Printed Page:-04 **Subject Code:- BME0401**

Roll. No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech (Working Professional)

SEM: II - THEORY EXAMINATION (2024 - 2025)

Subject: Heat & Mass Transfer

Time: 3 Hours **Max. Marks: 100**

General Instructions:

IMP: *Verify that you have received the question paper with the correct course, code, branch etc.*

1. *This Question paper comprises of* ***three Sections -A, B, & C.*** *It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.*

2. *Maximum marks for each question are indicated on right -hand side of each question.*

3. *Illustrate your answers with neat sketches wherever necessary.*

4. *Assume suitable data if necessary.*

5. *Preferably, write the answers in sequential order.*

6. *No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.*

SECTION-A 20

1. Attempt all parts:-

1-a. Thermal diffusivity of a substance is (CO1,K1) 1

(a) Inversely proportional to thermal conductivity

(b) Directly proportional to thermal conductivity

(c) Directly proportional to the square of thermal conductivity

(d) Inversely proportional to the square of thermal conductivity

1-b. Upto the critical radius of insulation (CO1, K1) 1

(a) Convection heat loss will be less than conduction heat loss

(b) Heat flux will decrease

(c) Added insulation will increase heat loss

(d) Added insulation will decrease heat loss

1-c. A fin protrudes from a surface which is held at a temperature higher than that of its environment. The heat transferred away from the fin is. [CO2,K1] 1

(a) Heat escaping from the tip of the fin

(b) Heat conducted along the fin length

(c) Convective heat transfer from the fin surface

(d) Sum of heat conducted along the fin length and that convected from the surface.

1-d. The value of Biot number is very small (less than 0.01) when (CO2,K1) 1

(a) The convective resistance of the fluid is negligible

(b) The conductive resistance of the fluid is negligible

(c) The conductive resistance of the solid is negligible

(d) None of these

1-e. A region of fluid motion near a plate in which temperature gradient exist is(CO3,K1) 1

(a) Thermal boundary layer

(b) Diathermia boundary layer

(c) Turbulent flow

(d) Laminar flow

1-f. Forced convection in a liquid bath is caused by (CO3, K1) 1

(a) Intense stirring by an external agency

(b) Molecular energy interactions

(c) Density difference brought about by temperature gradients

(d) Flow of electrons in a random fashion

1-g. A perfectly black body (CO4, K1) 1

(a) Absorbs all the incident radiation

(b) Allow all the incident radiation to pass through it

(c) Reflects all the incident radiation

(d) Has its surface coated with lamp black or graphite

1-h. Radiation heat transfer is characterized by (CO4, K1) 1

(a) Due to bulk fluid motion, there is a transport of energy

(b) Thermal energy transfer as vibrational energy in the lattice structure of the material

(c) Movement of discrete packets of energy as electromagnetic waves

(d) There is circulation of fluid by buoyancy effects

1-i. Air enters a counter flow heat exchanger at 70°C and leaves at 40°C. Water enters at 30°C and leaves at 50°C. The LMTD in degree C is:(CO5,K2) 1

(a) 5.65

(b) 4.43

(c) 19.52

(d) 20.17

1-j. Capacity ratio is defined as the product of. [CO5,K1] 1

(a) Mass and temperature

(b) Mass and specific heat

(c) Specific heat and temperature

(d) Time and temperature

2. Attempt all parts:-

2.a. How does the heat conduction differ from convection? (CO1, K1) 2

2.b. Define effectiveness of the fin. [CO2,K1] 2

2.c. Define thermal boundary layer thickness. (CO3, K1) 2

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2.d. Define concept of Black body. (CO4, K1) 2

2.e. What is Excess temperature in boiling? (CO5, K1) 2

SECTION-B 30

3. Answer any five of the following:-

3-a. A 4 m high and 6 m wide wall consists of 18 cm × 30 cm cross-section horizontal bricks (k = 0.72 W/m.K) separated by 3 cm thick plaster layer (k = 0.22 W/m.K). There are also 2 cm thick plaster layers on each side of wall and 2 cm thick rigid foam (k = 0.026 W/m.K) on the inner side of the wall. The indoor and outdoor temperatures are 22°C and – 4°C and convection heat transfer coefficients are 10 W/m^2.K and 20 W/m^2.K respectively. Assuming one dimensional steady state conditions. Calculate heat transfer rate from the composite wall. (CO3, K3) 6

