Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–V (NEW) EXAMINATION – WINTER 2020

Subject Code:3150501 Date:27/01/2021

Subject Name:Mass Transfer Operations I

Time:10:30 AM TO 12:30 PM Total Marks: 56

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1	**(a)**	Discuss the factors affecting choice of separation method.	**03**
	(b)	Differentiate between packed towers/tray towers.	**04**
	(c)	Discuss in detail classification of mass transfer operations with examples.	**07**
Q.2	**(a)**	Explain mass transfer operation between two immiscible phases.	**03**
	(b)	Explain material balance for single stage leaching.	**04**
	(c)	Methane diffuses at steady state through a tube containing helium for the case equimolar counter diffusion. At point 1, the partial pressure of methane is 55 kPa and at point 2, 0.03 m apart is 15 kPa. The total pressure is 101.325 kPa and temperature is 298 k, at this temperature and pressure the value of diffusivity is 6.75×10^{-5} m^2/s. Calculate the partial pressure of methane at point 0.02 m apart from point 1 for the above case.	**07**
Q.3	**(a)**	Define selectivity, absorption factor and ideal stage.	**03**
	(b)	Explain mass, heat and momentum transfer analogies.	**04**
	(c)	Explain the following terms with respect to tray towers: (i) Flooding (ii)Priming (iii) Coning (iv)Weeping (v) Dumping (vi)Tray Spacing (vii)Theoretical Tray	**07**
Q.4	**(a)**	Differentiate between random and regular packing.	**03**
	(b)	Define liquid extraction giving typical example. Explain equilateral–triangular co-ordinate and the mixture rule.	**04**
	(c)	Explain selection criteria for choice of solvent for gas absorption.	**07**
Q.5	**(a)**	With neat diagram discuss Venturi Scrubber.	**03**
	(b)	Discuss local and overall mass transfer coefficients.	**04**
	(c)	Derive equations to calculate rate of steady state diffusion of ‘A’ through non-diffusing ‘B’ and also for steady state equimolal counter diffusion in case of gases.	**07**
Q.6	**(a)**	Explain counter current multiple contact, Shanks system for leaching.	**03**
	(b)	Discuss in detail about Film theory for mass transfer coefficient.	**04**
	(c)	Enlist different industrial liquid extractors and explain any one in detail with neat figure.	**07**
Q.7	**(a)**	Explain preparation of solids for leaching.	**03**
	(b)	Discuss agitated batch crystallizer with neat sketch.	**04**

	(c)	A hot solution containing 2000kg of $MgSO_4$ and water at 57^OC and with a concentration of 30 weight% $MgSO_4$ is cooled to 30^0C and $MgSO_4.7H_2O$ crystals are removed. The solubility at 30^0C is 35.5 kg $MgSO_4$ per100 kg water. Calculate the yield of crystals and % yield of crystallization. Assume that no water is vaporized. Atomic weight: Mg=24, S=32, O=16, H=1	**07**
Q.8	**(a)**	Explain caking of crystals and methods to prevent it.	**03**
	(b)	Define super saturation and explain Meir's super saturation theory. Explain stages of crystallization. Explain stages or mechanism of crystallization.	**04**
	(c)	Discuss the system of three liquids- one pair partially soluble and the effect of temperature on ternary equilibria.	**07**

****

Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2021

Subject Code:3150501 Date:01/01/2022

Subject Name:Mass Transfer Operations I

Time:02:30 PM TO 05:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define: Plait point, selectivity and distribution coefficient in liquid-liquid extraction.	**03**
	(b)	Explain design principles of mass transfer equipments.	**04**
	(c)	A coal gas 0.01075 kmol/s at 26ºC, and $1.07*10^5$ N/m^2 containing 2% by volume of light oil vapors is to be freed of its light oil(Benzene) by scrubbing with wash oil as an absorbent and a 95% removal is required. The wash oil is to enter at 26 ºC, containing 0.005 mole fraction benzene, and has an average molecular weight 260. An oil circulation rate of wash oil is 0.001787 kmol/sec. Take vapor pressure of benzene at 26ºC is 13330 N/m^2. Assume ideal solution of wash oil-benzene. Calculate number of ideal stages.	**07**
Q.2	**(a)**	Explain the influence of solvent solubility on extraction.	**03**
	(b)	Explain the stage wise construction for insoluble liquids in liquid-liquid extraction.	**04**
	(c)	Oxygen is diffusing through a stagnant layer of methane 5 mm thick. The temperature is 20ºC and the pressure 100 kN/m^2. The concentrations of oxygen on the two sides of the film are 15% and 5% by volume. The diffusivity of oxygen in methane at 20ºC and 100 kN/m^2 is 2.046 x 10-5 m^2/s. Calculate: (a) Rate of diffusion of oxygen in kmol/ m^{2}s. (b) What will be the rate of diffusion if total pressure is raised to 200 kN/m^2, other conditions remaining unaltered?	**07**
		OR	
	(c)	Oxygen (A) is diffusing through carbon monoxide (B) under steady state condition with carbon monoxide non-diffusing. The total pressure is 1×10^5 N/m^{2}and temperature is 0^0C. The partial pressure of oxygen at two planes 2.0 mm apart is respectively 13000 and 6500 N/m^2. The diffusivity for the mixture is 1.87×10^{-5} m^2/s. Calculate the rate of diffusion of oxygen in kmol/s through each square meter of the two planes.	**07**
Q.3	**(a)**	Compare N type flux and J type flux.	**03**
	(b)	Classify gas-liquid mass transfer operations with principle.	**04**
	(c)	Derive the equation of N flux for steady state diffusion of A through non-diffusing B for gases.	**07**
		OR	
Q.3	**(a)**	Compare diffusivity of gases and diffusivity of liquids.	**03**
	(b)	Compare Penetration theory with Film theory with reference to molecular diffusion.	**04**
	(c)	Derive the equation of N flux for equimolal counter diffusion for gases	**07**

