SEPARATION PROCESS - II
(CHEN 3103)

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) For dehumidification operation, position of operating line should be
(a) above equilibrium curve (b) below equilibrium curve
(c) coincide with adiabatic saturation line (d) none of these.

(ii) Lewis number is the ratio of
(a) mass diffusivity to momentum diffusivity
(b) thermal diffusivity to mass diffusivity
(c) momentum diffusivity to thermal diffusivity
(d) none of these.

(iii) Selectivity of a solvent used in extraction should be
(a) 1 (b) > 1 (c) < 1 (d) 0.

(iv) Moisture contained by a solid substance which exerts an equilibrium vapor pressure equal to that of pure liquid is
(a) unbound moisture (b) bound moisture
(c) free moisture (d) critical moisture.

(v) _____ is the concentration difference driven membrane process
(a) ultrafiltration (b) reverse osmosis
(c) dialysis (d) microfiltration.

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

(vii) _____ extractor uses centrifugal force for separating two phases
(a) Kuhni (b) Podbielniak
(c) Sciebel colum (d) Karr column.

(viii) Bollman extractor
(a) is a static bed leaching equipment
(b) is used for extraction of oil from oilseed
(c) is a centrifugal extractor
(d) employs only counter-current extraction.

(ix) For drying of perishable material, the most appropriate dryer is
(a) truck dryer (b) rotary dryer
(c) drum dryer (d) freeze dryer.

(x) The larger is the interfacial tension of the solvent liquid
(a) the easier the dispersion of one liquid in the other
(b) the more readily coalescence of emulsions occurs
(c) cannot be predicted
(d) none of the above.

Group – B

2. (a) What do you understand by 'psychrometric ratio'? What is its physical significance?

(b) Differentiate between percentage humidity and relative humidity.

(c) A dryer requires 1.7 m^3/s of air at 65^0C and a humidity of 0.040 (kg water vapour/kg dry air). This is to be prepared from ambient air (dry-bulb temp. 28^0C and 18^0C wet-bulb temp.) by direct injection of steam into the air stream followed by passage of the air over steam-heated tubes. Calculate the kilograms of steam required per second for direct injection.

(1 + 2) + 3 + 6 = 12

3. (a) Discuss the working principle of a natural draft cooling tower.

(b) Determine the humid volume of an air-water vapour mixture having 38^0C dry-bulb and 26^0C dew point at 1atm pressure.

(c) A horizontal spray chamber with re-circulated water is used for adiabatic humidification and cooling of air. The active part of the chamber is 2.1m long and has a cross section of $1.9m^2$. With an air rate of 3.0 m^3/s at dry-bulb temperature of 66^0C and an absolute humidity of 0.0170 kg water/kg dry air, the air is cooled and humidified to a dry-bulb temperature of 41^0C. If a duplicate spray chamber operated in the same manner were to be added in series with the existing chamber, what would be the humidity and temperature of outlet air?

3 + 2 + 7 = 12

Group – C

4. (a) Give examples of extraction and leaching operations used in industry.

(b) Soybean flakes containing 22 wt% oil are to be leached in a counter current multistage process to contain 0.8 kg oil/100 kg inert solid using fresh and pure hexane solvent. For every 1000 kg soybeans, 1000 kg hexane is used. Experiments give the following retention of solution with the solids in the underflow, where N is kg inert solid/kg solution retained and y_A is wt. fraction of oil in solution:

N	y_A
1.73	0
1.52	0.20
1.43	0.30

Calculate the exit flows with compositions and the number of theoretical stages needed.

2 + 10 = 12

5. Pure water is to be used in a two-stage system to extract acetic acid from 400 kg of a feed solution containing 25% acetic acid in isopropyl ether. The equilibrium data is given as under: Equilibrium data at 25^0C is given below:

Water Layer (wt%)			Isopropyl ether layer (wt%)		
Acetic acid	***Water***	***Isopropyl ether***	***Acetic acid***	***Water***	***Isopropyl ether***
0.0	98.8	1.2	0	0.6	99.4
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.3	84.4	2.3	4.82	1.9	93.3
25.5	71.1	3.4	11.4	3.9	84.7
36.7	58.9	4.4	21.6	6.9	71.5
44.3	45.1	10.6	31.1	10.8	58.1
46.4	37.1	16.5	36.2	15.1	48.7

If 150 kg fresh water is used in each stage, calculate the overall percent recovery of the acid in the total outlet water.

12

Group – D

6. (a) Describe the classification of the commercial dryers.

(b) (i) Mention different types of nucleation during crystallization.

(ii) A salt solution weighing 10,500 kg with 31 wt% Na_2CO_3 is cooled to 20^0C. The salt crystallizes as decahydrate. What will be the yield of $Na_2CO_3.10H_20$ crystals if the solubility is 21.5 kg anhydrous Na_2CO_3/100 kg of total water? Calculate the yield If 3.2% of total weight of the solution is lost by evaporation of water.

4 + (3 + 5) = 12

7. (a) What is the difference between 'free moisture' and 'unbound moisture'? Is critical moisture content of a wet solid constant?

(b) A batch of solid is to be dried from 24% to 6% moisture content. The drying rate at constant rate period is 0.3×10^{-3} kg/m^2.s. The drying surface is 1 m^2/40 kg dry weight. The critical moisture content is 20% on dry basis. The rate of drying against moisture content during falling rate period is given below. Determine time for drying.

X (kg moist./kg dry solid	0.20	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	0.064
N x 10^3 (kg/m^2.s)	0.30	0.27	0.24	0.21	0.18	0.15	0.097	0.07	0.043	0.025

(3 + 2) + 7 = 12

Group – E

8. (a) (i) Define Molecular-weight-cut-off of a membrane.
(ii) Write down the working principle of pervaporation.

(b) A macromolecular solution (mol.wt. = 6000; concentration 1 mass %) is passed through a tubular UF membrane of 1 cm internal diameter and 1 m long at 28^0C. Pure water permeability of 1.54×10^{-5}m^3/m^2.s is obtained using this membrane. Calculate the flow velocity to be maintained in the tube in order to prevent formation of a gel layer on the membrane surface. [Data given: Rejection coefficient, = 0.99; Applied Pressure difference = 1.5 bar; Diffusivity of solute, = 8×10^{-7} cm^2/s; Viscosity of the solution = 3 cp; Concentration at which the solute forms a gel, C_g = 10.5%.Pore blockage and fouling may be ignored.].

(2 + 3) + 7 = 12

9. (a) Explain the working principle and industrial application of Electrodialysis.

(b) A liquid containing dilute solute A at a concentration of 3.1×10^{-2} kg mol/m^3 is flowing rapidly past a membrane of thickness 2.9×10^{-5} m. The distribution coefficient K' = 1.5 and $D_{AB} = 7.0 \times 10^{-11}$ m^2/s in the membrane. The solute diffuses through the membrane and its concentration on the other side is 0.52×10^{-2} kg mol/m^3. The mass transfer coefficient in the upstream side is large and can be considered as infinite and that at the downstream side is 2.03×10^{-5} m/s. Calculate the flux and the concentrations at the membrane interfaces.

(c) Calculate the osmotic pressure of a solution containing 0.10 g mol KCl/1000g H_2O at 25^0C. Given that density of water at 25^0C is 997 kg/m^3.

4 + 5 + 3 = 12