BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION MO/2024)

CLASS: BTECH **SEMESTER: V**
BRANCH: CHEMICAL ENGINEERING **SESSION: MO/2024**

SUBJECT: CL301 MASS TRANSFER OPERATION-II

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates
5. Mention the roll no. in the graph paper and submit along with answer sheet.

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Q.1(a)	Five hundred kilograms of aqueous feed containing 50 mass% acetone is contacted with a solvent containing 98 % chloroform and 2 % acetone. The mass ratio of the feed to the solvent is 1:1. Calculate the mass and composition of the extract and also fraction of acetone in the feed extracted. The operation is carried out at 25 ^{0}C and the equilibrium and tie line are given below.	[5]	1	5

	Aqueous Phase (Mass fraction)	
Water	Chloroform	Acetone
x_a	x_b	x_c
0.8297	0.0123	0.158
0.7311	0.0129	0.256
0.6229	0.0171	0.36
0.456	0.051	0.493
0.345	0.098	0.557
	Chloroform Phase (Mass Fraction)	
Water	Chloroform	Acetone
y_A	y_B	y_C
0.013	0.70	0.287
0.022	0.557	0.421
0.044	0.429	0.527
0.103	0.284	0.613
0.186	0.204	0.61

Q.1(b)	Oil is extracted from crushed seeds by a low boiling hydrocarbon. The following experimental data are collected on the concentration and solid content of the overflow, and the solution retained in the underflow. The concentrations of both the streams are equal on "solid-free basis". Calculate and plot the experimental "equilibrium data "(i) on a right triangular diagram.	[5]	1	5

Overflow		*Underflow*
Kg oil per kg clear solution	*Kg solid per kg solution*	*Kg inerts per kg solution*
0.0	0.0	0.67
0.05	0.002	0.66
0.20	0.005	0.64
0.25	0.007	0.625
0.30	0.01	0.60
0.35	0.013	0.58
0.40	0.017	0.55
0.45	0.022	0.51
0.50	0.029	0.46

Q.2(a)	What are the factors which govern the operation of cooling tower. Mention the advantages and disadvantages of forced draft cooling tower.	[2+3]	2	2
Q.2(b)	A cooling tower of 50 m^2 cross-sectional area is required to cool the warm water from 42 ^{0}C to 29 ^{0}C at a rate of 425250 kg/h. The ambient air at 32 ^{0}C has a wet-bulb temperature of 22 ^{0}C and air rate (moist) is 6000 kg/h.m^2. The overall mass transfer coefficient, ($k_Y^{/}\bar{a}$) is 740.375 kg/m^3h ($\Delta Y^{/}$); where, "a" is specific interfacial area of air-water contact. Determine (a) the minimum air rate and (b) overall gas-phase enthalpy transfer units. (c) Keeping other conditions unchanged, if the wet-bulb temperature is changed to 25.5 ^{0}C, what will be the cold-water temperature?	[5]	2	6

Given: Tie lines are vertical; Absolute humidity and enthalpy.
at T_{G1} = 32 ^{0}C & T_{W1} = 22 ^{0}C are 0.013 kg/ kg dry air and 65.44 KJ / kg.
at T_{G1} = 32 ^{0}C & T_{W1} = 25.5 ^{0}C are 0.017 kg / kg dry air and 75.682 KJ / kg.

T (°C)	*lnPv* (Antoine Equation)	p^v (bar)	*Y'* (kg moist/kg dry air)	*H'* kJ/kg dry air
21	-3.694517	0.024859	0.0156487	60.84463
23	-3.572406	0.028088	0.0177391	68.22991
25	-3.452184	0.031676	0.0200784	76.26473
27	-3.333809	0.035657	0.0226937	85.02109
29	-3.217237	0.040066	0.025615	94.57904
31	-3.102429	0.04494	0.028876	105.0278
33	-2.989343	0.05032	0.0325139	116.4669
35	-2.877943	0.05625	0.0365707	129.0081
37	-2.76819	0.062776	0.0410932	142.7765
39	-2.660049	0.069945	0.0461344	157.9135
41	-2.553483	0.07781	0.0517539	174.5789
43	-2.448459	0.086427	0.0580195	192.9541
45	-2.344944	0.095853	0.0650086	213.2463
47	-2.242905	0.10615	0.0728098	235.6928

Q.3(a)	Mention the classification of dryers. A slab of paper 1.5 m × 1.5 m × 5 mm thick is to be dried under constant drying conditions from 65% to 5% moisture. The equilibrium moisture is 2.5% and the critical moisture content is 46%. All moisture contents are on dry basis. The drying rate at the critical point has been estimated to be 1.30 kg/(hr)(m^2). The density of the dry pulp is 220 kg/m^3. Assuming drying to take place from one large face only, estimate the drying time to be provided.	[2+3]	3	2, 4
Q.3(b)	A granular wet solid is taken on a tray (1 m × 0.6 m) and dried in a stream of hot air (120 °C; humidity = 0.02 kg/kg dry air; velocity = 4.5 m/s). The initial moisture content of 28% (dry basis) is to be reduced to 0.5 %. From laboratory tests it is known that the critical moisture content is 12 % and the equilibrium moisture is negligible. The falling rate of drying is linear in the moisture content. If the solid loading (dry basis) is 35 kg/m^2, calculate the drying time. Assume that the air flow is large, and its temperature drop across the tray is small.	[5]	3	5
Q.4(a)	Write down the characteristics and properties of adsorbents. Differentiate between the physical and chemical adsorption.	[2+3]	4	2
Q.4(b)	Explain the Langmuir isotherm with proper assumptions. Write down the steps involved in determining the number of stages needed for a multistage cross-current adsorption process.	[2+3]	4	2, 3

PTO

Q.5(a)	A laboratory MSMPR crystallizer has 0.05 m^3 suspension holdup. Measurements on a sample of suspension drawn from the crystallizer show a mass weighted average particle size of 400 microns. Other data: the average holding time = 50 min; the suspension density M_T = 120 kg crystals/m^3 of the suspension; true density of the crystals ρ_c = 2400 kg/m^3; volume shape factor = φ_v = 0.523. Calculate the crystal growth rate and nucleation rate.	[5]	5	4
Q.5(b)	A 0.02 Molar feed solution containing a macromolecular solute is to be concentrated to 0.1 Molar concentration by batch ultrafiltration at 25 ^{0}C. The solute rejection is 95 % and the effect of concentration polarization can be ignored for simplicity. If the upstream pressure is 3.5 atm (gauge) and the downstream pressure is essentially atmospheric, calculate the effective pressure driving force at the beginning and at the end of the process. Also estimate the fractional reduction in the solvent flux at the end of the process.	[5]	3	4

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