MODULE :- 01

[2M] – Define (must ask)

[5M] – process and numerical

MODULE - I

Imp [2M]

Soft water :- water which does not prevent lathering with soap.

or

water which forms lather with soap.

Hard water :- water which prevent lather with soap.

or

water which does not forms lather with soap. But forms a white precipitate i.e scum. water containing bicarbonate $(HCO_3)_2$, chlorides Cl^- and sulphates SO_4 of Calcium (Ca^{2+}) And magnesium (mg^{2+}) is termed as Hard water

ex:-

(1) $2C_{17}H_{35}COONa + Ca(HCO_3)_2 \longrightarrow (C_{17}H_{35}COO)_2Ca + 2NaHCO_3$

sodium stearate

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

Calcium stearate

(3) $2C_{17}H_{35}COONa + mgSO_4 \longrightarrow (C_{17}H_{35}COO)_2mg + Na_2SO_4$

magnesium stearrate

Degree of Hardness :- It is the total quantity of Hardness causing Salt present in water

It is expressed in terms of $CaCO_3$ equivalent quantity.

$2C_{17}H_{35}COONa + mgCl_2 \longrightarrow (C_{17}H_{35}COO)_2mg + 2NaCl$

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

$2C_{17}H_{35}COONa \quad mgSO_4 \longrightarrow (C_{17}H_{35}COO)_2Mg + Na_2SO_4$

$2C_{17}H_{35}COONa \quad mg(HCO_3) \longrightarrow (C_{17}H_{35}COO)_2mg + 2NaHCO_3$

[2 m] Imp

Types of Hardness :

Carbonate :- $CaCO_3$, $MgCO_3$

Bicarbonate $Mg(HCO_3)_2$, $Ca(HCO_3)_2$

Causing Temporary Hardness

→ is Called Carbonate hardness or Alkaline hardness

→ If tempory Hard water is used in steam production, then sludge formation take place

Temporary Hardness

(1) It is caused by carbonates CO_3 and bicarbonates HCO_3 of calcium Ca^{2+} and magnesium Mg^{2+} in water.

(2) This hardness can be easily removed by Boiling the water

Due to boiling calcium Ca^{2+} and magnesium Mg^{2+} bicarbonates are converted into insalube carbonates which are easily removed.

(i) $$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow + H_2O + CO_2\uparrow$$
Calcium bicarbonate → Calcium Carbonate

(ii) $$Mg(HCO_3)_2 \xrightarrow{\Delta} Mg(OH)_2\downarrow + 2CO_2\uparrow$$
magnesium bicarbonate → magnesium Hydroxide

$CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$, $Ca(NO_3)_2$ and $Mg(NO_3)_2$

Causing permanent hardness

→ is called Non-Carbonate Hardness or non-alkaline hardness

→ If permanent Hard water is used in steam production, then scale formation take place.

permanent Hardness

(1) It is caused by dissolved chlorides, sulphates and Nitrates of Calcium Ca^{2+} and magnesium Mg^{2+}

(2) These salts cannot be removed by simple boiling

(3) It requires chemical treatment like lime soda method or softening method like ion exchonged.

zeolite method $Ca(HCO_3)_2 + Na_2Ze \rightarrow CaZe + 2NaHCO_3$

1 ppm = 1 $CaCO_3$ mg/L

1 $CaCO_3$ mg/L = 1 ppm

Units of Hardness of water :- 1 ppm = 1 $CaCO_3$ mg/L

(Imp) in numerical

Calculation of Equivalent of $CaCO_3$:-

The equivalent of $CaCO_3$ for hardness causing substance can be calculated by following formula

$$\text{Equivalent of } CaCO_3 = \frac{\text{mass of Hardness producing substance}}{\text{equv. wt of Hardness producing substance}} \times \text{equiv. wt of } CaCO_3$$

called multiplication factor

50

$$\text{Equivalent of } CaCO_3 = \frac{\text{mass of Hardness producing substance}}{\text{mole. wt of Hardness producing substance}} \times \text{mol. wt of } CaCO_3$$

100

Ca^{2+}/Mg^{2+} $\boxed{\text{C C S BiC N}}$ Trick to learn

	Salt	multiplication factor (equi. wt)	(mol. wt)
	Ca^{2+}	50/20	100/40
	Mg^{2+}	50/12	100/24
Carbonate	$CaCO_3$	50/50	100/100
	$MgCO_3$	50/42	100/84
Chloride	$CaCl_2$	50/55.5	100/111
	$MgCl_2$	50/47.5	100/95
Sulphate	$CaSO_4$	50/68	100/136
	$MgSO_4$	50/60	100/120
Bicarbonate	$Ca(HCO_3)_2$	50/81	100/162
	$Mg(HCO_3)_2$	50/73	100/146
Nitrate	$Ca(NO_3)_2$	50/82	100/164
	$Mg(NO_3)_2$	50/74	100/148

CO_2	50/22	100/44
HCl	50/36.5	100/~~36.5~~ 73
H_2SO_4	50/49	100/98
HCO_3^-	50/61	100/122

49

$CaCO_3$ 50

$MgCO_3$ 42

Ca^{2+} 20

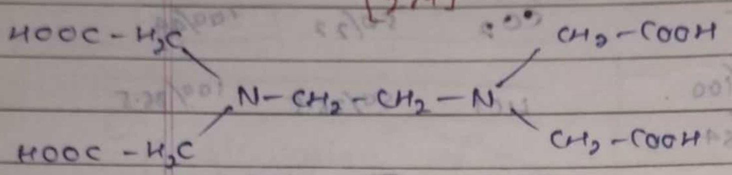
50

68

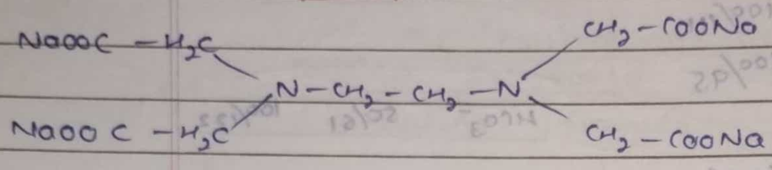
Estimation of hardness of water :-

ask structure [2M]

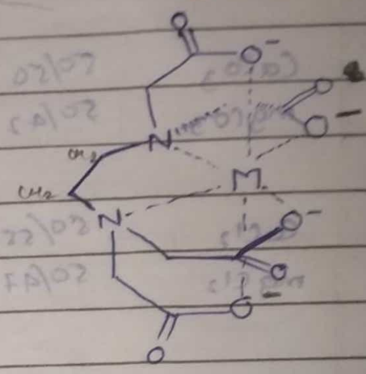
[2M]



EDTA



Di sodium salt of EDTA



EDTA complex with metal ion

EDTA titration method

(1) Estimation of hardness of water can be carried out by complexometric titration using EDTA as complexing agent and buffer at pH 10 against a std. solution of EDTA

(2) EBT as indicator, EBT when add to water form an unstable wine-red coloured complex with calcium (Ca^{2+}) and magnesium (Mg^{2+})

$$Ca^{2+}/Mg^{2+} + EBT \xrightarrow[NH_4-NH_4Cl]{pH\ 8.5-10\ buffer} [Mg^{2+}/Ca^{2+}-EBT]$$

(unstable wine-red complex)

(3) on the addition of EDTA, Disodium salt of EDTA react quickly with hardness causing metal ions to form cyclic co-ordinate complex (chelate).

