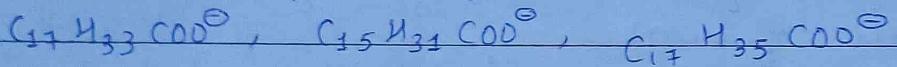


Unit = 1.

Water Treatment

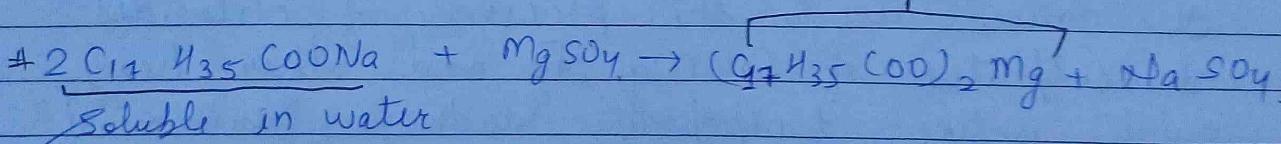
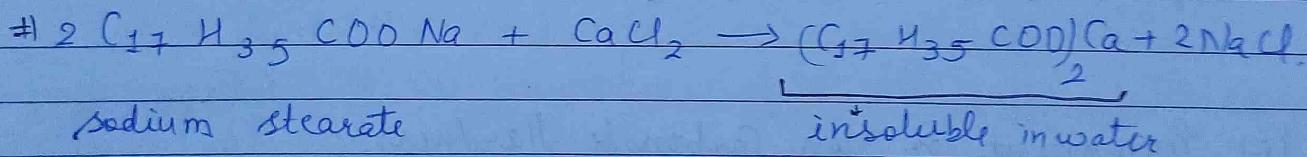
Hardness of Water = hardness of water is that characteristics which prevents the foaming of soap. This is due to the presence of certain salts of Ca, Mg and other heavy metals dissolved in it.

A sample of hard water when treated with soap [Na, K salts of iron fatty acid like oleic, palmitic, stearic]



doesn't produce leather but on the other hand form a white scum or ppt.

This ppt is formed due to the formation of insoluble salts of Ca, Mg.



Hard Water = Water which doesn't produce leather with soap solution, readily but forms a white ppt. is called hard water.

Soft Water: Water which lathers easily on shaking with soap sol^n is called soft water, such water does not contain dissolved Ca and Mg salts in it.

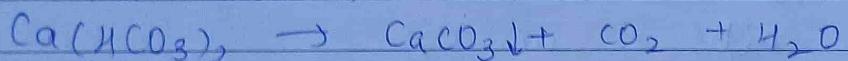
Types of Hardness:

(i) Temporary (ii) Permanent hardness

(ii) Temporary or Carbonate Hardness:

It is caused by the presence of dissolved bicarbonates of Ca, Mg salts and heavy metals & the carbonate of iron.

Temporary hardness is destroyed by boiling of water when bicarbonates are decomposed, carbonates or hydroxides are formed which settle down at the bottom.



(ii) Permanent or Non Carbonate Hardness :

It caused due to the presence of chlorides and sulphates of Ca, Mg, Fe and other heavy metals. Unlike temporary hardness, permanent hardness is not destroyed on boiling.

Equivalent of CaCO_3 : The concⁿ of hardness as well as non hardness causing ions are usually expressed in terms of equivalent amount of CaCO_3

X

$$\text{Eq of } \text{CaCO}_3 = \left[\frac{\text{mass of hardness}}{\text{producing substance}} \right] X$$

The choice of CaCO_3 in particular is due to molecular weight is 100

$$\text{Eq wt} = \frac{100}{n} \Rightarrow \underline{\underline{50}}$$

and it is the most insoluble salt that can be ppted in water treatment

$$\text{Eq of } \text{CaCO}_3 = \left[\frac{\text{mass of hardness}}{\text{producing sub}} \right] \times \left[\frac{\text{chemical eq of } \text{CaCO}_3}{\text{producing substance}} \right]$$

Units of Hardness

- 1) Parts per million (ppm) \Rightarrow Parts of Calcium carbonate equivalent hardness per 10^6 parts of water
- 2) mg/l \Rightarrow It is number of milligram of CaCO_3 equivalent hardness present in litre of water
 $1 \text{ mg/l} = 1 \text{ ppm} = 0.07 \text{ Cl} = 0.1 \text{ Fr}$

$$3) \text{ Clark's degree } ({}^\circ \text{C}) = \frac{1 \text{ grain of hardness}}{1 \text{ gallon} / 70,000 \text{ grains}} \Rightarrow \frac{1}{7 \times 10^4}$$

$$4) \text{ French degree (Fr)} = \frac{1 \text{ part of hardness}}{10^5 \text{ parts of water}}$$

$$5) 1 \text{ USA degree} = \frac{1 \text{ grain}}{583,00 \text{ grains}}$$

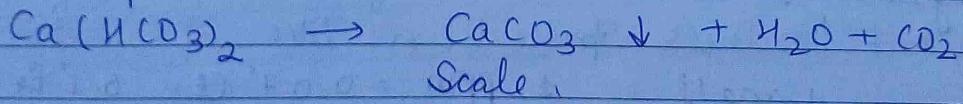
$$6) 1 \text{ German degree} = \frac{1 \text{ grain}}{56000 \text{ grains.}}$$

