BIRLA INSTITUTE OF TECHNOLOGY
MESRA – 835215, RANCHI, INDIA

UG

Name: …… Roll No.: ……..

Branch: …… Signature of Invigilator: ……

Semester: IVth Date: 28/04/2022 (MORNING)

Subject with Code: **CL208 HEAT TRANSFER OPERATIONS**

Marks Obtained	Section A (30)	Section B (20)	Total Marks (50)

INSTRUCTION TO CANDIDATE

1. The booklet (question paper cum answer sheet) consists of two sections. First section consists of MCQs of 30 marks. Candidates may mark the correct answer in the space provided / may also write answers in the answer sheet provided. The Second section of question paper consists of subjective questions of 20 marks. The candidates may write the answers for these questions in the answer sheets provided with the question booklet.
2. The booklet will be distributed to the candidates before 05 minutes of the examination. **Candidates should write their roll no. in each page of the booklet.**
3. Place the Student ID card, Registration Slip and No Dues Clearance (if applicable) on your desk. All the entries on the cover page must be filled at the specified space.
4. Carrying or using of mobile phone / any electronic gadgets (except regular scientific calculator)/chits are strictly prohibited inside the examination hall as it comes under the category of unfair means.
5. No candidate should be allowed to enter the examination hall later than 10 minutes after the commencement of examination. Candidates are not allowed to go out of the examination hall/room during the first 30 minutes and last 10 minutes of the examination.
6. Write on both side of the leaf and use pens with same ink.
7. The medium of examination is English. Answer book written in language other than English is liable to be rejected.
8. All attached sheets such as graph papers, drawing sheets etc. should be properly folded to the size of the answer book and tagged with the answer book by the candidate at least 05 minutes before the end of examination.
9. The door of examination hall will be closed 10 minutes before the end of examination. Do not leave the examination hall until the invigilators instruct you to do so.
10. Always maintain the highest level of integrity. Remember you are a BITian.
11. Candidates need to **submit the question paper cum answer sheets before leaving the examination hall**.

BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS:BE **SEMESTER : IV**
BRANCH:CHEM **SESSION : SP/22**

SET-1
SUBJECT: CL 208 HEAT TRANSFER OPRATIONS

TIME: 10 AM- 12 NOON **FULL MARKS: 50**

INSTRUCTIONS:
1. The missing data, if any, may be assumed suitably.
2. Before attempting the question paper, be sure that you have got the correct question paper.
3. Candidates must attempt all questions maximum of 50 marks.

Group A: Multiple Choice Questions (numbered in English small alphabet), Ful Marks-30

Q.1 A tapered solid block (Fig i) is insulated on the curved surfaces. If heat flux at the face A is 200 W/m^2, the heat flux at face B is: (Assume steady state condition and no heat generation. A and B faces are not insulated) [1]
a) 800 W/m^2 b) 50 W/m^2 c) 100 W/m^2 d) none of these

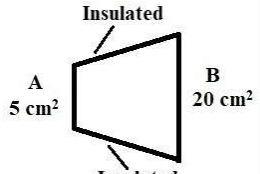

Fig i

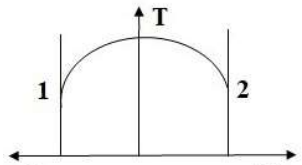

Fig ii

Q.2 Steady state temperature distribution in a plane wall is shown in Fig. ii (Q.1). The sign of temperature gradient at plane 1 is a) negative b) positive c) can't say [1]

Q.3 The thermal conductivity of most liquids increases with a) increase in temperature b) decrease in temperature c) remain same [0.5]

Q.4 Efficiency of a fin is the ratio of actual heat transfer rate to the rate of heat transfer if the a) fin temperature is lower than the base wall temperature, b) fin temperature is uniform and equal to the base wall temperature, c) fin temperature is higher than the base wall temperature, d) None of these [0.5]

Q.5 The steady-state temperature distribution in the very large thin plate with uniform surface temperature will be (a) Logarithmic (b) Parabolic (c) Hyperbolic (d) Linear [1]

Q.6 In the lumped parameter model, the temperature variation with time is (a) Exponential (b) Sinusoidal (c) Cubic (d) Linear [1]

Q.7 Thermal diffusivity of a substance is (a) Directly proportional to the thermal conductivity (b) Inversely proportional to the density of substance (c) Inversely proportional to specific heat (d) All the above [1]

