POORNIMA INSTITUTE OF ENGG. & TECH., JAIPUR
1FY2-03 ENGINEERING CHEMISTRY
Solution of I Mid Term Question Paper, 2018-19

PART – A

1. Use of Na_2CO_3 as water softener:

Caustic Embrittlement is **caused** by formation of NaOH by reaction of Na2CO3 and water, in which the material of a boiler becomes brittle due to accumulation of **caustic** soda. As water evaporates in the boiler, the concentration of sodium carbonate increases in the boiler and gives NaOH.

$$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$$

The water evaporates and the amount of hydroxide keeps increasing progressively. This sodium hydroxide attacks the surrounding material and then dissolves the iron of the boiler as sodium ferrate. This causes embrittlement of iron. (Explain by Reactions)

2. Hot Lime Soda Require less amount of lime and soda, because:
   (1) Temporary hardness removes at high temperature.
   (2) Dissolved gases remove automatically at high temperature.
   (3) No need of Co-agulants at high temperature.

3. Annealing of Glass:
   When **glass** is **annealed**, it is slowly cooled to relieve any internal stresses. When not **annealed**, **glass** is more likely to crack when exposed to temperature changes.

4. Nut and bolt should be made up by same metal for prevention from Galvanic Corrosion. (Explain Galvanic Corrosion)
5. **Viscosity: It is a** resistance of a fluid (liquid or gas) to movement of neighboring portions relative to one another. **Viscosity** denotes opposition to flow. The reciprocal of the **viscosity** is **called** the fluidity, a measure of the ease of flow.

   Viscosity Index: The **viscosity index** (VI) is an arbitrary, unitless measure of the change of **viscosity** with temperature, mostly used to characterize the **viscosity**-temperature behavior of lubricating oils. It can be discussed as **High VI and Low VI.**

Part B:

6 (a): Numerical on Hardness

S. NO	Substance	Amount (mg/lt)	Multiplication Factor	$CaCo_3$ Equivalent	Type of Hardness
1	$Mg(HCO_3)_2$	25.5	100/146	25.5 *100/146 = 17.46	Temporary
2	$MgSO_4$	30.5	100/120	30.5 * 100/120 = 25.4	Permanent
3	$CaCl_2$	11.1	100/111	11.1 * 100/111 = 10	Permanent
4	$CaSO_4$	10	100/136	10 * 100/136 = 7.35	Permanent
5	$Ca(HCO_3)_2$	15.6	100/162	15.6 * 100/162 = 9.6	Temporary
6	KCl	45	NA	NA	NA

Temporary Hardness = 17.46 + 9.6 = 27.06 mg/lt

Permanent Hardness = 25.4 + 10 + 7.35 = 42.75 mg/lt

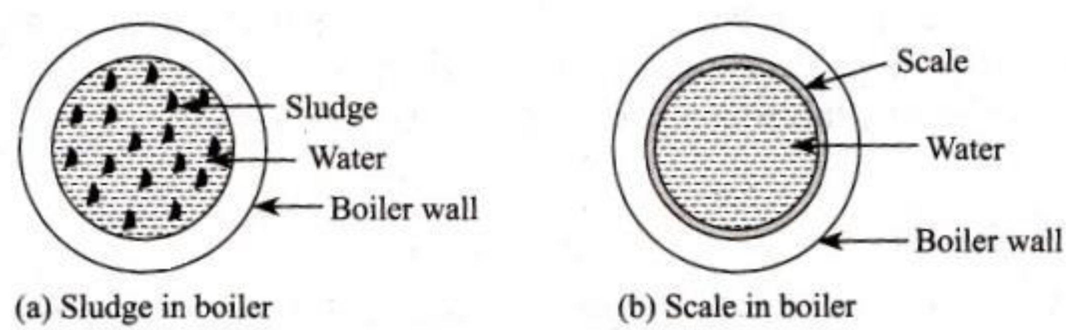
In Degree Clark:

Temporary Hardness = 27.06 *0.07 = 1.89 °Cl

Permanent Hardness = 25.4 * 0.07 = 2.99 °Cl

6(b) Define Scale and Sludge formation:

In boilers, water evaporates continuously and the concentration of the dissolved salts increases progressively. When their concentrations reach saturation point, they are thrown out of water in the form of precipitates on the inner walls of the boiler. If the precipitation takes place in the form of loose and slimy precipitate, it is called sludge. On the other hand, if the precipitated matter forms a hard, adhering crust/coating on the inner walls of the boiler, it is called scale.