(4) these complexes are replaced by stable complexes. At the end point, wine red complex disappears and the original blue colour of the dye appears

$$[Mg^{2+}/Ca^{2+}-EBT] + EDTA \xrightarrow[NH_4-NH_4Cl]{pH\ 8.5-10\ buffer} [Ca^{2+}/Mg^{2+}-EDTA] + EBT$$

coloured | stable complex | free (Blue)

50ml → 18 ml EDTA 50ml → 1 mg $CaCO_3$ → 20ml EDTA

50ml → 25 ml EDTA

Numerical

[5m] must ask

(1) 50ml of Hardness of water containing 1mg of pure $CaCO_3$ per ml consume 20ml of EDTA. 50ml of Hard water sample consume 25ml of EDTA solution. Use EBT Indicator. 50ml of water sample after boil and filtre consume 18ml of EDTA. Calculate various type of Hardness.

⇒

Strength of std Hard water = 1mg of $CaCO_3$ per ml

50ml of std Hard water = 50 mg of $CaCO_3$

50ml of std Hard water = 20ml of EDTA

∴ 20ml of EDTA = 50mg of $CaCO_3$

1ml of EDTA = $\frac{50}{20}$ mg of $CaCO_3$

Total Hardness :-

50ml of Hard water = 25ml of EDTA

$= 25 \times \frac{\cancel{50}}{\cancel{20}}$ mg of $CaCO_3$

For 1000ml of Hard water $= \frac{25 \times 5 \times \cancel{1000}^{500}}{\cancel{2} \times \cancel{50}}$ of $CaCO_3$

$\boxed{\text{Total Hardness of per litre of sample} = 1250 \text{ mg/L}}$

permanent Hardness :-

50ml of Hard water = 18ml of EDTA

$= 18 \times 50/20$ mg of $CaCO_3$

1ml of Hard water $= \frac{18 \times \cancel{50}}{\cancel{50} \times 20}$ mg of $CaCO_3$

∴ 1000ml of Hard water $= \frac{18 \times \cancel{1000}^{50}}{\cancel{20}}$ mg of $CaCO_3$

$\boxed{\text{permanent Hardness of per litre of sample} = 900 \text{ mg/L}}$

Total Hardness = Temporary Hardness + permanent Hardness

1250 = T.H + 900

$\boxed{T.H = 350 \text{ ppm}}$

Strength of SHW = 0.5 gm of $CaCO_3$ = 0.5 × 1000 mg of $CaCO_3$ = 25000

500 ml of SHW = 500 mg of $CaCO_3$

[5M]

(2) 0.5 gm of $CaCO_3$ was dissolved in 500 ml distilled water. 50 ml of this solution required 48 ml of EDTA for titration, 50 ml of Hard water sample required 15 ml of EDTA and after boil and filtered and same amount of solution requ. 10 ml of EDTA. Calculation Temporary Hardness

=> ~~Strength of Std Hard water = 0.5 g of $CaCO_3$~~ ~~$= \frac{0.5 \times 1000 \text{ mg}}{1000 \text{ ml}}$~~

~~0.5~~

500 ml of SHW contains 0.5 gm of $CaCO_3$ ~~0.5 gm $CaCO_3$ / 1000 ml of distilled water~~

500 ml of SHW contain 0.5×10^3 mg of $CaCO_3$ =

Strength of Std Hard water = 0.5 gm. of $CaCO_3$

1 ml of SHW contains $\frac{0.5 \times 10^3}{500}$ mg of $CaCO_3$ $= \frac{0.5 \times 1000 \text{ mg of } CaCO_3}{500 \text{ ml distilled water}}$

1 ml of SHW = 1 mg of $CaCO_3$

= 1 mg/L ~~of $CaCO_3$~~

50 ml of std Hard water = $\boxed{50 \text{ mg of } CaCO_3}$

50 ml of std Hard water = 48 ml of EDTA

~~1m of std Hard water = $\frac{48}{50}$ ml of EDTA~~

48 ml of EDTA = 50 mg of $CaCO_3$

1 m of EDTA = $\frac{50}{48}$ mg of $CaCO_3$

Total Hardness :-

50 ml of Hard water = 15 ml of EDTA

50 ml of H.W = $\frac{15 \times 50}{48}$ mg of $CaCO_3$

1 ml of Hard water = $\frac{15}{50} \times \frac{50}{48}$ mg of $CaCO_3$

1000 ml of Hard water = $\frac{15 \times 1000}{48}$ mg of $CaCO_3$

Total Hardness of per litre of sample	= 312.5 mg/L

Permonent Hardness :-

50 ml of Hard water = 10 ml of EDTA

$= 10 \times \frac{50}{48}$ of $CaCO_3$

1 ml of Hard water $= \frac{10 \times 50}{50 \times 48}$ of $CaCO_3$

1000 ml of Hard water $= \frac{10000}{48}$ of $CaCO_3$

Permonent Hardness per litre of somple = 208.3 mg/L

Total Hardness = Temporory Hardness + Permonent Hardness

312.5 = T.H + 208.3

T.H = 312.5
− 208.3

Temporory Hardness per litre of somple = 104.2 ppm

Permonent Hardness:-

100 ml of H.W = 25 ml of EDTA

100 ml of H.W $= \frac{25 \times 24}{30}$ mg of $CaCO_3$ eq.

1 ml of H.W $= \frac{25}{100} \times \frac{24}{30}$ mg of $CaCO_3$ eq.

1000 ml of H.W $= \frac{25 \times 1000 \times 24}{100 \times 30}$ mg of $CaCO_3$

permonent Hardness per litre of somple = 200 mg/ml

Total Hardness = T.H − P.H

400 = T.H − 200

Temporary Hardness per litre of sample = 200 ppm or mg/ml

(4) 1.3 gm of $CaCO_3$ was dissolved in HCl and the Solution made up to 1000ml with distilled water. 50ml of the solution 32ml of EDTA Sol. for titration. 50ml of Hard water Sample required 14ml of EDTA and After boiling and filtering required 8.5ml of EDTA Solution. Calculate Temporary, permanent and total Hardness of water

⇒ Strength of std Hard water = 1.3 gm of $CaCO_3$

$= \frac{1.3 \times 1000 \text{ mg of } CaCO_3}{1000 \text{ ml of distilled water}}$

