Name:

Enrolment No:

UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

Course : Heat Transfer — **Semester : IV**
Program : B. Tech. (CERP) — **Time : 03 hrs.**
Course Code: CHCE 2009/GNEG 257 — **Max. Marks : 100**

Instructions:

- ✓ Attempt **all** questions from **Section-A** (each carrying 10 marks), **Section-B** (each carrying 15 marks) and **Section-C** (carrying 20 marks).

Assume suitable data wherever necessary. The notations used here have the usual meanings.

SECTION-A

S. No.		Marks	CO
1.	A metallic ball (ρ = 2700 kg/m^3 and C_p = 0.9 kJ/kg-K) of diameter 7.5 cm is allowed to cool in air at 25 ^{0}C. When the temperature of the ball is 125 ^{0}C, it is found to cool at the rate of 4 ^{0}C per minute. Determine the heat transfer coefficient between the ball surface and air.	**10**	**CO1**
2.	A single effect evaporator is to concentrate (***xxxx***) kg/hr of 20% solution of sodium hydroxide to 50% solids, where (***xxxx***) are the ***last four digits*** of your **SAP ID**. The gauge pressure of the steam is 1.73 atm; the absolute pressure in the vapour space is 100 mmHg. The overall coefficient is estimated to be 1400 W/m^2.^{0}C. The feed temperature is 37.8 ^{0}C. Calculate the amount of steam consumed, the economy and the heating surface required. Data: Enthalpy of 20% solution = 127.931 kJ/kg Enthalpy of 50% solution = 513.95 kJ/kg B.P. of water at 100 mmHg = 126.11 ^{0}C B.P. of solution at 100 mmHg = 91.67 ^{0}C Enthalpy of water vapour at 91.67 ^{0}C = 2672 kJ/kg Heat of vaporization of steam (B.P. 126.11 ^{0}C) at 1.37 atm(g) = 2184 kJ/kg	**10**	**CO3**

SECTION-B

S. No.		Marks	CO
3.	Water is boiled at atmospheric pressure on a copper surface, which is electrically heated. Estimate the heat flux from the surface to water, if the surface is maintained at 110 ^{0}C. The properties of water at 100°C are: h_{fg} = 2257 kJ/kg, ρ = 958.4 kg/m^3, ρ_v = 0.5977 kg/m^3, C_p = 4.211 kJ/kg-K, μ_f = 277.5 × 10^{-6} N.s/m^2, Pr=1.75 The value of	**15**	**CO2**

	vapour liquid surface tension σ = 58.9×10^{-3} N/m and C_{sf} = 0.013. Estimate the peak heat flux also. For Nucleate boiling: $$\frac{C_p\,\Delta T_x}{h_{fg} Pr^n} = C_{sf}\left[\frac{(q/A)}{\mu\, h_{fg}}\sqrt{\frac{g_c\,\sigma}{g\,(\rho-\rho_v)}}\right]^{0.33}$$ For peak heat flux: $$\frac{q}{A} = \frac{\pi}{24} h_{fg}\,\rho_v\left[\frac{\sigma\, g\,(\rho-\rho_v)}{\rho_v^2}\right]^{0.25}\left[1+\frac{\rho_v}{\rho}\right]^{0.5}$$		
4.	For a hemispherical furnace, the flat floor is at 700 K and has an emissivity of 0.5. The hemispherical roof is at 1000 K and has emissivity of 0.25. Find the net radiative heat transfer from the roof to the floor.	**15**	**CO1**
5.	Steam in a condenser of a steam power plant is to be condensed at a temperature of 30 ^{0}C with cooling water entering at 14 ^{0}C and leaving at 22 ^{0}C. The surface area of tubes is 45 m^2 and the overall heat transfer coefficient is (***xxxx***) W/m^2-K, where (***xxxx***) are the ***last four digits*** of your **SAP ID**. Determine the mass flow rate of the cooling water needed and the rate of condensation of steam. Heat of condensation of steam, h_{fg} at 30 ^{0}C is 2430.5 kJ/kg.	**15**	**CO3**
6.	A 2 m × 1.5 m section of wall of an industrial furnace burning natural gas is not insulated, and the temperature at the outer surface of this section is measured to be 80°C. The temperature of the furnace room is 30°C, and the combined convection and radiation heat transfer coefficient at the surface of the outer furnace is 10 W/m^2-°C. It is proposed to insulate this section of the furnace wall with glass wool insulation (k =0.038 W/m-°C) in order to reduce the heat loss by 90 percent. Assuming the outer surface temperature of the metal section still remains at about 80°C, determine the thickness of the insulation that needs to be used.	**15**	**CO1**
	SECTION-C		
7.	A chemical industry produces 200 tons of sulfuric acid per day when running at 24 hours. The acid is cooled in a counter flow double pipe heat exchanger from 60 ^{0}C to 40 ^{0}C. The cooling medium employed is water, which enters the heat exchanger at 15 ^{0}C and leaves at 20 ^{0}C. The acid flows through the inner pipe, while water flows through the annulus. The inner and outer diameters of the inner pipe are 70 mm and 80 mm, respectively, while that of outer pipe are 120 mm and 130 mm, respectively. The thermal conductivity of the inner pipe is 46.5 W/m-K. Use Dittus-Boelter's equation for the estimation of heat transfer coefficients. Calculate the (a) mass flow rate of water in kg/h.	**20**	**CO3**

	(b) length of the heat exchanger. The properties of water at mean bulk temperature are: $\rho = 998.2$ kg/m^3, $C_p = 4.18$ kJ/kg-K, k = 0.598 W/m-K and $\upsilon = 1.006 \times 10^{-6}$ m^2/s. The properties of acid at mean bulk temperature are: $\rho = 1800$ kg/m^3, $C_p = 1.465$ kJ/kg-K, k = 0.302 W/m-K and $\upsilon = 6.8 \times 10^{-6}$ m^2/s.		