Chapter Eleven

THERMAL PROPERTIES OF MATTER

MCQ I

11.1 A bimetallic strip is made of aluminium and steel $(\alpha_{Al} > \alpha_{steel})$. On heating, the strip will

    (a) remain straight.
    (b) get twisted.
    (c) will bend with aluminium on concave side.
    (d) will bend with steel on concave side.

11.2 A uniform metallic rod rotates about its perpendicular bisector with constant angular speed. If it is heated uniformly to raise its temperature slightly

    (a) its speed of rotation increases.
    (b) its speed of rotation decreases.
    (c) its speed of rotation remains same.
    (d) its speed increases because its moment of inertia increases.

11.3 The graph between two temperature scales A and B is shown in Fig. 11.1. Between upper fixed point and lower fixed point there

are 150 equal division on scale A and 100 on scale B.
The relationship for conversion between the two scales is given by

(a) $\dfrac{t_A - 180}{100} = \dfrac{t_B}{150}$

(b) $\dfrac{t_A - 30}{150} = \dfrac{t_B}{100}$

(c) $\dfrac{t_B - 180}{150} = \dfrac{t_A}{100}$

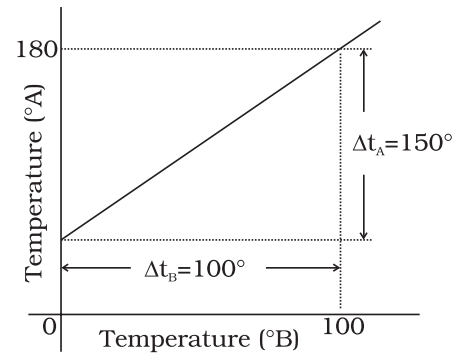(d) $\dfrac{t_B - 40}{100} = \dfrac{t_A}{180}$

Fig. 11.1

11.4 An aluminium sphere is dipped into water. Which of the following is true?

(a) Buoyancy will be less in water at $0°$C than that in water at $4°$C.

(b) Buoyancy will be more in water at $0°$C than that in water at $4°$C.

(c) Buoyancy in water at $0°$C will be same as that in water at $4°$C.

(d) Buoyancy may be more or less in water at $4°$C depending on the radius of the sphere.

11.5 As the temperature is increased, the time period of a pendulum

(a) increases as its effective length increases even though its centre of mass still remains at the centre of the bob.

(b) decreases as its effective length increases even though its centre of mass still remains at the centre of the bob.

(c) increases as its effective length increases due to shifting of centre of mass below the centre of the bob.

(d) decreases as its effective length remains same but the centre of mass shifts above the centre of the bob.

11.6 Heat is associated with

(a) kinetic energy of random motion of molecules.

(b) kinetic energy of orderly motion of molecules.

(c) total kinetic energy of random and orderly motion of molecules.

(d) kinetic energy of random motion in some cases and kinetic energy of orderly motion in other.

11.7 The radius of a metal sphere at room temperature *T* is *R*, and the coefficient of linear expansion of the metal is α. The sphere is heated a little by a temperature ΔT so that its new temperature is $T + \Delta T$. The increase in the volume of the sphere is approximately

(a) $2\pi R \, \alpha \, \Delta T$

(b) $\pi R^2 \alpha \, \Delta T$

(c) $4\pi R^3 \alpha \, \Delta T / 3$

(d) $4\pi R^3 \alpha \, \Delta T$

11.8 A sphere, a cube and a thin circular plate, all of same material and same mass are initially heated to same high temperature.

(a) Plate will cool fastest and cube the slowest

(b) Sphere will cool fastest and cube the slowest

(c) Plate will cool fastest and sphere the slowest

(d) Cube will cool fastest and plate the slowest.

MCQ II

11.9 Mark the correct options:

(a) A system *X* is in thermal equilibrium with *Y* but not with *Z*. System *Y* and *Z* may be in thermal equilibrium with each other.

(b) A system *X* is in thermal equilibrium with *Y* but not with *Z*. Systems *Y* and *Z* are not in thermal equilibrium with each other.

(c) A system *X* is neither in thermal equilibrium with *Y* nor with *Z*. The systems *Y* and *Z* must be in thermal equilibrium with each other.

(d) A system *X* is neither in thermal equilibrium with *Y* nor with *Z*. The system *Y* and *Z* may be in thermal equilibrium with each other.

11.10 'Gulab Jamuns' (assumed to be spherical) are to be heated in an oven. They are available in two sizes, one twice bigger (in radius) than the other. Pizzas (assumed to be discs) are also to be heated in oven. They are also in two sizes, one twice big (in radius) than the other. All four are put together to be heated to oven temperature. Choose the correct option from the following:

(a) Both size gulab jamuns will get heated in the same time.

(b) Smaller gulab jamuns are heated before bigger ones.

(c) Smaller pizzas are heated before bigger ones.

(d) Bigger pizzas are heated before smaller ones.

11.11 Refer to the plot of temperature versus time (Fig. 11.2) showing the changes in the state of ice on heating (not to scale).
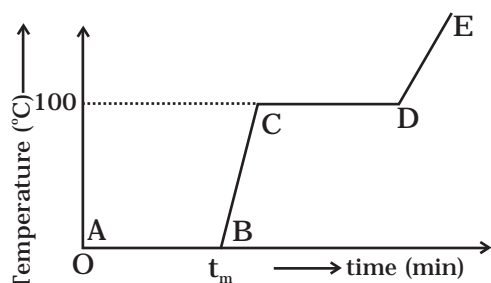

Fig. 11.2

Which of the following is correct?

