Name :
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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	Derive the general three dimensional heat conduction equation in Cartesian coordinates and write down its special forms	**4**
	Answer b or c	
b	A hollow sphere of pure iron contains a liquid chemical mixture which releases 30 kW of energy. The I.D and O.D of the sphere are 15 cm and 30 cm respectively. If the outside surface temperature of the sphere is 40^0 C, determine the temperature at a location 2.5 cm from the outer surface. Take k = 70 W/mK.	**5**
c	Derive the expression for temperature distribution and rate of heat transferred through a plane wall of thickness 2L with internal generation q° W/m^3. Assume one dimensional steady state conduction.	**5**

Q.no.	**Module 2**	**Marks**
2a	What are Biot and Fourier numbers. Explain their physical significance.	**4**
	Answer b or c	
b	An aluminium fin (k= 200 W/mK) 3 mm thick and 7.5 cm long protrudes from a wall at 300 ^{0}C. The ambient temperature is 50 ^{0}C with h= 10 W/m^2 K. Compute the heat loss from the fin. Also calculate its efficiency.	**5**
c	Describe lumped heat capacity analysis. Obtain the expression for temperature distribution for a solid initially at a temperature T_0, which is suddenly placed in a convective atmosphere of Temperature T_{∞}, using lumped capacity analysis.	**5**

Q.no.	Module 3	Marks
3a	Explain the development of hydrodynamic and thermal boundary layer for laminar flow over a flat plate	**4**
	Answer b or c	
b	Air at 27^0 C flows over a flat plate at a velocity of 2 m/s. The plate is heated over its entire length to a temperature of 60 ^{0} C. Calculate the heat transfer for the first 20 cms of the plate. The properties of air at 43.5 ^{0} C are kinematic viscosity = 17.36 x 10 $^{-6}$ m^2/s, thermal conductivity = 0.0275 W/mK., Prandtl No. = 0.7 and specific heat capacity = 1.006kJ/kg ^{0} C	**5**
c	Explain heat transfer in fluidized beds.	**5**

Q.no.	Module 4	Marks
4a	Explain different types of fluxes used in molecular diffusion.	**4**
	Answer b or c	
b	For the diffusion of A through a binary mixture of components A and B derive the following relations, stating the assumptions made: $n_A = -D_{AB}\nabla\rho_A + w_A(n_A + n_B)$	**5**
c	Using equations of change, derive Fick's second law of diffusion for a multi-component system.	**5**

Q.no.	Module 5	Marks
5a	Define effectiveness factor and explain its significance.	**5**
	Answer b or c	
b	Linton and Sherwood conducted experiments on the dissolving of cast tubes of cinnamic acid (A) into water (B) flowing through the tubes in turbulent flow. In one run, with a tube of 5.23 cm internal diameter, Re = 35800 and Sc = 1450, they measured a Stanton number for mass transfer, St_D, of 0.0000351. Compare this experimental value with predictions by the Reynolds and Chilton-Colburn analogies. The following correlation may be used for Fanning friction factor $f = 0.00140 + 0.125(Re)^{-0.32}$	**7**
c	Species A undergoes the irreversible chemical reaction A $\rightarrow$ C while diffusing through a homogeneous phase B. Assuming concentration of A to be very low in the mixture with B, obtain expression for steady state concentration profile of A. Choose appropriate boundary conditions.	**7**

Q.no.	Module 6	Marks
6a	Overall resistance to mass transfer in a typical experiment is observed to be a strong function of temperature. Is mass transfer in this case gas phase controlled or liquid phase controlled? Explain.	**5**
	Answer b or c	
b	Compare film theory and penetration theory of interphase mass transfer, listing the assumptions involved, advantages and limitations.	**7**
c	For a system in which component A is transferring from the gas phase to the liquid phase, the equilibrium relation is given by $P_{A,i} = 0.8X_{Ai}$ where $P_{A,i}$ is the equilibrium partial pressure in atm. and $X_{A,i}$ is the equilibrium liquid concentration in mole fraction. At one point in the apparatus, the liquid stream contains 4.5 mole % and the gas stream contains 9.0 mole % A. The total pressure is 1 atm. The individual gas-film coefficient at this point is $k_G = 3.0$ mole/m^2-s-atm. Fifty per cent of the overall resistance to mass transfer is known to be encountered in the gas phase. Evaluate i) The overall mass-transfer coefficient and individual liquid-film coefficient ii) The molar flux of A iv) The interfacial concentrations of A.	**7**