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

CLASS : BTECH **SEMESTER : III**
BRANCH: CHEMICAL ENGG/FOOD TECH **SESSION : MO/2025**
SUBJECT: CL24207 HEAT TRANSFER OPERATIONS
TIME: 3 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.

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Q.1(a)	A furnace wall is made of three layers — firebrick (0.10 m, k = 1.4 W/m·K), insulation brick (0.08 m, k = 0.2 W/m·K), and steel plate (0.01 m, k = 45 W/m·K). The inner surface temperature is 900˚C and the outer surface temperature is 120˚C.Find: (a)The rate of heat loss per m^2 of wall, and (b) The temperature at the interface between the insulation brick and steel layer.	[5]	1	3
Q.1(b)	An aluminum cube (k = 240W/m·K, ρ = 2700 kg/m^3, c_p = 900 J/kg·K) with side length 3 cm is initially at 350˚C. It is placed in a fluid at 50 ˚C with h = 120 W/m^2 .K. a) Calculate the time constant of the cube. b) What is the temperature of the cube after 45 seconds? c) What is the initial rate of cooling of the cube (in ˚C/s)?	[5]	1	3
Q.2(a)	Discuss how the thickness of the thermal boundary layer varies with: (i) Reynolds number (ii) Prandtl number Schematically show the velocity and thermal boundary layer profiles on a heated flat plate.	[5]	2	2
Q.2(b)	Water at 25˚C enters a copper tube (D = 25 mm, L = 2 m) with a velocity of 1.5 m/s. The wall temperature is constant at 80˚C. Properties at mean temperature: ρ= 997 kg/m^3, μ=0.001 Pa.s, c_p= 4180 J/kg.K, k=0.6W/m.K, Pr=5.0 Calculate: (a) The average heat transfer coefficient, and (b) The heat transfer rate. *(Use Dittus-Boelter equation)*	[5]	2	3
Q.3(a)	Describe Wein's Displacement law and Stefan-Boltzmann's law.	[5]	3	2
Q.3(b)	Discuss the concept of radiation shields and outline their practical applications.	[2]	3	2
Q.3(c)	A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T1 = 800 K and T2 = 500 K and have emissivities ε1= 0.2 and ε2 = 0.7. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield.	[3]	3	3
Q.4(a)	Define: steam economy, boiling point elevation, film boiling, nucleate boiling.	[5]	4	2
Q.4(b)	Draw a schematic of a triple-effect forward-feed evaporator and write the corresponding material balance and energy balance equations for each effect with assumptions.	[5]	4	3
Q.5(a)	Describe the construction and working of a floating head shell-and-tube heat exchanger. Discuss its main components, advantages, and disadvantages.	[5]	5	2
Q.5(b)	A shell-and-tube heat exchanger employs a liquid in the shell that is heated from 30◦C to 55◦C by a hot gas in the tubes that is cooled from 100◦C to 60◦C. Calculate the effectiveness of the heat exchanger.	[2]	5	3
Q.5(c)	A small steam condenser is designed to condense 0.76 kg/min of steam at 83 kPa with cooling water at 10◦C. The exit temperature is not to exceed 57◦C. The overall heat-transfer coefficient is 3400W/m^2 · ◦C. Calculate the area required for a double-pipe heat exchanger. Tsat =95.6◦C, hfg =2.27×10^6 J/kg.	[3]	5	3

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