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Question Paper Code : 80923

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Sixth/Eighth Semester

Mechanical Engineering

ME 8693 — HEAT AND MASS TRANSFER

(Common to : Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours Maximum : 100 marks

(Use of Approved HMT data book is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Illustrate the Fourier's law of heat conduction.

2. Write the expression to determine thermal conductivity as the function of temperature.

3. Mention the expression to determine the rate of heat transfer by convection.

4. What is called thermal boundary layer thickness?

5. What is known as Film wise condensation?

6. Write the significance of drop wise condensation.

7. How do you define black body?

8. Define the term "Emissivity".

9. State the Fick's first law of diffusion.

10. What is molecular diffusion?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive an expression to determine the rate of heat transfer through a composite plane wall consisting of three layers having different thermal conductivity. (6)

(ii) Obtain an expression to determine the rate of heat transfer through the thick walled cylinder. (7)

Or

(b) A tube 60 mm OD is insulated with a 50-mm layer of silica foam, for which the conductivity is 0.055 W/m°C, followed with a 40-mm layer of cork with a conductivity of 0.05 W/m°C. If the temperature of the outer surface of the pipe is 150°C and the temperature of the outer surface of the cork is 30°C, calculate the heat loss in watts per meter of pipe. (13)

12. (a) (i) Describe briefly about the natural convection and forced convection with neat diagrams. (6)

(ii) Explain briefly about the formation of thermal boundary layer on a flate plate with condition of fluid is hotter than the plate surface. (7)

Or

(b) (i) A thin 100 cm long and 10 cm wide horizontal plate is maintained at a uniform temperature of 150°C in a large tank full of water at 75°C. Estimate the rate of heat to be supplied as heat is dissipated from either side of the plate. (7)

(ii) A large vertical plate 4 m high is maintained at 60°C and exposed to atmospheric air at 10°C. Calculate the heat transfer from the plate if it is 10 m wide. (6)

13. (a) Describe in detail about the relation between the heat flux versus temperature drop for boiling water with different regimes of boiling with neat diagram. (13)

Or

(b) Derive an expression to determine Heat Transfer Coefficient for a Vertical tube provided for the flow of condensate film in Laminar. (13)

14. (a) (i) Consider a 20 cm diameter spherical ball at 800 K suspended in air. Assuming the ball closely approximates a blackbody, determine (6)

(1) the total blackbody emissive power and

(2) the total amount of radiation emitted by the ball in 5 min.

(ii) State and explain briefly about the Stefan Boltzman's law, Plank's law and Wien's displacement law for black body radiation. (7)

Or

(b) (i) Consider the 5 m × 5 m × 5 m cubical furnace, whose surfaces closely approximate black surfaces. The base, top, and side surfaces of the furnace are maintained at uniform temperatures of 800 K, 1500 K, and 500 K, respectively. Determine (6)

(1) the net rate of radiation heat transfer between the base and the side surfaces (view factor = 0.8) and

(2) the net rate of radiation heat transfer between the base and the top surface (view factor = 0.2)

(ii) A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 K and have emissivities of plate 1 = 0.2 and plate 2 = 0.7, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield. (7)

15. (a) (i) Prove that: $D_{AB} = D_{BA}$ (diffusion of A through B equal to B through A). (6)

(ii) Pressurized hydrogen gas is stored at 358 K in a 4.8 m outer-diameter spherical container made of nickel. The shell of the container is 6 cm thick. The molar concentration of hydrogen in the nickel at the inner surface is determined to be 0.087 kmol/m^3. The concentration of hydrogen in the nickel at the outer surface is negligible. The binary diffusion coefficient for hydrogen in the nickel at the specified temperature is 1.2×10^{-12} m^2/s. Determine the mass flow rate of hydrogen by diffusion through the nickel container. (7)

Or

(b) Dry air at 300°C and 1 atm flows over a wet flat plate of 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, D = 0.26×10^{-4} m^2/s. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Describe in detail about the construction details and working principle of double pipe heat exchanger and 1-2 pass heat exchanger with neat diagrams. (15)

Or

(b) A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2 °C, determine the length of the heat exchanger required to achieve the desired heating. (15)