NOVEL SEPARATION PROCESSES
(CHEN 3232)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) An example of a hydrophobic membrane material is
(a) cellulose acetate (b) polycarbonate
(c) polypropylene (d) polyethersulphone.

(ii) The separation mechanism for reverse osmosis is
(a) sieving (b) solution diffusion
(c) sorption-diffusion (d) none of these.

(iii) Kedem-Katchalsky model can be used for _____ operation.
(a) ultrafiltration (b) microfiltration
(c) nanofiltration (d) reverse osmosis

(iv) Polydmethyl siloxane is a _____ polymer.
(a) glassy (b) rubbery
(c) ion exchange (d) cellulose derivative

(v) Pressure differential for Reverse osmosis is generally
(a) 1-10 bar (b) 10-100 bar
(c) 10^3 - 10^4 bar (d) none of these.

(vi) Cetylpyridinium chloride is a/an _____ surfactant.
(a) Cationic (b) anionic
(c) Non-ionic (d) amphoteric

(vii) Sodium dodecyl sulphate is a/an
(a) non-ionic surfactant (b) anionic surfactant
(c) cationic surfactant (d) none of these.

(viii) For diagnostic application the frequency of ultrasound is in the range of _____.
(a) 2-18 MHz (b) 20-30 MHz
(c) 2-18 kHz (d) 20-30 kHz

(ix) The main toxin removed by haemodialysis is
(a) Ammonia (b) Urea
(c) Creatine (d) Tyrosine.

(x) With increasing ionic strength, zeta potential
(a) decreases (b) increases
(c) may increase or decrease (d) remains constant.

Group- B

2. (a) (i) Write down the classification of synthetic membranes.
(ii) Mention membrane materials for microfiltration membrane.
(iii) Define MWCO. [(CO1)(Remember/LOCQ)]

(b) A 0.025 molar feed solution containing a macromolecular solute is to be concentrated to 0.11 molar concentration by batch ultrafiltration at 25^0C. The solute rejection is 94%. The effect of concentration polarization may be ignored. If the upstream pressure is 5 atm (gauge) and the downstream pressure is essentially atmospheric. Calculate the effective driving force at the beginning and at the end of the process. Also find out the fractional reduction in solvent flux at the end of the process. [(CO1)(Evaluate/HOCQ)]

(2 + 1 + 3) + (5 + 1) = 12

3. (a) How does concentration polarization phenomenon affect solvent flow? Obtain an expression for concentration polarization modulus for ultrafiltration? [(CO1)(Analyze/IOCQ)]

(b) A 80 μm thick polysulphone microporous membrane has an average porosity of 0.38. Pure water flux through the membrane is 26 m^3/m^2 .h at a pressure of 1.4 bar at 25^0C. The average pore size is estimated to be 1 μm. Calculate the tortuosity of the pores, the resistance to flow offered by the membrane and its water permeability. The viscosity of water at 25^0C is 09 cp. [(CO1)(Evaluate/HOCQ)]

(2 + 4) + 6 = 12

Group - C

4. (a) In a patient with acute kidney failure, a haemodialyser is used to purify blood. Blood from the patient's body is pumped through a concurrent haemodialysis unit at 350 ml/min and the blood urea concentration is reduced from 210 mg% to 15 mg%. The available membrane area is 1.25 m^2. The volume of blood in the patient's body can be taken as approximately 5 liter. If the dialysate flowrate is maintained at a very high value, and the time required for dialysis is 9700 s, estimate the average mass transfer coefficient. Assume the dialysate fluid to be solute- free. [(CO2)(Apply/IOCQ)]

(b) Explain the principle behind electrodialysis with a diagram. [(CO2)(Understand/LOCQ)]

8 + 4 = 12

5. (a) Selective permeation of CO_2 from a mixture of 12% CO_2 (A) and 88% CH_4 (B) occurs at 35°C and 10 atm pressure in a small apparatus with a well-mixed feed compartment. An asymmetric polysulphone membrane of 1 μm thickness is used. The permeate side is continuously swept with Nitrogen gas. The following data are given:
α_{AB} = 22, Henry's law constant for CO_2 solubility in polysulphone at 35°C = 2.1, permeability of CO_2 = 5.6 barrer. Calculate the CO_2 flux, its average diffusivity in polysulphone and the permeance of methane in polysulphone.
[(CO2)(Apply/IOCQ)]

(b) Explain the principles and application of gel-permeation chromatography.
[(CO3)(Understand/LOCQ)]

8 + 4 = 12

Group – D

6. (a) What will be the effect of solvent viscosity on the acoustic cavitation during ultrasound assisted extraction process? [(CO3)(Analyse/IOCQ)]

(b) Find out the intensity of the ultrasound inside a medium of density 1000 kg/m^3. Sound velocity through the medium at ambient condition = 1500 m/s. Ultrasound is generated at 30 kHz with a peak pressure of 90 kPa.
[(CO3)(Apply/IOCQ)]

4 + 8 = 12

7. (a) With example, discuss cloud point extraction. [(CO3)(Analyze/IOCQ)]

(b) (i) Mention different types of centrifuge devices for solid liquid separation.
(ii) What do you understand by centrifuge sigma factor? State its significance.
[(CO3)(Analyze/IOCQ)]

(c) With example, discuss miceller enhanced separation process.
[(CO3)(Analyze/IOCQ)]

3 + (3 + 3) + 3 = 12

Group - E

8. (a) What do you understand by electrical double layer and Debye length?
[(CO4)(Evaluate/HOCQ)]

(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. (i) State principle of electrophoresis.
(ii) Mention different types of electrophoresis.
(iii) What do you understand by isoelectric focusing? [(CO4)(Remember/LOCQ)]

(4 + 4 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.37	47.92	17.71

Course Outcome (CO):

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