Chapter 11. Thermal Properties of Matter

I. One mark questions (PART – A):

1. What is heat? (K)
2. Mention the SI unit of heat. (K)
3. Give the dimensional formula for heat. (A)
4. Mention the SI unit of temperature. (K)
5. What is the principle behind working of liquid thermometers? (A)
6. Name a liquid used in liquid-glass thermometers. (K)
7. What is the value of ice point in Fahrenheit scale? (K)
8. What is the value of steam point in Fahrenheit scale? (K)
9. Write the relationship between Fahrenheit scale and Celsius scale. (K)
10. State Boyle's law. (K)
11. Write the mathematical statement of Boyle's law. (A)
12. If the pressure of a gas is halved keeping its temperature constant, what happens to its volume? (A)
13. State Charles' law. (K)
14. Write the mathematical statement of Charles' law. (A)
15. The volume of a gas is V. If the temperature of the gas is doubled without changing the pressure, what is the new volume of the gas?(A)
16. Graphically represent the variation of pressure with temperature at constant volume for a dilute gas. (S)
17. What is the value of 100 ^{0}C in absolute scale temperature? (A)
18. When an object is heated, its temperature increases by 40 ^{0}C. Express the change in temperature in Kelvins. (U)
19. What is thermal expansion? (K)
20. What is linear expansion of a material? (K)
21. What is area expansion of a material? (K)
22. What is volume expansion of a material? (K)
23. Give the SI unit of linear expansion coefficient. (K)
24. Define linear expansion coefficient. (K)
25. Define area expansion coefficient. (K)
26. Define volume expansion coefficient. (K)
27. Give the relationship between α_l and α_a. (U)
28. Write the relationship between α_l and $\alpha_{v.}$ (U)
29. If the area expansion coefficient of a solid is *a*, what is the value of the volume expansion coefficient? (U)
30. How does fractional change in a dimension of a solid vary with change in its temperature? (U)
31. A copper sphere has a spherical cavity at its centre. If the sphere is heated, what happens to the volume of the cavity? (A)
32. What is thermal stress? (K)
33. At what temperature the density of water is maximum? (K)
34. Give an example for a substance which contracts on heating. (U)
35. How does the volume expansion for gases vary with temperature? (K)
36. Which among solids, liquids and gases have low coefficient of expansion? (K)
37. Write the relation connecting coefficient of volume expansion and the coefficient of area expansion. (U)
38. Define heat capacity of a substance. (K)

39. Give the SI unit of heat capacity. (K)
40. Define specific heat capacity of a substance. (K)
41. Write the SI unit of specific heat capacity. (K)
42. Define molar specific heat capacity of a substance. (K)
43. Mention the SI unit of molar specific heat capacity. (K)
44. How does the specific heat capacity of a substance vary with the mass of the substance? (A)
45. Mention a factor on which specific heat capacity of a substance depends. (A)
46. Write the value of specific heat capacity of water. (K)
47. A certain amount of heat Q will warm 1 g of material A by 3 ^{o}C and 1 g of material B by 4 ^{o}C. Which material has the greater specific heat? (S)
48. Define molar specific heat capacity at constant volume. (K)
49. Define molar specific heat capacity at constant pressure. (K)
50. Why is water used as a coolant in automobile radiators? (A)
51. What is calorimetry? (K)
52. Name the device which is used for measurement of heat exchange? (U)
53. Write the principle of calorimetry. (A)
54. Define melting point of a substance. (K)
55. What is regelation? (K)
56. While skating over ice, water acts as a lubricant. Mention the principle behind this. (A)
57. Define boiling point of a liquid.(K)
58. What do you call the temperature at which liquid and vapour states of a substance coexist? (U)
59. What is sublimation? (K)
60. Which states of a substance coexist during its sublimation? (K)
61. Define latent heat of a substance. (K)
62. Mention the SI unit of latent heat. (K)
63. Give the dimensional formula of latent heat. (A)
64. Define latent heat of fusion. (K)
65. Define latent heat of vaporization. (K)
66. 100 ^{o}C steam burn is more damaging than burn with 100 ^{o}C water. Give reason. (A)
67. How does melting point of ice change with increase in pressure? (U)
68. How does boiling point of water change with increase in pressure? (U)
69. Why cooking is difficult at high altitudes? (A)
70. What is the principle of pressure cooker? (K)
71. If we plot a graph of temperature of a substance versus the heat supplied to the substance, what is the slope of the graph during change of state? (A)
72. Why does food cook faster in a pressure cooker? (A)
73. What is conduction? (K)
74. What is convection? (K)
75. Which is the most significant mode of heat transfer in solids? (K)
76. Which kind of heat transfer dominates in fluids? (K)
77. Which kind of heat transfer involves actual motion of matter? (K)
78. Mention the SI unit of thermal conductivity. (K)
79. How does thermal conductivity of a solid depends on its area of cross section? (K)
80. Why cooking pots have copper coating on the bottom? (A)
81. An iron chair feels colder than a wooden chair on a cold day. Why? (A)

