Numerical on Hardness

Simple Hardness

1. How many grams of $MgSO_4$ dissolved per litre gives 84ppm of hardness. **Ans: 0.1008 gram**
2. A water sample contains 204ppm of $CaSO_4$. Calculate the hardness. **Ans: 150ppm.**
3. Calculate temporary, permanent and total hardness of water sample containing: $Mg(HCO_3)_2$=14.6mg/L, $MgCl_2$=19.0mg/L, $MgSO_4$=24mg/L, $CaCL_2$=22.2mg/L, NaCl=5.35 mg/L.
   Ans: 10ppm, 60ppm, 70ppm.
4. A water sample on analysis was found to contain the following impurities: $Mg(HCO_3)_2$=7.3mg/L, $Ca(HCO_3)_2$=16.2mg/L, $MgSO_4$=12.0mg/L, $CaSO_4$=13.6,g/L, K_2SO_4=5.35 mg/L. Calculate temporary, permanent and total hardness of water sample.
   Ans: 15ppm, 20ppm, 35ppm.

Zeolite Process

1. A zeolite bed on softening 7000 liters of hard water required 60 liters of 10% NaCl solution for regeneration. Calculate the hardness of water in ppm. **Ans: 732.6 ppm.**
2. A water sample having hardness 250ppm was softened by zeolite process. The exhausted zeolite bed required 50 liters of 15% NaCl solution for regeneration. Calculate the quantity of water softened using the zeolite bed.
   Ans: 25641 liters.
3. A zeolite bed got exhausted after softening 5000 liters of hard water. Hardness of water was 250ppm. How many liters of 10% NaCl solution would be required to regenerate zeolite bed. **Ans: 14.7 liters.**
4. A zeolite softener was 90% exhausted when 10000 liters of hard water was passed through it. The softener required 200 liters of NaCl of strength 5gram/L. Find the hardness of water. **Ans: 85.47ppm.**

Lime-Soda Process

1. Calculate the amount of lime and soda required for softening of 50000 liters of hard water containing: $Mg(HCO_3)_2$=14.6mg/L, $MgCl_2$=19.0mg/L, $MgSO_4$=24mg/L, $CaCL_2$=22.2mg/L.
   Ans: Lime: 2.22 kg, and Soda: 3.18kg
2. Calculate the amount of lime and soda required for softening of 10000 liters of hard water containing: $Mg(HCO_3)_2$=7.3mg/L, $Ca(HCO_3)_2$=16.2mg/L, $MgSO_4$=12.0mg/L, $CaSO_4$=13.6,g/L, HCL=3.65 mg/L.
   Ans: Lime: 0.259 kg, and Soda: 0.265kg
3. Calculate the amount of lime (74% pure) and soda (90% pure) required for softening of 50000 liters of hard water containing: $Mg(HCO_3)_2$=73.0mg/L, $CaCl_2$=222.0mg/L, $MgSO_4$=120.0mg/L, $Ca(NO_2)_2$=164.0mg/L.
   Ans: Lime: 1.0 kg, and Soda: 2.356kg
4. Calculate the amount of lime and soda required for softening of 15000 liters of hard water which analyzed as follows: Temporary Ca Hardness=20ppm, Total Permanent Hardness=15ppm and Permanent Mg Hardness=10ppm. **Ans: Lime: 330gm, and Soda: 238.5gm**

Ques 3: → Calculate temp, perm & total hardness of water sample containing $Mg(CHCO_3)_2 = 14.6 mg/l$, $MgCl_2 = 19.0 mg/L$, $MgSO_4 = 24 mg/L$, $CaCl_2 = 22.2 mg/L$ NaCl = 5.35 mg/L.

Ans:-

$CaCO_3$ eqn

$Mg(CHCO_3)_2 - 14.6 mg/L = 14.6 \times \frac{100}{146} = 10 ppm$

$MgCl_2 - 19.0 mg/L = 19.0 \times \frac{100}{95} = 20$ "

$MgSO_4 - 24 mg/L = 24 \times \frac{100}{120} = 20$ "

$CaCl_2 - 22.2 mg/L = 22.2 \times \frac{100}{111} = 20$ "

NaCl – 5.35 mg/L. do not create hardness

Temp. hardness = 10 ppm

Perm " = 20+20+20 = 60 ppm

Total " = 10 +60 = 70 ppm.

Ques 1:- How many grams of $MgSO_4$ dissolved per Litres gives 84 ppm of hardness.

Ans:-

$$\text{Hardness due to salt} = CaCO_3 \text{ eqn of salt} = \text{Amount of salt}_{\text{mg/l or ppm}} \times \frac{\text{m.wt of } CaCO_3 (100)}{\text{m.wt of salt}}$$

$$84 = \text{Amount of salt} \times \frac{100}{120}$$

Amount of salt = 100.8 mg/l = 0.1008 g/l

Ques 2:- A water sample contains 204 ppm of $CaSO_4$. Calculate the hardness

Ans:- $\text{Hardness} = 204 \times \frac{100}{136} = 150$ ppm.