Sludges and scales in boiler

7 (a): Numerical on EDTA method

Step 1: (Strength of SHW) = 15mg/ml
Step 2: Standardization of EDTA =
20 ml SHW = 25ml EDTA or 25ml EDTA = 20 ml SHW
Therefore 1ml EDTA = 20 *15/25 = 12 mg $CaCO_3$
Step 3: Total Hardness
100 ml sample water = 18 ml EDTA
OR 100 ml sample water = 18*12 mg $CaCO_3$
Therefore 1000 ml sample water = 18*12 * 1000 /100 =2160 ppm
Step 4: Permanent Hardness
100 ml sample water = 12 ml EDTA
OR 100 ml sample water = 12*12 mg $CaCO_3$
Therefore 1000 ml sample water = 12*12 * 1000 /100 =1440 ppm
Step 4: Temporary Hardness = 2160 – 1440 = 720ppm
7 (b)
Complete the following reaction and identify the process:
It is Calgon internal conditioning method of water treatment.
$Na_2[Na_4(PO_3)_6] + 2CaSO_4 \rightarrow Na_2[Ca_2(PO_3)_6] + 4NaSO_4$

8: Numerical on Lime and Soda Calculation

S. NO	Substance	Amount (mg/lt)	Multiplication Factor	$CaCo_3$ Equivalent	Requirement
1	$Mg(HCO_3)_2$	7.5	100/146	7.5 *100/146 = 5.13	2L
2	HCl	10.5	100/73	0.5 * 100/73 = 14.3	L + S
3	$Al_2(SO_4)_3$	38.2 (23.2 +15)	100/114	38.2 * 100/114 = 33.5	L + S
4	$MgCl_2$	12.5	100/95	12.5 * 100/95 = 13.15	L + S
5	NaCl	20	NA	NA	NA

Lime = 74/100 [2*5.13 + 14.3 + 33.5 + 13.15] *50,000/10^6 *100/80 * 120/100 = 4.80 kg

Soda = 106/100 [14.3 + 33.5 + 13.15] *50,000/10^6 *100/85 * 120/100 = 4.56 kg

9 (a): Numerical on Zeolite method

Zeolite Softener

$N_1V_1 = N_2 V_2$

N_1 = Normality of water, V_1 = Volume of Water,

N_2 = Normality of NaCl, V_2 = Volume of NaCl

$N_1 * 10000 = 15000/(58.5*1000) * 200$

$N_1 = 0.005$;

Therefore, Hardness of water = Normality *Equivalent Weight of $CaCO_3$ *1000

0.005 * 50 * 1000 = 256.41ppm

9 (b)

Gypsum is responsible for preventing **quick setting** of cement.

NOTE: Give reaction of C3A with water and then C3A with water but in presence of gypsum.

10 Numerical on Lime and Soda Calculation

S. NO	Substance	Amount (mg/lt)	Multiplication Factor	$CaCo_3$ Equivalent	Requirement
1	$CaSO_4$	68	100/136	68 * 100/136 = 50	S
2	$Mg(HCO_3)_2$	146	100/146	146 * 100/146 = 100	2L
3	$MgSO_4$	30	100/120	30 * 100/120 = 25	L+S
4	$MgCl_2$	47.5	100/95	47.5 *100/95 = 50	L+S
5	$NaHCO_3$	61	100/168	61 * 100/168 =36.3	L- S

Calculate answer by following steps:

Lime = 74/100 [2*100 + 25 + 50 + 36.5] * (100 * 10^5 * 31)/10^6 * 20

Soda = 106/100 [50 + 25 + 50 - 36.5] * (100 * 10^5 * 31)/10^6 * 20

11(a). Pilling Bedworth Rule

Potassium (0.471) < Sodium (0.541) < Lithium (0.561) <Aluminium (1.28) < Nickel & platinum (1.65) < Iron (1.7)

Explanation of Pilling Bedworth Rule for dry oxidative corrosion:

If: PBR < 1 (Non Protective); If: PBR > 1 (Protective)

11(b)

Glass used in Automobile Windows: Safty Glass

Safty glass is composed layers of glass and plastic held together by an interlayer. When this glass is broken, it is held in place by an interlayer, typically of polyvinyl butyral (PVB), between its two or more layers of glass, which crumble into small pieces. When tempered safety glass is struck it does not break into sharp jagged pieces of shrapnel-like glass as normal window panes or mirrors do. Instead, it breaks into little pebble-like pieces, without sharp edges. It is used in the side and rear windows of automobiles.

