CBCS SCHEME

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15AE53

Fifth Semester B.E. Degree Examination, July/August 2021
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer any FIVE full questions.***
2. ***Use of heat and mass transfer data hand book is permitted.***

1 a. State the laws governing three basic modes of heat transfer. **(05 Marks)**

b. Determine the heat transfer through the plane of length 6m, height 4m and the thickness 0.03. The temperature of inner and outer surfaces are 100°C and 40°C. Thermal conductivity of wall is 0.55W/mk. **(04 Marks)**

c. An insulated steel pipe carrying a hot liquid inner diameter of the pipe is 25cm, wall thickness is 2cm, thickness of insulation is 5cm, temperature of hot liquid is 100°C, temperature of surrounding is 20°C, inside heat transfer co-efficient is 730W/m^{2}K and outside heat transfer coefficient is 12W/m^{2}K. Calculate the heat loss per meter length of the pipe. Take K_{steel} = 55W/mK and $K_{insulating\ material}$ = 0.22W/mK. **(07 Marks)**

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

b. State and explain the Fick's law of diffusion. **(04 Marks)**

c. A 0.8m height and 1.5m wide double plane window consists of two thick layers of glass (K = 78W/mK) separated by a 10mm wide stagnant air space (K = 0.026W/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 co-efficient on the inside and the outside surfaces of the window as 10W/m^{2}K and 40W/m^{2}K. **(08 Marks)**

3 a. Derive the general three dimensional conduction equations in Cartesian co-ordinates and state the assumption made. **(10 Marks)**

b. A 40×40cm copper slab 5mm 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 = 900kg/m^3 specific heat (C) = 0.38kJ/Kg K, K = 370W/mK and convective heat transfer co-efficient (h) = 90W/m^{2}K. **(06 Marks)**

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

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

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

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

6 a. Using Buckingham's Pi theorem, obtain a relationship between N_u, P_r and G_r for free convection heat transfer. **(08 Marks)**

b. Explain the following :
   i) Velocity boundary layer
   ii) Thermal boundary layer
   iii) Thermal Entry. **(08 Marks)**

7 a. A boiler furnace lagged with plate steel is lined with fire 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 fireclay bricks to the small compared with the size of the furnace, calculate the loss of heat per unit area by radiation between the lagging and setting ('ε' for steel = 0.6, 'ε' for fire clay = 0.8). **(06 Marks)**

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

8 a. Derive an expression for LMTD of a counter flow heat exchanger. State 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 1.4cm. The length of each tube pass in the heat exchanger is 5m, and the overall heat transfer co-efficient is 310W/m^2°C water flows through the tubes at a rate of 0.2kg/s and the oil through the shell at rate of 0.3kg/s. The water and the oil enter at the temperature of 20°C and 150°C respectively. Determine the rate of heat transfer in the heat exchanger and the out let temperature of the water and oil. **(08 Marks)**

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)**

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

b. 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)**

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