Q.1 a) Hot lime soda is ~~be~~ preferred over cold lime soda because :

i) Coagulants are not required.

ii) Faster reactions take place.

iii) Mechanical stirrer is not required as the steam helps to mix the chemicals with water

iv) Time required for precipitation is less

c) Vol. of sample = 20 ml

Vol. of FAS for blank (V_2) = 14 ml

Vol. of FAS for excess unreacted dichromate (V_1) = 11 ml

Normality of FAS (N) = 0.1 N

$$COD = \frac{(V_2 - V_1) \times N \times 8 \times 1000}{\text{Vol. of sample}}$$

$$= \frac{(14 - 11) \times 0.1 \times 8 \times 1000}{20}$$

$$= 120 \text{ ppm}$$

d) Limitations of Zeolite method:

i) The water should not be acidic. If it is acidic, the acid will interfere with regeneration reaction of brine with ~~ze~~ exhausted zeolite.

ii) Water should not be turbid. ~~Tur~~ Turbidity in water may cause the zeolite membrane to break.

iii) It should not have coloured impurities like Mn^{2+}, Fe^{2+} which will form strong bonds with zeolite structure. Thus, the exhausted zeolite will be difficult to reg[...]te.

e)

Temporary hardness	Permanent hardness
(i) The hardness caused by CO_3^{2-} & HCO_3^- of Ca^+, Mg^+, other heavy metals is called temporary hardness.	(i) The hardness caused by Cl^-, SO_4^-, NO_3^- of Ca^+, Mg^+, other heavy metals is called permanent hardness.
(ii) This type of hardness can be removed by mere boiling.	(ii) This type of hardness can not be removed by mere boiling; it required softening methods.
(iii) Ex: $CaCO_3$, $MgCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$	(iii) Ex: $CaSO_4$, $MgSO_4$, $Ca(NO_3)_2$, $Mg(NO_3)_2$

f) Principle of Reverse Osmosis:

The flow of solvent molecules from a solution of lower concentration ~~to~~ (dilute) to a solution of higher concentration (concentrated), through a semi permeable membrane, when pressure greater than osmotic pressure is applied to the ~~higher~~ lower concentration solution, is called reverse osmosis.

Bleaching Powder : $CaOCl_2 \cdot H_2O$.

When Bleaching powder is mixed in water.

$$CaOCl_2 \cdot H_2O + H_2O \rightarrow CaOH_2 + HOCl$$

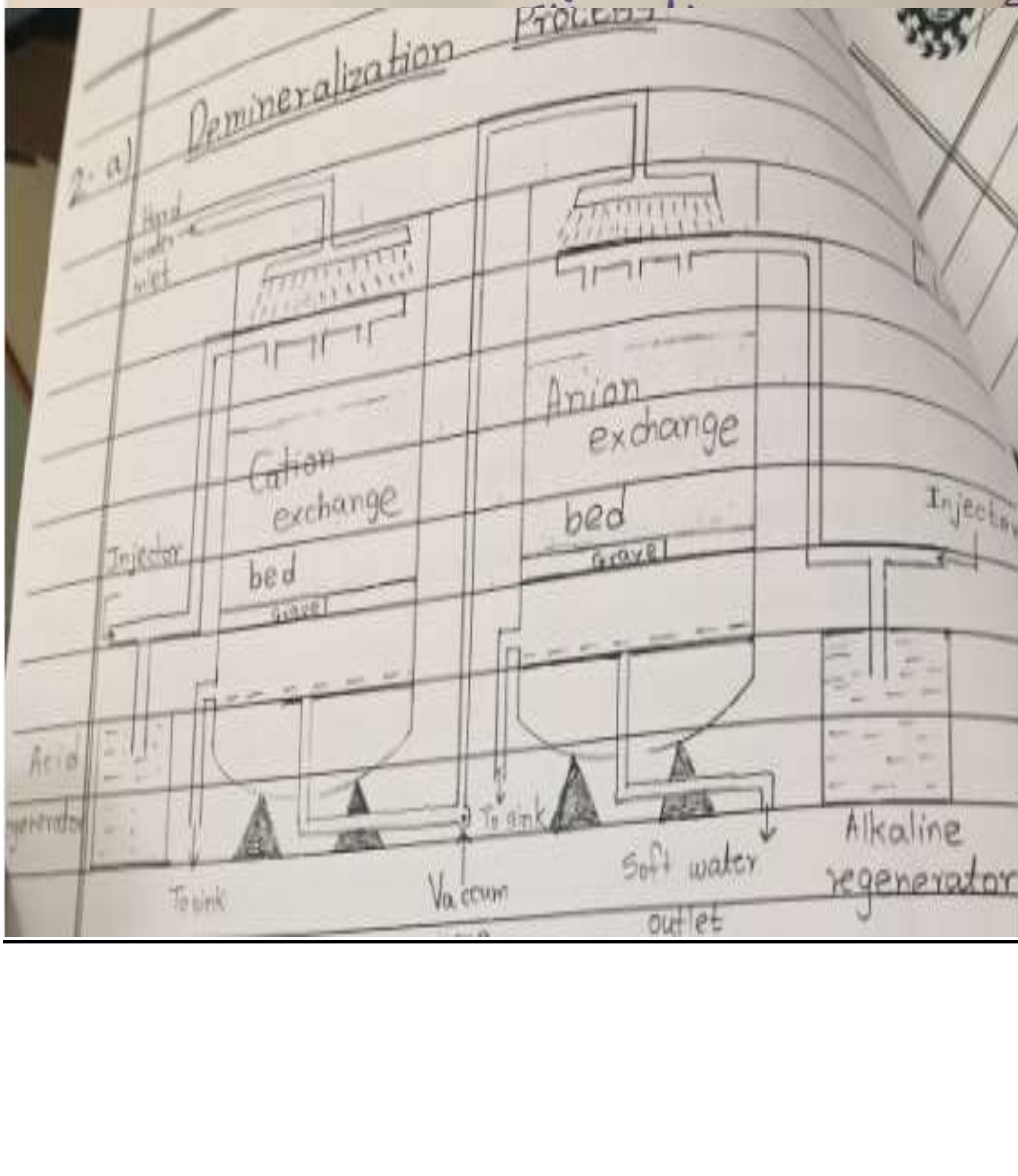
HOCl (Hyperchlorous acid) is the main disinfectant which kills the bacteria.

