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Question Paper Code : X 20842

B.E./B.Tech. DEGREE EXAMINATIONS, NOV./DEC. 2020
Fifth/Sixth/Seventh Semester
Mechanical Engineering
ME 6502 – HEAT AND MASS TRANSFER
(Common to Mechanical Engineering (Sandwich) Mechanical and Automation Engineering)
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. What are various modes of heat transfer ?

2. What is lumped capacitance analysis ?

3. What is Dittus-Boelter equation ? When does it apply ?

4. Define Grashof number and explain its significance in free convection heat transfer.

5. Give examples for pool boiling and flow boiling.

6. What are fouling factors ?

7. What are the properties of a black body ?

8. Define Radiosity.

9. Distinguish between mass concentration and molar concentration.

10. Give examples for natural and forced mass Transfer.

PART – B **(5×13=65 Marks)**

11. a) i) Consider a 1.2 m high and 2 m wide double-pane window consisting of two 3 mm thick layers of glass (k = 0.78 W/mK) separated by a 12 mm wide stagnant air space (k = 0.026 W/mK). Determine the steady rate of heat transfer through this double-pane window and the temperature of its inner surface when the room is maintained at 24°C while the temperature of the outdoors is –5°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be 10 W/m^2K and 25 W/m^2K respectively. **(7)**

ii) Derive the general 3-dimensional heat conduction equation in Cartesian coordinates. **(6)**

(OR)

b) A cylinder 1 m long and 5 cm in diameter is placed in an atmosphere at 45°C. It is provided with 10 longitudinal straight fins of material having k = 120 W/mK. The height of 0.76 mm thick fins is 1.27 cm from the cylinder surface. The heat transfer coefficient between cylinder and atmospheric air is 17 W/m^2 K. Calculate the rate of heat transfer and the temperature at the end of fins if surface temperature of cylinder is 150°C. **(13)**

12. a) i) Air at a pressure of 8 kN/m^2 and a temperature of 250°C flows over a flat plate 0.3 m wide and 1 m long at a velocity of 8 m/s. If the plate is to be maintained at a temperature of 78°C estimate the rate of heat to be removed continuously from the plate. **(7)**

ii) A heated sphere having a diameter of 30 mm is maintained at a temperature of 90°C and is placed in water stream at 20°C. The water flow velocity is 3.5 m/s. Calculate the heat loss from the sphere. **(6)**

(OR)

b) i) Determine the average heat transfer coefficient over the entire length from a vertical plate of height 2 m to the surrounding air, if it is known that the surface temperature of the plate is 105°C. Assume the ambient temperature is 15°C. **(7)**

ii) A 10 mm diameter spherical steel ball at 260°C is immersed in air at 90°C. Estimate the rate of convective heat loss. **(6)**

13. a) i) Hot water enters a counter flow heat exchanger at 95°C . This hot water is used to heat a cool stream of water from 8 to 40°C. The flow rate of the cool water is 1.2 kg/s, and that of the hot water is 2.7 kg/s. The overall heat-transfer coefficient is 850 $W/m^2 °C$. What is the area of the heat exchanger and its effectiveness ? **(8)**

ii) Name and brief the different types of heat exchangers. **(5)**

(OR)

b) i) A hot stream is cooled from 120°C to 30°C while the cold stream temperature changes from 20°C to 60°C. Find out the LMTD for both counter current and co-current phenomenon. Justify how counter current is effective than co-current ? **(5)**

ii) What is flow boiling and pool boiling ? Describe how heat transfer coefficient m in regimes of pool boiling. **(8)**

14\. a) Assuming the sun (diameter = 1.4×10^9 m) as a black body having a surface temperature of 5750 K and at a mean distance of 15×10^{10} m from the earth (diameter = 12.8×10^6m). Estimate the following :

i) Total energy emitted by the sun.

ii) The emission received per m^2 just outside the atmosphere of earth.

iii) The total energy received by the earth if no radiation is blocked by the atmosphere of the earth. **(13)**

(OR)

b) Calculate the net radiant heat exchange per m^2 area for two large parallel plates of temperatures 427°C and 27°C respectively. ε (hot plate) = 0.9 and ε (cold plate) = 0.6. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer if ε (shield) = 0.4. **(13)**

15\. a) Two large vessels contain uniform mixture of air and sulphur dioxide at 1 atm and 273 k, but at different concentrations. Vessel 1 contains 80% air and 20% SO_2 by volume or mole percentage whereas vessel 2 contains 30% air and 70% SO_2 by mole percentage. The vessels are connected by a 10 cm inner diameter 1.8 m long pipe. Determine the rate of transfer of air between these two vessels by assuming that a steady state transfer takes place. The mass diffusivity of air – SO_2 mixture at 1 atm and 273 K is 0.122×10^{-4} m^2/s.

(OR)

b) The water in a 5m × 15m outdoor swimming pool is maintained at a temperature of 27°C. The average temperature and relative humidity are 37°C and 40% respectively. Assuming a wind speed of 2m/s in the direction of the long side of the pool, estimate the mass transfer coefficient for the evaporation of water from the pool surface and the rate of evaporation in kg/day.

PART – C **(1×15=15 Marks)**

16. a) A uniform sheathing of plastic insulation (k = 0.18 W/m°C) is applied to an electric cable of 8 mm diameter. The convective heat transfer coefficient on the surface of bare cable as well as insulated cable was estimated as 12.5 W/(m^2°C) and a surface temperature of 45°C was observed when the cable was directly exposed to ambient air 20°C. Determine :

i) the thickness of insulation to keep the wire as cool as possible and

ii) the surface temperature of insulated cable if the intensity of current flowing through the conductor remains unchanged.

(OR)

b) Air is to be heated by passing it over a bank of 3 m long tubes inside which steam is condensing at 100°C. Air approaches the tube bank in the normal direction at 20°C and 1 atm with a mean velocity of 5.2 m/s. The outer diameter of the tubes is 1.6 cm, and the tubes are arranged staggered with longitudinal and transverse pitches of 4 cm. There are 20 rows in the flow direction with 10 tubes in each row. Determine the rate of heat transfer and the rate of condensation of steam inside the tubes.