82. Which type of heat transfer does not require a transport medium? (U)
83. Which kind of heat transfer does a room hater use? (U)
84. Name the mode of heat transfer from sun to earth. (U)
85. Which is the fastest mode of heat transfer? (U)
86. Which type of heat transfer is common to all bodies? (U)
87. State Newton's law of cooling. (K)
88. Draw characteristic cooling curve for a hot liquid. (S)
89. Give an example for a greenhouse gas. (U)
90. State Kirchhoff's law of radiation. (K)
91. Define absorptivity of a substance. (K)
92. Define emissivity of a substance. (K)
93. What is the value of absorptivity of a perfect blackbody? (A)
94. State Stefan's law of radiation. (K)
95. State Wein's law. (K)

II. Two mark questions (PART – B):

1. Convert 37 ^{0}C into ^{0}F. (S)
2. Write a note on absolute scale of temperature. (U)
3. State and explain Boyle's law. (U)
4. State and explain Charles' law. (U)
5. Differentiate between heat and temperature. (U)
6. Write ideal gas equation and explain the terms. (K)
7. Define heat capacity of a substance. Mention its SI unit. (K)
8. Define specific heat of a substance. Mention its SI unit. (K)
9. Define molar specific heat of a substance. Mention its SI unit. (K)
10. What is calorimetry? Give the principle of calorimetry.
11. Explain why 'two bodies at different temperatures T_1 and T_2 if brought in thermal contact do not necessarily settle to the mean temperature'. (A)
12. Define latent heat of a substance. Mention its SI unit. (K)
13. Mention any two kinds of heat transfer. (K)
14. Write any two properties of radiation. (K)
15. Give any two factors on which the rate of heat flow through a solid depends. (U)
16. What is sea breeze? Explain. (U)
17. What is land breeze? Explain. (U)
18. Why are the vessels of a thermos flask are silvered and the gap between them is evacuated? (A)
19. Why are two thin blankets are warmer than one thick blanket? (A)
20. Which coloured clothes are comfortable in winter? Why? (A)
21. Which coloured clothes are comfortable during summer? Why? (A)
22. State and explain Wien's displacement law. (K)
23. A star's emission spectrum peaks at a wavelength of 500 nm. Calculate the surface temperature of the star assuming the star to be a blackbody. (S)
24. Write a note on Greenhouse effect. (U)
25. State and explain Stefan's law. (K)
26. State Newton's law of cooling. Draw cooling curve.(K+S)

III. Three mark questions (PART – C):

1. Find the temperature of a substance at which Celsius scale and the Fahrenheit scale have the same value. (S)
2. Write a note on the anomalousthermal expansion of water. How does it help aquatic animals to survive in polar regions? (U)
3. Show that the volume expansion coefficientat constant pressure for gases is equal to reciprocal of the absolute temperature. (U)
4. Derive the relation connecting coefficient of linear expansion and the coefficient of volume expansion for small change in temperature. (U)
5. Arrive at a relation connecting the coefficient of linear expansion and coefficient of area expansion. (U)
6. Mention three types of heat transfer. (K)
7. Mention three properties of thermal radiation. (K)

IV. Five marks questions (PART – D):

1. State the laws of thermal conductivity. Define thermal conductivity of a solid. Mention its SI unit. (K)
2. Derive the relation connecting (a) linear expansion coefficient and area expansioncoefficient for solid(b) linear expansion coefficient and volume expansion coefficient for a solid. (U)
3. Mention any five properties of thermal radiation. (K)

V. Five mark numerical problems(All S):

1. A steel tape 1 m long is correctly calibrated for a temperature of 27.0 ^{o}C. The length of a steel rod is measured by this tape is found to be 63.0 cm on a hot day when the temperature is 45.0 ^{o}C. What is the actual length of the rod on that day? What is the length of the same steel rod on a day when the temperature is 27 ^{o}C? (Coefficient of linear expansion of steel = 1.20 x 10^{-5} K^{-1})
   (Ans: 63.016 cm; 63.0 cm)
2. A large steel wheel is to be fitted on to a shaft of the same material. At 27 ^{o}C, the outer diameter of the shaft is 8.70 cm and the diameter of the central hole in the wheel is 8.69 cm. The shaft is cooled using dry ice. At what temperature of the shaft does the wheel slip on the shaft? Assume coefficient of linear expansion of the steel to be constant over the required temperature range. (Coefficient of linear expansion of steel = 1.20 x 10^{-5} K^{-1})
   (Ans: – 69 ^{o}C)
3. A hole is drilled in a copper sheet. The diameter of the hole is 4.24 cm at 27 ^{o}C. What is the change in diameter of the hole when the sheet is heated to 227^{o}C? (Coefficient of linear expansion of copper is 1.70 x 10^{-5} K^{-1})
   (Ans: 1.44 x 10^{-4} m)
4. A brass wire 1.8 m long at 27 ^{o}C is held taut with little tension between two rigid supports. If the wire is cooled to a temperature of – 39 ^{o}C, what is the tension developed in the wire, if its diameter is 2.0 mm? (For brass, linear expansion coefficient = 2 x 10^{-5} K^{-1} and Young's modulus = 91 GPa)
   (Ans: 3.8 x 10^{2} N)
5. A brass rod of length 50 cm and diameter 3 mm is joined to a steel rod of the same length and diameter. What is the combined change in length of the combined rod at 250 ^{o}C, if the original lengths are at 40 ^{o}C? Is there a thermal stress developed across the junction? The ends of the rod are free to expand. (Linear expansion coefficient = 2 x 10^{-5} K^{-1} and that for steel = 1.20 x 10^{-5} K^{-1})
   (Ans: 0.34 cm, No thermal stress)

