Semester:	I	Branch:	AI,IT,IOT,EC,EE
Subject:	Engineering Chemistry	Subject Code:	IFY2-03
Time:	1.5 Hours	Maximum Marks:	20

Session (I/II/III): II

PART A (short-answer type questions)
(All questions are compulsory) (3*2=6)

Q.1 What are the requisites of drinking water?

Q.2 Give two advantages of ion exchange method over zeolite method.

Q.3 Differentiate between galvanization and tinning

PART B (Analytical/Problem solving questions)
(Attempt any 2 Questions) (2*4=8)

Q.4 Calculate the quantity of lime (90% pure) and soda (85% pure) required for softening 50,000 litres of water containing following salts $Ca(CO_3)_2$ = 100 mg/L; $Mg(CO_3)_2$ = 84 mg/L; $MgSO_4$ = 480 mg/L; $CaCl_2$ = 22.2 mg/L.

Q.5 Discuss rusting of iron with the help of electrochemical theory of corrosion.

Q.6 Give reasons for the scale formation in boilers and how it is prevented by the conditioning of water.

PART C (Descriptive/Analytical/Problem solving/Design questions)
(Attempt any 1 Question) (1*6=6)

Q.7 What is the hardness of water? Explain the determination of hardness of water by complexometric titration using EDTA including steps like principle, reagents required, procedure and calculations.

Q8 Explain manufacturing of Portland cement by Rotary Kiln with the help of labelled diagram. Also, give important chemical reactions involved in the process.

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Submitted By: Dr. Poonam Ojha		

Q.1 What are the requisites of drinking water?

- It should be colorless, and odorless.
- It should be good in taste.
- Turbidity should be less than 10ppm. .
- It should be free from objectionable gases like H_2S
- PH should be in the range of 7.0 – 8.5 pH
- Total hardness should be less than 500 ppm.
- Chloride content should be less than 250 ppm.
- Florid content should be less than 1.5 ppm.
- Sulphate content should be less than 250ppm.

Q.2 Give two advantages of ion exchange method over zeolite method..

Ans **Advantages**:

1. Ion exchange methods removes both cation and anions from hard water.
2. Ion excange process can be used to soften highly acidic or alkaline water.

Q.3 Differentiate between galvanization and tinning.

Ans **Galvanizing**

1. Zinc is used for coating. Since this method is more electropositizinc sacrificially protects the iron
2. Zinc continues to protect the underlying iron through galvanic cell action in the galvanized article, even if the zinc layer is broken

Tinning :

1. Tin is used for coating. Due to its noble nature and higher corrosion resistance, Tin protects the base metal, iron from corrosion.
2. Tin is non-toxic and protects the iron at the base until the coating is perfect. Any coating break creates fast iron corrosion.

Q.4 Calculate the quantity of lime (90% pure) and soda (85% pure) required for softening 50,000 litres of water containing following salts $Ca(CO_3)_2$ = 100 mg/L; $Mg(CO_3)_2$ = 84 mg/L; $MgSO_4$ = 480 mg/L; $CaCl_2$ = 22.2 mg/L.

Ans Conversion into $CaCO_3$ equivalents:

S.N.	Component	Amount	M.F.	$CaCO_3$ equ.(mg/L)
1.	$CaCO_3$ (T)	100	100/100	100 mg/L
2.	$MgCO_3$ (T)	84	100/84	100 mg/L

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3. $MgSO_4$ (P)	480	100/120	$480 \times \frac{100}{120} = 400 \text{ mg/L}$
4. $CaCl_2$ (P)	22.2	100/111	$22.2 \times \frac{100}{111} = 20 \text{ mg/L}$

$$Lime = \frac{74}{100}\left[100 + 2 \times 100 + 400\right] \times \frac{50,000}{10^6} \times \frac{100}{90} = 28.77 \text{ kg}$$

$$Soda = \frac{106}{100}\left[400 + 20\right] \times \frac{50,000}{10^6} \times \frac{100}{85} = 26.18 \text{ kg}$$

Q.5 Discuss rusting of iron with the help of electrochemical theory of corrosion.

