| Reg. No. | | | | | | | | | | |
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# MANIPAL INSTITUTE OF TECHNOLOGY
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## V SEMESTER B.TECH. END SEMESTER EXAMINATIONS DEC 2020

SUBJECT: MASS TRANSFER II [CHE 3101]

**REVISED CREDIT SYSTEM**
**(02/01/2020)**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

| | | |
|---|---|---|
| **1A.** | 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 $\alpha$ are known). | **3** |
| **1B.** | Consider Ponchon-Savarit method. Derive the theoretical expressions to determine heat load on condenser, reboiler and the hypothetic stream with a neat schematic diagram (marking all the streams). Also discuss about the significance of the hypothetic stream. | **5** |
| **1C.** | 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** |
| **2A.** | 100 moles of benzene and toluene containing 50 mole% benzene is subjected to a differential distillation at atmospheric pressure till the composition of the benzene in the residue is 33% by mole. Calculate the total moles of the mixture distilled. Assume $\alpha = 2.4$ | **3** |
| **2B.** | 1000 kg of crushed oil seeds (19.5% oil, 80.5% meal) is extracted in a three-stage cross-current unit using 500 kg of pure hexane in each stage. The equilibrium data are as follows: | **5** |

| **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 |

Calculate the fraction of oil extracted using PS method.

**2C.** Calculate the equilibrium vapor phase composition of a liquid hexane–water mixture at 50°C, assuming that hexane and water are completely immiscible. **2**

The Antoine constant are given for pressure in torr at 50°C

| Constants | Hexane | Water |
|---|---|---|
| A | 6.87024 | 8.07131 |
| B | 1168.72 | 1730.63 |
| C | 224.21 | 233.426 |

**3A.** A mixture of 35 mole % A and 65 mole % B is to be separated in a distillation column. 96% of the component A from the feed is in the distillate. The concentration of A in the distillate is 93 mole %. The feed is half vapor and reflux ratio is 4. The relative volatility is 2.5. How many equilibrium stages are required in each section of the column? **5**

**3B.** Determine the minimum reflux ratio for the conditions given in question 3A. **2**

**3C.** What are the assumptions involved in Mc Cabe Thiele (MT) method? Discuss about the graphical and physical considerations in MT method which proves that its assumptions are justified. **3**

**4A.** A feed of 1000 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 2%. Determine the number of ideal stages required if the solvent rate is 1.3 times the minimum. (Use rectangular coordinate system) **10**

| **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 |

**5A.** Discuss about spiral wound membranes and bundle of hollow fibers with schematic representation. Which among these is generally used in RO systems? **4**

**5B.** Write a short note on any two pressure driven membrane types with their applications. **2**

**5C.** Write a short note on any two solid-liquid contacting equipment which operates in counter-current mixing with a neat schematic diagram. **4**

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