Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(S), DECEMBER 2019

Course Code: ME302

Course Name: Heat and Mass Transfer

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks. Marks

1 a) Write down the general heat conduction equation in Cartesian coordinates. Reduce the equation for steady state one dimensional heat conduction across a plane wall with internal heat generation (3)

b) With proper figures, derive an equation for steady state temperature distribution across a plane wall with internal heat generation. Both the surfaces have unequal temperatures ($T_1 and\ T_2$) and subjected to convection heat transfer. The surface heat transfer coefficient is h and fluid temperature is T_∞. (7)

2 a) Derive an equation for the thermal resistance across a hollow sphere (4)

b) A hollow sphere of inside radius 3 cm and outside radius 5 cm is electrically heated at the inner surface at constant rate of 10^5 W/m^2. At the outer surface it dissipates heat by convection into a fluid at temperature 100°C with heat transfer coefficient 400W/m^{2}K. The thermal conductivity of the material of sphere is 15W/mK. Determine inner and outer surface temperatures. (6)

3 a) Explain Hydrodynamic Boundary Layer for flow over a flat plate (3)

b) Air at pressure of 1 atm and temperature 60°C flows over a flat plate which maintains a surface temperature of 100°C. The plate has a length of 0.2m (in the flow direction) and width of 0.1m. The Reynolds number based on the plate length is 40000. What is the rate of heat transfer from plate to air? If the free stream velocity of air is doubled and the pressure is increased to 2.5 atm, what is the rate of heat transfer? (7)

4 a) Explain the physical significance of Prandtl No. and Nusselt No. (4)

b) Atmospheric air at 25°C and velocity of 0.5m/s flows over a 50W incandescent bulb whose surface temperature is maintained at 140°C. The bulb may be approximated as a sphere of 50 mm diameter. What is the rate of heat loss by convection to air? (6)

PART B

Answer any three full questions, each carries 10 marks.

5	a)	Explain Lumped system analysis	(4)
	b)	The temperature of a gas stream is measured with a thermocouple. The junction may be approximated as a sphere of diameter 1 mm, thermal conductivity 25W/mK, density 8400kg/m^3, specific heat 400J/kgK. The heat transfer coefficient between the junction and the gas stream is 560 W/m^{2}K. How long will it take for the thermocouple to record 99% of the applied temperature difference?	(6)
6		Aluminium fins of triangular profile are connected to a plane wall whose temperature is 250^{o}C. The fin base thickness is 2 mm and length is 6 mm. The system is in ambient air at a temperature of 20^{o}C and surface convection coefficient is 40W/m^{2}K. What are the fin efficiency and effectiveness? What is the heat dissipated per unit width by a single fin? Properties may be evaluated at base temperature.	(10)
7	a)	Explain the effectiveness of a heat exchanger	(3)
	b)	A shell and tube steam condenser is to be constructed of 2.5 cm outer diameter and 2.2 cm inner diameter single pass horizontal tubes with steam condensing at 54^{o}C outside the tubes. The cooling water enters each tube at 18^{o}C with a flow rate of 0.7 kg/s and leaves at 36^{o}C. The heat transfer coefficient for the condensation of steam is 8000W/m^{2}K. Calculate the tube length neglecting wall thermal resistance.	(7)
8	a)	Illustrate with sketches, the temperature profiles for hot and cold fluids as a function of distance along the flow path for a counter flow heat exchanger with $C_h<C_c$, $C_h=C_c$, $C_h>C_c$. C_h and C_c represent the heat capacities of hot and cold fluid respectively.	(3)
	b)	Derive an equation for the effectiveness (ε) of a concentric tube counter flow heat exchanger in terms of NTU and Capacity Ratio (C)	(7)

PART C

Answer any four full questions, each carries 10 marks.

