R9

Code 9A23501

B.Tech. III Year I semester (R09) Supplementary May 2012 Examinations
HEAT TRANSFER IN BIOPROCESSES
(Biotechnology)

Time: 3 hours **Max. Marks: 70**

Answer any FIVE questions
All questions carry equal marks
Steam tables are permitted in the examination hall.

1 (a) Explain the mechanism of heat conduction by conduction. Discuss the governing equation.
(b) The wall of a cold storage consists of three layers, an outer layer of ordinary brick 25 mm thick, a middle layer of cork 10 cm thick, and an inner layer of cement 6 mm thick. The thermal conductivities of the materials are brick 0.7, cork 0.043, and cement 0.72 W/m ^{o}C. The temperature of the outer surface of the wall is 30 ^{o}C, and that of the inner is – 15 ^{o}C. Calculate the steady state rate of heat gain per unit area of the wall, the temperatures at the interfaces of the composite wall.

2 (a) Derive the equation for steady state heat transfer through a cylindrical tube of inner radius r_1 and r_2. State the assumptions made.
(b) How does a fin enhance heat transfer at a surface? Define an ideal fin.
(c) A 15 cm schedule 40 steam main carries saturated steam at 10.7 bar (gauge), and the temperature is 190 ^{o}C. The inside and outside diameters of the pipe are 15.4 cm and 16.8 cm respectively. The thermal conductivity of the pipe wall is 51 W/m ^{o}C. The pipe is insulated with a 10 cm thick fiber glass blanket (k = 0.072 W/m^{o}C) . If the outer surface temperature of the insulation is 41^{o}C, calculate the rate of heat loss over a 10 m section of the pipe.

3 (a) Identify the dimensionless groups for correlating the variables that influence forced convection heat transfer to a fluid flowing through a circular pipe.
(b) An oil with Pr = 1960, ρ= 860 kg/m^3, ν= 1.6 X 10 $^{-4}$ m^2/s, and k = 0.14 W/m ^{o}C enters a 2.5 mm diameter tube 60 cm long. The oil entrance temperature is 20 ^{o}C, the mean flow velocity is 30 cm/s, and the tube wall temperature is 120 ^{o}C. Calculate the heat transfer rate.

4 (a) What is free convection? Discuss the empirical relations for free convection.
(b) A large vertical plate 4.0 m high is maintained at 60 ^{o}C and exposed to atmospheric air at 10 ^{o}C. Calculate the heat transfer if the plate is 10 m wide. Properties of interest at film temperature 308 K are k = 0.02685 W/m ^{o}C, ν = 16.5 X 10^{-6} m^2/s and Pr = 0.7. Employ the relation Nu = 0.10(Gr Pr) $^{1/3}$.

5 (a) Explain the different regimes of boiling with the help of pool boiling curve. Note the salient points of the curve and give relevant equations for finding heat transfer coefficient in the different regimes.
(b) Saturated steam at 1 atm pressure condenses on the outside of a 30 cm diameter tube whose surface is maintained at 95 ^{o}C. The tube is 15 m long. Calculate the amount of steam condensed per hour.

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6 (a) Discuss the general design of shell and tube heat exchanger with the help of neat schematic diagrams.
(b) Write note on plate type heat exchangers.

7 (a) Discuss the different methods of feeding a multiple effect evaporator.
(b) A solution of organic colloids in water is to be concentrated from 6% to 44% solids in a single effect evaporator. Steam is available at a gauge pressure of 1.03 atm (120.5 °C). A pressure of 120 mm Hg absolute (1.958 atm) is to be maintained in the vapor space. The feed rate to the evaporator is 18,000 kg/hr. The overall heat transfer coefficient can be taken as 2650 W/m^2 °C. The solution has a negligible elevation in boiling point and a negligible heat of dilution. Calculate the steam consumption, the economy and the heat surface required if the temperature of the feed is 51.7 °C. The specific heat of the feed is 3.77 J/g °C and latent heat of vaporization of the solution may be taken equal to that of the water. Radiation losses may be neglected.
Data:
Latent heat of solution at 1.958 atm (51.7 °C) = 2379 kJ/kg.
Latent heat of steam at 120.5 °C = 2200 kJ/kg.

8 (a) Write the analogy equations relating the heat, mass and momentum transfer.
(b) Discuss the effect of temperature on batch sterilization.

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