CLASS – 11

WORKSHEET- THERMAL PROPERTIES OF MATTER

(1 mark questions)

1. What is heat?

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2. What are the Si and CGS units of heat? How are they related?

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3. What is thermometry?

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4. Define temperature.

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5. State the principles of thermometer.

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6. What is temperature of the triple point of water on an absolute scale whose unit interval size is equal to that of the Fahrenheit scale?

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7. There is a hole in the middle of a copper plate. When heating the plate, diameter of hole would

(a) always increase (b) always decrease
(c) remains same (d) none of these

8. If α, β and γ are coefficients of linear, superficial and volume expansion respectively, then:

(a) $\frac{\beta}{\alpha}=\frac{1}{2}$ (b) $\frac{\beta}{\gamma}=\frac{2}{3}$ (c) $\frac{\gamma}{\alpha}=\frac{3}{2}$ (d) $\frac{\beta}{\alpha}=\frac{\gamma}{\beta}$

9. Why iron rims are heated red hot before being put on cart wheels?

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10. Two identical rectangular strips one of copper and other of steel, are riverted to form a bimetallic strip. What will happen on heating?

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11. For a perfectly black body, its absorptive power is
(a) 1 (b) 0.5 (c) 0 (d) infinity

12. The unit of Stefan's constant in SI system will be
(a) Joule/m^2s (b) Joule/m^2sK^4 (c) Joule/msK^4 (d) Joule/m^2K^4

13. Animals curl into a ball, when they feel very cold why?

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14. If the temperature of a blackbody is increased from 500K to 1000K, by what factor the rate of emission of energy from it changes?

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15. Pieces of copper and glass are heated to the same temperature. Why does the piece of copper feel hotter on touching?

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16. Why it is much hotter above a fire than by its side?

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17. How can one determined the surface temperature of the stars?

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18. What are the basic requirements of a cooking utensils in respect of specific heat, thermal conductivity?

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(2 marks Questions)

19. Distinguish clearly between heat and temperature.

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20. Why is mercury used in thermometer?

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21. An object has a temperature of 50°E. What is the temperature in degrees Celsius and in Kelvin?

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22. What do you mean by triple point of water? Why is it unique?

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23. Two absolute scales A and B have triple point of water defined to be 200A and 350B. What is the relation between T_A and T_B?

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24. A thin rod having L_0 of 0°C and coefficient of linear expansion α has its two ends maintained at temperatures θ_1 and θ_2 respectively. Find its new length.

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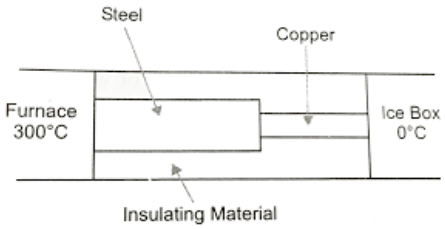
25. A large steel wheel is to be fitted on to a shaft of the same material. At 27°C, the outer diameter of the shaft is 8.70cm and the diameter of the central hole in the wheel is 8.69cm. The shaft is cooled using ;dry ice'. At what temperature of the shaft does the wheel slip on the shaft? Assume coefficient of linear expansion of the steel to be constant over the required temperature range: α_{steel}: 1.20×10^{-5} K^{-1}.

26. Show that the coefficient of area expansions, $(\Delta A/A)/\Delta T$, of a rectangular sheet of the solid is twice its linear expansivity, α_1.

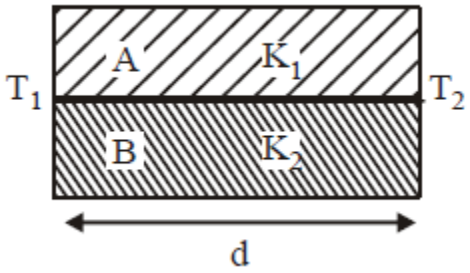
27. 0.15kg of ice at 0°C is mixed with a 0.30kg of water at 50°C in a container. Find the resultant temperature. Given the Latent heat of fusion of ice = 3.35×10^5 J/kg and c_{water} = 4200 j kg^{-1} K^{-1}.

