Reg.No.										

MANIPAL UNIVERSITY

Fourth Semester B.E.(Chemical Engineering)

END SEMESTER EXAMINATION – MAY 2016

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 in the radial direction for the case of a long cylinder of radius 'R' with uniformly distributed heat source having variation in thermal conductivity. Consider wall surface temperature as T_w.	**(12 marks)**
1B.	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 and 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, ρ = 7865 kg/m^3, C_p = 0.46 kJ/kg°C	**(8 marks)**
2A.	The composite wall of an oven consists of three materials, two of which are of known thermal conductivity, k_A = *20* W/m.°C and k_c = 50 W/m.°C and known thickness, L_A = *0.3* m and L_c = 0.15 m. The third material, B, which is sandwiched between materials A and C, is of known thickness, L_B = 0.15 m, but unknown thermal conductivity k_B. Under steady state conditions, measurements reveal an outer surface temperature of 20°C, an inner surface temperature of 600°C, and oven air temperature of 800°C. The inside convection coefficient h is known to be 25 W/m^2. °C. What is the value of k_B?	**(8 marks)**
2B.	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.	**(5 marks)**
2C.	Aniline is to be cooled from 60.6°C to 21.1°C in the inner pipe of a double pipe heat exchanger having outside area of 6 m^2.Toluene flows counter-currently to that of aniline and it is entering jacket at 18.3°C. Calculate the outer temperature of toluene, LMTD and overall heat transfer coefficient. Data given below may be used. Data: Aniline: Specific heat J/kg°C: 2300; Toluene: 1800 Flow rate kg/hr: Aniline: 4500; Toluene: 8000	**(7 marks)**
3A.	A copper fin of diameter 4 mm and length 25 mm is used to transfer heat from a base surface at a temperature of 350 K to ambient air at 300 K by natural convection. Calculate the heat transfer rate. Assume the fin tip to be adiabatic. The geometry is assumed to be placed horizontally. Properties of air over the working temperature range: $\gamma = 18.41\times10^{-6}$ m^2/s, Pr = 0.704, k = 0.0282 W/m-K and $\beta = 0.003$ K^{-1}. Properties of copper over the working temperature range: k = 400 W/m-K.	**(6 marks)**

3B.	Derive the Prandtl's Analogy equation? What is Prandtl mixing length?	**(10 marks)**
3C.	The overall heat transfer coefficient due to convection and radiation for a steam pipe at 200°C running in a large room at 30°C is 17.95 W/m^2°C. Calculate the heat transfer coefficient due to convection and radiation. Take emissivity of pipe surface as 0.8.	**(4 marks)**
4A.	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.	**(10 marks)**
4B.	Cold water leading to a shower enters a thin walled double pipe counter flow heat exchanger at 0.25 kg/s at 15°C and is heated to 45°C by hot water that enters at 100°C and 3 kg/s. If the overall heat transfer coefficient is 950 W/m^2-°C, determine the heat transfer rate and the area of the heat exchanger by $\varepsilon - NTU$ method. Assume specific heat of water to be 4180 J/kg°C. Given: m_c = 0.25 kg/s, m_h = 3 kg/s, T_{ci} = 15 °C, T_{hi} = 100 °C, T_{co} = 45 °C, U = 950 W/m^2°C	**(10 marks)**
5A.	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 ν = 18.99×10^{-6} m^2/sec k = 2.49×10^{-2} kcal/hr mºC	**(6 marks)**
5B.	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	**(8 marks)**
5C.	(i)What are the differences between film-wise condensation and drop-wise condensation? (ii) Explain about heat transfer in liquid metals and heat transfer in fluidized bed reactor?	**(6 marks)**