Ques 4 - A water sample on analysis was found to contain the following impurities.

$Mg(CHCO_3)_2 = 7.3 mg/L$, $Ca(CHCO_3)_2 = 16.2 mg/L$, $MgSO_4 = 12.0 mg/L$

$CaSO_4 = 13.6 mg/L$, $K_2SO_4 = 5.35 mg/L$

Ans 4:

		$CaCO_3$ eqn
$Mg(HCO_3)_2$	= 7.3 ppm	$= 7.3 \times \frac{100}{146} = 5$ ppm
$Ca(HCO_3)_2$	= 16.2 "	$= 16.2 \times \frac{100}{162} = 10$ "
$MgSO_4$	= 12.0 "	$= 12.0 \times \frac{100}{120} = 10$ "
$CaSO_4$	= 13.6 "	$= 13.6 \times \frac{100}{136} = 10$ "
K_2SO_4	= 5.35 "	do not create hardness.

Temporary hardness = 5 + 10 = 15 ppm
Permanent " = 10 + 10 = 20 "
Total " = 15 + 20 = 35 ppm.

Zeolite process

Ques 1

A zeolite bed on softening 7000 liters of hard water required 60 liters of 10% NaCl soln for regeneration. Calculate the hardness of water in ppm.

Ans:-

100 ml of NaCl contains = 10 gram of NaCl.
1000 " " " " = 100×10^3 mg of NaCl.
60 liters " " " = $60 \times 100 \times 10^3$
= 6×10^6 mg of NaCl
= $6 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn

According to zeolite process:
Amount of water softened by zeolite bed ≡ Amount of NaCl required for regeneration.

⇒ 7000 liters of hard water ≡ 60 liters of 10% NaCl soln
" " " " " = $6 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn
1 " " " " = $\frac{6 \times 10^6 \times 50}{7000 \times 58.5}$ " " " "
1 " " " " = 732.6 mg of $CaCO_3$ eqn

Ques 2: A water sample having hardness 250 ppm was softened by Zeolite process. The exhausted zeolite bed required 50 liters of 15% NaCl soln for regeneration. Calculate the quantity of water softened by zeolite bed.

Ans:
100 ml of NaCl solution contains = 15 gram of NaCl
1000 " " " " = 150×10^3 mg of NaCl.
50 liters " " " = $150 \times 10^3 \times 50$
= 7.5×10^6 mg of NaCl
= $7.5 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn

⇒ Suppose x liters of hard water is softened by zeolite bed

Then
x liters of hard water = $7.5 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn
1 " " " " = $\frac{7.5 \times 10^6}{x} \times \frac{50}{58.5}$ " " " "

⇒ $\frac{7.5 \times 10^6}{x} \times \frac{50}{58.5} = 250$ ⇒ $x = 25641$ liters.

Ques 3: A zealite bed got exhausted after softening 5000 liters of hard water. hardness of water was 250 ppm. How many liters of 10% NaCl soln would be required to regenerate zeolite bed.

Ans ÷ Suppose x liters of 10% NaCl soln is required to regenerate zeolite bed

100 ml of NaCl solution contains = 10 grams of NaCl
1000 " " " " = ~~100~~ 100×10^3 mg of NaCl
x liters " " " = $x \times 10^5$ mg of NaCl
= $x \times 10^5 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn.

5000 liters of hard water = x liters of 10% NaCl
" " " " " = $x \times 10^5 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn
1 " " " " = $\frac{x \times 10^5 \times 50}{5000 \times 58.5}$ " " " "

⇒ $\frac{x \times 10^5 \times 50}{5000 \times 58.5} = 250$

⇒ $x = 14.7$ liters

⇒ 14.7 liters of 10% NaCl is required.

Ques 4 :- A zeolite softner was 90% exhausted when 10000 liters of hard water was passed thrugh it. The softner required 200 liters of NaCl soln of strength 5 gram/L - Find the hardness of water.

Ans :- 1 litre of NaCl solution contains = 5 gram of NaCl.

200 " " " " " $= 5 \times 10^3 \times 200$ mg of NaCl

$= 10 \times 10^6$ mg of NaCl

$= 10 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn.

10000 liters of hard water = 200 liter of NaCl of strength 5g/L

" " " " " $= 10 \times 10^6 \times \frac{50}{58.5}$ mg of $CaCO_3$ eqn

1 " " " " $= \frac{10 \times 10^6 \times 50}{10000 \times 58.5}$ " " " "

hardness $= 85.47$ ppm.