Q.4	**(a)**	Define the following terms with respect to tray tower a) Priming b) Coning c) Weeping	**03**
	(b)	Explain the prevention of vortex formation in mechanically agitated vessel.	**04**
	(c)	Explain "two resistance theory" briefly.	**07**
		OR	
Q.4	**(a)**	Define the following terms with respect to tray tower a) Flooding b) Dumping c) Tray Spacing	**03**
	(b)	Explain the characteristics of fill for packed tower.	**04**
	(c)	Explain use of local overall coefficients.	**07**
Q.5	**(a)**	Define: a) Absorption factor b) Crystallization c) selectivity of solvent	**03**
	(b)	Explain Meir's super saturation theory of crystallization.	**04**
	(c)	Explain construction and working of Ballman Extractor with neat sketch.	**07**
		OR	
Q.5	**(a)**	Define: a) Recoverability of solvent b) absorption c) striping	**03**
	(b)	Describe Swenson-Walker crystallizer.	**04**
	(c)	Explain typical equilibrium diagrams in leaching operation briefly	**07**

****

Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – SUMMER 2021

Subject Code:3150501 Date:09/09/2021

Subject Name:Mass Transfer Operations I

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.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	What are different methods of conducting mass transfer operations at commercial scale?	**03**
	(b)	With reference to concept of equilibrium, Explain the principles for interphase mass transfer between two insoluble phases.	**04**
	(c)	State different theories used to explain the meaning of mass transfer coefficients. Explain any one in detail.	**07**
Q.2	**(a)**	Draw classification chart of mass transfer operations.	**03**
	(b)	Explain the temperature and pressure dependency of diffusivity of gases and liquid.	**04**
	(c)	State and explain Fick's first law of diffusion Also, differentiate between flux N_A and J_A. Additionally, Prove that for unidirectional binary diffusion $J_A = - J_B$.	**07**
		OR	
	(c)	Calculate the rate of diffusion of Acetic acid (A) across a film of non-diffusing water (B) solution 1 mm thick at 17°C when the concentrations on opposite sides of the film are respectively 9 and 3 weight % acid. The diffusivity of acetic acid in the solution is 0.95×10^{-9} m^2/s. Density of 9 and 3 weight % aqueous solutions is 1012 kg/m^3 and 1003.2 kg/m^3 respectively. $M_A = 60$, $M_B = 18$.	**07**
Q.3	**(a)**	Classify gas-liquid equipment based on phases being dispersed with examples.	**03**
	(b)	Define the terms : (i) Flooding (ii) Coning (iii)Weeping (iv)Dumping	**04**
	(c)	Write a short note on minimum liquid gas ratio in case of gas absorption.	**07**
		OR	
Q.3	**(a)**	Define absorption factor A and Stripping factor S.	**03**
	(b)	Explain HETP, HTU and NTU for packed bed absorption column.	**04**
	(c)	Differentiate between Tray tower and Packed tower.	**07**
Q.4	**(a)**	Define ideal and non-ideal solutions with reference to multi-component absorption and state the characteristics of ideal solution.	**03**
	(b)	Enlist different industrial liquid extraction equipment and explain any one in detail.	**04**
	(c)	Discuss the system of three liquids- one pair partially soluble and the effect of temperature on these ternary equilibria in case of liquid extraction.	**07**
		OR	
Q.4	**(a)**	Explain gas absorption with chemical reaction in brief.	**03**