= 1.3 mg/ml

1ml of Hard water = 1.3 mg of $CaCO_3$

$\boxed{50\text{ml of Hard water} = 50 \times 1.3 \text{ mg of } CaCO_3}$

50 ml of Hard water = 32 ml of EDTA

∴ 32ml of EDTA = 50×1.3 mg of $CaCO_3$

1ml of EDTA = $\frac{50 \times 1.3}{32}$ mg of $CaCO_3$

= 2.03 mg of $CaCO_3$

Total Hardness

50ml of Hard water = 14 ml of EDTA

= 14×2.03 mg of $CaCO_3$

= 28.42

1 ml of Hard water = $\frac{28.42}{50}$ mg of $CaCO_3$

1000ml of Hard water = $\frac{28.42 \times 1000}{50}$ mg of $CaCO_3$

$\boxed{\text{Total Hardness of per litre of Sample} = 568.4 \text{ mg/L}}$

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permanent Hardness :

50 ml of Hard water = 8.5 ml of EDTA

$= 8.5 \times 2.03$ mg of $CaCO_3$

1 ml of Hard water $= \frac{8.5 \times 2.03}{50}$ mg of $CaCO_3$

1000 ml of Hard water $= \frac{8.5 \times 2.03 \times 1000}{50}$ mg of $CaCO_3$

$\boxed{\text{permanent Hardness per litre of sample} = 345.1 \text{ mg/L}}$

Total Hardness = Temporary Hardness + permanent Hardness

Temporary Hordness = T.H − P.H

= 568.4 − 345.1

$\boxed{\text{Temporary Hardness} = 223.3 \text{ ppm or } \frac{mg}{ml}}$

(5) 0.25 gm of $CaCO_3$ was dissolved in HCl and the sol. made up to 250 ml with distilled water. 50 ml of the solution required 20 ml of EDTA solution for titration. 50 ml of Hard water sample required 18 ml of EDTA Hardness and 50 ml of same sample after boiling and filtering required 10 ml of EDTA solution. Calculate temporary of water

=> Strength of std Hard water = 0.25 gm of $CaCO_3$

$= \frac{0.25 \times 1000 \text{ mg of } CaCO_3}{250 \text{ ml of distilled } H_2O}$

= 1 mg of $CaCO_3$

50 ml of Hard water = 50 mg of $CaCO_3$

50 ml of Hard water = 20 ml of EDTA

20 ml of EDTA = 50 mg of $CaCO_3$

1 ml of EDTA $= \frac{50}{20}$ mg of $CaCO_3$

= 2.5 mg of $CaCO_3$

Total Hardness :-

$50 ml$ of Hard water $= 18 ml$ of EDTA

$= 18 \times 2.5$ of $CaCO_3$

$1 ml$ of Hard water $= \frac{18 \times 2.5}{50}$ of $CaCO_3$

$= 0.9$ of $CaCO_3$

$1000 ml$ of Hard water $= 0.9 \times 1000$ of $CaCO_3$

$\boxed{\text{Total Hardness per litre of sample} = 900 \frac{mg}{ml}}$ ~~of CaCO3~~

permonent Hardness :-

$50 ml$ of Hard water $= 10 ml$ of EDTA

$= 10 \times 2.5$ of $CaCO_3$

$1 ml$ of Hard water $= \frac{25}{50}$ of $CaCO_3$

$1000 ml$ of H.W $= \frac{\cancel{25}^{500} \times 1000}{\cancel{50}_{2}}$ ~~of Ca~~

$\boxed{\text{permonent Hardness} = 500 \frac{mg}{ml}}$

Total Hardness = Temporary Hardness + permonent Hardness

Temporary Hardness = Total Hardness - permonent Hardness

$= 900 - 500$

$\boxed{\text{Temporary Hardness} = 400 \text{ ppm or } \frac{mg}{ml}}$

Softening of water :

(1) water used in various industries or in boiler. This water should be free from all the impurities and hardness producing substance to avoid corrosion, foaming, priming, scale and sludge formation.

(2) The process of removing hardness causing impurities from water is called softening of water

LIME SODA PROCESS :

In this method

It uses
lime $Ca(OH)_2$
Soda Na_2CO_3

saluble Ca^{2+}/mg^{2+} ~~saltwater~~ salt in water $\longrightarrow$ chemically convert into insaluble compound

In this method saluble hardness causing impurities are converted into insaluble precipitates which can be removed by settling and filtration

Principle :

(1) lime and soda react with all the hardness causing impurities in water to convert them into precipitates which may be removed by settlement and filtration.

(2) following are few reaction taking place after addition of lime and soda.

(3) Both temporary and permanent hardness causing salt as well as dissolved gases, acids are converted into insaluble precipitates

$$\underbrace{\begin{matrix} Ca - \text{impurities} \\ mg - \text{impurities} \end{matrix}}_{\text{saluble}} \begin{matrix} \longrightarrow \\ \longrightarrow \end{matrix} \underbrace{\begin{matrix} \text{ppt } CaCO_3 \\ \text{ppt } mg(OH)_2 \end{matrix}}_{\text{Insaluble}}$$

Settle down $\rightarrow$ Filter $\rightarrow$ Soft water

L All temporary hardness impurity of Ca

2L All temporary hardness impurity of mg

S

$\boxed{\text{Reaction with lime}}$:-

reaction of lime to remove Temporary Hardness

$$\begin{cases} Ca(HCO_3)_2 + \underset{lime}{Ca(OH)_2} \longrightarrow 2\,Ca(C \\ Mg(HCO_3)_2 + 2\underset{lime}{Ca(OH)_2} \longrightarrow Mg(C \end{cases}$$

Constituents	requirement
$CaCO_3$ and $Ca(HCO_3)_2$, CO_2	L
$MgCO_3$ and $Mg(HCO_3)_2$	L+L = 2L
All permonent hardness impurity of Ca, i.e $CaCl_2$, $CaSO_4$, $Ca(NO_3)_2$	S
All permonent hardness impurity of Mg i.e $MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$	L+S
mineral acids like HCl, H_2SO_4, HNO_3	L+S
CO_2	L
$FeSO_4$ and $Al_2(SO_4)_3$	L+S
$NaHCO_3$	L−S
Impurities like NaCl, KCl, Na_2SO_4, K_2SO_4, SiO_2 and Fe_2O_3	Do not consume Lime and soda

reaction of lime to remove Permonent Hardness ↑ mg

① $MgCl_2 + \underset{lime}{Ca(OH)_2} \longrightarrow Mg(OH)_2 \downarrow + {}^{*}CaCl_2$

${}^{*}CaCl_2 + \underset{soda}{Na_2CO_3} \longrightarrow CaCO_3 \downarrow + 2NaCl$ } L+S

