Code No: 56079 **R09**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year II Semester Examinations, December - 2017
HEAT TRANSFER IN BIOPROCESSES
(Bio-Technology)

Time: 3 hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks

Missing Data's May Be Suitably Assumed:

1.a) State Fourier's law of heat conduction. Mention its applications.
b) Explain the mechanism of heat transfer by free convection and forced convection.
c) Calculate the heat loss per m^2 of surface area for an insulating wall composed of 25.4 mm thick fiber insulating board, where the inside temperature is 352.7 K and the outside temperature is 297.1 K. The thermal conductivity of the fiber insulating board is 0.048 W/m K. [5+6+4]

2.a) A thick walled cylindrical tubing of hard rubber having an inside radius of 5 mm and an outside radius of 20 mm is being used as a temporary cooling coil in a bath. Ice water is flowing rapidly inside and the inside wall temperature is 274.9 K. The outside surface temperature is 297.1 K. A total of 14.65 Watts of energy must be removed from the bath by the cooling coil. How many meters of tubing are needed? Thermal conductivity of rubber at 273 K is 0.151 W/m K. Assume that this value will be used for the range of 274.9 K to 297.1 K.
b) What is the use of fins?
c) Define fin efficiency. How it is calculated? [10+2+3]

3.a) Explain the determination of heat transfer coefficient for heat transfer by forced convection in turbulent flow using: dimensional analysis method and empirical equations method.
b) Toluene is being condensed at 110^0C on the outside of copper condenser tubes with outer diameter D_o = 0.75 inch through which cooling water is flowing at an average temperature of 26.7^0C. Individual heat transfer coefficients are: for cooling water, h_i = 2270 W/m^2 ^{0}C and for toluene h_o = 2840 W/m^2 ^{0}C. Inside diameter of the tube is D_i = 0.62 inch. Neglecting the resistance of the tube wall, what is the tube wall temperature? [10+5]

4.a) Describe the mechanism of drop wise and film wise condensation of vapors.
b) Explain the calculation of maximum heat flux, minimum flux and critical temperature drop in heat transfer to boiling liquids. [7+8]

5.a) Discuss the relationship between reflectivity, absorptivity and transmissivity in radiation heat transfer.
b) Define total emissive power and emissivity of a body.
c) State Kirchhoff's law of radiation. Mention its significance and applications. [6+5+4]

6.a) What are the limitations for LMTD?

b) With neat sketch explain the construction and working principle of double pipe heat exchanger. [5+10]

7.a) Derive an expression for the amount of heat transferred through the heating surface area using heat and material balances for single effect evaporator.

b) Draw simplified diagram of forward feed triple effect evaporator and explain the forward feed operation. [10+5]

8.a) Explain the statement of Colburn analogy and Reynolds analogy between heat transfer and fluid friction.

b) Discuss the various heat sources used for batch sterilization process. [8+7]

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