Laboratory Glass: Hard Glass and Borosilicate Glass

Hard glass has a high viscosity at high temperatures. Its softening point is also high, which makes it a bit difficult to meltThis type of glass is less dense then soft glass known as soda-lime glass.

Borosilicate glass is a type of glass with silica and boron trioxide as the main glass-forming constituents. Borosilicate glasses are known for having very low coefficients of thermal expansion ($\sim 3 \times 10^{-6}\ K^{-1}$ at 20 °C), making them resistant to thermal shock, more so than any other common glass.

PART – C

12(a) Demineralization or Ion Exchange Process

- This process removes almost all the ions present in water.
- Ion exchangers are resins with a long chain, cross-linked, insoluble organic polymers.
- The functional groups attached to the chains are responsible for the ion exchanging properties.

The following two types of resins are used for demineralization process:

1. Cation exchange resins and

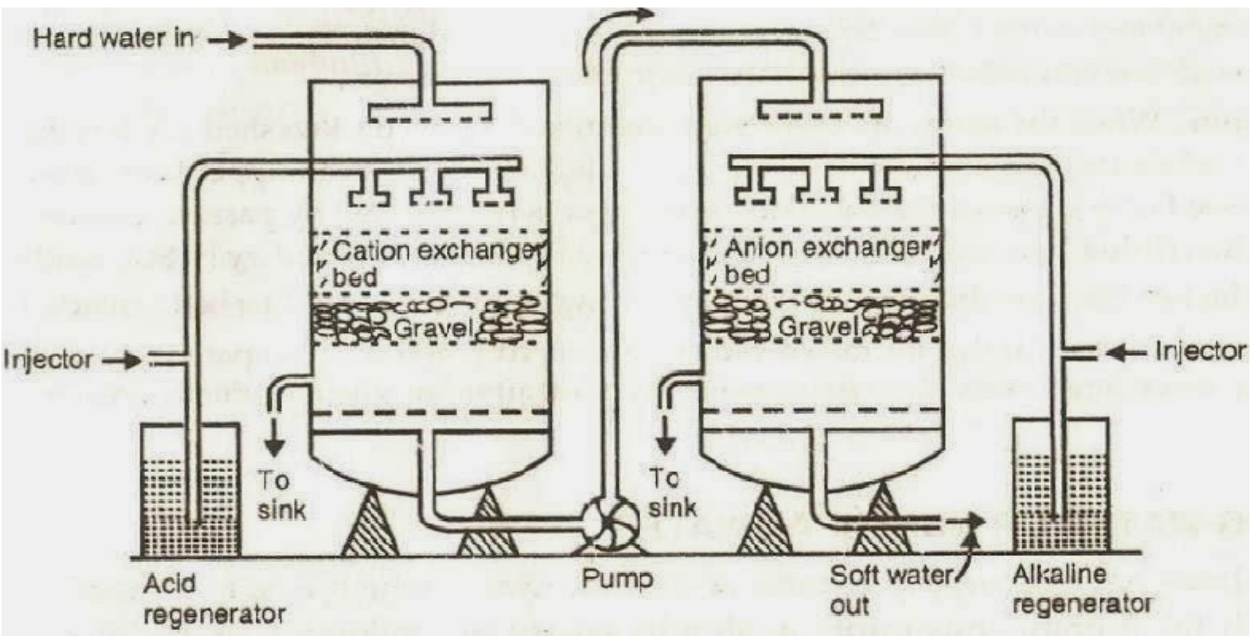
2. Anion exchange resins

1. **Cation exchange resins**

- possess acidic group such as –COOH or –SO3H groups.
- Cations in hard water are exchanged with H^+ ions of this resins.
- This resin may be represented as RH.
- examples: sulphonated coal, sulphonated polystyrene

2. Anion exchange resins

- possess basic groups such as OH- or NH2- group.
- Anions in hard water are exchanged with –OH ions of this resins.
- It may be represented as ROH.
- examples – cross-linked quaternary ammonium salts, urea-formaldehyde resin.