② $MgSO_4 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + {}^{*}CaSO_4$

${}^{*}CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + Na_2SO_4$ } L+S

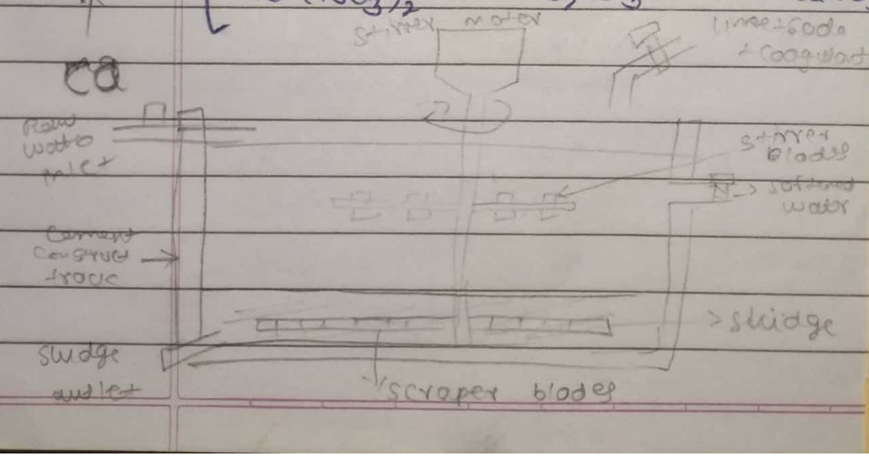
③ $Mg(NO_3)_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + {}^{*}Ca(NO_3)_2$

${}^{*}Ca(NO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2Na(NO_3)_2$ } L+S

$\boxed{\text{Reaction with soda}}$:- (Na_2CO_3)

reaction of ~~lime~~ soda to remove Permonent Hardness ↑ Ca

$$\left.\begin{array}{l} CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaCl \\ CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + Na_2SO_4 \\ Ca(NO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2Na(NO_3)_2 \end{array}\right\} S$$



$$CaCO_3 \text{ equivalent} = \frac{\text{Quantity of Hardness Producing substance}}{\text{eq/mol. weight of Hardness producing substance}} \times \text{eqv./mol. wt of } CaCO_3$$

$$\text{Lime} = \frac{74}{100}\left[\begin{matrix}CaCO_3 \text{ equiv. of} \\ \text{lime consuming} \\ \text{impurity}\end{matrix} - \begin{matrix}CaCO_3 \text{ eq. of} \\ \text{lime producing} \\ \text{impurity}\end{matrix}\right] \times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\,\text{purity}}$$

$$\text{Soda} = \frac{106}{100}\left[\begin{matrix}CaCO_3 \text{ equ. of} \\ \text{soda consuming} \\ \text{impurity}\end{matrix} - \begin{matrix}CaCO_3 \text{ eq. of} \\ \text{soda producing} \\ \text{impurity}\end{matrix}\right] \times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\,\text{purity}}$$

In ISE For [5M]

Numerical

① Calculate the quantity of lime (80%) pure and soda (95% pure) required to soften 75,000 litre of water containing following salts per litre.

Constituents	Quantity in ppm	multiplication factor	requi...	$CaCO_3$ equ.
$Mg(HCO_3)_2$	56	50/73	2L	38.356
H_2SO_4	4.9	50/49	L+S	5
$MgCl_2$	29.75	50/47.5	L+S	31.315
$CaCl_2$	141	50/55.5	S	127.02
NaCl	3.6	$\cancel{50/}$ -	-	-
SiO_2	26.2	$\cancel{50/}$ -	-	-

$$lime = \frac{74}{100}\left[2\times 38.356 + 5 + 31.315\right] \times \frac{75000}{1000} \times \frac{100}{80}$$

$$= \frac{74 \times 113.027 \times 75}{80} = 7841.2\ g \qquad = 7.8412 \times 10^{-3}\ g$$

$$= \underline{7.8412 \times kg}$$

$$Soda = \frac{106}{100}\left[5 + 31.315 + 127.02\right] \frac{75000}{1000} \times \frac{100}{95}$$

$$= \frac{106 \times 163.335 \times 75}{95}$$

$$= 13668.56\ g$$

$$= 13.66 \times 10^{-3}\ g \qquad = \underline{13.66 \times kg}$$

② Calculate the quantity of lime (90% pure) and soda (95% pure) required to soften 50,000 litre water containing following impurities

Constituent	Quantity	M.F	requirement	$CaCO_3$ equ.
$Mg(HCO_3)_2$	54	50/73	2L	36.98
H_2SO_4	9.8	50/49	L+S	10
$CaCl_2$	24	50/55.5	S	21.621
NaCl	8.6	-	-	-
SiO_2	16.2	-	-	-
$MgCl_2$	20	50/47.5	L+S	21.05

$$lime = \frac{74}{100}\left[\begin{matrix}2\times 36.98 + 10 \\ + 21.05\end{matrix}\right] \times \frac{50000}{1000} \times \frac{100}{90}$$

$$= \frac{74 \times \cancel{83.96}^{105.01} \times 5}{9} = 4317.07 = 4.317 \times 10^{-3} g$$

$$= \underline{4.317 \times kg}$$

$$soda = \frac{106}{100}\left[\begin{matrix}21.621 + 21.05 \\ + 10\end{matrix}\right] \frac{50000}{1000} \times \frac{100}{95}$$

$$= \frac{106 \times \cancel{31.621}^{52.671} \times 50}{95} = 2938.48 g = 2.938 \times 10^{-3} g$$

$$= \underline{2.938 \times kg}$$

do as practice 2

(3) Calculate the quantity of lime (90% pure) and soda (95% pure) required to soften 50,000 liters of water containing following salt per litre:

Constituent	Quantity	multiplication factor	requirement	$CaCO_3$ equivalent
$mg(HCO_3)_2$	55	50/73	2L	37.67
H_2SO_4	4.9	50/49	L+S	5
$CaCl_2$	28	50/55.5	S	25.225
$mgCl_2$	10	50/47.5	L+S	10.5
NaCl	3.6	–	–	
SiO_2	26.2	–	–	

$$lime = \frac{74}{1000}\left[2\times 37.67 + 5 + 10.5\right] \frac{50000}{1000} \times \frac{100}{90}$$

$$= 8.2\left[\quad 90.84\right]\times 5 = 744.8 \times 5 = 3724 g$$

$$= 3.724 \times 10^{-3} kg$$

$$= \underline{3.724 kg}$$

$$soda = \frac{106}{100}\left[5 + 25.225 + 10.5\right] \frac{50000}{1000} \times \frac{100}{95}$$

$$= \left[\quad 40.725 \quad\right] 0.526 \times 106$$

$$= 55.78 \times 40.725$$

$$= 2271.6405$$

$$= 2.271 \times 10^{-3} g$$

$$= 2.271 kg$$

75

(Q9) Calculate the quantity of lime (80% pure) and soda (85% pure) required to soften 10^6 liters of water containing following salts per litre

