Ques- Write the chemical name and formula of zeolite. Give the different chemical Reaction Take place in zeolite process.

Treatment of water

(1) Zeolite or permutit process-

The name zeolite is derived from greek word (zein + lithos) which means boiling stone.

The chemical formula of zeolite is

$Na_2Al_2O_3 \cdot x SiO_2 \cdot Y H_2O$

$x = 2-10$

$Y = 2-6$

Sodium zeolite used as water softening is represented as Na_2Z

Z = Insoluble zeolite Radicals.

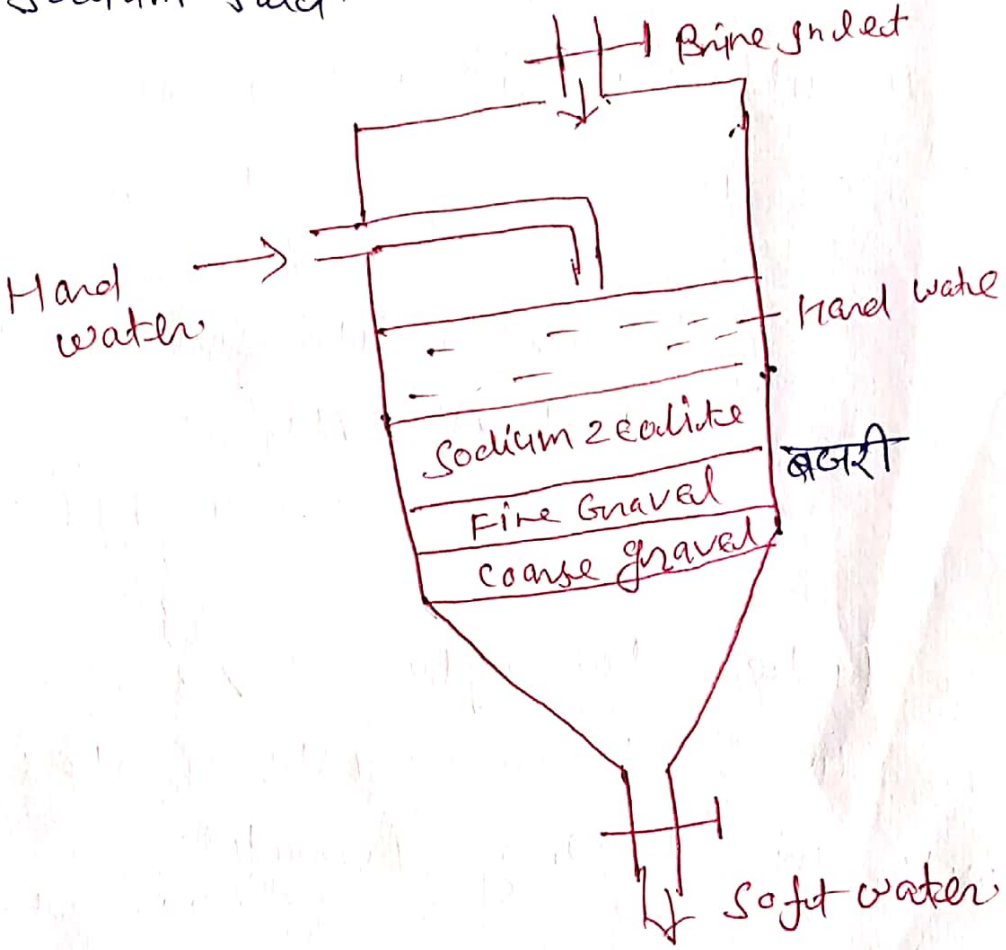
Zeolite water softeners ⇒

A zeolite softener consists of steel tank packed with thin layer of permutit.

The water enter at top and passes through a bed of zeolite. The water passing through bed of zeolite bed where Ca^{++} and Mg^{++} ions are removed from the water by zeolite and simultaneously releasing equivalent amount of Na^+ in exchange.

