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Total number of printed pages - 04

B.TECH
PCE31104

3rd Semester Regular Examination 2016 - 17

MASS TRANSFER – I

BRANCH : Chemical

Time : 3 Hours

Max Marks : 100

Question Code : Y642

Answer Part-A which is compulsory and any four from Part-B.

The figures in the right-hand margin indicate marks.

Assume suitable notations and any missing data wherever necessary.

Answer all parts of a question at a place.

Part – A (Answer all the questions)

1. Answer the following questions : 2 x 10

(a) When the size of pores approaches the mean free path of the gaseous molecules, the diffusion is known as _____.

- i. pressure diffusion
- ii. thermal diffusion
- iii. forced diffusion
- iv. Knudsen diffusion

(b) Transfer of different species of molecules takes place within a gas/vapour or liquid due to random velocities of molecules, is known as _____.

- i. random diffusion
- ii. molecular diffusion
- iii. eddy diffusion
- iv. forced diffusion

(c) Diffusion coefficient is a function of _____ and _____.

- i. temperature and concentration
- ii. temperature and pressure
- iii. temperature and concentration gradient
- iv. pressure and concentration

(d) There is a bulk flow in equimolar counter diffusion.

- i. True
- ii. False

(e) Reynolds analogy is valid for _____ and _____.

- i. $N_{Pr} = 1$ and $N_{Sc} = 1$
- ii. $N_{Pr} = 1$ and $N_{Nu} = 1$
- iii. $N_{Nu} = 1$ and $N_{Sc} = 1$
- iv. $N_{Pr} = 1$ and $N_{Sh} = 1$

(f) What is the range of overall tray efficiencies for gas absorbers?

- i. 50 to 65 %
 ii. 65 to 80 %
 iii. 80 to 95 %
 iv. none of these
- (g) For more volatile components in a mixture the k-values are _____ where for the less volatile components they are _____.
 i. < 1 and $= 1$
 ii. $= 1$ and > 1
 iii. > 1 and < 1
 iv. > 1 and $= 1$
- (h) As a thumb rule, optimum reflux ratio for many systems lies in the range of _____ times the R_{min} .
 i. 0.8 to 1
 ii. 1 to 1.2
 iii. 1.2 to 1.5
 iv. 1.5 to 1.8
- (i) For subcooled liquid feed and superheated vapour feed the q-values are :
 i. $q > 1$ and $q < 0$
 ii. $q > 0$ and $q < 1$
 iii. $q = 1$ and $q < 0$
 iv. $q > 1$ and $q = 0$
- (j) Wet bulb depression is the difference between _____ and _____ temperatures.
 i. dry-bulb and dew point
 ii. dew point and wet bulb
 iii. dry bulb and wet bulb
 iv. none of these

2. Answer the following questions :

2 x 10

- (a) State Fick's first law of diffusion.
 (b) What is mass flux?
 (c) What is the significance of mass transfer coefficients ?
 (d) What are the industrial applications of absorption ?
 (e) What are the factors that influence HETP ?
 (f) What are the situations in which steam distillation is commonly employed ?
 (g) Explain why in a distillation column, temperatures are lowest at the top and highest at the bottom ?
 (h) What are the assumptions involved in McCabe-Thiele method? Under what conditions these assumptions are justified ?
 (i) Define adiabatic saturation temperature.
 (j) What are the different types of equipment used in industry for water cooling?

Part – B (Answer any four questions)

3. (a) For a gaseous mixture of A and B (A diffusing and B non-diffusing) derive the relation for molar flux of A:

$$N_A = \frac{CD_{AB}}{Z_2 - Z_1} \ln \left(\frac{1 - x_{A2}}{1 - x_{A1}} \right) \quad 10$$

- (b) In an O₂-N₂ mixture at 1 atm and 25⁰C, the concentrations of O₂ at two planes 3 mm apart are 10 and 20 volume % respectively. Calculate the rate of diffusion of O₂ (in kmol/m².s) in case of equimolar counter diffusion of the two gases. The diffusivity for this system is 0.206 cm²/s. 05

4. (a) What are overall mass transfer coefficients ? How are they related to individual film coefficients ? 10

- (b) In a mass transfer apparatus operating at 1 atm. pressure the individual mass transfer coefficients are:

$$k_x = 22 \text{ kmol/m}^2 \cdot \text{h} (\Delta x = 1) \text{ and} \\ k_y = 1.07 \text{ kmol/m}^2 \cdot \text{h} (\Delta y = 1).$$

The equilibrium compositions of the gaseous and liquid phases are characterized by Henry's law:

$$p^* = 0.08 \times 10^6 x \text{ mmHg.}$$

Determine the overall mass transfer coefficients K_x and K_y. Also find the ratio of diffusion resistance of liquid to gas phases. 05

5. (a) Briefly explain the Two-film theory with a neat diagram. 05

- (b) Draw a neat diagram of a packed column and name different parts of it. Mention the desirable features of a packed column. 05

- (c) What are the various types of packings used in packed column? Mention the general guidelines involved in the selection of packings for mass transfer equipment. 05

6. (a) What is an absorption equilibrium diagram ? Write the effect of temperature on absorption equilibrium ? 05

- (b) A packed tower is designed to absorb SO₂ from air by scrubbing the gas with water. The entering gas is 20% SO₂ by volume and the leaving gas contains 0.5 % SO₂ by volume. The entering water is SO₂ free. The water flow is twice the minimum. The air flow rate (SO₂ free basis) is 975 kg/hr.m². The temperature is 30⁰C and the total pressure is 2 atm. The equilibrium data is governed by:

$$y = 21.8 x$$

where, y and x are in mole fraction units. Calculate the number of overall gas-phase transfer units. 10

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7. (a) For a binary liquid mixture, draw a neat material balance diagram for continuous fractionating column and derive the equations for operating lines of rectification and stripping sections. **10**

(b) What is optimum reflux ratio ? **05**

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8. A continuous distillation column is used to distill 30,000 kg/hr of a mixture of 40 % benzene and 60 % toluene by weight. The top and bottom products are found to contain 97 % benzene and 3 % benzene respectively. The feed consists of $\frac{3}{4}$ th vapour and $\frac{1}{4}$ th liquid. A reflux ratio of 3.5 may be used. Find: (i) the material balance, (ii) the number of plates, and (iii) the location of feed plate.

Data: VLE data for benzene-toluene system:

x	0.0	0.2	0.4	0.6	0.8	1.0
y	0.0	0.38	0.61	0.78	0.92	1.0

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9. (a) What are psychrometric line and Lewis relation ? **05**

(b) What is an atmospheric cooling tower ? What are its characteristics ? Draw a neat diagram of it. **05**

(c) What are hygrometers ? **05**
