Register No.: ..... Name: .....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SIXTH SEMESTER B.TECH DEGREE EXAMINATION (R), MAY 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code: **20CHT302**

Course Name: **Mass Transfer Operations - II**

Max. Marks: **100** **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. State Raoult's law and derive an equation for total pressure for an ideal binary mixture.
2. Define relative volatility and its significance in distillation process.
3. Show the material and energy balance in flash distillation column.
4. List any three limitations of Mccabe Thiele method.
5. Differentiate the significance of HETP and HTU.
6. Discuss about extractive and azeotropic distillation.
7. Mention any three applications of LLE process.
8. Highlight the properties of solvents used in liquid-liquid extraction process.
9. Identify the factors affecting rate of leaching.
10. Compare micro and ultra-filtration.

PART B

(Answer one full question from each module, each question carries 14marks)

MODULE I

11. An equimolar feed mixture containing benzene and toluene is distilled such that 60% of feed is distilled out. Determine the compositions of the distillate and the residue when the separation takes place under (14)
    (i) equilibrium distillation.
    (ii) differential distillation.
    The average relative volatility of benzene with respect to toluene is 2.5.

OR

12. a) Derive Rayleigh's equation for differential distillation. Explain the process with a neat diagram. (7)
    b) Illustrate the steam distillation process. (7)

MODULE II

13. Write the design procedure of Mccabe Thiele method showing operating line for stripping and enriching sections and discuss about various thermal conditions of feed. (14)

OR

14. It is desired to separate a mixture containing 40% n-heptane and 60% ethyl benzene to produce a distillate containing 97% n-heptane and a residue containing 99% ethyl benzene at 760 mm Hg. Using a reflux ratio of 2.5, determine the number of equilibrium stages needed for a saturated liquid feed by McCabe- Thiele method. Take α = 2. (14)

MODULE III

15. Write the steps involved in determining the number of stages and minimum reflux by Ponchon-Savarit method with a sketch. (14)

OR

16. A methanol-water solution containing 36 mole% methanol at 26.7°C is continuously distilled to yield a distillate containing 91.5 mole% methanol and a residue containing 99 mole% water. The feed enters at its bubble point. Distillate is totally condensed and refluxed at its bubble point. (14)

(i) Calculate the minimum reflux ratio

(ii) For a reflux ratio of 3, estimate the number of plates by Ponchon-Savarit method.

Enthalpy data

x or y mole fraction of methanol	Enthalpy of saturated liquid kJ/kmol	Enthalpy of saturated vapour kJ/kmol
0	8000	48000
1	7500	39000

Equilibrium data

x, %	4	10	20	30	50	70	90	95
y, %	23	42	58	66	78	87	96	98.15

x, y are mole fractions of methanol in liquid and vapour phase respectively.

MODULE IV

17. 1000 kg/hr of an acetone-water mixture containing 20% by weight of acetone is to be counter-currently extracted with trichloroethane. The recovered solvent to be used is free from acetone. The water and trichloroethane are insoluble. Estimate the number of stages required if 1.5 times the minimum solvent is used for 90% recovery of acetone. The equilibrium relationship is given by y = 1.65x, where x and y are weight fractions of acetone in water and trichloroethane respectively. (14)

OR

18. a) Describe the working principles of pulsed column and spray-type extractors. (10)

b) Explain binodal solubility curve in a triangular co-ordinate system. (4)

MODULE V

19. a) Mention the types of equipment used in leaching process and elaborate any one. (7)

b) In a single-stage leaching of soybean oil from flaked soybeans with hexane, 100 kg of soybeans containing 20 wt.% oil is leached with 100 kg of fresh hexane solvent. The value of N for the slurry underflow is essentially constant at 1.5 kg insoluble solid/kg solution retained. Calculate the amounts and compositions of the overflow and the underflow the stage. (7)

OR

20. A liquid containing dilute solute A at a concentration $C_1 = 3\times10^{-2}$ kg mol/m^3 is flowing rapidly past a membrane of thickness $L = 3.0\times10^{-5}$ m. The distribution coefficient $K' = 1.5$ and $D_{AB} = 7.0\times10^{-11}$ m^2/s in the membrane. (14)

The solute diffuses through the membrane, and its concentration on the other side is $C_2 = 0.50\times10^{-2}$ kmol/m^3. The mass-transfer coefficient k_{c1} is large and can be considered as infinite, and $k_{c2} = 2.02\times10^{-5}$ m/s.

(i) Derive the equation to calculate the steady-state flux N_A and make a sketch.

(ii) Calculate the flux and the concentrations at the membrane interfaces.

****