Reg.No:												

VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN
[AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY, CHENNAI]
Elayampalayam - 637205, Tiruchengode, Namakkal Dt., Tamil Nadu.

Question Paper Code: 9010

B.E. / B.Tech. DEGREE END -SEMESTER EXAMINATIONS – MAY / JUNE 2024
Fifth Semester
Biotechnology
U19BT516 – HEAT AND MASS TRANSFER
(Regulation 2019)

Time: 3.00 Hours Maximum: 100 Marks

Answer ALL the questions

Knowledge Levels (KL)	K1 - Remembering	K3 -Applying	K5 - Evaluating
	K2 -Understanding	K4- Analyzing	K6 - Creating

PART – A

(10 x 2 = 20 Marks)

Q.No.	Questions	Marks	KL	CO
1.	State Fourier's law of heat conduction.	2	K1	CO1
2.	Calculate the loss of heat per unit area from steam pipe to the surrounding air by radiation mode. Take emissivity of 0.90. Temperature of Steam pipe = 398K Temperature of Air = 303K	2	K2	CO1
3.	What is effectiveness of a heat exchange?	2	K2	CO2
4.	Write the application of Baffles in Heat exchanger.	2	K2	CO2
5.	Explain the effect of pressure in diffusivity of gases?	2	K3	CO3
6.	How does mass transfer coefficient vary with D_{AB} in film theory and penetration theory?	2	K3	CO3
7	Write a note on flooding in packed towers.	2	K2	CO4
8.	What do you mean by HETP? State the factors on HETP depends.	2	K1	CO4
9.	State Rayleigh's equation.	2	K2	CO5
10.	How is the slope of the feed line estimated in distillation?	2	K2	CO5

PART – B

(5 x 13 = 65 Marks)

Q.No.			Questions	Marks	KL	CO
11.	a)	i.	What do you many by thermal conductivity? Write a brief note on its variation with temperature.	7	K2	CO1
		ii.	Derive the expression for heat transfer through cylinder. Assume k_1, k_2, k_3 be the thermal Conductivities of materials and x_1, x_2 and x_3 be the respective thickness. Assume hot face and cold face temperature be T_1 and T_2 respectively.	6		
			(OR)			
	b)		Calculate the critical radius of insulation for asbestos [k=0.17W/m^{2}K] surrounding a pipe and exposed to room air at 298K with h=3.0 W/m^{2}K. Calculate the heat loss from a 473 K (200 degree centigrade) 50 mm diameter pipe when covered with the critical radius of insulation and without insulation. Would any fiber glass insulation having thermal conductivity of 0.04 W/Mk cause decrease in heat transfer.	13	K3	CO1
12.	a)	i.	Explain briefly about Boiling and Condensation processes.	5	K2	CO2
		ii.	A shell and tube heat exchanger is to be provided with tubes of 31 mm O.D 27 mm, I.D 4 m long. It is required for heating water from 295 K to 318 K with the help of condensing steam at 393 K on the outside of the tubes. Determine the number of tubes required if water flow rate is 10 kg/s. Heat transfer coefficient on the steam side and water side are 6000 W/(m^2.K) and 850 W/m^{2}K respectively.	8		
			(OR)			
	b)		A solution containing 10% solids is to be concentrated to a level of 50% solids. Steam is available at a pressure of 0.20 MPa saturation temperature of 393K. Feed rate to the evaporator is 30000 kg/hr. The evaporator is working at reduced pressure such that boiling point is 323K. The overall heat transfer coefficient is 2.9kW/m^{2}K. Estimate steam Economy and heat transfer surface for: i. Feed introduced at 293 K ii. Feed introduced at 308 K Data: Specific heat of feed = 3.98 kJ/(kg. K) Latent heat of condensation of steam at 0.20 Mpa = 2202kJ/kg Latent heat of vaporization of water at 323 K = 2383kJ/kg.	13	K2	CO2
13.	a)	i.	Show that for equimolar counter diffusion, $D_{AB} = D_{BA}$.	5	K3	CO3
		ii.	Give the mathematical expression for analogy between heat, mass and momentum transport for laminar and turbulent flow. Write the meaning of each term.	8		
			(OR)			