Ans: Rusting of Fe in neutral aqueous solution of electrolytes like NaCl in the presence of atmospheric oxygen is a common example of this type of corrosion. The surface of iron will be usually coated with a thin film of iron oxide. However if this oxide film develops some cracks, anodic areas are created on the surface. While pure metal parts act as cathode. Thus anodic areas are very small surface parts. The rest of the surface of the metal forms cathodes. Thus at the anodic part iron metal dissolves as Fe+2 ions with the liberation of es.

$$Fe \text{ ------> } Fe^{+2} + 2e^-$$

The liberated es flow from anodic to cathodic areas through iron metal during which they interact with dissolved oxygen and moisture.

$$\tfrac{1}{2} O_2 + H_2O + 2e^- \rightarrow 2OH^-$$
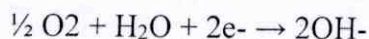
The Fe+2 ions and OH ions diffuse and form ferrous hydroxide precipitate when they meet with each other

$$Fe^{+2} + 2OH^- \text{ -------> } Fe(OH)_2$$

If enough O2 is present Fe(OH)2 is easily oxidized to Fe(OH)3 (ferric hydroxide)

$$4 Fe(OH)_2 + O_2 + 2H_2O \text{ ------> } 4Fe(OH)_3$$
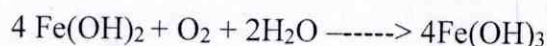
The product called yellow rust actually corresponds to $Fe(OH)_3.H_2O$.

If the supply of O2 is limited, the corrosion product may be even black anhydrous magnetite Fe_3O_4.

That deposits in pores or cracks in the oxide film, the rate of oxidation rapidly decreases to zero.

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Solution of Question Paper
I Mid-Term Examination, Dec. -2022

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Q.6 Give reasons for the scale formation in boilers and how it is prevented by the conditioning of water.

Ans In boiler, when hard water is used for generation of steam, the concentration of dissolved salts increases progressively due to evaporation of water. When concentration reaches to beyond the saturation point, dissolved solids are starts to precipitate out.

Scales: If the precipitates form hard adherent coatings on the inner walls of boilers, it is called scales.

- Scales are hard, adhering precipitates formed on the inner walls of the boilers.
- Scales stick very firmly on to the inner walls of the boiler.
- These are not removed even using chisel and hammer.

Reasons for formation of scales

- **Decomposition of calcium bicarbonate:** The calcium bicarbonate at high temperature decomposes to calcium carbonate which is insoluble salt, forms scale in low pressure boilers.
$$Ca(HCO_3)_2 \rightarrow CaCO_3 \downarrow + H_2O + CO_2$$

- **Hydrolysis of Magnesium salts:** Magnesium salts gets hydrolyzed at high temperature forming $Mg(OH)_2$ precipitation which forms scale.
$$MgCl_2 + H_2O \rightarrow Mg(OH)_2 \downarrow + 2HCl$$

- **Decomposition of calcium sulphate:** The solubility of $CaSO_4$ in water decreases with the increase in temperature and forms precipitation on the surface of the boiler. This type of scales is formed in high-pressure boilers.

- **Presence of silica:** SiO_2 present even in small quantities, deposits as Calcium silicates ($CaSiO_3$) or Magnesium silicates ($MgSiO_3$). These deposits form hard scale and are very difficult to remove.

Prevention of scales:
- If scales are loose then, it can be removed by blow down operation or with the help of scraper or wire brush.
- By giving thermal shocks

Disadvantage of Scale Formation
- Wastage of fuel.
- Danger of Explosion.
- Decrease is efficiency.
- Corrosion.

Q.7 What is the hardness of water? Explain the determination of hardness of water by complexometric titration using EDTA including steps like principle, reagents required, procedure and calculations.

Ans: Hardness of water is due to salt of Calcium and Magnesium ions and other heavy Metals.

