ST.ANNE'S CET

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY QUESTION FOR HEAT AND MASS TRANSFER

TWO MARKS

1. State Fourier's law of heat conduction.
2. Define and distinguish between steady state, unsteady state and transient state of heat transfer.
3. Give the examples of heat generation applications.
4. Define fin efficiency and fin effectiveness.
5. Write note on electrical analogy for conduction problem.
6. What is meant by unsteady heat conduction?
7. Define error function and its significance.
8. What is lumped capacity?
9. What is meant by thermal boundary layer?
10. Discuss nucleate boiling.
11. Discuss fouling factor.
12. Discuss drop wise condensation.
13. Define radiation shape factor.
14. Discuss electromagnetic wave theory and quantum wave theory of radiation.
15. Define absorption factor.
16. Explain the concept of blackbody radiation.
17. Define mass transfer coefficient.
18. Distinguish between molecular diffusion and thermal diffusion.
19. Explain diffusion in turbulent flow.
20. Explain the similarity between heat transfer and mass transfer.
21. State the mode of heat transfer.
22. Derive the unit of Thermal conductivity.
23. Give electrical analogy for heat conduction through two layers of plane wall with convective boundaries.
24. Write the expression for log-mean area of a cylinder.
25. Give minimum of two examples for multi dimensional heat transfer.

26. What is the significance of Biot number in heat transfer?
27. Define lumped capacity system in transient conduction?
28. What for Heisler chart are used?
29. Define Thickness of Hydrodynamic boundary layer.
30. Define effectiveness of heat exchangers.
31. What are the dimensionless numbers normally involved in the analysis of natural convection.
32. What is fouling factor?
33. With a sketch indicate the concept of black body.
34. What is the reciprocity theorem of thermal radiation?
35. State Wien's displacement law.
36. What are the gases normally absorb and emit heat radiations.
37. What are the similarities between heat transfer and mass transfer?
38. From the following pick out the quantities which how the same unit. Kinematic viscosity, Dynamic viscosity, Surface tension, Mass diffusion coefficient, Film heat transfer coefficient, Mass transfer coefficient.
39. State Ficks law of mass transfer.
40. What are the mechanisms of mass transfer?
41. How conduction takes place in solids.
42. Give a typical expression for variable thermal conductivity.
43. Write Fourier conduction equation for steady state unidirectional heat conduction with heat generation in plane wall.
44. Calculate critical insulation radius over a copper tube if thermal conductivity of Cu is 386 w/mK and convective heat transfer coefficient is 1544 w/m^2K.
45. Define conduction shape factor in two dimensional heat transfers.
46. What is the significance of Fourier number?
47. Give expression for time constant of a thermocouple.
48. What is the use of Grober chart?
49. Define Thickness of thermal boundary layer.
50. How natural convection occurs?
51. What are the types of condensation?

52. Sketch the graph "Temperature Vs length of tube" of a counter flow heat exchanger.
53. Show that "Absorptivity + Reflectivity + Transmissivity = 1".
54. Sketch a network representing the radiation heat transfer between three gray surfaces.
55. Determine the temperature of a body which emits maximum emissive power at a wave length of 2.636μm.
56. Define gray body.
57. State the condition under which mass transfer takes place.
58. Derive the unit of mass diffusion coefficient.
59. What is equimolal counter diffusion?
60. Give any two applications of mass transfer analysis.
61. What is meant by isotropic material?
62. Define critical insulation radius.
63. Give an expression for efficiency of long fin.
64. What are the boundary conditions for end insulated short fin.
65. Define Fourier Number.
66. Give examples of transient heat conduction.
67. Mention an example for semi infinite body.
68. What is lumped capacity analysis applicable in transient conduction?
69. Define free convection. Give an example.
70. What is nucleate boiling?
71. Name the theory meant for film wise condensation.
72. Give an expression for NTU.
73. State and express Stefan- Boltzmann law.
74. Define emissive power of gray body.
75. Find out the temperature of a body for which maximum energy associated wave length is 2.9 X 10^{-6} m.
76. Give the emissivity of a gray body for which absorptivity is given as 0.8.
77. Enumerate the industrial importance of mass transfer.
78. What are the types of mass transfer? Give one example to each.

