Reg.No. \_\_\_\_\_\_\_\_\_\_\_\_



**End Semester Examination – Nov/Dec – 2017**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| **Code :** | **14ME2019** | **Duration :** | **3hrs** |
| **Sub. Name :** | **HEAT AND MASS TRANSFER** | **Max. marks :** | **100** |

**(Permitted to use Heat and Mass Transfer Data Book)**

**ANSWER ALL QUESTIONS (5 x 20 = 100 Marks)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q. No. | Sub Div. | Questions | Course  Outcome | Marks |
| 1. | a. | A hollow sphere 10 cm I.D. and 30 cm O.D. of a material having thermal conductivity 50 W/mK is used as a container for a liquid chemical mixture. Its inner and outer surface temperatures are 300oC and 100oC respectively. Determine the heat flow rate through the sphere. Also estimate the temperature at a point quarter of the way between the inner and outer surfaces. | CO1 | 10 |
| b. | 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 metre will not exceed 1450 W. Assuming that the inner and outer surface temperatures are 1200oC and 15oC respectively, calculate the thickness of insulation required. | CO1 | 10 |
| (OR) | | | | |
| 2. | a. | A 10 cm O.D. steam pipe carrying saturated steam at 1373 kPa is lagged to 20 cm diameter with magnesia (k=0.07 W/mK) and further lagged with laminated asbestos of thermal conductivity 0.08 W/mK to 25 cm diameter. The whole pipe is further protected by a layer of canvas. If the temperature under the canvas is 20oC, find the mass of steam condensed in 12 hours on 150 m length of pipe. Neglect thermal conductivity effect of the pipe material. The saturation temperature of the steam is 467.14K and the latent heat of condensation of the steam is 1963.15 kJ/kg. | CO1 | 10 |
| b. | Evaluate the thickness of rubber insulation necessary in the case of a 10 mm diamtere copper conductor to ensure maximum heat transfer to the atmosphere, given the thermal conductivity of rubber as 0.155 W/mK and the surface film coefficient as 8.5 W/m2K. Estimate this maximum heat transfer rate per metre length of the conductor if the temperature of the rubber is not to exceed 65oC while the atmosphere is at 30oC. | CO1 | 10 |
| 3. | a. | A thin square metal plate made of Aluminium has the following temperature boundary conditions: Left edge: 100oC; Right edge: 100oC; Top edge: 500oC; Bottom edge: 100oC. Determine the temperature at four node points on the metal plate by performing a detailed numerical analysis assuming the distance between the node points to be equal in both the horizontal and vertical directions. Label the four node points as T1, T2, T3, T4. | CO1 | 10 |
|  | b. | The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as a 1-mm-diameter sphere. The properties of the junction are k = 35 W/mK, ρ = 8500 kg/m3 , and Cp = 320 J/kgK, and the convection heat transfer coefficient between the junction and the gas is h = 210 W/m2K. Determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference. | CO1 | 10 |
| (OR) | | | | |
| 4. | a. | An ordinary egg can be approximated as a 5-cm-diameter sphere. The egg is initially at a uniform temperature of 5°C and is dropped into boiling water at 95°C. Taking the convection heat transfer coefficient to be h = 1200W/m2K, determine how long it will take for the center of the egg to reach 70°C. | CO1 | 8 |
|  | b. | Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate. The properties of engine oil at the film temperature of 40°C are: ρ = 876 kg/m3, Pr = 2870, k = 0.144 W/mK, ν = 242 X 10-6 m2/s. | CO1 | 12 |
|  |  |  |  |  |
| 5. | a. | Using dimensional analysis obtain an expression for Nusselt number in terms of Grashof number and Prandtl number for natural convection heat transfer. | CO1 | 10 |
|  | b. | A 6-m-long section of an 8-cm-diameter horizontal hot water pipe shown in passes through a large room whose temperature is 20˚C. If the outer surface temperature of the pipe is 70˚C, determine the rate of heat loss from the pipe by natural convection. The properties of air at the film temperature of 45˚C and 1 atm are k = 0.02699 W/mK, Pr = 0.7241, ν = 1.749 X 10-5 m2/s. | CO1 | 10 |
| (OR) | | | | |
| 6. | a. | A double-pane window consists of two glass panes separated by air. Someone claims that the air space in a double-pane window enhances the heat transfer from a house because of the natural convection currents that occur in the air space and recommends that the double-pane window be replaced by a single sheet of glass whose thickness is equal to the sum of the thicknesses of the two glasses of the double-pane window to save energy. Do you agree with this claim? Justify with a detailed explanation. | CO1 | 8 |
|  | b. | A turbine blade 6 cm long and having a cross-sectional area 4.65 cm2 and perimeter 12 cm, is made of stainless steel (k=23.3 W/mK). The temperature at the root is 500oC. The blade is exposed to a hot gas at 870oC. The heat transfer coefficient between the blade surface and gas is 442 W/m2K. Determine the temperature distribution and rate of heat flow at the root of the blade. Assume the tip of the blade to be insulated. | CO1 | 12 |
| 7. | a. | Saturated steam at 120oC is condensing on the outer tube surface of a single pass heat exchanger. The heat transfer coefficient is 1800 W/m2K. Determine the surface area of a heat exchanger capable of heating 1000 kg/h of water from 20oC to 90oC. Also compute the rate of condensation of steam. Assume latent heat of condensation of steam as 2200 kJ/kg. | CO2 | 15 |
|  | b. | How does the log mean temperature difference (LMTD) for a heat exchanger differ from the arithmetic mean temperature difference (AMTD)? For specified inlet and outlet temperatures, which one of these two quantities is larger? | CO2 | 5 |
| (OR) | | | | |
| 8. | a. | Helium diffuses through a plane plastic memebrane 1 mm thick. The concentration of helium in the membrane is 0.02 kmol/m3 at the inner surface and 0.005 kmol/m3 at the outer surface. If the binary diffusion coefficient of helium with respect to the plastic is 10-9 m2/s, what is the diffusion flux of helium through the plastic? | CO3 | 10 |
|  | b. | Determine the mole fraction of the water vapor at the surface of a lake whose temperature is 15°C and compare it to the mole fraction of water in the lake. Take the atmospheric pressure at lake level to be 92 kPa. The saturation pressure of water at 15°C is 1.705 kPa | CO3 | 10 |
|  | | **Compulsory:** |  |  |
| 9. |  | A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T1=800 K and T2=500 K and have emissivities Є1=0.2 and Є2=0.7, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield. | CO1 | 20 |

ALL THE BEST