CS/B.Tech(CHE)/SEM-6/CHE-601/2012

2012

SEPARATION PROCESSES - II

Time Allotted : 3 Hours   *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1.   Choose the correct alternatives for any *ten* of the following :

                                        10 × 1 = 10

   i)   At a fixed total pressure, humidity depends only on the

      a)   partial pressure of vapour in the mixture

      b)   heat capacity of the vapour

      c)   density of the vapour

      d)   none of these.

   ii)   When the temperature and humidity of air is low, we usually use …………… draft cooling tower.

      a)   natural   b)   forced

      c)   induced   d)   none of these.

6014   [Turn over

iii) Which of the following parameter remains almost constant during adiabatic saturation of unsaturated air ?

    a) Dry bulb temperature   b) Dew point

    c) Wet bulb temperature   d) None of these.

iv) Leaching of sugar from sugar beets is done by

    a) hot water   b) hexane

    c) dilute H_2SO_2 d) lime water.

v) In extraction, as the temperature increases, the area covered by binodal curve

    a) decreases   b) increases

    c) remains unchanged   d) none of these.

vi) Driving force in ultrafiltration process is

    a) osmotic pressure difference

    b) transmembrane pressure difference

    c) concentration difference

    d) none of these.

vii) The artificial kidney follows the application of

    a) osmosis   b) dialysis

    c) reverse osmosis   d) ultrafiltration.
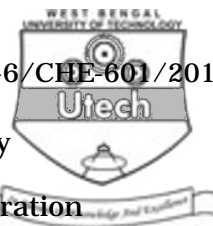
viii) Desalination of sea water can be done by

    a)   microfiltration   b)   ultrafiltration

    c)   nanofiltration   d)   reverse osmosis.

ix) In a constant rate drying, the exposed surface of the wet-solid is

    a)   supersaturated with liquid

    b)   unsaturated with liquid

    c)   saturated with liquid

    d)   none of these.

x) Make up water is required in a cooling tower to replace the water lost by

    a)   evaporation

    b)   drift

    c)   blowdown and leakage

    d)   all of these.

xi) In a non-hydrated pure crystal, the mole fraction $\left(X_F \right)$ is equal to

    a) > 1 b) < 1

    c) 0 d) 1.

xii) ………………… is the steady state temperature attended by a small amount of liquid evaporation into a large quantity of unsaturated gas-vapour mixture.

    a)   Dry bulb temperature   b)   Wet bulb temperature

    c)   Dew point   d)   None of these.

GROUP – B
(Short Answer Type Questions)
Answer any *three* of the following. 3 × 5 = 15

2. What is Lewis number ? Show that its value for the air-water system is nearly unity. 2 + 3

3. What is selectivity ? How a solvent is selected for liquid-liquid extraction ? 2 + 3

4. A material is dried in a tray-type batch dryer using constant-drying conditions. When the initial free moisture content was 0.28 kg free moisture/kg dry solid, 6.0 hrs was required to dry the material to a free moisture content of 0.08 kg free moisture/kg dry solid. The critical free moisture content is 0.14. Assuming a drying rate I the falling-rate region, where the rate is a straight line from the critical point to the origin, predict the time to dry a sample from a free moisture content of 0.33 to 0.44 kg free moisture/kg dry solid.

5. 150 kg of a nicotine-water solution containing 1% nicotine is to be extracted with 250 kg of kerosene at 20°C. Water and kerosene are essentially immiscible in each other. Determine the percentage extraction of nicotine after one stage operation. At the dilute end of the system, the equilibrium relationship is

$$Y^* = 0.798X$$

where Y and X are expressed as kg nicotine/kg kerosene and kg nicotine/kg water, respectively.

6. a) Write down the sequence of stages in the evolution of a crystal.

   b) What are the parameters controlling the crystal size distribution in a crystallizer ? Explain them briefly.

   2 + 3

GROUP – C
(Long Answer Type Questions)
Answer any *three* of the following.　　　3 × 15 = 45

7. a) What do you understand by "unbound moisture" and "equilibrium moisture" ?

   b) How drying time can be calculated in case of batch drying under constant drying condition ?

   c) A wet solid of 23.5% moisture content is to be dried to 1% moisture in a tray drier. A laboratory test shows that it requires 7.3 hours to reduce the moisture content of the same solid to 2%. The critical moisture content is 4.5% and the equilibrium moisture content is 0.25%. The falling rate of drying is linear in the free moisture content. Calculate the drying time of the solid if the same drying conditions maintained as those in lab test. All moisture given is in dry basis.　　　3 + 5 + 7

8. a) A counter-flow induced-draft cooling tower operates with inlet and exit water temperatures of 40°C and 27°C when the inlet air-bulb and wet-bulb temperatures are 33°C and 25°C respectively. The tower has 1.3 m of stacked plastic fill and the flow rates are G_y = 9852 kg/m^2.h and G_x = 10750 kg/m^2.h. Determine (i) the number of transfer units, (ii) height of a transfer unit based on the overall gas-phase driving force and (iii) the temperature approach.

   The equilibrium distribution data are given as under :

Temp.,°C	25°C	30°C	35°C	40°C	45°C
Enthalpy, kJ/kg.K	70	100	128	165	211

   b) Write a short note on natural draft cooling tower.

   　　　12 + 3

9. A mixture weighing 1000 kg contains 23 wt % acetone and 77 wt % water and is to be extracted by 500 kg methyl isobutyl ketone (MIK) in a single-stage extraction. Determine the amounts and compositions of the extract and raffinate phase.

Equilibrium data :

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		

10. a)   i)   What do you understand by osmotic pressure ?
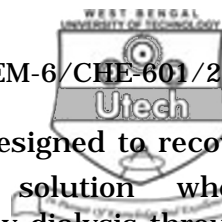
ii) A membrane process is being designed to recover solute A from a dilute solution where $c_1 = 2.0 \times 10^{-2}$ kg mol A/m^3 by dialysis through a membrane to a solution where $c_2 = 0.3 \times 10^{-2}$ kg mol A/m^3. The membrane thickness is 1.59×10^{-5} m, the distribution coefficient K' = 0.75, $D_{AB} = 3.5 \times 10^{-11}$ m^2/s in the membrane, the mass transfer coefficient in the dilute solution is $k_{c1} = 3.5 \times 10^{-5}$ m/s and $k_{c2} = 2.1 \times 10^{-5}$ m/s. Calculate the total resistance and steady state flux.

iii) For ultrafiltration, derive the following equation :

$$J = k \ln \frac{c_m - c_p}{c_b - c_p}$$

b) What is crystallization ? How are the crystallizers classified ? $\qquad$ 2 + (5 + 4) + 4

11. a) Write short notes on any *two* of the following :

   i) Bollman extractor

   ii) Spray drier

   iii) Podbielniak extractor.

b) In a single stage leaching of soybean oil from flaked soybeans with hexane, 100 kg of soybeans containing 22 wt % oil is leached with 80 kg of hexane solvent containing 3 wt % soybean oil. The value of *N* for the slurry underflow is essentially constant at 1.5 kg insoluble solid/kg solution retained. Calculate the amounts and compositions of the overflow the underflow slurry leaving the stage. $(2 \times 2\frac{1}{2}) + 10$