

JK LAKSHMIPAT UNIVERSITY, JAIPUR
INSTITUTE OF ENGINEERING AND TECHNOLOGY
End Term Examination (Regular/Backlog), November 2017
B. Tech/ M. Tech (as applicable) in Chemical Engineering, Semester Fifth

Roll No.....

COURSE CODE: CHE507

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Mass Transfer Operations-II

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. **Assume suitable data wherever required and mention it clearly.**
3. Writing appropriate **units, nomenclature, and drawing neat sketches/ schematics/ flow chart** wherever, required are an integral part of the answer.

- Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10
- i. The temperature at which a vapour-gas mixture becomes saturated when cooled at constant total pressure with a liquid is called
(a) Bubble Point (b) Dew point (c) Wet-bulb temperature (d) Dry-bulb temperature
 - ii. the steady-state temperature reached by a small amount of liquid evaporating into a large amount of unsaturated vapour-gas mixture is called
(a) Dry-bulb temperature (b) Wet-bulb temperature (c) Dew point (d) Bubble point
 - iii. For pure air at atmospheric conditions the Lewis number is
(a) <1 (b) $>>1$ (c) $=1$ (d) ∞
 - iv. For pure air at atmospheric conditions the Schmidt number is
(a) <1 (b) >1 (c) $=1$ (d) $>>1$
 - v. If $y^* = x$, the relative volatility, α , for a binary system is always
(a) Zero (b) one (c) infinity (d) one except at $x=0$ or 1 .
 - vi. The Lewis number of a mixture is one when mass diffusivity is equal to
(a) Momentum diffusivity (b) thermal diffusivity
(c) thermal conductivity (d) $1/\text{thermal diffusivity}$
 - vii. Component A is said to be more volatile than component B, if for all temperature in the closed interval $T_A < T < T_B$
(a) The vapour pressure of A is less than the vapour pressure of B
(b) The vapour pressure of A is more than the vapour pressure of B
(c) The vapour pressure of A is equal to 1 atm
(d) The vapour pressure of A is equal to the vapour pressure of B
 - viii. The flash process is carried out by
(a) Reducing the pressure on the feed stream (b) Cooling the feed at constant pressure
(c) Increasing the pressure on the feed stream (d) None of the above
 - ix. The slope of the operating line in the rectifying section of a distillation column is unity if the reflux ratio is
(a) Zero (b) one (c) infinity (d) Minimum
 - x. In a distillation operation the reflux ratio may vary between
(a) Zero and one (b) Zero and Infinity (c) Minimum and Infinity (d) one and two
- Q.2 Short answer type questions (4 questions @ 2.5 marks) 10

- A. Define and explain the boiling point diagram for benzene and toluene mixture.
- B. Define and derive the correlation for relative volatility for binary mixture.
- C. Draw the minimum reflux condition on x-y diagram for binary mixture.
- D. Draw the five feed conditions on x-y diagram for binary mixture.

Q.3A Drive the Fenske-Underwood equation for calculation minimum reflux ratio. 05

Q.3B A mixture of 35 mole% A and 65 mole% B is to be separated in distillation column. The concentration of A in the distillate is 93 mole% of all A is in distillate. The feed is half vapour and reflux ratio is 4:1. The relative volatility is 2.5. How many equilibrium stages are required in each section of column? What could be the minimum reflux ratio for such operation? 05

Q.4A Derive the correlation for flash vaporization of a binary mixture with suitable diagram. 05

Q.4B A charge of 50 kmol of a mixture of benzene and chlorobenzene having 55 mole% of the less volatile is to be batch distilled. (a) If 25 moles of the solution is vaporized and condensed as the distillate, calculate the concentration of the accumulated distillate. (b) If the concentration of the accumulated product is to be 72 mole % benzene, calculate its amount. The relative volatility of benzene in the mixture is 4.15. 05

Q.5A Derive the correlation for feed line equation for binary mixture. 05

Q.5B The feed consist of methanol and water containing 80 mole % methanol and 20 mole % water. The overhead product is to contain 99 mole% methanol and the bottom product contains 0.5 mole% methanol. The feed is cold and for each mole of feed, 0.2 moles of vapour is condensed on the feed plate. The reflux ratio is 1.35 and the reflux is at its bubble point. Calculate the minimum reflux ratio. 05

Q.6A Write the ten difference in distillation and extraction operations. 05

Q.6B1 A 25% solution of dioxane in water is to be continuously extracted at a rate of 1000 kg/h in countercurrent extraction system with benzene to remove 95% of dioxane. The equilibrium distribution of dioxane between water and benzene is as follows: 05

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

At these concentration, benzene and water are substantially insoluble. Determine number of theoretical stages required if 900 kg benzene is used per hour.

OR

Q.6B2 Write the correlation for material balances of crystallizer with suitable diagram. 05

Q.7A Calculate the yield of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ crystals when 1000kg saturated solution of MgSO_4 at 353K is cooled to 303K assuming 10% of the water is lost by evaporating during cooling. The solubility of MgSO_4 at 353K and 303K are 64.2kg/100kg water and 40.8kg/100kg water respectively. 05

Q.7B1 Write the working principle of the Oslo/Krystal Evaporative Crystallizer with suitable diagram. 05

OR

Q.7B2 A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 25% by weight Na_2CO_3 is cooled at 293K and crystals of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ are 05

precipitated. At 293K, the solubility is 21.5 kg anhydrous Na_2CO_3 per 100 kg water. Calculate the yield of Na_2CO_3 crystals obtained if 5% of the original water in the system evaporated on cooling.

- Q.8A Derive the correlation for determination of the number of Trays-The McCabe Thiele method, with suitable diagram. 10
- Q.9A Derive the correlation for determination of the number of stages for continuous multistage countercurrent extraction of one pair partially miscible. 10
- Q.9B1 A solution containing 500 kg of Na_2SO_4 and 2500 kg of water is cooled from 333K to 283K in an agitated mild steel vessel weighing 750 kg. At 283K, the solubility of anhydrous salt is 8.9 kg per 100 kg water. Na_2SO_4 crystallizes as $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$. If 2% of the original water is lost by evaporation during cooling, calculate the heat that must be removed and yield of hydrated crystals in kg. The heat capacity of the solution and mild steel are 3.6 & 0.5 kJ/kg.K respectively. The heat of solution is -78.5 MJ/kmol and the latent heat of vaporization of water is 2395 kJ/kg., 10
- Q.9B2 Derive the correlation for determination of the number of stages for multistage cross current leaching with suitable diagram. 10

*****Good Luck*****