- 1) Sludge and Scale formation in Boilers =
- 2) Sludge = When hard water is used for boilers, on continuous evaporation, the salts present in hard water gets saturated, finally deposited in areas where flow is slow.
When these ppts are loose and slimy in nature is called as Sludge.

- Removed by scrapping with a brush.
- Formed by presence of $MgCO_3$, $MgCl_2$, $MgSO_4$ etc.
- More soluble in hot water
- Sludge can be prevented by
 - using soft water for boiler operation.
 - Removing concentrated salty water from time to time.

2) Scales: Hard deposits on inner surface of the boilers which are difficult to remove
Scale form' due to:

(a) Low pressure boilers



(b) High pressure boilers,



$CaCO_3$ forms hard scale due to inc in temp, its solubility decreases

Hard scales are formed when SiO_2 is present in hard water.

$CaSiO_3$, $MgSiO_3$ [difficult to remove]
 Mg salts forms $Mg(OH)_2$ forming soft scale

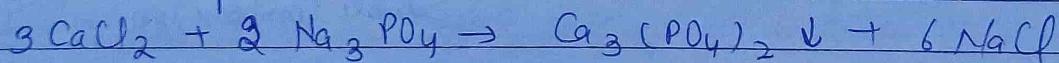
Removal of Scales by :

- Wooden scraper or wire brush
- Blow down operation for loose scales. In this, removal of hard water from a tap at bottom of boiler & replenishing water with softened water called 'make up' water.
- Thermal Shocks, alternate heating and cooling to make scales brittle
- Chemical treatment with 5-10% HCl for carbonates & EDTA for Ca/Mg Salts forming complexes.

Internal Treatment for Prevention of Scale formation = Phosphate

(i) Colloidal Conditioning:

In high pressure boilers, scale formⁿ can be avoided by adding Na_3PO_4 , which reacts with hardness of water forming non adherent and easily removable, soft sludge of Ca & Mg phosphates, which can be removed by blow down operation.



NaH_2PO_4 (sodium dihydrogen phosphate) acidic

Na_2HPO_4 (disodium hydrogen phosphate) weak alkaline

Na_3PO_4 (trisodium phosphate) (alkaline)

Note - Ca cannot pptd below a pH of 9.5
 Na_3PO_4 is most suitable.

(ii) Colloidal Conditioning:

In low pressure boilers, scale formⁿ can be avoided by adding organic substances like Kerosene, tannin, agar agar (gel), which get coated over the scale forming precipitates, yielding non sticky and loose deposits, which can easily be removed by blow down.

(iii) Carbonate Conditioning:

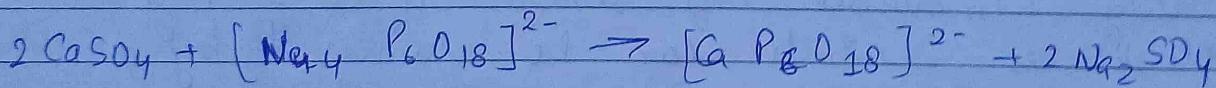
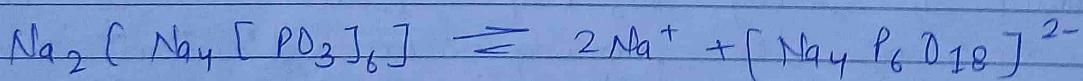
Sodium carbonate in boilers,



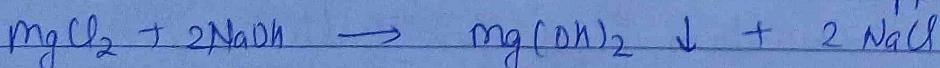
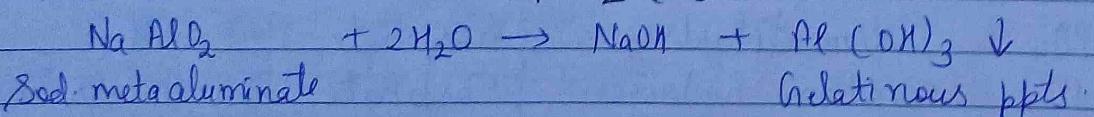
(iv) Calgon Conditioning:

Sodium hexa meta phosphate $(\text{NaPO}_3)_6^-$

It prevents scale and sludge formⁿ by forming soluble complex compound with CaSO_4



Soluble Complexion

(v) Treatment with NaAlO_2 (sodium aluminate)

flocculent ppt of $\text{Mg(OH)}_2 + \text{Al(OH)}_3$ entraps dust, colloidal impurities.

