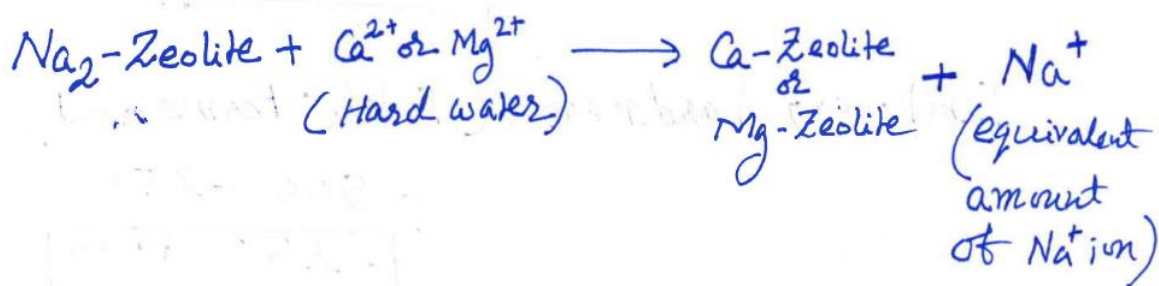Treatment of hard water with a solid insoluble material produced soft water with increased amount of sodium ion (Na^+). Identify the process and write the reactions involved in the process.

$\underline{Zeolite\ (Hydrated\ Sodium\ Alumino\ Silicate)}$: Solid insoluble material.

$$Na_2-Zeolite + \underset{(Hard\ water)}{Ca^{2+}\ or\ Mg^{2+}} \longrightarrow \underset{Mg-Zeolite}{\overset{Ca-Zeolite}{or}} + Na^+ \text{ (equivalent amount of } Na^+ \text{ ion)}$$

Calculate the hardness in degree French (°Fr) of 200 mL water sample with 100 mg $CaSO_4$ and 95 mg $MgCl_2$.

200 mL water contains 100 mg $CaSO_4$

1000 mL water contains $\dfrac{100 \times 1000}{200}$ mg $CaSO_4$

= 500 mg $CaSO_4$

200 mL water contains 95 mg $MgCl_2$

1000 mL water contains $\dfrac{95 \times 1000}{200}$ mg of $MgCl_2$

= 475 mg

Total hardness (in ppm) = Hardness due to $CaSO_4$ + Hardness due to $MgCl_2$

$= 500 \times \dfrac{100}{136} + 475 \times \dfrac{100}{95}$

= 867.6

Total hardness in °Fr (deg degree french)

= 86.76

In the determination of hardness by EDTA method, 50 mL of standard hard water (0.01 M $CaCl_2$ solution) requires 40 mL of EDTA solution. While for 50 mL of sample hard water, 20 mL of EDTA solution is required. After boiling 50 mL of the same sample water, 10 mL of EDTA solution is required. Calculate the permanent and temporary hardness in ppm.

(b) Standardization of EDTA

Volm. of EDTA Soln. = 40 mL
Molarity of EDTA soln. = X (?)
volm. of v Hard water = 50 mL
   Standard
Molarity of Hard water = 0.01 M

$40 \times X = 50 \times 0.01$

$X = 0.0125 M$

Sample hard water = 50 mL
EDTA Soln. = 20 mL

1000 mL 1 M EDTA . Soln. ≡ 100 g $CaCO_3$ ($CaCO_3$ mol Wt. 100)

20 mL 0.0125 m EDTA Soln ≡ $\dfrac{100 \times 20 \times 0.0125}{1000}$ g Ca CO_3

0.025 g = 25 mg $CaCO_3$

50 mL Sample hard water containing 25 mg $CaCO_3$
1000 mL   "   "   "   "   , $\dfrac{25 \times 1000}{50}$ = 500 mg

