Name: **Enrolment No:**	

UPES
End Semester Examination, May 2023

Course: Process Heat Transfer **Semester: IV**
Program: B Tech (Chemical Engineering) **Time: 03 hrs.**
Course Code: CHCE2021 **Max. Marks: 100**

Instructions: (a) In case of any missing data, please make necessary assumptions with proper reasoning, (b) Only the use of scientific calculator is allowed after the approval from the invigilator.

SECTION A (5Q x 4M= 20Marks)

Q. No.	Statement of question	Marks	CO
Q 1	Write the expression for calculating the rate of heat radiation by a gray body along with the S.I. units of all variables.	**4**	**CO1**
Q 2	What do you understand by thermal contact resistance? Write its expression.	**4**	**CO2**
Q 3	Differentiate between the drop wise and film wise condensation?	**4**	**CO3**
Q 4	Draw a schematic diagram of a cross flow heat exchanger where the flow configuration is, *one fluid mixed and one fluid unmixed*.	**4**	**CO4**
Q 5	Recalling the definition of Nusselt number, derive its expression.	**4**	**CO1**

SECTION B (4Qx10M= 40 Marks)

Q. No.	Statement of question	Marks	CO
Q 6	Consider a 0.8-m-high and 1.5-m-wide double-pane window (**Fig. 3**) consisting of two 4-mm-thick layers of glass (k = 0.78 W/m · °C) separated by a 10-mm-wide stagnant air space (k = 0.026 W/m · °C). Determine the **steady rate of heat transfer** through this "*double-pane window*" and the **temperature of its inner surface** for a day during which the room is maintained at 20 °C while the temperature of the outdoors is -10 °C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h_1 = 10 W/m^2 · °C and h_2 = 40 W/m^2 · °C. **OR** On the basis of similar points (or parameters) differentiate between conduction, convection and radiation mode of heat transfer.	**10** **10**	**CO1**
Q 7	Consider a 5-m-high, 8-m-long, and 0.22-m-thick wall whose representative cross section is as given in the figure below. The thermal conductivities of various materials used, in W/m · °C, are $k_A = k_F = 2$, k_B = $\boldsymbol{k_{roll} + 10}$, $k_C = 20$, $\boldsymbol{k_D = k_{roll}}$, and $k_E = 35$. The left and right surfaces of the wall are maintained at uniform temperatures of 300°C and 100°C, respectively. Determine, **(a)** Draw the thermal resistance network with	**10**	**CO2**

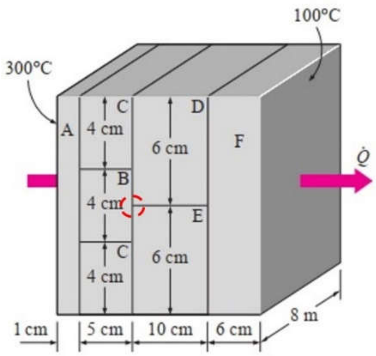
	all the parameters at each points, (**b**) the rate of heat transfer through the entire wall. Mention all necessary assumptions with proper reasons for each. Here, k_{roll} = last two digits of your roll number. **For, example:** If, Roll number: R820219007, then thermal conductivity, k_{roll} = 07 W/m · °C 		
Q 8	Define Boiling. Draw the boiling curve for water and show different regimes on that. Explain Nucleate boiling regime. Which boiling regime is usually preferred? Why ?	**10**	**CO3**
Q 9	Derive the expression of log mean temperature difference (ΔT_{lm}) of a parallel flow double pipe heat exchanger. Draw a schematic diagram of the temperature profile across the length of the heat exchanger	**10**	**CO4**
	SECTION-C (2Qx20M=40 Marks)		
Q 10	A 2-kW resistance heater wire with thermal conductivity k = 15 W/m · °C, diameter D = 0.4 cm, and length L = 50 cm is used to boil water by immersing it in water (**Fig. 1**). Assuming that the variation of the thermal conductivity of the wire with temperature is significant, (a) derive the differential equation that describes the variation of the temperature of the wire during steady operation. (b) Is there any heat generation? If yes, find the value or if no, give reasons. (**Mention all other necessary assumptions with reasons**)	**20**	**CO1**
Q 11	A single counter-flow double pipe heat exchanger is used to heat 1.25 kg/s of water (tube side) from 35 ºC to 80 ºC by coiling an oil [c_p = 2.0 kJ/(kg ºC)] from 150 ºC to 85 ºC along its annular side. The overall heat-transfer coefficient is 850 W/(m^2 ºC). A similar arrangement is to be built at another plant location, but it is desired to compare the performance of a single counter flow heat exchanger with that the performance of two smaller counter-flow heat exchanger connected in series on the water side and parallel on the oil side. The oil flow is equally split equally between the two exchangers and it may be assume that the overall heat transfer coefficient for the two smaller heat exchanger is the same as that of the larger heat exchanger. If the smaller exchanger cost is 20 percent more per unit surface area, which would be more economical arrangement, the one large exchanger or two small exchangers ? Draw the schematic	**20**	**CO4**

	diagram for both type of arrangements. (**Mention all other necessary assumptions with reasons**)		

