

Assignment-1

Part-A

Q1) Which salts are responsible for temporary and permanent hardness of water.

Ans Temporary = Presence of Ca, Mg bicarbonates and carbonate of iron.

Permanent = Presence of chlorides and sulphates of Ca, Mg, Fe.

Q2) What are different unit of hardness.

Write formula of inter conversion of these units.

Ans ppm, mg/l, $^{\circ}\text{Cl}$ (degree clark), $^{\circ}\text{F}$ (degree french), $(^{\circ}\text{d})$ degree german are units of hardness

$$1 \text{ ppm} = 1 \text{ mg/l} = 0.07^{\circ}\text{Cl} = 0.1^{\circ}\text{F} = 0.056^{\circ}\text{dH}$$

Q3) What is priming and foaming?

Ans = Priming = It is carryover of water droplets along with steam. Process of 'wet steam' formation is priming.

Foaming = Production of persistent foam in boilers which ~~donot~~ break easily. It is due to presence of substance like oils (reduce surface tension of water).

Q4) Write general formula of Zeolites.

Ans $M_x/n \cdot (\text{AlO}_2)_x \cdot (\text{SiO}_2)_y \cdot m\text{H}_2\text{O}$

M = metal cation (Na^+ , Ca^{2+})

n = valency of M

x = no of Al atoms

y = no of Si atoms

$y/x \geq 1$ (ratio of Si/Al is atleast 1:1)

m = no of water molecules associated

Zeolites are microporous, aluminosilicate, minerals commonly used in water softening catalysis.

Q5) Write names of internal treatment methods used for water softening.

Ans

- Colboidal Conditioning
- Phosphate Treatment
- Carbonate Conditioning
- Calgon Conditioning
- Treatment with NaAlO_2
- Electrical Conditioning
- Radioactive Conditioning
- Complexometric Method.

Part B

Q2) Describe Ion Exchange Method for softening of hard water.

Ans

~~Ion Exchange~~ method is a widely used technique that involves the removal of Ca^{2+} and Mg^{2+} ions which are responsible for water hardness, replacing with Na^+ or K^+ .

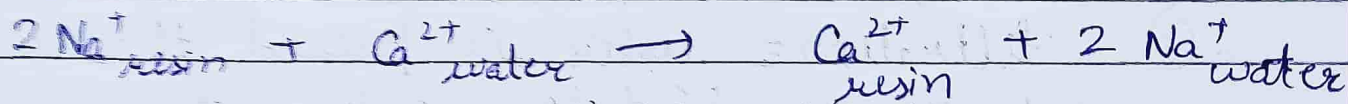
~~Ion Exchange Resin~~: Uses a resin that contains Na^+ or K^+ ions. Resin is typically in form of

small beads or granules and is packed in a column or vessel.

Resin are insoluble, cross linked, long chain organic polymers with a microporous structure and "functional group" attached, are responsible for ion exchange.

Process = ① Hard water flows through ion exchange resin. Resin beads are saturated with Na^+ or K^+

② Ions are exchanged Ca^{2+} & Mg^{2+} with Na^+ or K^+



③ Flow water is softened.

④ Over time, resin becomes saturated with Ca^{2+} , Mg^{2+} and loses its effectiveness.

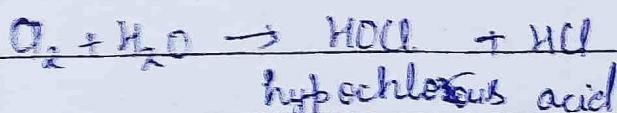
Resin must be regenerated using a concentrated "salt sol" (NaCl or KCl).

Q2) Explain different methods used for Sterilization, Treatment of water for Domestic Purposes.

Ans It is crucial to ensure it is free from harmful microorganisms.

① Boiling = Boil water for 10-15 minutes. all the disease producing bacteria are killed.

② Chlorination = Addition of Cl or Cl compounds



Provides residual disinfection.

- ③ UV radiation -
Water is exposed to UV light typically through a UV lamp.
Kills microorganisms by destroying their DNA. Effective against bacteria, viruses.
- ④ Ozonation - O_3 gas is bubbled through water. Oxidizes and kills bacteria and removes some chemicals and tastes.
- ⑤ Distillation -
Water is heated to produce steam, which is then condensed back into liquid form. Removes salts, most chemical contaminants.
- ⑥ Filtration - Water is passed through filter to remove particle, sediments. Remove particulates. Advanced filters can remove viruses and protozoa.
- ⑦ Iodine Treatment - Addition of iodine tablets or tincture to water. Used in emergency situations.

