| Roll No | | | | | | | | | | | | |
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# PRESIDENCY UNIVERSITY
# BENGALURU
## School of Engineering

## Make Up Examinations – December 2025

**Semester:** MK

**Course Code**: PET2008

**Course Name**: Heat and Mass Transfer for Petroleum Engineering

**Department:** PETROLEUM ENGINEERING

**Date**: 26 – 12- 2025

**Time**: 1.00pm to 04.00pm

**Max Marks**: 100

**Weightage**: 50%

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**Instructions:**

*(i) Read the all questions carefully and answer accordingly.*

*(ii) Do not write any matter on the question paper other than roll number.*

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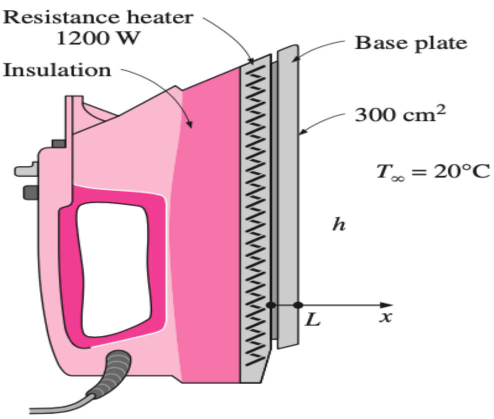
### PART A

**Answer any FIVE Questions. Each question carries 4 marks.** **(5Qx 4M= 20M)**

| Q.No | Questions | Marks | CO | RBT |
|---|---|---|---|---|
| 1. | Describe boiling and condensation. | 4 | CO1 | L1 |
| 2. | Describe coefficient of thermal conduction (K). State at least on example of metal which has good thermal conductivity. | 4 | CO1 | L1 |
| 3. | Define black body. State one Example. | 4 | CO1 | L1 |
| 4. | State newton’s law of cooling along with its mathematical expression. | 4 | CO2 | L1 |
| 5. | Describe Emissive power. State its unit. | 4 | CO2 | L1 |
| 6. | State Fick’s First Law of diffusion. | 4 | CO3 | L1 |
| 7. | Explain the term diffusion in mass transfer. | 4 | CO3 | L1 |

## PART B

**Answer EIGHT Questions. Each question carries 10 marks.** **(8Qx 10M= 80M)**

| Q.No | Questions | Marks | CO | RBT |
|---|---|---|---|---|
| **8.** | Consider the base plate of a 1200-W household iron that has a thickness of $L$=0.5 cm, base area of $A$=300 $cm^2$, and thermal conductivity of $k$=15 W/m · °C. The inner surface of the base plate is subjected to uniform heat flux generated by the resistance heaters inside, and the outer surface loses heat to the surroundings at $T_\infty$ = 20°C by convection, as shown in below figure. Taking the convection heat transfer coefficient to be $h$=80 $W/m^2$ · °C and disregarding heat loss by radiation, obtain an expression for the variation of temperature in the base plate, and evaluate the temperatures at the inner and the outer surfaces.   | **10** | **CO1** | **L3** |
| **OR** | | | | |
| **9.** | Consider a person standing in a room maintained at 22°C at all times. The inner surfaces of the walls, floors, and the ceiling of the house are observed to be at an average temperature of 10°C in winter and 25°C in summer. Determine the rate of radiation heat transfer between this person and the surrounding surfaces if the exposed surface area and the average outer surface temperature of the person are 1.4 $m^2$ and 30°C, respectively. (Given that the emissivity of a person is 0.95; σ = Steffan Boltzmann constant = 5.67 x $10^8$ $W/m^2$ $K^4$.) | **10** | **CO1** | **L3** |

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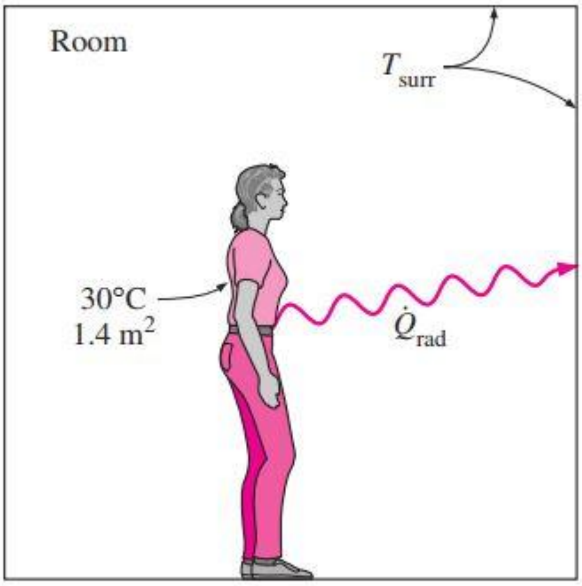
| |  | | | |
| **10.** | In counter flow heat double pipe heat exchanger, water is heated from 25°C to 65°C by oil with specific heat of 1.45 KJ/Kg.K and mass flow rate of 0.9 kg/s. The oil is cooled from 210°C to 140°C. If overall heat transfer coefficient (U) is 410 W/m²K. Calculate the following:<br>a. The rate of heat transfer<br>b. The mass flow rate of water, if its specific heat is 4.2 KJ/Kg.K<br>c. The surface area of the heat exchanger. | **10** | **CO1** | **L3** |
| | **OR** | | | |
| **11.** | The steam condenser is transferring 250 KW of thermal energy at the condensing temperature of 65°C. The cooling water enters the condenser at 20°C with a mass flow rate of 7500 kg/hr. Solve the LMTD, if overall heat transfer co- efficient for condenser surface, U =1250 W/m². | **10** | **CO1** | **L3** |
| **12.** | Radiation heat transfer involves the movement of heat through the emission, transmission, and absorption of electromagnetic waves. Unlike conduction and convection, which depend on a medium for heat transfer, radiation can take place in a vacuum and is not contingent on the presence of matter. Various fundamental laws govern this phenomenon. Discuss the following laws that governs radiation heat transfer:<br>a) Stefan's Boltzmann Law<br>b) Planck's law | **10** | **CO2** | **L2** |
| | **OR** | | | |
| **13.** | Explain the mechanisms of scaling and fouling in heat exchangers. Provide detailed insights into the factors influencing these phenomena and their detrimental effects on heat exchanger performance. Additionally, discuss preventive measures and | **10** | **CO2** | **L2** |