9	a)	Explain the terms-Radiation intensity, Emissive power, Radiosity	(5)
	b)	What is Wein's Displacement Law? Explain with the help of Planks distribution	(5)
10		With proper figures, derive an equation for view factor of two arbitrarily oriented surfaces and arrive at the reciprocity relation	(10)
11	a)	What is a diffuse emitter? For such an emitter, how is the intensity related to the	(3)

total emissive power?

b) Calculate the radiation exchange per unit area between two parallel plates of temperature 400^oC and 25^oC. Emissivities of hot and cold plates are 0.9 and 0.7 respectively. Find the percentage reduction in heat transfer of a radiation shield of emissivity 0.25 is placed in between the plates (7)

12 a) Discuss Fick's Law of diffusion (4)

b) Nitrogen gas is maintained at 3.5 bar and 1 bar on opposite sides of a rubber membrane which is 0.25 mm thick. The system temperature is 25^oC. What is the molar diffusive flux of nitrogen through the membrane? (6)

13 a) Discuss Schmidt No, Lewis No and Sherwood No (5)

b) Explain steady state equimolar counter diffusion in liquids (5)

14 Air at 1 atm and 30^oC flows over a vessel full of water at velocity 4m/s. The partial pressure of water vapour present is 0.0070 bar. If water surface is at temperature of 15^oC, calculate the evaporation rate of water. Take Diffusion coefficient as $25.83 \times 10^{-6} m^2/s$. Saturation pressure of water at 15^oC is 0.017 bar. (10)

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SIXTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), MAY 2019

Course Code: ME302

Course Name: Heat and Mass Transfer

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks. Marks

1	a)	What are the mechanisms of heat transfer? How are they distinguished from each other?	(5)
	b)	A hollow sphere (k = 65 W/mK) of 120 mm inner diameter and 350 mm outer diameter is covered 10 mm layer of insulation (k =10 W/mK). The inside and outside temperatures are 500°C and 50°C respectively. Calculate the rate of heat flow through this sphere.	(5)
2	a)	Derive the general heat conduction equation in Cartesian coordinates	(10)
3	a)	Explain velocity boundary layer and thermal boundary layer with neat sketches.	(5)
	b)	Discuss the significance Nusselt number and Prandtl number in convection	(5)
4		Air at 20°C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. If the plate is 1 m wide and at 80°C, calculate the following at x = 300 mm. i. Hydrodynamic boundary layer thickness ii. Thermal boundary layer thickness iii. Local friction coefficient iv. Average heat transfer coefficient v. Heat transfer rate	(10)

PART B

Answer any three full questions, each carries 10 marks.

5		An aluminium alloy fin (k = 200 W/mK) of 1 m width, 3.5 mm thick, and 2.5 cm long protrudes from a wall. The base is at 420°C, the ambient air temperature is 30°C and the heat transfer coefficient is 11 $W/m^2.K$. Find the rate of heat loss and fin efficiency, if the fin tip is insulated.	(10)
6		Derive equations of temperature distribution and heat dissipation for an infinitely long fin	(10)
7		Derive an expression for Log Mean Temperature Difference in the case of a counter flow heat exchanger.	(10)
8		In a double pipe heat exchanger hot water flows at a rate of 14 kg/s and gets	(10)

cooled from 370K to 340K. At the same time 14 kg/s of cooling water at 303K enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270 W/m^2 K. Determine the effectiveness and the heat transfer area required, assuming two streams are in parallel flow. Assume the specific heat for the both the streams = 4.2 kJ/kg K.

PART C

Answer any four full questions, each carries 10 marks.

9 a) Define Irradiation and Radiosity for a grey body. (3)

b) State and Explain Wein's displacement law (3)

c) Distinguish between a black body and gray body (4)

10 Derive the following relation for the radiant heat exchange between two gray surfaces (10)

$$(Q_{12})_{net} = \frac{A_1\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1} + \frac{1}{\bar{F}_{1-2}} + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2}}$$

11 Calculate the heat exchange by radiation between the surfaces of two long cylinders having radii 120 mm and 60 mm respectively. The axes of the cylinders are parallel to each other. The inner cylinder is maintained at a temperature of 130°C and emissivity of 0.6. Outer cylinder is maintained at a temperature of 30°C and emissivity of 0.5. (10)

12 a) State and explain the governing law for Diffusion mass transfer? (4)

b) Discuss the analogy between heat transfer and mass transfer (6)

13 a) What are the different modes of mass transfer, give examples for each (6)

b) Explain the phenomenon of equimolar counter diffusion with an example (4)

14 a) Define and explain the physical significance of (4)

i) Schmidt number

ii) Sherwood number

b) Dry air at 30^{0}C and 1 atm flows over a wet flat plate 600 mm long at a velocity of 50 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion co-efficient of water vapour in air, (6)

D = 0.26 x 10^{-4} m^2/s

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