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 liquid extraction if selectivity is unity, then _____ .
(a) separation of the constituents is most effective
(b) no separation will occur
(c) amount of solvent required is minimum
(d) solvent flow rate should be very low

(ii) Recirculation of hot and humid discharged air reduces tower effectiveness for _____ .
(a) natural draft cooling tower (b) forced draft cooling tower
(c) induced draft cooling tower (d) atmospheric draft cooling tower.

(iii) The apex of an equilateral triangular coordinate (in ternary liquid system) represents a _____.
(a) pure component (b) binary mixture
(c) ternary mixture (d) none of these.

(iv) Which of the following play an important role in problem of simultaneous heat and mass transfer?
(a) Schmidt number (b) Prandtl number
(c) Lewis number (d) Sherwood number.

(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) In case of nucleation in crystallization interfacial energy between solid and liquid _____ .
(a) is more than that of the energy released during formation of the crystal
(b) is less than that of the energy released during formation of the crystal
(c) is equal to the energy released during formation of the crystal
(d) is either more than or equal to the energy released during formation of the crystal.

(vii) Molecular weight cut-off of a membrane is the molecular weight of that component , _____of which is rejected by the membrane
(a) 80% (b) 100%
(c) 95% (d) 90%.

(viii) Consider a constant rate drying of a moist solid on a tray. Substantial heat transfer to the solid occurs from the tray floor. If the wet bulb temperature of the drying gas is T_W and the surface temperature of the solid is T_S, then _____.
(a) $T_S<T_W$ (b) $T_S=T_W$
(c) $T_S>T_W$ (d) both (a) and (b).

(ix) Which type of membrane/membrane material is mandatory for water permeation?
(a) hydrophobic (b) hydrophilic
(c) nylon (d) polyvinyl alcohol.

(x) The assumption(s) for MSMPR type crystalliser .....
(a) is the product must be in equilibrium with the magma within crystalliser
(b) is that it follows McCabe 'ΔL' law
(c) is that the process is at steady state condition
(d) all of these.

Group – B

2. (a) Define the following:
(i) Absolute mass humidity
(ii) Humid heat
(ii) Humid volume
(iv) Relative humidity.

(b) Obtain the equation of adiabatic cooling lines in psychrometric chart.

(2 + 2 + 2 + 2) + 4 = 12

3. (a) (i) Write down the classification of cooling tower.
(ii) Discuss the working principle of an induced draft cooling tower.

(b) A dryer requires 1.6 m^3/s of air at 60^0C and a humidity of 0.040 kg water vapour/kg dry air). This is to be prepared from ambient air having a humidity of 0.02 kg water vapour/kg dry air by direct injection of steam into the air stream followed by passage of the air over steam-heated tubes. Calculate the kilograms of steam per second required for direct injection.

(3 + 4) + 5 = 12

Group – C

4. (a) How do you select solvent for liquid-liquid extraction. Define distribution coefficient.

(b) A mixture weighing 1000 kg contains 22 wt % acetone and rest water and is to be extracted by 540 kg methyl isobutyl ketone (MIK) in a single-stage extraction at 300 K.

Determine the amounts and compositions of the extract and raffinate phase. Equilibrium data Acetone-Water-Methyl Isobutyl Ketone (MIK) at 298K:

Composition data (wt%)			**Acetone distribution data (wt%)**	
MIK	**Acetone**	**Water**	**Water Phase**	**MIK Phase**
98.0	0	2.00	2.5	4.5
93.2	4.6	2.33	5.5	10.0
77.3	18.95	3.86	7.5	13.5
71.0	24.4	4.66	10.0	17.5
65.5	28.9	5.53	12.5	21.3
54.7	37.6	7.82	15.5	25.5
46.2	43.2	10.7	17.5	28.2
12.4	42.7	45.0	20.0	31.2
5.01	30.9	64.2	22.5	34.0
3.23	20.9	75.8	25.0	36.5
2.12	3.73	94.2	26.0	37.5
2.2	0	97.8		

(2 + 2) + 8 = 12

5. (a) Give examples of two commercially used leaching operations. Discuss the working principle of one commercially used leaching equipment.

