$2\text{NaHCO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCO}_3 + \text{Na}_2\text{CO}_3 + 2\text{H}_2\text{O}$	$\frac{1}{2}\text{L} - \frac{1}{2}\text{s}$	$\frac{100}{84} \times \frac{1}{2}$
•	$\text{NaAlO}_2$	$\text{NaAlO}_2 + 2\text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 \downarrow + \text{NaOH}$ [ $1\text{NaOH} - \frac{1}{2}\text{Ca}(\text{OH})_2$ ]	$-\text{L} \times \frac{1}{2}$	$\frac{100}{82} \times \frac{1}{2}$
•	$\text{NaHCO}_3$	$2\text{NaHCO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCO}_3 + \text{Na}_2\text{CO}_3 + 2\text{H}_2\text{O}$	$\frac{1}{2}\text{L} - \frac{1}{2}\text{s}$	$\frac{100}{84} \times \frac{1}{2}$
•	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	$2\text{FeSO}_4 + 2\text{Ca}(\text{OH})_2 + 2\text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \rightarrow 2\text{Fe}(\text{OH})_3 + 2\text{CaCO}_3 + 2\text{Na}_2\text{SO}_4$	$\text{L} + \text{s}$	$\frac{100}{278}$

1. calculate the amount of lime & soda Required for softening of 25000 litre of water having following Impurities.

- $\text{Ca}(\text{HCO}_3)_2$  = 4.86 ppm
- $\text{Mg}(\text{HCO}_3)_2$  = 7.30 ppm
- $\text{CaSO}_4$  = 6.80 ppm
- $\text{MgCl}_2$  = 5.7 "
- $\text{MgSO}_4$  = 9 ppm
- $\text{SiO}_2$  = 3 ppm  $\rightarrow \times$
- $\text{NaCl}$  = 3.85 ppm  $\rightarrow \times$

It is capable of removing other Impurities other than Ca & Mg.

\* Recognize the Impurity which is not in the table

\*  $\text{CaCO}_3$  Equivalent  $\rightarrow$  calculate  $\text{CaCO}_3 = 100$

### $\text{CaCO}_3$ Equivalent -

Molecular weight of  $\text{CaCO}_3$   $\times$  Amount of Imp.  
" " of Impurity (ppm)

$$\text{Ca}(\text{HCO}_3)_2 = \frac{100 \times 4.86}{162}$$

$$0.617 \times 4.86 = 2.99$$

$$\Rightarrow \text{Mg}(\text{HCO}_3)_2 = \frac{100}{146} \times 7.30 \\ = 0.68 \times 7.30 \\ = 4.96$$

$\frac{16}{9} \text{ (3)}$

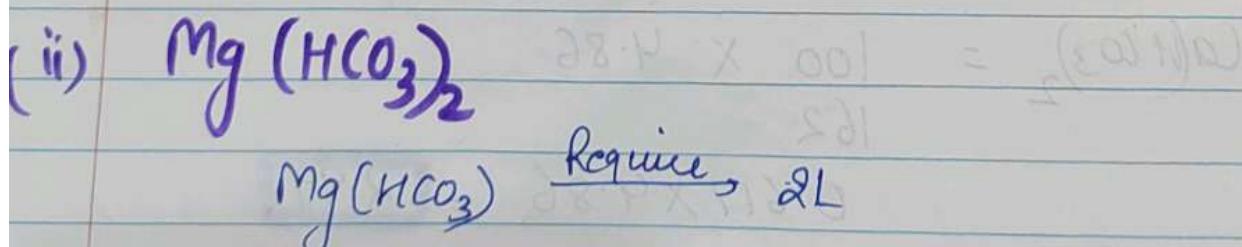
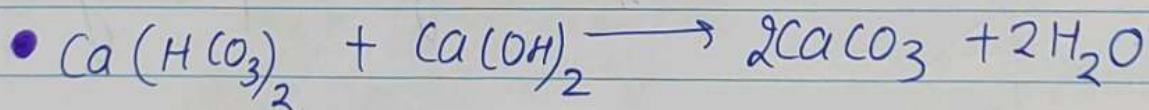
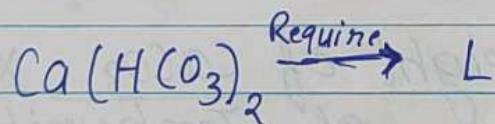
$$\Rightarrow \text{CaSO}_4 = \frac{100}{136} \times 6.80 \\ = 0.73 \times 6.80 \\ = 4.96$$

