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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (Regular), DECEMBER 2022
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. Distinguish between J_A and N_A and state how these are expressed by Fick's law?
2. List the analogies between mass, heat and momentum transfer with expressions.
3. List out various random packings used in industry. Also sketch any one of them.
4. Describe the desirable properties for a good tower packing used in gas-liquid contact operation.
5. Define overall efficiency, Murphree stage efficiency and Point efficiency of a tray column.
6. Define N_{tOG}, N_{tG}, N_{tL} and show how they are related.
7. What are the major applications of humidification operations?
8. List any three industrial applications each for adsorption for gaseous and liquid separations.
9. Discuss the different regions of a typical rate-of drying curve.
10. State and explain delta-L law of crystal growth. When does this law fail?

PART B

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

MODULE I

11. a) In an ammonia-air mixture, the concentrations of ammonia at two points 100 mm apart are 20 percent (mol) and 5 percent (mol) respectively. The system is maintained at a total pressure of 101.3 kPa and a temperature of 298 K. At 298 K diffusivity of Ammonia in air is 2.26 x 10^{-5} m^2/s. Evaluate the following: (7)
    i) Rate of diffusion assuming that ammonia alone diffuses.

ii) Rate of diffusion assuming equimolar counter diffusion.

b) Develop expressions for the concentration profile for diffusion of A through stagnant B and equimolar counter diffusion (7)

OR

12. a) What are the general principles underlying the film and penetration theories for mass transfer across phase boundaries.? (7)

b) Derive the relations between overall mass transfer coefficients based on gas phase and liquid phase systems with individual gas phase and liquid phase mass transfer coefficients. (7)

MODULE II

13. a) Identify the internals of a tray tower with the help of a neat sketch. What are the different tray types? (7)

b) Explain the causes and effects of Flooding, Coning, Weeping and Priming in tray columns. (7)

OR

14. a) Explain with neat sketch, types of packing materials used in packed columns. Mention the merits and demerits of each. (7)

b) Compare the advantages and disadvantages of packed columns and tray columns. (7)

MODULE III

15. a) It is desired to absorb 90% of the acetone in a gas containing 1 mole% acetone in air in a counter-current tray column. The total inlet gas flow to the column is 30 kg-mole/hr, and pure water is to be used to absorb the acetone. The process is to operate isothermally at 300 K and a total pressure of 101.32 kPa. The equilibrium solubility relationship for acetone in water is y = 2.53 x. Determine: (7)

i) the minimum pure water flow in kg-mole/hr

ii) the number of theoretical trays required for the separation if the pure water flow is 1.2 times the minimum by graphical method and

iii) compare your answer using the Kremser-Brown-Souders (KBS) Equation.

b) What major factors are to be considered while selecting a suitable solvent for absorption? (7)

OR

16. a) 1000 kg/hr acetone air mixture containing 5 mole% acetone is admitted into a continuous counter current absorber operating at atmospheric pressure and at a constant temperature of 27 °C. It is scrubbed with pure water at a rate of 20% more than the minimum required such that 90% of acetone from the gas phase is absorbed. (7)

The equilibrium relationship is given by the equation y = 2.53x, where x and y are mole fraction. Given H_{tG} = 0.353m, H_{tL} = 0.323m. Gas mixture can be assumed dilute. Calculate the height of the tower.

b) Define HTU and NTU for a packed column. Explain how NTU is determined by general graphical method. (7)

MODULE IV

17. a) Explain adsorption wave and breakthrough curve in fixed bed adsorption. (7)

b) List the desirable properties of a good adsorbent. (7)

OR

18. a) Deduce the equation for wet bulb depression and explain how adiabatic saturation temperature is equal to WBT for air water system. (7)

b) Compare between forced draft and induced draft cooling towers with neat diagrams. (7)

MODULE V

19. a) Explain the mechanism of moisture movement in constant-rate period and falling-rate period during drying operations. (7)

b) The filter cake from a process unit is dried for 7 hrs under constant drying conditions in a tray drier to reduce its moisture content from 40% to 25%. Determine the time required to dry the same material to 10% moisture content under the same conditions. The critical moisture content and the equilibrium moisture content are 18% and 2% respectively. All moisture contents given are on dry basis. Make suitable assumptions if required. (7)

OR

20. a) Describe the construction and working of a Draft Tube Baffle Crystalliser with a neat diagram. (7)

b) 1000 kg of an aqueous solution of Na_2CO_3 containing 15% carbonate by weight is fed to a crystalliser. 75% of the carbonate is recovered as $Na_2CO_3.10H_2O$ by evaporation of water and subsequent cooling to 278 K. The solubility of Na_2CO_3 at 278 K is 9.0% (weight). Determine: (7)

(i) The quantity of crystals formed.

(ii) The amount of water evaporated.

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