Reg.No.										

MANIPAL UNIVERSITY

Fourth Semester B.Tech.(Chemical Engineering)

END SEMESTER EXAMINATION –MAY 2017

SUBJECT: HEAT TRANSFER OPERATIONS (CHE 2202)

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

- **Answer all questions.**
- **Missing data, if any, may be assumed suitably.**

1A.	Derive an expression for temperature distribution and heat flow through a solid sphere having variation in thermal conductivity.	(8 marks)
1B.	The inside surface of a brick wall (k = 1 W/m°C) of 10 cm thickness is at a temperature of 930°C and the outside surface is exposed to ambient air at 30°C providing a heat transfer coefficient of 20 W/m^2°C. Calculate the temperature of the outside surface. Calculate the thickness of insulation (k = 0.1 W/m°C) that is needed so that outside surface temperature exposed to air will not exceed 90°C	(6 marks)
1C.	What is effectiveness of fin and derive a relation for the same.	(6 marks)
2A.	Stainless steel ball of diameter 3 cm is uniformly heated to a temperature of 800°C. It is to be hardened by first cooling in an oil bath to a temperature of 100°C . The heat transfer coefficient and the oil bath temperature are 700 W/m^2°C and 40°C respectively. What is the time required for this process? Properties of Stainless steel are: k = 61 W/m°C, density = 7865 kg/m^3, C_p = 0.46 kJ/kg°C	(8 marks)
2B.	What is Biot number? Derive an expression using Biot number for determination of temperature and heat flow distribution for a plane wall with internal heat generation rate.	(12 marks)
3A.	In an industry, 0.6 kg/sec of oil (C_p = 2.5 kJ/kg K) is to be cooled in counter current flow heat exchanger from 110 ºC to 35 ºC by using cooling water at 20 ºC.The overall heat transfer coefficient is 1500 W/m^{2}K. If the exit temperature of water is not to exceed 80 ºC, using NTU method, calculate (a) Water flow rate (b) Heat transfer area required (c) Effectiveness of heat exchanger	(6 marks)
3B.	Explain about enthalpy balances in heat exchanger?	(4 marks)
3C.	Water is passed through annular space of 5 cm outer tube diameter and 3 cm inner tube diameter at 0.5 m/sec velocity. Wall temperature of inner tube is maintained at 80°C.Inlet water temperature is 20°C.Find heat transfer coefficient between water and tube. Data are given below: Density of water = 988 kg/m^3, C_p at constant pressure = 0.993 kcal/kg°C Thermal conductivity of water = 0.557 kcal/hr.m°C, kinematic viscosity = 0.55 x 10^{-6} m^2/sec, viscosity correction factor = 1	(10 marks)

4A.	A hot square plate (50 cm) at 100 ºC is exposed to atmospheric air at 20 ºC. Find the heat loss from both surfaces of the plate. i) if the plate is kept at vertical plane ii) if the plate is kept in horizontal plane Air properties at an average temperature of 60 ºC: Density = 1.06 kg/m^3 C_p = 0.24 kcal/kg ºC Kinematic viscosity= 18.99 × 10^{-6} m^2/sec k = 2.49 × 10^{-2} kcal/hr mºC	(5 marks)
4B.	What is Prandtl mixing length? Explain Prandtl Analogy? Derive an expression to determine Stanton number as $N_{st} = \frac{f/2}{1 + \delta\sqrt{f/2}(Pr-1)}$	(10 marks)
4C.	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 radiative heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield.	(5 marks)
5A.	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 the number of tubes and length of the heat exchanger.Assume correction factor for LMTD as 0.86.	(10 marks)
5B.	Write a short note on the following: (i) Pool boiling (ii) Nucleate boiling (iii) Dropwise condensation (iv) Kirchoff's law of radiation (v) Radiation shield	(10 marks)