BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSC — **SEMESTER : V**
BRANCH: FOOD TECHNOLOGY — **SESSION : MO/2022**

SUBJECT: FT302 HEAT TRANSFER IN FOOD PROCESSING

TIME: 3:00 Hours — **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q		Question	Marks	CO	BL
Q1	(a)	What is critical thickness of insulation? What is the difference between Biot number and Nusselt number?	[1+1]	1	2
Q1	(b)	Water flows at 50 °C inside a 2.5-cm-inside-diameter tube such that h_i = 3500 W/m^2. °C. The tube has a wall thickness of 0.8 mm with a thermal conductivity of 16 W/m. °C. The outside of the tube loses heat by free convection with h_o = 7.6 W/m^2 °C. Calculate the overall heat-transfer coefficient and heat loss per unit length to surrounding air at 20 °C.	[4]	2	4
Q1	(c)	An aluminum sphere mass of 5.5 kg and initially at a temperature of 290 °C is suddenly immersed in a fluid at 15 °C with heat transfer co-efficient 58 W/m^2 K. Estimate the time required to cool the aluminum to 95 °C for aluminum take ρ = 2700 kg/m^3, c = 900 J /kg K, k = 205 W/m.K.	[4]	2	3
Q2	(a)	What is meant by the radiation shape factor? A sphere of radius R_1 is enclosed in a sphere of radius R_2. Find the shape factor of radiation heat transfer of the outer sphere with respect to inner sphere?	[1+1]	2	1, 2
Q2	(b)	Two large parallel planes with emissivity of 0.3 & 0.5 are maintained at temperature of 527 °C & 127 °C respectively. A radiation shield having emissivity of 0.05 on both sides is placed between them. Calculate, 1) Heat transfer rate between them without shield. 2) Heat transfer rate between them with shield.	[4]	2	4
Q2	(c)	An insulated cylindrical pipe of 0.2 m diameter has a surface temperature of 45 °C. It is exposed to black body surroundings at 25 °C. The emissivity & absorptivity of the insulation surface are 0.96 & 0.93 respectively. The convective heat transfer co-efficient outside the insulation surface is 3.25 W/m^{2}K. The surrounding fluid may be assumed to be transparent. Evaluate the percentage contribution from radiation to the total heat transfer rate to the surroundings.	[4]	2	5
Q3	(a)	Define effectiveness of heat exchanger. What is meant by the “minimum” fluid?	[1+1]	1	2
Q3	(b)	Suppose a person stated that heat cannot be transferred in a vacuum. How do you respond?	[2]	1	2
Q3	(c)	Explain the dielectric, ohmic and infrared heating process.	[3]	4	1
Q3	(d)	Name few microwaves heating equipment. What are the advantages of microwave and radio-frequency heating in food processing?	[1+2]	4	1
Q4	(a)	What is a fouling factor? When is the LMTD method most applicable to heat-exchanger calculations?	[1+1]	3	1, 2
Q4	(b)	Water flows at the rate of 65 kg/min through a double pipe counter flow heat exchanger. Water is heated from 50 °C to 75 °C by an oil flowing through the tube. The specific heat of the oil is 1.780 KJ/Kg.K. The oil enters at 115 °C and leaves at 70 °C. The overall heat transfer co-efficient is 340 W/m^2. K. Calculate the following, 1) Heat exchanger area, 2) Rate of heat transfer.	[4]	3	4
Q4	(c)	When 0.6 kg of water per minute is passed through a tube of 2 cm diameter, it is found to be heated from 20 °C to 60 °C. the heating is achieved by condensing steam on the surface of the tube and subsequently the surface temperature of the tube is maintained at 90 °C. Determine the length of the tube required for fully developed flow. Given: At bulk mean temperature properties of water, ρ = 995 kg/m^3, v = 0.657 x 10-6 m^2/s, Pr = 4.340, K = 0.628 W/m. K, Cp = 4178J/kg. K, for laminar flow Nu = 3.66 & for turbulent flow Nu = 120	[4]	3	5

Q5	(a)	Distinguish between nucleate and film boiling.	[2]	5	1
Q5	(b)	Define the steam economy and capacity of an evaporator.	[2]	5	1
Q5	(c)	Draw the triple effect forward feed evaporator.	[2]	5	2
Q5	(d)	It is desired to concentrate a 20% salt solution (20 kg of salt in 100 kg of solution) to a 30% salt solution in an evaporator. Consider a feed of 300 kg/min at 30 ^{o}C. The boiling point of the solution is 110 ^{o}C, the latent heat of vaporization is 2100 KJ/Kg, & the specific heat of the solution is 4 KJ/Kg.K. Find the rate at which heat must be supplied (in KJ/min) to the evaporator?	[4]	5	5

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