$$RH_2 + CaCl_2 \longrightarrow RCa + 2HCl$$

$$RH_2 + MgSO_4 \longrightarrow RMg + H_2SO_4$$

$$RH + NaCl \longrightarrow RNa + HCl$$

$$R'(OH)_2 + 2HCl \longrightarrow R'Cl_2 + 2H_2O$$

$$R'(OH)_2 + H_2SO_4 \longrightarrow R'SO_4 + 2H_2O$$

Regeneration of resins

The exhausted cation exchange resin is regenerated by dilute HCl solution through it.

$$RCa + 2HCl \longrightarrow RH_2 + CaCl_2$$
$$RNa + HCl \longrightarrow RH + NaCl$$

The exhausted anion exchange resin is regenerated by dilute NaOH solution through it.

$$R'Cl_2 + 2NaOH \longrightarrow R'(OH)_2 + 2NaCl$$

Advantages

- Residual hardness is 2 ppm and it is suitable for use in boilers.
- Highly acidic or highly alkaline water can be softened by using this process.

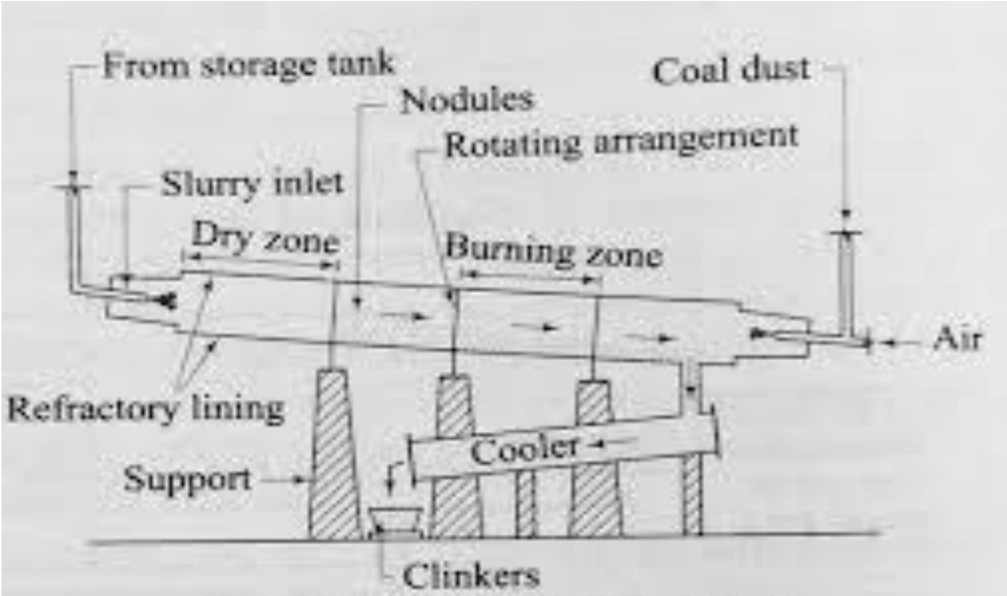
Limitations

- Quite expensive.
- Turbidity, the efficiency of the process is reduced.
- Water containing Fe and Mn cannot be treated because they form stable product with the resins.

12 (b) Differences between zeolite and demineralization processes

S. No.	Zeolite Process	Demineralization process
1	Only cations are exchanged.	Both cations and anions are exchanged.
2	Since acidic water decomposes the zeolite it cannot be treated.	Acidic water can be treated.
3	Treated water contains more dissolved salts which causes priming, foaming and caustic embrittlement in boilers	Water treated by this process contains no dissolved salts and no priming or foaming is caused.
4	Disadvantages Water with Fe, Mn and turbidity cannot be treated.	Disadvantages Water with Fe, Mn and turbidity cannot be treated.

13 (a)



