Seat No.: ________ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– V (New) EXAMINATION – WINTER 2019

Subject Code: 2150501 **Date: 25/11/2019**

Subject Name: Mass Transfer Operation - 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.**

			MARKS
Q.1	**(a)**	What are the effects of temperature and pressure on diffusivity of gases and liquids? Justify your answer with suitable equations.	**03**
	(b)	Compare Penetration theory with Film theory with reference to molecular diffusion.	**04**
	(c)	A service attendant accidently spills 50 liters of gasoline, which quickly spreads over a level surface of area 8 m^2. Estimate the time required for the gasoline to evaporate into the stagnant air above the surface of the liquid. The diffusivity of gasoline in air is 0.65 $m^2\ h^{-1}$. The air temperature is 298 K. Evaporation may be assumed to take place through a film of air of 2 m thickness. Vapour pressure of gasoline at 298 K is 76 mmHg. The density of gasoline is 720 kg m^{-3} and the molecular weight of gasoline is 200. The operation takes place at 1 atm pressure.	**07**
Q.2	**(a)**	Classify the mass transfer operations based on direct contact of two immiscible phases with examples.	**03**
	(b)	With the help of Fick's law of diffusion prove that $D_{AB} = D_{BA}$.	**04**
	(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°C. 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**
		OR	
	(c)	Oxygen is diffusing through a stagnant layer of methane 5 mm thick. The temperature is 20°C 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 20°C and 100 kN/m^2 is 2.046 x 10^{-5} m^2/s. Calculate: (a) Rate of diffusion of oxygen in kmol/ m^2s. (b) What will be the rate of diffusion if total pressure is raised to 200 kN/m^2, other conditions remaining unaltered?	**07**
Q.3	**(a)**	Compare distillation and liquid-liquid extraction operation.	**03**
	(b)	Establish any two analogies between Mass transfer and Heat transfer operations using dimensionless numbers.	**04**
	(c)	During absorption of carbon tetrachloride from a mixture of air-CCl_4 by an organic oil, the gas and liquid phase mass transfer coefficients have been estimated to be 0.32 and 5.26 kmol/(hr)(m^2)(mol fraction), respectively. The equilibrium relation under the operating conditions is given by $y^* = 20\ x$, where y and x are mole fractions of CCl_4 in gas and liquid phases respectively. Estimate the overall mass transfer coefficients, K_y, and K_x.	**07**

OR

Q.3	**(a)**	Define the terms : Conning, Weeping and Dumping	**03**
	(b)	Name the equipments used in Leaching operation. Discuss any one in brief.	**04**
	(c)	5000 kg/hr of a SO_2-air mixture containing 5% by volume of SO_2 is to be scrubbed with 2,00,000 kg/hr of water in a packed tower. The exit concentration of SO_2 is reduced to 0.15%. The tower operates at 1 atm. The equilibrium relation is given by: Y = 30 X Y = Mole SO_2 / Mole air; X = Mole SO_2 / Mole water If the packed height of tower (Z) is 0.42 m, Calculate the height of transfer unit (HTU).	**07**
Q.4	**(a)**	Mention different types of packings for gas absorption operation and their selection criterion.	**03**
	(b)	Acetic acid can be recovered from its aqueous solution by extraction using suitable organic solvent. Various organic solvents are available in market. Discuss significant criteria for solvent selection.	**04**
	(c)	Deduce the following relationships between overall mass transfer coefficients (represented by K_y and K_x) and individual mass transfer coefficients (represented by k_y and k_x). $\frac{1}{K_y} = \frac{1}{k_y} + \frac{m'}{k_x}$ and $\frac{1}{K_x} = \frac{1}{m''k_y} + \frac{1}{k_x}$	**07**

OR

Q.4	**(a)**	With respect to tray tower discuss the function of following parts. 1) Downspout 2) Weir 3) Demister pad	**03**
	(b)	Deduce equitation of solvent to feed ratio for single stage liquid-liquid extraction.	**04**
	(c)	Explain Meir's super saturation theory of crystallization with neat sketch.	**07**
Q.5	**(a)**	If 100 kg of a solution of acetic acid (C) and water (A) containing 30% acid is to be extracted three times with isopropyl ether (B) at 20°C, using 40 kg of solvent in each stage, determine the quantities and compositions of the various streams. How much solvent would be required if same final raffinate concentration were to be obtained with one stage? Use following equilibrium data.	**14**

Water layer		Isopropyl ether layer	
wt fraction C	wt fraction B	wt fraction C	wt fraction B
0.0069	0.012	0.0018	0.993
0.0289	0.016	0.0079	0.984
0.1330	0.023	0.0482	0.933
0.3670	0.044	0.2160	0.715
0.4640	0.165	0.3620	0.487

OR

Q.5	**(a)**	Outline the industrial applications of leaching.	**03**
	(b)	List and discuss the factors that affect leaching operation.	**04**
	(c)	With a neat sketch explain the working of Swenson Walker Crystallizer.	**07**

****