UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2021

Course: Mass Transfer-I
Program: B. Tech CERP
Course Code: CHCE-3003

Semester: IV
Time 03 hrs.
Max. Marks: 100

Instructions:

SECTION A (30 Marks)

S. No.		Marks	CO
Q.1	Air (25°C, 1 atm) passes over a test tube which is partially filled with a solution. Oxygen is quickly absorbed in this solution. The depth of empty space above the solution is 5 cm. The diffusivity of oxygen in nitrogen at given conditions is 0.21 cm^2/s. What is the rate of absorption of oxygen from air in the solution at steady state? (A) 1.3×10^{-3} kg/m^2.s (B) 1.3×10^{-4} kg/m^2.s (C) 1.3×10^{-5} kg/m^2.s (D) 1.3×10^{-6} kg/m^2.s	5	CO1
Q.2	Which of the following is the correct expression for average mass transfer coefficient by Penetration theory (A) $k_{L,avg} = 2\sqrt{\dfrac{D_{AB}}{\pi t_c}}$ (B) $k_{L,avg} = \sqrt{\dfrac{D_{AB}}{\pi t_c}}$ (C) $k_{L,avg} = \dfrac{D_{AB}}{\pi t_c}$ (D) $k_{L,avg} = \dfrac{2\,D_{AB}}{\pi t_c}$	5	CO2
Q.3	The well-known Kremser Equation (also called the Kremser-Brown-Souders equation) is used to calculate : (A) Height of the packed column (B) Diameter of the packed column (C) Number of plates in a tray column (D) Flooding conditions in packed/Tray column	5	CO3
Q.4	Which one is the true statement about trays in a tray column? (A) The Bubble-cap tray is a relatively new class of tray that provides variable area for the gas or vapor flow. (B) The valve trays are now widely used for gas absorption and distillation due to high flexibility, high turndown ratio and relatively low cost.	5	CO3

	(C) Small holes in sieve trays increase entrainment and cause weeping		
	(D) A sieve trays is the oldest type of tray in which holes are generally made by drilling.		
Q.5	Consider a mixture of 40 mole% benzene (1), 40 mole% toluene (2) and 20 mole% p-xylene (3). The following relative volatility values are known at 1 atm total pressure: $\alpha_{12} = 2.4\ and\ \alpha_{32} = 0.43$. What is the value of α_{31} ?	5	CO4
Q.6	One mole of a solution of A and B (enthalpy = 900 kcal/kmol; x = 0.4) is mixed with two moles of another solution of the components (enthalpy = 1200 kcal/kmol, x = 0.8). What is the enthalpy and composition of the mixture?	5	CO4

SECTION B (50 Marks)

Q. 1	Two large vessels containing gaseous mixtures of A and B at different concentrations but at the same total pressure are connected by a tapered tube of length 15 cm and end diameters 1 cm and 4 cm. What should be the diameter of a cylinder tube of the same length that allows the same rate of transport of A?	10	CO1
Q. 2	Air containing 5 % CO_2 enters a tube of 40 mm i.d. at the bottom at a velocity of 4 m/s. The inner wall of the tube is irrigated with a strong solution of NaOH. The tube has 3 m wetted section and 75% of the entering CO_2 is absorbed before the gas leaves the tube. Calculate the gas-phase mass transfer coefficient. Since the CO2 reacts instaneously with strong NaOH solution, concentration of CO_2 at gas-liquid interface can be considered zero.	10	CO2
Q. 3	A countercurrent absorption tower receives 100 kmol of a gas mixture per hour having 15 % of a solute. It is required to absorb 95 % of the solute. 'Pure' solvent enters at a rate of 80 kmol/h at the top. (a) What is the equation of the operating line if the concentrations are expressed in the mole ratio unit? (b) If the mole fraction unit is used, what would be the slope of the operating line at a section where the bulk gas concentration is 10%.	10	CO3
Q. 4	What are common types of flooding in a tray tower? Explain the mechanism of each type.	10	CO3
Q. 5	Ten kmol of a feed having 65 mole % benzene and 35 mole% toluene is batch distilled at 1 atm pressure. Calculate the moles of distillate produced and the composition of the bottom product if the distillation is done until (a) 75 mole% of the feed benzene leaves with the vapor (b) The accumulated distillate contains 75 mole% of benzene. Take relative volatility of benzene over toluene equal to 2.51.	10	CO4

Section C (20 Marks)			
Q. 1	A feed mixture of A and B (45 mole% A and 55 mole% B) is to be separated into a top product containing 96 mole% A and a bottom product having 95 mole% B. The feed is 50 % vapor and the reflux ration is 1.5 times the minimum. What is the equation of the feed line? Determine the number of ideal trays required and the location of the feed tray. The average relative volatility of A over B can be considered 2.8.	**20**	**CO4**