BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

December, 2013

02970

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Answer **any seven** questions . All questions carry **equal** marks. Use of scientific calculator is **permitted**.*

---

1. (a) A steam pipe ($\epsilon = 0.85$) of 0.5 m diameter has a surface temperature of 550 K. The pipe is located in a room at 30°C and the convection heat transfer coefficient is 28 W/m^2K. Calculate the combined heat transfer coefficient and the rate of heat transfer per unit length of the pipe. 5

   (b) What do you mean by critical radius of insulation ? Derive an expression for critical radius of insulation over a cylinder. 5

2. (a) Define Fick's law of diffusion. Explain how does diffusion take place ? 5

   (b) Distinguish between the surface and volumetric radiation. What is the wavelength range for infra red and visible radiation ? 5

3. (a) Show that the temperature profile for heat conduction through a plane wall with a heat source and constant thermal conductivity is parabolic. 5

(b) A load of peas at a temperature of 25°C is to be cool down in a room at a constant air temperature of 1°C. How long the peas will require to cool down to 2°C when the surface heat transfer coefficient of the peas is 5.81 W/m^2K ? 5

4. (a) One end of a long rod is inserted into a furnance while the other projects into ambient air. Under steady state the temperature of the rod is measured at two points 75 mm apart and found to be 125°C and 88.5°C, respectively, while the ambient temperature is 20°C. If the rod is 25 mm diameter and $h = 23.36\ W/m^2K$, find the thermal conductivity of the rod material. 5

(b) Derive an expression for heat transfer and temperature distribution for a rectangular fin with its tip at adiabatic condition. 5

5. (a) With the help of Buckingham π - theorem show that for forced convection heat transfer 5

$$Nu_d = C\ Re_d^a\ Pr^b$$

(b) A rectangular plate is 120 cm long in the direction of flow and 200 cm wide. The plate is maintained at 80°C when placed in nitrogen that has a velocity of 2.5 m/s and a temperature of 0°C. Determine the average heat transfer coefficient and the total heat transfer from the plate. 5

The properties of Nitrogen at 40°C are $P = 10142\ kg/m^3$, $C_p = 1.04\ kJ/kgK$; $\upsilon = 15.63 \times 10^{-6}\ m^2/s$ and $k = 0.0262\ W/mK$.

6. (a) Derive an expression for radiation heat transfer for two surface enclosure. What are the assumptions ? 5

(b) Consider a diffuse circular disk of diameter D and area A_j and a plane diffuse surface of area $A_i << A_j$. The surfaces are parallel, and A_j is located at a distance L from the centre of A_j. Obtain an expression for the view factor F_{ij}. 5

7. (a) What is evaporation ? Draw a sketch of single effect evaporator and explain its working principle. 5

(b) Explain various application of boiling heat transfer. 5

8. (a) Determine the overall heat transfer coefficient U_o based on the outer surface of a steel pipe with an ID of $D_i = 2.5$ cm and an OD of $D_o = 3.34$ cm [k = 54 W/m°C] for the following flow and fouling conditions : 5

$h_i = 1800\ W/(m^2\ °C)$; $h_o = 1250\ W/m^2\ °C$;
$F_i = F_o = 0.00018\ m^2\ °C/W$

(b) Consider a cross flow heat exchanger with hot and cold fluids entering at uniform temperatures. Illustrate with sketches the exit temperature distribution for the following cases : 5

(i) Both fluids are unmixed and

(ii) Cold fluid is unmixed, hot fluid is mixed.

9. (a) Show that for a mass transfer in a boundary layer over a flat plate is given by : 5

$$Sh = 0.664\ Re_L^{1/2}\ S_C^{1/3}$$

(b) Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gases or liquids. 5

10. (a) A tube is coated on the inside napthalene and has an inside diameter of 20 mm and a length of 1.10 m. Air at 318 K and an average pressure of 101.3 kPa flows through this pipe at a velocity of 0.8 m/s. Assuming that the absolute pressure remains essentially constant, calculate the concentration of nepthalene in the exit air. Use the physical properties given below : 5

$D_{AB} = 6.92 \times 10^{-6}$ m^2/s Vapour pressure $p_{Ai} = 74.0$Pa $\mu_{air} = 1.932 \times 10^{-5}$Pa $\rho_{air} = 1.114$ kg/m^3.

(b) Derive the continuity equation for a binary mixture. 5