Process ⇒ In this process hard water passes at a specific rate through the bed of zeolite.

The Ca^{++} and Mg^{++} ions are taken by zeolite and Represented by CaZ_2 or MgZ_2, while outcoming water have equivalent amount of sodium salt.



$Ca(HCO_3)_2 + Na_2Z \longrightarrow CaZ + 2NaHCO_3$.

$Mg(HCO_3)_2 + Na_2Z \longrightarrow MgZ + 2NaHCO_3$

$CaSO_4 + Na_2Z \longrightarrow CaZ + Na_2SO_4$

$MgSO_4 + Na_2Z \longrightarrow MgZ + Na_2SO_4$

$CaCl_2 + Na_2Z \longrightarrow CaZ + 2NaCl$

$MgCl_2 + Na_2Z \longrightarrow MgZ + 2NaCl$.

Regeneration ⇒ After some time zeolite is completely changed into calcium and magnesium zeolite then it get exhausted. It can be Regenerated by treating 10% NaCl (Brine) solution.

$CaZ + 2NaCl \longrightarrow Na_2Z + CaCl_2$

$MgZ + 2NaCl \longrightarrow Na_2Z + MgCl_2$.

Advantage of zeolite process-

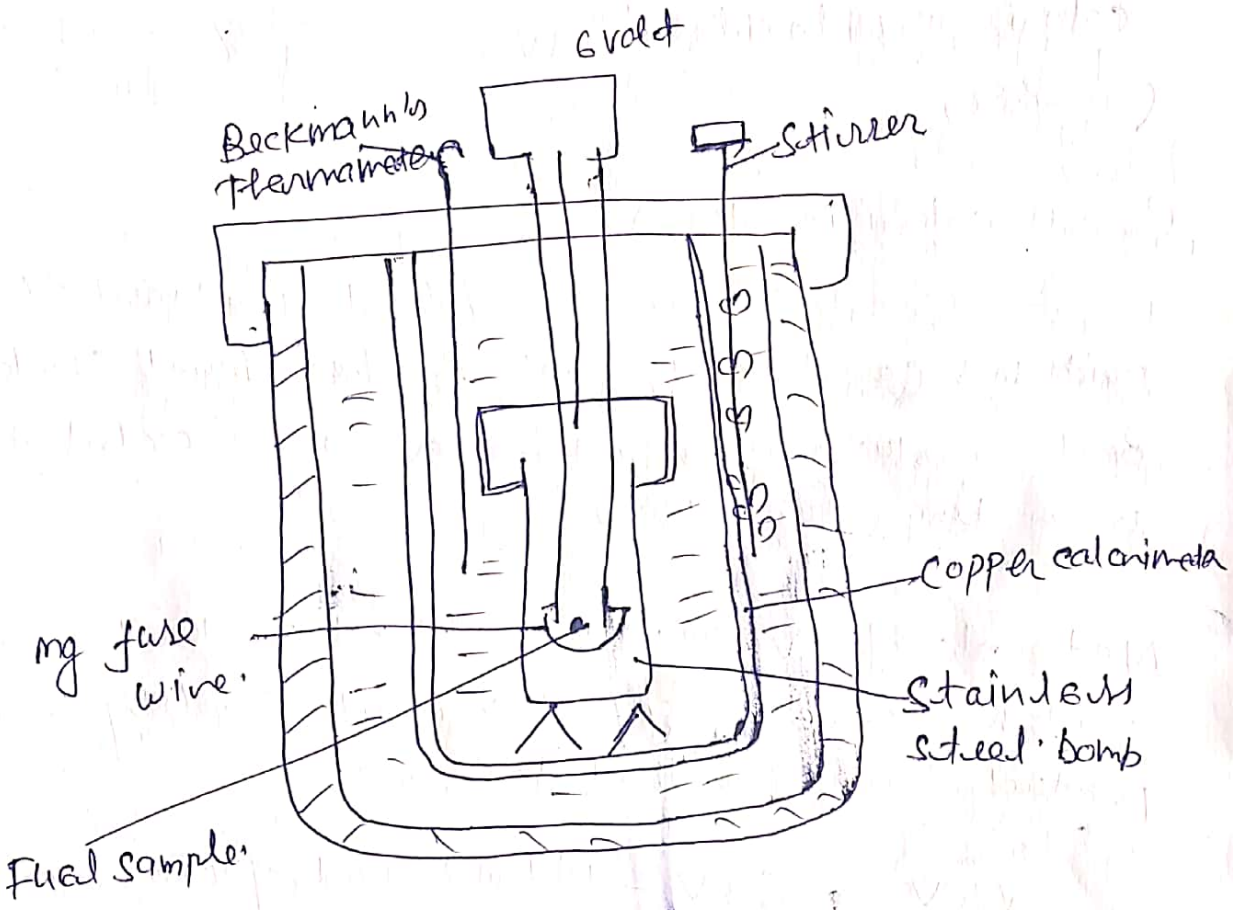
1. Removed the hardness almost completely (about 10 ppm hardness only)
2. equipment used is compact, occupying small space.
3. process automatically adjust with variation of hardness.
4. process does not involve any type of precipitation so no problems of sludge formation
5. It requires less time for water softening.

