Ref. No.: Ex/FTBE/BS/B/T/217/2025

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2025

HEAT TRANSFER

Time: 3 hrs (50 Marks for each Part) **Full Marks: 100**

Use separate answer scripts for each Part

Part-I (50 Marks)

Group-A

Answer any one question **1×10 = 10**

1. Define arithmetic mean area, logarithmic mean area and geometric mean area. Where these area are used in heat transfer? Write the expression of Furrier's laws. Where these are applicable? 3+2+5 = 10
2. Write the different types of convection processes. How N_{Nu} is related with N_{Re} and N_{Pr} in case of turbulent flow in a pipe line? Derive the expression of overall heat transfer coefficient in a shell and tube type heat exchanger. 3+2+5 = 10

Group-B

Answer any two questions **2×20 = 40**

3. (a) Derive the expression for conductive heat transfer rate under unsteady state conduction. What is thermal diffusivity? 8+2 = 10

   (b) A thick walled tube of stainless steel (A) having a K = 21.63 W/m.K with dimension of 0.0254 m ID and 0.0508 m OD is covered with a 0.0254m thick layer of an insulation, K = 0.2423 W/m.K. The inside wall temperature of the pipe is 811K and the outside surface of the insulation is at 310.8 K. For a 0.305 m length of pipe, calculate the heat loss and also the temperature at the interface between the metal and insulation. 10
4. (a) Name one dimension less group in which both thermal conductivity and heat transfer coefficient present. How it is related with other dimensionless groups in convective heat transfer in a pipe line under laminar flow condition? Write short note on natural convection. 2+3+5 = 10

   (b) Determine the heat transfer coefficient for water flowing in a tube of 16mm diameter at a velocity of 3m/s. the temperature of the tube is 24^0C and the water enters at 80^0C and leaves at 36^0C. Use the Dittus-Boelter equation $N_{Nu} = 0.023\ N_{Re}^{0.8} N_{Pr}^{0.3} (\mu/\mu_w)^{0.14}$

   The properties of water at arithmetic mean temperature of bulk = (80+36)/2 = 58^0C are:

   ρ = 984.1 kg /m^3; C_p = 4178 J/kg.K; = 485× 10^{-6}Pa.s; K = 0.657 W/m.K; at 24^0C, $\mu = 920 \times 10^{-6}$ Pa.s. 10
5. (a) What are the basic steps of radiative heat transfer? Define absorptivity, emissivity, transmitivity and write there correlation. Define black body & gray body. 3+3+4 = 10

   (b) The wall of a drying chamber are build up of a layer of red brick (K = 0.7 W/m.K) of thickness 250mm and a layer of felt (K = 0.046 W/m.K) of thickness 20 mm. the temperature of the outside surface of red brick layer is 110^0C and that of felt layer is 25^0C. Calculate the heat loss from 1 m^2 of the wall. 10

[Turn over

Ref. No.: **Ex/FTBE/BS/B/T/217/2025**

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2025

HEAT TRANSFER

Time: 3 hours FM: 100

Part: II

(Answer question no 4 and any two from the rest)

1. What is the importance of regeneration in plate heat exchanger explain with example?
   A square slab of butter which is 46.2 mm thick at a temperature of 277.6 k in a cooler is removed and placed at a temperature of 292K. The side and bottom is consider to be insulated. The convective coefficient is constant at 8.52 W/m^2. K. calculates the temperature the temperature of the butter at the surface and at 25.4 mm below the surface after 5 hr of exposer. 5+15=20

2. Saturated steam at 62.1 kPa is condensing on a vertical tube 0.349 m long having an outer diameter of 0.039 m and a surface temperature of 87^0 C. calculate the average heat-transfer coefficient using SI units. Use the following data for properties of water and steam
   Tsat =90^0 C, h_{fg} = 2.283x106 J/kg, ρ_l =966.7 kg/m3, ρv =0.391 kg/m3, μ_l = 3.24x10-4 Pa.s, κ_l =0.675 W/m.K.
   Describe the design procedure of plate heat exchanger. 15+5=20

3. Water is being boiled at 1 atm abs pressure in a jacketed kettle with steam condensing in the jacket at 114.6^0 C. the inside diameter of the kettle is 0.656 m and the height is 0.984 m. bottom should be consider as flat. Both the bottom and side up to 0.656 is jacketed. The kettle surface for heat transfer is 3.2 mm stainless steel with a k of 16.27 w/m.K. the condensing steam coefficient h_i inside the jacket has been estimated as 10300 W/m^2 K. Predict the boiling heat transfer coefficient h_0 for the bottom surface of the kettle. 20

4. Write down the relationship between heat transfer coefficient and temperature difference during film boiling and nucleate boiling phenomenon. Discuss different mechanism of condensation process. 5+5=10