28. Draw experimental curves between wavelength λ and intensity of radiation E λ emitted by a black body maintained at different constant temperatures.

29. What is the temperature of the steel-copper junction in the steady state of the system shown in the figure. Length of the steel rod = 15.0cm, length of the copper rod = 10.0cm, temperature of the furnace = 300°C, temperature of the other end = 0°C. The area of cross section of the steel rod is twice that of the copper rod. (Thermal conductivity of steel = 50.2 Js^{-1} m^{-1} K^{-1} and of copper = 385Js^{-1} m^{-1} K^{-1})



30. Two rods A and B of different materials are welded together as shown in the figure. Their thermal conductivities are K_1 and K_2. Find the thermal conductivity of the composite rod.



31. The triple points of neon and carbon dioxide are 24.57 K and 216.55 K respectively. Express these temperatures on the Celsius and Fahrenheit scales.
[Ans. (a) – 248.58°C, - 415.44°F, - 56.6°C, - 69.88°C]

32. The coefficient of volume expansion of glycerin is $49\times10^{-5\circ}\ C^{-1}$. What is the fractional change in its density for a 30°C rise in temperature? [Ans. 0.0147]

(3 marks Questions)

33. In an isotropic solid, has coefficients of linear expansions, α_x, α_y and α_z for three mutually perpendicular directions in the solid, what is the coefficient of volume expansion for the solid?

34. Find out the increase in moment of inertia I of a uniform rod (coefficient of linear expansion α) about its perpendicular bisector when its temperature is slightly increased by ΔT.

35. The coefficient of volume expansion of glycerine is $49\times10^{-5}°C^{-1}$. What is the fractional change in its density for a 30°C rise in temperature?

36. A brass wire 1.8m long at 27°C is held taut with little tension between two rigid supports. If the wire is cooled to a temperature of – 39°C, what is the tension developed in the wire, if its diameter is 2.0mm? Coefficient of linear expansion of brass = 2.0×10^{-5} K^{-1}, Young's modulus of brass = 0.91×10^{11} Pa.

37. A copper block of mass 2.5kg is heated in a furnace to a temperature of 500°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} $°C^{-1}$, heat of fusion of water = 335 Jg^{-1}).

38. 2 kg of ice at – 20°C is mixed with 5kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and the ice are 1 kcal/kg°C and 0.5 kcal/kg°C while the latent heat of fusion of ice is 80 kcal/kg.

39. Explain briefly the anomalous expansion of water. How the fishes can survive in extreme winter when lake ponds are frozen?

40. Determine between three modes of heat transmission.

41. A pan filled with hot food cools from 94℃ to 86℃ in 2 minutes, when the room temperature is 20℃, How long will it take to cool from 70℃ to 69℃?

42. A body cools in 7 minutes from 60℃ to 40℃. What will be the temperature of the body after next 7 minutes? The temperature of the surroundings is 10℃. Assume that Newton's law of cooling holds good throughout the process.

43. The electrical resistance in ohms of a certain thermometer varies with temperature according to the approximate law: $R = R_0[1 + 5 \times 10^{-3}(T - T_0)]$.
The resistance is 101.6 Ω at the triple point of water, and 165.5 Ω at the normal melting point of lead (600.5K). What is the temperature when the resistance is 123.4Ω?

[Ans. 384.8K]

44. Two ideal gas thermometers A and B use oxygen and hydrogen respectively. The following observations are made:

Temperature	Pressure (thermometer A)	Pressure (thermometer B)
Triple point of water	1.250×10^5 Pa	0.200×10^5 Pa
Normal melting Point of sulphur	1.797×10^5 Pa	0.287×10^5 Pa

(a) What is the absolute temperature of normal melting point of sulphur as read by thermometers A and B?