79. Define mass transfer coefficient.
80. Give the significance of Stanton number.
81. Generally, good electrical conductors are also good thermal conductors. Why?
82. Give the significance of fin effectiveness.
83. Give four applications of heat conduction with internal generation.
84. Give a composite sphere. Write the steady state heat conduction equation with possible boundary conditions.
85. What is significance of Biot number in unsteady conduction heat transfer?
86. Give the rules to be followed while constructing the flux plot in two-directional conduction.
87. Define a semi-infinite solid.
88. What is significance of Prandtl number?
89. Distinguish between Nucleate boiling and convection boiling?
90. What is NTU method of analysis of heat exchangers preferred?
91. Draw the boundary layers over a hot plate immersed in cold air and mark all the relevant terminology.
92. What is meant by irradiation? Give its units.
93. What are the applications of radiation shields?
94. Distinguish between a gray body and a black body.
95. Explain the importance of radiation shape factor.
96. What is Lewis number? How is it important?
97. Differentiate between diffusive and convective mass transfer.
98. Define the Fourier number for mass transfer.
99. Define diffusion coefficient.
100. What is the application of the concept of critical insulation thickness?
101. What is meant by Thermal diffusivity? What is its importance?
102. Large numbers of thin fins are prepared over small number of thick fins. Why?
103. What is meant by thermal resistance? What are its units?
104. Give two applications of lumped heat analysis.
105. Give the importance of Fourier Number.

106. How can electrical analogy be used in transient conduction?

107. Write down the Prantdl's boundary layer equations and the boundary conditions.

108. Which is better with regard to rate of condensation dropwise of film? Why?

109. What is significance of Nusselt number? Where is it used?

110. Give four applications of compact heat exchangers.

111. Define intensity of radiation. Write its units.

112. What is the meant by reciprocity relation between shape factors?

113. Compare radiation characteristics of a solid surface with those of a gaseous mixture.

114. What is solar constant? Give the value.

115. Define Stefan's law.

116. Give the applications of convective mass transfer.

117. Compare convective heat transfer with convective mass transfer.

118. What is the significance of Schmidt number?

SIXTEEN MARKS QUESTION

1. Derive an equation for critical radius of insulation of a sphere. Compare it with that of a cylinder.
2. A slab of copper is submerged in a constant temperature both at temperature T_∞. An electric current through the slab causes a uniform heat generation of $\dot{q}$ W/m^3. The convective heat transfer coefficient on each face of the slab is the same, h, resulting in a temperature distribution in the slab.
3. Define critical insulation thickness. Derive an expression for critical insulation radius in case of a thin wire. Explain its significance with a graph.
4. A motor body 360mm in external diameter and 240mm long is provided with longitudinal fins of 15mm thickness and 40mm height. The base temperature of the fins may be taken as 55 ^{0}C, and the atmospheric temperature 30^{0}C. Determine number of fins required to dissipate 340 W.

5. A stainless steel pin fin (K=16 W/m.K) 10 cm long and 1 cm diameter is fitted to a wall which is exposed to a boiling water convection situation where h= 5000 $W/m^2.K$. Check whether or not the installation of this fin is desirable.
6. A current of 200 A is passed through a stainless steel wire 3 mm in diameter. The resistivity of steel may be taken as 70μΩ-cm and the length of the wire is 1m. The wire is submerged in a liquid at 110 ^0C and experiences a convective heat transfer coefficient of 4 kW/m^2-K. Taking K for wire as 19 W/m.K, calculate the central temperature of the wire.
7. An aluminium sphere weighing 7 kg and initially at a temperature of 260^0C is suddenly immersed in a fluid at 10 ^0C. If h=50 W/m^2-K. Compute the time required to cool the sphere to 90 ^0C. Also calculate the temperature reached by the sphere after 3 minutes of immersion. For aluminium ρ= 2707 kg/m^3 C_p = 9000 J/kg-K, K= 204 W/m.K.
8. A slab of aluminium 10 cm thick is originally at a temperature of 500 ^0C. it is suddenly immersed in a liquid at 100 ^0C resulting in a heat transfer coefficient of 1200 W/m^2-K. Determine the temperatures at the center and on the surface after 1 minute. Also calculate the total heat removed from the slab per unit area during this period. For aluminium ρ= 2700 kg/m^3, α =8.4 X 10^{-5} m^2/s , K= 215 W/m.K, C_p = 0.9 kJ/kg-K.
9. A steel sphere of 10 cm diameter is suddenly immerged in a tank of oil at 10 ^0C. Initial temperature of sphere is 250 ^0C (h= 280 W/m^2-K). How long will it take for the center of the sphere to cool to 150 ^0C.
10. A pipe of 60 cm diameter carrying steam at 150 ^0C for heating purposes and a pipe of 20 cm diameter carrying water at 10 ^0C and laid underground at considerable depth, their center distance being 1m. Find the net heat transfer between the two pipes if they are placed parallel to each other. Length of each pipe 50m, K for soil 0.35 W/m.K.
11. Demonstrate the two dimensional heat flow calculating using numerical method of analysis.
12. A long pipe of 0.6 m outside diameter is buried in earth with axis at a depth of 1.8 m. the surface temperatures of pipe and earth are 95 ^0C and 25 ^0C respectively.

