Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FOURTH SEMESTER B.TECH DEGREE EXAMINATION (S), AUGUST 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT204**

Course Name: **Heat Transfer Operations**

Max. Marks : **100** **Duration: 3 Hours**

Use of Photostat copies of the following equations duly attested by the concerned faculty shall be permitted in the exam hall.
1. Heisler chart and table.
2. Thermophysical property tables and charts.
Approved temperature profile Reynolds and Nusselt number relationships table.

(Answer all questions. Each question carries 3 marks)

1. Compare and contrast the three modes of heat transfer
2. What do you understand by critical radius of insulation and give its expression?
3. Briefly explain the significance of heat transfer coefficient.
4. What is velocity and thermal boundary layer?
5. Compare and contrast two types of condensation.
6. State Stefan Boltzmann's law of radiation.
7. What is meant by a pitch? Draw a schematic arrangement of a square pitch?
8. Define LMTD correction factor.
9. Why the economy of a single effect evaporator is less than one?
10. Define the terms capacity, steam economy and steam consumption for an evaporator.

PART B

(Answer one full question from each module, each question carries 14marks)

MODULE I

11. a) A 12 cm diameter long bar initially at a uniform temperature of 40^{o}C is placed in a medium at 650^{o}C with a convective co-efficient of 22 W/m^{2}K. calculate the time required for the bar to reach 255^{o}C and C_p = 1050 J/kg K. (7)

    b) Derive equation for the steady state heat conduction through a composite wall. (7)

OR

12. A steel pipe line (k=50 W/mK) of I.D is 100 mm and O.D 110 mm is to be covered with two layers of insulation each having a thickness of 50 mm. The thermal conductivity of first insulation materials is 0.06 W/mKand that of second is 0.12 W/mK. Calculate the loss of heat per metre length of pipe and the interface temperature between the two layers of insulation when the temperature of the inside tube surface is 250˚C and that of outside surface of the insulation is 50˚C. (14)

MODULE II

13. Derive an expression for forced convection heat transfer using dimensional analysis. (14)

OR

14. A 2.54 cm diameter pipe is maintained at a constant temperature of 90°C. Water flow inside the tube at 4 m/s. if the inlet and outlet temperatures are 40°C and 60°C respectively. Calculate the length of the tube necessary to accomplish heating. Use the following data ρ =990kg/m^3, μ = 4 x10^{-4} kg/ms, k = 0.664 W/ m°C, C_p = 4174J/kg°C (14)

MODULE III

15. Explain the regimes of boiling heat transfer with the help of a boiling curve for water. (14)

OR

16. a) Calculate the net radiant interchange per square meter for very large planes at temperature of 703K and 513K respectively. Assume that the emissivities of hot and cold planes are 0.85 & 0.75 respectively. (7)

    b) Dry steam at 373 K (100^{0}C) condenses on the outside surface of a horizontal pipe of outside diameter 25 mm. The pipe surface is maintained at 357 K (84^{0}C) by circulating water through it. Determine the mean heat transfer coefficient, the heat transfer per unit length of the pipe and the condensate rate per unit length of the pipe. Data: The properties of the condensate at the film temperature of 350K are, μ = 306x10^{-6} Ns/m^2 , k=0.668 W/mK ρ =974 kg/m^3 λ=2225 kJ/kg (7)

MODULE IV

17. A refrigerator is designed to cool 250kg/h of hot liquid of specific heat 3350J/kgK at 120^{0}C using a parallel flow arrangement. 1000kg/h of cooling water is available for cooling purposes at a temperature of 10^{0}C. If the overall heat transfer coefficient is 1160W/m^{2}K and the surface area of the heat exchanger is 0.25m^2, calculate the outlet temperatures of the cooled liquid and water and also the effectiveness of the heat exchanger. (14)

OR

18. a) Derive an expression for LMTD for a co-current flow heat exchanger (7)

b) Hot oil with a capacity rate 2500 W/K flows through a double pipe heat exchanger. It enters at 360^0C and leaves at 300^0C. Cold fluid enters at 30^0C and leaves at 200^0C. If the overall heat transfer coefficient is 800W/m^2K, determine the heat exchanger area required for (a) parallel flow (b) counter flow. (7)

MODULE V

19. Discuss the different feeding arrangements in multiple effect evaporators with neat sketches. (14)

OR

20. An evaporator is operating at atmospheric pressure. It is desired to concentrate the feed from 5% solute to 20% solute (by weight) at a rate of 5000kg/hr. Dry saturated steam at a pressure corresponding to saturation temperature of 399 K (126˚C) is used. The feed is at 298K (25˚C) and boiling point rise (Elevation) i.e. B.P.E.(B.P.R) is 5 K. The overall heat transfer coefficient is 2350W/(m^2.K). Calculate the economy of the evaporator and the area of heat transfer to be provided. Data: Latent heat of condensation of steam at 399 K = 2185kJ/kg Latent heat of vaporization of water at 373K = 2257 kJ/kg, Specific heat of feed = 4.187 kJ/kg.K (14)

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