B.TECH/CHE/5TH SEM/CHEN 3103/2016

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) In adiabatic humidifier ……..
(a) enthalpy of air and liquid temperature remain constant
(b) temperature of air increases
(c) temperature of air decreases
(d) both (a) & (c).

(ii) If the absolute humidity of an air-water vapour mixture is increased, its dew point .....
(a) increases (b) decreases
(c) remains constant (d) none of these.

(iii) Which of the following employs an accessory known as "drift eliminator"?
(a) Schiebel column (b) Rotary dryer
(c) Induced draft cooling tower (d) Rotating Disc contactor.

(iv) 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.

(v) The temperature of water cooled in cooling tower is always ……. temperature of entering air.
(a) more than the wet bulb (b) less than the wet bulb
(c) equal to the wet bulb (d) equal to the dry bulb.

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

(vii) The population density function of the crystals in a MSMPR crystallizer is $8.23 \times 10^{11}\exp(-9.58L)$ number/m^4; L is in mm. The coefficient of variation of crystal size distribution is ……
(a) 64% (b) 38% (c) 52% (d) None of these.

(viii) A wet material is kept on a cross-flow tray drier with air temperature at 50°C and humidity 0.015 kg of moisture/kg of dry air. There is no radiation and conduction heat transfer to the solid. During constant temperature drying the solid surface temperature is ……
(a) 28°C (b) 35°C (c) 41°C (d) 20°C.

(ix) During pervaporation process the driving force for the mass transfer across the membrane can be explained by ..... thermodynamics
(a) equilibrium (b) non-equilibrium
(c) both (a) & (b) (d) none of these.

(x) For a hollow fibre microfiltration module the driving force for the separation through membrane is given by .....
(a) ΔP_{TMP} (b) $\Delta P_L - \Delta\pi_{Osmosis}$
(c) $\Delta P_{TMP} - \Delta\pi_{Osmosis}$ (d) both (a) & (c).

Group – B

2. (a) Write down Lewis number. What do you understand by "Lewis relation"? State its significance.

(b) Write down the differences of natural draft and forced draft cooling tower.

(c) Air enters the drying chamber of a tray dryer at 85°C after having been heated from an ambient condition of 25°C and 50 percent humidity. If the air leaves the drying chamber at 85 percent humidity as the result of an adiabatic saturation process within the dryer, what is the temperature and humidity of this exhaust air?

(1 + 1 + 1) + 5 + 4 = 12

3. A counter - flow induced draft cooling tower operates with inlet and exit water temperatures of 40°C and 29°C respectively when the inlet air dry-bulb and wet-bulb temperatures are 32°C and 25°C respectively. The tower has 1.2 m of stacked plastic fill and operates with air (dry basis) mass velocity of 9,750 kg/m^2.h and water mass velocity of 10,720 kg/m^2.h. Determine
(i) enthalpy of inlet air and outlet air

(ii) number of transfer units
(iii) height of a transfer unit
(iv) the temperature approach.

4 + 5 + 2 + 1 = 12

Group – C

4. (a) What do you understand by selectivity and distribution coefficient in case of Liquid-liquid-extraction?

(b) Discuss in brief the working principle of an industrial leaching equipment.

(c) A Nicotine-water solution contains 24 grams of Nicotine per litre. Calculate the quantity of kerosene with which 1 litre of this solution must be shaken at 308 K in order to reduce nicotine concentration to 1.8 gm/litre in the water phase. If molecular weight of Nicotine is 250 and distribution coefficient K is given as (Y/X) = 0.60 where,
Y = Concentration of Nicotine in water, mol/litre and
X = Concentration of Nicotine in Kerosene, mol/litre.

(2 + 1) + 4 + 5 = 12

5. (a) Mention in brief the advantages of super-critical fluid extraction.

(b) Pure isopropyl ether (A) at a rate of 600 kg/h is being used to extract an aqueous solution at a rate of 200 kg/h with 35 wt% acetic acid (C) by counter current multistage extraction at 25^{0}C. The exit acid concentration in the aqueous phase is 12 wt%. Calculate the number of stages required. Equilibrium data at 25^{0}C 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

2 + 10 = 12

Group – D

6. (a) "When uncrushed solid lump of high porosity will be kept on a tray drier, the slope of the falling rate with time of drying in a drying curve becomes very high." – Justify the appropriateness of the statement after commenting on the trueness of it.

