Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2022

Programme Name: B. Tech in Applied Petroleum Engineering, Spl. Gas **Semester : IV**
Course Name : Mass Transfer Operations **Time : 03 hrs.**
Course Code : CHCE 2017 **Max. Marks : 100**
Nos. of page(s) : 2
Instructions: The exam will be <u>OPEN BOOK and OPEN NOTES</u>. The students are allowed any textbooks, photo-copied and hand-written notes. Graph papers are needed for the solution.

Please make necessary assumptions and mention them whenever and wherever necessary

SECTION A [30]

S. No.		Marks	CO
Q1.	Starting from $N_A = N.\ X_A + J_A$, show that $\mathbf{j_A + j_B = 0}$ Here, N, N_A and J_A are the molar fluxes in kmol/m^2.sec and j_A and j_B are mass fluxes in kg/m^2.sec. ρ_A is the density and v_A, v are the velocities.	**[10]**	**CO1**
Q2.	A bubble of oxygen is dissolving in a pool of water inside a bubble column. The bulk concentration of oxygen in a bubble is 0.04 kmol/m^3. You may assume a negligible concentration of oxygen in the water. The liquid-side and gas-side overall mass transfer coefficients are given by For the Liquid phase $Sh = 2 * Re^{0.8} Sc^{0.2}$ For Gas-phase $Sh = 1.1 * Re^{0.6} Sc^{0.1}$ The diameter of the column is 0.2 m, and the average velocities of oxygen and water are 0.15 m/s and 1 m/s respectively. Data: (see table below) (a) Calculate and decide which side (Gas or liquid) is controlling the mass transfer. (b) If the equilibrium condition is given by $y_{Ai} = 0.5X_{Ai}$, Calculate the interface concentrations.	**[20]**	**CO2**

Data for Q2:

	Oxygen	Water
Density (Kg/m^3)	6.5	1000
Viscosity (Pa. sec)	2.04 x 10^{-4}	0.001
Diffusivity (m^2/sec)	2 x 10^{-9}	1.65 x 10^{-9}
δ (m)	0.0001	0.0001

SECTION B [30]

S. No.		Marks	CO
Q3.	a) If you have a Liquid-Liquid mixture that needs to be separated what are the various criteria that you as an engineer will need to check before you decide its separation methodology?	**[15]**	**CO3**

	b) What are the major engineering problems that you expect to experience while handling solid-gas and solid-liquid mass transfer processes? c) As an engineer you noticed that the product specifications for an absorption process in a packed column are not being achieved. What all factors may be affecting the behavior of the column?		
Q4.	Sour water (H_2S+water) is added to a stripping column containing 0.98% H_2S in water at 450 kmol/hr. The process is carried out in a packed column of 2.5 m^2 cross-sectional area and containing 1.5 mm ceramic saddle packings at 90^oC and 1 atm. Pure steam is added from the bottom at 200 kmol/hr to remove 98% H_2S from the water. Calculate the height of the packing required for the process if the overall mass transfer coefficient is K_L. a = 150 kmol/hr.m^3. The equilibrium relation is given by **y = 1.58x.** Assume no condensation of steam is occurring in the column. *(Hint: You may take necessary assumptions)*	**[15]**	**CO4**

SECTION C [40]

Q5.	A distillation unit consists of a partial reboiler a bubble cap column and a total condenser. The overall plate efficiency is 65%. The feed is a 50% vapor-liquid mixture consisting of 60 mol% ethanol in water. This liquid is fed to the optimal plate. The column is to produce a distillate containing 95 mol% more volatile and bottoms of 95 mol% less volatile. Calculate the following for an operating pressure of 1 atm: a) The value for $(L/D)_{min}$ b) Minimum number of real plates to carry out the desired separation c) If the optimum reflux ratio is 50% more than the minimum, calculate the actual number of plates needed d) Optimum feed tray location e) Molar flow rate (kmol/hr) of product and residue produced if 1000 kmol/hr of feed is fed The equilibrium data is as follows:	**[40]**	**CO4**

Y*	0.21	0.37	0.51	0.64	0.72	0.79	0.86	0.91	0.96	0.98
X	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95