3-b. Derive an expression for critical radius of insulation of a cylinder. (CO1, K3) 6

3-c. A person is found dead at 5 p.m. in a room where temperature is 20°C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient is estimated to be 8 W/m2.K. Modelling the human body a 30 cm diameter, 1.70 m long cylinder, calculate actual time of death of the person. Take thermo physical properties of the body : k = 6.08 W/m.K, $\rho = 900$ kg/m^3, C = 4000 J/kg.K.(CO2,K3) 6

3-d. What is transient heat conduction? State two example of transient heat conduction. [CO2,K2] 6

3.e. Air at 20°C and 1 atm, flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 60°C. Assuming unit depth in the z direction, calculate the heat transfer from the plate. Properties of the fluid are given as: $\rho = 1.128$ kg/m^3, $\mu = 1.906\times10^{-5}$ kg/m.s, Pr = 0.7, k = 0.02723 W/m·°C, c_p = 1.007 kJ/kg·°C.
$N_{uL} = Pr^{1/3}(0.037\ R_{eL}^{0.8} - 871)$ (CO3, K3) 6

3.f. Define absorptivity, reflectivity and Transmissivity in reference of radiation. (CO4, K2) 6

3.g. Discuss Film-wise and dropwise condensation. (CO5, K3) 6

SECTION-C 50

4. Answer any one of the following:-

4-a. Derive general heat conduction equation in Cartesian coordinates and mention the assumptions for this derivation. (CO1,K3) 10

4-b. Steam at 300^0C flows in a stainless steel pipe of thermal conductivity, k=30 W/m K whose inner and outer diameters are 5cm and 5.5cm respectively. The pipe is covered with 5cm. thick glass wool (thermal conductivity=0.038 W/m K). Heat is lost to the surroundings at 20^0C by convection and radiation with a combined heat transfer coefficient of 15 W/m^2 K. Taking the inside heat transfer coefficient as 80 W/m^2 K, calculate the heat lost per meter length of the pipe. (CO1, K3) 10

5. Answer any one of the following:-

5-a. A HSS sphere of 20 mm in diameter initially at 600°C is exposed to a current of 10

air at 30°C with convection coefficient of 150 W/m^2.K. Calculate the Time required to cool the sphere to 100°C. Take properties of mild steel as : k = 43 W/m.K, $\rho = 7850$ kg/m^3, C = 474 J/kg.K, $\alpha = 0.045$ m^2/s. (CO2, K3)

5-b. Derive the governing equation of fins of uniform cross-section.(CO2,K3) 10

6. Answer any <u>one</u> of the following:-

6-a. Discuss the following with their applications: (CO3,K3) 10
(a) Reynold's Number (b) Grashof number
(c) Nusselt Number (d) Prandtl number

6-b. Water flows at 30°C at 10 kg/s through the diffuser having 5 cm diameter at the entrance and 10 cm diameter at its exit. Calculate the fluid velocity and Reynolds number at the inlet and exit of the diffuser.[CO3, K3] 10

7. Answer any <u>one</u> of the following:-

7-a. A spherical tank of 2 m diameter is used to store liquid nitrogen at – 170°C. It is kept in an evacuated cubic enclosure whose sides are 3 m long. The emissivity of the spherical tank and enclosure are $\varepsilon 1 = 0.2$ and $\varepsilon 2 = 0.9$, respectively. If the temperature of cubic enclosure is 33°C, determine the net rate of radiation heat transfer to liquid nitrogen. (CO4, K3) 10

7-b. Two large parallel planes with emissivity 0.6 are at 900 K and 300 K. A radiation shield with one side polished and having emissivity of 0.05, while the emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temperature of shield is to be kept minimum? Justify your answer. (CO4, K3) 10

8. Answer any <u>one</u> of the following:-

8-a. A double pipe heat exchanger is used to heat water with a mass flow rate of 15 kg/s from 15°C to 33°C. The heating fluid enters at 75°C with a capacity rate of 25 kW/K and the mean overall coefficient of heat transfer is 1570 W/m2.K. Determine the surface areas for counter flow and parallel flow arrangements. (CO5, K3) 10

8-b. Explain pool boiling curve and its different regions in details. (CO5, K2) 10