# GANDHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, ODISHA, GUNUPUR (GIET UNIVERSITY)

B. Tech (Third Semester - Regular) Examinations, November – 2024

## 23BCHPC23001 – HEAT TRANSFER

(Chemical Engineering)

Time: 3 hrs Maximum: 60 Marks

**Answer ALL questions**

**(The figures in the right hand margin indicate marks)**

**PART – A** **(2 x 5 = 10 Marks)**

Q.1. Answer ***ALL*** questions

| | Question | CO # | Blooms Level |
|---|---|---|---|
| a. | Define Fourier's law of heat conduction. What are the assumptions made for Fourier's law of heat conduction? | CO2 | K1 |
| b. | Why at the critical thickness of insulation the rate of heat transfer is maximum? | CO3 | K4 |
| c. | A hot fluid enters in a DPHE at $15^{0}$C and to be cooled to $94^{0}$C by a cold fluid which enters at $38^{0}$C and heated to $66^{0}$C.Shall they be directed in parallel or counter? | CO1 | K2 |
| d. | Define Stefan-Boltzmann Law. | CO6 | K1 |
| e. | Draw a neat sketch for 1-2 parallel counter flow heat exchangers. | CO5 | K2 |

**PART – B** **(10 x 5=50 Marks)**

<u>Answer ***ALL*** the questions</u>

| | Question | Marks | CO # | Blooms Level |
|---|---|---|---|---|
| 2. a. | Derive the expression for one dimensional steady state heat conduction through a composite cylinder. | 5 | CO1 | K1 |
| b. | Calculate the rate of heat loss through the vertical walls of a boiler furnace of size 4m by 3 m by 3 m high. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/mK, a layer of ceramic blanket insulation of thermal conductivity 0.2 W/mK and 8 cm thick, and a steel protective layer of thermal conductivity 55 W/mK and 2 mm thick. The inside temperature of the fire brick layer was measured at $600^{0}$C and the temperature of the outside of the insulation $60^{0}$C. Also find the interface temperature of layers. | 5 | CO1 | K1 |
| | (OR) | | | |
| c. | Derive the expression for one dimensional steady state heat conduction through a composite sphere. | 5 | CO1 | K4 |
| d. | A spherical container of negligible thickness holding a hot fluid at $140^{0}$C and having an outer diameter of 0.4 m is insulated with three layers of each 50 mm thick insulation of $k_1 = 0.02$: $k_2 = 0.06$ and $k_3 = 0.16$ W/mK. (Starting from inside). The outside surface temperature is $30^{0}$C. Determine (i) the heat loss, and (ii) Interface temperatures of insulating layers. | 5 | CO2 | K3 |
| 3.a. | Derive Nusselt equation by Dimensional analysis for free convection heat transfer. | 6 | C03 | K3 |
| b. | Analyze the following dimensionless number and their importance<br>i. Reynolds Number ii. Prandlt Number iii. Nusselt Number | 4 | C02 | K2 |
| | (OR) | | | |
| c. | Derive Nusselt equation by Dimensional analysis for forced convection heat transfer. | 6 | C03 | K2 |
| d. | Analyse the empirical correlation for long tube in laminar flow and for the for the turbulent flow. | 4 | C03 | K2 |

| | | | | | |
|---|---|---|---|---|---|
| 4.a. | Water flows at the rate of 65 kg/min through a double pipe counter flow heat exchanger. Water is heated from $50^0$C to $7^0$C by an oil flowing through the tube. The specific heat of the oil is 1.780 kJ/kg.K. The oil enters at $115^0$C and leaves at $70^0$C. The overall heat transfer co-efficient is 340 W/$m^2$K.calcualte the following<br>1. Heat exchanger area 2. Rate of heat transfer | 8 | C04 | K3 |
| b. | When LMTD correction factor used in heat exchanger calculation. | 2 | C04 | K1 |
| | (OR) | | | |
| c. | A counter flow double pipe heat exchanger using superheated steam is used to heat water at the rate of 10500 kg/hr. The steam enters the heat exchanger at $180^0$C and leaves at $130^0$C. The inlet and exit temperature of water are $30^0$C and $80^0$C respectively. If the overall heat transfer coefficient from steam to water is 814 W/$m^2$ K, calculate the heat transfer area. What would be the increase in area if the fluid flow were parallel? | 8 | C04 | K2 |
| d. | What are the various types of baffles used in heat exchangers. | 2 | C04 | K2 |
| 5.a. | Do the Heating area calculation for a Single effect evaporator. | 2 | CO5 | K2 |
| b. | Analyse the material and energy balance for Multiple effect forward feed arrangement evaporation process. | 8 | CO5 | K4 |
| | (OR) | | | |
| c. | Differentiate between capacity and economy of an evaporator. | 2 | CO5 | K1 |
| d. | An evaporator is to be fed with 5000 kg/hr of solution containing 10% solute by weight. The feed at $40^0$C is to be concentrated to a solution containing 40% by weight of the solute under an absolute pressure of 1.03 kg/$cm^2$. Steam is available at an absolute pressure of 1.03 kg/$cm^2$.Saturation temperature of the steam is $134^0$C.The overall heat transfer coefficient is 1500 kcal/hr$m^{20}$C. Calculate Heat transfer area that should be provided. | 8 | CO5 | K4 |

| Temperature $^0$C | Enthalpy, kcal/kg | |
|---|---|---|
| | Vapour | Liquid |
| 40 | 613.5 | 40.5 |
| 100 | 639.2 | 100.0 |
| 134 | 651.4 | 134.4 |

| | | | | |
|---|---|---|---|---|
| 6.a. | Differentiate between black and grey body. | 4 | CO6 | K1 |
| b. | A furnace radiation at 2000K. Treating it as a black body radiation, calculate the<br>(i)Monochromatic radiant flux density at 1 μm wavelength.<br>(ii)Wavelength at which emission is maximum and the corresponding radiant flux density<br>(iii)Total emissive power and<br>(iv)Wavelength λ such that emission from 0 to λ is equal to the emission from λ to ∞. | 6 | CO6 | K3 |
| | (OR) | | | |
| c. | Derive the expression for the rate of heat transfer by radiation within infinite Long parallel plates. | 4 | CO6 | K1 |
| d. | A sphere of radius 10 mm at a temperature of 600 K is dipped into the liquid at 300 Kelvin with a convective coefficient of 100 W/mK. find the time required to become temperature of the sphere equals to 500 K<br>The sphere has, c = 375 (J/Kg.K), ρ = 8700( Kg/$m^3$), K = 360 w/mK | 6 | CO6 | K3 |

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