(b) What do you think us the reason for slightly different answers from A and B?

[Ans. (a) (i)392.46K (ii) 391.75K]

45. A steel tape 1m long is correctly calibrated for a temperature of 27.0°C. The length of a steel rod measured by this tape is found to be 63.0 cm on a hot day when the temperature is 45.0°C. What is the actual length of the steel rod on that day? What is the length of the same steel rod on a day when the temperature is 27.0°C? Coefficient of linear expansion of steel = 1.20×10^{-5}°/C? [Ans. 63.0136 m]

46. A large steel rod is to be fitted on to a shaft of the same material. At 27°C the outer diameter of the shaft is 8.70 cm and the diameter of the central hole in the wheel is 8.69cm. The shaft is cooled using 'dry ice' (solid carbon dioxide). 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. [Ans. – 68.8°C]

47. A hole is drilled in a copper sheet. The diameter of the hole is 4.24 cm at 27.0°C. What is the change in the diameter of the hole when the sheet is heated to 227°C? Coefficient of linear expansion of copper = $170\times10^{-5}°C^{-1}$? [Ans. 1.44×10^{-2} cm]

48. A brass wire 1.8m long at 27°C is held taut with little tension between two rigid supports. If the wire is cooled to a temperature of – 39°C, what is the tension developed in the wire, if its diameter is 2.0mm? Coefficient of linear expansion of brass = $2.0\times10^{-5}°C^{-1}$, Young's modulus of brass = 0.91×10^{11} Pa. [Ans. 3.77×10^{2} N]

49. A brass rod of length 50cm and diameter 3.0 mm is joined to a steel rod of the same length and diameter. What is the change in length of the combined rod at 250°C, if the original lengths are at 40°C? Is there a 'thermal stress' developed at the junction? The ends of the rod are free to expand. Coefficient of linear expansion of brass = $2.0\times10^{-5\circ}$ C^{-1} and that of steel=$1.2\times10^{-5\circ}$ C^{-1}. [Ans. 0.34 cm]

50. 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 Jg^{-1} C^{-1}. [Ans. 103.02°C]

51. A copper block of mass 2.5 kg is heated in a furnace to a temperature of 500°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 Jg^{-1} $C^{-}1$, and heat of fusion of water = 335 Jg^{-1}). [Ans. 1.455 kg]

52. In an experiment on the specific heat of a metal, a 0.20kg of the metal at 150°C is dropped in a copper calorimeter (of water equivalent 0.025 kg) containing 150 cm^3 of water at 27°C. The final temperature is 40↑8C. Compute the specific heat of the metal.

[Ans. 0.1 cal g^{-1} C° C^{-1}]

53. Given below are observations on molar specific heats at room temperature of some common gases

Gas	Molar specific heat (C_V) (cal mol^{-1} K^{-1})
Hydrogen	4.87
Nitrogen	4.97
Oxygen	5.02
Nitric oxide	4.99
Carbon monoxide	5.01
Chlorine	6.17

The measured molar specific heats of these gases are markedly different from those for monoatomic gases [Typically molar specific heat of a monoatomic gas is 2.92 cal/mol K]. Explain this difference. What can you infer from the somewhat larger (than the rest) value for chlorine?

54. A child running a temperature of 101°F is given an antipyrin (i.e. a medicine that lowers fever) which causes an increase in the rate of evaporation of sweat from his body. If the fever is brought down to 98°F in 20 min, what is the average rate of extra evaporation caused by the drug? Assume the evaporation mechanism to be the only way by which heat is lost. The mass of the child is 30kg. The specific heat of human body is

approximately the same as that of water, and latent heat of evaporation of water at that temperature is about 580 cal g^{-1}. [Ans. 4.31 g min^{-1}]

55. A 'thermocole' carbicoal icebox of side 30cm has a thickness of 5.0cm. If 4.0 kg of ice are put in the box, estimate the amount of ice remaining after 6h. The outside temperature is 45°C and coefficient of thermal conductivity of thermocle = 0.01 Js^{-1} m^{-1}° C^{-1}. Given heat of fusion of water = 335×10^3 Jkg^{-1}. [Ans. 3.687 kg]