Q3] Why hardness is expressed in terms of equivalents of $CaCO_3$. A given sample of water contains following salts
 $MgSO_4$ - 50 mg/l, $Mg(HCO_3)_2$ - 73 mg/l,
 $CaSO_4$ - 68 mg/l. Calculate degree of hardness in $^\circ F$, $^\circ C$ and ppm.

Ans - Hardness in terms of $CaCO_3$ because it has molar mass of 100 and most insoluble ppt. It is most common scale forming material and its equivalent weights simplify the calculations.

Multiplication factor.

$$\textcircled{*} \text{MgSO}_4 = \text{eq wt.} = \frac{120}{60} \Rightarrow 2$$

$$\text{Mg(HCO}_3)_2 = \text{eq wt} = \frac{146}{73} \Rightarrow 2$$

$$\text{CaSO}_4 = \text{eq wt} = \frac{136}{68} \Rightarrow 2$$

$$\text{eq wt of CaCO}_3 = 50 \text{ g/mol.}$$

$$\# \text{ CaCO}_3 \text{ equivalent of MgSO}_4 = 50 \times \left(\frac{50}{60} \right) \Rightarrow 41.54 \text{ mg/l.}$$

$$\text{Mg(HCO}_3)_2 = \left(\frac{73}{73} \right) \times 50 \Rightarrow 50 \text{ mg/l.}$$

$$\text{CaSO}_4 = \frac{68}{68} \times 50 \Rightarrow 50 \text{ mg/l.}$$

$$\# \text{ Total hardness} = 141.54 \text{ ppm}$$

$$^{\circ}\text{F} = 0.1 \times 141.54 \Rightarrow 14.1^{\circ}\text{F}$$

$$^{\circ}\text{C} = 0.07 \times 141.54 = 9.89^{\circ}\text{C}$$

Part C) Q1) 100 ml of a sample of water required 20 ml of 0.1 M EDTA for titration using EBT as indicator. After boiling 100 ml of same sample, required 10 ml of 0.01 M EDTA. Calculate total, permanent, and temporary hardness.

Ans Vol of water sample = 100 ml

$$\text{Total hardness} = \frac{20 \text{ ml} \times 0.01 \text{ M} \times 100.0}{100} \times 100$$

$$= 200 \text{ mg/l of CaCO}_3$$

$$1 \text{ mg/l of CaCO}_3 = 50 \text{ ppm} = \frac{100}{2} \text{ eq wt}$$

$$\text{Total Hardness in ppm} = 2 \times 50 = 100 \text{ ppm.}$$

$$\text{Permanent Hardness} = \frac{100 \times 10 \times 0.01 \times 1000}{100} = 100 \text{ mg/L of CaCO}_3$$

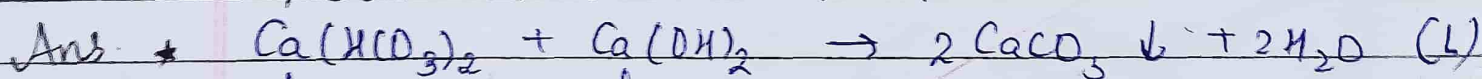
$$\text{Permanent hardness in ppm} = 1 \times 50 = 50 \text{ ppm}$$

Temporary hardness =

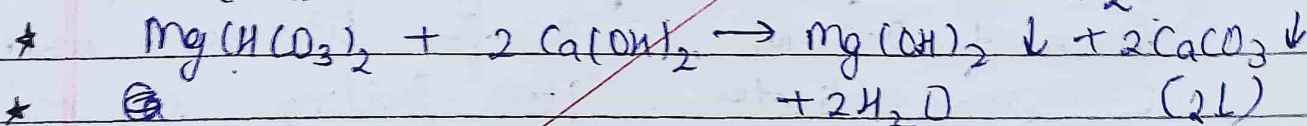
$$200 - 100 = 100 \text{ ppm}$$

$$\text{Total hardness} = \frac{\text{Vol of EDTA (before ^{after} boiling)} \times \text{Molarity} \times 1000}{\text{Vol of water sample}}$$