$\text{NaAlO}_2 \leftarrow$ Bauxite ore.

(ii) Electrical Conclitration:

Sealed glass bulbs, containing mercury connected to battery, are set rotating in the boiler.

When water boils, mercury bulbs emit electrical discharges, which prevent scale formation.

(iii) Radioactive:

Tablets containing radioactive salts are placed inside boiler water at few points.

(iv) Complementary method:

Adding 1.5% Alkaline ($\text{pH} = 8.5$) soln to EDTA to feed water. The EDTA binds the scale forming cations to form stable, soluble complex.

Also prevents deposition of iron oxides

➤ Reduces the carrying capacity of oxides with steam

➤ Protects boiler units from corrosion by wet steam.

Caustic Embrittlement:

Type of boiler corrosion, caused by using highly alkaline water in the boiler. During softening process by lime soda process, free Na_2CO_3 , present in small portion.

In high pressure boilers, Na_2CO_3 decomposes



This makes water 'caustic'.

NaOH water flows into minute hair cracks.

Dissolving iron of boiler as Sodium ferrocate. Bricks, joints, rivets etc. cause embrittlement.

Tin at + conc' dilute NaOH - Tin at
earths, boulders NaOH soln.

Tin surrounded by dil NaOH becomes cathodic side, which the iron in contact with conc' NaOH becomes anodic part, which is dissolved or corroded.

~~Caustic embrittlement can be avoided.~~

(i) By using Sodium phosphate as softening reagent instead of Sodium carbonate.

(ii) by adding tannin, lignin to boiler water, these blocks like cracks, preventing infiltration of caustic soda.

(iii) By adding Sodium sulphate to boiler water, Na_2SO_4 blocks cracks.

$[\text{Na}_2\text{SO}_4 \text{ conc'}]$ ratio is kept as $1:1$,
 $[\text{NaOH conc}]$ 40 dm.

$2:1$, $3:1$ in boiler at pressure upto 20 and above 20 atm resp.

Boiler Corrosion

Decay of boiler material by a chemical or electrochemical attack by its envt.

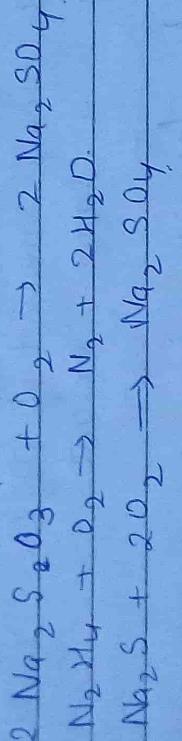
Main Reasons for Boiler Corrosion?

- Dissolved oxygen, water usually contains about 9 mg/l of dissolved oxygen 1 l of room temp. 20 in water , in presence of prevailing high temp, attacks boiler material.



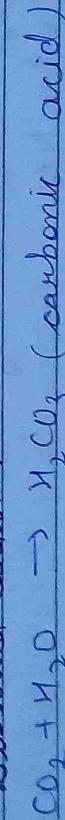
Removal of DO =

(i) By addition of calculated quantity of Sodium Sulfite or Hydrogen or Sulfide,



(ii) By mechanical de-aeration i.e. water spraying in a perforated plate filter tower, heated from sides and connected to vacuum pump.
High temp, low pressure, large exposed surface

(iii) Dissolved Carbon:

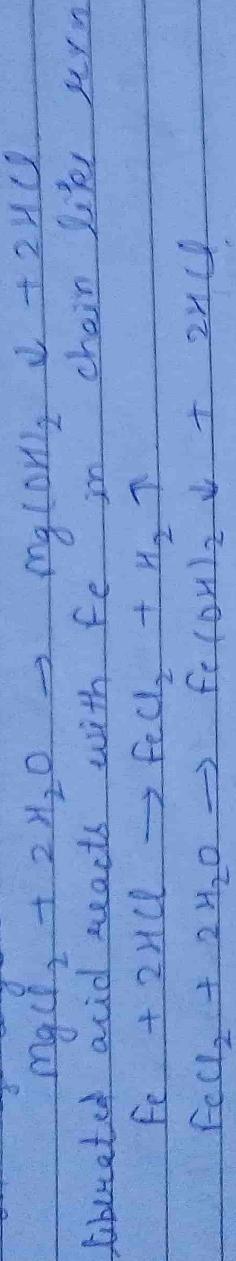


Show corrosive effect
 CO_2 released inside the boiler, if water used for steam generation contains bicarbonate
 $\text{Mg}(\text{HCO}_3)_2 \xrightarrow{\Delta} \text{MgCO}_3 + \text{H}_2\text{O} + \text{CO}_2$

Removal of CO_2 :

(i) By adding calculated quantity of ammonia
 $2\text{NH}_4\text{OH} + \text{CO}_2 \rightarrow (\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O}$
(ii) By mechanical de-aeration process along with oxygen.

