CBCS SCHEME

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15AE53

Fifth Semester B.E. Degree Examination, June/July 2019
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of Heat and mass transfer data handbook is permitted.***

Module-1

1 a. A 0.8 m height and 1.5 m wide double-plane window consists of two thick layers of glass (K = 78 W/mK) separated by a 10 mm wide stagnant air space (K = 0.026 W/mK). Determine the rate of heat transfer through this window and the temperature of the inside surface when the room is maintained at 20°C and the outside air is at −10°C, take the convection heat transfer coefficient on the inside and the outside surfaces of the window as 10 W/m^2K and 40 W/m^2K. **(08 Marks)**

b. State and explain the ficks law of diffusion. **(04 Marks)**

c. A solid cylinder rod of diameter 10 mm and length 150 mm is insulated on its cylinder surface. Determine the heat flow rate through the rod if K = 0.78 W/mK the temperature at the ends of the rod are 0°C and 100°C respectively. **(04 Marks)**

OR

2 a. An insulated steel pipe carrying a hot liquid inner diameter of the pipe is 25 cm, wall thickness is 2 cm thickness of insulation is 5 cm, temperature of hot liquid is 100°C, temperature of surrounding is 20°C inside heat transfer coefficient is 730 W/m^2K and outside heat transfer coefficient is 12 W/m^2K. Calculate the heat loss per meter length of the pipe. Take K_{steel} = 55 W/mK and $K_{insulating\ material}$ = 0.22 W/mK. **(10 Marks)**

b. State the laws governing three basic modes of heat transfer. **(06 Marks)**

Module-2

3 a. A 40 × 40 cm copper slab 5 mm thick at a uniform temperature of 250°C, suddenly has its surface temperature lowered to 30°C. Find the time which the slab temperature becomes 90°C, ρ = 900 kg/m^3, specific heat = 0.38 kJ/kgK, K = 370 W/mK and convective heat transfer coefficient (h) = 90 W/m^2K. **(06 Marks)**

b. Derive the general three dimensional conduction equation in Cartesian coordinates and state the assumption made. **(10 Marks)**

OR

4 a. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment of heat conduction problem. **(10 Marks)**

b. A stainless steel rod of outer diameter 1 cm originally at a temperature of 320°C is suddenly immersed in a liquid at 120°C for which the convective heat transfer coefficient is 100 W/m^2K. Determine the time required for the rod to reach a temperature of 200°C. **(06 Marks)**

Module-3

5 a. Define clearly and give expression for:
i) Reynolds number ii) Nusselt number
iii) Prandtl number iv) Stanton number **(08 Marks)**

b. A hot square plate 50 cm × 50 cm at 100°C is exposed to atmosphere air at 20°C. Find the heat loss from both surfaces of the plate, if (i) Plate is kept vertical (ii) Plate is kept horizontal. Use the following relations:
i) $N_u = 0.13\ (GrPr)^{1/3}$ vertical position
ii) $N_u = 0.71\ (GrPr)^{1/4}$ for upper surface
iii) $N_u = 0.35\ (GrPr)^{1/4}$ for lower surface **(08 Marks)**

OR

6 a. Explain the following:
i) Velocity boundary layer
ii) Thermal boundary layer
iii) Thermal entry **(08 Marks)**

b. Using Buckingham's Pi theorem, obtain a relationship between Nu, Pr and Gr for free convection heat transfer. **(08 Marks)**

Module-4

7 a. Obtain an expression for the rate of heat transfer when radiation shield is introduced between two parallel plates. **(10 Marks)**

b. A boiler furnace lagged with plate steel is lined with five clay bricks on the inside. The temperature of the outer side of the brick setting is 127°C and the temperature of the inside of the steel plate is 50°C. Assuming the gap between plate steel and fire clay bricks to be small compared with the size of the furnace, calculate the loss of heat per unit area by radiation between the lagging and setting ($\in$ for steel = 0.6, $\in$ for fire clay = 0.8). **(06 Marks)**

OR

8 a. Derive an expression for LMTD of a counter flow heat exchanger, state the assumption made. **(08 Marks)**

b. Hot oil is to be cooled by water in a 1-shell-pass and 8-tube-passes heat exchanger. The tubes are thin walled and are made of copper with an inner diameter of 1.4 cm. The length of each tube pass in the heat exchanger is 5m, and the overall heat transfer coefficient is 310 $W/m^2°C$ water flows through the tubes at a rate of 0.2 kg/s and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enters at the temperature of 20°C and 150°C respectively. Determine the rate of heat transfer in the heat exchanger and the outlet temperatures of the water and oil. **(08 Marks)**

Module-5

9 a. Explain the heat transfer concept for the following:
i) Rocket thrust chamber
ii) Gas turbine combustion chamber **(08 Marks)**

b. Explain the concept of ablative heat transfer. **(08 Marks)**

OR

10 a. A mixture of O_2 and N_2 with their partial pressure in the ratio 0.21 to 0.79 in a container at 25°C. Calculate the molar concentration, the mass density, the mole fraction, and the mass fraction of each species for a total pressure of 1 bar. **(04 Marks)**

b. Derive an expression for species conservation equation. **(12 Marks)**

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