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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

07 THRISSUR CLUSTER

SECOND SEMESTER M.TECH. DEGREE EXAMINATION APRIL 2018

Chemical Engineering

Process Control

07CH6106 ADVANCED HEAT AND MASS TRANSFER

Time:3 hours **Max.Marks: 60**

Answer all six questions. Part 'a' of each question is compulsory.

Answer either part 'b' or part 'c' of each question

(*Use of standard heat and mass transfer data book may be permitted*)

Q.no.	Module 1	Marks
1a	Explain thermal conductivity. Comment on the variation of thermal conductivity of solids, liquids and gases with temperature.	4
	Answer b or c	
b	Obtain the expression for temperature distribution and rate of heat transferred for radial conduction in a hollow cylinder of length L and having inner and outer radii r_i and r_o respectively. Let the temperatures at the inner and outer surfaces of the cylinder be T_i and T_o respectively. Assume steady state conduction without generation of heat.	5
c	A furnace wall is composed of three layers, 10cm of firebrick (k=1.560 W/mK), followed by 23 cm of kaolin insulating brick (k = 0.073W/mK), and finally 5 cm of masonry brick (k = 1.0 W/mK). The temperature at the inner wall surface is 1370 K and the outer surface is at 360 K. What are the temperatures at the contacting surfaces?	5

Q.no.	Module 2	Marks
2a	Describe the use of Heisler Charts	4
	Answer b or c	
b	Derive the expressions for temperature distribution and rate of heat flow in a rectangular long fin of uniform cross section	5
c	It is known that oranges can be exposed to freezing temperatures for short periods of time without sustaining serious damage. Consider a 0.10 m diameter orange, originally at a uniform temperature of 5 ^{0}C, suddenly exposed to surrounding air at -5 ^{0}C. For a surface coefficient between the air and orange surface, of 15 W/m^2 K, how long will it take for the surface of the	5

orange to reach 0 ^{0}C?

Properties of orange are the following

Density = 940 kg/m^3

Thermal conductivity = 0.47 W/mK

Specific heat = 3.8 kJ/kg.K

Q.no.	Module 3	Marks
3a	Explain thermal boundary layer.	4
	Answer b or c	
b	Discuss the exact analysis of laminar boundary layer over a flat plate	5
c	The velocity and temperature distributions in a pipeline are known to be of the form $u(r) = C_1 r + C_2 r^2$ $T(r) = C_3 + C_4 r + C_5 r^2$ where C_1, C_2, C_3, C_4 and C_5 are constants. Obtain an expression for bulk mean temperature.	5

Q.no.	Module 4	Marks
4a	Compare the effect of temperature and pressure on diffusivity of gases and liquids citing appropriate equations.	4
	Answer b or c	
b	Derive expressions for flux in unimolecular diffusion and equimolal counter diffusion for a binary system.	5
c	Derive species continuity equation for a binary system with constant ρD_{AB}.	5

Q.no.	Module 5	Marks
5a	Define the following dimensionless parameters and discuss their physical significance i. Reynolds number ii. Shmidt number iii. Sherwood number iv. Lewis number v. Stanton Number for mass transfer	5
	Answer b or c	
b	A gas stream at 98 kPa and 300 K is flowing with a velocity of 18 m/sec on the top surface of a thin flat sheet of volatile solid of length 0.5 m, whose mass diffusivity in the gas is 5.98 x 10^{-6} m^2/s. Kinematic diffusivity of the gas is 3 x 10^{-5} m^2/s. If concentration of the diffusing species at the gas-solid interface is 9 x10^{-6} kmol/m^3, calculate the mass transfer coefficient over the flat plate.	7

c	Obtain rate equation for diffusion and reaction taking place in a spherical pellet.	**7**

Q.no.	**Module 6**	**Marks**
6a	Explain the boundary layer theory of mass transfer	**5**
	Answer b or c	
b	State the two resistance theory of interphase mass transfer. Obtain the relation between overall gas phase mass transfer coefficient and individual film mass transfer coefficients.	**7**
c	A packed tower has been designed to strip component A from an aqueous stream into a counter-flowing air stream. At a given plane in the tower, the concentrations of the two adjacent streams are $p_{A,G}$ = 4 x 10^3 Pa and $C_{A,L}$= 4 kgmol/m^3 of solution. Under the given flow conditions, the overall gas mass-transfer coefficient, K_G is equal to 2.46 x 10^{-8} kgmol/m^2.s.Pa and 60% of the resistance to mass transfer is encountered in the gas phase. At the tower's operating condition of 290 K and 101.3 kPa, the system satisfies Henry's law with a Henry's law constant of 1400 Pa/(kgmol/m^3). Determine a) the individual gas-film coefficient k_G; b) the individual liquid-film coefficient k_L; c) the interfacial gas concentration p_{AL} and d) the overall liquid mass-transfer coefficient K_L.	**7**