The Ca^{+2}/Mg^{+2} ions present in water react with sodium salt of this fatty aid and produced insoluble precipitate in place of lather formation.

$$2C_{17}H_{35}CooNa \quad + \quad CaCl_2 \quad \rightarrow \quad (C_{17}H_{35}Coo)_2C_a \downarrow \quad + \quad 2NaCl$$

Sodium Stearate   Calcium Stearate
(Soap)   (Insoluble)

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Solution of Question Paper
I Mid-Term Examination, Dec. -2022

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$$2C_{17}H_{35}CooNa \; + \; MgSO_4 \quad \rightarrow \quad (C_{17}H_{35}Coo)_2Mg\downarrow \; + \; Na_2SO_4$$

Sodium Stearate   Magnesium Stearate
(Soap)   (Insoluble)

Types of Hardness

1. Temporary hardness

It is due to the presence of bicarbonate of Ca^{+2}/Mg^{+2} ion. It can be decomposed to form insoluble carbonate or hydroxide on heating,

$$Ca(HCO_3)_2 \xrightarrow{\Delta} C_aCO_3\downarrow + CO_2 + H_2O$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + CO_2 + H_2O$$
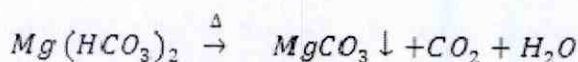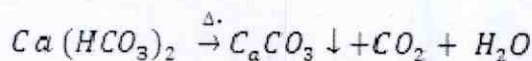
Temporary hardness is also known as carbonate or alkaline hardness.

2. Permanent Hardness

It is due to the presence of chlorides and sulphates of Calcium and Magnesium, iron and other heavy metals. It cannot be removed by simple boiling of water but requires some specific methods like lime soda method, zeolite method etc. It is also known as noncarbonated or non alkaline hardness of water.

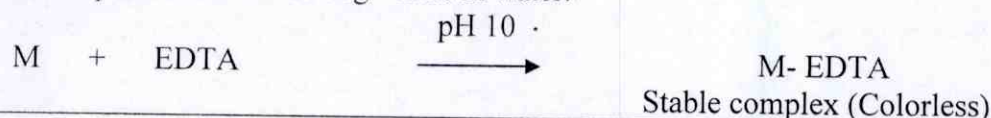### Determination of hardness of water by complexometric method using EDTA.

This method uses complexometric method titration of water sample with EDTA using Erichrome Black T as indicator. It is based on the fact that bivalent hardness causing metal ions $(eq. C_a^{+2}, Mg^{+2})$ form stable complexes with EDTA.

Theory:

Step-1 When Indicator EBT is added to hard water, it combines with Ca^{+2} or Mg^{+2} and forms unstable metal– EBT complex of wine red colour.

			pH 10	
M $Ca^{+2,}Mg^{+2}$	+	EBT Eriochrome Black-T Indicator	$\longrightarrow$	M – EBT Unstable complex
		Blue		Wine Red
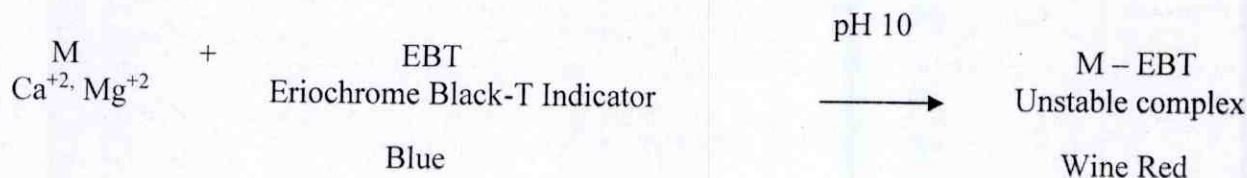
Step-2 When hard water is titrated against EDTA solution then EDTA or its disodium salt forms stable complex with Ca^{+2} or Mg^{+2} ions in water.

			pH 10	
M	+	EDTA	$\longrightarrow$	M- EDTA Stable complex (Colorless)

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Solution of Question Paper

I Mid-Term Examination, Dec. -2022

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Step-3 When more EDTA is run from burette and once all free metal ions are comlplexed with EDTA, it starts taking metal ions from M-EBT complex. The moment all the metal ions leave EBT and join EDTA, the EBT turns in to its own blue colour and the end point is observed that is **wine red to blue**

$$M - EBT + EDTA \longrightarrow M\text{-}EDTA + EBT$$

Wine Red		Metal – EDTA Stable complex Colourless		Blue
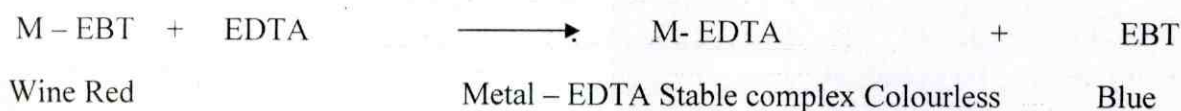
Procedure:

1. Preparation of Boiled Water Sample

Boil 200 ml of water sample to half of its vol means 100 ml. All the bicarbonates are completely decomposed. Filter it and make the solution to 200 ml by adding 100 ml distilled water. This sample contains only permanent Hardness.

