B.Tech I Semester Sessional Examination September 2024

APPLIED CHEMISTRY FOR ENGINEERS [CHM 1072]

Scheme of valuation

Type: MCQ

Q1. What type of polymer can a monofunctional monomer form? (0.5)

1. Linear polymer
2. Branched polymer
3. Crosslinked polymer
4. ** No Polymerization

Q2. The following factor is the main cause of polymer plasticity (0.5)

1. High crystallinty
2. ** High slipping power of linear polymers
3. Cross linking of polymers
4. Introduction of bulky side groups in polymer chains

Q3. Which of the following is NOT a general property of epoxy resins? (0.5)

1. High bonding strength to various substrates
2. ** High transparency and light transmission
3. Excellent resistance to corrosion and chemicals
4. High strength-to-weight ratio

Q4. Which of the following is a biobased biodegradable polymer? (0.5)

1. Polybutylene succinate (PBS)
2. Polycaprolactone (PCL)
3. ** Polyhydroxyalkanoates (PHA)
4. Nylon

Q5. Which of the following is an example of an intrinsically conducting polymer ? (0.5)

1. PVC doped with conductive fillers
2. Polypropylene filled with carbon black
3. ** Polyacetylene
4. Polyethylene doped with conductive fillers

Q6. Which of the following statements regarding reverse osmosis is true? (0.5)

1. It increases the concentration of salts in the purified water
2. ** It requires high pressure to reverse the natural osmotic process
3. It allows both water and dissolved salts to pass through the membrane
4. Reverse osmosis works in the absence of any external pressure

Q7. Which component of photopolymers helps in adjusting the properties of the final product, such as flexibility or color? (0.5)

1. Oligomers
2. ** Additives
3. Photoinitiators
4. Monomers

Q8. The two reactants used in the preparation of polyurethane are (0.5)

1. Ethylene glycol and terphthalic acid
2. ** Diisocyanate and diol
3. Adipic acid and hexamethylene diamine
4. Adipic acid and Ethylene glycol

Q9 Identify the example for 1D nanomaterial (0.5)

1. Nanocoatings

2. ** Nanotubes
3. Quantum dots
4. Nanofilms

Q10. Which of the following is NOT an application of self-healing materials? (0.5)

1. **Disposable cups
2. Aerospace components
3. Protective coatings for electronics
4. Drug delivery

Type: DES

Q11. Describe how the following properties of polymers are related to their structure

Ans:

i) Crystallinity – Any 2 points – 1 M
ii) Elasticity- Any 2 points – 1 M

Mn = 60,320 - 1M

Mw= 67,062.06 -1 M (4)

Q12. Select the material/method of choice among the following for the given application with appropriate reasoning;

i. Poly vinyl amide or Polythiophene as electroresponsive polymers
ii. Nanofiltration or ultrafiltration membranes allow water and some salts to pass through the membrane while retaining multivalent ions
iii. PVD or CVD techniques for giving an anticorrosive coating of SiC on metal filters which are porous, cylindrical and curved.

Ans:

i) Polythiophene – ½ M

Polythiophene with alternate single and double bond is conducting and capable of dynamically adjusting their physicochemical characteristics upon exposure to electric signals. - ½ M

ii) Nanofiltration – ½ M
With a pore size range of 0.1 to 10nm, nanofilters allow water and some salts to pass through the membrane while retaining multivalent ions - ½ M

iii) CVD technique – ½ M
Has good throwing power and hence can be used to uniformly coat complex shaped components and deposit films. (3)

Q13. Describe how p-doping increases the conductivity of conducting polymers using an illustration. Differentiate between the doping mechanisms of semiconductors and conducting polymers. (3)

Ans:

p-doping: It involves treating an intrinsically conducting polymer with a Lewis acid, thereby oxidation process takes place and positive charges on the polymer backbone are created. Some

of the common P-dopant used are I2, Br2, AsF5, PF6, naphthylamine, etc. used for example During oxidation process the removal of π electrons from polymer backbone led to the formation of a delocalized radical called ion called polaron having a hole in between valence band and conduction band. The second oxidation of the polaron results in the two positive charge carriers in each chain called bipolaraon, which are mobile due to delocalization. These delocalized charge carriers are responsible for conductance when placed in electric field. - 2 M

