Question Paper

Exam Date & Time: 04-Dec-2023 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FIRST SEMESTER B.TECH. DEGREE EXAMINATIONS - NOVEMBER/DECEMBER 2023
SUBJECT: CHM 1071 / CHM-1071 - ENGINEERING CHEMISTRY

Marks: 50 **Duration: 180 mins.**

Answer all the questions.

1A)	Explain the construction and working of glass electrode. Derive the expression for potential of glass electrode.	(4)
1B)	i) Write the cell reaction and calculate the pH of the solution when the cell Pt | H_2| $H^+_{(x)}$|| KCl $_{(0.1\ M)}$ | Hg_2Cl_2|Hg is set up at 298 K, which provides an EMF of 0.65 V*(EMF of normal calomel electrode is 0.2810 V).* ii) Give reason: Weston cadmium cell is used for emf measurements. (3+1 = 4 marks)	(4)
1C)	Give reasons for the following: i) Salt bridge is used in the construction of an electrochemical cell. ii) Pure chromium is not used as anode during chromium plating.	(2)
2A)	i) The concentration of yeast t-RNA in an aqueous solution is 20 M. The absorbance is found to be 0.418 when this solution is placed in a 2.00 cm cuvette and 516 nm radiations are passed through it. a) Calculate the specific absorptivity. b) What will be the absorbance if the solution is 10 M? ii) Explain the conductometric titration of strong acid vs weak base with illustration. (2+2 = 4 marks)	(4)
2B)	i) Differentiate between Temporary and Permanent Hardness. Write any two advantages of lime soda process. ii) Explain any two disadvantages of scale formation in boilers. (2+2 = 4 marks)	(4)
2C)	Briefly explain Phosphate and Calgon Conditioning.	(2)
3A)	Explain how the following factors affect the rate of corrosion: i) relative electrode potential ii) pH iii) hydrogen overvoltage iv) temperature	(4)
3B)	Explain the mechanism of electrochemical theory of corrosion with an example. Why should anodic inhibitors be used in the sufficient concentration to prevent corrosion?	(4)
3C)	Explain the sacrificial anode method of corrosion protection.	(2)
4A)	a) Explain how the structure of a polymer influences the following properties: i) Tensile strength ii) Chemical resistance b) Polymers molecule with different degree of polymerization such as 500, 750, 950 and 1500 are mixed in molecule ratio 1:2:3:4 in a sample of high polymer of ethylene. (Mol. Mass= 28). Calculate	(4)

	Number average and Weight average molecular weight of the polymer. (2+2 = 4 marks)	
4B)	i) Explain the principle and working of liquid crystals display unit. ii) Differentiate between particle and fiber reinforced composites.	(4)
4C)	With a neat diagram, describe the physical vapor deposition process.	(2)
5A)	i) Explain the construction and working of Li ion battery. ii) Discuss the origin of single electrode potential.	(4)
5B)	i) Define glass transition temperature of a polymer. Mention any four factors affecting it. ii) Discuss the types of hydrogen bonding with suitable example in each case.	(4)
5C)	What is liquid metal corrosion? How it is different from wet corrosion?	(2)

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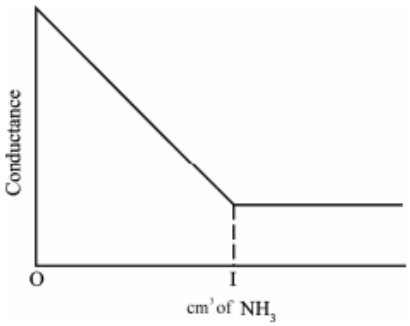
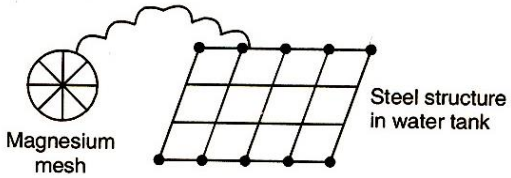
Scheme of evaluation
Course name: Engineering Chemistry [CHM 1071]
End semester
04-12-2023

