Ref. No. : Ex/FTBE/PC/B/T/315/2025

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING THIRD YEAR FIRST SEMESTER - 2025

Subject : MASS TRANSFER OPERATION I **Time : 3 Hrs** **Full Marks :100**

Part - I (50 Marks)

Instructions : Use Separate Answer scripts for each part.
Answer question no. 6 and and any three from the rest.

1. Explain how Equilateral Triangular Coordinates can be used to determine composition of the three phases in liquid-liquid extraction (LLE). 10
2. Explain with a diagram how in a system of three liquids- with one pair partially soluble, compositions of extract and raffinate can be determined? What are plait point and a solutropic system? 10
3. Explain how selectivity, distribution Coefficient, recoverability and interfacial tension of the extracting solvent become important in the choice of a solvent for LLE? 10
4. Give three examples of how solid foods are prepared for leaching. On what factors do the rate of leaching of a substance depend? 5+5
5. The natural colour from blackberry is to be extracted with water. The saturated concentration of the colour in the water is found to be 1.45 kg/m^3. In a laboratory scale extractor of 1050 ml volume, it has taken 8 min to extract the colour from the berry at the concentration of 980 ppm. Under similar conditions in a commercial plant of 12 m^3 capacity it is desired to extract 13 kg of the colour into the water. How much time would be taken for this leaching process? 10
6. Answer any two (10+10)
   (a) Fields of usefulness of liquid liquid extraction
   (b) Single stage batch extractor in leaching.
   (c) Hildebrandt extractor

[Turn over

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B.E. Food Technology and Bio-Chemical Engineering - Third Year - First Semester 2025

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 diffusion processes 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 80 kPa and 20 kPa, respectively. The total pressure is 1.1 atm. and temperature is 27°C with diffusivity of A equals to 71.03 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) Difference between k_y and k_x (iii) Inter-phase mass transfer (iv) Liquid 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) 5mm thick at 300 °K. The concentration of HCl at point 1 on one boundary of the film is 18 wt% (ρ_1= 1060.7 kg/m^3) and on the other boundary, at point 2, is 9wt% (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**