Cat. No: Eden 1203
Title: Heat and Mass Transfer

I. Answer the following questions:

A. Choose the correct answer:

1. Amount of heat flow through a bo
   a) Directly proportional to the su
   b) Inversely proportional to the th
   c) Dependent on the material of th
   d) All the above
2. _____ needs no medium for heat transfer
   a) Conduction b) Convection
   c) Radiation d) None
3. The thermal conductivity is expressed as
   a) kcal/hr-m^2-°C b) kcal/hr-m-°C
   c) kcal/hr-°C d) kcal/m^2-°C
4. The analogy of conductivity in heat transfer to fluid flow is
   a) velocity of fluid
   b) density of fluid
   c) viscosity of fluid
   d) dielectric constant of fluid
5. Stefan-Boltzmann's law is applicable to
   a) grey body b) white body
   c) black body d) all the above

B. Fill in the blanks: 5 x 1 = 5

1. Mass transfer by molecular diffusion occurs as a result of driving potential caused by _____ gradient.
2. In heat exchangers, NTU stands for _____.
3. The negative sign in Fourier's equation is inserted to satisfy the _____law of thermodynamics.
4. The fins are used to _____ the heat flow from the surface.
5. The unit of overall heat transfer coefficient is _____.

II. Write short notes on any FIVE questions (5 x 2=10)

1. Define fouling factor and effectiveness of heat exchanger.
2. Define emissivity of an object and geometrical or shape factor.
3. Classify the types of heat exchangers based on the type of contact, direction of flow and type of construction.

4. Derive an expression for the shape factor in case of radiation exchange between two surfaces.
5. Derive an expression for conduction heat transfer through a hollow sphere.
6. State Fick's law of diffusion. What are its limitations.
7. Differentiate between parallel, counter and cross flow heat exchanger with neat sketch.

III. Write short essay on any FIVE questions (5 x 4=20)

1. Explain shell and tube heat (one pass tube - side) exchanger with a neat sketch.
2. A cold storage wall of 3 m x 6 m is constructed of 15 cm thick concrete of thermal conductivity =1.37 W/m°C. Insulation must be provided to maintain a heat transfer rate through the wall at or below 500 W. If the thermal conductivity of the insulation is 0.04 W/m°C, compute the required thickness of insulation. The outside surface temperature of the wall is 38 °C and the inside wall temperature is 5 °C.
3. Derive an expression for the Log Mean Temperature Difference (LMTD) in a single pass double-pipe parallel flow heat exchanger.
4. Derive an expression for steady state heat conduction through a composite wall.
5. What is insulation? Derive expression for critical thickness of insulation in case of pipes
6. (a) State and explain Wien's Displacement law. Show that $E_{b\lambda}$ will be maximum when $\lambda_{max} T = 2900\ \mu K$.
   (b) Assuming sun as black body radiating the heat at 5000 K, find the maximum monochromatic emissive power of the sun's surface.
7. A liquid food (specific heat =4.0 kJ/kg °C) flows in the inner pipe of a double-pipe heat exchanger. The liquid food enters the heat exchanger at 20 °C and exits at 60 °C. The flow rate of the liquid food is 0.5 kg/s. In the annular section, hot water at 90 °C enters the heat exchanger and flows counter-currently at a flow rate of 1 kg/s. The average specific heat of water is 4.18 kJ/kg °C. Assuming steady-state conditions.
   a) Calculate the exit temperature of water.
   b) Calculate the LMTD.
   c) If the average overall heat transfer coefficient is 2000 W/m^2 °C and the diameter of the inner pipe is 5 cm, calculate the length of heat exchanger.

IV. Write short note on any *ONE* of the following (1 x 10=10)

1. Define mass transfer? Write its application of mass transfer phenomenon in food processing?
2. Derive general heat conduction equation in:
   a. Cartesian coordinate b. Cylindrical coordinates c. Spherical coordinates

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