Rotary kiln for wet process
FIG. 6-3

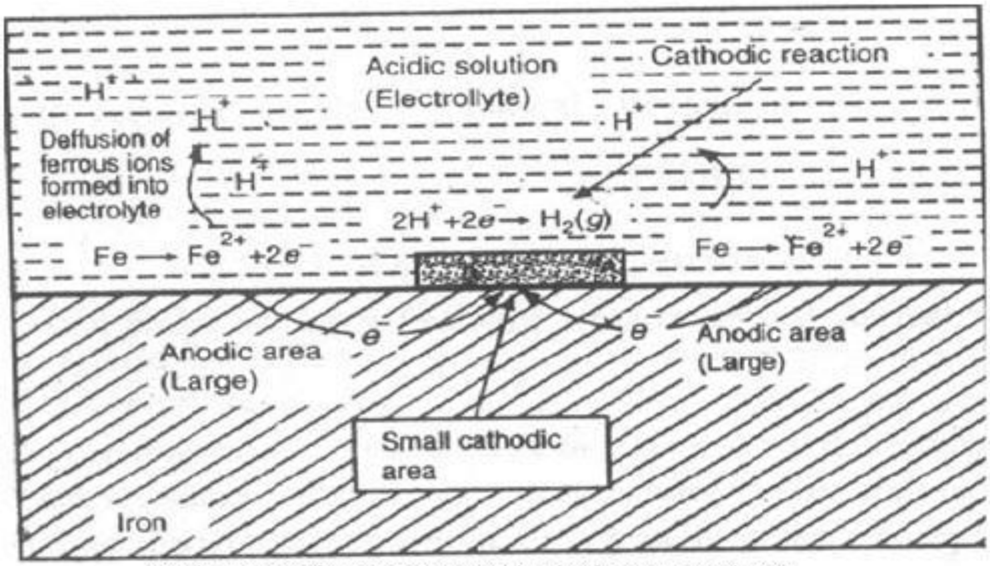
Discussion of Cement Manufacturing Process in following points:

(1) Definition
(2) Raw Material
(3) Process
  (a) Mixing
  (b) Burning
  (c) Cooling
  (d) Grinding with Gypsum
  (e) Packaging

13(b): Thick Film Mechanism: Discussion about following points

- Thick Layer of lubricant of at least 1000A
- Multilayer arrangement of molecules
- Low viscosity oil
- Diagram

14 **(a) Corrosion is a natural process**



Mechanism of wet corrosion by hydrogen evolution

Discussion about complete mechanism

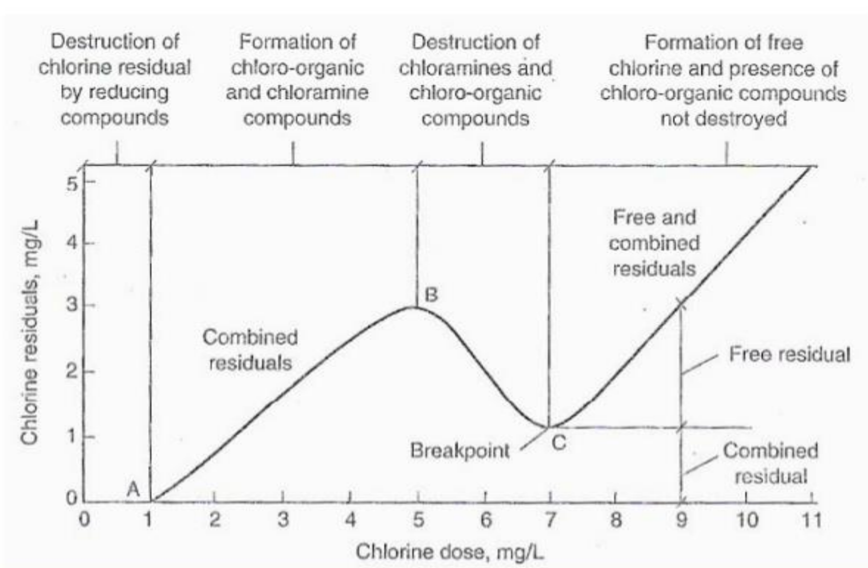
- At Cathod: Oxidation of metal with release of electrons
- At Anode:Reduction by two processes
  By hydrogen evolution and By absorption of Oxygen
- Movement of ions and formation of rust

14 (b): Galvanization and Tinning

- Explain Cathodic and Anodic behavior of Zinc and Tin to prevent iron
- Also compare anodic and cathodic behavior when cracking takes place
- Compare factor: size of anode and cathod

15: Short Notes

(a) Break Point Chlorination: Discussion of following curve



(b) **Sacrificial Protection Method:** Protection of parent metal with more active metal e.g. Protection of iron by connecting it with zinc.

(c) Flash and Fire Point: The **fire point** of a fuel is the lowest temperature at which the vapour of that fuel will continue to burn for at least 5 seconds after ignition by an open **flame**. At the **flash point**, a lower temperature, a substance will ignite briefly, but vapor might not be produced at a rate to sustain the **fire**.

(d) Carry Over: Discuss about following points

Primming: Formation of wet steam

Foaming: Formation of stable bubbles