

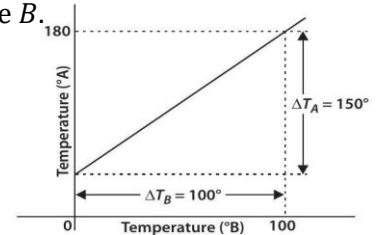


# THERMAL PROPERTIES OF MATTER

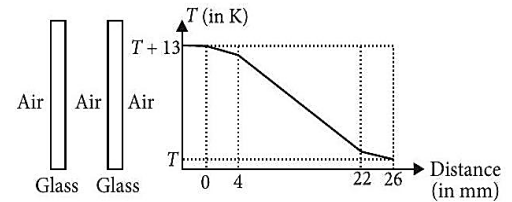
## OBJECTIVE TYPE QUESTIONS

### Multiple Choice Questions (MCQs)

- Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The energy radiated per second by the first sphere is
  - greater than that by the second
  - less than that by the second
  - equal in both cases
  - the information is incomplete to draw any conclusion
- A bimetallic strip is made of aluminium and steel ( $\alpha_{Al} > \alpha_{steel}$ ). On heating, the strip will
  - remain straight
  - get twisted
  - will bend with aluminium on concave side
  - will bend with steel on concave side.
- On a temperature scale Y, water freezes at  $-160^\circ Y$  and boils at  $-50^\circ Y$ . On this Y scale, a temperature of 340 K would be read as: (colder freezes at 273 K and boils at 373 K)
  - $-106.3^\circ Y$
  - $-96.3^\circ Y$
  - $-86.3^\circ Y$
  - $-76.3^\circ Y$
- Driver of truck gets his steel petrol tank filled with 75 L of petrol at  $10^\circ C$ . If  $\alpha_{steel}$  is  $24 \times 10^{-6} / ^\circ C$  and  $\gamma_{petrol}$  is  $9.9 \times 10^{-4} / ^\circ C$ , the overflow of petrol at  $30^\circ C$  is
  - 1.35 L
  - 1.38 L
  - 1.45 L
  - 1.48 L
- A uniform metallic rod rotates about its perpendicular bisector with constant angular speed. If it is heated uniformly to raise its temperature slightly
  - its speed of rotation increases
  - its speed of rotation decreases
  - its speed of rotation remains same
  - its speed increases because its moment of inertia increases
- The graph between two temperature scales A and B is shown in figure. 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
  - $\frac{T_A - 180}{100} = \frac{T_B}{150}$
  - $\frac{T_A - 30}{150} = \frac{T_B}{100}$
  - $\frac{T_B - 180}{150} = \frac{T_A}{100}$
  - $\frac{T_B - 40}{100} = \frac{T_A}{180}$
- A one litre flask contains certain quantity of mercury. If the volume of air inside the flask remains the same at all temperatures, then the volume of mercury in the flask is (volume expansion coefficient of mercury is 20 times that of flask)
  - 100cc
  - 50cc
  - 200cc
  - 150cc
- An ideal gas is expanding such that  $PT^2 = \text{constant}$ . The coefficient of volume expansion of the gas is
  - $\frac{1}{T}$
  - $\frac{2}{T}$
  - $\frac{3}{T}$
  - $\frac{4}{T}$



- 9 The figure shows a cross-section of a double glass unit of a window on a vertical wall. A graph of the temperatures at different points within the unit is given below.



The temperature difference across the unit is 13 K. It has a cross-sectional area of  $1.3 \text{ m}^2$  and the rate of heat flow through it is  $65 \text{ W}$ . Then the correct statement is

(Glass has a thermal conductivity of  $1 \text{ W m}^{-1} \text{ K}^{-1}$ )

