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

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 answerscript for each part.

PART 1 (50 Marks)

Answer question no. 5 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). 15

2. With suitable illustrations show how number of stages can be determined for insoluble liquids for multistage crosscurrent extraction of LLE. 15

3. Give three examples of how solid foods are prepared for leaching. On what factors do the rate of leaching of a substance depend? 10+5

4. Anthocyanin from blackberry is to be extracted with water. The saturated concentration of the colour in the water is found to be 1.3 kg/m3. In a laboratory scale extractor of 950 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 m3 capacity it is desired to extract 14 kg of the colour into the water. How much time would be taken for this leaching process? 15

5. Answer any one 5
   (a) LLE in competition with the process of distillation.
   (b) Three selection criteria for choice of a solvent in LLE.
   (c) Determination of solvent to feed ratio in a single stage batch extraction in LLE.
   (d) Single stage batch extraction in leaching.

[Turn over

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

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

Full Marks: 50 (Part II)

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) Evaluate the rate of diffusion of water from a pool of water at the bottom of a 5 m well to dry air flowing over the top of the well. Assume that the air in the well is stagnant, the temperature is 27°C, the vapor pressure of water at 27°C is 3.14 kPa, and the diffusivity of water vapor in air is 2.62×10^{-5} m^2/sec. **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 60 kPa and 20 kPa, respectively. The total pressure is 101.32 kPa and temperature is 27°C with diffusivity of A equals to 70.5 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) evaluate 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 20 wt%(ρ_1= 1060.7 kg/m^3) and on the other boundary, at point 2, is 10 wt%(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**