	b)	i.	Explain the theories used to determine the mass transfer coefficient.	5	K3	CO3
		ii.	Ammonia is diffusing through a stagnant mixture consisting of one third Nitrogen and two-thirds Hydrogen by volume. The total pressure is 1 atm and the temperature is 200°C. Calculate the rate of diffusion of ammonia through a film of gas 0.5 mm thick, when ammonia concentration changes across the film is 12% and 7% by volume. The diffusivities at 200°C and 1 atm pressure are D_{AB} = 5.391 X 10^{-5} m^2/s and D_{BC} = 1.737 X 10^{-4} m^2/s.	8		
14.	a)	i.	Benzene is to be recovered from a cool gas by scrubbing it with wash oil as an absorbent. 855 m^3 of coal gas containing 2% by volume of benzene are to be handled per hour and a 95% removal is required. The operating temperature and pressure are 299.7 K and 106.658 kPa. The wash oil has an average molecular weight of 260 and contains 0.005 mole fraction benzene as it enters the absorber. Calculate the minimum oil circulation rate. Equilibrium Data is given by = Y/1+Y = 0.125 X/1+X	8	K3	CO4
		ii.	Explain in detail about choice of solvent used for absorption and absorption with chemical reaction.	5		
			(OR)			
	b)	i.	Explain briefly hydrodynamics/ pressure drop characteristics of packed columns.	5	K3	CO4
		ii.	A mixture of acetone vapour and air containing 5% by volume of acetone is to be freed of its acetone content by scrubbing it with water in a packed bed absorber. The flow rate of the gas mixture 700 m^3/hr. of acetone free air measured at N.T.P and that of water is 1500kg/hr. The absorber operates at an average temperature of 293K and pressure of 101 kPa. The scrubber absorbs 98% of the acetone. The equilibrium relationship for the acetone vapour -water system is given by -Y =1.68X where Y*= kg mole acetone/kg mole dry air X = kg mole acetone/kg mole water. Calculate the mean driving force and estimate the number of transfer units (NTU) and height of column required if height of transfer unit (HTU) is 2 meters.	8		
15.	a)	i.	Explain the process of Azeotropic distillation	5	K4	CO5
		ii.	Draw the X-Y Plot and show on it the operating lines in case of flash distillation for f = 0 f = 1 and 0 < f < 1.0	8		
			(OR)			

b) A mixture of benzene and toluene containing 60 moles % benzene is to be separated to give product of 95 mole % benzene and bottom product containing 10 moles % benzene. The feed enters a column at its bubble point. It is proposed to operate the column with reflux ration of 2.5. It is required to find the number of theoretical plates needed and position of feed plate. The vapor liquid equilibrium data are given below. — 13 — K4 — CO5

x	0	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
y	0	0.13	0.21	0.375	0.5	0.6	0.7	0.77	0.83	0.9	0.95	1.0

PART – C

(1 x 15 = 15 Marks)

Q. No			Questions	Mark	KL	CO
16.	a)	i.	Calculate the heat transfer area of 1-2 heat exchangers from the following data: Inlet and outlet temperatures of hot fluid are 423K and 353 K respectively. Over all heat transfer coefficient = 4100 W/(m^2K) Heat Loss: 407kW L.M.T.D correction factor = 0.84	7	K3	CO2
		ii.	An oil is cooled from 353K to 313 K in oil cooler. The inlet temperature of water is 303 K. Calculate the temperature of cooling water leaving the cooler and logarithmic mean temperature difference assuming flow to be counter current, if the mass flow rate of oil and water are 1.4kg/s and 2.9kg/s respectively. Cp for oil = 2.135kJ/kg.K Cp for water = 4.187 kJ/kg.K	8		
			(OR)			
	b)	i.	The vapor pressures of A and B are 200 mm Hg and 400 mm Hg. The total pressure is 760 mm Hg. Estimate the relative volatility?	5	K4	CO5
		ii.	A feed mixture of A and B (45 moles %A and 55 mol % B) is to be separated into a top product containing 96 mol %A and bottom product having 95 mol % B. The feed is 50% vapour and reflux ratio is 1.5 times the minimum. Determine the number of ideal trays required and the location of feed tray. Given $\alpha_{AB} = 2.8$.	10		