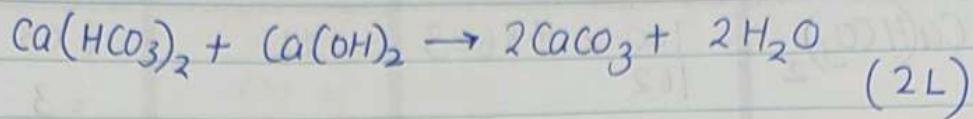
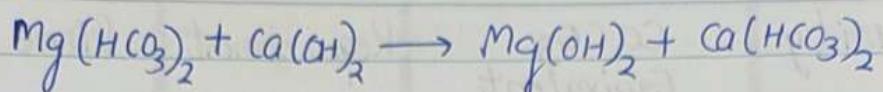
$$\Rightarrow \text{MgCl}_2 = 1.05 \times 5.7 \\ = 5.9$$

$$\Rightarrow \text{MgSO}_4 = \frac{100}{120} \times 9 = 7.5$$

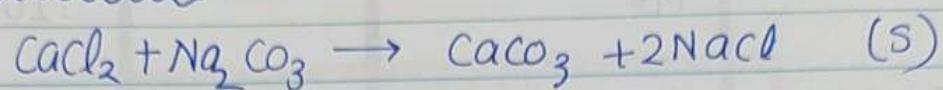
\* Now, we will find the Requirement of each and every impurity.

$\Rightarrow$  Requirement:

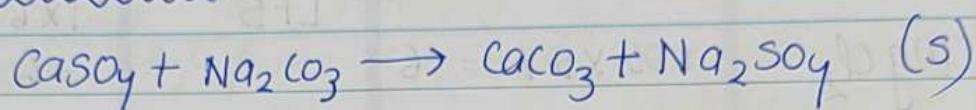




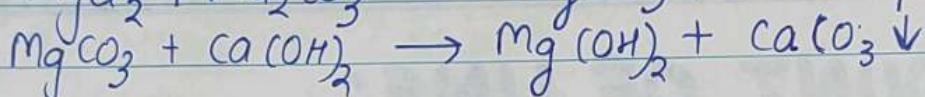
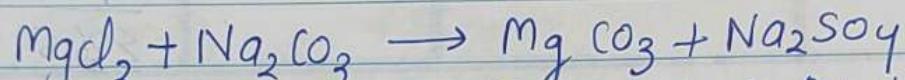
(ii)  $\text{CaCl}_2$ :



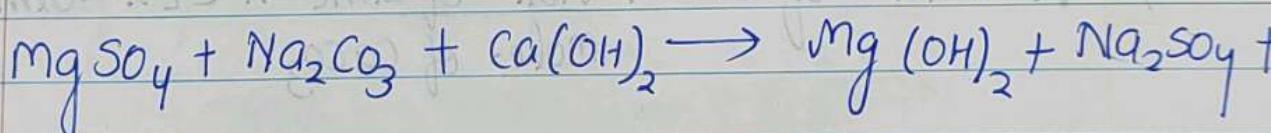
(iii)  $\text{CaSO}_4$ :



(iv)  $\text{MgCl}_2$ :



(v)  $\text{MgSO}_4$ :



\* Tabulate the whole Information.