Q.8 The wall of a pipe of radius 1 m is maintained at a uniform temperature of 200°C and is covered by insulation of thickness 0.1 m. The temperature of ambient air outside the insulated pipe is 20°C has heat-transfer coefficient of 10 $W/m^2.K$. The thermal conductivity of insulation material is 0.05 W/m.K. If heat transfer occurs at steady state, the temperature (in °C) of the outer surface of insulation is (a) 45.1°C (b) 33.7°C (c) 51.6°C (d) 28.2°C [2]

Q.9 If the hydrodynamic boundary layer thickness is higher than the thickness thermal boundary layer, the Prandtl number is i) lower than one ii) higher than one iii) equal to one iv) none of these [1]

Q.10 For a turbulent flow in a circular pipe, if pipe diameter is reduced by half the film heat transfer coefficient a) increases approximately by $4^{0.8}$, b) increases approximately by $2^{0.8}$, c) decreases approximately by $4^{0.8}$, d) decreases approximately by $2^{0.8}$ [1]

Q.11 Natural convection takes place in a liquid in a container if it is a) heated from the bottom b) cooled from the side walls d) cooled from the top iv) all of these [1]

Q.12 For a vertical surface the critical Rayleigh number is close to a) 10^6 b) 10^7 c)10^8 d) 10^9 [0.5]

Q.13 Grashof number has significant role in heat transfer by (a) Conduction (b) Radiation (c) Natural convection (d) Forced convection [1]

Q.14 In case of laminar flow over flat plate, the convective heat-transfer coefficient (a) Decreases with increase in free stream velocity (b) Increases with distance (c) Increases if more viscous fluid is used (d) Increases if denser fluid is used [1]

Q.15 What does a high value of Prandtl number indicate? (a) Rapid heat transfer by forced convection to heat transfer by natural convection (b) Rapid diffusion of momentum compared to diffusion of energy (c) Rapid heat transfer by conduction compared to heat transfer by convection (d) All of the above [1]

Q.16 Liquid bismuth flows at a rate of 4.5 kg/s through a tube of 5 cm diameter. Bismuth enters the tube at 415°C and is heated to 440°C as it flows through the tube. If viscosity, specific heat, thermal conductivity and Prandtl number of bismuth at average bulk temperature are 1.34×10^{-3} kg/m.s, 0.149 kJ/kg.°C, 15.6 W/m.°C and 0.013 respectively, the Peclet number equals to [2]
(a) 1892 (b) 1112 (c) 1245 (d) 1592

Q.17 With which of the following "Leidenfrost effect" is associated (a) Condensation of vapor on a cold surface (b) Boling of liquid on a hot surface (c) Evaporation of a solution (d) Exchange of heat between two fluids [1]

Q.18 Which is of the following statement is incorrect? (a) Film boiling regime is usually avoided in commercial equipment (b) In subcooled boiling, temperature of the heating surface is more than the boiling point of the liquid (c) There occurs a transition from nucleate to film boiling at critical point on the boiling curve (d) Nucleate boiling gets promoted on a smooth surface [1]

Q.19 In nucleate boiling, the pressure inside the bubble is higher than the pressure of the surrounding liquid. Assuming that both liquid and vapor are saturated, the temperature of the liquid will always be (a) At 100°C (b) Lower than the temperature of the vapor (c) Equal to the temperature of the vapor (d) Higher than the temperature of the vapor [1]

Q.20 Economy of evaporators used for concentrating sugarcane juice is the ratio of (a) kg of concentrate juice produced to kg of steam supplied (b) kg of steam supplied to kg of sugarcane juice fed (c) kg of water vaporized to kg of steam supplied (d) kg of sugarcane juice fed to kg of water vaporized [1]

Q.21 Limitation of Nusselt's analysis of film condensation on a vertical surface is (a) Flow in the condensate film is one-dimensional (b) Non-consideration of convection effects (c) Linear temperature distribution in the film (d) All of above [1]

Q.22 In presence of non-condensable gas with vapor, the condensation heat transfer coefficient a) increases b) decreases c) remain same [0.5]

Q.23 A 10-cm-diameter disk is placed at the center and parallel (at the hemisphere base) to a 20-cm-diameter hemisphere. Designating the hemisphere as surface 1, the disk as surface 2, and a large surrounding room as surface 3, F_{12} is a) 0.0625 b) 0.125 c) 0.5 d) none of these [2]

