Reg. No. : | | | | | | | | | | | |

Question Paper Code : 41383

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

Sixth Semester

Mechanical Engineering

ME 3691 — HEAT AND MASS TRANSFER

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

(Heat and Mass transfer Data Book)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define thermal conductivity.
2. What are the uses of Heisler charts?
3. Define Peclet number and mention its significance.
4. Why heat transfer coefficients for natural convection are lower than forced convection?
5. What is dropwise condensation?
6. How fouling in the heat exchangers can be prevented?
7. Define Radiosity.
8. What are radiation shields?
9. Compare mass transfer with heat transfer.
10. Define Sherwood number and mention its significance.

PART B — ($5 \times 13 = 65$ marks)

11. (a) (i) A hollow sphere 10 cm I.D and 30 cm O.D of a material having thermal conductivity 50 W/mK is used as a container for a liquid chemical mixture. Its inner and outer surface temperatures are 300 °C and 100 °C respectively. Determine the heat flow rate through the sphere. Also estimate the temperature at a point a quarter of the way between the inner and outer surfaces. (7)

(ii) An egg with mean diameter of 45 mm and initially at 25 °C is placed in a boiling water pan for 5 minutes and found to be boiled to the consumer taste. For how long should a similar egg for the same container be boiled when taken form a refrigerator at 5 °C. For the egg: k = 10 W/mK, ρ = 1200 kg/m³, C = 2 kJ/kgK and h = 100 W/m²K. (6)

Or

(b) (i) A furnace wall is made up of three layers, one is fire brick, one is insulating layer and one is red brick. The inner and other surfaces temperatures are at 870 °C and 40 °C respectively. The respective conductive heat transfer coefficient of the layers is 1.163, 0.14 and 0.872 W/m°C and the thickness are 22 cm, 7.5 cm and 11 cm. Find the rate of heat loss per sq. meter and the interface temperatures. (7)

(ii) Two long rods of same diameter, one made of brass (k = 84 W/mK) and other of copper (k = 372 W/mK) have their ends inserted in a furnace. At a distance 100 mm away from the furnace, the temperature of brass rod is 130 °C. At what distance from the furnace end, the same temperature would be reached in the copper? (6)

12. (a) (i) Air at 27 °C flows over a flat plate at a velocity of 2 m/s. The plate is heated over its entire length to a temperature of 60 °C calculate the heat transfer for the first 20 cm of the plate. Take properties of air at 43 °C. (7)

(ii) Water is heated from 20 °C to 60 °C as it flows through a 20 mm diameter electric heated tube. The flow rate of water is 0.1 kg/sec. Determine heat transfer coefficient and wall temperature. (6)

Or

(b) (i) Liquid Na is to be heated from 120 °C to 180 °C and flows at 2.3 kg/sec through a 25 mm diameter tube. The tube is maintained at constant temperature. Determine heat transfer coefficient. (7)

(ii) A flat plate 1.0 m wide and 1.5 m long is to be maintained at 90 °C in air with a free stream temperature of 10 °C. Estimate the velocity at which air must flow over the flat plate so that the rate of heat from the plate is 3.75 kW. (6)

13. (a) (i) The flow rates of hot and cold-water streams running through a parallel flow heat exchanger are 0.2 kg/sec and 0.5 kg/sec. Inlet temperature of the hot and cold fluids are 75 °C and 20 °C. Exit temperatures of hot water is 45 °C. If the individual heat transfer coefficient on both sides are 650 W/m² K, calculate area of heat exchanger. (7)

(ii) Write short notes on effect of non-condensable gases on the condensation? (6)

Or

(b) (i) Hot oil with a capacity rate of 250 W/K flows through a double pipe heat exchanger. If enters at 360 °C and leaves at 300 °C. Cold fluid enters at 30 °C and leaves at 200 °C. If the overall heat transfer coefficient is 800 W/m^{2}K. Determine the heat exchanger area required for (1) Parallel flow and (2) Counter flow. (7)

(ii) With neat sketch, explain about various regimes of pool boiling. (6)

14. (a) (i) Two concentric cylinders of 300 mm and 400 mm diameter are kept at 400 °C and 300 °C respectively. Determine Q_{12} for case L = 0.5 and $L = \infty$. (7)

(ii) Two parallel plates of 2 m × 1 m are kept at 400 K and 600 K with 0.5 m distance. Determine the heat exchange by radiation. (6)

Or

(b) (i) The inner sphere of a liquid oxygen container is 40 cm diameter and outer sphere is 50 cm diameter. Both have emissivities (ε = 0.05). Determine the rate at which liquid oxygen would evaporate at −183 °C when the outer sphere temperature is 20 °C. Latent heat of oxygen is 210 kJ/kg. (7)

(ii) Two large parallel plates are kept at 1000 °C and 500 °C and emissivity of plates are one, then determine heat radiated, If the respective plate emissivity is 0.8 and 0.5, determine the heat radiated. (6)

15. (a) (i) Determine the rate of evaporation of water from bottom of a test tube of 10 mm diameter, 150 mm long into dry stagnant air at 25 °C. (7)

(ii) Air at 25 °C and atmospheric pressure flow with a velocity of 3 m/s inside a 10 mm diameter tube of 1 m length. The inside surface of the tube contains a deposit of napthlene. Determine the average mass transfer coefficient. (6)

Or

(b) (i) CO_2 and air experience diffusion through a circular tube of 50 mm diameter and 1 m long. The system is at 1 atm, 25°C Partial pressure of CO_2 at end of tube is 190 mm Hg and other end of tube is 95 mm Hg. Determine mass flow rate of CO_2 and air. Take molecular weight of air is 28.96 and take 760 mm Hg is equal to 1 bar. (7)

(ii) Air at 35 °C DBT and 35% RH flows over a water surface 150 mm long and 500 mm wide at 101.2 kPa along the direction parallel to 150 mm. The velocity of air is 2 m/s and the temperature of water surface is 30 °C. Assume diffusion coefficient D as 0.26×10^{-4} m^2/s. Find the amount of water evaporated. (6)

PART C — (1 × 15 = 15 marks)

16\. (a) For the plates of two large parallel plates maintained at 800 °C and 300 °C and 0.3 and 0.5 respectively. Find the percentage reduction in heat transfer when a polished aluminium radiation shield ($\varepsilon = 0.05$) is placed between them. Also find the temperature of the shield. (15)

Or

(b) With neat sketch, derive 3-D general heat conduction equation in cartesian coordinates and deduce the equation to Fourier's equation, poisson's equation and Laplace equation. (15)