(iii) Acids from dissolved salts:
Water containing dissolved Mg salts liberates acidic
on hydrolysis.



Presence of even a small amount of Mg(OH)_2 will cause
conversion of iron to a large extent.

Brimming And foaming:
When boiler is steaming, some particles of liquid water are carried along with
the steam. This process of 'wet steam' formation
is brimming.

Brimming is caused by :-

- Presence of large amount of dissolved solids,
- High steam velocities
- Sudden boiling
- Improper boiler design
- Sudden rise in steam production rates

foaming: Production of persistent foam or bubbles in
boilers which don't break easily,
foaming is due to presence of substances like
oils (reduce surface tension of water),

* Brimming and foaming usually occurs together.

They are objectionable because,

- * dissolved salts in boiler water are removed by wet steam to super heater and turbine blades where they get deposited as water evaporates.
- This deposit reduces their efficiency.
- * dissolved salts may enter parts of other machinery thereby decreasing life of machinery.
- * actual height of water column cannot be judged properly, making maintenance of boiler becomes difficult.

Bumping can be avoided by:

- fitting mechanical steam purifier
- avoiding rapid change in steam pressure
- maintaining low level of boilers.
- Efficient softening & filtration of boiler feed water

Foaming can be avoided by:

- Adding anti foaming chemicals like castor oil
- Removing oil from boiler water by adding sodium aluminate

Chemical Analysis of water

1) Prepⁿ of std water

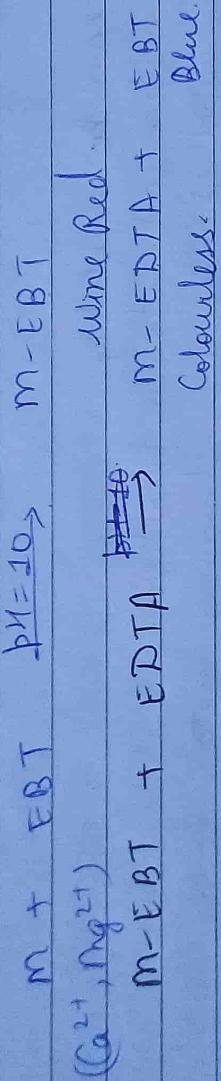


2) Prepⁿ of EDTA



③ Prep' of EBT indicator
Exchanted Black T (an alcoholic sol'n of
blue dye)
0.5 g EBT in 100 ml ethanol.

④ Buffer sol'n ($\text{pH} = 10$)
6.7-5 g NH_4Cl + 57.0 ml of NH_3 1 l
10 ml of water
Buffer ($\text{pH} = 10$)
EBT (2-3 days)



V_1 = Vol of EDTA
Std. Water) EDTA V_3 = Boiled water EDTA
 V_2 = Water Sample | EDTA

1) Std. Water = used for calibration of EDTA.
50 ml = V_1 ml of EDTA sol'n.
1 ml = $\frac{50}{V_1}$ mg CaCO_3 eq.

2) Water Sample = 50 ml eq of CaCO_3 = V_2 ml of EDTA

$$50 \text{ ml} = \frac{V_2}{V_1} \times 50$$

$$50 = \frac{V_2}{V_1} \times 1000 \text{ eq of } \text{CaCO}_3$$

3) Boiled Water = $1000 \times \frac{V_2}{V_1}$ eq of CaCO_3

Temporary hardness = (Total - Permanent)

$$= 1000 \left[\frac{V_2}{V_1} - \frac{V_3}{V_1} \right] \text{ ppm}$$

$$= \frac{V_2 - V_3}{V_1} \times 1000 \text{ ppm.}$$

Q1) A sample of ground water as Ca^{2+} , Mg^{2+} , 150 mg/l and 60 mg/l resp., find total hardness in ppm.