Constituent	Quantity	multiplication factor	requirement	$CaCO_3$ equivalent
$Ca(HCO_3)$	162	50/81	L	100
$MgCl_2$	9.5	50/47.5	L+S	10
$CaCl_2$	111	50/55.5	S	100
CO_2	44	50/22	L	100
$Mg(HCO_3)_2$	7.3	50/73	2L	5
$MgSO_4$	60	50/60	L+S	50
NaCl	3.6			
HCl	36.5	50/36.5	L+S	50

$$lime = \frac{74}{100}\left[100 + 10 + 100 + 10 + 50 + 50\right] \times \frac{1000000}{1000} \times \frac{100}{80}$$

$$= 74 \times \frac{\cancel{270}\ 320}{8} \times 100 = \cancel{249750\ g} \quad = 296000\ g$$

$$\cancel{= 249.750 \times 10^{-3} g} \quad = 2961 \times 10^{-3}\ g$$

$$\cancel{= 249.75\ kg} \quad = 296\ kg$$

$$soda = \frac{106}{100}\left[10 + 100 + 50 + 50\right] \times \frac{10000000}{1000} \times \frac{100}{85}$$

$$= \frac{106 \times 210}{85} \times 1000 = 261882\ g$$

$$= 261.882 \times 10^{-3} g$$

$$= 261.882 \times kg$$

1m = 10 lakh
= 1000000

(5) Calculate the quantity of lime (90% pure) and washing soda (100% pure) required for treating one million liters of water containing following impurities

Constituent	Quantity	multiplication factor	requirement	$CaCO_3$ equivalent
$CaSO_4$	236	50/68	S	~~196.667~~ 173.529
$MgSO_4$	10	50/60	L+S	8.33
$MgCl_2$	55	50/47.5	L+S	57.89
H_2SO_4	45	50/49	L+S	45.91
SiO_2	50	—	—	—

$$Lime = \frac{74}{100}\left[(8.33) + (57.89) + 45.91)\right] \frac{10^6}{1000} \times \frac{100}{90}$$

$$= 74 \frac{(112.13)}{9} \times 10000 = \frac{8297.62 \times 1000}{9}$$

$$= 921.957 \times 100$$

$$= 92195.7$$

$$= 92.201 \times 10^{-3}\ g$$

$$= 92.01 \times kg$$

$$Soda = \frac{106}{100}(173.529 + 8.33 + 57.89 + 45.91) \times \frac{1000000}{1000}$$

$$= \cancel{106(285.659) \times 1000}$$

$$= \cancel{30279.854}$$

$$= 106(285.659) \times \frac{1000000}{10^3}$$

$$= \cancel{30279.854}$$

$$= \cancel{302.79\ 10000 \times 10^{-3} g}$$

$$= 30279.854 \times 10$$

$$= 302798.54 \times g$$

$$= 302.79 \times 10^{-3}\ g$$

$$= 302.79 \times kg$$

(6) Calculate the amount of lime (90% pure) and soda (95% pure) required to soften 75,000 liters of water containing following impurities.

Constituent	Quantity	M.F	requirement	$CaCO_3$ eqv.
$Mg(HCO_3)_2$	56	50/73	2L	38.356
$CaCl_2$	141	50/55.5	S	127.02
$MgCl_2$	29.75	50/47.5	L+S	31.31
H_2SO_4	4.9	50/49	L	5
NaCl	3.6	-	-	-
SiO_2	26.2	-	-	

$$lime = \frac{74}{\cancel{100}}\left[2\times 38.35 + 31.31 + 5\right]\frac{75,000}{\cancel{1000}} \times \frac{\cancel{100}}{90}$$

$$= 74 \times \frac{113.01 \times 75}{90} = 6968.95\ g$$

$$= 6.968 \times 10^{-3} g$$

$$= \underline{6.968 \times kg}$$

$$soda = \frac{106}{\cancel{100}}\left[127.02 + 31.31\right] \times \frac{75000}{\cancel{1000}} \times \frac{\cancel{100}}{95}$$

$$= 106 \times \frac{158.335 \times 75}{95} = 13250.13$$

$$= 13.25 \times 10^{-3} kg$$

$$= \underline{13.25 \times kg}$$

derived from two greek words
Zein (boiling) and Lithos (stone)

Zeolite ~~and~~ or Permutit process :

zeolite is hydrated Sodium Alumino Silicate. (Na_2Ze in short)

$$Na_2O \cdot Al_2O_3 \cdot xSiO_2 \cdot yH_2O$$

$x = 2-10$, $y = 2-6$

→ zeolite is capable of exchanging hardness causing ions like Ca^{2+}, Mg^{2+}

→ removal of hardness of water sodium zeolite (Na_2Ze) is used.

Two Types

Natural zeolite

- They are derived from green sands by heating them with NaOH.
- They are have lower exchange capacity but more durable

Synthetic zeolite

- They are porous and are prepared by heating Sodium Silicate, Sodium aluminate and aluminum sulphate.
- They are have Better exchange capacity but less durable

principle :

- zeolite can be represented as Na_2Ze.
- When hard water is passed through a bed of active granular Na_2Ze then loosely held sodium ions of [Sodium zeolite get exchange with heavy metal ion like Ca^{2+}, Mg^{2+} etc.] in water to make the water soft.
- Sodium zeolite (Na_2Ze) is converted into calcium ($CaZe$) and magnesium ($MgZe$) zelolite

$$Ca(HCO_3)_2 + Na_2Ze \rightarrow CaZe + 2NaHCO_3$$

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

unta hi NaCl lago hoga jitna Ca and Mg replace karne me laga

⇓

get hardness

Ca^{2+}/Mg^{2+} Hard water
⇓
convert
$CaZe/MgZe$ Zeolite Bed (Na_2Ze) (exhausted) ⇐ add NaCl (Brine Sol)
$CaZe/MgZe$
⇓
Na^+ Soft water
⇓
$Na_2Ze + CaCl_2/MgCl_2$

→ do not cause hardness therefore is

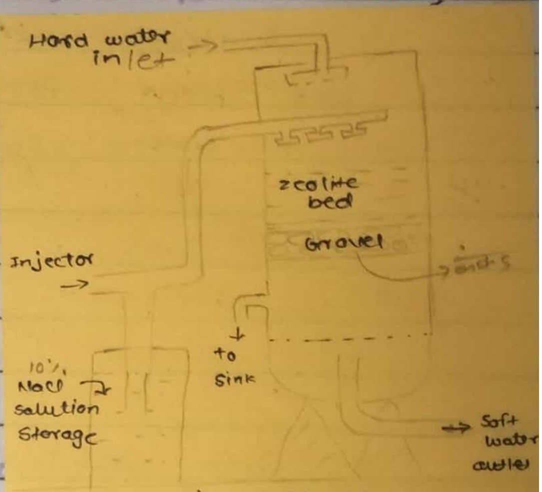
Date
Page 21

(1) Softening :

- In this process hard water is percolated through the bed of granular sodium zeolite ie Na_2Ze.

- Ca^{2+} and Mg^{2+} from water are retained by the zeolite and

- the water coming out from outlet contain sodium.



zeolite softener

Reaction taking place during softening process are :

$Ca(HCO_3)_2 + Na_2Ze \longrightarrow CaZe + 2NaHCO_3$

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

$CaCl_2 + Na_2Ze \longrightarrow CaZe + 2NaCl$

$MgSO_4 + Na_2Ze \longrightarrow MgZe + Na_2SO_4$

$MgCl_2 + Na_2Ze \longrightarrow CaZe + 2NaCl$

$CaSO_4 + Na_2Ze \longrightarrow MgZe + Na_2SO_4$

Advantages of zeolite process :-

(1) In this process water about less than 15 ppm Hardness produced.