Disadvantage of zeolite process–

1. The outgoing water contains more sodium salt.
2. This method only replace Ca^{++} and Mg^{++} ions by Na^{+}
3. High Turbidity water can not be soften by this method.
4. Acidic ions like HCO_3^- and CO_3^{--} leaves as such in water
5. When soften water is used in high pressure boiler, CO_2 is liberated by decomposition of $NaHCO_3$.

Ques- Explain the construction and working principle of Bomb calorimeter.

[Determination of calorific value using Bomb Calorimeter]



A Bomb Calorimeter have stainless steel lovey cylindrical bomb which the combustion take place. The bomb have a lid, the lid is attached with two stainless steel electrode and an oxygen inlet valve. A small ring is attached to electrode. This ring support the crucible. The bomb is placed in copper calorimeter. The calorimeter have a electrically operated stirrer and Beckmann's thermometer.

Beckmann thermometer can calculate $\frac{1}{100}^{th}$ of a degree.

Working ⇒ A known amount (1g) of given fuel is taken in clean crucible. In bomb lid O_2 is taken at 30 atm pressure. The temperature of water is noted. The electrode are then connected to a battery of 6 volt. The sample is burn and heat is liberated which is transfer to water uniform stirring is continued and maximum temp. is noted. The calorific value can be calculated as follows:

x = mass of fuel sample in g.

W = mass of water in calorimeter

w = water equivalent in g of calorimeter.

t_1 – Initial temp.

t_2 – Final temp.

L = Gross calorific value.

Heat liberated by burning of fuel = $x L$

Heat absorbed by apparatus = $w(t_2 - t_1)$.

Total heat absorbed by water, apparatus

$= (W + w)(t_2 - t_1)$.

Heat liberated = Heat absorbed

$x L = (W + w)(t_2 - t_1)$

$L = \frac{(W + w)(t_2 - t_1)}{x}$ cal/g

or (Kcal/Kg)

when H% Then

NCV = GCV − 0.09 × %H × 587 cal/g

Latent heat of steam = 587 cal/g.

2500
650
3150

2969.5

79

Ques- Explain the construction and working Principle of Bomb calorimeter.

The following data was obtained when coal Sample is treated in Bomb calorimeter.

weight of coal = 0.92 g H = 6%

weight of water Taken = 550 g

weight equivalent of calorimeter = 2,200 g

Rise in Temp = 2.42°C

Fuse wire correction = 10.0 cal

Acid correction = 50.0 cal.

Calculate GCV and NCV (Latent heat of Steam 580 cal/g).