TABLE:

Impurity	$\text{CaCO}_3$ Equivalent	Requirement	Lime	Soda
$\text{Ca}(\text{HCO}_3)_2$	$\frac{100}{162} \times 4.86 = 3$	1L	$1 \times 3 = 3$	-
$\text{Mg}(\text{HCO}_3)_2$	$\frac{100}{146} \times 7.30 = 5$	2L	$2 \times 5 = 10$	-
$\text{CaSO}_4$	$\frac{100}{136} \times 6.80 = 5$	5	-	5
$\text{MgCl}_2$	$1.05 \times 5.7 = 6$	L + S	$1 \times 6 = 6$	$1 \times 6 = 6$
$\text{MgSO}_4$	$\frac{100}{120} \times 9 = 7.5$	L + S	$1 \times 7.5 = 7.5$ $\Sigma 26.5$	$1 \times 7.5 = 7.5$ $\Sigma 18.5$

## ⇒ AMOUNT OF LIME:

⇒ Amount of Lime:  $\frac{\text{Mole. of Lime}}{\text{mole. of } \text{CaCO}_3} \times \text{Voln of H}_2\text{O}$   
 $\times 100\% \text{ purity of lime}$

$$= \frac{74}{100} \times 26.5 \times 2500 \times \frac{100}{100}$$

**Amount of Lime** = 490250 mg

Amount of Soda -

$$\frac{\text{No. of soda}}{\text{No. of } \text{CaCO}_3} \times 25 \times \text{vol. H}_2\text{O} \times 100/\text{purity of Soda}$$

$$\frac{106}{100} \times 18.5 \times 25000 \times 1$$

Amount of soda = 490250 mg

2 calculate the Amount of Lime 90% pure and Soda 93% pure. calculate the amount of lime and soda required for softening of 25000l. of water having following Impurities.

- $\text{Ca}(\text{HCO}_3)_2$  = 4.86 ppm
- $\text{Mg}(\text{HCO}_3)_2$  = 7.30 ppm
- $\text{CaSO}_4$  = 6.80 ppm
- $\text{MgCl}_2$  = 5.7 ppm
- $\text{MgSO}_4$  = 9 ppm

90/l. = 90 gm Lime + Impurity.

→ we will add more Lime.

$$\frac{100}{90} > 1 \quad \checkmark \text{ use this}$$

$$\frac{100}{100} = 1$$

$$\frac{90}{100} < 1 \quad \checkmark \text{ factor less than 1}$$

⇒ Amount of Lime -

$$= \frac{74 \times 26.5 \times 25000}{100} \times \frac{100}{90}$$

$$= \frac{4902500}{9}$$

⇒ Amount of lime = 544722.22 mg.

Extra lime Required = 544722.22 - 490250  
= 54472.22 mg.

⇒ Soda =  $490250 \times \frac{100}{93}$

$$= 527150.53$$

Extra soda Required = 527150.53 - 490250  
= 36900.53 mg

3 A Sample of water 25000 L (Same as ques 1)  
Calculate temporary hardness of water, permanent hardness & total hardness.

$$TH = 375$$

= 8 ppm (in equivalence of  $\text{CaCO}_3$ )

PH = 18.5 ppm (in equivalence of  $\text{CaCO}_3$ )

TH = 26.5 ppm (in equivalence of  $\text{CaCO}_3$ )

4. A water sample on Analysis, shows the following Impurities in water

	mg/L
$\text{Ca}^{2+}$	30
$\text{Mg}^{2+}$	18
$\text{HCO}_3^-$	122
$\text{CO}_2$	11
$\text{K}^+$	19 — X
$\text{Cl}^-$	33 — X

calculate the amount of lime and soda Required for softening of 1L of this water Sample.

- ⇒  $\text{Ca}^{2+}$  is from Permanent calcium Hardness.
- ⇒  $\text{Mg}^{2+}$  is from Permanent magnesium Hardness.
- ⇒  $\text{HCO}_3^-$  is from Sodium Bicarbonate ( $\text{NaHCO}_3$ )
- ⇒  $\text{H}^+$  is from Acidic Impurities

$\text{CaCO}_3$  Equivalent =

$$\bullet \quad \text{Ca}^{2+} = \frac{\text{Mol of } \text{CaCO}_3}{\text{Mol of Imp}} \times \text{Amount of Imp}$$

$$= \frac{100}{40} \times 30$$

$$= \frac{300}{4} = 75 \text{ mg}$$

⇒ Calcium carbonate Equivalent:

- $Mg^{2+} = \frac{100}{24} \times 18.6$

$$\begin{aligned} Mg^{2+} &= 75.00 \\ Mg^{2+} &= 75 \text{ mg} \end{aligned}$$

- $HCO_3^{2-} = \frac{100}{61} \times 122$

$$HCO_3^{2-} = 198.86 \text{ mg} / 199.958 = 200 \text{ mg}$$

- $CO_2 = \frac{100}{44.4} \times 11.1$   
= 25 mg

⇒ TABLE:

Impurities	<u>Caco<sub>3</sub></u> <u>Equi</u>	<u>Requirement</u>	Lime	Soda
Ca <sup>2+</sup> - 30		5	75	75
Mg <sup>2+</sup> - 18	75	S + L	75	75
HCO <sub>3</sub> - 122	75	$\frac{1}{2}L - \frac{1}{2}S$	100	- 100
CO <sub>2</sub> - 11	25	L	$\frac{25}{200}$	<u>1850</u>

1 Imp.       $\frac{1}{2}$  L  
2 Impurity + Lime  $\rightarrow$  Insoluble salts + Sodium Carbonate.

Amount of Lime =

$$\frac{74}{100} \times 200 \times 1 \times 1$$

Lime Required = 148 mg

Amount of Soda =

$$\frac{106}{100} \times 50 \times 1 \times 1$$

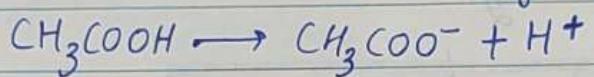
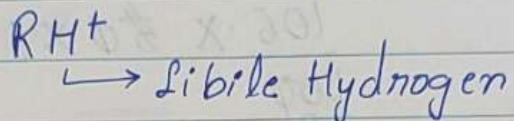
Soda Required = 53 mg

## ⇒ ION - EXCHANGE METHOD:

Ion Exchange Resin → used → softening of water.  
(Polymer)

- \* Resin ⇒ Styrene divinyl benzene co-polymer  
This undergoes chemical changes-
  - Sulphonation
  - carboxylation

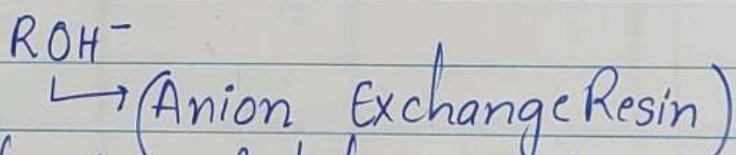
This is an Acidification Process  
↳ with this R Acquires  $H^+$  ions



$RH^+$  → Cation Exchange Resin.  
↳ (Exchange of cation → Property)

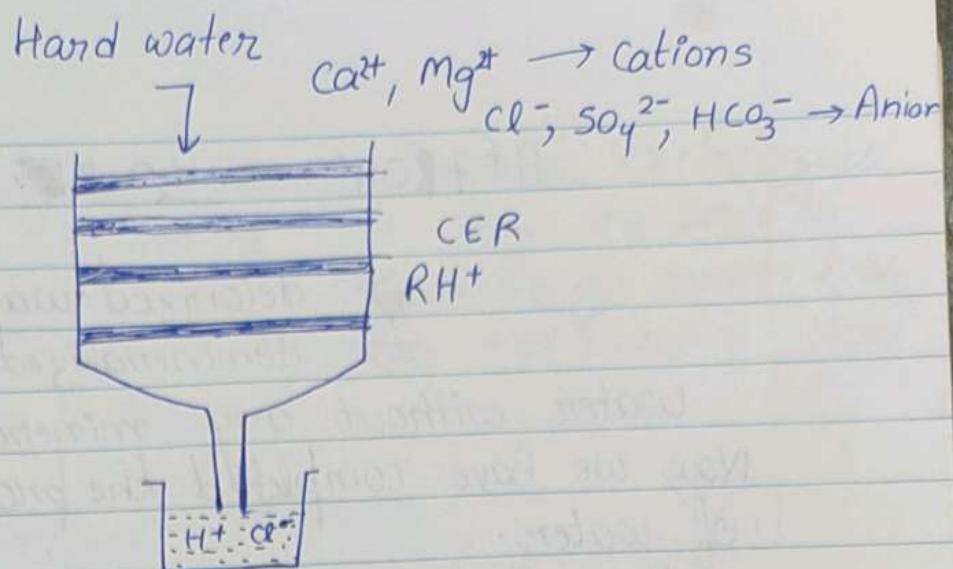
## ⇒ ANION EXCHANGE RESIN:

If it undergoes → Alkylation  
 $NaOH$



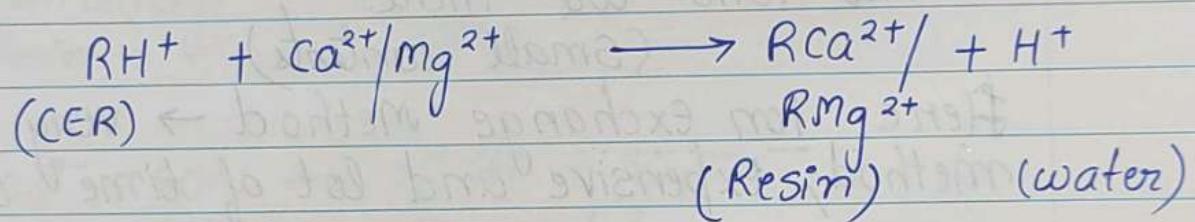
An Anion which gives & takes → Anions.

CER and AER → used for → softening of water

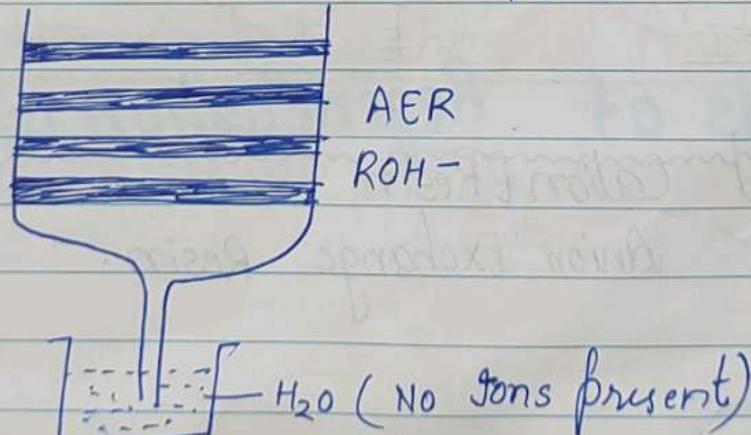
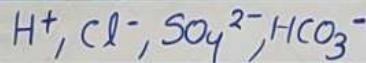


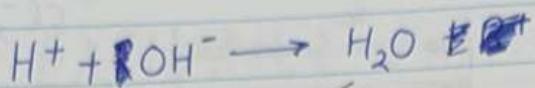
- Retained by the Resin  $\rightarrow$  CER and return  $\text{H}^+$  ion to the water
- water collected  $\rightarrow \text{H}^+, \text{Cl}^-, \text{SO}_4^{2-}, \text{HCO}_3^-$

Rxn:



We will take the water from first setup and place the same water in the second setup as shown below;

