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

CLASS: B.TECH. **SEMESTER : IV**
BRANCH: CHEM. ENGG. **SESSION : SP/2025**

SUBJECT: CL215 MASS TRANSFER OPERATION-I

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*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Consider loss of ethanol vapor by diffusion from a half-filled open test tube. At what point in the diffusion path will the contribution of bulk flow term to the molar flux will be maximum?	[2]	1	2
Q.1(b)	Water is evaporating from the placid surface of a lake and the vapor (A) diffuses through a stagnant film of air (B) of estimated thickness 3 mm. The water temperature is 25^0C and the air temperature is 27^0C.The relative humidity of air is 65 %. If the diffusivity of water vapor through air is 0.257 cm^2/s at 25 ^{0}C and 0.262 cm^2/s at 27^0C. Calculate the rate of evaporation in kg/m^2s. The saturation vapor pressure of water at 25°C and 27°C are 3.169 kPa and 3.57 kPa, respectively.	[4]	1	3
Q.1(c)	The solute *A* diffuses through the liquid *B* from point 1 to 2, distance l apart. The concentration of the solute at the two points are C_{A1} and C_{A2} respectively. Determine the diffusional flux if the diffusivity of A in B depends upon its concentration in the form $D_{AB} = K_1 + K_2C_A$. Consider both the cases of diffusion of (a) A through non-diffusing B and (b) equimolar counter diffusion of A and B.	[4]	1	3
Q.2(a)	Establish the relation between the mass transfer coefficients k_y and k'_y ?	[3]	2	2
Q.2(b)	Air bubbles of 0.005 m diameter rise through an otherwise stagnant pool of "oxygen-free" water at 30°C. The steady velocity of rise is 0.1m/s. If the diffusivity of O_2 in water at 25°C is 2.1×10^{-9} m^2/s, calculate the liquid side coefficient and the rate of mass transfer from a single bubble. The solubility of O_2 in water at 30°C can be calculated using Henry Law coefficient as 4.75×10^4 atm/mol fraction. The viscosities of water are 0.911 cP and 0.817 cP at 25^0C and 30^0C respectively. The Sherwood number for a sphere at high Reynolds number is given by: $$Sh = 2 + 0.6Re^{1/2}Sc^{1/3}$$	[7]	2	3
Q.3(a)	In the design of a packed absorption tower, how do HTU and NTU influence the overall height of the tower, and what does it imply about the system's mass transfer efficiency if a system has a high NTU but a low HTU?	[3]	3	2
Q.3(b)	Acetone from a mixture with air containing 2 mol % acetone is absorbed counter-currently in water in a plate tower containing 4 theoretical stages. The inlet gas rate is 40 Kmol/h and acetone free water is supplied to the column at a rate of 110 Kmol/h. The equilibrium relation is $y = 2.5x$. Determine the concentration of the solute in the exit liquid analytically as well as graphically.	[7]	3	3
Q.4(a)	Describe the formation of minimum and maximum boiling azeotropes with relevant diagrams and real-world examples.	[4]	4	2
Q.4(b)	A continuous rectification column with a reboiler and a total condenser is to be designed to separate a solution of n-heptane and octane having 70 mol% n-heptane. The overhead and bottom products should contain 95 mol% and 5 mol% n-heptane, respectively. The feed will be liquid at its boiling point and the reflux ratio will be 1.80 times the minimum reflux. The column is to operate at a pressure of 101.33 kN/m^2. Assuming the overall plate efficiency to be 70%, determine the number of plates to be provided in the column.	[6]	4	3

Equilibrium data for the system are as under:

x	0	0.13	0.22	0.32	0.46	0.57	0.69	0.82	0.92	1.0
y*	0	0.24	0.37	0.50	0.65	0.74	0.83	0.91	0.96	1.0

where x and y* are mole fractions of n-heptane in liquid and vapour, respectively.

PTO

Q.5(a)	What are the key components in multicomponent distillation? Describe with example.	[2]	5	2
Q.5(b)	A feed 100 kmoles/h of saturated liquid containing 10 mole % LNK, 55 mole % LK, and 35 mole % HK and is to be separated in a distillation column. The reflux ratio is 1.2 the minimum. It is desired to have 99.5 % recovery of the light key in the distillate. The mole fraction of the light key in the distillate should be 0.75. Equilibrium data: α_{LNK} = 4.0, α_{LK} = 1.0, α_{HK} = 0.75. Find (i) (ii) (iii) (iv) Minimum number of stages required by Fenske method Minimum reflux ratio by Underwood method Number of ideal stages at R = 1.2 R_{min} by Gilliland method Also find the number of ideal stages at rectifying section and the stripping section at the operating reflux ratio and location of feed stage.	[8]	5	4

::::::28/04/2025::::::M

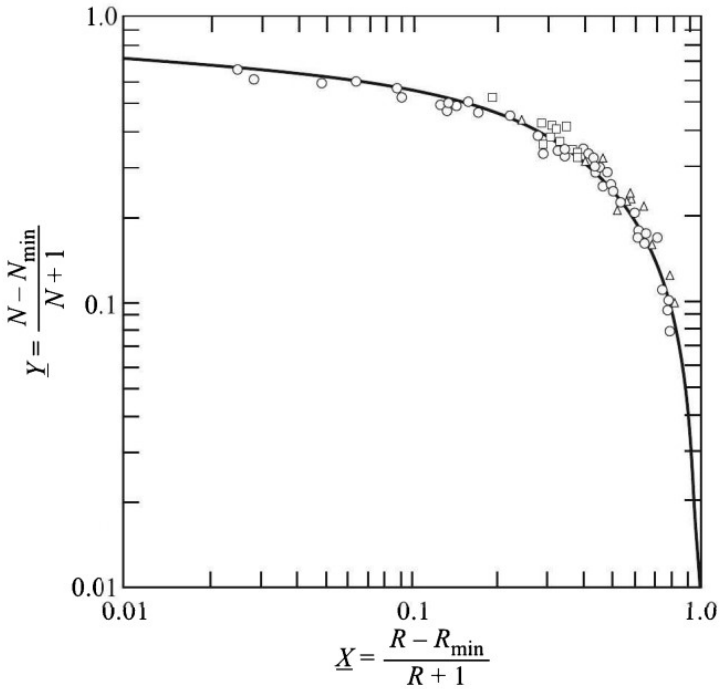

Fig 1: Graph used in Gilliland correlation for total no. of ideal stages