2. Standardization of EDTA:

a) Pipette out 10 ml of standard hard water sample in a conical flask.

b) Add 2 ml of buffer solution and 2 drops of Eriochrome Black – T as an indicator.

c) Titrate it against EDTA solution from burette till the colour changes from wine red to blue.

d) Repeat it to get concordant reading – V_1 ml

3. Determination of Total hardness of water sample:

a) Pipette out 10 ml of sample hard water in a conical flask.

b) Add 2 ml of buffer solution and 2 drops of Eriochrome   Black – T as an indicator.

c) Titrate it against EDTA solution from burette till the colour changes from wine red to blue.

d) Repeat it to get concordant reading – V_2 ml

4. Determination of Permanent hardness of water sample:

a) Pipette out 10 ml of boiled water sample in a conical flask.

b) Add 2 ml of buffer solution and 2 drops of Eriochrome Black – T as an indicator.

c) Titrate it against EDTA solution from burette till the colour changes from wine red to blue.

d) Repeat it to get concordant reading – V_3 ml

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Calculations:

1. Standardization of EDTA

1 ml of standard hard water contains = 1 mg of $CaCO_3$

10 ml of standard hard water = 10 mg of $CaCO_3$

V_1 ml of EDTA = 10 ml of standard hard water

V_1 ml of EDTA = 10 mg of $CaCO_3$ eq. hardness

1 ml of EDTA = $10/V_1$ mg of $CaCO_3$ eq. hardness

Strength of EDTA = $10/V_1$ mg/ml of EDTA

2. Determination of Total hardness of water sample

10 ml of water sample = V_2 ml of EDTA solution

V_2 ml of EDTA solution = $10/V_1$ x V_2 mg of $CaCO_3$ eq.

10 ml of water sample = $10/V_1$ x V_2 mg of $CaCO_3$ eq.

1 ml of water sample = $10/V_1$ x $V_2/10$ mg of $CaCO_3$ eq.

1000 ml of water sample = V_2/V_1 x 1000 mg of $CaCO_3$ eq. or ppm

3. Determination of Permanent hardness of water sample

10 ml of boiled water sample = V_3 ml of EDTA solution

V_3 ml of EDTA solution = $10/V_1$ x V_3 mg of $CaCO_3$ eq.

10 ml of water sample = $10/V_1$ x V_3 mg of $CaCO_3$ eq.

1000 ml of water sample = $10/V_1$ x $V_3/10$ mg of $CaCO_3$ eq.

1000 ml of water sample = V_3/V_1 x 1000 mg of $CaCO_3$ eq. or ppm

4. Temporary Hardness of water sample = Total hardness – Permanent hardness

Q.8 Explain manufacturing of Portland cement by Rotary Kiln with the help of labelled diagram. Also, give important chemical reactions involved in the process.

Ans   Raw materials required for cement manufacturing are:

The manufacture procedures of Portland cement is described below.

Mixing:Dry Process: The both calcareous and argillaceous raw materials are firstly crushed in the gyratory crushers to get 2-5cm size pieces separately. The crushed materials are again grinded to get fine particles into ball or tube mill.

Wet Process: The raw materials are firstly crushed and made into powdered form and stored in silos. The clay is then washed in washing mills to remove adhering organic matters found in clay.

The powdered limestone and water washed clay are sent to flow in the channels and transfer to grinding mills where they are completely mixed and the paste is formed, i.e., known as slurry.

