Reg.No.										

MANIPAL UNIVERSITY

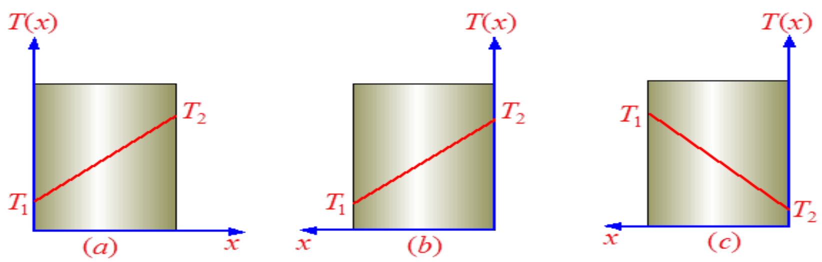
Fourth Semester B.Tech. (Chemical Engineering)

END SEMESTER EXAMINATION – MAY 2016

SUBJECT: HEAT TRANSFER OPERATIONS (CHE 208)

Time : 3 hrs **Max Marks: 100**

- **Answer any FIVE full questions and all questions carry equal marks.**
- **Missing data, if any, may be assumed suitably.**

<table>
<tr><td>1A.</td><td>Derive an expression to determine the temperature distribution (T) and heat flow (Q) for a hollow sphere with uniform internal heat generation.</td><td>(12 marks)</td></tr>
<tr><td>1B.</td><td>Consider a plane wall 100mm thick and of thermal conductivity 100 W/m.K. Steady state conditions are known to exist with T_1= 400 K and T_2= 600 K . Determine the heat flux and the temperature gradient dT/dx for the co-ordinate systems shown below:

</td><td>(8 marks)</td></tr>
<tr><td>2A.</td><td>What is critical radius of insulation?
Consider a steam pipe of 10 cm inner diameter and 11 cm outer diameter is covered with an insulating material (k = 0.8 W/m.ºC). The steam temperature and the ambient temperatures are 200ºC and 20ºC respectively. If the convective heat transfer coefficient between the insulating surface and air is 8 W/m^{2}ºC.Find the critical radius of insulation. For this value of r_0, calculate the heat loss per metre of pipe and the outer surface temperature. Neglect resistance of the pipe material.</td><td>(10 marks)</td></tr>
<tr><td>2B.</td><td>A large vertical plate of 6m high and 1.2 m wide is maintained at a constant temperature of 57ºC and exposed to atmospheric air at 4ºC. Calculate the heat loss by free convection by the plate.
Properties of air at an average temperature of 30.5 ºC:
Density = 1.16 kg/m^3 ; C_p = 1.007 KJ/kg ºC ;
Kinematic viscosity = 15.89 x 10^{-6} m^2/sec; K = 26.3 x 10^{-2} W/mºC</td><td>(6 marks)</td></tr>
<tr><td>2C.</td><td>Derive an expression for unsteady state heat conduction. State its assumptions.</td><td>(4 marks)</td></tr>
<tr><td>3A.</td><td>A cylinder 1m long and 5cm in diameter is placed in an atmosphere at 45 ºC . It is provided with 10 longitudinal straight fins of material having k=120 W/m°C. The height of 0.76mm thick fins is 1.27cm from the cylinder surface. The heat transfer coefficient between cylinder and atmosphere air is 17 W/m^2.°C. Calculate the rate of heat transfer and the temperature at the end of fins if surface temperature of cylinder is 150°C.</td><td>(10 marks)</td></tr>
<tr><td>3B</td><td>Define NTU and effectiveness of heat exchanger? Derive a relationship between them for parallel type heat exchanger.</td><td>(10 marks)</td></tr>
</table>

4A.	Water is flowing at the rate of 10,000 kg/hr through the tubes of a water-water heat exchanger and is heated from 25 ºC to 70 ºC.Hot water at 90 ºC is available but the minimum discharge temperature of the water has to be 76 ºC.U_i of 25 mm diameter tube in a shell and tube exchanger is 900 kcal/hr m^2 ºC.If the hot water makes one shell pass and the design water velocity in the tube is 0.45 m/sec.Calculate length of the heat exchanger.Assume correction factor for LMTD as 0.86.	**(10 marks)**
4B.	Water at the rate of 68 kg/min is heated from 35°C to 75°C by oil having a specific heat of 1.9 kJ/kg-K. The fluids are used in a counterflow and parallel flow double pipe heat exchanger, and the oil enters the exchanger at 110°C and leaves at 75°C. The overall heat transfer coefficient is 320 W/m^2.C. Calculate the heat exchanger area for counterflow and parallel flow heat exchangers independently. Assume c_p = 4.180 kJ/kg-K for water.	**(10 marks)**
5A.	Compare the efficiency of a plate fin of length (L) as 1.5cm and thickness 2.0 mm for the following 2 cases. (i)Fin material is made of aluminium (k=210 W/mK) and the heat transfer coefficient is 285 W/m^2K. (ii)Fin material is made of steel (k = 40 W/mK) and heat transfer coefficient is 510W/m^2K	**(8 marks)**
5B.	Write a short note on the following: (i) Pool boiling (ii) Nucleate boiling (iii) Drop-wise condensation (iv) Stefan Boltzmann law	**(12 marks)**
6A.	A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 K and have emissivities ε_1= 0.2 and ε_2= 0.2, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield.	**(8 marks)**
6B.	Determine the heat transfer coefficient for water flowing in a pipe of 4.2 cm diameter at a velocity of 8 m/s. The temperature of the tube wall is 82ºC and water enters at 25 ºC and leaves at 57 ºC. Physical properties of water are given below: ρ = 990 kg/m^3 k = 0.63 W/mK μ = 7 x 10^{-4} Ns/m^2 C_p = 4160 J/kg ºC $\mu_{82\,ºC}$ = 3.54 x 10^{-4} Ns/m^2 Use all the equations given below for finding out heat transfer coefficient: Dittus-Boltzer equation,Sieder Tate equation and Coulburn j-H factor.	**(12 marks)**