Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 (India)

MID (ODD) Semester Examination 2023-24

Programme Name: B.Tech / M.Tech / MBA / M.Sc / MCA **Semester:** III

Course Code: CHN 13104 **Course Name:** Heat Transfer Operations

Branch: CHEMICAL ENGINEERING **Student Reg. No.:**

Duration: 1.5 Hours **Max. Marks:** 20

Instructions:

1. Attempt all questions.

Q.1		MCQ (1 MARKS EACH) PLEASE ANSWER <(a) or (b) or(c) or (d)>	(5)	
	1.1	Loss of heat from unlagged steam pipe to ambient air is by a) Conduction b) Convection c) Radiation d) All of the above	(0.5)	CO1,CO2
	1.2	Unsteady state heat conduction occurs when a) Temperature distribution is independent of time b) Temperature distribution is dependent on time c) Heat flows in one direction only d) Three dimensional heat flow is concerned	(0.5)	CO1
	1.3	An insulator should have a) Low thermal conductivity b) High Thermal conductivity c) Less resistance to heat flow d) a porous structure	(0.5)	CO2
	1.4	Which of the following has highest thermal conductivity a) Brick b) Air c) Water d) Silver	(0.5)	CO1,CO2
	1.5	Which area is used in case of heat flow by conduction through a cylinder a) Logarithmic mean area b) Arithmetic mean area c) Geometric mean area d) None of these	(0.5)	CO1
	1.6	Most metals are good conductor of heat because of a) Transport of energy b) Free electrons and frequent collision of atoms c) Lattice defects d) Capacity to absorb energy	(0.5)	CO1
	1.7	Cork is a good insulator because a) It is flexible b) It can be powdered c) Low density d) It is porous	(0.5)	CO1
	1.8	Consider the following parameters (i) Composition (ii) Density (iii) Porosity	(0.5)	CO1

		(iv) Structure Then, thermal conductivity of glass wool varies from sample to sample because of variation is a) i and ii b) i, ii, iii and iv c) i and iii d) i, ii and iii		
	1.9	Chose the correct one with respect to the critical radius of insulation a) There is more heat loss i.e. conductive b) There occurs a decrease in heat flux c) Heat loss increases with addition of insulation d) Heat loss decreases with addition of insulation	(0.5)	CO2
	1.10	What is the thermal conductivity of cotton in W/m K? a) 0.03 b) 0.04 c) 0.05 d) 0.06	(0.5)	CO1

Q.2	Comment on a Range (1) b Approach (1) c LMTD(Derive it) (3)	5	CO4
Q.3	A heat exchanger is required to cool 20 kg/s of water from 360K to 340K by means of 25 kg/s of water entering at 300K. If the overall coefficient of heat transfer is constant at 2000 W/(m^2K). Calculate the surface area required in (a) A counter current concentric tube exchanger. (b) a co-current flow concentric tube exchanger.	3	CO2, CO4
Q.4	An ice box has walls constructed of a 10 mm layer of cork board contained between two wooden walls each of 20 mm thick. Find the rate of heat removed per unit area if the inner wall is kept at 263 K while the outer surface temperature is 303 K . Find out the zone in the wall where the temperature is 293 K Thermal conductivities of cork board and wood are 0.041 and 0.105 W/(m.K).	2	CO1
Q.5	A furnace wall made up of steel plate 10 mm thick lined on the inside with silica brick 150 mm thick lined on the outside with magnesite brick 150 mm thick. The temperature on the inside edge of wall is 973 K and outside is 288 K. Calculate the quantity of heat passed in watts per m^2. It is required to reduce the heat flow to 1163 W/m^2 by means of an air gap between steel plate and magnesite brick. Estimate the width of this gap. Thermal conductivities in W/(m.K) are 16.86, 1.75, 5.23 and 0.033 respectively for steel, silica brick , magnesite brick and air.	3	CO1, CO2
Q.6	Derive an expression for heat transfer through a furnace wall made of three different materials in series. Assume k_1, k_2 and k_3 be the thermal conductivities of materials and x_1,x_2 and x_3 the respective thickness. Assume hot face and cold face to be T_1 and T_2 respectively.	2	CO1

मोतीलालनेहरूराष्ट्रीयप्रौद्योगिकीसंस्थानइलाहाबाद
प्रयागराज-211004 (भारत)
Motilal Nehru National Institute of Technology Allahabad
Prayagraj - 211 004 (India)

<Chemical Engineering>,
End Semester Examination, Session 2022-23 (Even)

Programme: <B.Tech> **Branch:** <Chemical> **Semester:** <3rd>
Course Name: <HEAT TRANSFER OPERATIONS>
Course Code: <CHN13104> **Max. Marks:** <40>
Time: <2.5> HRS **Registration No.:** 2 0 2 2 2 0 6 8