Total Hardness = $\boxed{500 \, mg/Lit \ \& \ 500 \, ppm}$

Sample hard water (Boiled) = 50 mL
: EDTA Soln. = 2 10 mL

Permanent hardness $\boxed{250 \, ppm}$

Temporary hardness = (Total - Permanent)
= 500 - 250
$\boxed{= 250 \, ppm}$

A hard water sample has 13.6 ppm of calcium sulphate, 9.5 ppm of magnesium chloride, 11.1 ppm of calcium chloride and 14.6 ppm of magnesium bicarbonate. If the water is softened by lime and soda process, what would be the quantities of lime and soda required to soften 1000 litre of this water? (All values are $CaCO_3$ equivalent)

Q.2 a) All values are in $CaCO_3$ equivalent

$CaSO_4 = 13.6\ ppm$; $MgCl_2 = 9.5\ ppm$

$CaCl_2 = 11.1\ ppm$; $Mg(HCO_3)_2 = 14.6\ ppm$

$$Lime = \frac{74}{100}\left\{(2\times Temp.\ Mg^{2+}\ Hardness) + Perm.\ Mg^{2+}\ hardness\right\}$$

$$= \frac{74}{100}\times\left\{(2\times14.6) + 9.5\right\} = 28.638\ mg\ per\ 1\ litre$$

$$\boxed{= 28.638\ g\ for\ 1000\ Litre}$$

$$Soda = \frac{106}{100}\left\{Perm.\ Ca^{2+}\ hardness + Perm.\ Mg^{2+}\ hardness\right\}$$

$$= \frac{106}{100}\left\{(13.6 + 11.1) + 9.5\right\} = 36.252\ mg\ for\ 1\ Litre$$

$$\boxed{= 36.252\ g\ for\ 1000\ Litre}$$

Treatment of 1000 litre hard water with zeolite produced soft water. Analysis of the water indicated presence 0.25 g /litre NaCl. Calculate the hardness of the water.

Ans:
58.5 g NaCl ≡ 50 g $CaCO_3$

1 g NaCl ≡ 50/58.5 g $CaCO_3$

0.25g NaCl ≡ (50/58.5) X 0.25 g $CaCO_3$ = **0.21367 g (in 1 Lit water)**

213.6 ppm

500 mL hard water sample contains 20 mg of $CaCl_2$, 35 mg $MgCl_2$, 25 mg of $Ca(HCO_3)_2$ and 30 mg of $Mg(HCO_3)_2$. Calculate the total hardness and the hardness which can be removed by boiling of the water sample.

Ans
$CaCl_2$= 36.03 ppm; $MgCl_2$= 73.68 ppm; $Ca(HCO_3)_2$= 30.86 ppm; $Mg(HCO_3)_2$= 41.09 ppm

Total hardness= 181.66 ppm.

Hardness which can be removed by boiling = 71.95 ppm

0.5 g of $CaCO_3$ was dissolved in HCl and the solution was made up to **500 mL** with distilled water. **50 mL** of this solution required **25 mL** of EDTA solution for titration. **50 mL** of hard water sample required **15 mL** of EDTA and after boiling and filtering required **10 mL** of EDTA solution. Calculate the total permanent and temporary hardness.

Total Hardness: 600 ppm
Permanent Hardness: 400 ppm
Temporary Hardness: 200 ppm

A zeolite softener removed completely the hardness of 5,000 litres of hard water. The softener required 55 litres of NaCl solution containing 100 grams/ litre of NaCl for regeneration. Calculate the hardness of the hard water sample.

Q.2 b)   Total NaCl required = 55 × 100

$$= 5500 \, g$$

2 moles of NaCl ≡ 1 mol of $CaCO_3$

2 × 58.5 = 107 g NaCl ≡ 100 g $CaCO_3$

$$5500 \, g \, NaCl \quad = \quad \frac{100}{107} \times 5500 \, g \, CaCO_3$$

$$= 5140.186 \, g \, CaCO_3$$

                    Hard water
5000 lit. of   contains 5140.186 g $CaCO_3$

1 lit of " , $\frac{5140.186}{5000} \, g \, CaCO_3$

$$= 1.028 \, g \, CaCO_3/lit$$

$$= 1028 \, mg/lit$$

$$\boxed{= 1028 \, PYM}$$