(b) In a tray drier, the wet solid is kept on tray of 0.2 m^2 area, while the overall drying area is 0.1 m^2. The weight of dry solid is 3 kg and the humidity of drying air is 0.015 kg per kg of dry air. If the solid needs to be dried from 28% to 3% moisture content (on wet basis) under the aforesaid drying condition, calculate the drying time required based on the experimental information given below.

Time (hr)	Weight of the moist solid (kg)	Time (hr)	Weight of the moist solid (kg)
0	4.2	3.25	3.516
0.25	4.145	3.5	3.480
0.50	4.091	3.75	3.448
0.75	4.035	4.0	3.421
1.0	3.978	4.25	3.394
1.25	3.920	4.5	3.368
1.5	3.868	4.75	3.345
1.75	3.811	5.0	3.323
2.0	3.756	5.5	3.285
2.25	3.704	6.0	3.253
2.5	3.653	6.5	3.226
2.75	3.605	7.0	3.202
3.0	3.558	7.5	3.183

3 + 9 = 12

7. (a) "During crystallization process, the metastable zone ensures the growth of the crystal as the change in solution free energy with respect to the change in the solute concentration change is constant. However, the minimimal free energy could not be achieved here." – Justify the correctness of the statement.

(b) A continuous, vacuum-evaporating crystallizer of the DTB type is to be used to produce 907 kg/h of $Al_2(SO_4)_3.18H_2O$ (particle density = 1682 kg/m^3). The magma contains 0.15 m^3 crystals/m^3 magma and the residence time of the magma in the crystallizer is 2 h. The desired predominant crystal size on a mass basis is 0.417 mm. Estimate the required crystal growth rate in mm / h, necessary

nucleation rate in number of nuclei/h.m^3 of mother liquor in the crystallizer and number of crystals produced per hour after assuming the MSMPR model.

3 + 9 = 12

Group – E

8. (a) A solution of two different proteins, one of molecular weight 100 kDa and the other one is of 66 kDa, is fed to a UF membrane module of molecular weight cut-off 50 kDa. The condition was maintained in a way so that the denaturation of proteins was completely restricted (ideal case). What should be the percentage rejection for both the proteins?

(b) A reverse osmosis unit is to demineralize 760,000 l/d of tertiary treated effluent. Pertinent data are as follows: mass transfer coefficient = 0.2068 l/(d-m2)(kPa) at 25^{o}C, pressure difference between the feed and product water = 2400 kPa, osmotic pressure difference between the feed and product water = 310 kPa, lowest operating temperature = 10^{o}C, and Area required at 10^{o}C = 1.58 x Area required at 25^{o}C. Determine the membrane area required for demineralization.

(c) If the TDS level is enormously high in brackish water, which one you prefer most for desalination of water – Reverse osmosis or Electro-dialysis process? Justify your answer.

2 + 6 + 4 = 12

9. (a) Write briefly the basic difference between bulk, supported and emulsion liquid membrane.

(b) Calculate the HLB of a blend comprising of 70% Tween 80 (HLB = 15) and 30% Span 80 (HLB = 4.3) surfactant system. Do you feel the emulsion liquid membrane can be formulated with the said blending of surfactant? Justify your answer.

(c) For the separation of ethanol from water a pervaporation process was employed, where the membrane is made up off polyvinyl alcohol. The feed and permeate contains 8.8 wt% and 10 wt% of ethanol respectively. Feed temperature = 60^{o}C for a permeate side pressure at 76 mm of Hg. The permeate flux = 2.48 kg/m^{2}h. The vapour pressure of ethanol (MW: 46.07) and water (MW: 18.02) at 60^{o}C are 352 and 149 mm of Hg respectively. Liquid phase activity

coefficient for ethanol (1) -water (2) at 60^{o}C are given by

$$\ln\gamma_1 = 1.6276\left[\frac{0.9232x_2}{1.6276x_1 + 0.9232x_2}\right]^2 ; \ln\gamma_2 = 0.9232\left[\frac{1.6276x_1}{1.6276x_1 + 0.9232x_2}\right]^2$$

Calculate the permeance for water and ethanol.

3 + (1 + 2) + 6 = 12