Registration No. | | | | | | | | | | |

Total number of pages: 03 **B.Tech.**
PCE3I104

3rd Semester Regular/Back Examination 2017-18
MASS TRANSFER - I
BRANCH : CHEM, PT
Time : 3 Hours
Max Marks : 100
Q.CODE : B1192

Answer Question No.1 and 2 which are compulsory and any four from the rest.
The figures in the right hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.
Use of Humidity Chart is permitted. Answer all parts of a question at a place.

1. Answer the following questions : **(2x10)**

(a) Which of the following solutes has the highest diffusivity in water ?
- i. tert-butanol
- ii. iso-propanol
- iii. methanol
- iv. none of these

(b) The breathing process within the lungs involves:
- i. diffusion of A through non-diffusing B
- ii. equimolar counter diffusion
- iii. multicomponent non-equimolar counter diffusion
- iv. none of these

(c) The optimum ratio of the actual liquid rate to the minimum liquid rate for gas absorption generally lies between:
- i. 0.0 and 1.0
- ii. 0.5 and 1.5
- iii. 1.2 and 2.0
- iv. none of these

(d) With the increase of liquid viscosity, the tray efficiency generally:
- i. increases
- ii. decreases
- iii. remains unchanged
- iv. increases then decreases

(e) Which of the following quantities is appreciably dependent on the solubility of a gas in the solvent ?
- i. HTU
- ii. NTU
- iii. Specific interfacial area
- iv. All of these

(f) The relative volatility of A in a mixture of A and B is 1.5. What is the mole fraction of B in the first droplet condensed from an equimolar saturated vapour mixture of A and B ?
- i. 0.4
- ii. 0.5
- iii. 0.6
- iv. none of these

(g) For decolourization/deodorization of vegetable oils which method is preferred?
- i. batch distillation
- ii. steam distillation
- iii. flash distillation
- iv. none of these

(h) The q values for a feed of saturated liquid and saturated vapour are:

i. > 1 and < 1
ii. = 1 and < 1
iii. = 0 and = 1
iv. = 1 and = 0

(i) Which type of tower is most favoured in the chemical process industries ?

i. Induced draft tower
ii. Hyperbolic tower
iii. Spray tower without a fill
iv. none of these

(j) What is the maximum possible humidity of air at 30^0C and 1.3 atm pressure in kg/kg dry air?

i. 0.042
ii. 0.009
iii. 0.0207
iv. None of these

2. Answer the following questions : **(2x10)**

(a) Under what conditions are the mass average velocity and the molar average velocity of the components of a mixture equal ?

(b) How does the binary gas-phase diffusivity depend upon the total pressure and temperature ?

(c) Mention the physical significance of HTU and NTU.

(d) What do you understand by absorption and stripping factors ?

(e) Which solventsare recommended for drying of air in a H_2SO_4 plant and drying of natural gas ?

(f) What are the important factors that determine the selection of a batch distillation column for the separation of a liquid mixture ?

(g) What happens if a distillation column heated by open steam is operated at total reflux for a long time ?

(h) Discuss about optimum reflux ratio in distillation.

(i) What are the important factors that influence the design and operation of a cooling tower ?

(j) What are the common packings and materials for a cooling tower ?

3. (a) Derive the Stefan's method for the determination of diffusivity with a neat sketch. **(7)**

(b) A tube of small diameter was filled with acetone (ρ = 0.80 gm/cm^3) upto 1.15 cm from top and maintained at a temperature of 20^0C in a gentle current of air. After 6 hours the level of liquid fell to 2.25 cm from the top. Calculate the diffusivity of acetone in air if the barometric pressure was 750 mm Hg. Vapour pressure of acetone at 20^0C is 180 mm Hg. R = 82.06 cm^3.atm/gmol.K. **(8)**

4. (a) In a chemical plant, a gas containing 4 % cyclo-hexane and 96 % inerts has to be treated with a non-volatile absorption oil in a packed tower. It is required to remove 98 % of the cyclo-hexane of the feed gas. The feed solvent is free from cyclo-hexane. If the feed gas rate is 80 kmol /hr, calculate the minimum solvent rate. The equilibrium relation is given by: **(7)**

$$Y = 0.2\ X / (1 + 0.8\ X)$$

(b) Discuss in detail about the minimum liquid rate for absorption with suitable diagrams. **(8)**

5. A gas mixture containing 12mol % SO_2 and88mol % air at 1 atmtotal pressure and 30^0C is to be scrubbed with water to remove 95 % of the SO_2 in a tower packed with 30 mm ceramic rings. The feed gas rate is 1400 kg/hr. Calculate: **(15)**

i. The minimum liquid rate and
ii. The tower diameter if the liquid rate is 1.2 times the minimum and the tower operates at 75 % of the flooding velocity.

For the calculation of the tower diameter, the liquid may be assumed to have properties like water. The equilibrium data for SO_2-water system in mole fraction unit (30^0C and 1 atm total pressure) are:

10^4x	0	0.562	1.403	2.8	4.22	8.42	14.03	19.65	27.9
10^3y	0	0.790	2.23	6.19	10.65	25.9	47.3	68.5	104

6. **(a)** A charge of 60 kmol of a mixture of benzene and chlorobenzene having 50mol % of the less volatile is to be batch-distilled. If 30 moles of the solution is vaporized and condensed as the distillate, calculate the concentration of the accumulated distillate. Also, if the concentration of the accumulated product is found to be 70mol % benzene, calculate its amount. The relative volatility of benzene in the mixture is 4.0. **(6)**

(b) Discuss in detail the Ponchon-Savarit method. **(9)**

7. 1000 kg/hr of an ethanol-water solution containing 0.28 mole fraction of ethanol is to be separated in a distillation column to produce a distillate containing 0.85 mole fraction ethanol and a residue containing 0.08 mole fraction ethanol. The feed enters the column at its boiling point. Using an operating reflux of 3.2 times the minimum, determine the moles of vapour leaving the top plate and the composition of vapour and liquid leaving 2nd and 3rd plates counted from the top of the column, using the following equilibrium data: **(15)**

Mole fraction ethanol in vapour (y_1)			0	0.10	0.20	0.30	0.40	0.50
Mole fraction ethanol in liquid (x_1)			0	0.01	0.025	0.04	0.08	0.16
y_1	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90
x_1	0.25	0.375	0.50	0.60	0.70	0.78	0.85	0.90

8. **(a)** Determine the following psychrometric properties of a moist air sample having a dry-bulb temperature 27^0C and a humidity of 0.015 kg/kg dry air using the psychometric chart and/or the vapour pressure equation for water: i. relative humidity, ii. Dew point, iii. Adiabatic saturation temperature, iv. Wet-buld temperature, v. humid volume, and vi. humid heat. **(8)**

The Antoine equation for water is: ln P_A^0 (bar) = 11.9 -3984.9/(T-39.7). The total pressure is 1 atm.

(b) Discuss the construction and operation of a natural draft cooling tower with a neat diagram. **(7)**

9. **Write short notes on:**

(a) Selection of solvent for absorption **(5)**

(b) McCabe-Thiele's method **(5)**

(c) Sling psychrometer **(5)**