

Seat No.: \_\_\_\_\_

Enrolment No. \_\_\_\_\_

## GUJARAT TECHNOLOGICAL UNIVERSITY

### BE - SEMESTER-VI(NEW) – EXAMINATION – SUMMER 2019

**Subject Code:2163609**
**Date:10/05/2019**
**Subject Name: Basic of Mass Transfer**
**Time:10:30 AM TO 01:00 PM**
**Total Marks: 70**
**Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

	MARKS
<b>Q.1</b> (a) Define following terms: (1) Diffusivity (2) Mass transfer coefficient (3) Absorption Factor	03
(b) Explain direct contact of two Immiscible Phases.	04
(c) A layer of benzene 3 mm deep lies at the bottom of an open tank 5 m in diameter. The tank temperature is 295 K and the diffusivity of benzene in air is $8 \times 10^{-6} \text{ m}^2/\text{s}$ at this temperature. If the vapor pressure of benzene in the tank is 13.3 kN/m <sup>2</sup> and diffusion may be assumed to take place through stagnant air film of 3 mm thick. How long (in sec) will it take for the benzene to evaporate? The density of the benzene is 880 Kg/m <sup>3</sup> . Molecular weight of benzene is 78 kg/Kmol.	07
<b>Q.2</b> (a) Prove that $D_{AB} = D_{BA}$ with proper assumptions.	03
(b) Derive an equation of flux $N_A$ For diffusion from a sphere in to the infinite air medium.	04
(c) An ethanol (A) Water (B) solution in the form of a stagnant film 2.0 mm thick at 293 K is in contact at one surface with an organic solvent in which ethanol is soluble and water is insoluble. Hence, $N_B = 0$ . At point 1 the concentration of ethanol is 16.8 wt% and the solution density is $\rho_1 = 972.8 \text{ Kg/m}^3$ . At point 2 the concentration of ethanol is 6.8 wt% and $\rho_2 = 988.1 \text{ Kg/m}^3$ . The diffusivity of ethanol is $0.740 \times 10^{-9} \text{ m}^2/\text{s}$ . Calculate the Steady State flux $N_A$ . Take the molecular weights of ethanol and water as 46.05 and 18.02 respectively.	07
<b>OR</b>	
(c) Derive the equation of flux $N_A$ for A diffusing through non diffusing B; assume the ideal gases.	07
<b>Q.3</b> (a) Differentiate J and N flux.	03
(b) Explain Film theory of Mass Transfer.	04
(c) In a laboratory experiment, the solute A is being absorbed from a mixture with an insoluble gas in a falling film of water at 30 °C and pressure of 1.45 bar. The gas phase mass transfer coefficient $k_c = 90.3 \text{ Kmole/h(m}^2\text{)} (\text{Kmol/m}^3)$ . It is known that 13.6 % of the total mass transfer resistance lies in gas phase. At a particular section of the apparatus the mole fraction of the solute in the liquid is known to be $x_i = 0.00201$ . The equilibrium solubility of the gas in water at the given temperature is $p = 3.318 \times 10^4 x^*$ , where p is partial pressure of gas in mm Hg and $x^*$ is the solubility of A in water in mole fraction. <b>Calculate:</b> a) The overall liquid phase mass transfer coefficient b) The individual gas phase driving force $\Delta p$ and $\Delta y$	07

OR

- Q.3 (a) Discuss different types of Diffusivity. 03  
 (b) Discuss application of the molecular diffusion. 04  
 (c) Derive the equation of overall resistance using two phase mass transfer theory, from both the liquid and gas phase. 07
- Q.4 (a) Briefly explain the difference between Absorption, Adsorption and Extraction. 03  
 (b) Write a short note on a choice of solvent for Absorption. 04  
 (c) A coal gas is to be freed of its light oil by scrubbing with wash oil as an absorbent and the light oil recovered by stripping the resulting solution with steam. **Absorber:** Gas in  $0.250 \text{ m}^3/\text{s}$  at  $26^\circ\text{C}$ ,  $P_t = 1.07 \times 10^5 \text{ N/m}^2$  Containing 2.0% by volume of light oil vapors. The light oil will be assumed to be entirely benzene and a 95% removal is required. The wash oil is to enter at  $26^\circ\text{C}$ , containing 0.005 mole fraction benzene and has an average molecular weight is 260. An oil circulation rate of 1.5 times the minimum is to be used. Wash oil-benzene solutions are ideal. The temperature will be constant at  $26^\circ\text{C}$ . At  $26^\circ\text{C}$ , the vapor pressure of benzene is  $13330 \text{ N/m}^2$ . Assume the system as a counter current packed tower. Compute the oil circulation rate required. 07

OR

- Q.4 (a) Define different moistures, (a) unbound (b) bound (c) equilibrium 03  
 (b) Discuss Minimum Liquid-Gas Ratio theory for absorbers. 04  
 (c) A gas mixture containing 15 mole % 'A' and 85 mole % inerts is fed to an absorption tower where it is contacted with liquid solvent 'B' which absorbs 'A'. The mole ratio of solvent to gas entering the tower is 1.5:1. The gas leaving the absorber contains 2.5 % 'A', 1.5 % 'B' and rest is inert on mole basis. 07

**Calculate:**

- (i) the percentage of the original solute 'A' that remains un recovered.  
 (ii) the fraction of solvent 'B' fed to the tower lost in gas leaving the column.

- Q.5 (a) Discuss minimum reflux ratio theory. 03  
 (b) Explain role of Raoult's law in distillation and derive the following equation  $y = \alpha x / 1 + (\alpha - 1)x$  04  
 (c) A binary feed has  $q = 0.25$  is separated in a staged distillation column. 07  
 The mole fraction of the more volatile component in the distillate product is 0.95. The molar flow rate of the distillate is 50% of the feed flow rate and the McCabe-Thiele method can be used to analyze the column. The q-line intersects the operating line of the enriching section at (0.35, 0.5) on the x-y diagram. Calculate the slope of the Stripping section operating line.

OR

- Q.5 (a) Explain positive and negative deviation from ideality. 03  
 (b) Explain Drying Rate Curve. 04  
 (c) Calculate the time (in hours) required to reduce the moisture contents of a solid from 0.66 to 0.25 Kg moisture/Kg dry solid. The rate of drying  $N$  (Kg Water evaporated/ $\text{m}^2 \text{ s}$ ) is given as following. 07

$$N = 0.0015 X \text{ for } X \leq 0.3$$

$$= 0.00045 \text{ for } X > 0.3$$

where  $X$  = Kg moisture/Kg dry solid. The drying surface is  $0.025 \text{ m}^2/\text{Kg dry solid}$

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