- (a) The unit is in steady state and in thermal equilibrium.  
 (b) The unit is in steady state but not in thermal equilibrium.  
 (c) The unit is not in steady state but is in thermal equilibrium.  
 (d) The unit neither in steady state nor in thermal equilibrium.
- 10 Two rods of different materials having coefficients of linear expansion  $\alpha_1$  and  $\alpha_2$  and Young's modulus  $Y_1$  and  $Y_2$  respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of rods. If  $\alpha_1 : \alpha_2 = 2 : 3$ , the thermal stress developed in the two rods are equal provided  $Y_1 : Y_2$  equal to  
 (a) 2 : 3                      (b) 4 : 9                      (c) 1 : 2                      (d) 3 : 2
- 11 Two rods, one of aluminium and the other made of steel, having initial lengths  $l_1$  and  $l_2$  are connected together to form a single rod of length  $(l_1 + l_2)$ . The coefficient of linear expansion of aluminium and steel are  $\alpha_a$  and  $\alpha_s$  respectively. If the length of each rod increases by the same amount, when their temperatures are raised by  $T^\circ\text{C}$ , then the ratio  $\frac{l_1}{l_1 + l_2}$  is  
 (a)  $\frac{\alpha_s}{\alpha_a}$                       (b)  $\frac{\alpha_a}{\alpha_s}$                       (c)  $\frac{\alpha_s}{\alpha_a + \alpha_s}$                       (d)  $\frac{\alpha_a}{\alpha_a + \alpha_s}$
- 12 The triple point of carbon dioxide is 216.55 K the corresponding temperature on the Celsius and Fahrenheit scale is  
 (a)  $56.45^\circ\text{C}, -69.61^\circ\text{F}$                       (b)  $-56.45^\circ\text{C}, 69.61^\circ\text{F}$   
 (c)  $56.45^\circ\text{C}, 69.61^\circ\text{F}$                       (d)  $-56.45^\circ\text{C}, -69.61^\circ\text{F}$
- 13 To increase the length of brass rod by 2% its temperature should increase by ( $\alpha = 0.00002 \text{ }^\circ\text{C}^{-1}$ )  
 (a)  $800^\circ\text{C}$                       (b)  $900^\circ\text{C}$                       (c)  $1000^\circ\text{C}$                       (d)  $1100^\circ\text{C}$
- 14 The quantities of heat required to raise the temperatures of two copper spheres of radii  $r_1$  and  $r_2$  ( $r_1 = 1.5r_2$ ) through 1 K are in the ratio of  
 (a)  $\frac{27}{8}$                       (b)  $\frac{9}{4}$                       (c)  $\frac{3}{2}$                       (d) 1
- 15 Find the stress developed inside a tooth cavity filled with copper when hot tea at temperature of  $57^\circ\text{C}$  is drunk. (Take temperature of tooth to be  $37^\circ\text{C}$ ,  $\alpha = 1.7 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$  and bulk modulus for copper =  $140 \times 10^9 \text{ N m}^{-2}$ )  
 (a)  $1.43 \times 10^8 \text{ N m}^{-2}$                       (b)  $4.13 \times 10^8 \text{ N m}^{-2}$   
 (c)  $2.12 \times 10^4 \text{ N m}^{-2}$                       (d)  $3.12 \times 10^4 \text{ N m}^{-2}$
- 16 A 10 kW drilling machine is used to drill a bore in a small aluminium block of mass 8 kg. Find the rise in temperature of the block is 2.5 minutes, assuming 50% power is used up is heating the machine itself or lost to the surrounding. (Specific heat of aluminium =  $0.91 \text{ J g}^{-1} \times \text{ }^\circ\text{C}^{-1}$ )  
 (a)  $100^\circ\text{C}$                       (b)  $103^\circ\text{C}$                       (c)  $150^\circ\text{C}$                       (d)  $155^\circ\text{C}$
- 17 The densities of two substances are in the ratio 2 : 3 and their specific heats are 0.12 and 0.09 CGS units respectively. The ratio of their thermal capacities per unit volume is  
 (a) 8 : 9                      (b) 1 : 2                      (c) 3 : 2                      (d) 4 : 9
- 18 22320 cal of heat is supplied to 100 g of ice at  $0^\circ\text{C}$ . If the latent heat of fusion of ice is  $80 \text{ cal g}^{-1}$  and latent heat of vaporization of water is  $540 \text{ cal}^{-1}$ , the final amount of water thus obtained and its

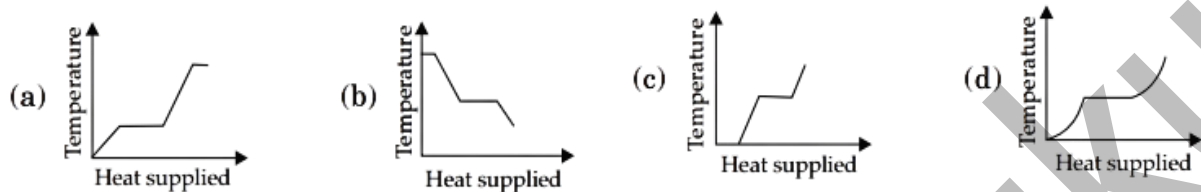
temperature respectively are

- (a) 8 g, 100°C      (b) 100 g, 90°C      (c) 92 g, 100°C      (d) 8 g, 100°C

19 Two absolute scale  $A$  and  $B$  have triple points of water defined to be at  $200A$  and  $350B$ . The relation between  $T_A$  and  $T_B$  is

