Ref. No. : Ex/FTBE/PC/B/T/315/2024

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING THIRD YEAR FIRST SEMESTER - 2024

Subject : MASS TRANSFER OPERATION I

Time : 3 Hours **Full Marks : 100**

Use Separate answer scripts for each part

PART - I (Marks : 50)

Answer Question No. 5 and any two from the rest.

Rectangular graph paper may be used solve problems.

1. (a) State some fields of usefulness of liquid-liquid extraction (LLE).
   (b) Explain how equilateral coordinates help in the calculations of concentration of the components of a ternary system in LLE? 8+12

2. A feed of 115 kg/min of 1.4% mixture of acetic acid in water is to be extracted with 1-butanol at 1 atm and 30^0C. The desired outlet concentration in the exiting stream is 0.16 wt % acetic acid. The solvent, pure 1-butanol is fed countercurrently to the feed with a flow rate of 76 kg/min. Determine the composition of the exiting 1-butanol (i.e. the extract phase). Also find the no. of equilibrium stages needed. The equilibrium equation for the system is y= 1.623 x. 20

3. What are the factors influencing the rate of a leaching process? Deduce an expression for single stage batch extraction in leaching. 7+13

4. Soyabeans containing 16% oil is extracted with n-hexane in a countercurrent battery to recover 85% of the oil. The final concentration of oil in the extract is 40%. The crushed beans in the underflow carry with them 50% of solution in each stage. Find the number of ideal stages and final concentration of oil in the raffinate if the underflow and overflow rates are constant throughout the process. 20.

5. Answer any one of the following: 10

   (i) Operating line for insoluble liquids in multistage crosscurrent extraction in LLE.
   (ii) Role of selectivity, insolubility of the solvent, interfacial tension and relative volatility in the choice of solvent for LLE.
   (iii) Preparation of solids in leaching
   (iv) Single stage batch extractor for leaching.

[Turn over

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B.E. Food Technology and Bio-Chemical Engineering - Third Year - First Semester 2024

Subject: **MASS TRANSFER OPERATION I** (FTBE/PC/B/T/315)

PART - II (Marks : 50)

Answer Question No. 1 (Compulsory) and any two from the following:

Q.1 a) State Fick's law. b) Considering the definition of the reference frame of the observer for a binary gas mixture of A and B undergoing mass transfer operation from one region to another region, show that $N_A = Ny_A + J_A$, where N_A, N, y_A and J_A signifies the usual notations. c) Estimate the value of k_G/ k'_G, where k_G and k'_G are the gas phase mass transfer coefficients for equimolar counter-current diffusion between A and B and for A diffuses through non-diffusing B, respectively, for a binary gas mixture. Give the schematic representation of the interphase under consideration.

2+4+4=10

Q.2 a) Deduce the steady state molar flux equation for equimolar counter-current diffusion. (b) In a counter-current equimolar diffusion, A diffuses through B across a distance of 5mm apart. The partial pressure of A at point 1 and 2 are 75 kPa and 25 kPa, respectively. The total pressure is 101.32 kPa and temperature is 27°C with diffusivity of A equals to 70.8 cm^2/sec. Estimate the molar flux of A at steady state condition. (c) Also estimate the molar flux of A considering B non-diffusing. (d) Comparing the values (molar flux) in two different cases, which operation is preferred?

5+7+6+2=20

Q.3. Write short notes on **4×5=20**

(i) Mass transfer resistance (ii)Relation between K_G and K_L (iii) Inter-phase mass transfer (iv) Gas film controlling resistance

Q.4. (a) For an inter-phase mass transfer operation, gas –liquid inter-phase is formed between the bulk gas phase and the bulk liquid phase. Solute A in the gas phase is noticed to have dissolved in the bulk liquid phase with time across the inter-phase. Assuming Henry's law to be valid for the case, (i) estimate K_L/K_G (where K_L and K_G are the overall liquid phase and overall gas phase mass transfer coefficients across the inter-phase, respectively). (ii) If solute A is of low solubility in the liquid, then which resistance controls the mass transfer and why? (b) HCl(A) diffuses through a thin film of water(B) 4mm thick at 283 °K. The concentration of HCl at point 1 on one boundary of the film is 15 wt%(ρ_1= 1060.7 kg/m^3) and on the other boundary, at point 2, is 5wt%(ρ_2= 1020.2 kg/m^3). The diffusivity of HCl in water is 2.5×10^{-9} m^2/sec. Calculate the flux of HCl considering water to be stagnant **6+4+10=20**