Name : ……………………………………………………

Roll No. : …………………………………………………

Invigilator's Signature : …………………………………

CS/B.TECH (FT-OLD)/SEM-5/CHE-514/2012-13
2012
UNIT OPERATION OF CHEMICAL ENGINEERING-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)   In batch distillation with constant reflux with time overhead product composition

   a)   increases

   b)   decreases

   c)   does not vary

   d)   may increase or decrease depending upon the system.

ii) Stripping column distillation means

a) feed to be distilled is supplied at an intermediate point of the column

b) the feed to be distilled is supplied at the bottom of the column

c) feed is an azeotropic mixture

d) feed to distilled is added to the top of the column.

iii) Relative volatility α_{AB} stands for

a) $xa \, / \, ya$　　　　　　b) ya/xa

c) $xa \, p_A{}^o + xb \, p_B{}^o$　　d) $p_A{}^{sat} \, / \, p_B{}^{sat}$.

iv) Reverse osmosis membrane has a pore size of

a) 0·1 – 10 micron　　　b) 0·5 – 10 nm

c) 1 – 10 nm　　　　　　d) 10 – 30 micron.

v) Which of the following operations does not involve leaching ?

a) Dissolving gold from ores

b) Dissolving pharmaceuticals products from bark or roots

c) Dissolving sugars from cells of beet

d) Removing nicotine from water solution of kerosene.

vi) Diffusivity of a constituent A in solution B has the unit

    a)   m/s   b) m^2/s

    c) m^3/s d) $k\,mol/(m^2/s)$.

vii) The slope of operating line for the stripping section of distillation column is

    a)   0   b) ∞

    c)   < 1   d)   > 1.

viii) The dew point of an unsaturated mixture of vapour and gas does not depend on

    a)   the temperature of the mixture

    b)   the total pressure of the mixture

    c)   the composition of the mixture

    d)   all of these.

ix) For a single component absorber the operating line

    a)   always lies below the equilibrium solubility curve

    b)   always lies above the equilibrium solubility curve

    c)   is straight only when plotted in terms of the mole fraction unit

    d)   has a negative slope for countercurrent operation.

x) Which of the following systems is an example of maximum boilling azeotrop ?

    a)   Carbon disulphide-acetone

    b)   Ethanol-water

   c)   Benzene-ethanol

    d)   Acetone-chloroform.

xi) Corresponding to Nusselt number in heat transfer, the dimensionless group in mass transfer is

   a) Sherwood number   b) Schmidt number

   c) Peclet number   d) Stanton number.

xii) Wetted wall tower experiment determines

   a) molal diffusivity

   b) volumetric coefficient

   c) mass transfer coefficient

   d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) Define critical moisture content and equilibrium moisture content.

   b) A material is to be dried from 16% moisture by weight (wet basis) to 0·5% by circulation of hot air. The fresh air contains 0·02 kg of water/kg of dry air. Find the volume of fresh air required, if 1000 kg/hr of dried material is to be produced. The exit humidity of air is 0·09 kg water/kg of dry air. The air enters at 301 K and at 1 atm pressure.   2 +3

3. For a binary gas mixture of *A* & *B*, prove that the diffusion coefficient D_{AB} and D_{BA} are numerically equal.
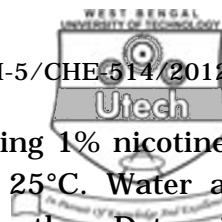
4. 50 kg of a nicotine water solution containing 1% nicotine is to be extracted with 250 kg kerosene at 25°C. Water and kerosene are essentially immiscible in each other. Determine the percentage extraction of nicotine after one stage of extraction. At the dilute end of the system equilibrium relation is

$$Y^* = 0.798 \ X \ ,$$

where Y and X are expressed as kg of nicotine per kg of kerosene, and kg of niocotine per kg of water respectively.

5. a) Do you expect flooding in a co-current packed tower absorption column ? Explain your answer.

   b) Define HETP. 3 + 2

6. Write a note on choice of solvent for liquid-liquid extraction.

GROUP – C

(Long Answer Type Questions)

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

7. a) What is Murphree plate efficiency ? Can it be greater than 100% ? Explain your answer.

   b) 4000 kg mol/hr of a liquid feed at its boiling point containing 70 mol% of benzene (*A*) and 30 mol% of toluene (*B*), is fed to a stripping tower maintained at 101·3 kPa pressure. The bottom product flow is to be 60 kg mol/hr containing 10 mol% of *A* and rest *B*.

   Calculate the kg mol/hr of overhead product, its composition and number of theoretical stages required :

x :	1·000	0·780	0·581	0·411	0·258	0·130	0
y :	1·000	0·900	0·777	0·632	0·456	0·261	0

2 + 3 + 10

8. a) What is the reflection coefficient in reverse osmosis ?

b) A cellulose acetate membrane with an area of 4×10^{-3} m^2 is used at 25°C, to determine permeability of a feed solution containing 12 kg Nacl/m^3,

ρ_1 = 1005·5 kg/m^3. The product solution has a concentration of 0·0468 kg NaCl/m^3, ρ_2 = 993·5 kg/m^3. The measured product flow rate is

$3·84 \times 10^{-8}$ m^3/sec and the pressure difference used is 56 atm. Calculate the permeability constant and solute rejection ratio.

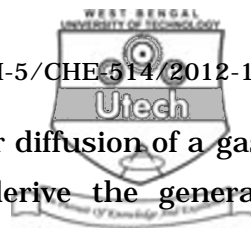| gm mol NaCl/kg H_2O	Osmotic pressure in atm
0	0
0·01	0·47
0·10	4·56
0·50	22·55
1·00	45·80
2·00	96·2

3 + 12

9. a) What is aqueous two-phase extraction ?

b) "Extraction process is sometimes pH dependent." Explain.

c) Explain Stefan method for the determination of vapour diffusivity. 2 + 3 + 10

10. a) For the case of steady state molecular diffusion of a gas *A* through a non-diffusing gas *B*, derive the general working equation for the flux N_A .

b) A mixture of acetone vapour and air containing 5% by volume of acetone is to be freed of its acetone content by scrubbing with water in a packed bed absorber. The flow rate of gas mixture is 700 m^3/hr of acetone free air measured at N.T.P. and that of water is 1500 kg/hr. The absorber operates at an average temp. of 20°C and presure of 101 kPa. The scrubber absorbs 98% of acetone.

The equilibrium relationhip for acetone vapour-water system is given by

$$Y^* = 1{\cdot}68\ X,$$

where *Y* = kmol of acetone/kmol of dry air

X = kmol of acetone/kmol of water.

Calculate the mean driving force for absorption.

c) Define

i) Height of transfer units

ii) Number of transfer units. 5 + 6 + 4

11. a) Define steam distillation. What are the advantages of steam distillation process ?

b) How can vapour liquid curve be constructed for an ideal two-component solution ?
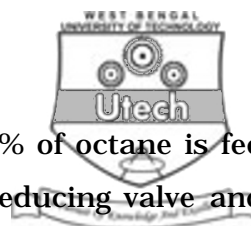
c) A feed of 50 mol% of hexane and 50% of octane is fed into a pipe still through a pressure reducing valve and then into a flash disengaging chamber. The vapour and liquid leaving the chamber are assumed to be in equilibrium. If the fraction of the feed converted to vapour is 0·5, find the composition of the top and bottom products. The following table gives the equilibrium data of the system :

Mole fraction of hexane in liquid	1·00	0·69	0·40	0·192	0·045	0·00
Mole fraction of hexane in vapour	1·00	0·932	0·78	0·538	0·17775	0·00

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