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) The term "Approach" in a cooling tower means
(a) The difference between inlet and outlet temperature of water
(b) The difference between inlet and outlet temperature of air
(c) The difference between inlet water temperature and outlet air wet-bulb temperature
(d) The difference between outlet water temperature and inlet air wet-bulb temperature.

(ii) Drift in a cooling tower is
(a) the water entrained by the circulating air
(b) dependent on the water lost by evaporation
(c) desirable
(d) all of (a), (b) and (c).

(iii) 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.

(iv) Rate of leaching increases with increase in
(a) Pressure (b) Viscosity
(c) Temperature (d) Size of the solid.

(v) Film layer model for crossflow membrane filtration process is applicable for
(a) microfiltration (b) ultrafiltration
(c) both (a) and (b) (d) nanofiltration and reverse osmosis.

(vi) Observed rejection (R_0) is given by
(a) $R_O = 1 - \frac{C_p}{C_b}$ (b) $R_O = 1 - \frac{C_p}{C_m}$
(c) $R_O = 1 - \frac{C_b}{C_p}$ (d) $R_O = 1 - \frac{C_m}{C_p}$

(vii) The relative saturation of a partially saturated mixture can be increased by _____ of the mixture
(a) by reducing the temperature (b) by increasing total pressure
(c) by reducing total pressure (d) both (a) and (b).

(viii) Which of the following is most suitable for extraction in a system having very low density difference?
(a) Mixer-settler extractor (b) Pulsed extractor
(c) Podbielniak extractor (d) Packed extractor.

(ix) 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

(x) At critical moisture content during drying, the surface of the solid is
(a) having film layer of moisture
(b) free of any moisture
(c) having dry spot
(d) having moisture whose vapour pressure is less than that of pure water vapour pressure.

Group – B

2. (a) Water at rate of 14 kg/s is to be cooled from 45^0C to 30^0C by contact with air in an induced draft cooling tower. Entering air has a dry-bulb temperature of 30^0C, wet-bulb temp. 25^0C. An air (with vapour) of 1.5 times the minimum is to be used. Make up water will come from a well and it contains a hardness of 450 ppm of dissolved solids. The circulating water should not contain more than 1800 ppm hardness. Given K_Ya = 0.90 kg/m^3.s.Δy for a liquid rate at least 2.7 kg/m^2.s and a gas rate of 2.0 kg/m^2.s. Compute (i) the height of the packed section and (ii) the make-up water requirement.

(b) With sketch, discuss the working principle of cross-flow induced draft cooling tower.
8 + 4 = 12

3. (a) Derive the equation of psychrometric line.

(b) State Lewis relation.

(c) On a particular day the weather forecast states that the dry-bulb temperature is 37^0C, while the relative humidity is 50% and the barometric pressure is 101.325 kPa. Find (i) absolute humidity, (ii) dew point and (iii) enthalpy of moist air on that day.
Given: Vapour pressure of water at 37^0C = 6.2795kPa.
6 + 1 + (2 + 1 + 2) = 12

Group – C

4. (a) What are the advantages and disadvantages of carrying out extraction at higher temperature.

   (b) Explain, in brief, the working principle of Podbielniak Extractor.

   (c) 1000 kg/h of a nicotine-water solution containing 1% nicotine is to be counter currently extracted with pure kerosene at 20°C so as to reduce the nicotine content to 0.1%. Water and kerosene are essentially insoluble. Determine the minimum kerosene rate.
   The equilibrium data is given below:

x′, (kg nicotine / kg water)	0	0.001	0.0025	0.005	0.0075	0.0099	0.0204
y′*, (kg nicotine / kg kerosene)	0	0.0008	0.002	0.0046	0.0069	0.0091	0.0187

2 + 3 + 7 = 12

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

   (b) Mention two equipments for leaching used in industry.

   (c) In a single stage leaching of soy-bean oil from flaked soybeans with hexane, 110 kg of soybeans containing 23 wt% oil is leached with 90 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.

3 + 1 + 8 = 12

Group – D

6. (a) "Multieffect crystallizer provides better steam economy compared to multistage crystallizer." – Justify the correctness of the statement after stating the definition for steam economy.

   (b) Using evaporation type crystallizer $MgSO_4.7H_2O$ crystal has been formed from 3000 kg of saturated solution at 35°C. Initially 2 kg of the crystal of size 50μm was added to the solution as seed. At 35°C, the solubility of the crystal is 30% (w/v) and supersaturation is given as 0.01 gm of crystal per gm of solution. Data: $\rho_{solution}$ = 1.34g/cc; $\rho_{crystal}$ = 1.68 g/cc; molecular weight of the crystal=246.6; viscosity of solution = 0.008 Pas; Diffusivity of $MgSO_4$ = 1.1×10^{-5} m^2/s; final crystal size = 400μm. Find the amount of water evaporated out, magma volume and the crystallizer volume if 70% of the crystallizer will be occupied?

4 + 8 = 12

7. (a) "With increase in 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. Point out the critical moisture content and equilibrium moisture content and find out the time required for reducing moisture content from 20% to 2% on wet basis.

2 + 10 = 12

Group – E

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

   (b) Using Onsager's reciprocal relationship show that the solvent flux through membrane can be given by $L_P(\Delta P - \Delta\pi)$, where L_P is the permeability, ΔP is TMP and $\Delta\pi$ is the osmotic pressure. Assume that the solvent flux is proportional to chemical potential, which is again a function of the concentration and pressure.

5 + 7 = 12

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

   (b) It is required to produce 20000 m^3 per day of potable water having a salt concentration not more than 300 ppm from sea water containing 3.3% salt. An asymmetric cellulose acetate membrane (thickness 0.8 μm) having a water permeability of 70 l/m^2hMPa and salt rejection of 98% is used. The feed side pressure is 75 atm that on the permeate side is 1 atm. If 30% of the feed water permeates through the membrane, calculate the required membrane area. The polarisation modulus is 1.2.

3 + 9 = 12