

Reg No.: _____

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth semester B.Tech examinations (S), September 2020

Course Code: ME302**Course Name: Heat and Mass Transfer***Use of heat and mass transfer data book permitted*

Max. Marks: 100

Duration: 3 Hours

PART A*Answer any three full questions, each carries 10 marks.*

Marks

- 1 a) Derive the expression for critical thickness of a cylinder. What is the importance of critical thickness of insulation? (4)
- b) A hollow sphere of inner radius 30 mm and outside radius 50 mm is electrically heated at its inner surface at a constant rate of 10^5 W/m^2 . The outer surface is exposed to a fluid at 30°C with $h = 170 \text{ W/m}^2\text{K}$. Thermal conductivity of the material is 20 W/m K . Calculate the inner and outer surface temperatures. (6)
- 2 a) Air at velocity of 3m/s and at 20°C flows over a flat plate along the length. The length, width and thickness of the plate are 100cm , 50cm , 2cm respectively. The top surface of the plate is maintained at 100°C . Calculate the heat lost by the plate and temperature at bottom surface of the plate for steady state conditions. Thermal conductivity of plate material is 23 W/mK . (5)
- b) A vertical plate 15cm high and 10cm wide is maintained at 140°C . Calculate the maximum heat dissipation rate from both sides of the plate in ambient air at 20°C by free convection (5)
- 3 a) Derive the general heat conduction equation in Cartesian coordinates, state the assumptions. (8)
- b) Good electrical conductors usually have the property of high thermal conductivity. Why? (2)
- 4 a) Using Buckingham pi theorem derive the expression for flow through a tube under forced convection. Make suitable assumptions (7)
- b) Explain the importance of hydrodynamic and thermal boundary layers in heat transfer. (3)

PART B

Answer any three full questions, each carries 10 marks.

- 5 a) An aluminium sphere weighing 6kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with $h = 60 \text{ W/m}^2 \text{ C}$. Estimate the time required to cool the sphere to 100°C. (7)
- b) Define fin efficiency and effectiveness (3)
- 6 a) Explain the features of pool boiling process with the curve (5)
- b) Derive an expression for heat flow from a fin with tip insulated (derivation may start from solution of general fin differential equation, $\theta = C_1 e^{mx} + C_2 e^{-mx}$, with clear statement of boundary conditions) (5)
- 7 a) Classify heat exchangers based on flow direction .Explain why a counter flow is superior arrangement. When do we use specifically use parallel flow heat exchangers? (3)
- b) Derive the expression for LMTD of a parallel flow heat exchanger (7)
- 8 The following are the details of a parallel flow heat exchanger - Heat capacity of cold flow entering at 40°C = 20000 W/K, Heat capacity of hot flow entering at 150°C = 10000 W/K, $A = 30 \text{ m}^2$, $U = 500 \text{ W/m}^2 \text{ K}$. Determine heat transfer rate and exit temperatures (10)

PART C

Answer any four full questions, each carries 10 marks.

- 9 a) State and prove Kirchoff's law of radiation (3)
- b) Two black discs of diameter 50 cm each are placed parallel to each other concentrically at a distance of 1m. Disc temperatures are 727°C and 227°C . Calculate the heat transfer between discs if no other surface is present in between. (7)
- 10 a) What are radiation shields? Mention some of their applications (2)
- b) Two concentric cylinders have inner and outer radius with 5cm and 10cm and length 20cm. Calculate the view factors (8)
- 11 Determine the heat lost by radiation per meter length of 80mm diameter pipe at 300°C, if (i) Located in a large room with red brick walls at temperature of 27°C (ii) Enclosed in a 160 mm diameter red brick conduit at a temperature of 27°C. Emissivities of pipe material and brick 0.79 and 0.93 respectively (10)
- 12 a) State Fick's law of mass diffusion, explaining all the terms (3)
- b) Air at atm temperature 25°C, 18% RH flows through a pipe of 25mm inside dia (7)

with a velocity of 4.5m/s. The inside is constantly wetted with water so as to maintain a water film on the inside the surface. Determine evaporation rate per m^2 of surface area. Kinematic viscosity = $15.6 \times 10^{-6} m^2/s$, $Sc = 0.6$, Diffusion coefficient = $0.26 \times 10^{-4} m^2/s$, density under saturated conditions at $25^\circ C = 0.231 kg/m^3$.

- 13 Derive the expression for mass transfer for the case of isothermal evaporation from the bottom of a small tube through surrounding stagnant gas. (10)
- 14 a) Discuss the analogy between heat transfer and mass transfer (5)
- b) Estimate the diffusion rate of water from bottom of a test tube 1.5cm in diameter and 15cm long into dry atmospheric air at $25^\circ C$. $D = 25.6 \times 10^{-6} m^2/s$ (5)