(2) requires less time for softening.

(3) The process can be made automatic and continuous

(4) The equipment requires less space.

(5) Its operation is easy and simple.

(2) Regeneration :

- When the zeolite bed is exhausted completely it can be regenerated by using brine (10% NaCl).

- Brine is most widely used because it is cheap and product formed by it in regeneration are $CaCl_2$ and $MgCl_2$ which are Highly soluble

Reaction taking place are :

$CaZe + 2NaCl \longrightarrow CaCl_2 + Na_2Ze$

$MgZe + 2NaCl \longrightarrow MgCl_2 \quad Na_2Ze$

Disadvantage :-

(1) The treated water contains more sodium salt than in lime-soda process.

(2) water with High acidity and High alkalinity can't be introduced in zeolite softener.

(3) water containing large quantities of Fe^{2+} and Mn^{2+} when passed through bed, the ions get converted into their respective zeolite which can't be regenerated easily.

(4) The method only replace Ca^{2+} and Mg^{2+} ions, but acidic ions (like HCO_3 and CO_3) leaves behind in the softened water.

For ISE [5M]

(4) The hardness of 20,000 litres of hard water sample was completely removed by passing it through a zeolite Softener. The zeolite softener requires 600 litres of sodium chloride sol. Containing 11g of NaCl per litre for regeneration. Determine the hardness of water sample.

=> amount of NaCl = 600 × 11 g

= 6600 × 1000 mg

= 6600000 mg

$CaCO_3$ equ. of Hardness $= 6600000 \times \frac{50}{58.5}$

$= 5641025.641$ mg of $CaCO_3$

Hardness of 20000 litre of water sample $= 5641025.641$

Hardness of 1 litre of water sample $= \frac{5641025.641}{20000}$ mg/L

$= 282.05$

$\boxed{\text{Hardness of water sample} = 282.05 \text{ ppm}}$

Volume

(5) A zeolite softener was completely exhausted and was regenerated by 50 litre of NaCl solution containing 115 gm per litres of NaCl. How many litres of sample of water of hardness 450 ppm can be softened by this softner.

1 litre of NaCl = 115 gm per litre of NaCl

50 litre of NaCl = 115 × 50 g of NaCl

= 5750 g of NaCl

= 5750 000 mg of NaCl

$CaCO_3$ of equivalent $= 5750000 \times \frac{50}{58.5}$

$= 4914529.915$

Hardness of water $= \frac{CaCO_3 \text{ of equivalent}}{\text{Volume of water}}$

Volume of water $= \frac{CaCO_3 \text{ of eq.}}{\text{Hardness of water}}$

$= \frac{4914529.915}{450}$

$\boxed{\text{Volume of water} = 10921.1 \text{ ppm}}$

(6) The hardness of 10500 litres of hard water sample was completely removed by passing it through a zeolite softener. The zeolite softener requires 5500 litres of sodium chloride solution containing 1000 mg of NaCl per litre for regeneration. Determine the hardness of water sample.

=> amount of NaCl $= 5500 \times 1000$

$= 5500000$ mg ↳ already in milligram

$CaCO_3$ equivalent of Hardwater $= 5500000 \times \frac{50}{58.5}$

$= 4700854.7$

Hardness of 10500 litres of hard water $= 4700854.7$

Hardness of 1 litres of Hard water $= \frac{4700854.7}{10500}$

$\boxed{\text{Hardness of water sample} = 447.7 \text{ ppm}}$

Volume

(9) A zeolite softener was completely exhausted and was regenerated by 55 liters of NaCl solution containing 118gm per litre of NaCl. How many litres of sample of water of hardness 350 ppm can be softened by this softener.

⇒

amount of NaCl = 55 × 118 g
= 6490 g = 6490000 mg

$CaCO_3$ of equivalent = $6490000 \times \frac{50}{58.5}$

= 5547008.54 mg

$\boxed{\text{Hardness of water} = \frac{CaCO_3 \text{ of equivalent}}{\text{Volume of water}}}$

Volume of water = $\frac{CaCO_3 \text{ of equivalent}}{\text{Hardness of water}}$

= $\frac{5547008.54}{350}$

$\boxed{\text{volume of water} = 15848.5 \text{ litre}}$

(9) An exhausted zeolite softener and was regenerates by 75 litre of NaCl solution having strength of 75 g/l If hardness of water is 300 ppm then calculate the total volume that can be softened by zeolite softener.

amount of NaCl = 75 × 75 g
= ~~1125~~ 5625 g
= ~~1125000~~ 5625000 mg

$CaCO_3$ equivalent of Hardness = $\frac{\cancel{1125000}\ 5625000 \times 50}{58.5}$

= ~~961538.46~~ 4807692.3

Volume of water = $\frac{CaCO_3 \text{ equivalent}}{\text{Hardness of water}}$ = $\frac{\cancel{961538.46}\ 4807692.3}{300}$

= 16025.64

$\boxed{\text{Total volume of water} = 1.6 \times 10^4 \text{ litre}}$

(8) A zeolite softener was completely exhausted and was regenerated by 48 liters of NaCl sol. Containing 105 gm per liter of NaCl. How many liters of Sample of water of hardness 255 ppm can be softened by this softener?

⇒ amount of NaCl $= 48 \times 105$ g

$= 5040 \times 1000$ mg

$= 5040000$ mg

$CaCO_3$ equivalent of Hardness $= 5040000 \times \frac{50}{58.5}$

$= 4307692.3$

volume of water $= \frac{CaCO_3 \text{ of equivalent}}{\text{Hardness of water}}$

$= \frac{4307692.3}{255}$

$\boxed{\text{Volume of water} = 16892.9 \text{ litres}}$

For practice

(10) The zeolite softener was complete exhausted and was regenerated by passing 100 litre of NaCl solution. Containing 60 gram/litre of NaCl. How many litre of water Hardness 400 ppm can be softener by the softener (Ans = 1.28×10^4 L)

amount of NaCl $= 100 \times 60$ g

$= 6000 \times 1000$ mg

$= 6000000$ mg

$CaCO_3$ equivalent of Hardness $= 6000000 \times \frac{50}{58.5}$

$= 5128205.128$ mg

Hardness of water $= \frac{CaCO_3 \text{ of equivalent}}{\text{volume of water}}$

volume of water $= \frac{5128205.128}{400}$

$= 12820.6282$

$\boxed{\text{volume of water} = 1.28 \times 10^4 \text{ L}}$

In an ion-exchanger, all hardness causing cation are removed by cation exchanger while anion-exchanger remove anion of the constituent present in water

Ion exchange or Demineralization - the amount of acid used for generation of cation resin refers to the Hardness of H_2O

- In this process of removal of ions (both cations and anions) from a sample of water. Since it removes all inorganic minerals
  ↳ It is termed as demineralization process

- Ion exchanger resins → Insoluble cross linked → long chain organic molecules with a micro porous structure
  ↓
  functional group attached to the chain → are responsible for the ion exchanging properties.