Q. No.	Scheme of evaluation
1 (A)	i) Construction **1M** Working **1 M** Derivation **2M**
1 (B)	**i) Solution:** **At anode:** $H_2(g) \rightarrow 2H^+ + 2e^-$ **[0.5 M]** **At cathode:** Hg_2Cl_2 (s) + $2e^-$ ----> 2Hg (l) +2 Cl^- (aq) **[0.5 M]** **$E = E^O - 0.0591 \log [Cl^-]$ at 298 K** $E^O = 0.2810$ V E = 0.281 - 0.0591 log [0.1] = 0.281-(-0.0591) **E = 0.3401 V [1M]** $E_{cell} = E_{cal} - (-0.0591\ pH)$ 0.65 = 0.3401 + 0.0591 pH **pH=5.24 [1M]** ii) Weston standard cell has a constant, reproducible emf and negligible variation of emf with temperature. [**1M]**
1 (C)	i) The salt bridge consists of a saturated solution of a salt such as KCl or NH_4NO_3, whose ions have almost same migration velocities. The positive and negative ions of the salt in the salt bridge migrate with equal speed into cathode and anode compartments respectively, thereby minimizing liquid junction potential. **[1M]** ii) These electrodes become passive in acidic medium and they result in a black deposit. **[1M]**
2 (A)	i) **a)** l = 2.00 cm c = 20.00 M A=0.418 = 0.418/2.00 cm X 20 M **Answer = 0.01045 dm^3/mol/cm**. **[1M]** b) ε = 0.0209 dm^3/mol/cm. l = 2.00 cm c = 10.00 M A=? So A =εlc A = 0.01045 dm^3/mol/cm. X 2.00 cm X 10 **Answer = 0.209** **[1M]**

	ii) Eg: HCl Vs NH_4OH During the titration of a strong acid with a weak base, the following reaction is going to takes place: $HCl + NH_4OH \rightarrow NH_4Cl + H_2O$ **[0.5 M]** Explanation **[1M]** Graph **[0.5M]** The variation in the conductance value is as shown in the Figure 2.  Figure 2- Conductometric titration of a strong acid (HCl) Vs. a weak base (NH_4OH)
2 (B)	Differentiate between Temporary and Permanent Hardness. (Any two) **[1M]** Advantages of lime soda process (any two): **[1M]** 1. It is very economical 2. If the process is combined with sedimentation, lesser amounts of coagulants shall be needed. 3. The process increases the pH of the treated water, thereby corrosion is reduced. 4. In addition to the removal of hardness, the quantities of minerals in the water are reduced. 5. Due to alkaline nature of treated water, amount of pathogenic bacteria in water is considerably reduced. ii) Explain about any two disadvantages of scale formation in boilers (2) **Ans:** Disadvantages of Scale Formation in boilers (any two)- **2M** 1. Wastage of fuel: Scales have a low thermal conductivity, so the rate of heat transfer from boiler to inside water is greatly decreased. In order to provide a steady supply of heat to water, excessive or over-heating is done and this causes increase in fuel consumption. 2. Lowering of boiler safety**:** Due to scale formation, over heating of boiler is to be done in order to maintain a constant supply of steam. The over -heating of the boiler tube makes the boiler material softer and weaker and this causes distortion of boiler tube and makes the boiler unsafe to bear the pressure of the steam, especially in high -pressure boilers. 3. Decrease in efficiency: Scales may sometimes deposit in the valve and condensers of the boiler and choke them partially. This results in decrease in efficiency of the boiler. 4. Danger of explosion: When thick scales crack, due to uneven expansion, the water comes suddenly in contact with over-heated iron plates. This causes formation of a

	large amount of steam suddenly. So sudden high- pressure is developed, which may even cause explosion of the boiler.
2 (C)	Briefly explain about Phosphate and Calgon Conditioning (2) Phosphate Conditioning- **1M** In high pressure boilers, scale formation can be avoided by adding sodium phosphate which reacts with hardness of water forming non-adherent and easily removable soft sludge of calcium and magnesium phosphate which can be removed by blow down operation. $3CaCl_2 + 2Na_3PO_4 \longrightarrow Ca_3(PO4)_2 + 6NaCl \downarrow$ Calgon Conditioning- **1M** It involves adding calgen (Sodium hexa meta phosphate) to boiler water. It prevents the scale and sludge formation by forming soluble complex compound with $CaSO_4$. $Na_2[Na_4(PO_3)_6] \longrightarrow 2Na^+ + [Na_4P_6O_{18}]^{2-}$ $2CaSO_4 + [Na_4P_6O_{18}]^{2-} \longrightarrow [Ca_2P_6O_{18}]^{2-} + 2Na_2SO_4$ soluble complex ion
3 (A)	Explain how the following factors affect the rate of corrosion. [**1M each**] **Anodic and cathodic area** Smaller the anodic area and larger the cathodic area greater the corrosion process. Example zinc and tin coated iron with a pin hole crack in the coating. Severe corrosion in the latter case due to larger cathodic area and smaller anodic area. But in the former case less corrosion due to smaller cathodic area. **pH:** PH -lower than 3 severe corrosion occur even in the absence of air in iron pH – 3 to 10 presence of oxygen essential pH above 10 -corrosion practically ceases in iron. **Electrode potential** Larger the potential difference between anode and cathode higher is the rate of corrosion. **Nature of the corrosion product** Oxide layer- stoichiometric, highly insoluble, nonporous, low ionic and electronic conductivity -prevent the corrosion Oxide layer- appreciable conductivity, porous non stoichiometric composition – fails to prevent the corrosion.
3 (B)	According to electrochemical theory of corrosion, when a metal is exposed to corrosive environment, the process of corrosion sets in by the formation of a large number of 'anodic' and the 'cathodic' areas on the metal surface (micro galvanic cells). The difference in potential between anodic and cathodic areas is the driving force for the flow of electrons. Corrosion always occurs at the 'anodic area' of the metal due to oxidation process and thus electrons are liberated. At anodic sites; $Fe \rightarrow Fe^{2+} + 2e-$ ---------- **1M**

