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**Question Paper Code : 50870**

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017  
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

Use of HMT data book permitted.  
Answer ALL questions.

PART – A

(10×2=20 Marks)

1. What are the factors affecting thermal conductivity of material ?
2. What are Heisler charts ?
3. What is Grashoff number ?
4. List some characteristics of boundary layer.
5. Differentiate Pool boiling and forced convection boiling.
6. What are the factors on which overall heat transfer coefficient depends ?
7. What are the properties of a black body ?
8. Define Radiosity.
9. What are the different modes of mass transfer ?
10. Define mass transfer coefficient.

PART – B

(5×13=65 Marks)

11. a) The rate of heat generation in a slab of thickness 160 mm with thermal conductivity of  $180 \text{ W/m}^\circ\text{C}$  is  $1.2 \times 10^6 \text{ W/m}^3$ . If the temperature of each of the surface of solid is  $120^\circ\text{C}$ . Determine.
  - i) The temperature at the mid and quarter planes.
  - ii) The heat flow rate and temperature gradient at the mid plane.

(13)

(OR)

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- b) A fin 5 mm thick and 45 mm long has its base on a plane plate which is maintained at  $125^{\circ}\text{C}$ . The ambient temperature is  $25^{\circ}\text{C}$ . The conductivity of fin material is  $55 \text{ W/m}^{\circ}\text{C}$  and the heat transfer coefficient is  $145 \text{ W/m}^{\circ}\text{C}$ . Determine :
- Temperature at the end of the fin
  - Temperature at the middle of the fin
  - Heat dissipated by the fin per metre width. (13)

12. a) Air at atmospheric pressure and  $200^{\circ}\text{C}$  flows over a plate with a velocity of  $5 \text{ m/s}$ . The plate is  $15 \text{ mm}$  wide and is maintained at temperature of  $120^{\circ}\text{C}$ . Calculate the thickness of hydrodynamic and thermal boundary layers and the local heat transfer coefficient at a distance of  $0.5 \text{ m}$  from the leading edge. Assume that flow is on one side of the plate. Take  $\rho = 0.815 \text{ kg/m}^3$ ,  $\mu = 24.5 \times 10^{-6} \text{ Ns/m}^2$ ,  $\text{Pr} = 0.7$ ,  $k = 0.0364 \text{ W/mK}$ . (13)

(OR)

- b) A vertical cylinder  $1.5 \text{ m}$  high and  $180 \text{ mm}$  in diameter is maintained at  $100^{\circ}\text{C}$  in an atmosphere environment of  $20^{\circ}\text{C}$ . Calculate the heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as  $\rho = 1.06 \text{ kg/m}^3$ ,  $\nu = 18.97 \times 10^{-6} \text{ m}^2/\text{s}$ ,  $C_p = 1.004 \text{ kJ/kg}^{\circ}\text{C}$ , and  $k = 0.1042 \text{ kJ/mh}^{\circ}\text{C}$  (13)
13. a) A vertical plate  $3.2 \text{ m}$  high maintained at  $54^{\circ}\text{C}$  is exposed to saturated steam at atmospheric pressure. Calculate the heat transfer rate per unit width. (13)

(OR)

- b) The flow rate of hot and cold water streams running through a parallel flow heat exchanger are  $0.2 \text{ kg/s}$  and  $0.5 \text{ kg/s}$  respectively. The inlet temperatures on the hot and cold sides are  $75^{\circ}\text{C}$  and  $20^{\circ}\text{C}$  respectively. The exit temperature of hot water is  $45^{\circ}\text{C}$ . If the individual heat transfer coefficients on both the sides are  $650 \text{ W/m}^2^{\circ}\text{C}$ . Calculate the area of heat exchanger. (13)
14. a) Assuming the sun (diameter =  $1.4 \times 10^9 \text{ m}$ ) as a black body having a surface temperature of  $5750 \text{ K}$  and at a mean distance of  $15 \times 10^{10} \text{ m}$  from the earth (diameter =  $12.8 \times 10^6 \text{ m}$ ). Estimate the following :
- Total energy emitted by the sun
  - The emission received per  $\text{m}^2$  just outside the atmosphere of earth.
  - 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  $427^\circ\text{C}$  and  $27^\circ\text{C}$  respectively.  $\epsilon$  (hot plate) = 0.9 and  $\epsilon$  (cold plate) = 0.6. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer if  $\epsilon$  (shield) = 0.4. (13)
15. a) Hydrogen gas is maintained at pressure of 2.4 bar and 1 bar on opposite sides of a plastic membrane 0.3mm thick. The binary diffusion coefficient of hydrogen in the plastic is  $8.6 \times 10^{-8} m^2/s$  and solubility of hydrogen in the membrane is 0.00145 kg mole/ $m^3$  bar. Calculate under uniform temperature conditions of  $24^\circ\text{C}$ , the following.
- Molar concentration of hydrogen at the opposite faces of membrane
  - Molar and mass diffusion flux of hydrogen through the membrane
- (OR)
- b) Oxygen is diffusing through stagnant carbon monoxide at  $0^\circ\text{C}$  and 760 mm Hg pressure under steady state conditions. The partial pressure of oxygen at two planes 3.5 mm apart is 90 mm of Hg and 20 mm of Hg respectively. Calculate the rate of diffusion of oxygen in gm-mole/s through  $cm^2$  area. Assume diffusivity of oxygen in carbon monoxide =  $0.17 cm^2/s$  and gas constant =  $82.06 cm^3 atm/gm$  mole K.

PART - C

(1×15=15 Marks)

16. a) The interior of a refrigerator having inside dimensions of  $0.5 m \times 0.5m$  base area and 1 m height is to be maintained at  $6^\circ\text{C}$ . The walls of the refrigerator are constructed of two mild steel sheet 3mm thick ( $k = 46.5 W/m^\circ\text{C}$ ) with 50mm of glass wool insulation ( $k = 0.046 W/m^\circ\text{C}$ ) between them. If the average heat transfer coefficients at the outer and inner surfaces are  $11.6 W/m^2^\circ\text{C}$  and  $14.5 W/m^2^\circ\text{C}$  respectively. Calculate :
- The rate at which heat must be removed from the interior to maintain the specified temperature in the kitchen at  $25^\circ\text{C}$ .
  - The temperature on the outer surface of the metal sheet.
- (OR)
- b) A counter flow heat exchanger is to heat air entering at  $400^\circ\text{C}$  with a flow rate of 6kg/s by the exhaust gas entering at  $800^\circ\text{C}$  with a flow rate of 4 kg/s. The overall heat transfer coefficient is  $100 W/m^2K$  and the outlet temperature of the air is  $551.5^\circ\text{C}$ . Specific heat at constant pressure for both air and exhaust gas can be taken as  $1100 J/kgK$ . Calculate the heat transfer area needed and number of transfer units. (15)