Classified into two types

Cation exchange resins

(1) They are capable of exchanging H^+ ions with other cations and they always contain $-COOH^+$ or $-SO_3H^+$ as functional group

(2) represented RH_2

e.g Divinyl benzene copolymer, formaldehyde resin

Dowex - 50

Anions exchange resins

Quaternary ammonium → $R_3N^+OH^-$

Quaternary phosphanion → $R_3P^+OH^-$

(1) They are capable of exchanging OH^- ions with other anion

(1) These resins containing basic functional group $-NH_2$

(2) The (OH^-) is loosely bonded to the group and easily exchange with all anions present in water

(3) represented $R'(OH)_2$

e.g copolymer of styrene and divinyl benzene,

Amberlite 400 etc.

Dowex - 3

Principle :- ① When raw water passes through cation exchanger resin, all cation from water are absorbed in exchange of H^+ – thus, sulphates, chlorides and bicarbonates are converted into corresponding acid HCl, H_2SO_4 and H_2CO_3.

② After this when it passes through anion exchanger resins, all anions are absorbed in exchange OH^-.

– The water obtained is of distilled water quality.

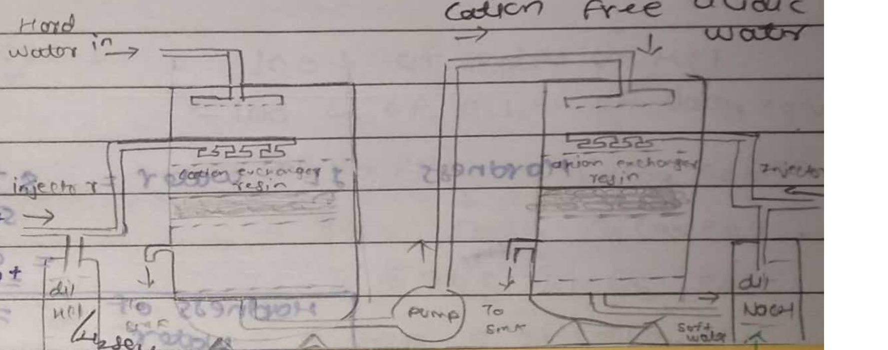
$Ca^{+2}Cl_2$
$Mg^{+2}Cl_2$ Na^+Cl^-
K^+Cl^-

Reaction of cation exchanger resin :

$H_2R + 2Na^+ \longrightarrow Na_2R + 2H^+$

$RH_2 + Ca^{2+} \longrightarrow CaR + 2H^+$

$RH_2 + Mg^{2+} \longrightarrow MgR + 2H^+$



Reaction of anion exchanger resin :

$R'(OH)_2 + 2Cl^- \longrightarrow R'Cl_2 + 2(OH)^-$

$R'(OH)_2 + 2HCO_3^- \longrightarrow R'(HCO_3)_2 + 2(OH)^-$

$R'(OH)_2 + SO_4^{-2} \longrightarrow R'SO_4 + 2(OH)^-$

Advantages :-

(1) It can be used to soften highly acidic water.
(2) It can be used to soften highly alkaline water.
(3) very fast process
(4) soft water formed is suitable for high pressure boilers
(5) water of nearly zero hardness can be obtained.

Disadvantage :-

(1) Equipment used is costly.
(2) chemical used are expensive.
(3) Resins are costly.
(4) The plant used occupies more space
(5) If turbid water is used, turbidity must be removed first.

Regeneration : when anion and cation exchangers are used, they get exhausted and stop working. To regenerated,

dil HCl is poured over cation exchanger

$CaR + 2HCl \longrightarrow RH_2 + CaCl_2$

$Na_2R + 2HCl \longrightarrow RH_2 + 2NaCl$

dil NaOH is poured over anion exchanger

$RSO_4 + 2NaOH \longrightarrow R(OH)_2 + Na_2SO_4$

$RCl_2 + 2NaOH \longrightarrow R(OH)_2 + 2NaCl$

$R(HCO_3)_2 + 2NaOH \longrightarrow R(OH)_2 + 2NaHCO_3$

Note :- $1N$ of $CaCO_3$ equ. $= 50g$

Numerical :-

① After treating 50000 L of water by ion exchanger, the cationic resin required 350 L of 0.5N HCl and anionic resin required 350 L of 0.5N NaOH solution for regeneration. Calculate hardness of water sample.

⇒ In an ion-exchanger, all hardness causing cation are removed by cation exchanger while anion exchanger removed anion of constituent present in water.

Hence, amount of the acid used for regeneration of cation resin refers ~~as~~ to the hardness of water.

Total Hardness 50000 L water $= 350 L$ of $0.5N\ HCl$
$= 350 L$ of $0.5N\ CaCO_3$ eq.
$= (350 \times 0.5) L$ of $1N\ CaCO_3$ eq.
$= 175 L$ of $1N\ CaCO_3$ eq.
$= (175 \times 50) g$ of $CaCO_3$ eq.
$= 8750\ g$ of $CaCO_3$ eq.

Hardness 1L water $= \frac{8750}{50000}$
$= 0.175\ g$ of $CaCO_3$ equivalent
$= 0.175 \times 1000\ mg$ of $CaCO_3$ eq.

$\boxed{\text{Hardness of water} = 175\ mg/L \text{ or ppm}}$

② After treating 10^4 L of water by ion exchanger, the cation resin required 400 L of 0.1N HCl and anion resin required 400 L of 0.1N NaOH sol. Find the Hardness of the above sample of water

⇒

Total Hardness 10^4 L water $= 400 L$ of $0.1N\ HCl$
$= 400 L$ of $0.1N\ CaCO_3$ equ.
$= (400 \times 0.1)$ ~~g~~ L of $CaCO_3$ equ.
~~= 40 g of $CaCO_3$ equivalent~~
~~= (40 × 50) g of $CaCO_3$~~
$= 40 L$ of $1N\ CaCO_3$
$= (40 \times 50) g$ of $CaCO_3$
$= 2000\ g$ of $CaCO_3$ eq.

Hardness 1 L of water $= \frac{2000}{10^4}$

$= 0.2$ g of $CaCO_3$ equivalent

$= 0.2 \times 1000$ mg of $CaCO_3$ eq.

$= 200$ mg of $CaCO_3$ eq.

Hardness of water $= 200$ mg/L or 200 ppm

ans = 50 ppm

(3) After treating 10^4 L of water by ion exchanger the cation resin required 100 L of 0.1N of HCl and anion resin required 100 L of 0.1N of NaOH

sol. Find the hardness of the above sample of water

$\Rightarrow$

Total Hardness 10000 L water $= 100$ L of 0.1N of HCl

$= 100$ L of 0.1 N of $CaCO_3$ equ

$= (100 \times 0.1)$ N of $CaCO_3$ equ

$= (10 \times 50)$ g $CaCO_3$ equ

$= 500$ g $CaCO_3$ eq.

