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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (R,S), DECEMBER 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. State Fick's law of diffusion and define the terms. Also, find the unit of diffusion coefficient.
2. Describe any three dimensionless groups in mass transfer and comment on its significance.
3. Summarize the terms flooding, weeping and coning with respect to a plate column.
4. List the merits and demerits of plate and packed columns for gas-liquid contact.
5. Define Absorption factor and Stripping Factor using Kremser equation. Explain its significance.
6. Differentiate between overall tray efficiency and Murphree efficiency.
7. List any three relevant industrial applications of humidification.
8. Compare physical and chemical adsorption.
9. List the industrial applications of drying.
10. State Mier's supersaturation theory.

PART B

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

MODULE I

11. a) A crystal of $CuSO_4$ falls through a tank of pure water at 20 °C. Estimate the rate at which the crystal dissolves by the calculation of flux of $CuSO_4.5H_2O$ from the crystal surface to the bulk solution. Molecular diffusion occurs through a film of water 0.0305 mm thick around the crystal. At the inner side of the film adjacent to the crystal surface, the concentration of $CuSO_4.5H_2O$ is 0.229 mole fraction. The solution density is 1193 kg/m^3. The outer surface of the film is pure water. Diffusivity of $CuSO_4.5H_2O$ is 7.29×10^{-10} m^2/s. (7)

b) Summarize Film theory and Penetration theory of mass transfer, the assumptions involved and find the expression for molar flux according to both theories. (7)

OR

12. a) Derive from the first principle the general rate equation for the steady state unidirectional molecular diffusion in gases at rest and in laminar flow for the following cases. (8)
(i) For diffusion of A through non-diffusing B.
(ii) For equimolar counter diffusion

b) State two film theory of mass transfer. Derive the relationships connecting overall mass transfer coefficients and individual film coefficients in gas phase and liquid phase. (6)

MODULE II

13. a) With neat sketch, describe the constructional features and design constrains of a packed tower. (8)

b) Compare the advantages and disadvantages of packed columns and tray columns. (6)

OR

14. a) Explain with neat sketch the construction and working of a tray tower. (8)

b) Explain the principle and working of a venturi scrubber and wetted wall column. Also mention its industrial applications. (6)

MODULE III

15. a) Hydrogen sulphide is to be removed from a mixture of hydrogen sulphide and methane using monoethanolamine as solvent. The feed gas containing 20% H_2S is admitted to a plate absorber at a rate of 2000m^3/h at 303 K and 101.3 kPa. The equilibrium relation y=1.1x is found to be applicable in the concentration range of interest. The solvent enters the column free of H_2S at a rate of 1.2 times the minimum. If it is desired to remove 90% of sulphide from the gas, determine: (8)
(a) Minimum solvent flow rate, kmol/h
(b) The number of theoretical stages by graphical method
(c) The number of theoretical plates using Kremser equation

b) For dilute mixtures, show that the number of transfer units based on gas phase for a counter current gas absorption on a packed tower is given by $N_{tOG}=(y_1-y_2)/(\Delta y)_{LM}$ (6)

OR

16. a) An aqueous solution is stripped off ammonia at 303 K and 100 kPa in a plate column. At a particular plate in the column it is found that the air entering is essentially free of ammonia and air-water ratio is 2 kmol/kmol. The solution entering the plate contains 0.1% ammonia. (7)

The murphree vapour efficiency is 80% and the Henry's law constant is 130 kPa/mole fraction at 303 K. Determine the exit water composition.

b) With graphical representations explain the determination of minimum liquid to gas ratio in absorption columns. (7)

MODULE IV

17. a) Compare the advantages and disadvantages of natural draft cooling towers and mechanical draft cooling towers. (7)

b) Describe adsorption isotherms. Summarize the different types of adsorption isotherms. (7)

OR

18. a) Derive the equation for wet bulb depression. State Lewis relation and mention its significance. (7)

b) Explain the significance of adsorption wave used in adsorption operation. (7)

MODULE V

19. a) An aqueous solution of Na_2CO_3 containing 15% carbonate by weight is subjected to crystallization at a rate of 1000 kg/h by evaporation and cooling at 278 K. 40% of water in the feed is evaporated. If the solubility of Na_2CO_3 at 278 K is 9.0% (by weight). Determine, (8)

(a) Quantity of $Na_2CO_3.10H_2O$ crystals formed

(b) The yield of crystals

b) With neat diagram explain the working of an industrial crystallizer. (6)

OR

20. a) It takes 9 hours for a porous solid to reduce the moisture content from 45 to 10% when dried in a batch drier under constant drying conditions. Critical moisture content is 25% and equilibrium moisture content is 3%. All moisture content are on dry basis. Assuming that the rate of drying during falling rate period is proportional to free moisture content, how long should it take to dry the sample of solid material from 35% to 5% under same drying conditions. (8)

b) Explain the principle and working of an industrial drier with a neat diagram. (6)

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