Calculate the heat loss from the pipe per meter length. The conductivity of earth is 0.51 W/m^{0}C.

13. Copper cylinder (α =1.12 X 10^{-4} m^2/s), 600 mm in diameter and 750 mm in length is initially at a uniform temperature of 20 ^{0}C. When the cylinder is exposed to hot flue gases, its surface temperature suddenly increases to 480 ^{0}C. Calculate a) the temperature at the centre of cylinder after 3 min, b) time required to reach 350 ^{0}C at the centre.
14. Water flows at a velocity of 12 m/s in a straight tube of 60 mm diameter. The inside surface of pipe is maintained at a temperature of 70 ^{0}C while the flowing water is heated from 15 ^{0}C to 45 ^{0}C. Determine the length of the tube required.
15. Determine the surface area required for a one shell pass and four tube passes heat exchanger which is required to cool 3200 kg/hr of Benzene (C_p = 1.74 kJ/kg-K) from 72 ^{0}C to 42 ^{0}C. The cooling water (C_p = 4.18 kJ/kg-K) at an inlet temperature of 15 ^{0}C flows at the rate of 2200 kg/hr. assume over all heat transfer coefficient as 280 W/m^2-K.
16. Air passes through a tube of 50 mm inside diameter with a velocity of 5 m/s. the air which is at 2 atm and at 40 ^{0}C is heated as it passes through the tube, the tube wall being at 80^{0}C. a) Find the heat transfer for 1 m length of the tube. b) The bulk mean temperature over a 3 m length of the tube.
17. A square vertical plate (800 mm by 800 mm) is exposed to saturated steam at atmospheric pressure. The plate temperature is maintained at 84 ^{0}C, check whether the condensate film is laminar or turbulent and calculate the mass of steam condensed per hour.
18. A horizontal uninsulated steam pipe of outer dia. 15 cm carries saturated steam at 105 ^{0}C. The temperature of the air surrounding the pipe is 30 ^{0}C. Calculate the quantity of condensation at the end of a 250 cm section of the pipe.
19. Show that $\acute{\varepsilon} = \frac{NTU}{1+NTU}$ for counterflow and $\acute{\varepsilon} = 1/2(1 - e^{-2NTU})$ for parallel flow if the capacity rates of the hot and cold fluids are equal. Explain why counter flow is more effective than parallel flow.
20. Two parallel black discs of diameter 0.5m placed 1m apart are maintained at 1000 K and 500 K respectively. Calculate the heat flow between the discs when (a)

they see nothing else but each other (b) they are connected by right cylindrical black refractory surface.

21. Prove that the radiation exchange between two infinite parallel planes per unit area is:

$$q_{12} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

Where ε_1 and ε_2 are emissivities of the two planes.

22. Explain the concept of black body with a neat sketch.
23. Derive an expression connecting absorptivity, reflectivity and transmissivity and explain the nature of bodies when these quantities individually take a value of 1.
24. The net radiation from the surface of two parallel plates maintained at temperature T_1 and T_2 is to be reduced by 79 times. Calculate the number of shields to be placed between the two surfaces to achieve this reduction, assuming the emissivities of the shields to be 0.05 and that of the surfaces to be 0.8. Explain your answer.
25. A long cylindrical heater, 25 mm diameter, is maintained at 1000 K and has emissivity of 0.6. the heater is located in a room whose walls are maintained at 300 K. find the percentage reduction in heat transfer if it is surrounded by radiation shield 0.5 m in diameter and emissivity of 0.1. Also find the temperature of the shield.
26. Estimate the diffusion rate of water from the bottom of a test tube 10 mm in diameter and 15 cm long into dry air at 25^oC. Take the diffusion coefficient of water through air as 0.255 X 10^{-4} m^2/s.
27. Dry air at 27 ^oC and 1 atm. Flows over a wet flat plate 50 cm long at a velocity of 50 m/s. calculate the mass transfer coefficient of water vapour in air at the end of the plate.
28. Ammonia and air experience equimolar counter diffusion in a circular tube of 3 mm diameter and 200 mm long. The system is at a total pressure of 1 atmosphere and temperature of 25 ^oC. If each end of the tube is connected to large reservoirs of air and ammonia, estimate the mass rate of air and ammonia through the tube.
29. The area of a surface of water is 0.65 m X 0.65 m. air at 50 ^oC and 1 atm. With relative humidity of 40% blows over the surface of water with a velocity of 2.3 m/s. the surface temperature of water is 30 ^oC. calculate amount of water evaporated per hour per m^2 of water surface.
30. Write notes on:
    a) Dimensionaless numbers in mass transfer and their significance.
    b) Equimolal counter diffusion.
31. Derive the equation for the diffusion rate of evaporated liquid into a stagnant gas. State the assumptions made.