	(b)	Discuss various factors to be considered in making choice of solvent for liquid extraction.	**04**
	(c)	150 kg of nicotine-water solution containing 1% nicotine is to be extracted with 250 kg of kerosene at 20^{o}C. Water and kerosene are essentially immiscible in each other, Determine the % extraction of nicotine after single stage. The equilibrium relationship is Y*=0.798 X, where X and Y* are expressed as kg nicotine/kg kerosene and kg nicotine/kg water respectively.	**07**
Q.5	**(a)**	State different types of packing materials and explain their selection criterion.	**03**
	(b)	What is crystallization? Discuss effect of temperature on solubility.	**04**
	(c)	Discuss the preparation of solids in leaching and also explain rate of leaching.	**07**

OR

Q.5	**(a)**	Write a note on Ventury scrubber.	**03**
	(b)	Explain any one crystallization equipment in detail.	**04**
	(c)	Explain Shanks system for leaching.	**07**

****

Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V(NEW) EXAMINATION – SUMMER 2022

Subject Code:3150501 Date:04/06/2022

Subject Name:Mass Transfer Operations I

Time:02:30 PM TO 05:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	(a)	State and discuss the Fick's law of Diffusion along with the significance of N & J flux.	03
	(b)	Prove that $D_{AB} = D_{BA}$.	04
	(c)	Discuss in brief about choice of separation methods.	07
Q.2	(a)	Derive the relation for steady state diffusion of A through non-diffusing B.	03
	(b)	Ammonia is diffusing through a stagnant gas mixture consisting of 1/3 N_2 and 2/3 H_2 by volume. The total pressure is 206.8 kN/m^2 and temperature 54^0C. Calculate the rate of diffusion of ammonia through a film of gas 0.5 mm thick, when concentration change across the film is 10 % to 5% by volume. The diffusivity of ammonia in gas mixture is 2.45×10^{-5} m^2/s.	04
	(c)	A volatile organic compound C_6H_6 costing Rs. 6/kg is stored in a tank of 10 m. dia. and open at top. A stagnant air film 10 mm thick is covering the surface of the compound beyond which the compound is deficient. If temp. is 25 ^OC and vapor pressure of the compound is 150 mm Hg and diffusivity is 0.02 m^2/hr. calculate the loss in Rs/day.	07
		OR	
	(c)	State the assumptions of film theory and derive the relation for mass transfer coefficient.	07
Q.3	(a)	Derive the relation for two film resistance theory in terms of overall mass transfer coefficient for gas and liquid.	03
	(b)	Write a short note on loading and flooding in packed tower.	04
	(c)	Expound briefly with neat sketch the working of tray tower and the problems associated with its working.	07
		OR	
Q.3	(a)	State the characteristics of ideal solution.	03
	(b)	Discuss the selection criteria for solvent in absorption.	04
	(c)	A coal gas is to be freed of its light oil by scrubbing with wash oil as an absorbent. The circumstances are as follows: Absorber: Gas in 0.250 m^3/s at	07

26°C, Pt = 1.07×10^5 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°C, containing 0.005 mole fraction benzene and has an average molecular weight 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°C. At 26°C, the vapor pressure of benzene is 13330 N/m^2. Compute the oil circulation rate.(Solve analytically)

Q.4 **(a)** State the mixture rule **03**

(b) Write a short not on the system of three liquids-one pair partially soluble in extraction. **04**

(c) State the selection criteria for solvent in extraction. **07**

OR

Q.4 **(a)** Write a short note on heap leaching. **03**

(b) Expound briefly the Shanks system. **04**

(c) A solution of nicotine in water containing 1% nicotine is to be extracted with kerosene at 293 k. Water and kerosene are essentially insoluble. The equilibrium relation is **07**

$$y' = 0.9\,x'$$

Determine the % extraction of nicotine if 100 kg of feed solution is extracted with 150 kg solvent.
Repeat for three theoretical stages using 50 kg solvent each.

Q.5 **(a)** Explain equilibrium diagrams in leaching. **03**

(b) Write in short about preparation of solids in leaching. **04**

(c) State the various leaching equipments and explain the working of Bollman extractor. **07**

OR

Q.5 **(a)** Define super saturation and state the techniques to achieve it. **03**

(b) Explain with neat schematic diagram the working of Oslo Krystal evaporative crystallizer. **04**

(c) Calculate the yield of MgSO4.7H2O crystals when 1000 kg saturated solution of MgSO4 at 353 k is cooled to 303 k assuming 10% of the water is lost by evaporation during cooling. **07**

Data Given:
Solubility of MgSO4 at 353 K = 64.2 kg/100 kg of water.
Solubility of MgSO4 at 303 K = 40.8 kg/100 kg water.

****