Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE SEM-VII Examination-Nov/Dec.-2011

Subject code: 170102 **Date: 22/11/2011**

Subject Name: Theory of Heat 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)** Derive general heat conduction equation in Cartesian coordinates **07**

(b) The walls of a refrigerated truck consist of 1.5 mm thick steel sheet (k=18 W/m-K) at the outer surface, 20 mm thick timber lining (k=0.11 W/m-K) on the inner surface and 25 mm thick cork (k=0.04 W/m-K) in between. The temperatures at the inside and outside surfaces of the truck are 0°C & 30°respectively. **07**

Calculate (1) necessary refrigeration capacity of the plant.
(2) timber-cork interface temp.

Q.2 **(a)** Derive equations of temperature distribution and heat dissipation for infinite long fin. **07**

(b) A fin 30 cm long and 10 cm diameter throughout is made of steel alloy thermal conductivity 43 W/m-K. The fin attached to a plane heated wall 200°C temp. extends into surroundings at 25°C and heat transfer coefficient 120 W/m^2-K. Work out the heat flow rate from the fin to the surroundin Assume that the tip of the fin is insulated and thermal radiation effect negligible. **07**

OR

(b) Differentiate between conductivity and conductance? What are their units. Also draw the temp. gradient through a plane wall when the thermal conductivity: **07**

(i) remains constant with increase in temp.
(ii) increases with increase in temp.
(iii)decreases with increase in temp.

Q.3 **(a)** Distinguish between natural and forced convection heat transfer. **07**

(b) The surface of a 2 m long flat plate is maintained at 50 °C. Water at a temp. of 10°C and a velocity of 0.6 ms^{-1} flows over the surface. Calculate the heat transfer rate per unit width of plate. **07**

OR

Q.3 **(a)** Explain lumped heat capacity method and state its assumptions. **07**

(b) Estimate the time required to cook a carrot in boiling water at atmospheric pressure. The carrot is initially at room temp 25 °C and the cooking requirement stipulates that a minimum temp. of 95 °C is reached at the center of carrot. Treat the carrot as a long cylinder of 20 mm diameter and having the following properties: **07**

ρ=1025 kg/m^3, Cp = 4000 J/kgK, k= 0.48 W/m-K
convective heat transfer coefficient h = 2000 W/m^2-K.

Q.4 **(a)** What are the fouling factors? Explain their effect in Heat Exchanger design. **07**

(b) The hot air at 135 °C needed for a drying plant is obtained by passing 2.5 kg/s of atmospheric air at 1 bar pressure and 27°C temp. over tubes through which hot oil is circulated. The tube have 2 cm bore, 1.5 mm thickness and are made of material having thermal conductivity 52.5 W/m-K. The oil enters these tubes at 305 °C and leaves at 210 °C. Assuming that air is flowing in opposite direction to oil, calculate **07**

a) Overall heat transfer coefficient
b) Total heating surface
c) No. of tubes & passes if the overall length of the heater is restricted to 3.2 m.

For air: C_p= 1005 J/kg-K, R=287 J/kg-K & h from air to metal=172.42 W/m^{2}K

For oil: C_p=1885 J/kg-K, k = 0.129 W/m-K, μ=2.07 x 10^{-3} kg/m-s,

flow rate = 500 kg/m^2-s and heat transfer coefficient for oil to metal is governed by $Nu=0.023(Re)^{0.8}(Pr)^{0.3}$.

OR

Q.4 **(a)** Write Von-karman integral momentum equation, for the hydrodynamic laminar boundary layer of fluid flowing over stationary plate. Using this equation, derive the expression for hydrodynamic boundary layer thickness considering the cubic velocity profile. **07**

(b) Explain dropwise and filmwise condensation. **07**

Q.5 **(a)** Describe the phenomenon of radiation from real surfaces. **07**

(b) Using dimensional analysis, obtain a general form of equation for Forced Convective heat transfer. **07**

OR

Q.5 **(a)** What is the Stephen-Boltzmann Law? Explain the concept of total emissive power of a surface. **07**

(b) A thermos flask has a double walled bottle and the space between the walls is evacuated so as to reduce the heat flow. The bottle surfaces are silver plated and the emissivity of each surface is 0.03. If the contents of the bottles are at 100 °C. Find the rate of heat loss from the thermos bottle to the ambient air at 27 °C. What thickness of cork (k=0.03 W/m-K) would be required if the same insulating effect is to be achieved by the use of cork ? **07**

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