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) Reverse osmosis membrane has pore size in the range of
(a) 0.1 – 1 nm (b) 1 – 2 nm (c) 1-100 nm (d) 100 – 10^4 nm.

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

(iii) Pressure differential for ultrafiltration is generally
(a) 0.5 – 2 bar (b) 2-10 bar
(c) 10 - 100 bar (d) 10^3 - 10^4 bar.

(iv) Pick out the correct statement:
(a) Using membrane process, a high degree of separation is always possible
(b) Membrane process cannot be used for heat sensitive substances
(c) Membrane processes are inherently simple
(d) Phase change occurs in all membrane processes.

(v) _____ is a rubbery polymer.
(a) Cellulose acetate (b) Polyisoprene
(c) Polystyrene (d) Polysulphone

(vi) Cetyl pyridinium chloride (CPC) is a/an
(a) non-ionic surfactant (b) anionic surfactant
(c) cationic surfactant (d) none of these.

(vii) For haemodialysis, a commonly used membrane material is
(a) poly-vinyl alcohol (b) poly-imides
(c) poly-carbonates (d) cellophane.

(viii) A membrane process used for separation of alcohol from water is
(a) Ultrafiltration (b) Pervaporation
(c) Reverse Osmosis (d) Dialysis.

(ix) The unit of gas permeability is
(a) Tesla (b) Siemens
(c) Barrer (d) Ohm-cm.

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

Group- B

2. (a) A reverse osmosis membrane is to be used at 25^0C for a NaCl feed solution containing 2.3 g NaCl/L (density 998.5 kg/m^3) has a water permeability constant of 4.8×10^{-4} kg/(s.m^2.atm)and a solute permeability constant of 4.41×10^{-7} m/s. Given: Applied pressure difference is 28 atm., osmotic pressure difference is 1.89 atm. Calculate (i) the water flux, (ii) solute rejection and (iii) solute concentration in permeate. [(CO1)(Evaluate/HOCQ)]

(b) (i) Write down the classification of synthetic membranes.
(ii) Mention the membrane material and applications w.r.t. nanofiltration.
[(CO1)(Remember/LOCQ)]

7 + (3 + 2) = 12

3. (a) A 0.05 molar feed solution containing macromolecular solute is to be concentrated to 0.1 molar concentration by batch ultrafiltration at 25^0C. Calculate the effective pressure driving force at the beginning and at the end of the process.
Given : Observed rejection = 95%. The upstream pressure is 5 atm. (gauge) and downstream pressure is atmospheric. [(CO1)(Evaluate/HOCQ)]

(b) A 78 μm thick polysulphone microporous membrane has an average porosity of 0.36. Pure water flux through the membrane is 23 m^3/m^2 .h at a pressure of 1.3 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 0.9 cp.
[(CO1)(Evaluate/HOCQ)]

6 + 6 = 12

Group - C

4. (a) A cocurrent haemodialyser is used to reduce urea content in the blood of a patient from 300 mg% to 30 mg%. The blood flow rate is 300 ml/min. The membrane area is 1.5 m^2. If the blood volume is 5 litre and the the overall mass transfer coefficient is 1.2×10^{-6} m/s, estimate the time required for dialysis. Assume the dialysate is solute free and dialysate flow rate is significantly higher than blood flow rate. [(CO2)(Apply/IOCQ)

(b) Explain the operating principle of electrodialysis.
[(CO2)(Understand/LOCQ)]

8 + 4 = 12

5. (a) Selective permeation of CO_2 from a mixture of 20% CO_2 (A) and 80% 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 1.5 μm thickness is used. The permeate side is continuously swept with Nitrogen gas. The following data are given:
α_{AB} = 24, Henry's law constant for CO_2 solubility in polysulphone at 35℃ = 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) Mention three industrial applications of pervaporation.
[(CO2)(Remember/LOCQ)]
9 + 3 = 12

Group – D

6. (a) Explain the effect of frequency on generated ultrasonic energy.
[(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 50 kHz with a peak pressure of 100 kPa.
[(CO3)(Apply/IOCQ)]
4 + 8 = 12

7. (a) Discuss the principle of centrifugal sedimentation. Obtain the expression of *sigma value*. [(CO3)(Analyze/IOCQ)]

(b) Give an example of separation by emulsion liquid membrane.
[(CO3)(Remember/LOCQ)]
(6 + 4) + 2 = 12

Group – E

8. (a) What do you understand by 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)]
4 + (3 + 2) + 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	39.58	40.62	19.80

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 usingphase 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 understandthe advantages of doing so

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