Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC- SEMESTER–VI • EXAMINATION – SUMMER 2014

Subject Code: X61903 Date: 03-06-2014

Subject Name: Heat and Mass Transfer

Time:10.30 am to 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.**
4. **Notations carry usual meaning.**

Q.1 **(a)** Explain the concept of lump parameter approach. Prove that the temperature of a body at any time τ during heating or cooling is given by the relation: **07**

$$\frac{T-T_\infty}{T_i-T_\infty}=e^{-B_iF_o}$$

(b) What do you understand by critical radius of insulation? Derive an expression for critical radius of insulation in case of cylindrical body **07**

Q.2 **(a)** Develop expressions for temperature distribution and heat transfer under one dimensional steady state heat conduction for a cylindrical body. **07**

(b) The temperature of air in a reservoir is measured with the aid of a mercury-in-glass thermometer placed in a steel protective well filled with oil. The thermometer shows the temperature at the end of the well 84°C.How large is the measurement error due to transfer of heat by conduction along the protective well if the temperature at the base of the well is 40°C.The well is 12cm long, its thickness is 1.5mm and thermal conductivity of well material is 55.8 W/mK. Heat transfer coefficient between well and air is 23.5 $W/m^{2^\circ}K$. **07**

OR

(b) A furnace wall is made up of a steel plate 1 cm thick, lined on the inner surface with silica bricks 15 cm thick, and on the outer surface with magnesite bricks 15 cm thick. The temperature on the inner edge of the wall is 700°C and on the outer edge is 150°C .Find the heat lost in W/m^2 and the temperature at the interface of steel and magnesite bricks. Take the value of thermal conductivities for steel, silica bricks and magnesite bricks as 16.86,1.74 and 5.23 W/mK respectively. **07**

Q.3 **(a)** Derive an expression of effectiveness of parallel flow heat exchanger in terms of NTU and CR. Hence write expression for condenser. **07**

(b) Water enters the tubes of a small heat exchanger at 20°C and leaves at 40 °C. On the shell side 25 kg/min of steam is condensing at 60°C.Calculate overall heat transfer coefficient and the required flow rate of the water if the exchanger area is $12m^2$.The latent heat at 60°C is equal to 2358.7kJ/kg. **07**

OR

Q.3 **(a)** Using dimensional analysis show that heat transfer by natural convection is given by Nu=f(Gr,Pr) **07**

(b) A flat plate 1 m wide and 1.5 m long is to be maintained at 90 °C in air with a free stream temperature of 10 °C .Determine velocity at which the air must flow over the flat plate so that rate of energy dissipation from the plate is 3.75 kW. Assume that the flow over the plate is turbulent and it experiences the transition from laminar to fully turbulent flow at $Re_{critical}=5\times10^5$. **07**

Properties at a temperature of 50 °C :

$\rho = 1.0877$ kg/m^3

$c_p = 1007.3$ J/kg K

$\mu = 2.029\times 10^{-5}$ kg/m.s

k=0.02813W/m K

Pr=0.703

The above process can be described by the following equation:

$Nu_L = [0.036Re_L^{4/5} - 836]Pr^{1/3}$

Q.4 **(a)** What are radiation shields? Prove heat exchange equation for N no. of shields. **07**

(b) Determine heat lost by radiation per meter length of 80 mm diameter pipe at 300 °C ,if **07**

(i) Located in a large room with red brick walls at a temperature of 27°C.

(ii) Enclosed in a 160 mm diameter red brick conduit at a temperature of 27°C.

Take emissivity of pipe and brick conduit as 0.79 and 0.93 respectively.

OR

Q.4 **(a)** Develop an expression for net heat exchange between two grey bodies/surfaces. **07**

(b) (i) Define the terms: absorptivity, reflectivity and transmissivity of radiation **03**

(ii) State and explain Wien's displacement law. **04**

Q.5 **(a)** Discuss various regimes of pool boiling. **07**

(b) Derive an expression for the temperature distribution and heat transfer rate for a fin of infinite length. **07**

OR

Q.5 **(a)** A 40 mm deep cylindrical vessel is filled with water up to a level of 20mm.It is exposed to dry air having pressure of 1 bar and temperature of 35°C.The mass diffusivity of water is 0.25×10^{-4} m^2/s. Calculate the time required for all the water to evaporate. **07**

(b) Prove that steady state mass diffusion rate through a plane film of thickness L is given by the equation $m_A=A(D/L)(C_{A1}-C_{A2})$. **07**

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