B.TECH. DEGREE EXAMINATIONS: NOV/DEC 2010

Seventh Semester

BIOTECHNOLOGY

U07BT504: Mass Transfer Operations

Time: Three Hours   **Maximum marks: 100**

Answer ALL Questions:

PART A (10 x 1 = 10 Marks)

1. The unit of volumetric diffusivity is

   a) cm^2/sec b) cm/sec   c) cm^3/sec d) cm^2/sec^2

2. The diffusivity in a binary gas mixture is related to the temperature as

   a) $D \alpha T$ b) $D \alpha T^{0.5}$ c) $D \alpha T^{1.5}$ d) $D \alpha T^2$

3. Mass transfer coefficient if defined as

   a) Flux = Co-efficient / concentration   b) Co-efficient = Flux / concentration

   c) Flux = concentration difference /Co-efficient   d) Co-efficient = Flux x concentration

4. Penetration theory relates average mass transfer co-efficient with diffusivity as

   a) $K \alpha D$ b) $K \alpha D^{0.5}$ c) $K \alpha D^{1.5}$ d) $K \alpha D^2$

5. Raoult`s law is applicable to

   a) Ideal solutions   b) real solutions

   c) non-ideal gases   d) the mixture of water and alcohol

6. Relative volatility doesn't change appreciably with change in

   a) temperature   b) vapour pressure of either component

   c) total pressure   d) partial pressure

7. Selectivity of solvent used in extraction should be

   a) 1   b)> 1   c) <1   d) 0

8. In extraction, as the temperature increases, the area of heterogeneity

   a) decreases   b) increases   c) remains unchanged   d) depends on molar ratio

9. To remove all the moisture from a wet solid requires exposure to

   a) perfectly dry air   b) highly humid air

   c) Immiscible solvent   d) cold air

10. If moisture content of solid on dry basis is X then the same on wet basis is

   a) $\dfrac{X}{X+1}$ b) $\dfrac{X}{1-X}$ c) $\dfrac{X+1}{X}$ d) $\dfrac{1-X}{X}$

PART B (10 x 2 = 20 Marks)

11. State and explain Fick`s law of diffusion.

12. Distinguish molecular diffusion and Eddy diffusion.

13. List the assumptions of Reynold`s analogy.

14. Discuss inter-facial mass transfer.

15. Define: HTU and NTU

16. State Rayleigh`s equation.

17. Mention any four applications of extraction.

18. What do you mean by critical solution temperature?

19. What is meant by free moisture?

20. Define: drying rate.

PART C (5 x 14 = 70 Marks)

21. a) (i) Explain about the classification of diffusion and derive an expression for mass flux for steady state diffusion of A through a Non-diffusing B. (7)

    (ii) In an oxygen-nitrogen gas mixture at a pressure of 1 atm and 25° C, the concentration of oxygen at two planes 0.002 cm apart are 25% and 15% respectively. Calculate the rate of diffusion of oxygen in $\dfrac{kgmoles}{m^2 s}$ assuming equimolal counter diffusion. Diffusivity of oxygen in nitrogen is 0.181 x 10^{-4} m^2/s. (7)

(OR)

  b) (i) State Fick`s law of diffusion and also explain a method for determining diffusivity, experimentally. (8)

    (ii) Calculate the rate of diffusion. NaCl at 20^0C through a stationary film of water 1 mm thickness where the concentration are 20% and 10% by weight respectively on either side of the film. Diffusity is 1.35 x 10^{-5} m^2/sec. (6)

22. a) (i) Explain   a) Film theory   b) Boundary layer theory (8)

    (ii) Sulphur dioxide is absorbed from air into water in packed absorption tower. At a certain location in the tower, the mass transfer flux is 0.027 kmol SO$_2$ / m^2 hr and the liquid phase concentrations in mole fraction are 0.0025 and 0.0003 respectively at the two-phase interface and in the bulk liquid. If the diffusivity of SO$_2$ in water is 1.7 x 10^{-5} m^2/s, determine the mass transfer coefficient, k$_c$ and film thickness. (6)

(OR)

b) (i) Obtain an expression for overall mass transfer coefficient in terms of film coefficient.(8)

(ii) At 293 K the solubility of ammonia in water is given by Henry`s law p = 0.3672 C, where p is in atmosphere and C is in $kmol/m^3$. A mixture of 15% ammonia and 85% air by volume at 1 atm is in contact with an aqueous solution containing 0.147 gmol/lit. The air velocity is such that k_G / k_L= 0.9. Find the concentration of ammonia and partial pressure at interface. (6)

23. a) (i) Discuss the factors to be considered in the choice of solvent for absorption. (6)

(ii) An effluent gas containing 12% benzene is to be scrubbed in a packed scrubber continuously, operating in counter current manner at 43^0C and 1 atm pressure. The tower is to be designed for treating 1.5 m^3 of entering gas per hour per square metre of the tower cross section such that the exit gas will contain 1% benzene. The solvent for scrubbing is mineral oil which will enter the top of the tower at a rate of 28 gmoles/hr $m^{2\ of}$ tower cross section, with a benzene content of 1%. Determine the height of the tower. Assuming the height of transfer unit to be 0.75 m. The system may be considered as a diluent system. The equilibrium concentrations at the operating conditions may be estimated by y* = 0.263x. (8)

(OR)

b) (i) Explain briefly the principles and applications of Steam distillation and Simple distillation. (8)

(ii) A continuous rectifying column treats a mixture of 40% benzene and 60% toluene. The mixture separates into a product of 90% overhead and 98% bottom. The feed enters as a liquid at its boiling point. If a reflux ratio of 3.5 is used. Estimate the height of the tower. The average height of transfer unit may be taken as 0.97m. (6)

X	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0.22	0.38	0.51	0.63	0.70	0.78	0.85	0.91	0.96

24. a) (i) What are the various factors to be considered for selection of a solvent in extraction? (8)

(ii) Describe the various liquid-liquid extractors with sketches. (8)

(OR)

b) (i) Explain Multi stage cross current extraction operation with diagram. (6)

(ii) A solution of nicotine in water containing 1% nicotine is to be extracted with kerosene at 293 K. Water and kerosene are essentially insoluble. Assume equilibrium relationship as: $Y = 0.9\ X$. Where, Y is kg nicotine/kg kerosene and x is kg nicotine/kg water. Determine the % extraction of nicotine if 100 kg of feed solution is extracted with 150 kg solvent. (8)

25. a) (i) Explain the various regimes of drying with a neat drying rate curve. (4)

(ii) A batch of solid for which the following table of data applies is to be dried from 25% to 6% moisture under conditions identical to those for which the data were tabulated. The initial weight of the wet solid is 300 kg and the drying surface is 1 m^2/ 8 kg weight. Determine the time for drying?

X	0.35	0.25	0.20	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.064
N	0.3	0.3	0.3	0.266	0.239	0.208	0.180	0.150	0.097	0.07	0.025

where, X – Moisture content (kg moisture / kg dry solid)

N – Flux (kg moisture evaporated / m^2. hr) (10)

(OR)

b) (i) Explain the following

a) Adsorption isotherm   b) Break through curves (8)

(ii) Explain about Single stage leaching with diagram. (6)

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