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

CLASS: B.TECH. **SEMESTER : III**
BRANCH: CHEMICAL ENGINEERING **SESSION : MO/2022**

SUBJECT: CL219 HEAT TRANSFER OPERATION

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.

			Marks	CO	BL
Q1	(a)	What is a lumped system? When can the unsteady temperature in a spatial body be considered uniform?	[1.5+1.5]	1	2
Q1	(b)	What would be your recommendation if you find that the value of critical insulation radius is greater than the outer radius of the pipe?	[1]	1	4
Q1	(c)	Explain why the temperature boundary layer grows much more rapidly than the velocity boundary layer in liquid metals	[2]	3	4
Q1	(d)	A 12 cm diameter long bar initially at a uniform temperature of 40 ^oC is placed in a medium at 650 ^oC with a convective co-efficient of 22 W/m^2K calculate the time required for the bar to reach 255 ^oC. Take k = 20W/mK, ρ = 580 kg/m^3 and c = 1050 J/kg K.	[4]	2	5
Q2	(a)	How is natural convection different from forced convection?	[1.5]	1	2
Q2	(b)	Write note on Reynolds analogy.	[2.5]	1	1
Q2	(c)	What is the physical significance of Prandtl number and how does it affect the relationship between the thickness of hydrodynamic and thermal boundary layers?	[2]	3	2
Q2	(d)	Water at the rate of 1 kg/s is forced through a tube with a 2.5-cm ID. The inlet water temperature is 15◦C, and the outlet water temperature is 50◦C. The tube wall temperature is 14◦C higher than the water temperature all along the length of the tube. What is the length of the tube? Given: K_{water} = 0.614 W/mK, $C_{p\ water}$ = 4179 J/Kg.K, viscosity $_{water}$ = 8.6×10^{-4} $N.s/m^2$	[4]	2	5
Q3	(a)	Define black body and grey body.	[2]	1	2
Q3	(b)	Explain any one law of radiation.	[2]	1	1
Q3	(c)	A hemispherical furnace of 1 m radius has the inner surface (emissivity =1) of its roof maintained at 800 K, while its floor (emissivity = 0.5) is kept at 600 K. Find the net radiative heat transfer in KW from the roof to the floor.	[3]	3	4
Q3	(d)	Consider 2 large parallel plates, one at 727 ^oC with emissivity = 0.8 and the other at 227 ^oC with emissivity = 0.4. An aluminium radiation shield with an emissivity = 0.05 on both sides is placed between the plates. Calculate % reduction in heat transfer rate between the plates because of the shield.	[3]	2	5
Q4	(a)	Differentiate between film type and drop-wise condensation.	[1]	4	2
Q4	(b)	What are the assumptions used for condensation to determine film thickness.	[2]	4	2
Q4	(c)	Explain the pool boiling curve for heat transfer.	[3]	4	1

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Q4	(d)	An aqueous solution of a solute is concentrated from 5% to 20% (mass basis) in a single effect short tube evaporator. The feed enters the evaporator at a rate of 10 kg/sec and at a temperature of 300 K. Steam is available at a saturation, pressure of 1.3 bar. The pressure in the vapour space of the evaporator is 0.13 bar and the corresponding saturation temperature of steam is 320 K. If the overall heat transfer co-efficient is 5000 W/m^2K, Calculate 1) Steam economy, 2) Heat Transfer surface area.	[4]	4	5

Data:	*Enthalpy (KJ/Kg)*	*Heat of vaporization (KJ/Kg)*
Saturated steam (1.3 bar, 380 K)	----	2000
Saturated steam (0.13 bar, 320 K)	2200	----
Feed (5%, 300 K)	80	----
Concentrated liquor (20%, 325 K)	400	----

Boiling point elevation is 5 K

Q5	(a)	When is the LMTD method most applicable to heat-exchanger calculations?	[1]	5	3
Q5	(b)	What are purposes of different pitches and baffles inside heat exchangers?	[1]	5	2
Q5	(c)	A counter flow double-pipe heat exchanger is to be used to heat 0.7 kg/s of water from 35 to 90 ◦C with an oil flow of 0.95 kg/s. The oil has a specific heat of 2.1 kJ/kg ◦C and enters the heat exchanger at a temperature of 175◦C. The overall heat-transfer coefficient is 425 W/m^2◦C. Calculate the area of the heat exchanger and the effectiveness.	[4]	5	5
Q5	(d)	A feedwater heater uses a shell-and-tube exchanger with condensing steam in one shell pass at 120 ◦C. Water enters the tubes at 30 ◦C and makes four passes to produce an overall U value of 2000 W/m^2◦C. Calculate the area of the exchanger for 2.5 -kg/s mass flow of the water, with a water exit temperature of 100 ◦C. Suppose the exchanger has been in service a long time such that a fouling factor of 0.0002 m^2◦C/W is experienced. What would be the exit water temperature under these conditions?	[4]	5	5

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