$$\text{Ca}^{2+} = 150 \text{ mg/l}$$

$$\text{Mg}^{2+} = 60 \text{ mg/l}$$

$$\text{Equivalent of } \text{CaCO}_3 \text{ for } \text{Ca}^{2+} = \frac{150}{40/2} \times 50 \text{ mg/l}$$

$$= 375 \text{ ppm.}$$

$$\text{Equivalent of } \text{CaCO}_3 \text{ for } \text{Mg}^{2+} = \frac{60 \times 50}{24/2} \text{ mg/l.}$$

$$= 250 \text{ ppm}$$

Total hardness = 625 ppm

Q2) A sample of water for analysis has been found to contain

$$\text{Ca(HCO}_3)_2 = 4.86 \text{ ppm}$$

$$\text{Mg(HCO}_3)_2 = 5.84 \text{ ppm}$$

$$\text{CaSO}_4 = 6.80 \text{ ppm}$$

$$\text{Mg SO}_4 = 8.40 \text{ ppm}$$

$$\text{Ans} = \text{Ca(HCO}_3)_2 \text{ equivalents of } \text{CaCO}_3 = \frac{4.86}{162/2} \times 50$$

$$= 3 \text{ ppm}$$

$$\text{Eq. of } \text{CaCO}_3 \text{ for Mg(HCO}_3)_2 = \frac{5.84 \times 50}{146/2}$$

$$= 4 \text{ ppm}$$

$$\begin{aligned}
 \text{Eq of } \text{CaCO}_3 \text{ for } \text{CaSO}_4 &= \frac{6.80}{136/2} \times 50 \\
 &= 5 \text{ ppm} \\
 \text{Eq of } \text{CaCO}_3 \text{ for } \text{MgSO}_4 &= \frac{8.40}{120/2} \times 50 \\
 &= 7 \text{ ppm}.
 \end{aligned}$$

Total hardness = 19 ppm.

Temporary (SO₄²⁻ ions) = ~~7~~ 7 ppm.

Permanent (due to SO₄²⁻ ions) = 12 ppm.

(3) 100 ml of water sample has a hardness eq to 12.5 ml of 0.08 normal MgSO₄. what is its hardness in ppm.
 [500 ppm = Ans]

Try 100 ml of a sample of hard water neutral life exactly 12 ml of 0.12 normal HCl using methyl orange as indicator. what kind of hardness is present. Express in terms of CaCO₃.

~~$$\text{Ans 3) "conc" MgSO}_4 = \frac{12.5}{100} \times \frac{0.08}{2} = 0.01 \text{ N}$$~~

$$[\text{MgSO}_4] = \frac{0.01}{2} \Rightarrow 0.005 \text{ M}$$

$$\text{MgSO}_4 \text{ g/l} = \frac{0.005 \times 1000}{100} = 0.5 \text{ g/l}$$

$$\text{ppm} = 0.5 \times 1000 = 500 \text{ ppm.}$$

~~$$= 0.001 \times 50$$~~

$$N = \frac{W_0}{E_{\text{equiv}}} \times \frac{1000}{V(\text{ml})}$$

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Ans 3) 20 ml. of STD Hard water (15 gm) CaCO_3) required
25 ml EDTA solⁿ for end point. 100 ml of
water sample required 18 ml of EDTA solⁿ while
same water after boiling required 12 ml of
EDTA solⁿ. Calculate the Carbonate and
non carbonate hardness.

Ans 3) 100 ml of water sample = $12.5 \times 0.08 \text{ N}$
 $= 1 \text{ ml of } 1\text{N} \text{ CaCO}_3$
 $= 0.001 \times 50 \text{ g CaCO}_3 \text{ eq}$
 $= 0.05 \text{ g CaCO}_3 \text{ eq}$

$$1000 \text{ ml of water} = \frac{50 \times 1000}{100} \Rightarrow 500 \text{ mg } \mu\Omega$$

Ans 4) $N \times 100.0 = \frac{52 \times 0.12}{100}$
 Hardness (mg/l as CaCO_3) = $0.12 \times \frac{52 \times 1000}{100}$
 $= 720 \text{ mg/l CaCO}_3$

NaOH in hard water neutralises carbonates and
bicarbonates so temporary hardness is present.

Ans 5) Amount of CaCO_3 in 2 ml = $15 \times \frac{20}{100} \Rightarrow 0.3 \text{ g}$
 $= 300 \text{ mg}$

1 ml of EDTA = $\frac{300 \text{ mg}}{25 \text{ ml}} \Rightarrow 12 \text{ ml of } \text{CaCO}_3$
 In 18 ml \Rightarrow Total hardness = $18 \times 12 \Rightarrow 216 \text{ mg/l}$
 CaCO_3

(Ans) Permanent hardness :-

- * 12 ml of EDTA x 12 mg/ml
- * 144 mg/l of CaCO_3

Temporary hardness = Total - permanent

$$\Rightarrow 216 - 144 \Rightarrow 72 \text{ mg/l}$$

Softening Methods :-
Water used for industrial purpose should be significantly pure.

Process of removing hardness producing salts from water, is known as softening of water.

