A **269B1** **Total pages: _**

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SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(R,S), MAY 2024

B. Tech Chemical Engineering

(2020 SCHEME)

Course Code : 20CHT302

Course Name : Mass Transfer Operations II

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

Scientific calculator and statistical table is allowed in the examination hall.
Graph sheets may be provided.

PART A

(Answer all questions. Each question carries 3 marks)

1. Show that the relative volatility of an ideal solution is equal to the ratio of the vapour pressures of pure components.
2. What are the advantages and disadvantages of steam distillation?
3. What are the five different thermal conditions of the feed in distillation?
4. Explain the role of a partial condenser in distillation process.
5. What are the properties of the solvent used for extractive distillation?
6. Describe the steps for the calculation of minimum number of plates using Ponchon - Savarit method.
7. Define selectivity.
8. Explain single stage extraction for a partially miscible system with a neat sketch.
9. Describe leaching and the factors affecting rate of leaching.
10. Draw the three non-ideal leaching equilibrium curves.

PART B

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

MODULE I

11. a) Derive Rayleighs equation. 8
    b) Explain simple distillation with a neat sketch. 6

OR

12. 1) Explain the boiling point diagram with a neat sketch. 8
    2) What are the limitations of distillation as a separation technique? 6

MODULE II

13. A plate column equipped with a total condenser and a kettle - type reboiler is used to separate 100 kmol/ h of a benzene - toluene solution containing 50 mol% benzene into a distillate product containing 95 mol% benzene and a bottom product containing 5 mol% benzene. The column is operated at 101.3 kPa. The feed is partially vaporised and is one third vapour and two third liquid. Determine the following: 14
    (a) Minimum number of plates required graphically and analytically using an average relative volatility of 2.39.
    (b) Minimum reflux ratio.

The equilibrium data for benzene - toluene system at 101.3 kPa:

x	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1
y	0	0.205	0.369	0.502	0.618	0.706	0.789	0.849	0.907	0.955	0.978	1

OR

14. a) Derive an equation for the enriching section operating line for the case of open steam. 6
    b) An aqueous solution of ethyl alcohol containing 12 mol% alcohol is sent to a distillation column operated at 101.3 kPa for producing a distillate containing 85 mol% alcohol.It is desired to have 90% recovery of alocohol as distillate. The feed enters the column at a rate 100 kmol/h, as saturated liquid. A total condenser is used and the reflux ratio employed is 3. No reboiler is used and direct steam at 101.3 kPa is admitted to the bottom plate. Determine 8
    (a) Steam consumption, kg/h
    (b) Composition of the bottoms
    (c) The number of theoretical plates

Equilibrium data at 101.3 kPa (mole fraction of ethanol)

x	0.019	0.0721	0.0966	0.1238	0.1661	0.22337	0.2608	0.3273	0.3965	0.5079	0.5198	0.5732	0.6763	0.7472	0.8943
y	0.17	0.3891	0.4375	0.4704	0.5089	0.54445	0.5580	0.5836	0.6122	0.6564	0.6599	0.6841	0.7385	0.7815	0.8943

MODULE III

15. a) Compare packed column and plate column. 5
    b) Derive an equation to calculate the height of the packed column in distillation. 9

OR

16. A methanol-water solution containing 30 mol% methanol enters a distillation column as saturated liquid. It is continuously distilled to produce a distillate containing 95 mol% methanol and a residue containing 4% methanol. Distillate is totally condensed and the reflux is at its bubble point. The equilibrium data (mole fraction methanol) are: 14

x	0	0.05	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1
y	0	0.267	0.418	0.517	0.570	0.665	0.729	0.779	0.825	0.870	0.915	0.958	0.979	1

Enthalpy data:

	Saturation Enthalpy,kJ/kg	
	Liquid	Vapour
Methanol	5000	40000
water	7500	48000

Determine the following:
(a) Minimum reflux ratio.
(b) Number of plates required for a reflux ratio of 2.

MODULE IV

17. An aqueous solution containing 20 weight% of a valuable solute is subjected to liquid -liquid extraction in a three-stage cross flow unit using a pure solvent. The final raffinate should contain not more than 10 mol% of the solute present in the original feed. The equilibrium data under operating conditions are: 14

Weight fraction of solute in aqueous layer	0.06	0.12	0.18	0.24
Weight fraction of solute in extract layer	0.24	0.4	0.56	0.73

Selectivity is infinity. If equal quantities of solvent are used in all stages, determine:
(a)Total quantity of solvent used per 100 kg feed.
(b) Total quantity of extract obtained as per condition (a).
(c) Average composition of the combined extract.

OR

18. a) What are the characteristics of the solvent used for extraction? 8
    (b) Explain the industrial applications of extraction. 6

MODULE V

19. Black ash containing 45 weight% Na_2CO_3 and the rest water-insolubles is extracted with water such that 96% of soda ash in it is recovered. The underflow carries with it 15 kg water with every 100 kg insolubles. Determine the total quantity of water used and the concentration of the combined extract if the leaching has been carried out for a feed rate of 1000 kg/h of black ash in a two-stage cross flow cascade system where equal amounts of water are added in both the stages. 14

OR

20. Explain the classification of membrane separation processes with neat diagrams. 14

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