APPENDIX- A (This page has to be submitted along with the answer script)

Name of student: Roll number:

Signature of invigilator:

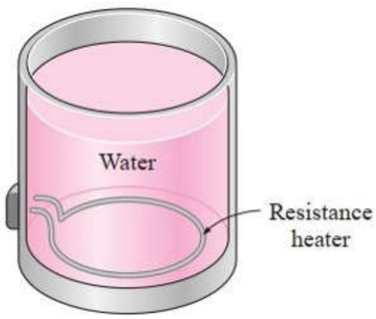


Fig. 1: Schematics of the resistance heater

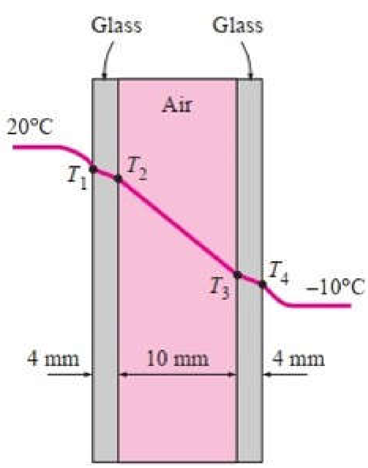


Fig. 2: Schematics of the double pane window

(This page has to be submitted along with the answer script)

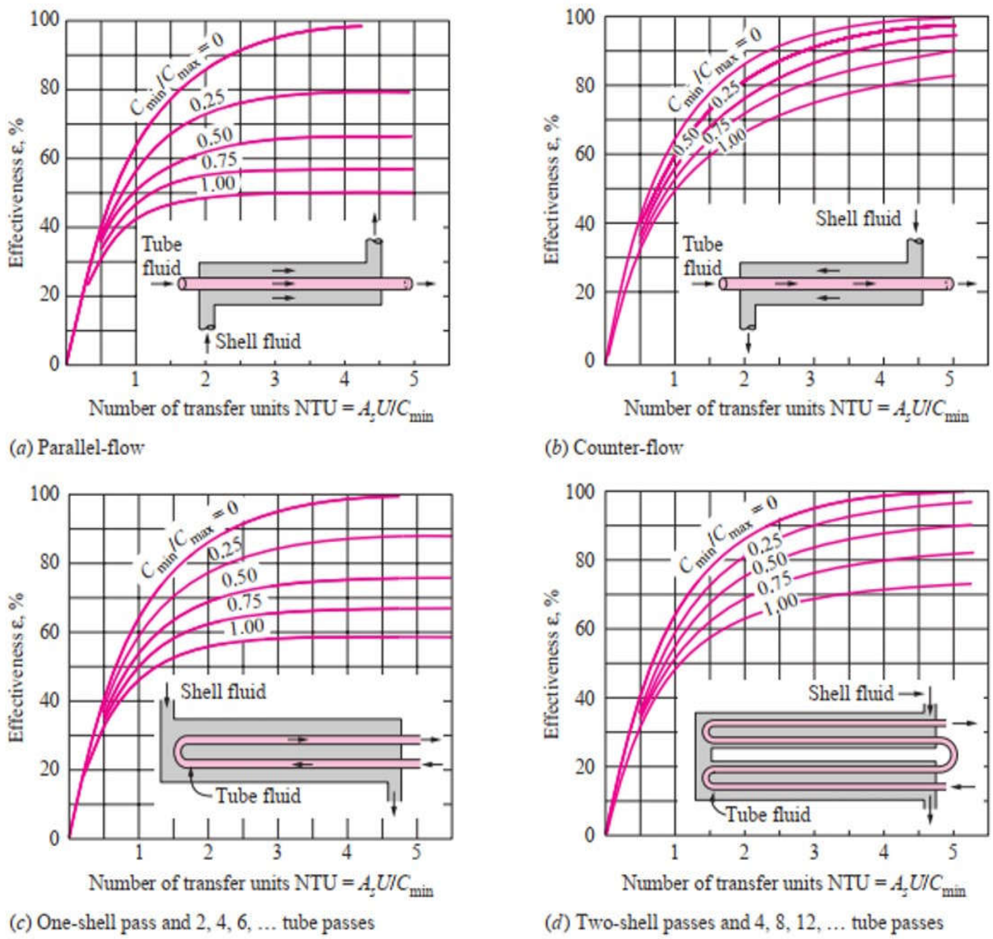


Fig. 3: Effectiveness of heat exchangers at various values of NTU.