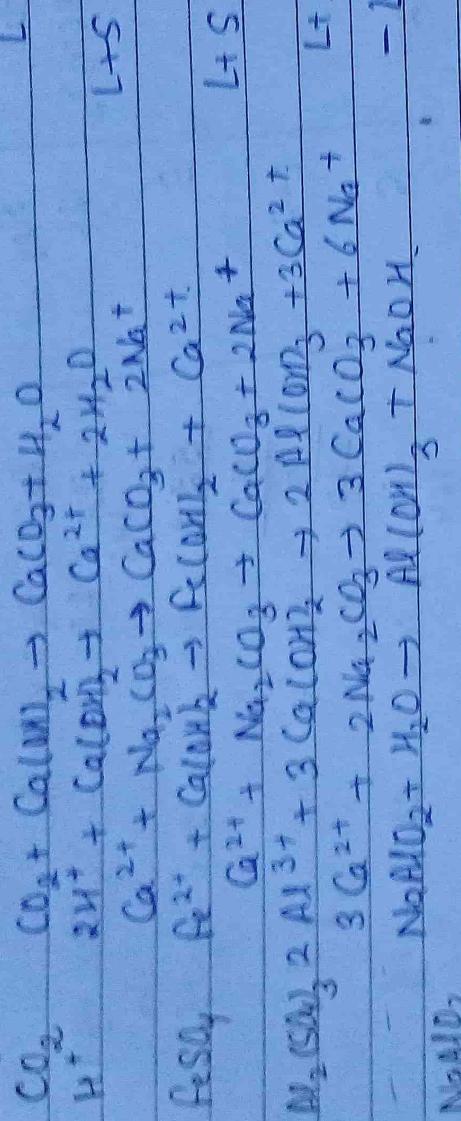
a) Lime - Soda Process :- (15-30 ppm)



In this process, CaCO_3 and $\text{Mg}(\text{OH})_2$ so ppted, are filtered off.

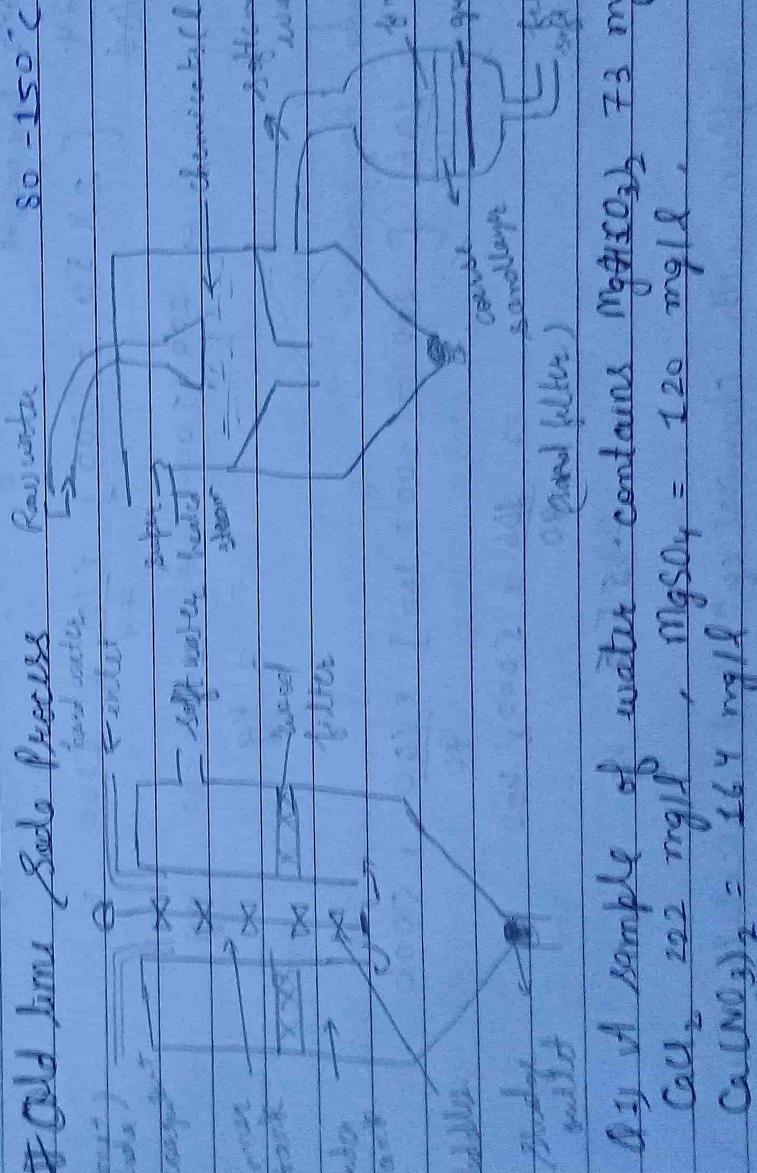
Constituent	Reaction	Need
Ca^{2+}	$\text{Ca}^{2+} + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{Na}^+$	S
Mg^{2+}	$\text{Mg}^{2+} + \text{Ca}(\text{OH})_2 \rightarrow \text{Mg}(\text{OH})_2 + \text{Ca}^{2+}$	L + S
Ca^{2+}	$\text{Ca}^{2+} + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{Na}^+$	L - S
HCO_3^-	$2\text{HCO}_3^- + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_3^{2-}$	L - S
$\text{Ca}(\text{HCO}_3)_2$	$\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \rightarrow 2\text{CaCO}_3 + 2\text{H}_2\text{O}$	L
$\text{Mg}(\text{HCO}_3)_2$	$\text{Mg}(\text{HCO}_3)_2 + 2\text{Ca}(\text{OH})_2 \rightarrow 2\text{CaCO}_3 + \text{Mg}(\text{OH})_2 + 2\text{H}_2\text{O}$	L
	\downarrow	
	$\text{[Ca}(\text{HCO}_3)_2 \text{ converted to]}$	