Ans- $$HCV = \frac{[(W+w)(t_2-T_1)] - [\text{Acid} + \text{Fuse wire correction}]}{x}$$

$$= \frac{(550+2200)\times 2.42 - [50+10]}{0.92}$$

$$= 7168 \text{ cal/g}$$

$$NCV = GCV - 0.09 \times \%H \times \text{Latent Heat of Steam.}$$

$$= 7168 - 0.09 \times 6 \times 580$$

$$= 6855.8 \text{ cal/g.}$$

Ques - Illustrate the principle of Lime soda process.
(2024) 2019, 21

Lime Soda process (L·S). (1)

The principle of L·S process is to chemically convert all soluble hardness causing intermediate in to insoluble precipitate which may be removed by setting and filteration.

(a) Lime Removes the temporary Hardness (Ca and Mg)

$$Ca(HCO_3)_2 + \underset{\text{Lime}}{Ca(OH)_2} \longrightarrow 2CaCO_3\downarrow + 2H_2O \quad (L)$$

$$\left.\begin{aligned} Mg(HCO_3)_2 + Ca(OH)_2 &\longrightarrow MgCO_3 + CaCO_3 + 2H_2O \\ MgCO_3 + Ca(OH)_2 &\longrightarrow Mg(OH)_2 + CaCO_3 \end{aligned}\right] (2L)$$

(b) Lime Removed permanent magnesium hardness and dissolved Ion and Aluminium salt.

$$\left.\begin{aligned} MgCl_2 + Ca(OH)_2 &\longrightarrow Mg(OH)_2\downarrow + CaCl_2 \\ CaCl_2 + \underset{(\text{Soda})}{Na_2CO_3} &\longrightarrow CaCO_3\downarrow + 2NaCl \end{aligned}\right] (L+S)$$

$$\left.\begin{aligned} MgSO_4 + Ca(OH)_2 &\longrightarrow Mg(OH)_2 + CaSO_4 \\ CaSO_4 + Na_2SO_4 &\longrightarrow CaCO_3 + Na_2SO_4 \end{aligned}\right] L+S$$

$$\left.\begin{aligned} FeSO_4 + Ca(OH)_2 &\longrightarrow Fe(OH)_2 + CaSO_4 \\ CaSO_4 + Na_2CO_3 &\longrightarrow CaCO_3 + Na_2S_4 \end{aligned}\right] L+S$$

$$\left.\begin{aligned} Al_2(SO_4)_3 + 3Ca(OH)_2 &\longrightarrow 2Al(OH)_3 + 3CaSO_4 \\ 3CaSO_4 + 3Na_2CO_3 &\longrightarrow 3CaCO_3 + 3Na_2CO_3 \end{aligned}\right] L+S$$

(c) Lime Removed free mineral acids, dissolved CO_2 and H_2S.

$$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$$
$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaCl \quad \Big] \; L+S$$

$$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + +2H_2O$$
$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4 \quad \Big] \; L+S$$

$$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 \downarrow + H_2O \; (L)$$

$$H_2S + Ca(OH)_2 \longrightarrow CaS \downarrow + 2H_2O \; (L).$$

(d) Soda Removed all the Soluble calcium permanent Hardness.

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + NaCl \; (S)$$
$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4 \; (S)$$

Advantage of Lime soda process.

1. It is very cheap and economical.
2. Less amount of coagulant is required.
3. Iron and manganese is also removed.
4. The number of pathogenic bacteria are also reduced due to alkaline nature of water.

Disadvantage of Lime soda process.

1. Careful observation and skill supervision is required.
2. Formation of large amount of sludge.
3. Lime soda process do not produced water of zero hardness.
4. Soften water from L-S process is not good for boilers.

Q4 as - Calculate the calorific value by Theoritical calculation of calorific value. (2021, 23).

Theoritical calculation of calorific value of fuel.

