Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/CHE/New/SEM-6/CHE-601/2013

2013

SEPARATION PROCESS-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.

Graph papers and Psychometric chart will be supplied by the institution.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

   i) Selectivity (in extraction) is analogous to ..... of distillation.

      a) diffusivity b) relative volatility

      c) volatility d) transfer coefficient.

   ii) In a counter-current extractor as the axial mixing increases, the extraction efficiency

      a) increases

      b) decreases

      c) remains unchanged

      d) depends on the pressure of the system.

iii) Tie lines of leaching operation are not vertical when

a) the time contact is not sufficient

b) solute dissolves in solid

c) solute adsorbs is solid

d) all of these.

iv) Air, initially at 101.3 kPa and 40°C with RH of 50% is cooled at constant pressure to 30°C. The cooled air has

a) a higher dew point

b) a higher relative absolute humidity

c) a higher relative humidity

d) a higher WBT.

v) When an unsaturated air-water mixture is heated at constant pressure, then

a) Partial pressure of water vapour increases

b) Specific humidity decreases

c) Relative humidity increases

d) Relative humidity decreases.

vi) With increasing solute concentration in the bulk solution, the ultrafiltration flux

a) increases b) decreases

c) remains unchanged d) none of these.

vii) Which of the following substances may undergo case hardening if the drying rate is fast ?

a) Sand b) Soap bar

c) Wood chips d) Wet PVC beads.

viii) When the temperature and humidity of air are low we usually use ..... draft cooling tower.

a) Natural b) Forced

c) Induced d) None of these.

ix) Which of the following types of nucleation is predominant in a continuous industrial crystallizer ?

a) Homogeneous nucleation

b) Nucleation by attrition

c) Contact nucleation

d) Heterogeneous nucleation.

x) Steady state temperature attended by a small amout of liquid evaporating into a large quantity of unsaturated gas-vapour mixture is called the

a) dry bulb temperature

b) wet bulb temperature

c) dew point

d) none of these.

xi) 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 these.

xii) Rejection coefficient of a reverse osmosis membrane is given by

a) $B(\Delta P - \Delta \prod)/(1 + B(\Delta P - \Delta \prod))$

b) $B(\Delta P + \Delta \prod)/(1 + B(\Delta P - \Delta \prod))$

c) $B/(1 + B(\Delta P - \Delta \prod))$

d) $B(\Delta P - \Delta \prod)$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. a) Discuss the factors which govern the selection of solvents to be used for liquid-liquid extractions.

   b) Describe the procedure to determine the number of theoretical stages for counter-current multistage extraction. 2 + 3

3. 1000 kg (dry mass) of non-porous solid is dried under constant drying conditions with an air velocity of 0.75m/s. The area of drying surface is $55m^2$. If the initial rate of drying is $0.3g/(m^2.s)$, how long will it take to dry a material from 0.15 to 0.025 kg water/kg dry solid ? The critical moisture content is 0.125 kg water/kg dry solid. Assume that the falling rate is linear. The equilibrium moisture content may be assumed to be zero.

4. A batch of 500 kg of KCl is dissolved in water to make a saturated solution at 350K where the solubility is 30% by weight KCl in water. The solution is cooled to 293K at which the solubility is 25.4% by weight. Determine the quantity of crystals obtained if 3.5% of the original water evaporates on cooling.

5. Explain the basic principle of pervaporation and for a pervaporation module. Derive the expression for the stage cut or the ratio of flow rate of permeate to that of feed in terms of selectivity and inlet and outlet temperatures.

6. Write a short note on Podbielniak extractor.

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. An aqueous solution of solute *C* is to be extracted with pure solvent *B* to recover the solute. The equilibrium data in terms of weight % of solute in the two layers are given below :

Aqueous layer	2	8	15	20
Solvent layer	8	22	35	45

A feed 20% by weight of solute is to be treated in two consecutive cross-current cascades using aqueous solution to solvent ratio of 1.8. Calculate :

i) Concentration of final raffinate

ii) Amount of raffinate

iii) % recovery of solute

iv) Amount of solvent to be used for a single stage extraction to obtain the same final concentration. (Water and solvent are immiscible with each other).

8. Warm water at 45°C is to be cooled to 30°C by countercurrent contact with air in a tower packed with wood slats. The inlet air has a dry-bulb temperature of 31°C and a wet bulb temperature of 22°C. The mass flow rate of water is 5,450 $kg/m^2.h$ and that of air is 1.35 times the minimum. Determine

   a) the dry air flow rate to be used

   b) number of enthalpy transfer unit.

   [Psychrometric chart and mm graph papers are to be used.]

9. a) Briefly describe the solid preparation steps in leaching.

   b) A continuous countercurrent multistage system is to be used to leach oil from meal by benzene solvent. The process is to treat 2000 kg/hr of inert solid meal containing 800 kg oil and also 50 kg benzene. The inlet flow per hour is fresh solvent mixture containing 1310 kg benzene and 20 kg oil. The leached solids are to contain 120 kg oil. The value of N (kg inert solid/kg solution) for the slurry underflow is essentially constant at 1.85. Calculate the exit flows and compositions and the number of stages required. 3 + 12

10. a) A liquid containing dilute solute A at a concentration $C_1 = 3 \times 10^{-2}$ kg-mol/m^3 is flowing rapidly, passed a membrane of thickness $L = 3{\cdot}0 \times 10^{-5}$ m. The distribution coefficient

   $k = 1{\cdot}5$ & $D_{AB} = 7{\cdot}0 \times 10^{-11}$ m^2/sec in the membrane. The solute diffuses through the membrane and its concentration on the other side is

   $C_2 = 0{\cdot}5 \times 10^{-2}$ kg-mol/m^3. The mass transfer coefficient k_{c1} is large and can be considered as infinite and $k_{c2} = 2{\cdot}02 \times 10^{-5}$ m/sec. Calculate the flux & the concentrations at the membrane interfaces.

b) It is desired to use ultrafiltration for 800 kg of a solution containing 0.05 wt % of a protein to obtain a solution of 1.1 wt%. The feed is recirculated by the membrane with a surface area of 9.9 m^2. The permeability of the membrane is

$A_w = 2.5 \times 10^{-2}$ kg/s.m^2.atm. Neglecting the effects of concentration polarization if any, calculate the final amount of solution and the time to perform this using a pressure difference of 0.5 atm. 7 + 8

11. Write short notes on any *five* of the following : 5 × 3

a) Effect of air flow rate on cooling tower height

b) Significance of Ultrafiltration

c) Applications of RO in waste water treatment plant

d) Drum dryer

e) Vacuum crystalliser

f) Rotating disk contactor

g) Induced draft cooling tower.