Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- VIth SEMESTER–EXAMINATION – MAY- 2012

Subject code: 161906 **Date: 22/05/2012**

Subject Name: Heat and Mass Transfer

Time: 10:30 am – 01:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** With usual notations derive general heat conduction equation in Cartesian coordinates. Also obtain the same for no heat sources case. **08**

(b) Distinguish (1) Subcooled and Saturated boiling
(2) Nucleate and film boiling **06**

Q.2 **(a)** State and explain (i) Critical thickness of insulation
(ii) efficiency of fins (iii) effectiveness of fins **06**

(b) A hot gas at 330^{o}C with convection coefficient 222 W/m^{2}K is following through a steel tube of outside diameter 8 cm and thickness 1.3 cm. It is covered with an insulating material of thickness 2 cm, having conductivity of 0.2 W/mK. The outer surface of insulation is exposed to ambient air at 25^{o}C with convection coefficient of 55 W/m^{2}K. Calculate: (1) Heat loss to air from 5 m long tube.
(2) The temperature drop due to thermal resistance of the hot gases, steel tube, the insulation layer and the outside air. Take conductivity of steel = 50 W/m^{2}K. **08**

OR

(b) A steel tube of 5 cm inner diameter and 8 cm outer diameter (k = 16 W/mK), is covered with an insulation of 3 cm thickness (k = 0.3 W/mK). A hot gas at 350^{o}C h = 400 W/m^{2}K flows. Calculate the heat loss from the tube for 20 meter length. Also calculate the temperature at the interface of insulation and steel. **08**

Q.3 **(a)** Derive an expression for LMTD for counterflow heat exchanger. **06**

(b) A parallel flow heat exchanger has its tubes of 5 cm internal and 6 cm external diameter. The air flows inside the tubes and receives heat from hot gases circulated in the annular space of the tube at the rate of 100 kW. Inside and outside heat transfer coefficients are 250 W/m^{2}K and 400 W/m^{2}K respectively. Inlet temperature of hot gases is 500 ^{o}C, outlet temperature of hot gases is 300 ^{o}C, inlet temperature of air 50^{o}C, Exit temperature of air 140 ^{o}C. Calculate : **08**

(1) Overall heat transfer coefficient based on outer surface area

(2) Length of the tube required to affect the heat transfer rates. Neglect the thermal resistance of the tube.

(3) If each tube is 3 m length find the number of tubes required.

OR

Q.3 **(a)** Derive the expression for effectiveness of parallel flow heat exchanger.

06

(b) A chemical having a specific heat of 3.3 kJ/kg K flowing at the rate 20,000 kg/h enters a parallel flow heat exchanger at 120^oC. The flow rate of cooling water is 50,000 kg/h with an inlet temperature of 20^oC. The heat transfer area is 10 m^2 and overall heat transfer coefficient is 1200 $W/m^2\,^oC$. Taking specific heat of water as 4.186 kJ/kgK. Find: (1) effectiveness of the heat exchanger (2) Outlet temperature of water and chemical. **08**

Q.4 **(a)** Define and discuss velocity boundary layer and thermal boundary layer over a flat plate. Show the thickness of these layers for different Prandtl numbers. **07**

(b) The air at atmospheric pressure and temperature of 30^oC flows over one side of plate of a velocity of 90 m/min. This plate is heated and maintained at 100^oC over its entire length. Find out the following at 0.3 and 0.6 m from its leading edge. (1) Thickness of velocity boundary layer and thermal boundary layer. (2) Mass flow rate which enters the boundary layer between 0.3 m and 0.6 m per metre depth of plate. Assume unit width of plate. Properties of air at 30^oC: $\rho = 1.165\ kg/m^3$, $v = 16 \times 10\text{-}6\ m^2/s$, Pr = 0.701, $C_p = 1.005$ kJ/kgk, k = 0.02675 W/mK. **07**

OR

Q.4 **(a)** By dimensional analysis show that for forced convection heat transfer the Nusselt number can be expressed as a function of Prandtl number and Reynolds number. **07**

(b) Air at 20^oC and at atmospheric pressure flows at a velocity 4.5 m/s past a flat plate with a sharp leading edge. The entire plate surface is maintained at a temperature of 60^oC. Assuming that the transition occurs at a critical Reynolds number of 5×10^5, find the distance from the leading edge at which the boundary layer changes from laminar to turbulent. At the location calculate: (1) thickness of hydrodynamic and thermal boundary layer, (2) Local and average heat transfer coefficients, (3) Heat transfer rate from both sides per unit width of plate. Use $Nu_{xc} = 0.332\,(Re_{xc})^{1/2}(Pr)^{1/3}$. Assume cubic velocity profile and approximate method. Thermophysical properties of air at mean film temperature of 40^oC are, $\rho = 1.128\ kg/m^3$, $v = 16.96 \times 10^{-6}\ m^3/s$, k = 0.02755 W/mk and Pr=0.7. **07**

Q.5 **(a)** Derive the expression for radiant heat exchange between two finite black surfaces by radiation. **07**

(b) State and explain Fick's law of diffusion. Express Fick's law in terms of partial pressures of gases. **07**

OR

Q.5 **(a)** Differentiate between steady state and transient heat conduction. Explain two examples of heat conduction under unsteady state. **07**

(b) Derive the one dimensional radial steady state heat conduction through hollow cylinder without heat generation. Also obtain the expression of logarithmic mean are for hollow cylinder. **07**

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