Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), MAY 2019

Course Code: CH202

Course Name: PROCESS HEAT TRANSFER (CH)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two questions. Each question carries 15 marks.

1	a)	Derive the general heat conduction equation in cartesian coordinates.	7
	b)	Derive the equation for temperature profile for a lumped capacity system.	8
2	a)	A steel pipe 25 mm internal diameter and 33 mm outer diameter and insulated with rockwool carries steam at 451 K. If the surrounding air temperature is 294 K, calculate the rate of heat loss from one metre length of pipe. The thickness of insulation is 38 mm. Thermal conductivities of steel and rockwool are 44.97 W/m K and 0.175 W/m K respectively. The inside and outside heat transfer coefficients are 5678 W/m^2 K and 11.36 W/m^2 K respectively.	8
	b)	Derive critical radius of insulation for a cylinder.	7
3	a)	Derive the equation for temperature profile and heat flux for a solid cylinder with internal generation.	6
	b)	Explain the concept of thermal conductivity. Derive the equation for heat flux for a plane rectangular wall without internal generation.	3
	c)	A steel ball of 5 cm diameter at 200 ^oC is suddenly placed in a controlled environment maintained at 100 ^oC. How much time is required for the ball to attain a temperature of 150 ^oC. Given C_p = 450 J/kg K, k = 35 W/m K, h = 10 W/m^2 K, ρ = 8000 kg/m^3. Internal resistance can be neglected.	6

PART B

Answer any two questions. Each question carries 15 marks

4	a)	Using Buckingham's pi method, derive the relation between various dimensional groups in forced convection.	8
	b)	Water at 303 K enters a 25 mm I.D tube at a rate of 1200 l/h. Steam condenses on the outside surface of tube of 28 mm O.D at a temperature of 393 K and its film heat transfer coefficient may be taken as 6000 W/m^2 K. Estimate the length of the	7

tube required to heat water to 343 K. Data : k for tube wall = 348.9 W/m K, properties of water at mean temperature of 323 K are : k = 0.628 W/m K, ρ = 980 kg/m^3, μ = 6×10^{-4} kg/ms, Cp = 4.187 kJ/kg K.

5 a) Calculate the heat transfer coefficient for a fluid flowing through a tube having inside diameter 40 mm at a rate of 5500 kg/h. Assume that the fluid is being heated. Properties of the fluid at mean bulk temperature are : μ = 0.004 kg/ms, ρ = 1.07 g/cc, C_p = 2.72 kJ/ kg K, k = 0.256 W/m K. 7

b) Derive the expression for heat transfer rate by radiation for two infinitely long parallel planes whose temperatures are T_1 and T_2, emissivities are ε_1 and ε_2 respectively. Also determine the reduction in heat transfer rate when radiation shield of temperature T_3 and emissivity ε_3 is placed between two planes. 8

6 a) With a neat sketch draw the natural convection flow patterns for a i) cold vertical plate ii) horizontal plate with heated surface facing upwards iii) horizontal plate with heated surface facing downwards. 6

b) Two large parallel plates, one at 727 ^oC with emissivity ε_1=0.8 and other at 227 ^oC with emissivity ε_2= 0.4. An aluminium radiation shield with an emissivity ε_3=0.05 on both sides is placed between the plates. Calculate the % reduction in heat transfer rate between the two plates as a result of the shield. Use σ=5.67×10^{-8} W/m^2 K. 5

c) What are the advantages of a multipass heat exchanger over a single pass heat exchanger? Draw the temperature profile for a 1-2 exchanger. 4

PART C

Answer any two questions. Each question carries 20 marks.

7 a) With a neat sketch explain the working of a short tube vertical evaporator. 8

b) Derive Nusselt equation for film condensation over a vertical surface. 12

8 a) With neat sketches explain the various methods of feeding in multiple effect evaporators. 8

b) Derive the equation for temperature distribution and heat flux for infinitely long fin of uniform cross section. 10

c) Differentiate between dropwise and filmwise condensation. 2

9 a) A single effect evaporator is fed with 5000 kg/h of solution containing 1 % solute by weight. The feed temperature is 303 K. It is to be concentrated to 2 % solute by weight. The evaporation is carried out at atmospheric pressure (101.325 kPa) and 10

the area of the evaporator is 69 m^2. Saturated steam is supplied at 143.3 kPa as a heating medium. Calculate the steam economy and the overall heat transfer coefficient.

Data : Enthalpy of feed at 303 K = 125 .79 kJ/kg

Enthalpy of vapour at 101.325 kPa = 2676.1 kJ/kg

Enthalpy of saturated steam at 143.3 kPa = 2691.5 kJ/kg

Saturation temperature of steam = 383 K

Boiling point of saturation = 373 K

Enthalpy of product = 419.04 kJ/kg

Enthalpy of saturated water at 383 K = 461.30 kJ/kg

b) Explain with neat figure the various regimes of pool boiling. 10