Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)
MAKEUP EXAMINATIONS, MAY/JUNE 2019

SUBJECT: HEAT TRANSFER OPERATIONS

[CHE 2202]
REVISED CREDIT SYSTEM

Date : **Time: 2 – 5 PM** **MAX. MARKS: 50**

Instructions to Candidates:

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

1A. Derive an expression to determine heat flow (Q) for a hollow cylinder with uniform internal heat generation. **(6 marks)**

1B. 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. **(4 marks)**

Data	Aniline	Toluene
Specific heat J/kg°C	2300	1800
Flow rate kg/hr	4500	8000

2A. An ordinary egg can be approximated as a 5 cm diameter sphere. The egg is initially at a uniform temperature of 5^0 C and is dropped into boiling water at 95^0 C. Taking the convection heat transfer coefficient to be h = 1200 W/$m^{2.0}$ C, determine how long it will take for the center of the egg to reach 70^0 C.

Properties: k = 0.627 W/m.^{0}C and $\alpha = 0.151 \times 10^{-6}$ m^2/s **(4 marks)**

2B.	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 ratio of heat transfer rate. Assume the fin tip to be adiabatic. Properties of air over the working temperature range: $\vartheta = 18.41 \times 10^{-6}$ 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.	**(4 marks)**
2C.	Identify the mode of heat transfer for the following: (i) Heat loss from a thermos flask (ii) Heat transfer from a radiator (iii) Heating of water in a bucket with an immersion heater (iv) Condensation of steam in a condenser	**(2 marks)**
3A.	(i)Explain the concept of black body? What is monochromatic emissive power? (ii)What is Wein's Displacement Law?	**(2 marks)**
3B.	Water at the rate of 4 kg/sec is heated from 37ºC to 55ºC in a 1-2 shell and tube heat exchanger. On the shell side hot water is used as a heating fluid which flows inside the heat exchanger at a mass flow rate of 1.9 kg/sec and at a temperature of 94ºC. The overall heat transfer coefficient is 1420 $W/m^{2o}C$. The average velocity of water flowing inside the tubes is 0.366 m/sec.The diameter of the tubes is 1.9 cm. The correction factor value F = 0.9. The length of the tubes must not be longer than 3 metres because of space limitations. Calculate the number of tubes per pass.	**(5 marks)**
3C.	What is steam economy and capacity in an evaporator? Classify the different types of evaporator.	**(3 marks)**
4A.	A 7.5cm diameter iron pipe carries steam at a pressure of 7.12atm (167°C). The line is unlagged and is 60m long. It losses heat to the surroundings by conduction, convection and radiation. The surroundings are at 30°C. The emissivity of the pipe wall is 0.7 and the view factor may be assumed to be unity. The convection heat transfer coefficient may be taken as 7.0 kcal/hr m°C. If the latent heat of steam is 500 kcal/Kg. How many kilograms of steam will condense per hour. $\sigma = 4.875 \times 10^{-8}$ Kcal/hr m^2K^4	**(3 marks)**
4B.	It is desired to concentrate 5000kg/hr of a solution of sodium hydroxide from 10% to 25%solids in a single effect evaporator. Steam is available at 110 deg C and the vapor space is maintained at 410 mm of Hg. The boiling point of water corresponding to the vapor space is 84deg C. The solution has a boiling point	

	elevation of 10deg C. The enthalpies of the feed and thick liquor are 90 and 80 kcal/kg respectively and the enthalpy of vapor is 650kcal/kg. The feed enters at its boiling point corresponding to the vapor space pressure. Latent heat of vaporization is 534 kcal/kg (a) Calculate the steam consumption per hour (b) If the available heat transfer area is 35m^2, estimate the heat transfer coefficient.	**(5 marks)**
4C.	What are the differences between filmwise condensation and dropwise condensation?	**(2 marks)**
5A.	In a condensing unit steam flows outside the tubes 59 mm outer diameter, 54 mm inner diameter and water flows through the tube.The thermal conductivity of the tube material is 60 W/mk. Convection heat transfer coefficient on steam and water side is 12000 and 650 W/m^2K respectively.Assume dirt resistance of 0.0000877 m^2K/W on both sides of the tube.Calculate the heat transfer coefficient based on outside diameter of the tube.	**(3 marks)**
5B.	A batch of 1,000 kg of KCl is dissolved in sufficient water to make a saturated solution at 363 K, where the solubility is 35 wt % KCl in water. The solution is cooled to 293 K, at which temperature its solubility is 25.4 wt %. What is the weight of water required for the solution and the weight of KCl crystals obtained?	**(4 marks)**
5C.	Explain the following terminologies in crystallization (i)Super saturation (ii)Crystal growth	**(3 marks)**