Roll No. | | | | | | | | | | |

ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. / B. Tech (Full Time) - END SEMESTER (Arrear) EXAMINATIONS, NOV/DEC 2024

MECHANICAL ENGINEERING

ME5651 HEAT AND MASS TRANSFER

Note: Use of Standard HMT data book / charts permitted

(Regulation 2019)

Time: 3hrs

Max.Marks: 100

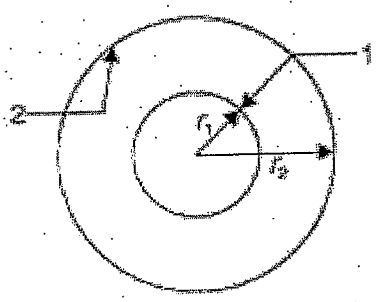
PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

Q. No	Questions	Marks
1	What is heat flux?	2
2	What is lumped system analysis?	2
3	What is external forced convection? How does it differ from internal forced convection?	2
4	How does the Grashof number differ from the Reynolds number?	2
5	What is the difference between pool boiling and flow boiling?	2
6	Classify heat exchangers according to flow arrangement and construction type.	2
7	Why is radiation usually treated as a surface phenomenon?	2
8	What is Radiosity?	2
9	Mention few applications involving mass transfer.	2
10	Give examples for liquid-to-gas diffusion processes.	2

PART- B (5 x 13 = 65 Marks)

Q. No	Questions	Marks
11 (a)	A wall of 0.5 m thickness is to be constructed from a material which has an average thermal conductivity of 1.4 W/mK. The wall is to be insulated with a material having an average thermal conductivity of 0.35 W/mK so that the heat loss per square meter will not exceed 1450 W. Assuming that the inner and outer surface temperatures are 1200 °C and 15 °C respectively, calculate the thickness of insulation required.	13
	OR	
11 (b)	A 40x40 cm copper slab 5 mm thick at a uniform temperature of 250 °C suddenly has its surface temperature lowered at 30 °C. Find the time at which the slab temperature becomes 90 °C. ρ = 9000 kg/m^3, c = 0.38 kJ/kg K, k = 370 W/mK and h= 90 W/m^{2}K.	13
12 (a)	Water at 50 °C enters a 1.5 cm diameter and 3 m long tube with a velocity of 1 m/s. The tube wall is maintained at a constant temperature of 90 °C. Calculate the heat transfer coefficient if the exit water temperature is 64 °C.	13
	OR	
12 (b)	Calculate the convective heat loss from a radiator 0.5 m wide and 1 m high maintained at a temperature of 84 °C in a room at 20 °C. Treat the radiator as a vertical plate.	13
13 (a)	Water enters a 2.5-cm-internal-diameter thin copper tube of a heat exchanger at 15°C at a rate of 0.3 kg/s, and is heated by steam condensing outside at 120°C. If the average heat transfer coefficient is 800 W/m^2 °C, determine the length of the tube required in order to heat the water to 115°C.	13
	OR	
13 (b)	Discuss the various regimes of pool boiling heat transfer.	13
14 (a)	Radiative heat transfer is intended between the inner surfaces of two very large isothermal parallel metal plates. While the upper plate (designated as plate 1) is a black surface and is the warmer one being maintained at 727 °C, and the lower plate (plate 2) is diffuse and gray surface with an emissivity of 0.7 and is kept at 227°C. Assume that the surfaces are sufficiently large to form a two surface enclosure and steady state condition to exist. Stephen Boltzmann constant as 5.67x10^{-8} W/m^{2}K^4. What is the irradiation (kW/m^2) for the upper plate?	13

	OR	
14 (b)	A solid sphere of radius r_1=20 mm is placed concentrically inside a hollow sphere of radius r_2= 30 mm as shown in the figure 14b. Calculate the view factor F_{21} for radiation heat transfer.  Figure 14b.	13
15 (a)	Pressurized hydrogen gas is stored at 358 K in a 4.8 m outer-diameter spherical container made of nickel. The shell of the container is 6 cm thick. The molar concentration of hydrogen in the nickel at the inner surface is determined to be 0.087 kmol/m^3. The concentration of hydrogen in the nickel at the outer surface is negligible. The binary diffusion coefficient for hydrogen in the nickel at the specified temperature is 1.2 x 10^{-12} m^2/s. Determine the mass flow rate of hydrogen by diffusion through the nickel container.	13
	OR	
15 (b)	Helium diffuses through a plane, plastic membrane 1 mm thick. The concentration of helium in the membrane is 0.02 k mol/m^3 at the inner surface and 0.005 k mol/m^3 at the outer surface. If the binary diffusion coefficient of helium with respect to the plastic is 10^{-9} m^2/s, what is the diffusion flux of helium through the plastic?	13

PART- C (1 x 15 = 15 Marks)

(Q.No.16 is compulsory)

Q. No	Questions	Marks
16.	Water enters a counter flow, double pipe heat exchanger at 15°C, flowing at the rate of 1300 kg/h. It is heated by oil (Cp = 2000 J/kg K) flowing at a rate of 550 kg/h from the inlet temperature of 94 °C. For an area of 1 m^2 and an overall heat transfer coefficient of 1075 W/m^{2}K, determine the total heat transfer and the outlet temperatures of water and oil.	15