When $pH < 7$, the above process takes place, thus, killing the bacteria & pathogen.

But, when $pH > 8.5$, the HOCl disintegrates into ions.

$$HOCl \ (pH > 8.5) \longrightarrow H^+ + OCl^-$$

4- The function of a coagulant in cold lime process is to help the soluble impurities present in water to get converted into insoluble impurities eg. $FeSO_4$, $NaAlO_2$.



I] The process of softening in the ion exchange involves passing raw water first through the cation exchanger and then anion exchange resi

I] The equipment consists of two cylinders which contain the cation exchange resin [½ and anion exchange resin. The outlet from cation exchanger is connected to anion exchanger seperated outlets are provided for draining purposes.

The hard water is passed first through the cation exchange resin, it removes all the cations like Ca^{2+}, Mg^{2+} from it and equivalent amount of H^+ ions are released from this column to water.

PAGE NO.:

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

Thus sulphates, chlorides, bicarbonates get converted into sulphuric, hydrochloric & carbonic acids. [½]

This acidic water emerging from cation exchanger is passed through the anion exchange which removes all the anions like SO_4^{2-}, Cl^- etc. present & equivalent amount of OH^- ions are released from this column to water.

$$ROH + Cl^- \longrightarrow RCl + OH^-$$ [½]

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

These H^+ & OH^- will immediately combine & form water

$$H^+ + OH^- \longrightarrow H_2O$$

Regeneration of the cationic resin is done by passing ~~weak~~ dilute acid HCl [½]

$$R_2Ca + 2HCl \longrightarrow 2RH + CaCl_2$$

Regeneration of anionic resin is done by passing dilute base NaOH

$$RCl + NaOH \longrightarrow ROH + NaCl$$

b) 20,000 l of hard water → 0.1 N ...

$\Rightarrow$ 300 l of 0.1N NaOH

$= 300 \times 0.1$ l of 1 N NaOH

$= 30$ l of 1N NaOH

we know,

1N 1L of NaOH = 50 g of $CaCO_3$ eq

30 l 1N of NaOH = (30×50) g of $CaCO_3$ eq

= 1500 g of $CaCO_3$ eq

$= 1500 \times 10^3$ mg of $CaCO_3$ eq

20,000 l of water $\rightarrow 15 \times 10^5$ mg of $CaCO_3$ eq

1 l of water $\rightarrow \frac{15 \times 10^5}{20,000}$

= 75 mg of $CaCO_3$

... soda (95%)