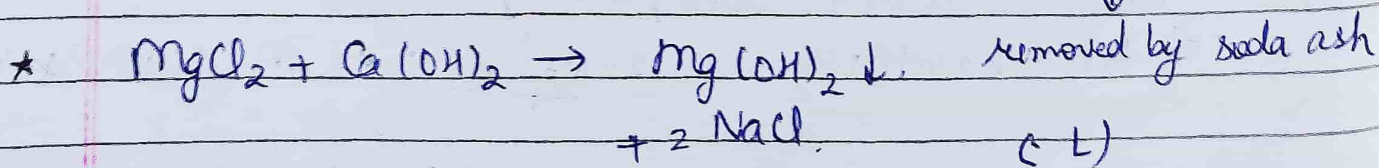
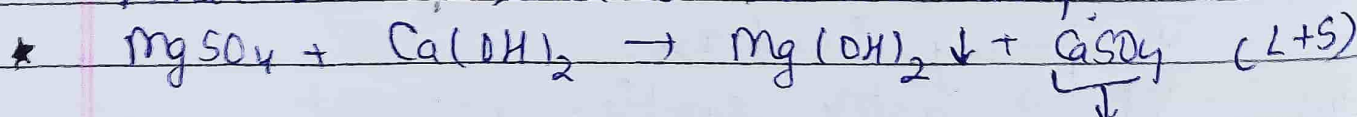
Q2] A hard water sample having following composition has to be softened using lime soda process
 MgSO_4 - 84 ppm, $\text{Mg}(\text{HCO}_3)_2$ = 56 ppm,
 CaSO_4 - 98 ppm, $\text{Ca}(\text{HCO}_3)_2$ = 220 ppm,
 MgCl_2 - 130 ppm. Calculate the amount of lime and soda required to soften 10^6 l of water. Also write chemical reaction involved in lime soda process.



Lime is used to remove $\text{Ca}(\text{HCO}_3)_2$



Soda ash is used to remove CaSO_4



Total lime requirement =

2L for $\text{Mg}(\text{HCO}_3)_2$ + 1L for $\text{Ca}(\text{HCO}_3)_2$ +
1L for MgCl_2 + 1L for MgSO_4

$$= 112 + 220 + 130 + 84 \Rightarrow 546 \text{ ppm}$$

$$\text{Total lime requirement (kg)} = \frac{546 \times 10^6}{1000 \times 10^6} \Rightarrow 546 \text{ Kg}$$

Total Soda Requirement =

1 S for CaSO_4 + 1 S for MgSO_4 -

$$\Rightarrow 98 + 84 \Rightarrow 182 \text{ ppm}$$

$$\text{Total Soda in kg} = \frac{182 \times 10^6}{1000 \times 10^6} = 182 \text{ kg}$$

Hence, total lime required is 546 kg
and total soda required is 182 kg

10^6

Q3] Explain Boiler Corrosion and Caustic Embrittlement.

Ans. Caustic Embrittlement = Type of boiler corrosion caused by using highly alkaline water in boiler.

Cause of Caustic Embrittlement =

Formⁿ of Concentrated caustic zones.

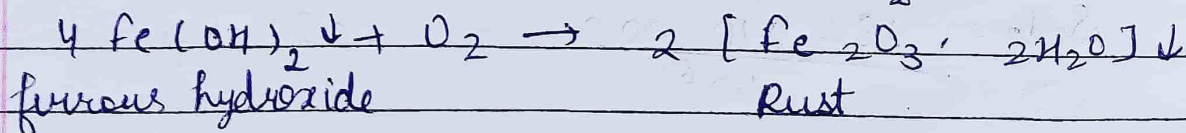
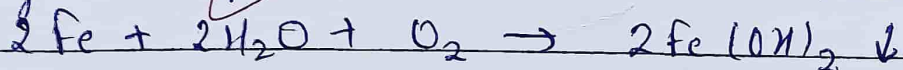
- o Adding tannin, lignin

- Adding Na_2SO_4 to boiler water.

- o Boiler designs to minimize area where concentrated caustic can be form

14. Boiler Corrosion & Degradation of boiler metal components due to chemical or electro-chemical reactions with water and its impurities.

DO in water in presence of prevailing high temp, attacks boiler material.



⑦ Dissolved Carbon =



CO₂ released inside the boiler, if water used for steam generation contains bicarbonate.

(3)

Acidic water =

Water with low pH can lead to dissolution of metal surfaces, causing thinning and pitting. Water containing dissolved Mg salts liberate acid on hydrolysis.



P
29/8/24