Total Hardness of 1 L water $= \frac{5\cancel{00}}{10\cancel{000}}$ g of $CaCO_3$ eq.

$= 5 \times 10^{-2}$ g of $CaCO_3$ eq

$= 50 \times 10^{-3}$ g of $CaCO_3$ eq

$= 50$ mg of $CaCO_3$

Hardness of water $= 50$ ppm

1N of $CaCO_3$ = 50 g of

(4) After treating $10^3 L$ of water by ion exchanger the cation resin required 300 L of 0.1N HCl and anion required 300 L of 0.5N NaOH solution. Find the hardness of the above sample in water

→ ---

Total Hardness $10^3 L$ of water $= 300 L$ of 0.1 N HCl

$= 300 L$ of 0.1 N of $CaCO_3$ equv.

$= (300 \times 0.1) L$ of 1N of $CaCO_3$ eq.

$= 30 L$ of 1N of $CaCO_3$

$= (30 \times 50)$ g of $CaCO_3$

$= 1500$ g of $CaCO_3$

Hardness 1 L of water $= \frac{1500}{1000}$ g of $CaCO_3$ eq.

$= 1.5$ g of $CaCO_3$ eq

$= 1.5 \times 1000 \times 10^{-3}$ g $CaCO_3$ eq

$= 1500$ mg of $CaCO_3$ eq

~~= 1500 ppm~~

?

(5) After treating 10^4 L of water by ion exchanger, the cation resin required 100L of 0.1N HCl and anion resin required 100L of 0.5N NaOH solution. Find the hardness of the above sample of water?

Total Hardness 10^4L of water $= 100$L of 0.1 N of HCl

$= (10 \times 50)$ g of $CaCO_3$ eq.

$= 500$ g of $CaCO_3$

Hardness 1L of water $= \frac{500}{10000}$ g of $CaCO_3$ eq.

$= \frac{5}{100} \times 1000 \times 10^{-3}$ $CaCO_3$ eq

$= 50$ mg of $CaCO_3$ eq

$= 50$ ppm

[5M] or [2M]

Determination of water pollution : by BOD and COD

↳ Biological oxidation process

(1) BOD [Biochemical oxygen demand] :

① - BOD of water is a measure of the amount of oxygen required for the biological oxidation of organic matter under aerobic conditions at 20°C and for a period of 5 days

↳ oxygen avability

anerobic condition ↳ oxygen are not avalible reaction

$$\text{organic matter} + O_2 \xrightarrow{\text{micro-organism}} CO_2 + H_2O$$

- Higher the BOD of a sample, higher will be the pollution in it.

② - slow process, It requires 5 days

③ - BOD is normally less than COD.

BOD of water is a measure the amount of oxygen requires to Bactoria while decomposing organic matter under aerobic condition at 20°C and for period of 5 days

④ - Formulae :- before initial

$$BOD = (DO_b - DO_i) \times \text{Dilution factor}$$

$$BOD = (DO_b - DO_i) \times \left(\frac{\text{ml of sample after dilution}}{\text{ml of sample before dilution}}\right)$$

DO_b — dissolve oxygen before incubation

DO_i — dissolve oxygen after incubation

- Significance BOD :-

(1) It indicates the amount of decomposable organic matter in sewage.

? (2) It provides the degree of pollution at any time in the sewage stream.

? (3) From BOD values, the self - purifying capacity of stream can be determine the oxygen required for the complete oxidation of both biodegradable and non-biodegradable

(2) COD [Chemical oxygen demand] :
↳ chemical oxidation process

① - COD is defined as the amount of oxygen required by organic matter in a water sample for its oxidation by a strong oxidizing agent such as acidified

② - Fast process. It requires 2-3 hours.

③ - COD is always more than BOD

④ - Formulae :

$$COD = \frac{(Blank - Back) \times \text{Normality of FAS} \times 8 \times 1000}{\text{Volume of waste water or effluent or sewage}}$$

- Significant COD :

(1) It helps in designing water treatment plant.

(2) It measures the effect of pollutants (organic matter) on dissolved oxygen

[2M] numerical

Numerical :- BOD

① A 50ml of sample contains 830 ppm of dissolved oxygen. After 5 days the dissolved oxygen value becomes 220 ppm after the sample has been diluted to 80ml. Calculate the BOD of the sample.

$\Rightarrow$

$$BOD = (DO_b - DO_i) \times \text{dilution factor}$$

$$= (830 - 220) \times \frac{\text{ml of sample after dilution}}{\text{ml of sample before dilution}}$$

$$= 610 \times \frac{80}{50}$$

$$= 976 \text{ ppm}$$

② A 50 ml of sample contains 780 ppm of dissolved oxygen. After 5 days the dissolved oxygen value becomes 210ppm after the sample has been diluted to 75ml. Calculate the BOD of the sample

$\Rightarrow$

$$BOD = (DO_b - DO_i) \times \text{dilution factor}$$

$$= (780 - 210) \times \frac{\text{ml of sample after dilution}}{\text{ml of sample befor dilution}}$$

$$= 570 \times \frac{75}{50}$$

$$= 855 \text{ ppm}$$

③ A 50ml of sample contain 900 ppm of dissolved oxygen. After 5 days the dissolved oxygen value becomes 360ppm after the sample has been diluted to 95ml. Calculate the BOD of the sample

$\Rightarrow$

$$BOD = (DO_b - DO_i) \times \text{dilution factor}$$

$$= (900 - 360) \times \frac{\text{ml of sample after dilution}}{\text{ml of sample befor dil}}$$

$$= 540 \times \frac{95}{50}$$

$$= 540 \times \frac{95}{50} = 1026 \text{ ppm}$$

Numerical :- COD

① 6 ml of waste water was refluxed with 25ml of $K_2Cr_2O_7$ solution and after refluxing the excess unreacted dichromate required 20ml of 0.1N FAS solution. A blank of distilled water. refluxing with 25ml of $K_2Cr_2O_7$ solution required 35ml of 0.1N FAS solution. Calculate COD of waste water sample

⇒ $$COD = \frac{(\text{Blank} - \text{Back}) \times \text{Normality of FAS} \times 8 \times 1000}{\text{Valume of water}}$$

$$= \frac{(35 - 20) \times 0.1 \times 8 \times 1000}{6}$$

$$= \frac{15 \times 8 \times 100}{6} = 2000\ ppm$$

② Calculate the COD of an effluent sample if 25 c.c of the effluent sample required 8.3 c.c of 0.001M $K_2Cr_2O_7$ for oxidation.

⇒ COD = Valume of water = 25 c.c = 25ml

(Blank - Back) = 8.3 c.c = 8.3ml

$$COD = \frac{(8.3) \times \text{Normality of FAS} \times 8 \times 1000}{25}$$

$$= \frac{8.3 \times 0.001 \times 1000 \times 8}{25}$$

COD = 2.656 ppm