Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.TECH(CHE)(N)/SEM-5/CHE-501/2012-13

2012
SEPARATION PROCESS-I

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 sheet (mm) will be supplied by the Institute on demand.

GROUP – A

(Multiple Choice Type Questions)

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

   i) The absorption factor along with its most economical value is given as

      a) Ratio of slope of equilibrium line to operating line; 1·2 to 2

      b) Ratio of slope of operating line to equilibrium line; 0·5 to 1

      c) Ratio of slope of operating line to equilibrium line; 1·25 to 2

      d) Ratio of slope of operating line to equilibrium line; 0 to 1.

ii) NTU is numerically equal to Number of Theoretical plates only when operating line

    a) lies below the equilibrium curve

    b) lies above the equilibrium curve

    c) and the equilibrium lines are straight and parallel

    d) is far from the equilibrium line.

iii) In physical terms, Schmidt number means

    a) Thermal diffusivity/mass diffusivity

    b) Thermal diffusivity/momentum diffusivity

    c) Momentum diffusivity/mass diffusivity

    d) Mass diffusivity/thermal diffusivity.

iv) Distillation process belongs to the which one of the following phases in contact ?

    a) Solid—liquid

    b) Solid—gas

    c) Liquid—liquid

    d) Vapour—liquid.

v) Steam distillation is used to separate

    a) azeotropes

    b) high boiling substances from non-volatile impurities

    c) heat sensitive materials

    d) mixtures of low relative volatility.

vi) Physical adsorption is

   a) an irreversible phenomenon

   b) a reversible phenomenon

   c) accompanied by evolution of heat

   d) both (b) and (c).

vii) A feed mixture of distillation contains 25% liquid and rest is vapour. q value of the mixture is

   a) 3   b) 0

   c) $\dfrac{1}{4}$ d) $\dfrac{3}{4}$.

viii) Wetted wall tower experiments determines

   a) molar diffusivity

   b) volumetric coefficient

   c) mass transfer coefficient

   d) none of these.

ix) At the azeotropic composition of a binary mixture, the relative volatility is

   a) 0   b) 1

   c) < 1   d) ∞.

x) With lowering of equilibrium pressure, at a given temperature the amount of adsorbate on the adsorbent

   a) increases

   b) decreases

   c) remains same

   d) either (a) or (b) depends on the system.

xi) Minimum number of theoretical plates are required in distillation process in case of

    a) Total Reflux

    b) Infinite Reflux

    c) Minimum Reflux

    d) Both (a) and (b).

xii) The length of the unused bed (LUB) is more if the mass transfer zone is

    a) wide

    b) narrow

    c) asymmetric

    d) symmetric.

GROUP – B
(Short Answer Type Questions)

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

2. Show that for a binary gas mixture, the diffusivity of A in B equals the diffusivity of B in A.　　　　5

3. Show that according to film theory, mass transfer coefficient is proportional to diffusivity and according to penetration theory, mass transfer coefficient is proportional to the square root of diffusivity.　　　　5
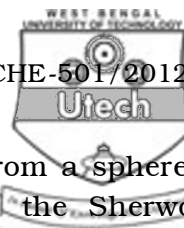
4. Prove that for equimolar counter-diffusion from a sphere to a surrounding stationary infinite medium, the Sherwood number based on the diameter of the sphere is equal to 2. 5

5. Hydrogen gas at 2 atm pressure and 250 C flows through a neoprene rubber with internal dia and outer dia of 25 mm and 50 mm respectively. The solubility of hydrogen is reported as $0 \cdot 053 \ m^3 S.T.P/m^3$ atm and the diffusivity of hydrogen gas through rubber is $0 \cdot 0000018 \ cm^2/sec$. Estimate the loss of hydrogen by diffusion per metre length of pipe. 5

6. How is the height of overall gas phase transfer unit H_{OG} related to the height of gas film transfer unit H_G and the height of liquid film transfer unit H_L if the equilibrium relationship is given by $y * = mx$ and gas flow rate and liquid flow rates are given by G_m and L_m ? 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. A spherical gas bulb of volume 500 c.c. contains air-NH_3 mixture in the volume ratio 4 : 1 at 40° C and 1 atm pressure. It is exposed to the atmosphere at the same temperature and pressure through a tapered capillary of length 5 cm. The diameter at the left hand side is 2 mm, and that at the right hand side, which is exposed to atmosphere, is 1 mm. If the gas bulb if left open as such, find the NH_3 concentration in the bulb after 15 minutes. D_{AB} for air-NH_3 at 0° C and 1 atm pressure is $0 \cdot 198 \times 10^{-4} \ m^2/s$. State all the assumptions made for solving the problem.

12 + 3
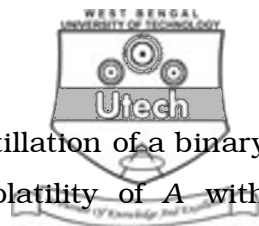
8. a) Derive Rayleigh equation of batch distillation of a binary mixture *A* and *B* where relative volatility of *A* with respect to *B* is α. Explain azeotropic distillation.

   b) The Antoine constants for benzene and toluene are as follows :

   For benzene : $A = 6\cdot906$, $B = 1211\cdot03$, $C = 220\cdot79$

   For toluene : $A = 6\cdot95$, $B = 1343\cdot9$, $C = 219\cdot37$

   The equation is as follows :

   Log $P° = A - B / (t + C)$ where $P° = $ mm Hg and t is in °C

   Determine vapour composition of a mixture in equilibrium with a liquid mixture of 0·5 mole fraction benzene and 0·5 mole fraction of toluene at 338 K. Will the liquid vaporize at $101\cdot3$ kN/m^2 ?

   c) The liquid of 50 mole % *n*-heptane (more volatile) and 50 mole % *n*-octane were subjected to a differential distillation at atmospheric pressure, with 60 mole % of the liquid distilled. Compute the composition of the composited distillate and the residue graphically [Graph paper (mm) will be required].

   The equilibrium data are given below :

x :	0·5	0·46	0·42	0·38	0·34	0·32
y *	0·689	0·648	0·608	0·567	0·523	0·497

   5 + 5 + 5

9. A liquid mixture of benzene-toluene is to be distilled in a fractionating tower at 101·3 kPa pressure. The feed of 100 kmol/h is liquid, containing 45 mol % of benzene and the rest is toluene enters at 327·6 K. A distillate containing 95 mol % of benzene and the bottoms containing 10 mol % of benzene are to be obtained. The reflux ratio is 4 : 1. The average heat capacity of the feed is 159 kJ/kmolK and the average latent heat is 32099 kJ/kmol. Calculate the amount of distillate, bottoms and the number of theoretical trays needed. Equilibrium data for this system are given below (at 101·325 kPa) :

x_A :	1·00	0·78	0·58	0·41	0·26	0·13	0·00
y_A	1·00	0·90	0·78	0·63	0·46	0·26	0·00

10. State basic assumptions for Langmuir type adsorption. Derive mathematical expression for Langmuir isotherm. Discuss the graphical method of determining usual parameters of the isotherm. 3 + 7 + 5

11. a) What are the desirable properties of an adsorbent ? Give examples of commonly used adsorbent.

 b) Write short notes on Breakthrough cure in adsorption.

 c) Show that Freundlich isotherm is a special case of Langmuir isotherm. 5 + 5 + 5