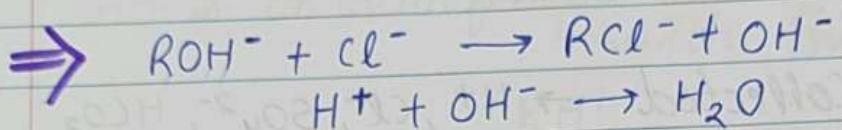




$\Rightarrow$  deionized water  
 $\Rightarrow$  demineralized water

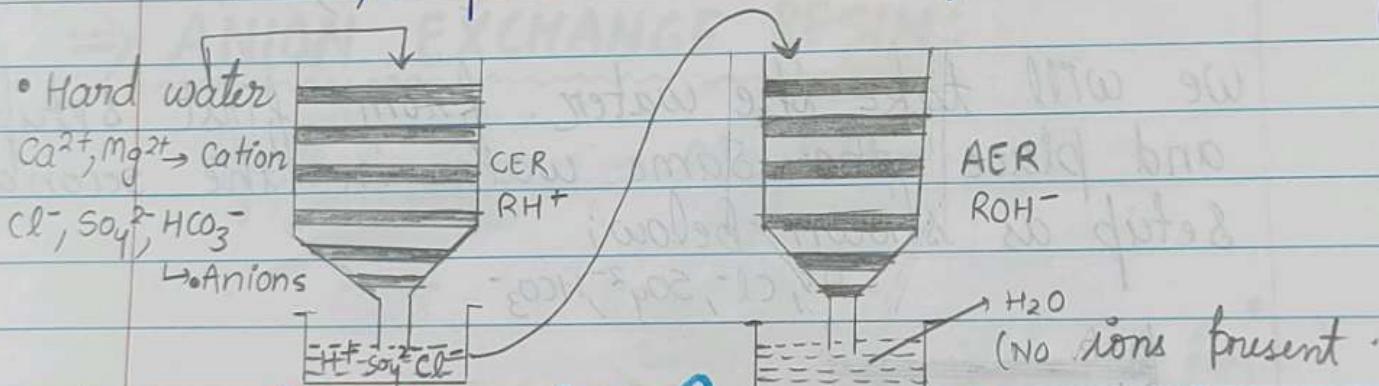
water without any minerals  $\uparrow$   
 Now we have completed the process of softening of water.

Here Exchange of negative ions take place.  
 Cation easily moves through the setup.



water softening by zeolite method  $\rightarrow$  then  $\rightarrow$   
 Na ions are there  
 (small contents)

Fluoride ion exchange method  $\rightarrow$  very efficient method; Expensive and lot of time consuming.



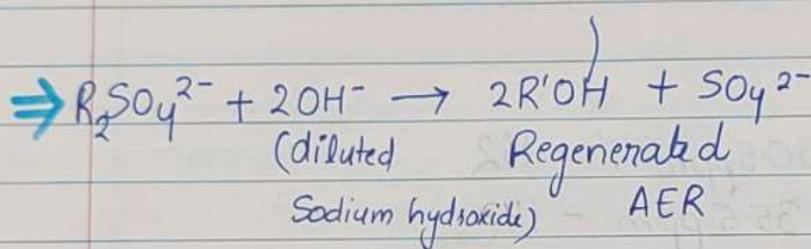
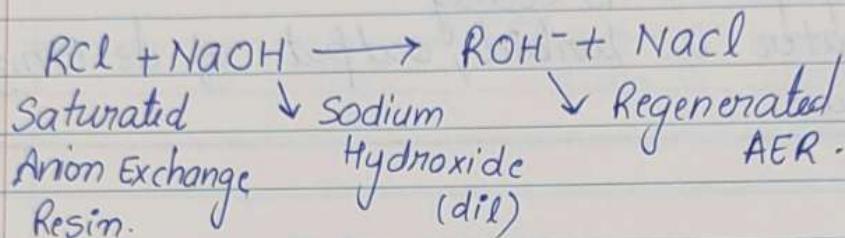
## $\Rightarrow$ Methods of Regeneration of:

- Exhausted Cation Exchange Resin
- Exhausted Anion Exchange Resin.

When capacity of cation and anion exchangers to exchange  $H^+$  and  $OH^-$  lost, they are said to be exhausted. It is when ion exchange resin has given all its  $H^+$  and  $OH^-$  ions to hard water. Now regeneration is required.

## ⇒ Regeneration of AER:

We want to regenerate  $\rightarrow \text{OH}^-$  in the AER. Here we will use NaOH (dil)  $\rightarrow$  for the process of regeneration.

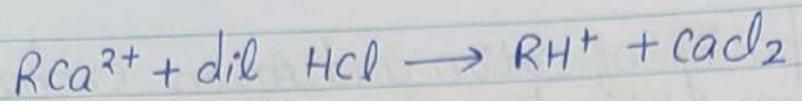


## ⇒ Regeneration of CER:

Regeneration is a chemical Process  $\Rightarrow$  add any kind of chemical.

Moreover, we can change the layers of the Resins  
↳ which is an expensive process.

We will use  $\rightarrow$  diluted HCl  $\rightarrow$  for Regeneration



Now it is ready to use Again.

### ⇒ Advantages:

- This process is very good to soften very acidic/basic  $\text{H}_2\text{O}$ .
- It produces water of very low hardness.

### ⇒ Disadvantages:

- The equipment is costly.
- If water is turbid, output of de-ionization is low.