6. The coefficient of volume expansion of glycerine is 49 x 10^{-5} K^{-1}. If the temperature of 50 cm^3 of glycerine is raised by 30^{o}C, what is the new volume of the liquid? Also calculate the fractional change in density of the liquidfor this 30^{o}C rise in temperature.
   (Ans: 50.735 cm^3; 1.5 x 10^{-2})
7. In an experiment on the specific heat of a metal, a 0.20 kg block of a metal at 150 ^{o}C is dropped in a copper calorimeter containing 150 cm^3 of water at 27 ^{o}C. The final temperature is 40 ^{o}C. Compute the specific heat of the metal. (Given: Specific heat capacities of copper and water are 386 J kg^{-1} K^{-1} and 4180 J kg^{-1} K^{-1})
   (Ans: 430 J kg^{-1} K^{-1})
8. When 0.15 kg of ice of 0 ^{o}C mixed with 0.30 kg of water at 50 ^{o}C in an insulated container, the resulting temperature is 6.7 ^{o}C.Calculate the heat lost by the hot water in the process and calculate the heat of fusion of ice. (s_{water} = 4186 J kg^{-1} K^{-1})
   (Ans: 5.44 x 10^4 J;3.34 x 10^5 J kg^{-1}
9. A copper block of mass 2.5 kg is heated in a furnace to a temperature of 500 ^{o}C and then placed on a large ice block. What is the maximum amount of ice that can melt? (Specific heat of copper = 0.39 J g^{-1} K^{-1}, heat of fusion of water = 335 J g^{-1})
   (Ans: 1.5 kg)
10. An iron bar of length 0.1 m and area of cross section 0.02 m^2 and a brass bar of length 0.2 m and area of cross section 0.02 m^2 are soldered together end to end. The free ends of the iron bar and brass bar are maintained at 100 ^{o}C and 0 ^{o}C respectively. The thermal conductivities of iron and brass are 79 W m^{-1} K^{-1} and 109 W m^{-1} K^{-1} respectively. Calculate the temperature of the iron – brass junction. Also find the heat current through the compound bar.
   (Ans: 59.2 ^{o}C;645 W)
11. A cubical thermacolbox of side 30 cm has a thickness of 5.0 cm. If 4.0 kg of ice is put in the box, estimate the amount of ice remaining after 6 hours. The outside temperature is 45 ^{o}C, and coefficient of thermal conductivity of thermacol is 0.01 W m^{-1} K^{-1}. (Heat of fusion of water = 3.35 x 10^5 J kg^{-1}).
   (Ans: 3.7 kg)
12. The temperatures of equal masses of three different liquids *A*, *B* and *C* are 12 ^{0}C, 19 ^{0}C and 27 ^{0}C respectively. If *A* and *B* are mixed, the temperature of the mixture is 16 ^{0}C. If *B* and *C* are mixed, the temperature of the mixture is 23 ^{0}C. What is the temperature of the mixture if *A* and *C* mixed?
   (Ans: 20.6 ^{o}C)
13. A brass boiler has a base area of 0.15 m^2 and thickness 1.0 cm. It boils water at the rate of 6.0 kg/minute when placed on a gas stove. Estimate the temperature of the part of the flame in contact with the boiler. Thermal conductivity of brass = 109 W m^{-1} K^{-1}; Heat of vaporization of water = 2.256 x 10^6 J kg^{-1})
   (Ans: 238 ^{o}C)
14. A body cools from 80 ^{o}C to 50 ^{o}C in 5 minutes. Calculate the time it takes to cool from 60 ^{o}C to 30 ^{o}C. The temperature of the surrounding is 20 ^{o}C.
   (Ans: 9 minutes)
15. A 10 kW drilling machine is used to drill a bore in a small aluminium block of mass 8.0 kg. How much is the rise in temperature of the block in 2.5 minutes assuming 50 % of power is used up in heating the machine itself or lost to the surroundings. Specific heat of aluminium = 0.91 J g^{-1} K^{-1}.
   (Ans: 103 ^{o}C)