	The electrons set free at the anodic area flow through and are consumed at the cathodic area by following processes: Oxygen reduction is the most common cathode reaction, since any aqueous solution in contact with air contains dissolved oxygen. Hydrogen evolution occurs in acidic media. At cathodic sites; O_2 (g) + $2H_2O$ (l) + $4e^- \rightarrow 4OH^-$ (aq) Overall reaction; $2Fe + O_2$ (g) $+2H_2O$ (l) $\rightarrow 2Fe^{2+}$ (aq)$+ 2OH^-$ (aq) ---------- **1M** Reactions to the formation of hydrated ferric oxide (rust) Fe^{2+} (aq) + $2OH^-$ (aq) $\rightarrow$ Fe (OH)2 In presence of enough oxygen, ferrous hydroxide reacts with moisture and oxygen to give yellow rust. 4 Fe (OH)2 + 2 H_2O + $O_2 \rightarrow$ 2 [Fe_2O_3. $3H_2O$] (Yellow rust) If the supply of oxygen is limited, the corrosion product may be black anhydrous magnetite. 6 Fe (OH)2 + $O_2 \rightarrow$ 2 [Fe_3O_4. $3H_2O$] (Black Rust) ---------- **1M** Why should anodic inhibitors be used in the sufficient concentration to prevent corrosion? Insufficient concentration cannot completely cover the metal surface and induces pitting corrosion. ---------- **1M**
3 (C)	A more reactive metal is kept in contact with the metal structure to be protected as shown in Figure 16. The reactive metal becomes the anodic part, and the structure becomes the cathodic part of the corrosion cell. As the anode is sacrificed to protect the structur, this method is called sacrificial anode method. **1M**  Mg is more reactive than iron, and hence is usually used as the anode in contact with iron. Following reactions occur when Mg is made to couple with Iron. Anode: $2Mg_{(s)} \rightarrow 2Mg^{2+}{}_{(aq)} + 4e^-$ Cathode: $O_{2\,(g)} + 2H_2O_{\,(l)} + 4e^- \rightarrow 4OH^-{}_{(aq)}$ **1M**
4 (A)	**a**. Influence of the structure of a polymer on i) Tensile strength Explanation based on **Force of attraction.** **-1/2 M** Explanation based on **slipping power.** **-1/2 M** ii) Chemical resistance of the polymer depends upon the chemical nature of the monomers and their molecular arrangement. **Any two** of the following:

	Polymers containing polar groups like – OH, - COOH etc usually dissolve in polar solvents like water, ketone, alcohol etc., but these are chemically resistant to non-polar solvents. Similarly non-polar groups such as methyl, phenyl dissolve only in non-polar solvents like benzene, toluene, etc. Polymers of more aliphatic character - soluble in aliphatic solvents, chemical resistance more in aromatic solvents. Polymers with more aromatic groups dissolve more in aromatic solvents, chemical resistance more in aliphatic solvents**.** **-1M** b) Substitution is done with steps- Number average molecular mass– 30380 **-----1M** Weight average molecular mass – 33761-------**1M**
4(B)	**a**. Principle and working of liquid crystals display unit. **Answer:** **Diagram 1M** **LCD pixel with "OFF" state:** In the absence of an external electric field, when linearly polarized light enters the device, the LC film acts as an optical wave guide rotating the polarization of the light by 90°. Thus, the light reaches the second polarizer (analyzer/reflector) with its polarization plane parallel to the polarizer axis and is transmitted. In this configuration the display appears bright (off-state). **-1M** **LCD pixel with "ON" state:** when an electric field is applied (on-state), the LC molecules reorient to align the molecular director with the external electric field, causing the helical arrangement to be unwound. Consequently, the light passing through the LC film, is not guided through 90°, and is not able to pass through the second polarizer. The observer sees a black character on a sliver gray background. **-1M** **b**. Differentiate between particle and fiber reinforced composites. **(Any two) 1M**
4(C)	With a neat diagram, describe the physical vapor deposition process. Diagram **0.5 M** Explanation **1.5 M**
5 (A)	i) Construction **1M** Discharging or recharging reactions **1M** ii) Origin of single electrode potential- explanation with diagram **2M**
5 (B)	ii) Define glass transition temperature of a polymer-**1M** Mention any four factors affecting it – **1M** ii) Intramolecular and intermolecular hydrogen bonding with suitable example- **1M each [2M]**
5 (C)	Liquid metal corrosion **1M** How it is different from wet corrosion? Explanation **1M**