Lime-Soda Process

Temporary hardness :-

(i) $Ca(HCO_3)_2$ → 1 Lime [1 L]

(ii) $Mg(HCO_3)_2$ → 2 Lime [1 L]

Permanent hardness :-

$CaCl_2$, $CaSO_4$, $Ca(NO_3)_2$ → 1 Soda [1S]

$MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$ → 1 Lime + 1 Soda [1L + 1S]

Acid :-

HCl, H_2SO_4, HNO_3 → 1L + 1S.

Ques 1 – Calculate the amount of Lime + Soda required for softening of 50,000 liters of water containing.

$Mg(HCO_3)_2 = 14.6$ mg/L, $MgCl_2 = 19.0$ ppm, $MgSO_4 = 24$ ppm $CaCl_2 = 22.2$ ppm

Ans

Constituent	Amount	$CaCO_3$ eqn	L & S required
$Mg(HCO_3)_2$	14.6 ppm	$= 14.6 \times \frac{100}{146} = 10$ ppm	2L
$MgCl_2$	19.0 "	$= 19 \times \frac{100}{95} = 20$ "	1L + 1S
$MgSO_4$	24.0 "	$= 24 \times \frac{100}{120} = 20$ "	1L + 1S
$CaCl_2$	22.2 "	$= 22.2 \times \frac{100}{111} = 20$ "	1S

$$\text{Lime required} = \frac{74}{100}[20+20+20] \times 50000 = 2,22,0000 \text{ mg} = 2.22 \text{ kg}$$

$$\text{Soda "} = \frac{106}{100}[20+20+20] \times 50000 = 3180000 \text{ mg} = 3.18 \text{ kg}$$

Ques 2: Calculate the amount of Lime + soda required for softening of 10,000 liters of hard water containing:

$Mg(HCO_3)_2 = 7.3$ ppm, $Ca(HCO_3)_2 = 16.2$ ppm, $MgSO_4 = 12$ ppm, $CaSO_4 = 13.6$ ppm, $HCl = 3.65$ ppm

Ans:-

Constituent	Amount	$CaCO_3$ eqn	L & S req.
$Mg(HCO_3)_2$	7.3 ppm	$= 7.3 \times \frac{100}{146} = 5$ ppm	2L
$Ca(HCO_3)_2$	16.2 "	$= 16.2 \times \frac{100}{162} = 10$ "	1L
$MgSO_4$	12.0 "	$= 12 \times \frac{100}{120} = 10$ "	1L + 1S
$CaSO_4$	13.6 "	$= 13.6 \times \frac{100}{136} = 10$ "	1S
HCl	3.65 "	$= 3.65 \times \frac{50}{36.5} = 5$ "	1L + 1S

$$\text{Lime req} = \frac{74}{100}[10+10+10+5] \times 10,000 = 259000 \text{ mg} = 0.259 \text{ kg}.$$

$$\text{Soda req} = \frac{106}{100}[10+10+5] \times 10,000 = 265000 \text{ mg} = 0.265 \text{ kg}.$$

Ques 3: Calculate the amount of lime (74% pure) and soda (90% pure) required for the softening of 50,000 liters of hard water containing $Mg(HCO_3)_2 = 73$ ppm, $CaCl_2 = 222$ ppm, $MgSO_4 = 120$ ppm, $Ca(NO_3)_2 = 164$ ppm.

Ans:-

Constituent	Amount	$CaCO_3$ eqh	L & S req
$Mg(HCO_3)_2$	73.0 ppm	$73 \times \frac{100}{146} = 50$ ppm	2L
$CaCl_2$	222 "	$222 \times \frac{100}{111} = 200$ "	1S
$MgSO_4$	120 "	$120 \times \frac{100}{120} = 100$ "	1L+1S
$Ca(NO_3)_2$	164 "	$164 \times \frac{100}{164} = 100$ "	1S

Lime req $= \frac{74}{100}[100+100] \times 50{,}000 \times \frac{100}{74} = 1000000$ mg $= 1.0$ kg.

Soda " $= \frac{106}{100}[200+100+100] \times 50{,}000 \times \frac{100}{90} = 2355555.5$ mg $= 2.356$ kg.

Ques 4 :- Calculate the amount of soda required for softening of 15,000 liters of water, which analyzed as follows.

Temporary Ca hardness = 20 ppm

Total permanent " = 15 "

Permanent Mg hardness = 10 "

Ans :- Total permanent hardness = 15 ppm

Permanent mg " = 10 "

" Ca " = 15−10 = 5 ppm.

		L & S req
⇒ Temporary Ca hardness	− 20 ppm	~~1S~~ 1L
Permanent Mg "	− 10 "	1L+1S
" Ca "	− 5 "	1S

Lim req $= \frac{74}{100}[20+10] \times 15{,}000 = 3{,}30{,}000$ mg $=$ ~~330~~ 330 gram.

Sod " $= \frac{106}{100}[10+5] \times 15{,}000 = 238{,}500$ mg $= 238.5$ gram.