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, °Cl (degree clark), °F (degree french), (°d) degree german are units of hardness

$$1 \, ppm = 1 \, mg/l = 0.07°Cl = 0.1°F = 0.056°dH$$

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 $M_{x/n} \cdot (AlO_2)_x \cdot (SiO_2)_y \cdot m \, H_2O$
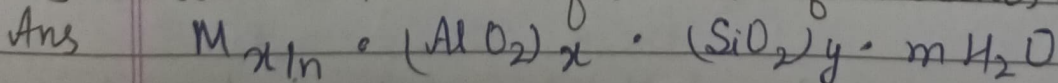
M = metal cation (Na^+, Ca^{2+})   n = valency of M
x = no of Al atoms   y = no of Si atoms

$y/x \geq 1$ (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 Colloidal Conditioning
Phosphate Treatment
Carbonate Conditioning
Calgon Conditioning
Treatment with $NaAlO_2$
Electrical Conditioning
Radioactive Conditioning
Complexiometric Method.

Part B

Q1) 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 Exchang 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^+

$$2 Na^+_{resin} + Ca^{2+}_{water} \rightarrow Ca^{2+}_{resin} + 2 Na^+_{water}$$
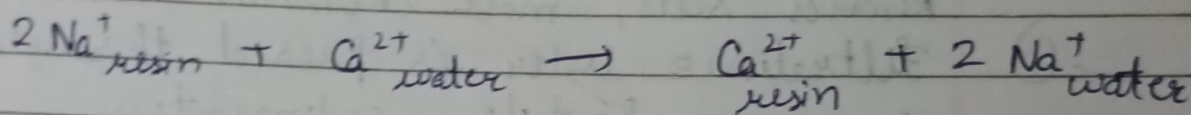
③ Now water is softened.

④ Over time, resin becomes saturated with Ca^{2+}, Mg^{2+} and loses its effectiveness. Resin must be regenerated using a concentrated salt sol^n (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

$$Cl_2 + H_2O \rightarrow HOCl + HCl$$
hypochlorous acid
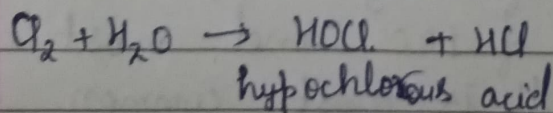
Provides residual disinfection.

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 °F, °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.

(1) $MgSO_4$:   eq wt = $\frac{120}{60}$ => 2

$Mg(HCO_3)_2$:   eq wt = $\frac{146}{73}$ => 2.

$CaSO_4$:   eq wt = $\frac{136}{68}$ => 2.

eq wt of $CaCO_3$ = 50 g/mol.

$CaCO_3$ equivalent of $MgSO_4$ = $50 \times \left(\frac{50}{60}\right)$ => 41.54 mg/l.

$Mg(HCO_3)_2$ = $\left(\frac{73}{73}\right) \times 50$ => 50 mg/l.

$CaSO_4$ = $\frac{68}{68} \times 50$ => 50 mg/l.

Total hardness = 141.54 ppm.
$°F$ = 0.1×141.54 => 14.1 $°F$
$°C$ = 0.07×141.54 = 9.89 $°C$

Part 5) 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
Total hardness = $\dfrac{20 \text{ ml} \times 0.01 \text{ M} \times 1000 \times 100}{100.}$

= 200 mg/l of $CaCO_3$

1 mg/l of $CaCO_3$ = 50 ppm   = $\frac{1}{2}$ eq wt
Total Hardness in ppm = 2×50 = 100 ppm.

Permanent Hardness $= 10\% \dfrac{10 \times 0.01 \times 1000}{100} = 100 \, mg/L$ of $CaCO_3$
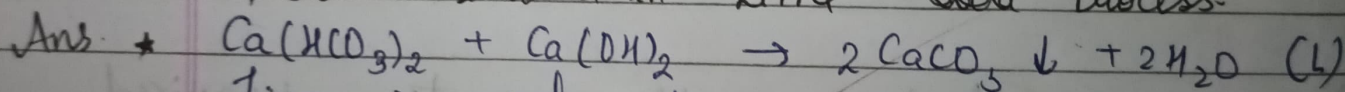
Permanent hardness in ppm $= 1 \times 50 = 50 \, ppm$

