1. a) Write the importance of heat transfer in bioprocess.
   b) Explain three modes of heat transfer.
   c) Describe various methods of heat transfer in bio processing with suitable examples. [15]

2. a) What is thermal diffusivity. Explain in detail and write its unit.
   b) Derive an expression for the rate of heat transfer through a composite plane wall consisting of three heterogeneous layers having thermal conductivity: K1, K2 and K3 respectively. [15]

3. Write about Internal heat flows (Inside Tubes or Ducts) and draw fully developed velocity and temperature profiles. [15]

4. Discuss briefly the phenomenon of nucleate and film boiling. Explain with a neat diagram the various zones of boiling. [15]

   b) Define thermal conductivity of material and write units of it. [7+8]

6. A heat exchanger heats 25,000 kg/hr of water entering at 30°C while cooling 20,000 kg/hr of water from 100°C to 80°C. Determine the area necessary for
   i) Parallel flow
   ii) Counter flow arrangement.
   Overall heat transfer coefficient may be assumed as 1,600 W/m²K. [7+8]

7. With the help of neat sketches, discuss the classification of evaporators. Also, explain why is multiple effect operation preferred over a single effect evaporation unit? [15]

8. a) What is meant by Del factor?
   b) What is meant by inactivation factor? Give an expression for it. [7+8]
1. Distinguish between conduction, convection and radiation modes of heat transfer. [15]

2. A plane brick wall, 25 cm thick, is faced with 5 cm thick concrete layer. If the temperature of the exposed brick face is 70°C and that of the concrete is 25°C, find out the heat lost per hour through a wall of 15 m x 10 m. Also, determine the interface temperature. Thermal conductivity of the brick and concrete are 0.7 W/m.K and 0.95 W/m.K respectively. [15]

3.a) Explain the physical significance of Nusselt and Reynold numbers
b) What is Sieder Tate equation and why is it used. [7+8]

4.a) Explain about film boiling:
   b) Discuss the merits and demerits of film wise and drop wise condensation. [7+8]

5.a) What is called a perfect black body? Give examples.
   b) What is emissivity of a body?
   c) State Kirchoff's law of radiation. [15]

6. Define LMTD and explain the reason for which this concept is introduced in heat exchanger design. Explain why correction factors are being used when applying this technique for the design of multi-pass heat exchangers. [15]

7. Write short notes on:
   a) Circulation evaporators
   b) Long tube evaporators
   c) Falling film evaporators
   d) Agitated film evaporators. [15]

8. What is the effect of temperature on Del factor? Explain how del factor varies during heating and cooling with neat sketch. [15]
1. a) Discuss the different modes by which heat is transferred. Give suitable example to illustrate your answer.
b) Write the Fourier heat equation for heat transfer by conduction. Give the units and physical significance of each term appearing in this equation.

2. Derive an expression for determining the rate of heat transfer through the thick wall of a hollow cylinder. Also, find the temperature profile and its nature. State your assumptions clearly.

3. Write the significance of:
   i) Reynolds number
   ii) Nusselt Number
   iii) Prandlt Number.

4. a) Condensing equipments are always designed for film-wise condensation - why?
b) Discuss the regimes of boiling heat transfer with the help of a boiling curve. Why are heat transfer coefficients lowered in film boiling as compared to nucleate boiling?

5. a) What do you understand by black body and grey body? Explain
   b) Define reflectivity, absorptivity and transmissivity.

6. Derive an expression for LMTD for a parallel flow double pipe heat exchanger with neat sketch.

7. Discuss the different methods of feeding in evaporators with neat diagrams.

8. a) Describe how effective is plate heat exchanger for continuous sterilization of Medium.
b) Is plate heat exchanger useful for Batch sterilization explain?
1. Obtain an expression for the quantity of heat flow through a hollow cylinder with a neat sketch. [15]

2. A steel pipe (K = 50 W/M.K) of I.D. = 100 mm and O.D. = 110 mm is to be covered with two layers of insulation, each having a thickness of 50 mm. Thermal conductivity of the first insulation material is 0.06 W/M.K and that of the second is 0.12 W/M.K. Calculate the loss of heat per meter 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 the outside surface of the insulation is 50°C. [15]

3.a) What is the significance of JH factor?
b) State Dittus-Boelter equation and Colburn equation for heat transfer and discuss their application. [7+8]

4.a) Explain pool boiling.
b) Write briefly on
   i) Critical temperature drop
   ii) Nucleate boiling. [7+8]

5.a) What are radiation shape factor, black body and grey body?
b) Differentiate between natural convection and forced convection. [7+8]

6.a) Explain Logarithmic mean temperature difference.
b) With neat diagram explain 2-4 shell and tube heat exchanger and indicate the various parts. [7+8]

7.a) Describe how a multiple effect evaporator is economical.
b) Without actually employing multiple effects, what are the other methods to achieve similar effect? [7+8]

8. Compare and contrast the performance of direct steam injection sterilizers with plate heat exchangers for continuous sterilization. [15]