- Semiconductors involve replacing atoms in the crystal lattice with dopant atoms that have fewer valence electrons than the host atoms. This substitution introduces holes in the valence band, allowing for electrical conductivity.
- Conducting Polymers involve the addition of a dopant molecule or ion that removes electrons from the polymer creating a positively charged (or negatively charged) site (polaron or bipolaron) along the polymer chain. This positively charged site acts as a hole, contributing to conductivity -1 M

Q14. Explain the construction and discharging reaction of modern maintenance free lead acid batteries. (3)

Construction – 1 M

- Lead grid electrodes maximize surface area
- Anode: Pb-Ca alloy
- Cathode: lead dioxide (PbO_2)
- Electrolyte: sulfuric acid solution (H_2SO_4), specific gravity ~1.25

  Or

- Lead grid electrodes maximize surface area
- Anode: Spongy lead
- Cathode: lead dioxide (PbO_2)
- Electrolyte: sulfuric acid solution (H_2SO_4), specific gravity ~1.25
- A catalyst (e.g. a mixture of 98% ceria (cerium oxide) & 2% platinum) that combines the hydrogen and oxygen produced during discharge back into the water.

Discharging reaction – 2 M

Discharging reactions

At the anode:

$Pb_{(s)} \rightarrow Pb^{2+}_{(aq)} + 2e^-$

$Pb^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow PbSO_{4(s)}$

$Pb_{(s)} + SO_4^{2-}{}_{(aq)} \rightarrow PbSO_{4(aq)} + 2e^-$

At the cathode:

$PbO_2(s) + 4H^+(aq) + 2e^- \rightarrow Pb^{2+}_{(aq)} + 2H_2O(l)$

$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow 2\ PbSO_4(s) + 2H_2O(l)$

Overall: $Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$ (3)

Q15. Write the reactions involved in Methanol oxygen fuel cell. What is the role of conducting membrane in PEMFC. (3)

Ans: Discharging reactions involved in Methanol oxygen fuel cell

Anode – $CH_3OH + H_2O \longrightarrow CO_2 + 6H^+ + 6e^-$

Cathode - $3/2O_2 + 6H^+ + 6e^- \longrightarrow 3H_2O$

Overall - $CH_3OH + 3/2\ O_2 \longrightarrow CO_2 + 2H_2O$ -2 M

The role of conducting membrane in PEMFC

1. It acts as electrolyte to provide ionic conduction b/w anode and cathode
2. Its serve as a separator for two reactant gases– 1 M (3)

Q16. Give any two advantages of the following;

a) Solid polymer electrolytes over Liquid electrolytes

b) Sodium ion batteries over Lithium ion batteries

c) Fuel cell over Galvanic cell (3)

Ans:

a) any two advantages

- No leakage.
- Non-flammable.
- Non-volatile.
- Thermal and mechanical stability.
- Easy fabrication.
- High achievable power density and cyclability. – 1M

b) any two advantages
Abundant in Earth's crust and seawater
Simpler, less energy-intensive extraction than lithium
Cost-effective raw material for large-scale storage – 1M

c) any two advantages

d) High fuel to electricity conversion efficiency of 70-75 % while a thermal power plant converts 35-40% chemical energy of coal into electrical energy.

e) Fuel cell products do not cause pollution problems such as noise pollution, chemical pollution and thermal pollution normally associated with conversional power plants.

f) Fuel cell power plants can be located near the point of use electricity such as on an urban location, rather than at a remote place. So transmission and distribution lose (~30%) could be avoided.
g) A fuel cell will produce a steady electric current as long as fresh reactants are available.

-1 M (3)

Q17. Define the following

i) Shelf life of a battery
ii) Flow batteries (2)

Ans: Shelf life is the period of storage under specified conditions during which a battery retains its performance level.

Flow batteries utilize liquid electrolytes stored in separate external tanks to store energy, providing the advantages of scalability and flexibility in terms of capacity. – 1M each (2)

Q18. Give reasons for the following;

a) Sulfation – explanation – 1M
b) Movement of lithium ion to either elctrodes during charging and discharging – 1M (2)

Q19. Describe the nickel metal hydride battery's nearly constant potential during its operation, taking into account the discharging process that is involved. (2)

Ans: Discharging reaction 1 M

Negative electrode

$M+H_2O+e^- \rightarrow MH+OH^-$

Positive Electrode

$Ni(OH)_2+OH- \rightarrow NiOOH+H_2O+e^-$

Entire battery

$M+Ni(OH)_2 \rightarrow MH+NiOOH$

Electrolyte concentration is constant – constant voltage - 1M (2)