(b) In a single stage leaching of soybean oil from flaked soybeans with hexane, 110 kg of soybeans containing 22 wt% oil is leached with 100 kg of solvent containing 2.5 wt % soybean oil. The value of N (kg insoluble solid/kg solution) for the slurry underflow is essentially constant at 1.55 kg insoluble solid/kg solution retained. Calculate the amount and compositions of the overflow and the underflow leaving the stage.

(1 + 3) + 8 = 12

Group – D

6. 150 g of crystals separated from 1L of suspension from an MSMPR crystalliser is subjected to screen analysis to get the following data.

Tyler mesh	12/14	14/20	20/28	28/35	35/48	Below 48
Mass (g)	28.5	29.2	37.5	27	24.7	3.1

12 (mesh number): 1410 µm (screen opening); 14: 1190 µm; 20: 841 µm; 28: 595 µm; 35: 420 µm; 48: 297 µm. The working volume of the crystallizer is 200 L; Rate of withdrawal of the slurry = 250Lph; Density of the crystal: 1400 kg/m^3; volume shape factor: 0.42.

(i) Determine the crystal growth and the zero size population density of the crystal
(ii) What is the nucleation rate?

8 + 4 = 12

7. (a) With increasing the humidity of the environment, the rate of drying will decrease." – Justify the correctness of the statement.

(b) 0.1 m^2 of wet sample is suspended from a weighing balance inside a dryer. The edges are sealed and drying takes place from both the large surfaces. Air (dry bulb temperature 65°C, wet bulb temperature 29°C) is flown over the wet material at 1.5 m/s. The following weights are recorded over time:

Time (h)	Mass (kg)	Time (h)	Mass (kg)	Time (h)	Mass (kg)
0	4.820	3.0	4.269	7.0	3.885
0.1	4.807	3.4	4.206	7.5	3.871
0.2	4.785	3.8	4.150	8.0	3.859
0.4	4.749	4.2	4.130	9.0	3.842
0.8	4.674	4.6	4.057	10.0	3.832
1.0	4.638	5.0	4.015	11.0	3.825
1.4	4.565	5.4	3.979	12.0	3.821
1.8	4.491	5.8	3.946	14.0	3.819
2.2	4.416	6.0	3.933	16.0	3.819
2.6	4.341	6.5	3.905		

The sample is then dried in an oven at 110°C, where the dry weight of the sample is 3.765 kg. Plot the rate-of-drying curve and find out the time required for moisture content from 20% to 2% on wet basis.

(3 + 9) = 12

Group – E

8. (a) "During the formulation of an emulsion liquid membrane, HLB value of the surfactant must be higher." – Justify the correctness of the statement.

(b) 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°C for a permeate side pressure at 76 mm of Hg. The permeate flux = 2.48 kg/m^2h. The vapour pressure of ethanol (MW: 46.07 kg/kmol) and water (MW: 18.02 kg/kmol) at 60°C are 352 and 149 mm of Hg respectively. Liquid phase activity coefficient for ethanol (1)-water(2) at 60°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 + 9) = 12

9. (a) What are the parameters that one must understand during the procurement of an ultrafiltration membrane?

(b) During the separation of oil from water using 10 kDa PES membrane, one had found the following volumetric flux with respect to time at 3 kg_f/cm^2 TMP. From the information find out (i) the fouling resistance over the membrane if the viscosity of water is 10^{-3} Pas (ii) membrane material resistance (assume there is no fouling initially) (iii) the observed rejection if the average permeate concentration of oil is 10^{-4} kg/m^3 and average concentration of oil over the membrane is equal to 0.005 kg/m^3 (iv) the volume fraction of oil in the permeate at 25 min if the mass transfer coefficient for oil = 2×10^{-9} m/s.

Time (min)	Volumetric flux (m^3/m^2s)
0	6.48671×10^{-6}
5	4.59475×10^{-6}
10	3.02121×10^{-6}
15	2.75685×10^{-6}
20	2.68961×10^{-6}
25	2.68961×10^{-6}

(4 + 8) = 12

Department & Section	Submission Link
CHE	https://classroom.google.com/c/MjgyNTMyNDY0Mjk1/a/MjgyNTMyNDY0MzUy/details