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2 NaOH is equivalent to $\text{Ca}(\text{OH})_2$

Old Lime Soda Process



Q1) A sample of water contains $\text{Mg}(\text{CO}_3)_2$ 73 mg/l
 CaCO_3 292 mg/l, MgSO_4 = 120 mg/l,
 $\text{Ca}(\text{NO}_3)_2$ = 164 mg/l

Calculate the quantity of lime (74% pure) and soda (90% pure) needed for softening 5000 l of water.

550-60 ppm] Old-lime,

Salts	Req	CaCO_3 equivalents
$\text{Mg}(\text{HCO}_3)_2$	2L	$\frac{73 \times 100}{146} \Rightarrow 50 \text{ mg/l}$
CaCl_2	S	$\frac{55.2 \times 100}{111} \Rightarrow 200 \text{ mg/l}$
MgSO_4	L+S	$\frac{120}{120} \times 100 \Rightarrow 100 \text{ mg/l}$
$\text{Ca}(\text{NO}_3)_2$	S	$\frac{164}{164} \times 100 \Rightarrow 100 \text{ mg/l}$

Lime requirement = $\text{Mg}(\text{HCO}_3)_2 + \text{MgSO}_4$
 Calcium, Lime weight

$$\frac{74}{100} \left[2 \times 50 + 100 \right] \times \frac{100}{74} \times 5000 \Rightarrow$$

$$\Rightarrow 200 \times 5000 \Rightarrow 10,00,000 \text{ mg.}$$

$$\Rightarrow 1 \text{ kg}$$

Soda Requirement =

$$\frac{10.6}{100} \left[200 + 100 \right] \times \frac{100}{90} \times 5000$$

$$\Rightarrow \frac{106}{90} \times 5000 \times 400$$

$$\Rightarrow 23555 \text{ kg}$$

- (2) Explain with chemical eq" and calculate the amount of lime and soda needed for softening 1 lakh litres of water contains the following:
 $\text{Mg} (7.3 \text{ mg/l}), \text{Al}_2(\text{SO}_4)_3 (34.2 \text{ mg/l}), \text{mg Cl}_2 (9.05)$
 $\text{Ca NaCl} (29.25)$
 Purity of lime 90%, Soda 98%.
 10% of chemicals are to be used in excess

If NaCl is a neutral salt doesn't participate in softening

$$2\text{NaCl} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$$

$$\text{Al}_2(\text{SO}_4)_3 + 3\text{Ca}(\text{OH})_2 \rightarrow 2\text{Al}(\text{OH})_3 + 3\text{CaSO}_4$$

$$\text{MgCl}_2 + \text{Ca}(\text{OH})_2 \rightarrow \text{Mg}(\text{OH})_2 + \text{CaCl}_2$$

$$\text{MgCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{MgCO}_3 + 2\text{NaCl}$$

$$\text{NaCl} = \frac{3.3}{36.5} \times 100 \Rightarrow 20 \text{ mg/l} \quad (L)$$

$$\text{Al}_2(\text{SO}_4)_3 = \frac{3042}{342} \times \frac{100}{10} \Rightarrow 10 \text{ mg/l} \quad (L)$$

$$\text{MgCl}_2 = \frac{9.5}{9.5} \times \frac{100}{10} \Rightarrow 10 \text{ mg/l} \quad (L + S)$$

