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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S6 (R,S) (FT/WP) Examinations April 2026 (2019 Scheme)

Course Code: MET302

Course Name: HEAT AND MASS TRANSFER

Max. Marks: 100 **Duration: 3 Hours**

Use of HMT data book permitted

PART A

Answer all questions, each carries 3 marks. Marks

1 State Fourier law of heat conduction with proper equation. (3)

2 What is the significance of Biot's number? (3)

3 What is the significance of Prandtl number? (3)

4 Draw a schematic diagram to represent the velocity distribution within a free convection boundary layer over a vertical heated flat plate. (3)

5 Mention any three wide applications of boiling and condensation processes. (3)

6 Mention any three reasons for fouling in heat exchangers. (3)

7 What is Wien's displacement law? Mention each terms. (3)

8 What is the difference between a gray body and a black body? (3)

9 Mention any three mass transfer applications of industrial importance. (3)

10 How is mass transfer analogous to heat transfer (Mention and three points)? (3)

PART B

Answer any one full question from each module, each carries 14 marks.

Module I

11 a) Write down the general heat conduction equation in rectangular coordinates. Deduce it to Poisson's equation and Laplace equation. (4)

b) An exterior wall of a house may be approximated by a 100 mm layer of common brick (k = 0.7 W/m°C), 40 mm layer of gypsum plaster (k = 0.48 W/m°C) and 60 mm layer of rock wool insulation (k = 0.065 W/m°C). The temperature inside the house is 25°C and the outside temperature is 10°C. Find the rate of heat leakage per unit area. Neglect convection effects. Give a sketch of the arrangement. (10)

OR

12 a) Derive the expression for critical radius of insulation of a cylindrical surface. (7)

b) A solid sphere made of pure copper of 10 cm diameter initially at a uniform (7) temperature of 250°C, is suddenly immersed in water maintained at a uniform temperature of 50°C. The heat transfer coefficient between the sphere and water is 200 W/m²K. Determine the temperature of the copper block 5 min after the immersion.

Module II

13 a) Sketch the thermal boundary layer formation during the flow of a cool fluid over a horizontal flat plate (4)

b) Dry air at 20°C and at atmospheric pressure flows over a flat plate (2.2 m x 1m) at a velocity of 1.8 m/s. The plate is maintained at 100°C and the flow is parallel to 2.2 m side. Calculate the heat transfer rate from the plate. (10)

OR

14 a) What is Reynolds analogy? What is its significance? (4)

b) A hot plate 1 m wide, 360 mm high and at 110°C is exposed on either side to ambient still dry air at 30°C. Calculate the following: (10)

(i) The boundary layer thickness at 180 mm from the leading edge of the plate

(ii) Local heat transfer coefficient at 180 mm from the leading edge of the plate

(iii) Average heat transfer coefficient over the surface of the plate

(iv) Total heat loss from the plate

Module III

15 a) What are the different forms of boiling heat transfer? (4)

b) With a neat sketch, explain the various regimes in the boiling curve of water. (10)

OR

16 Air is heated by hot exhaust gases in a parallel flow heat exchanger. Air enters the inner tube at 60°C and leaves at 120°C. The inside and outside diameters of the tube are 50 mm and 60 mm respectively. The length of the tube is 14.65 m. The hot gas enters the annulus at 450°C and leaves at 250°C. The inside and outside heat transfer coefficients are 120 W/m²°C and 195 W/m²°C respectively. Calculate the heat transfer rate. Neglect tube resistance. (14)

Module IV

17 a) Define i) emissivity, ii) reflectivity, iii) absorptivity, and iv) transmissivity (4)

b) A furnace is emitting radiation at 2500°C. Assuming the furnace as a black body, calculate : (10)

(i) Monochromatic emissive power at 1.2 μm length

(ii) Wavelength at which the emission is maximum

(iii) Maximum emissive power

(iv) Total emissive power

(v) Total emissive power of the furnace if it is assumed as a real surface with emissivity 0.8

OR

18 A cylindrical surface of 25 mm diameter, 100 mm length with an emissivity 0.8 is closed at both ends by two identical flat discs of 25 mm diameter, both having emissivity 0.85. Shape factor between two identical discs is 0.05. The surface is maintained at 500° C and both discs at 400° C. Calculate the net rate of radiant heat flow leaving from the surface and reaching to each of the discs. (14)

Module V

19 Derive the general mass diffusion equation in stationary media in rectangular coordinates. (14)

OR

20 a) An iron container of 15 mm wall thickness is used to store hydrogen at 1 atm and 20°C. The molar concentrations of hydrogen in the iron at the inside and outside surfaces are 1.2 kg mole/m^3 and zero respectively. Taking a suitable value of the diffusion coefficient, calculate the molar diffusion flux for hydrogen through the steel. (7)

b) Air at 1 atm and 20°C, containing small quantities of iodine, flows with velocity of 6 m/s inside a 30 mm diameter tube. Calculate mass transfer coefficient for iodine. Take $D = 0.82 \times 10^{-5}$ m^2/s (7)

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