

**B.TECH. DEGREE EXAMINATIONS: NOVEMBER 2009**

Fifth Semester

**BIOTECHNOLOGY**

U07BT504: Mass Transfer Operations

**Time: Three hours**

**Maximum Marks: 100**

**Answer ALL the Questions:-**

**PART A (20 x 2 = 40 Marks)**

1. Molecular diffusion is due to
  - a. thermal motion of the molecule
  - b. potential energy of the molecules
  - c. activation energy of the molecules
  - d. viscosity
2. Unsteady state molecular diffusion is represented by
  - a. Raoult's law
  - b. Fick's first law
  - c. Fick's Second law
  - d. Ideal gas law
3. Mass transfer coefficient is defined as
  - a. Flux =(coefficient) / (concentration difference)
  - b. Flux =(coefficient) (concentration difference)
  - c. Flux =(concentration difference) / (coefficient)
  - d. Flux = (Coefficient) + ( Concentration difference)
4. The mass transfer coefficients,  $k_g$  and  $k_y$  are related according to the relation
  - a.  $k_Y = k_G P$
  - b.  $k_Y = k_G P_{BM}$
  - c.  $k_G = k_Y / P^2$
  - d.  $k_Y = k_G$
5. Corresponding to Prandtl number in heat transfer, the dimensionless group in mass transfer is
  - a. Reynolds number
  - b. Sherwood number
  - c. Peclet number
  - d. Schmidt number
6. Schmidt number is a ratio of
  - a. momentum diffusivity to mass diffusivity
  - b. thermal diffusivity to mass diffusivity
  - c. thermal diffusivity to momentum diffusivity
  - d. viscosity to momentum diffusivity
7. A good solvent for gas absorption should have
  - a. high vapor pressure and low viscosity
  - b. high vapor pressure and high viscosity
  - c. low vapor pressure and low viscosity
  - d. low vapor pressure and high viscosity

8. Raoult's law is applicable to
- |                    |                    |
|--------------------|--------------------|
| a. ideal solutions | b. real solutions  |
| c. all solutions   | d. non-ideal gases |
9. Chemisorption is
- |                                    |  |
|------------------------------------|--|
| a. Same as vander waals adsorption | b. characterized by adsorption of heat |
| c. an irreversible phenomenon      | d. a reversible phenomenon             |
10. Moisture content by a substance in excess of the equilibrium moisture content is called
- |                      |                   |
|----------------------|-------------------|
| a. unbound moisture  | b. free moisture  |
| c. critical moisture | d. bound moisture |

**PART B (10 x 2 = 20 Marks)**

11. State Fick's first law of diffusion.
12. Name the mechanisms by which diffusion occurs in a solid.
13. Give the units for the mass transfer coefficients  $k_y$  and  $k_c$
14. When F type mass transfer co-efficient is preferred?
15. Define absorption factor
16. What is NTU and HTU?
17. What is distribution co-efficient in extraction?
18. Define Selectivity of the solvent for extraction process
19. What is bound moisture?
20. Name some common adsorbents used in industry

**PART C (5 x 14 =70 Marks)**

21. (a) Starting from the fundamentals, derive an expression for steady state diffusion of 'Gas A' through non diffusing 'Gas B'

**(OR)**

- (b) (i) In an process ammonia gas is diffusing under steady state conditions through a layer of stagnant air film 2.5 cm thick. The gas contains 23% by volume of ammonia on one side of the film. The diffused ammonia is immediately absorbed in water, on the other side of the film. The temperature is 29°C and pressure is 1 atmosphere. The diffusivity value can be taken as 60 cm<sup>2</sup>/hr. Calculate the amount of ammonia absorbed in 4 hours (8)
- (ii) Write a brief note on diffusion in biological gels (6)

- 22 (a) In an apparatus for the absorption of SO<sub>2</sub> in water at one point in the column the concentration of SO<sub>2</sub> in gas phase was 10% SO<sub>2</sub> by volume and was in contact with a liquid containing 0.4% SO<sub>2</sub> by weight. Pressure and temperature are 1 atm and 50°C respectively. The overall gas phase mass transfer coefficient is  $7.36 \times 10^{-10}$  kmole/m<sup>2</sup>s (N/m<sup>2</sup>). Of the total diffusional resistance 45% lies in gas phase and 55% in the liquid phase. Estimate: a) The molar flux based and overall mass transfer co-efficient; b) Individual mass transfer co-efficients for gas ( $k_G, k_y, k_C$ ) and liquid ( $k_x, k_L$ ); The interfacial composition in both phases. Equilibrium data at 50°C is given below:

Kg SO <sub>2</sub> /100 kg water	0.2	0.3	0.5	0.7
Partial pressure of SO <sub>2</sub> , mm Hg	29	46	83	119

(OR)

- (b) Obtain an expression for overall mass transfer coefficient in terms of film coefficients and also discuss the conditions for mass transfer controlled by gas and liquid phase

- 23 (a) A continuous column having both rectifying and stripping sections is to be designed to separate a binary feed mixture containing 50 mole percent n-heptane with a distillate product containing 98 mole percent heptane and a bottom product containing 98 percentage n-octane. The feed is at its boiling point and the tower operates to one atmosphere. Using equilibrium data given below, calculate:

(i) minimum reflux ratio

(ii) minimum number of theoretical plates

- (iii) if a reflux ratio of greater than the minimum reflux by 50 percent is used, how many theoretical plates will be required?

Equilibrium data :

x	0.1	0.3	0.5	0.7	0.9
y	0.195	0.585	0.69	0.840	0.950

(OR)

- (b) With neat sketches explain the working of mechanically agitated vessel absorber and packed column absorber

24. (a) (i) Discuss the selection of solvent for extraction process. (7)

(ii) A solution of picric acid in benzene contains 40 grams of picric acid per litre. Calculate the quantity of water with which 2 litre of this solution must be shaken at 18°C in order to reduce the picric acid concentration to 5 g/l in the benzene phase. Molecular weight of picric acid 229, and the distribution co-efficient  $K = C_E / C_R = 0.548$  Where  $C_E$  and  $C_R$  are concentration of picric acid in water and benzene. (7)

(OR)

(b) Derive an expression for multistage cross current extraction with partially miscible solvents

25 (a) A batch of dry solid is to be dried from 25% to 6% moisture content on wet basis. Critical weight of the material is 160 kilograms. Drying surface is 1 m<sup>2</sup> per 40 kg of dry weight. Rate of drying at critical point is  $0.3 \times 10^{-3}$  kg/m<sup>2</sup> sec. Critical moisture content is 0.2 kg H<sub>2</sub>O / kg dry solid. Flux vs moisture content data is given in table. Equilibrium moisture content = 0.064 kg H<sub>2</sub>O / kg dry solid. Estimate the time of drying.

Flux, $N \times 10^3$ kg/ m <sup>2</sup> sec	0.3	0.266	0.239	0.208	0.18	0.15	0.097	0.07	0.043	0.025
Moisture content (Dry basis)	0.2	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	0.064

(OR)

b) (i) Briefly discuss about adsorption isotherms (8)

(ii) Equilibrium isotherm data for adsorption of phenol from an aqueous solution to activated carbon are as follows:

C(g/ cm <sup>3</sup> )	0.004	0.0087	0.019	0.027	0.094	0.195
q (gm/gm)	0.0266	0.053	0.075	0.082	0.123	0.129

Determine the isotherm that fits the data and give the constants of the equation using the given units. (6)

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