NOVEL SEPARATION PROCESSES
(CHEN 3232)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Microfiltration membranes are
(a) symmetric isotropic (b) symmetric anisotropic
(c) asymmetric isotropic (d) asymmetric anisotropic.

(ii) Polyisoprene is an example of _____ polymer
(a) crystalline (b) glassy
(c) rubbery (d) none of these

(iii) The separation mechanism for microfiltration is
(a) sorption-diffusion (b) solution-diffusion
(c) sieving (d) sieving, solution-diffusion.

(iv) The required range of pressure differential for microfiltration is
(a) < 2 bar (b) 1 – 10 bar
(c) 7 – 70 bar (d) 10 -100 bar.

(v) Sodium dodecyl sulphate is a/an _____ surfactant.
(a) cationic (b) anionic
(c) amphoteric (d) nonionic

(vi) With decrease in ionic strength, zeta potential
(a) increases (b) decreases
(c) may increase or decrease (d) remains unaltered.

(vii) For hemodialysis, a suitable membrane material is
(a) PVC (b) Cellophane
(c) PVA (d) Ceramic.

(viii) A membrane separation method for separating alcohol from water is
(a) Nanofiltration (b) Dialysis
(c) Reverse Osmosis (d) Pervaporation.

(ix) What is the driving force for electrodialysis?
(a) Potential difference between electrodes
(b) Pressure difference between electrodes
(c) Current difference between electrodes
(d) None of these.

(x) The frequency of infrasonic sound is
(a) >20 kHz (b) >20 Hz but < 20 kHz
(c) 20 Hz (d) < 20 Hz.

Fill in the blanks with the correct word

(xi) In an RO plant, _____ is used as antiscalant.

(xii) _____ may be a reason for flux decline during ultrafiltration.

(xiii) _____ is a hydrophobic membrane material.

(xiv) For separation of uric acid from blood, we use _____.

(xv) The product of diffusivity and solubility is called _____.

Group - B

2. (a) In case of reverse osmosis, prove that, $R = \frac{B(\Delta P - \Delta\Pi)}{1 + B(\Delta P - \Delta\Pi)}$ *[(CO1)(Apply/IOCQ)]*

(b) A reverse-osmosis membrane to be used at 25^0C for a NaCl feed solution containing 2.6g NaCl/L , (density 999 Kg/m^3) has a water permeability constant 4.81 x 10^{-4} Kg/(s.m^2.atm.) and a solute permeability constant 4.42 × 10^{-7} m/s. Calculate the water flux, solute rejection, and solute concentration in permeate. [Given: ΔP = 27 atm., $\Delta\pi$ = 1.9 atm]. *[(CO1)(Evaluate/HOCQ)]*

6 + 6 = 12

3. (a) Mention membrane characterization methods. How can membranes be cleaned after operation? *[(CO1)(Remember/LOCQ)]*

(b) Obtain the expression of *concentration polarization modulus*. *[(CO1)(Analyze/IOCQ)]*

(c) An enzyme is being concentrated in a cross-flow ultrafiltration module. The mass transfer coefficient at the membrane surface is 2.8 × 10^{-5}cm/sec. The bulk concentration is 0.3 mass%. If the water flux is 0.42 m^3/m^2.h, calculate the polarization modulus and thickness of mass-transfer 'film'.
[Given: diffusivity of the enzyme = 8.1 × $10^{-7}$$cm^2$/sec and rejection of the solute = 94%]
[(CO2)(Evaluate/HOCQ)]

(2 + 3) + 4 + 3 = 12

Group - C

4. (a) What is the significance of the molecular weight cut off for a hemodialyis membrane. *[(CO2)(Analyse/IOCQ)]*

(b) A co-current hemodialyser is used to purify the blood of a patient at a rate of 300 ml/min. The urea concentration is reduced from 250 mg% to 20 mg%. If the blood volume is 5 liter and blood flow rate is negligible compared to

dialysate flow rate, and the time required for dialysis is to be not more than 3 hours, what should be the value of the overall mass transfer coefficient for a membrane area of 1.3 m^2? *[(CO2)(Apply/HOCQ)]*

3 + 9 = 12

5. (a) Why the product side of a pervaporation unit is maintained under vacuum? What is the function of the condenser in the pervaporation system? *[(CO2)(Analyse/IOCQ)]*

(b) There is a mixture of 20% CO_2 and 80% CH_4. We want to separate the carbon dioxide by permeating through a polysulphone membrane at 35°C and 10 atm pressure. The feed compartment is well-mixed. The membrane thickness is 1μm. The permeate side is subjected to continuous N_2-sweeping. Calculate the flux of CO^2 and average diffusivity of CO^2 in polysulphone. The ideal separation factor for CO^2/CH^4 is 22, the Henry's law constant for the given system is 2.1 cm^3 (STP)/cm^3 (atm). Permeability of CO_2 is 5.6 barrer. *[(CO2)(Apply/IOCQ)]*

(2 + 2) + 8 = 12

Group - D

6. (a) Why is low-frequency ultrasound mainly used for ultrasound-assisted separation? *[(CO3)(Evaluate/HOCQ)]*

(b) Write the different reactions involved in the generation of free radicals in ultrasonic cavitation. *[(CO3)(Understand/LOCQ)]*

(c) What is micelle? Discuss with example. *[(CO2)(Apply/IOCQ)]*

4 + 6 + 2 = 12

7. (a) With example discuss *cloud point extraction*. *[(CO3)(Remember/LOCQ)]*

(b) Discuss the working principle of centrifugal sedimentation. Obtain the sigma value. *[(CO3)(Remember/LOCQ)]*

(c) Write down the advantage of using miceller enhanced ultrafiltration over ultrafiltration. *[(CO3)(Remember/LOCQ)]*

3 + (3 + 3) + 3 = 12

Group - E

8. (a) Discuss about *electrical double layer* and *Debye length*. *[(CO4)(Remember/LOCQ)]*

(b) Define electro-osmotic flow. How does it affect electrophoresis performance? *[(CO4)(Remember/LOCQ)]*

(c) Write down Poisson-Boltzman equation and state its significance. *[(CO4)(Remember/LOCQ)]*

5 + 4 + 3 = 12

9. (a) Discuss various types of electrophoresis and its applications. *[(CO4)(Analyze/IOCQ)]*

(b) What do you understand by *electrophorectic mobility*? *[(CO4)(Understand/LOCQ)]*

(c) Give an example of *electric field enhanced ultrafiltration*. *[(CO4)(Understand/LOCQ)]*

6 + 3 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	42.71	26.04	31.25

Course Outcome (CO):

After the completion of the course

1. Students will be able to compare different membrane separation and develop the method for the fabrication of Inorganic and organic, symmetric and asymmetric membrane fabrication using phase inversion technique.
2. Students will be able to illustrate the process for membrane characterization and construct the transport equation through membrane for various membrane separation processes including pervaporation, dialysis.
3. Students will be able to understand the role of external fields and surfactants on different separation processes.
4. Students will be able to couple electrophoretic effects with separation techniques and understand the advantages of doing so.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*