Temporary hardness =
$$200 - 100 = 100 \, ppm$$
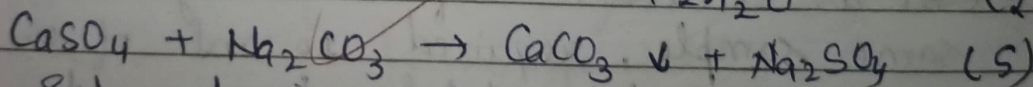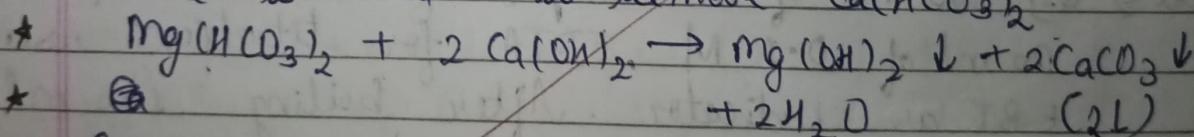
Total hardness $= \dfrac{Vol \, of \, EDTA \, (before \, boiling) \times Molarity \times 1000}{Vol \, of \, water \, sample}$
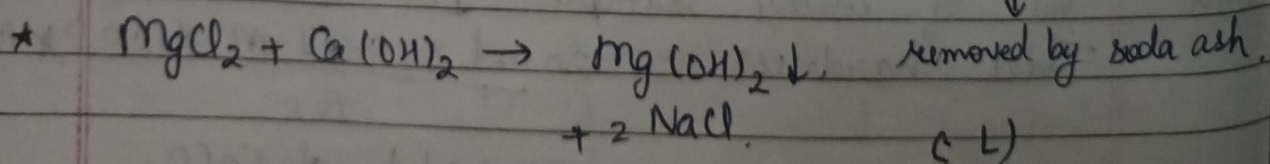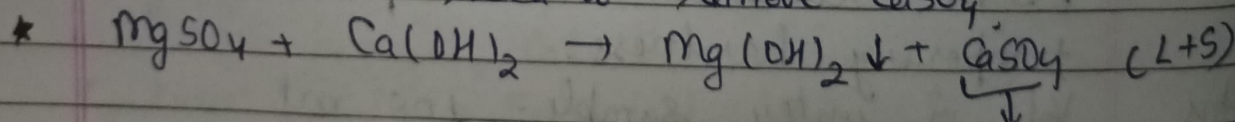
Q2) A hard water sample having following composition has to be softened using lime soda process $MgSO_4 - 84 \, ppm$, $Mg(HCO_3)_2 = 56 \, ppm$, $CaSO_4 - 98 \, ppm$, $Ca(HCO_3)_2 = 220 \, ppm$, $MgCl_2 - 130 \, ppm$. Calculate the amount of lime and soda required to soften $10^6 \, l$ of water. Also write chemical reaction involved in Lime Soda Process.

Ans $\star$ $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O$ (L)

Lime is used to remove $Ca(HCO_3)_2$

$\star$ $Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + 2CaCO_3 \downarrow$
$\star$ $+ 2H_2O$ (2L)

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$ (S)

Soda ash is used to remove $CaSO_4$

$\star$ $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + \underset{\downarrow}{CaSO_4}$ (L+S)

$\star$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow \quad$ removed by soda ash
$+ 2NaCl$ (L)

Total lime requirment =
2L for $Mg(HCO_3)_2$ + 1L for $Ca(HCO_3)_2$ +
1L for $MgCl_2$ + 1L for $MgSO_4$

= 112 + 220 + 130 + 84 =) 546 ppm.

Total lime requirement (kg) = $\dfrac{546 \times 10^6}{1000 \times 10^6}$ =) 546 Kg.

Total Soda Requirement =
1 S for $CaSO_4$ + 1 S for $MgSO_4$

=) 98 + 84 =) 182 ppm.

Total Soda in kg = $\dfrac{182 \times 10^6}{1000 \times 10^6}$ = 182 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.

Leading to brittle failure of the boiler metal, especially along grain boundaries

Causes of Caustic Embrittlement:
High Alkalinity.
$Form^n$ of Concentrated caustic zones.

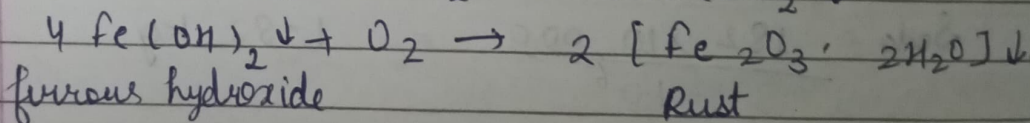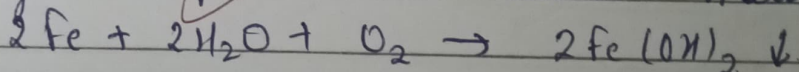Avoided by : o using Sodium Phosphate.
o Adding tannin, lignin.
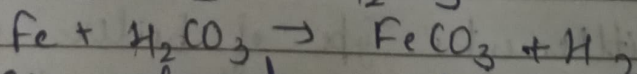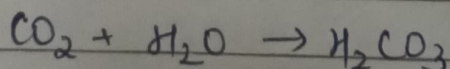o Adding Na_2SO_4 to boiler water.
o Boiler designs to minimize area where concentrated caustic can be form

Boiler Corrosion : Dedgradation of boiler metal components due to chemical or electro-chemical reactions with water and its impurities.

Causes: ① Dissolved oxygen :
DO in water in presence of prevailing high temp, attacks boiler material.
$$2Fe + 2H_2O + O_2 \rightarrow 2Fe(OH)_2 \downarrow$$
$$4Fe(OH)_2 \downarrow + O_2 \rightarrow 2[Fe_2O_3 \cdot 2H_2O] \downarrow$$
ferrous hydroxide   Rust

② Dissolved Carbon :
$$CO_2 + H_2O \rightarrow H_2CO_3$$
$$Fe + H_2CO_3 \rightarrow FeCO_3 + H_2$$
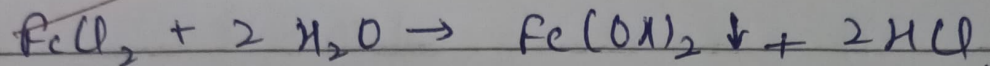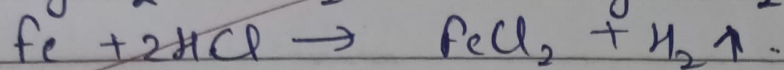CO_2 released inside the boiler, if water used for steam generation contains bicarbonate.

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.

$$MgCl_2 + 2H_2O \rightarrow Mg(OH)_2\downarrow + 2HCl$$

$$Fe + 2HCl \rightarrow FeCl_2 + H_2\uparrow.$$

$$FeCl_2 + 2H_2O \rightarrow Fe(OH)_2\downarrow + 2HCl.$$

29/8/24