Q.24 An annular space between two concentric cylinders (1 & 2) is filled with a gas whose emissivity and transmissivity are 0.3 and 0.7, respectively. The inside and outside radii of the annular space are r_1=10 and r_2=20 cm, and the emissivities of the surfaces are 0.5 (surface 1) and 0.3 (surface 2), respectively. The two cylinders are of equal length of 1 m. The inside surface is maintained at 900 K, while the outside surface is maintained at 400 K. Neglect convection heat transfer. F_{21}=0.45 and T_m is the temperature of the medium. The equation for node 1 relating surface 1 in the network diagram is given by [2]
a) $(\sigma(900)^4 - J_1)/15.92 + (J_1 - J_2)/25.26 + (J_1 - \sigma(T_m)^4)/53.05 = 0$
b) $(\sigma(900)^4 - J_1)/15.92 + (J_2 - J_1)/25.26 + (\sigma(T_m)^4 - J_1)/53.05 = 0$
c) $(\sigma(900)^4 - J_1)/15.92 + (J_2 - J_1)/50.52 + (J_1 - \sigma(T_m)^4)/53.05 = 0$ d) none

Q.25 In a direct contact heat exchanger, there is a) Mass transfer b) Heat transfer c) Heat & mass transfer d) None [0.5]

Q.26 The sequence of the modes of heat transfer in case of a heat exchanger is [0.5]
a) Cond + Conv + rad b) Conv+ Rad +Conv c) Conv +Cond +Conv d) None

Q.27 For the calculation of Overall Heat transfer coefficient U_D for given fouling factor R_f and Dirt Factor R_d, which one of the following expressions do we use? a) $(U_C^{-1} + R_d^{-1} + R_f)^{-1}$ b) $(U_C^{-1} + R_d + R_f)^{-1}$ c) $(U_C^{-1} + Rd + R_f^{-1})$ d) $(U_C^{-1} + R_d + R_f)$ [1]

Q.28 Consider we have a 1-2 Shell and Tube Heat Exchanger with tube diameter 20 mm and shell diameter 55mm, we have two fluids A & B, A is supply water and B is distilled water, we desire to have their flow rates as 15 m^3/s and 21 m^3/s respectively. Which fluid pass arrangement would be best suited for the HE? a) Parallel flow with A in tube and B in the shell side b) Counter flow with B in tube and A in the shell side c) Counter flow with A in tube and B in the shell side d) Parallel flow with B in tube and A in the shell side [2]

Group B: Broad Questions, Ful Marks-30

Q.1 A plane wall of thickness L is constructed of a material having a thermal conductivity that varies with temperature T according to the relation $k = k_0(1+bT)$. At x=0, $T=T_1$ and x=L, $T=T_2$. Derive an expression for the heat transfer in such a wall at steady state. Here k_0 and b are constants. [3]

Q.2 Water is to be heated from 20°C to 40°C in a 2.5-cm-ID smooth pipe at 0.2 kg/s. If the duct wall temperature is constant at 90°C, calculate i) the film heat transfer coefficient and ii) the length of the pipe. Water: ρ=996 kg/m^3; C_p=4178 J/Kg °C; μ=87×10^{-5} kg/m s; k=0.618 W/m °C. [4]

Q.3 An electric wire of 0.25 mm diameter, emissivity = 0.4 is placed within a tube of 2.5 mm diameter, emissivity = 0.6 having negligible thickness. This tube in turn is placed concentrically within a tube of 5 mm diameter, emissivity = 0.7. The length of the electric wire is equal to the lengths of tubes. If the surface temperature of the outer tube is maintained at 5°C, what must be the temperature of the wire so that the temperature of the inner tube can be maintained at 120°C? [5]

Q.4 A 1-1 pass shell and tube heat exchanger, consisting of tube bundle of 100 tubes (inner diameter = 25 mm and outer diameter = 29 mm) is used for heating 500 kg/min of water from 30°C to 70°C with the help of steam condensing at atmospheric pressure on the shell side. Calculate the overall heat-transfer coefficient based on the inner area and length of the tube bundle if the outside heat-transfer coefficient is 5000 $W/m^2.°C$. and the inside heat-transfer coefficient is given by the correlation: $Nu = 0.023(Re)^{0.8}(Pr)^{0.33}$. Assume that the fouling factor on the water side to be 0.0002 $m^2.°C/W$. Neglect the effect of fouling on the shell side and thermal resistance of the tube wall. Density, specific heat, thermal conductivity, dynamic viscosity, kinematic viscosity and Prandtl number of water at the mean temperature of 50°C are 988.1 kg/m^3, 4174 J/kg.°C, 0.6474 W/m.°C, $550x10^{-6}$ kg/m.s, $0.555x10^{-6}$ m^2/s and 3.54 respectively. [5]

Q.5 Describe the triple effect backward feed evaporator with diagram. [3]

:::::28/04/2022:::::