B.TECH/CHE/4TH SEM/CHEN 2202/2018

SEPARATION PROCESS – I

(CHEN 2202)

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) Surface renewal theory relates the mass transfer co-efficient (k) to diffusivity (D) as
(a) $k \propto D$ (b) $k \propto D^{0.5}$ (c) $k \propto D^{1.5}$ (d) $k \propto D^{2}$.

(ii) 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.

(iii) Dynamic liquid hold up in a packed tower is in the range
(a) 2-10% (b) 5-25% (c) 20-40% (d) above 40%.

(iv) In case of distillation, as the reflux ratio is increased, the intersection of both the operating lines
(a) moves towards the diagonal
(b) moves away from the diagonal
(c) does not at all move
(d) none of these.

(v) The length of the unused bed (LUB) is more if the mass transfer zone is
(a) wide (b) narrow (c) asymmetric (d) symmetric.

(vi) For BET model of adsorption, it is assumed that
(a) heat of adsorption = heat of liquefaction of the adsorbate
(b) heat of adsorption > heat of liquefaction of the adsorbate
(c) heat of adsorption < heat of liquefaction of the adsorbate
(d) heat of adsorption = 2 * heat of liquefaction of the adsorbate.

(vii) Stanton number for mass transfer is defined as
(a) $\frac{Nu}{\mathrm{Re}\,\mathrm{Pr}}$ (b) $\frac{Sh}{\mathrm{Re}\,Sc^{1/3}}$ (c) $\frac{Sh}{\mathrm{Re}\,Sc}$ (d) $\frac{pe}{Sh}$

(viii) When the feed to a distillation column is a superheated vapor, the slope of the feed line is
(a) positive (b) negative (c) 1 (d) -1.

(ix) The ratio of Murphree plate efficiency to point efficiency is 1 in which of the following models?
(a) Plug (b) Perfectly mixed
(c) Both (a) and (b) (d) Neither (a) nor (b).

(x) Operating velocity in a packed tower is usually ……. the flooding velocity
(a) half (b) twice (c) equal to (d) more than.

Group – B

2. (a) A sphere of naphthalene having a radius of 20 mm is suspended in a large volume of still air at 318K and 1atm. The surface temperature of the naphthalene can be assumed to be at 318 K and its vapour pressure at 318 K is 0.555 mm Hg. The D_{AB} of naphthalene in air at 318 K is 6.92×10^{-6} m^2/s. Calculate the rate of evaporation of naphthalene from the surface.

(b) Discuss the boundary layer theory of mass transfer in brief.

(c) What is knudsen diffusion?

6 + 4 + 2 = 12

3.(a) Acetic acid is diffusing through a layer of water under equimolar couter diffusion at 35°C and 1 atm pressure. The molal concentration of acid on the two sides of the gas film 0.5 mm thick are 70% and 20% respectively. Assuming the diffusivity of vapour to be 0.18 cm^2/s. Calculate the rate of diffusion of acid and water vapour in kg/hr through area of 150 cm^2.

(b) A test tube, 20 mm in diameter and 22 cm tall, half filled with ethyl acetate is kept open in air. The temperature is 25°C and ambient pressure is 1.013 bar. The vapour pressure of ethyl acetate at 25°C is 0.1264 bar and its diffusivity in air is 0.0866 cm^2/s, the density of the liquid is 900 kg/m^3. How long will it take for the level to drop down to 7cm, measured from the bottom of the test tube?

(c) How the diffusivity of gaseous component is dependent on temperature and pressure?

4 + 6 + 2 =12

Group – C

4. (a) A stream of aqueous methanol having 46 mol% methanol is to be separated into a top product having 94 mol% methanol and a bottom liquid with 5% methanol. The feed is at bubble point and operating pressure is 1 atm. A reflux ratio of 1.6 is suggested. Determine the number of actual trays if the overall efficiency is 40%.

The vapor-liquid equilibrium data is given below:

x	0	0.04	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1.0
y	0	0.23	0.42	0.58	0.67	0.73	0.78	0.83	0.87	0.92	0.96	0.98	1.0

(b) The stripping section operating line of a distillation column receiving saturated open steam for the separation of an aqueous solution is y= 1.1x - 0.022.
What is the bottom product composition?

10 + 2 = 12

5. (a) A charge of 50 kmol of a mixture of benzene and chlorobenzene having 55 mol% of the less volatile component is to be batch distilled. If 20 moles of the solution is vaporized and condensed as the distillate, calculate the concentration of the accumulated distillate.
Given: The relative volatility of benzene in the mixture is 4.15.

(b) Explain briefly about the construction of operating line for enriching section of a multistage tower using Ponchon Savarit method.

(c) Assuming components A and B form an ideal solution, obtain an expression for relative volatility α_{AB}.

5+ 4 + 3 = 12

Group – D

6. (a) How do you classify tower packing? What is packing factor?

(b) Using Kremser equation, determine the number of theoretical stages required for absorption of 90% acetone in a gas containing 5 mol% acetone in air in a counter current stage tower. The total inlet gas flow rate to the tower is 33 kg mol/ h and the total inlet pure water flow to be used to absorb the acetone is 105 kg mol /h. The process is to operate isothermally at 300K and a total pressure of 101.3kPa.
Equilibrium relation is given by : $y_a = 2.5\ x_a$.

(3 + 1) + 8= 12

7.(a) What do you understand by 'minimum liquid-gas ratio' in case of absorption in a absorption tower?

(b) In a petrochemical plant, a gas containing 5% cyclohexane and 95% inert has to be treated with a non-volatile absorption oil in a packed tower. It is required to remove 97% of the cyclohexane of the feed gas. The feed solvent is free from cyclohexane. If the feed gas rate is 84 kmol/hr, calculate the minimum solvent rate. The equilibrium relation is given as follows:

$Y = \frac{0.2X}{1+0.8X}$, where X and Y represent mole ratio of cyclohexane.

(c) Define 'absorption factor'.

4+7+1= 12

Group – E

8. (a) Write a short note on 'Mass Transfer Zone in a Packed Bed Adsorption Column'.

(b) State basic assumptions for Langmuir type adsorption. Derive mathematical expression for Langmuir isotherm.

5 + 2 + 5 =12

9. (a) With an example explain azeotropic distillation.

(b) Breakthrough data of acetone in air flowing through a bed of adsorbent are given below,

Time, min	C/C_o	Time, min	C/C_o
180	0	235	0.553
187.5	0	240	0.655
191	0.005	245	0.743
195	0.018	250	0.825
205	0.091	255	0.892
210	0.143	260	0.948
215	0.210	265	0.98
220	0.285	270	0.992
225	0.372		
230	0.46		

Superficial gas velocity is 0.25 m/s, C_0 is 0.13 gmol/m^3, bed height is 50cm. calculate, (i) the breakthrough time if the breakthrough concentration is taken as 2.5% of the feed concentration,(ii) the velocity of the stoichiometric front.

2+ 10 = 12