Volume $= 5 \times 10^3$ ltr

Impurity	Amt (ppm)	Equi. wt	M.F	DOH (in ppm)
$Mg(HCO_3)_2$	144	73	$50/73$	$144 \times 50/73 = 98.63$
$CaSO_4$	136	68	$50/68$	$136 \times 50/68 = 100$
$CaCO_3$	45	50	$50/50$	$45 \times 50/50 = 45$
HCl	40	36.5	$50/36.5$	$40 \times 50/36.5 = 54.79$
Na_2SO_4	15	—	—	Doesn't contribute to hardness

$$\text{Lime} = \frac{74}{100}\left[\text{Temp } Ca^+ + 2 \times \text{Temp } Mg^+ + H^+\right] \times \frac{V}{10^6} \times \frac{100}{\%\text{ purity}}$$

$$= \frac{74}{100}(45 + 2 \times 98.63 + 54.79) \times \frac{5 \times 10^3}{10^6} \times \frac{100}{80}$$

= 1.374 kgs.

$$\text{Soda} = \frac{106}{100}\left[\text{Perm. } Ca + H^+\right] \times \frac{V}{10^6} \times \frac{100}{\%\text{ purity}}$$

$$= \frac{106}{100}\left[100 + 54.79\right] \times \frac{5 \times 10^3}{10^6} \times \frac{100}{95}$$

= 0.864 kgs

Principle of EDTA method

I] The principle of this method is based on the fact that hardness causing ions like Ca^{2+}, Mg^{2+} form unstable complexes with the indicator Eriochrome Black T.

II] However when such complex is titrated with EDTA, since EDTA has more affinity to form stable complex with metal ions, it extracts metal ions from metal ion dye complex to form stable EDTA complex.

III] The colour of dye metal complex and dye are different. However change in pH is sharper at pH 10 while dye itself is blue colour at pH 10.

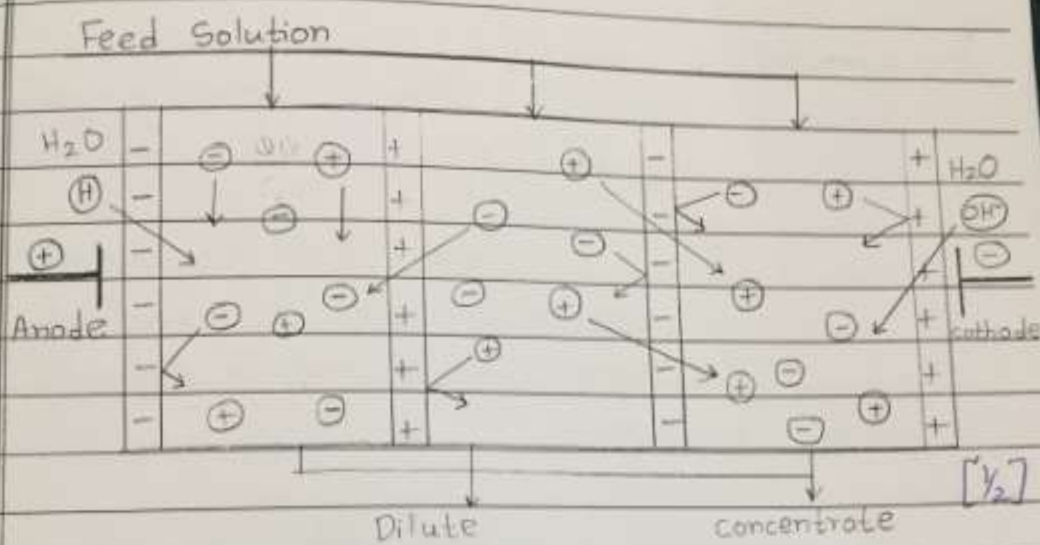
[iJ]

V] Hence by observing sharp change in colour, the exact end point of reaction involving complete extraction of metal ion by EDTA method can be determined. The result obtained by this method is more accurate than those obtained by soap solution meth

$$\underset{\text{Hard water}}{\{Ca^{2+}, Mg^{2+}\}} + \underset{\text{Indicator}}{\text{Eriochrome Black-T}} \xrightarrow{pH=10} \underset{\substack{\text{Unstable metal}\\ \text{ion-dye comple}\\ \text{(Wine red)}}}{\{Ca^{2+}, Mg^{2+}\ \text{Eriochr Black-T}\}}$$

$$\underset{\text{(Blue)}}{\{Ca^{2+}, Mg^{2+}\ \text{Eriochrome Black-T}\}} + EDTA \xrightarrow{pH=10} \underset{\substack{\text{Stable complex}\\ \text{(Colourless)}}}{\{Ca^{2+}, Mg^{2+}\ EDTA\}} + \text{Eriochrome Black T}$$

d) Electrodialysis process



[½]

I] Electrodialysis is a membrane process in which ions are transported through ion permeable membranes from one solution to another under the influence of an electrical potential gradient

II] Electrodialysis is used to transport salt ions from one solution through ion-exchange membran to another solution under the influence of an applied electric potential difference. [1]

Applications :-

Large scale brackish, and seawater desalina & salt production. [½]

Food processing

8

15% NaCl.