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| | strategies to mitigate scaling and fouling issues in the context of heat exchanger design and operation. | | | |
| **14.** | The radiation shape factor of the circular cylinder surface of thin hollow cylinder of 10 cm diameter and 10 cm length is 0.1716. Estimate the shape factor of curved surface of cylinder with respect to itself. | **10** | **CO2** | **L2** |
| | **OR** | | | |
| **15.** | The classic pool boiling curve represents a graph that displays the relationship between heat flux (q) and excess temperature ($\Delta T_{excess} = T_w - T_{sat}$). As the magnitude of the excess temperature rises, the curve progresses through four distinct phases: (1) natural or free convection, (2) nucleate boiling, (3) transition boiling, and (4) film boiling. Elucidate the statement. | **10** | **CO2** | **L2** |
| **16.** | A flat plate is placed in an airstream at a velocity of 2 $m/s^2$. Ammonia gas is being absorbed into water from the air at a temperature of 298 K. The concentration of ammonia in the bulk gas is $C_A$=0.01 $mol/m^3$. The convective mass transfer coefficient kc is 0.002 m/s. Determine the rate of mass transfer of ammonia from the air to the water in $mol/m^2 \cdot s$. | **10** | **CO3** | **L3** |
| | **OR** | | | |
| **17.** | In an experiment to determine 'k' of a very long solid cylindrical fin of 2.5 cm diameter. The base of fin is placed in a furnace with its large portion of it projecting into the room at 22 °C. After steady state, the temperature at two points, 10 cm apart are found to be 110 °C and 85 °C. Assuming the convective heat transfer coefficient (h) between rod and surrounding is 28.4 W/ $m^2$ K. Estimate the coefficient of conductivity of fin material (k). | **10** | **CO3** | **L3** |
| **18.** | A mixture of Helium (He) and Nitrogen ($N_2$) gas is contained in a pipe at 303K and 1 atm total pressure, which is constant throughout. At one end of the pipe (at point 1), the partial pressure of He is 0.55 atm. At the end (at point 2), it is 0.15 atm. Both the points are 0.4 m (40 cm) away. Solve the flux of Helium (He) at steady-state if $D_{AB}$ of the He-$N_2$ mixture is $0.687 \times 10^{-4}$ $m^2/s$. | **10** | **CO3** | **L3** |
| | **OR** | | | |
| **19.** | A mixture of noble gases (helium (MW=4 kg), argon (MW=40 kg), krypton (MW=84 kg) and xenon (MW=131 kg)) is at total pressure of 100 KPa and a temperature of 200 K. If the mixture has equal kmole fraction of each of the gases, estimate<br>a. The composition of mixture in terms of mass fractions<br>b. Total molar concentration<br>c. The mass density | **10** | **CO3** | **L3** |

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| **20.** | The following equation describe molecular mass transfer: $J_{Az} = -D_{AB}\frac{dC_A}{dz}$ , where symbols have usual meaning.<br>(i) Illustrate the name of the law.<br>(ii) Explain the assumptions of this law. | **10** | **CO3** | **L2** |
| **OR** | | | | |
| **21.** | Illustrate the conductive and convective mass transfer process, using proper examples and diagrams to illustrate each process. | **10** | **CO3** | **L2** |
| **22.** | A cylindrical container holds a gas at steady-state conditions, and a concentration gradient is established along its length. The gas is diffusing through a second stagnant gas within the container. The diffusivity of the gas is given as $D_{AB}$=1.8×10$^{-5}$ m$^2$/s and the length of the cylinder is L=0.2 mL. The concentration of the diffusing gas at one end of the cylinder is $C_A$=1.5 mol/m$^3$ and at the other end is $C_B$=0.8 mol/m$^3$. Using Fick's first law, calculate the steady-state molar flux $J_A$ of the diffusing gas. | **10** | **CO3** | **L3** |
| **OR** | | | | |
| **23.** | In a stirred tank reactor, a solute is being transferred from the liquid phase to a gas phase. The liquid-side mass transfer coefficient is $k_L$=1.5×10$^{-4}$ m/s, and the gas-side mass transfer coefficient is $k_G$=1.0×10$^{-3}$ m/s. The equilibrium concentration of the solute in the liquid is $C^*$=0.05 mol/m$^3$, and the concentration in the gas is $C_A$=0.02 mol/m$^3$. Determine the overall mass transfer coefficient and the rate of mass transfer. | **10** | **CO3** | **L3** |