(a) The region AB represents ice and water in thermal equilibrium.
(b) At B water starts boiling.
(c) At C all the water gets converted into steam.
(d) C to D represents water and steam in equilibrium at boiling point.

11.12 A glass full of hot milk is poured on the table. It begins to cool gradually. Which of the following is correct?

(a) The rate of cooling is constant till milk attains the temperature of the surrounding.
(b) The temperature of milk falls off exponentially with time.
(c) While cooling, there is a flow of heat from milk to the surrounding as well as from surrounding to the milk but the net flow of heat is from milk to the surounding and that is why it cools.
(d) All three phenomenon, conduction, convection and radiation are responsible for the loss of heat from milk to the surroundings.

VSA

11.13 Is the bulb of a thermometer made of diathermic or adiabatic wall?

11.14 A student records the initial length l, change in temperature ΔT and change in length Δl of a rod as follows:

S.No.	l (m)	ΔT ($^\circ$C)	Δl (m)
1.	2	10	4×10^{-4}
2.	1	10	4×10^{-4}
3.	2	20	2×10^{-4}
4.	3	10	6×10^{-4}

If the first observation is correct, what can you say about observations 2, 3 and 4.

11.15 Why does a metal bar appear hotter than a wooden bar at the same temperature? Equivalently it also appears cooler than wooden bar if they are both colder than room temperature.

11.16 Calculate the temperature which has same numeral value on celsius and Fahrenheit scale.

11.17 These days people use steel utensils with copper bottom. This is supposed to be good for uniform heating of food. Explain this effect using the fact that copper is the better conductor.

SA

11.18 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.

11.19 During summers in India, one of the common practice to keep cool is to make ice balls of crushed ice, dip it in flavoured sugar syrup and sip it. For this a stick is inserted into crushed ice and is squeezed in the palm to make it into the ball. Equivalently in winter, in those areas where it snows, people make snow balls and throw around. Explain the formation of ball out of crushed ice or snow in the light of P–T diagram of water.

11.20 100 g of water is supercooled to $-10°$C. At this point, due to some disturbance mechanised or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze?

$$\left[S_w = 1\,cal/g/°C \text{ and } L^w{}_{Fusion} = 80\,cal/g\right]$$

11.21 One day in the morning, Ramesh filled up 1/3 bucket of hot water from geyser, to take bath. Remaining 2/3 was to be filled by cold water (at room temperature) to bring mixture to a comfortable temperature. Suddenly Ramesh had to attend to something which would take some times, say 5-10 minutes before he could take bath. Now he had two options: (i) fill the remaining bucket completely by cold water and then attend to the work, (ii) first attend to the work and fill the remaining bucket just before taking bath. Which option do you think would have kept water warmer? Explain.

LA

11.22 We would like to prepare a scale whose length does not change with temperature. It is proposed to prepare a unit scale of this type whose length remains, say 10 cm. We can use a bimetallic strip made of brass and iron each of different length whose length (both components) would change in such a way that difference between their lengths remain constant. If $\alpha_{iron} = 1.2 \times 10^{-5}$ / K and $\alpha_{brass} = 1.8 \times 10^{-5}$ /K, what should we take as length of each strip?

11.23 We would like to make a vessel whose volume does not change with temperature (take a hint from the problem above). We can use brass and iron ($\beta_{vbrass} = 6 \times 10^{-5}$/K and $\beta_{viron} = 3.55 \times 10^{-5}$/K) to create a volume of 100 cc. How do you think you can achieve this.

11.24 Calculate the stress developed inside a tooth cavity filled with copper when hot tea at temperature of 57°C is drunk. You can take body (tooth) temperature to be 37° C and $\alpha = 1.7 \times 10^{-5}$/°C, bulk modulus for copper $= 140 \times 10^9$ N/m².
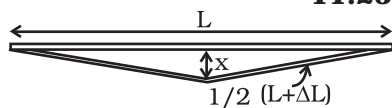
11.25 A rail track made of steel having length 10 m is clamped on a railway line at its two ends (Fig 11.3). On a summer day due to rise in temperature by 20° C , it is deformed as shown in figure. Find x (displacement of the centre) if $\alpha_{steel} = 1.2 \times 10^{-5}$ /°C.

Fig. 11.3

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

11.27 According to Stefan's law of radiation, a black body radiates energy σT^4 from its unit surface area every second where T is the surface temperature of the black body and $\sigma = 5.67 \times 10^{-8}$ W/m²K⁴ is known as Stefan's constant. A nuclear weapon may be thought of as a ball of radius 0.5 m. When detonated, it reaches temperature of 10^6K and can be treated as a black body.

(a) Estimate the power it radiates.

(b) If surrounding has water at $30°$C , how much water can 10% of the energy produced evaporate in 1 s?

$$\left[S_w = 4186.0\,\text{J/kg K} \quad \text{and} \quad L_v = 22.6 \times 10^5\,\text{J/kg} \right]$$

(c) If all this energy U is in the form of radiation, corresponding momentum is $p = U/c$. How much momentum per unit time does it impart on unit area at a distance of 1 km?