Instructions (related to question paper):
1. <ALL QUESTIONS ARE COMPULSORY>

			Marks	Correspondin course outcom with weightag (if any)
Q1		Derive the rate of heat flow through	(2)	CO1
	a	Thick walled cylinder	1	CO1
	b	Hollow sphere	1	CO1
Q2		What is critical radius of insulation?	(1)	CO1
Q3		How do we calculate the overall heat transfer coefficient and how does fouling factor impact overall heat transfer coefficient.	(2)	CO2
Q4		Comment on following	(3)	CO2
	a	Nusselt Number	1	CO2
	b	Prandtl Number	1	CO2
	c	Grashof Number	1	CO2
Q5		Explain in detail the three basic flow arrangement in Heat-Exchanger.	(3)	CO4
Q6		Comment on	(4)	CO4
	a	Range	1	CO4
	b	Approach	1	CO4
	c	LMTD(Derive it)	2	CO4
Q7		Comment on	(4)	CO5
	a	Boiling Mechanism	2	CO5
	b	Difference between Dropwise Condensation & Film Wise Condensation	2	CO5
Q8		Comment on	(4)	CO3
	a	Reflection , Absorption & Transmission of radiation	1	CO3
	b	Kirchoff's law	1	CO3
	c	Black body	1	CO3
	d	Grey body	1	CO3
Q9		Explain in detail along with diagram	(3)	CO4
	a	Double Pipe Heat Exchanger	1.5	CO4
	b	Shell and Tube Heat Exchanger	1.5	CO4
Q10		Water is to be heated from 298 K (25^{O}C) to 313 K (40^{O}C) at a rate of 30 kg/s. Hot water is available at 353 K (80^{O}C) at a rate of 24 kg/s for heating in a counter current exchanger. Calculate the heat transfer area required, if the overall heat transfer coefficient is 1220 W/(m^2 ·K).	(2)	CO4,CO
Q11		An oil is cooled from 353 K (80^{O}C) to 313 K (40^{O}C) in an oil cooler. The inlet temperature of water is 303 K (30^{O}C). Calculate the temperature of cooling water leaving the cooler and logarithmic mean temperature difference assuming flow to be counter current, if the mass flow rate of oil and water are 1.4 kg/s	(2)	CO4,CO

		and 2.9 kg/s respectively. Cp for oil = 2.135 kJ/(kg·K) Cp for water = 4.187 kJ/(kg·K)		
Q12		Crude oil flows at a rate of 1000 kg/h through the inside pipe of a double pipe heat exchanger and is heated from 303 K to 363 K . The heat is supplied by kerosene initially at 473 K flowing through the annular space. If the temperature of approach (minimum temperature difference) is 10 K, determine the heat transfer area for co-current flow and the kerosene flow rate. Cp for crude oil = 2.1 kJ/(kg·K) Cp for kerosene = 2.51 kJ/(kg·K) Uo = 465 W/(m^2 ·K)	**(2)**	**CO4,CO2**
Q13		A hot fluid enters a double pipe heat exchanger at a temperature of 423 K and to be cooled to 363 K by a cold fluid entering at 308 K and heated to 338 K. Shall they be directed in parallel flow or counter current flow to have a high rate of heat transfer?	**(2)**	**CO4,CO2**
Q14		A steel pipe [k = 50 W/(m·K)] of 100 mm I.D. and 110 mm O.D. is to be covered with two layers of insulation each having thickness of 50 mm. The thermal conductivity of the first insulation material is 0.06 W/(m·K) and that of second is 0.12 W/(m·K). Estimate the heat loss per 1 m length of pipe when the temperature of the inside tube surface is 523 K and that of the outer surface of insulation is 323 K .If the order of insulation material were reversed, i.e., the insulation with higher value of thermal conductivity was put first, calculate the change in the heat loss with all other conditions kept unchanged. Comment on results.	**(2)**	**CO1,CO2**
Q15		An exterior wall of house may be approximated by a 100 mm layer of a common brick [k = 0.70 W/(m·K)] followed by a 40 mm layer of gypsum plaster [k = 0.48 W/(m·K)]. What thickness of loosely packed rockwool insulation [k = 0.065 W/(m·K)] should be added to reduce the heat loss through the wall by 25%?	**(2)**	**CO1**
Q16		A furnace wall made up of steel plate 10 mm thick lined on the inside with silica brick 150 mm thick on the outside with magnesite brick 150 mm thick. The temperature on inside edge of the wall is 973 K and on the outside is 288 K . Calculate the quantity of heat passed in watts per m^2. It is required to reduce the heat flow to 1163 W/m^2 by means of an air gap between steel plate and magnesite brick. Estimate the width of this gap. Thermal conductivities in W/(m·K) are 16.86, 1.75, 5.23 and 0.033 respectively for steel, silica brick, magnesite brick and air.	**(2)**	**CO1**

COURSE OUTCOME	
CO1	To estimate steady state and transient heat transfer rates from/to object such as tanks, pipes, building etc.
CO2	To develop equations for different types of convection and solve for heat transfer rate by Convection
CO3	To estimate the rate of radiation heat transfer with and without participating medium.
CO4	To carry out thermal analysis of heat exchanger using LMTD and effectiveness method
CO5	Ability to identify the boiling and condensation and understand current research in Heat Transfer