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DEPARTMENT OF CHEMICAL ENGINEERING

V SEMESTER B.TECH. CHEMICAL ENGINEERING

END SEMESTER EXAMINATION

SUBJECT: MASS TRANSFER II (CHE 3152)

Exam Date & Time: 22-Nov-2022 (02:00 PM - 05:00 PM)

Time: 3 Hours **MAX. MARKS: 50**

<table>
<tr><th>Q. No</th><th>Question</th><th>M</th><th>CO</th><th>BL</th></tr>
<tr><td>1A.</td><td>1000 kg/h of a mixture containing 42 mole percent heptane and 58 mole percent ethyl benzene is to be fractionated to a distillate containing 97 mole percent heptane and a residue containing 99 mole percent ethyl benzene using a total condenser and feed at its saturated liquid condition. The enthalpy-concentration data for the heptane-ethyl benzene at 1 atm pressure are as follows:

Calculate the minimum reflux ratio using Ponchon-Savarit method
<table>
<tr><td>x</td><td>0</td><td>0.08</td><td>0.18</td><td>0.25</td><td>0.49</td><td>0.65</td><td>0.79</td><td>0.91</td><td>1</td></tr>
<tr><td>y</td><td>0</td><td>0.28</td><td>0.43</td><td>0.51</td><td>0.73</td><td>0.83</td><td>0.90</td><td>0.96</td><td>1</td></tr>
</table>
<table>
<tr><td>H_L (kJ/kmol) x 10^{-3}</td><td>24.3</td><td>24.1</td><td>23.2</td><td>22.8</td><td>22.05</td><td>21.75</td><td>21.7</td><td>21.6</td><td>21.4</td></tr>
<tr><td>H_V (kJ/kmol) x 10^{-3}</td><td>61.2</td><td>59.6</td><td>58.5</td><td>58.1</td><td>56.5</td><td>55.2</td><td>54.4</td><td>53.8</td><td>53.3</td></tr>
</table></td><td>5</td><td>2</td><td>3</td></tr>
<tr><td>1B.</td><td>Calculate the minimum number of stages for the data given in Question 1A.</td><td>3</td><td>2</td><td>3</td></tr>
<tr><td>1C.</td><td>A liquid mixture containing 50 mole % each of benzene and toluene at 40°C is to be continuously flash vaporized to vaporize 60 mole % of the feed. The residual liquid product contains 35 mole % benzene. If the enthalpies per mole of feed, the liquid product and the vapor product are respectively 2,5 and 30 kJ/mole, calculate the concentration of the distillate and the heat added in kJ per mole of vapor product</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2A.</td><td>A binary distillation column is operating under conditions specified below:
Feed rate = 350 kmol/h; Overhead product rate = 150 kmol/h;
Mole fraction of more volatile component in overhead product = 0.97
Mole fraction of bottom product = 0.02
Bottom product rate = 200 kmol/h
Reflux ratio = 3.5

In the stripping section it was found that the mole fraction of the more volatile component in the vapor leaving a plate is 0.33 while its mole fraction in the liquid coming out from the same plate is 0.25. Assuming constant molar overflow, determine whether the feed is vapor, liquid or partially vaporized.</td><td>4</td><td>3</td><td>4</td></tr>
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2B. A continuous fractionating column is to be designed for separating 10,000 kg per hour of a liquid mixture containing 40 mole percent methanol and 60 mole percent water into an overhead product containing 97 mole percent methanol and a bottom product having 98 mole percent water. A mole reflux ratio of 3 is used. Calculate (i) moles of overhead product obtained per hour and (ii) number of ideal plates and location of the feed plate if the feed is at its bubble point. | 4 | 3 | 3

x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0.417	0.579	0.669	0.729	0.78	0.825	0.871	0.915	0.959

2C. What is/are the assumption(s) of Mc Cabe Thiele method? Discuss about the thermodynamic and Graphical considerations to support these assumption(s). | 2 | 3 | 2

3A. For extraction of dioxane from water, benzene is used as an extraction solvent. The equilibrium distribution of dioxane between water and benzene is as given below: | 4 | 4 | 3

Weight % dioxane in water	5.1	18.9	25.2
Weight % dioxane in benzene	5.2	22.5	32

At these concentrations, water and benzene are insoluble. 1000 kg of solution containing 25% dioxane is to be extracted with benzene to remove 95% of the dioxane. The dioxane free benzene is used as the solvent. Calculate the solvent requirement for the single stage operation.

3B. Write a short note on any two solid-liquid contacting equipment which does not result in the clogging by fines with neat schematic diagram. | 4 | 5 | 1

3C. Dilute ethanol-water solutions can be continuously rectified to give at best the mixtures containing 89.4 mole % ethanol at atmospheric pressure, since this is the composition of minimum boiling azeotrope in the binary system. Ethanol can be further purified either by using n-pentane as entrainer or ethylene glycol as solvent. Write short notes on the methods which uses the above-mentioned compounds in the purification of ethanol and comment on the most desirable method. | 2 | 1 | 2

4A Crushed oil seeds containing 28 mass % oil is to be extracted with hexane to reduce the oil content to 0.8% in the underflow. 1 kg of solvent is used per kg of feed. Determine the no of stages required using counter-current leaching. | 5 | 5 | 3

Overflow (100 kg) solution			**Underflow (100 kg) slurry**		
W_A (kg)	**W_B (kg)**	**W_C (kg)**	**W'_A (kg)**	**W'_B (kg)**	**W'_C (kg)**
0.3	99.7	0	67.2	32.8	0
0.45	90.6	8.95	67.1	29.94	2.96
0.54	84.54	14.92	66.93	28.11	4.96
0.70	74.47	24.83	66.58	25.06	8.36
0.77	69.46	29.77	66.26	23.62	10.12
0.91	60.44	38.65	65.75	20.9	13.35
0.99	54.45	44.56	65.33	19.07	15.6
1.19	44.46	54.35	64.39	16.02	19.59
1.28	38.50	60.22	63.77	14.13	22.10
1.28	34.55	64.17	63.23	12.87	23.90
1.48	24.63	73.89	61.54	9.61	28.85

4B	What is the significance of introducing open steam in a distillation column? Also derive an expression to determine the slope of the lower operating line.	2	2	2
4C	Derive an expression to theoretically calculate the minimum number of trays if the relative volatility remains reasonably constant throughout the column (provided x_D, x_W and α are known).	3	1	2
5A	Write a shot note on the four steps involved in the extraction process with a neat block diagram.	2	4	1
5B	Discuss any two types of membranes used in food industries with their exact application. Also comment on the modules used for such membranes in food industries.	4	5	2
5C	A feed of 1200 kg aqueous solution of pyridine per hour (50% by mass) is to be extracted with pure benzene to reduce the solute content in the raffinate to 3%. Determine the minimum solvent rate	4	4	4

Water layer		Benzene layer	
Pyridine (mass %)	Benzene (mass %)	Pyridine (mass %)	Benzene (mass %)
1.17	0	3.28	94.54
3.55	0	9.75	87.46
7.39	0	18.35	79.49
13.46	0.15	26.99	71.31
22.78	0.25	31.42	66.46
32.15	0.44	34.32	64.48
42.47	2.38	36.85	59.35
48.87	3.99	39.45	56.43
49.82	4.28	39.27	55.72
56.05	19.56	48.39	40.05