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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : 20CHT301

Course Name: Mass Transfer Operations - I

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

Psychrometric chart is allowed, graph paper will be provided

PART A

(Answer all questions. Each question carries 3 marks)

1. Define Fick's law of diffusion. Interpret the equations of total flux (N_A) and molecular flux (J_A) for a binary mixture.
2. With the help of neat sketch describe the two-film theory.
3. Explain flooding and weeping with reference to a tray column.
4. With a neat sketch explain the working of a valve tray.
5. Define Murphree plate efficiency.
6. Describe the concept of Height Equivalent of Theoretical Plate (HETP).
7. Describe molal humidity. Express the molal humidity in terms of partial pressure of air for an air-water system.
8. Explain the Freundlich Adsorption isotherm.
9. A wet solid is to be dried from 70% to 10 % moisture (wet basis). Calculate the amount of moisture to be evaporated per 100 kg of the dried product.
10. Explain the Delta - *L* Law of crystal growth.

PART B

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

MODULE I

11. a) Based on the mass transfer coefficients, describe the conditions at which the gas and liquid sides controls the mass transfer. (4)

    b) Component A in a gas mixture of A and B is absorbed into a liquid phase at a rate of 0.15 mol/m^2 s. The interfacial mole fraction of gas phase (y_{Ai}) and liquid phase (x_{Ai}) are 0.035 and 0.01375 respectively. The fraction of A in the bulk of the gas phase is 0.05 and the mole fraction of A in the bulk of the liquid phase is 0.01. The equilibrium data for the given system is as follows: (10)

x_A	0	0.01	0.02	0.03	0.05
p_A	0	6.45	12.90	19.35	32.25

where p_A is the partial pressure of A in mmHg in the gas, and x_A is the molar fraction of A in the liquid. Calculate the overall mass transfer coefficient based on the gas phase. The system is at 2 atm and 15.5 ^{0} C.

OR

12. a) Derive the expression for the total molar flux equation for component A (N_A) for diffusion of A through stagnant B in terms of mole fraction of component B. (4)

b) Liquid benzene held in a vertical tube open at the top, is slowly diffusing into the atmosphere. Air flowing over the tube is continually sweeping the benzene vapour that has evaporated from the liquid. The system pressure is 770 mmHg, and the whole system is at constant temperature 26 °C. The vapour pressure of benzene at 26 °C is 100 mmHg and the diffusivity of benzene in air at 26 °C is 0.085 cm^2/s. If the distance of the liquid surface from the top of the open tube is 10 cm, calculate the rate of evaporation of benzene. (10)

MODULE II

13. a) Illustrate and explain the basic components of a tray tower. (10)
b) Explain the desirable characteristics of packing materials. (4)

OR

14. a) Compare the merits and demerits of plate tower and packed tower. (8)
b) Explain the use and working of venturi scrubber. (6)

MODULE III

15. a) Derive the expression for the number of transfer units based on the gas phase (N_{tOG}). (10)
b) Derive the equation of an operating line in terms of solute free molar flow rates for a counter current absorption column. (4)

OR

16. a) Carbon disulphide (CS_2) is to be recovered from a nitrogen-CS_2 mixture by scrubbing with a solute free absorbent oil. The gas enters the column at a rate of 60 kmol/h and it contains 8 % CS_2 by volume. The CS_2 content is to be reduced to 0.75 %. Assume that at equilibrium the system obeys the following relation (10)

$$Y = 0.485\ X$$

where Y is in kmol of CS_2/ kmol of nitrogen and X is the kmol of CS_2/ kmol of oil. Calculate the following:

i) The minimum solvent requirement
ii) Mole % CS_2 in exit liquid for a liquid to gas ratio 1.4 times minimum.
iii) Number of trays by graphical method.

b) Describe the factors to be considered while selecting the solvent for absorption. (4)

MODULE IV

17. a) For a specified dry bulb temperature and % saturation of an air-water system, explain the methods to calculate the following using a Humidity chart. (6)
    i) The absolute humidity
    ii) The dew point temperature of the system
    b) Explain the natural draft and forced draft cooling towers. (8)

OR

18. a) Describe adiabatic saturation temperature. (6)
    b) Explain the adsorption wave and different zones inside a packed bed adsorption column. (8)

MODULE V

19. a) Calculate the quantity of $MgSO_4.7H_2O$ crystals formed when 100 kg saturated solution of $MgSO_4$ at 353K is cooled to 303 K. During the crystallization process 15 % of the water is evaporated. The solubility of $MgSO_4$ at 353 K is 64.2 kg/100 kg water, while the solubility at 303 K is 40.8 kg/100 kg water. Atomic weight of Mg = 24, S=32, H=1, O=16. (8)
    b) With respect to drying define the following terms (i) Equilibrium moisture (ii) Free moisture (6)

OR

20. a) It takes 5hrs to reduce the moisture content of a wet solid from 60 % to 20 %. How long it would take to remove the moisture from 50 % to 10 % under same drying condition?. The critical and equilibrium moistures of the system were 27% and 5%, respectively. All moistures are on the dry basis. (9)
    b) Describe Miers theory of supersaturation. (5)

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