B.TECH / CHE /7TH SEM/ CHEN 4143/2017
ADVANCED SEPARATION PROCESS
(CHEN 4143)

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) A membrane for ultrafiltration is
(a) symmetric porous (b) asymmetric porous/ composite
(c) asymmetric nonporous (d) symmetric nonporous.

(ii) The solution-diffusion model is one important model to explain the mechanism of transport of water and solute in
(a) microfiltration (b) nanofiltration
(c) reverse osmosis (d) ultrafiltration.

(iii) In membrane distillation the pore size is of
(a) ultrafiltration range (b) microfiltration range
(c) nanofiltration range (d) both (a) and (b).

(iv) A Zeta potential more than _____ mV will give stable emulsion
(a) 20 (b) 10 (c)30 (d)5.

(v) The vapour pressure of the organic solvent in supported liquid membrane is _____ the vapour pressure of the stripping solution.
(a) higher than (b) lower than
(c) in equilibrium with (d) both (b) and (c).

(vi) During reverse osmosis, with increase in trans-membrane pressure _____
(a) solute flux increases (b) solute flux decreases
(c) solvent flux increases (d) solvent flux decreases.

(vii) Pervaporation method involves
(a) removal of ions
(b) production of potable water
(c) purification of aqueous stream
(d) separation and concentration of liquid mixture.

(viii) In a carrier facilitated separation using supported liquid membrane, the carrier should have
(a) high selectivity for the component to be separated
(b) rapid complexation and decomplexation kinetic constant at the membrane interface
(c) low solubility of the carrier in water
(d) all of the above.

(ix) Ion exchange chromatography is based on the
(a) electrostatic attraction (b) electrical mobility of ionic species
(c) adsorption chromatography (d) partition chromatography.

(x) The first step in two-dimensional gel electrophoresis generates a series of protein bands by isoelectric focusing. In a second step, a strip of this gel is turned 90 degrees, placed on another gel containing SDS, and electric current is again applied. In this second step, _____.
(a) proteins with similar isoelectric points become further separated according to their molecular weights.
(b) the individual bands become stained so that the isoelectric focus pattern can be visualized
(c) the individual bands undergo a second, more intense isoelectric focusing
(d) the proteins in the bands separate more completely because the second electric current is in the opposite polarity to the first current.

Group - B

2. (a) Discuss briefly the membrane characterization techniques.

(b) With examples, differentiate between symmetric, asymmetric membranes and composite membranes.

(c) A reverse osmosis membrane to be used (ΔP=27.3 atm) at 25^{0}C for a NaCl feed solution containing 2.5 gm NaCl /L (density =999 kg/m^3), has a water permeability constant 4.81 × 10^{-4} kg/s.m^2.atm and a solute permeability constant of 4.42 × 10^{-7} m/s. Calculate the water flux and solute rejection. Given: osmotic pressure difference is 1.9 atm and 1m^3 of downstream contains 997 kg of solvent.

4 + 3 + 5 = 12

3. (a) Mention names of membrane module used industrially.

(b) Show that for reverse osmosis, rejection $R = \frac{B(\Delta P - \Delta\pi)}{1 + B(\Delta P - \Delta\pi)}$. (notations bearing usual meaning.) What is the effect of concentration polarization during RO?

(c) Obtain an expression for 'concentration polarization modulus'.

2 + (3 + 2) + 5 = 12

Group - C

4. (a) A liquid mixture comprising of 8.8 wt% ethanol in water is fed to a pervaporation module at 60°C and permeate pressure of 76 mm of Hg. The module is fitted with a PVA membrane and the permeate contains 10 wt% ethanol. At 60°C, the vapour pressure of ethanol and water are 352 and 149 mm of Hg respectively. Calculate the permeance for water and ethanol. The liquid phase activity coefficient for ethanol-water system is given by the following equations:

$$\ln\gamma_{ethanol} = 1.6276\left[\frac{0.9232x_{water}}{1.6276x_{ethanol} + 0.9232x_{water}}\right]^2$$

$$\ln\gamma_{water} = 0.9232\left[\frac{1.6276x_{ethanol}}{1.6276x_{ethanol} + 0.9232x_{water}}\right]^2$$

'x' is the mole fraction and 'γ' is the activity coefficient.

(b) What is the significance of "transport coefficients" in Onsager's irreversible process theory?

9 + 3 = 12

5. (a) Applying HETP concept for a packed column chromatography, show that the number of theoretical plates is proportional to the square of the residence time of the component that shows resolution.

(b) What is gel filtration? Describe how the Molecular weight of a protein can be determined by gel filtration.

(c) If the following protein mixture is fractionated in a gel filtration column, comment on their elution characteristic with proper explanation.

Protein(s)	pI	Molecular weight
A	4.6	45
B	7	16.7
C	4.9	68.5
D	6.4	8.5
E	10.6	13

5 + 4 + 3 = 12

Group - D

6. (a) State the differences between emulsion, bulk and supported liquid membrane with proper diagram.

(b) In order to prepare an emulsion liquid membrane, emulsifier A (HLB=5) and emulsifier B (HLB=15) are mixed in the ratio of 1:3. What should be the value of HLB? Whether you will be able to prepare the membrane in order to remove the metals from wastewater? Justify your answer.

6 + 6 = 12

7. (a) Describe the organic solvent property in brief for supported liquid membrane.

(b) Show that for spontaneous micellization $(1 - F) < \sqrt{F/n}\left(\frac{1}{X_{cmc}}\right)^{\frac{N-1}{N}}$, where 'f' is monomer fraction in the micelle, 'N' is the aggregation number and 'x_{CMC}' is the total mole fraction of the surfactant in the solvated form.

5 + 7 = 12

Group - E

8. (a) What are the proper uses for agarose and acrylamide gels? What is the percentage of polyacrylamide in a gel characterised as 40%T and 0.3%C?

(b) An unknown protein migrates 4.2 cm during SDS PAGE. The entire gel cassette is 15 cm, sample well depth=2mm. Stacking gel is 6.4 cm long. Calculate the molecular weight of the protein based on the following information.

MW (kDa)	205	116	97	66	45
Migration (cm)	1	3.1	3.8	4.9	7.9

(3 + 3) + 6 = 12

9. (a) Why the SDS is omitted when proteins need to undergo isoelectric focusing?

(b) Why the isoelectric focusing is also called 2D electrophoresis?

(c) A protein has two fractions P_1 and P_2, which needs to be separated using IEF technique. pI for P_1 is equal to 8.1, while for P_2 it is 8.0. Around pH=8, the electrophoretic mobility gradient of the protein with the pH= -7.5×10^{-8} m^2/Vs and its diffusion coefficient =5.9×10^{-7} cm^2/s in 0.004 M NaCl solution at 20°C. The pH is within a range of 3 to 10 along a 7 cm strip. If one applies 4 V across the gel, will a separation between the fractions be achieved? Justify your answer.

2 + 5 + 5 = 12