∴ 1 L → 150 g of NaCl.

∴ 200 L → 200 × 150 g of NaCl.

∴ In terms of $CaCO_3$ equi

$$\rightarrow \frac{200 \times 150 \times 50}{58.5} \text{ g of } CaCO_3.$$

w,

otal hard water softned $= \dfrac{200 \times 150 \times 50 \times 10^3}{58.5 \times \cancel{x} \, 400}$

~~where x = hardness of water.~~

∴ $x = \dfrac{200 \times 150 \times 50 \times 10^3}{58.5 \times 400}$

$= 64102.56$ L of hard w...

Q.3. 1 lt water → 0.28 g of $CaCO_3$

c) ① Standardization:

100 ml SHW → 28 ml EDTA

But 100 ml SHW → $0.28\,g \times \frac{100\ ml}{1000\ ml}$ g of $CaCO_3$

→ ~~0.28~~ 0.028 g of $CaCO_3$

→ 28 mg $CaCO_3$

∴ 1 ml EDTA → $\frac{28}{28}$ mg $CaCO_3$

∴ 1 ml EDTA → 1 mg $CaCO_3$

② 50 ml sample water → 20 ml EDTA

But, 20 ml EDTA → 20 × 1 mg $CaCO_3$

→ 20 mg $CaCO_3$

∴ 1000 ml sample water → $20 \times \frac{1000}{50}$ mg $CaCO_3$

→ 400 mg $CaCO_3$

∴ Total hardness = 400 mg/lt = 400 ppm

③ 25 ml boiled water → 5 ml EDTA

But, 5 ml EDTA → 5 × 1 mg $CaCO_3$

→ 5 mg $CaCO_3$

∴ 1000 ml boiled water → $5 \times \frac{1000}{25}$ mg $CaCO_3$

→ 200 mg $CaCO_3$

∴ Permanent hardness = 200 [illegible] lit = [illegible]00 ppm

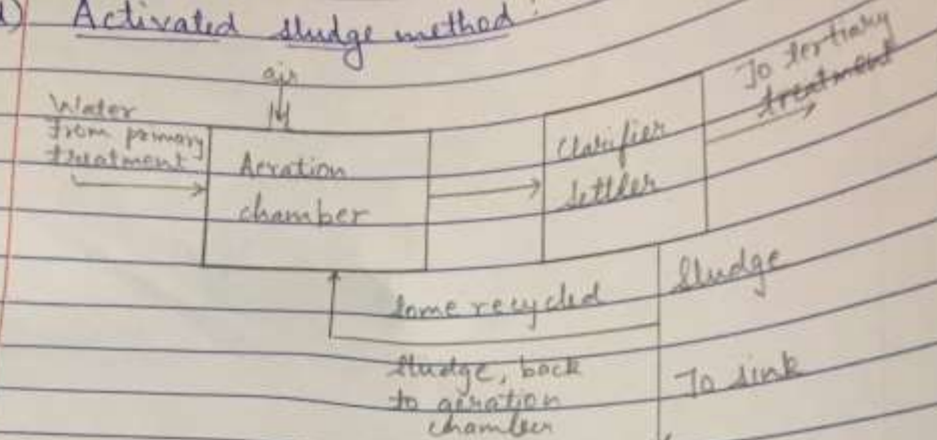
∴ Temporary hardness = Total hardness − Permanent hardness

= 400 − 200

= 200 ppm

Q.5]

d) Activated sludge method:



i) Water, after pre-limnary & primary treatment, is sent to aeration chamber.

ii) In the aeration chamber, micro-organisms are added intentionally & mixed with the water with the help of air & mechanical mixer. The reatension time is 4 to 24 hours

iii) The mixture is allowed to rest in the clarifier-settler tank. The retention time is 6 to 8 hours.

iv) The microorganisms grow well in the aerobic conditions. They break other organic matter into simpler substances.

v) As the microorganisms grow, they flocculate thus, forming sludge.

The sludge is removed by sedimentation & filteration. The sludge is dried in dryers & some of the sludge is recycled & sent back to aeration tank.

vii) The effluent water is sent for disinfection in tertiary treatment