Lime requirement =

$$\Rightarrow \frac{74}{100} [20 + 10 + 10] \times \frac{100}{90} \times 10^5$$

$$\Rightarrow 4440 \text{ g}$$

With 10% excess, lime req $\Rightarrow 4440 \times 1.1$

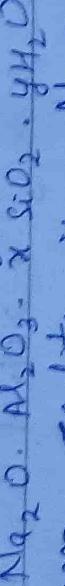
$$\Rightarrow 5484 \text{ g}$$

$$\text{Soda Req} = \frac{166}{100} [10] \times \frac{100}{98} \times 10^5$$

$$\Rightarrow 1189 \text{ g}$$

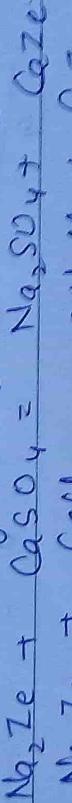
Permunt or Zeolite Process

Zeolite is hydrated sodium alumino silicate capable of exchanging reversibly its sodium for Ca^{2+} or Mg^{2+} , having general formula



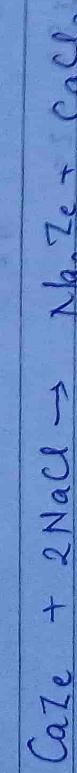
Natrolith.

Artificial zeolite used for softening purpose is
Permunt



Regeneration of Zeolite =

Process is also commercially successful since the
CaMg zeolites formed by passing hard water
through bed can be easily regenerated into
 Na_2Ze by passing brine through bed of
inactivated zeolites.



- Hardness of water can be removed comp upto 10 ppm.
 - less time for softening
- # Disadv = Coloured water or water containing suspended impurities cannot be used before filtration.
water containing acid cannot be used for softening

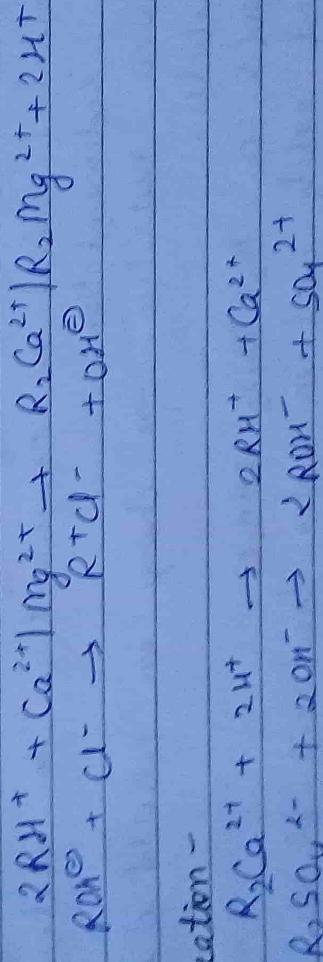
Ion Exchange or demineralization :-
Resins are organic polymers which are crosslinked having micro porous structure and the functional groups are attached to the chains which are responsible for ion exchange properties.

(a) Cation exchange -

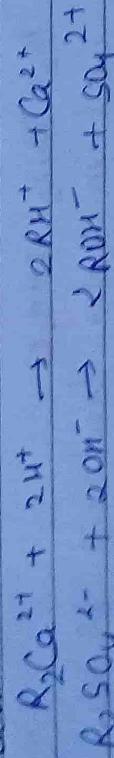
Phenol sulfonic acid formaldehyde resin, styrene - divinyl benzene copolymers which exchange their H^+ ions with cations present in water.

(b) Anion Exchange
Styrene divinyl benzene or amine for malachite copolymers.

Method -



Regeneration -



Draining Water or ll

- (a) Removal of suspended impurities
- * Screening - The raw water is passed through screens, having large number of holes when heating matters are retained by them.

* Sedimentation - It is a process of allowing water to stand undisturbed in big tanks, about 5 m deep, when most of suspended particles settle down at the bottom due to the force of gravity. The clear water is then drawn from tank with the help of pumps.

The sedimentation period in a sedimentation tank ranges from 2-6 hours. When water contains fine clay particles and colloidal matter, it becomes necessary to apply sedimentation with coagulation,

Sedimentation with coagulation -
process of removing fine suspended and colloidal impurities by addition of requisite amount of chemicals (called as coagulants) to water before sedimentation.
Coagulants neutralise -ve charge on colloidal clay particles.

* Alum ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$) is most widely used in water treatment plants.
 $Al_2(SO_4)_3 + Ca(HCO_3)_2 \rightarrow 2 Al(OH)_3 \downarrow + 3 CaSO_4 + 6 CO_2$

* $NaAlO_2 + 2H_2O \rightarrow Al(OH)_3 \downarrow + NaOH$.
pH range for best results is 5.5 - 8.0
 $Na_2SO_4 + 2 NaOH \rightarrow Mg(OH)_2 \downarrow + Na_2SO_4$

* $FeSO_4 + H_2O$ is commonly used for coagulation,
pH range = 8.5

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Fe(OH)₃ + H₂O + CO₂ → Fe(OH)₃·CO₂ + H₂O