According to Dulong the calorific value of some elementary as follows

Carbon	—	8080	cal/g
Hydrogen	—	34500	"
Sulphur	—	2240	"

If O_2 is also present it combines with H to give H_2O

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$
$$1 \quad 8 \quad 9$$

Fixed Hydrogen = mass of O_2 in fuel

∴ Amount of H present for combustion

= total mass of $H_2 - \frac{1}{8}$ mass of O_2 in fuel.

$= H - \frac{O}{8}$

Dulong formula for calculating calorific value.

$$HCV = \frac{1}{100}\left[8080 + 34500\left(H - \frac{O}{8}\right) + 2240 \times S\right]$$

① calculate GCV and NCV of a coal having fowling composition C = 82% H_2 - 8 O_2 = 5% S = 2.5 N_2 1.4 Ash = 2.1

$$HCV = \frac{1}{100}\left[8080 \times \%C + 34500\left[\%H - \frac{\%O}{8}\right] + 2240 \times S\right]$$

$$= \frac{1}{100}\left[8080 \times 82 + 34500\left[8 - \frac{5}{8}\right] + 2240 \times 2.5\right]$$

$$= \frac{1}{100}\left[662560 + 254437 + 5600\right]$$

$$= 9225.9 \text{ kg/kg}$$

$$NCV = GCV - 0.09 \times \%H \times 587$$

$$= 925.9 - 0.09 \times 8 \times 587$$

$$= 8803.26.$$

(Numericals)

① 10000 Lit of water treated with zeolite process required a total amount of 8 Lit of NaCl salt containing 150 g/L of NaCl for regeneration. Calculate the Hardness of water.

Soln —

$$H = \frac{50 \times m \times V_2 \times 10^3}{58.5 \times V_1}$$

$$= \frac{50 \times 8 \times 150 \times 10^3}{58.5 \times 10,000}$$

$$= 102.56 \text{ ppm}$$

② Calculate the amount of Lime and Soda required to Soften 25000 Lit of water having following analysis

$Ca(HCO_3)_2$ = 4.86 ppm $MgCl_2$ 5.7 ppm

$Mg(HCO_3)_2$ = 7.3 $CaSO_4$ 6.8 ppm

$MgSO_4$ = 9.0 ppm SiO_2 = 3.5 ppm

NaCl = 5.85 ppm

Soln (2)

$Ca(HCO_3)_2$ = 4.86 — L

$Mg(HCO_3)_2$ = 7.3 — 2L

$CaSO_4$ = 6.8 — S

$MgCl_2$ = 5.7 — L+S

$MgSO_4$ = 9.0 — L+S

Impurities	Amount	multiple factor	$CaCO_3$ equivalent
$Ca(HCO_3)_2$	4.8%	$\frac{100}{162} = 0.617$	$0.617 \times 4.8 = 2.96$
$Mg(HCO_3)_2$	7.3	100/146 = .685	$0.685 \times 7.3 = 5.00$
$CaSO_4$	6.8	100/135 = .735	$.735 \times 6.8 = 4.998$
$MgCl_2$	5.7	100/95 = 1.05	$1.05 \times 5.7 = 5.98$
$MgSO_4$	9.0	100/120 = .833	$.833 \times 9.0 = 7.49$

Lime required $= \frac{74}{100}[Ca(HCO_3)_2 + 2 \times Mg(HCO_3)_2 + MgCl_2 + MgSO_4]$

$= \frac{74}{100}[2.96 + 2 \times 5.00 + 5.98 + 7.49]$ × volume of H_2O

$= 19.58 \times 25000$

$= 489.69$ g

$= 490$ g.

Soda Required

$$= \frac{106}{100}\left[CaSO_4 + MgCl_2 + MgSO_4 \right] \times \text{volume of water}$$

$$= \frac{106}{100}\left[4.998 + 5.98 + 7.49 \right] \times \text{volume of water}$$

$$= 19.57 \times 25000$$

$$= 489.402$$

$$= 490\ g.$$