Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2023

Programme Name: B. Tech. in Chemical Engineering | **Semester : V**
Course Name : Mass Transfer II | **Time : 3 hrs**
Course Code : CHCE 3029 | **Max. Marks : 100**
Nos. of page(s) : 2
Instructions : Attempt all questions. Assume any missing data with proper justification.

S. No.		Marks	CO
	Section A		
Q.1	Discuss the solid-liquid extraction equilibrium. What are the different contact strategies for solid liquid extraction?	10	CO1
Q.2	Define inference, recirculation, cooling range and approach in cooling tower equipment.	10	CO1
Q.3	The equilibrium distribution of A in a gas-liquid system is linear, $Y = \alpha X$; where α is a function of temperature $$\ln \alpha = 0.3512 - \frac{26.462}{T\ (K)}$$ The flow rate of the phases (solute-free basis) are: $G_s = 38\ kmol/h$ and $L_s = 49.5\ kmol/h$. The feed gas has 8% solute in it. Calculation the temperature when absorption factor becomes unity	10	CO2
Q.4	The saturation enthalpy versus temperature data is important to determine the height of the cooling tower. Estimate five data points for saturation enthalpy curve. The vapor pressure of water can be calculated by the following expression $$\ln p_A^v\ (bar) = 11.96481 - \frac{3984.923}{T\ (K) - 39.724}$$	10	CO2
Q.5	A solid having 20 % solute, 2 % water and the rest inert is to be leached with water at a rate of 2 ton/h. The overflow leaving the countercurrent leaching cascade has 15 % solute and no solid. The underflow carries 0.5 kg solution per kg inert independent of solution concentration. If 97 % of the solute is to be recovered, determine the number of ideal stages required for this solid-liquid extraction operation	10	CO3

Q.6 A 25 % solution of dioxane in water is to be continuously extracted at a rate of 1000 kg/h in a countercurrent extraction system with benzene to remove 95 % of dioxane. The benzene and water are substantially insoluble at this concentration range. Estimate the number of theoretical stages required if 900 kg of benzene is used per hour. The equilibrium distribution of dioxane between water and benzene is as follows:

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

10 **CO3**

Section B

Q.7 The following breakthrough data at 1 atm and 20 °C on adsorption of methyl ethyl ketone (MEK) from air using a packed bed of fine particle of silicalite (a type of zeolite) is collected

$Time\ (min)$	9.5	19	21	25.7	34.3	39	42	46.7	51.4
C/C_o in	0	0.018	0.037	0.083	0.287	0.435	0.491	0.620	0.713
$Time\ (min)$	56.2	64.7	68.6	72.4	77.1	84.8	97.1	104.7	108.6
C/C_o in	0.768	0.852	0.935	0.972	0.963	0.970	0.981	0.991	1

Data: bed height 0.2 m, superficial gas velocity = 0.29 m/s, C_o = 0.11 gmol/m^3;

bed density = 700 kg/m^3

If the maximum permissible concentration of MEK in the effluent is specified at $C/C_o = 0.03$, determine the breakthrough time and length of mass transfer zone.

20 **CO4**

Q.8 In the laboratory drying test of a granular, hygroscopic wet solid, it took 8.5 hours to dry the solid from 28 % to 2 % moisture with a solid loading of 20 kg/m^2. The critical moisture content is 0.1 and equilibrium moisture content is 0.005. The falling rate of drying is linear in the moisture content. Calculate the time required for drying the material from 25 % to 1.5 % moisture under similar drying conditions. What are the highest and the lowest drying rates? All the moisture contents are on dry basis.

20 **CO4**