Name:
Reg No: C

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
07 THRISSUR CLUSTER
SECOND SEMESTER M.TECH. DEGREE EXAMINATION APRIL 2017

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 expression for the temperature profile and heat flux for a cylindrical shell with and without internal generation of heat	**4**
	Answer b or c	
b	A 150 mm thick rectangular concrete roof of a room is made up of concrete ($k=0.68W/m^oC$) and horizontal steel rods of 20mm diameter spaced 100mm between centres ($k=24W/m^oC$). The outer and inner roof surface temperatures are 5^oC and 23^oC respectively. Find the overall thermal resistance heat flux through the roof.	**5**
c	An orange of 60mm diameter produces heat at the rate of 32 W/m^3 while ripening. Estimate the maximum temperature at the core of orange if the skin is at 20^oC. Thermal conductivity of orange is 0.48W/mK	**5**

Q.no.	Module 2	Marks
2a	Derive the expression for the temperature profile and heat flux for a fin of uniform cross sectional area insulated at the end.	**4**
	Answer b or c	
b	A cylindrical horizontal electric heater rod dissipating heat is used to heat water at 25^oC in a water bath. The diameter of the rod is 5mm and length is 60cm. Find out the maximum heat dissipation rate from the heater, if the heater surface temperature is not to exceed 95^oC. Properties of water at 60^oC are: Thermal conductivity = 0.72W/m.K Density = 972 kg/m^3 Specific heat capacity = 4170J/kg.K Viscosity = $0.48x10^{-3}$ kg/m.s	**5**
c	Calculate the percentage increase in heat transfer, when straight rectangular fins are	**5**

added to steam contact surface of a plate in a plate exchanger used for heating water. The fins are 1.2 mm thick, 10 mm long and spaced 5 mm apart. The convective coefficients for steam and water are 32 W/m^2K and 260 W/m^2K respectively. Fin efficiency for steam side is 0.87

Q.no.	Module 3	Marks
3a	Discuss the heat transfer phenomena in packed and fluidised beds	**4**
	Answer b or c	
b	Derive the correlation for convective heat transfer coefficient by approximate integral analysis of boundary layer	**5**
c	Air at 20^oC with a uniform free stream velocity of 12m/s is moving parallel to a smooth flat plate heated to a uniform surface temperature of 100^oC. Find the length of laminar boundary layer on the plate (critical Reynolds number is $5x10^5$), the thickness of the hydrodynamic and thermal boundary layers at the critical length and the mean heat transfer coefficient over the portion of the plate covered by the laminar boundary layer. Properties of air at average temperature 60^oC are: Thermal conductivity = 0.03W/m.K Density = 1.07 kg/m^3 Specific heat capacity = 1.01J/kg.K Viscosity = $18x10^{-6}$ kg/m.s	**5**

Q.no.	Module 4	Marks
4a	Write down the characteristics of diffusivity of solids.	**4**
	Answer b or c	
b	State and explain different types of mass transfer fluxes. Derive the relation between N_A and J_A in a binary mixture of A and B.	**5**
c	Derive species continuity equation for a binary System. State the assumptions clearly.	**5**

Q.no.	Module 5	Marks
5a	Define Thiele modulus and discuss its significance.	**5**
	Answer b or c	
b	Derive Chilton and Colburn analogy of heat and mass transfer.	**7**
c	Derive rate expression for diffusion with simultaneous first-order irreversible homogeneous reaction.	**7**

Q.no.	Module 6	Marks
6a	Obtain the relation between overall mass transfer coefficient K_G and the individual film mass transfer coefficients in case of mass transfer between gas and liquid phases.	**5**
	Answer b or c	
b	Explain the boundary layer theory of mass transfer.	**7**

c Dry Air is passed across a flat surface at 300K and 100 kPa. The surface is covered with a thin film of an organic liquid which gets evaporated into the air stream. The mass transfer coefficient k'_y is estimated to be 1.2×10^{-5} kmol/m^2s. Assuming unidiffusion, determine **7**

a. The mass transfer coefficient k_y.

b. The rate of vapourisation of the liquid if the vapour pressure is 10 kPa at 300 K.