56. A brass boiler has a base area of 0.15 m^2 and thickness 1.0cm.It boils water at a\the rate of 6.0 kg min^{-1}, when placed on a glass stove. Estimate the temperature of the part of the flame in contact with the boiler. Thermal conductivity of brass = 109 Js^{-1} m^{-1} C^{-1} and heat of vaporization of water = 2256 Jg^{-1}. [Ans. 238°C]

(5 marks Questions)

57. Describe the principle, construction and working of a constant volume gas thermometer. Give its two advantages over mercury thermometer.

58. (a) Explain the terms specific heat and heat capacity.
(b) State Newton's law of cooling. Derive mathematical expression for it.

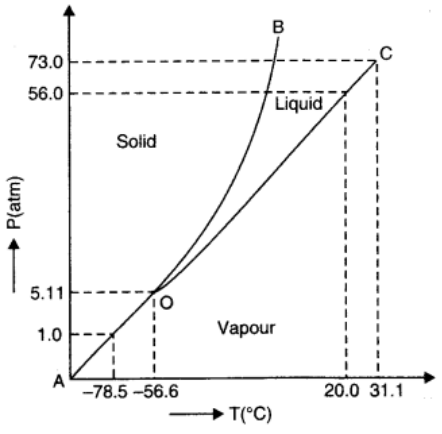
59. Answer the following:
(a) The triple point of water is a standard fixed in modern thermometry. Why? What is wrong in taking the melting point of ice and the boiling water as standard fixed points (as was originally done in Celsius scale)?

(b) There were two fixed points in the original Celsius scale as mentioned above which were assigned the number 0°C and 100°C respectively. On the absolute scale, one of the fixed points is the triple point of water, which on the Kelvin absolute scale is assigned the number 273.16 K. What is the other fixed point on this (Kelvin) scale?

(c) The absolute temperature (Kelvin scale) T is related to the temperature t_c on the Celsius scale by $t_c = T - 273.15$. Why do we have 273.15 in this relation, and not 273.16?

(d) What is the temperature of the triple point of water on an absolute scale whose unit interval size is equal to that of the Fahrenheit scale?

60. Answer the following questions based on the P-T phase diagram of carbon dioxide as shown in figure.



P-T phase diagram of CO_2

(i) At what temperature and pressure can the solid, liquid and vapour phases of CO_2 co-exist in equilibrium?
(ii) What is the effect of decrease of pressure on the fusion and boiling point of CO_2?
(iii) What are the critical temperature and pressure for CO_2? What is their significance?
(iv) Is CO_2 solid, liquid or gas at (a) – 70°C under 1 atm, (b) – 60°C under 10 atm, (c) 15°C under 56 atm?

61. Answer the following question based on the P-T phase diagram of CO_2:
(a) CO_2 at 1atm pressure and temperature – 60°C compressed isothermally. Does it go through the liquid phase?
(b) What happens when CO_2 at 4atm pressure is cooled from room temperature at constant pressure?
(c) Describe qualitatively the changes in a given mass of solid CO_2 at 10atm. pressure and temperature -65°C as it is heated up to room temperature at constant pressure.
(d) CO_2 is heated to a temperature 70↑8C and compressed isothermally. What changes in its properties do you expect to observe?

62. Explain why:

(a) a body with large reflectivity is a poor emitter.

(b) a brass tumbler feels much colder than a wooden tray on a chilly day.

(c) an optical pyrometer (for measuring high temperatures)calibrated for an ideal black body radiation gives too low a value for the temperature of a red hot iron piece in the open, but gives a correct value for the temperature when the same piece is in the furnace.

(d) the earth without its atmosphere would be inhospitably cold.

(e) heating systems based on circulation of steam are more efficient in warming a building then those based on circulation of hot water.