Burning of Raw Materials

The burning process is carried out in the rotary kiln

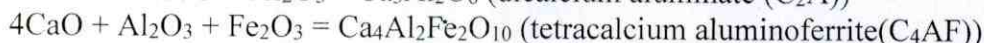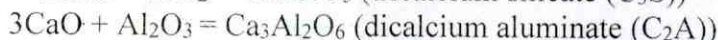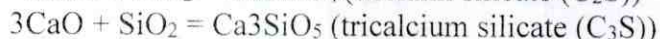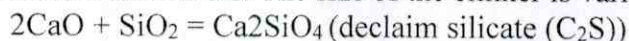| Branch/Semester: AI,IT,IOT,EC,EE/I	Subject: Engineering Chemistry	Subject Code: 1FY2-03
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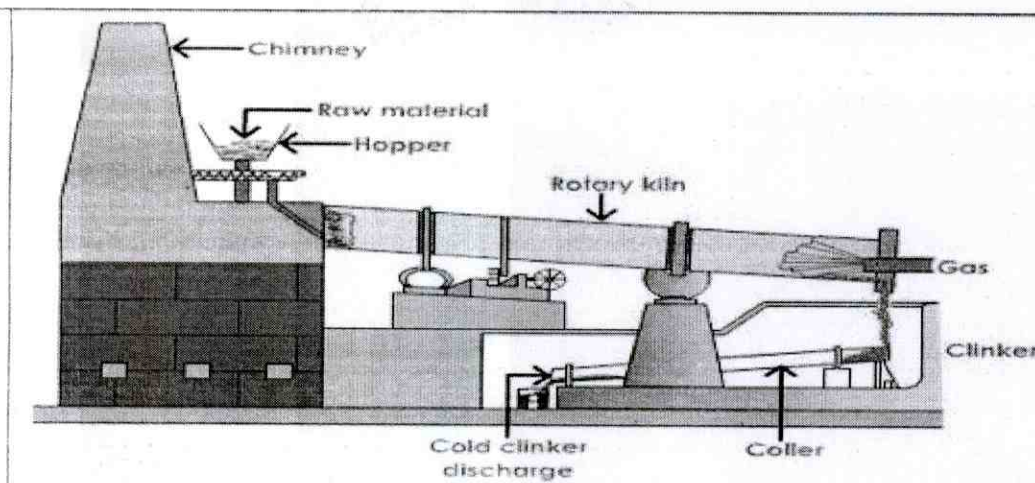
Fig: Rotary kiln for cement manufacturing

The rotary kiln is made up of steel tubes having the diameter of 2.5-3.0 meter and the length differs from 90-120meter. The inner side of the kiln is lined with refractory bricks. The kiln is slightly inclined position at the gradient of in 25 to 1 in 30. The raw mix of dry process of corrected slurry of wet process is injected into the kiln from the upper end. The kiln is heatedwith the help of powdered coal or oil or hot gases from the lower end of the kiln so that the long hot flames is produced. In the upper part, water or moisture in the material is evaporated at 400oC temp, so this process is known as Drying Zone The central part i.e. calcination zone, the temperature is around 10000C, where decomposition of lime stone takes place. The remaining material is in the form of small lumps known as nodules after the CO_2 is released.

$$CaCO_3 = CaO + CO_2$$

The lower part (clinkering zone) have temperature in between 1500-17000C where lime and clay are reacts to yielding calcium aluminates and calcium silicates. This aluminates and silicates of calcium fuse to gather to form small and hard stones are known as clinkers. The size of the clinker is varies from 5-10mm.

$$2CaO + SiO_2 = Ca2SiO_4 \text{ (declaim silicate } (C_2S))$$
$$3CaO + SiO_2 = Ca3SiO_5 \text{ (tricalcium silicate } (C_3S))$$
$$3CaO + Al_2O_3 = Ca_3Al_2O_6 \text{ (dicalcium aluminate } (C_2A))$$
$$4CaO + Al_2O_3 + Fe_2O_3 = Ca_4Al_2Fe_2O_{10} \text{ (tetracalcium aluminoferrite}(C_4AF))$$

The clinker coming from the burning zone are very hot. To bring down the temperature of clinkers, air is admitted in counter current direction at the base of the rotary kiln. The cooled clinkers are collected in small trolleys.

Grinding of Clinkers

The cooled clinkers are received from the cooling pans and sent into mills. The clinkers are grinded finely into powder in ball mill or tube mill. Powdered gypsum is added around 2-3% as retarding agent during final grinding.

Storage and packaging

The grinded cement is stored in silos, from which it is marketed either in container load or 50 kg bags.