- (a)  $T_A = 4/7T_B$       (b)  $T_B = 4/7T_A$       (c)  $T_A = 2/7T_B$       (d)  $T_B = 2/7T_A$

20 A block of ice at  $-10^\circ\text{C}$  is slowly heated and converted to steam at  $100^\circ\text{C}$ . Which of the following curves represents the phenomena qualitatively?



21  $0.1\text{ m}^3$  of water at  $80^\circ\text{C}$  is mixed with  $0.3\text{ m}^3$  of water at  $60^\circ\text{C}$ . The final temperature of the mixture is

(a)  $65^\circ\text{C}$       (b)  $70^\circ\text{C}$       (c)  $60^\circ\text{C}$       (d)  $75^\circ\text{C}$

22 A piece of ice (heat capacity =  $2100\text{ J kg}^{-1}\text{C}^{-1}$  and latent heat =  $3.36 \times 10^5\text{ J kg}^{-1}$ ) of mass  $m$  grams is at  $-5^\circ\text{C}$  at atmospheric pressure. It is given  $420\text{ J}$  of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that  $1\text{ g}$  of ice has melted. Assuming there is no other heat exchange in the process, the value of  $m$  is

- (a)  $4\text{ g}$       (b)  $6\text{ g}$       (c)  $8\text{ g}$       (d)  $10\text{ g}$

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

- (a) Buoyancy will be less in water at  $0^\circ\text{C}$  than that in water at  $4^\circ\text{C}$ .  
 (b) Buoyancy will be more in water at  $0^\circ\text{C}$  than that in water at  $4^\circ\text{C}$ .  
 (c) Buoyancy in water at  $0^\circ\text{C}$  will be same as that in water at  $4^\circ\text{C}$ .  
 (d) Buoyancy may be more or less in water at  $4^\circ\text{C}$  depending on the radius of the sphere.

24 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.

25 Two metal rods 1 and 2 of same lengths have same temperature difference between their ends. Their thermal conductivities are  $K_1$  and  $K_2$  and cross-sectional areas  $A_1$  and  $A_2$ , respectively. If the rate of heat conduction in 1 is four times that in 2, then

- (a)  $K_1A_1 = 4K_2A_2$       (b)  $K_1A_1 = 2K_2A_2$   
 (c)  $4K_1A_1 = K_2A_2$       (d)  $K_1A_1 = K_2A_2$

26 A body  $A$  of mass  $0.5\text{ kg}$  and specific heat  $0.85\text{ J g}^{-1}\text{ K}^{-1}$  is at a temperature of  $60^\circ\text{C}$ . Another body  $B$  of mass  $0.3\text{ kg}$  and specific heat  $0.9\text{ J g}^{-1}\text{ K}^{-1}$  is at a temperature of  $90^\circ\text{C}$ . When they are connected through a conducting rod, heat will flow from

- (a) A to B
- (b) B to A
- (c) heat can't flow
- (d) first from A to B, then B to A

27 The coefficient of expansion of a crystal in one direction ( $x$ -axis) is  $2.0 \times 10^{-6} \text{ K}^{-1}$  and that in the other two perpendicular ( $y$ -and  $z$ -axes) direction is  $1.6 \times 10^{-6} \text{ K}^{-1}$ . What is the coefficient of cubical expansion of the crystal?

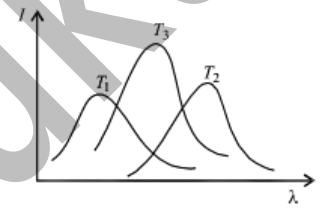
- (a)  $1.6 \times 10^{-6} \text{ K}^{-1}$
- (b)  $1.8 \times 10^{-6} \text{ K}^{-1}$
- (c)  $2.0 \times 10^{-6} \text{ K}^{-1}$
- (d)  $5.2 \times 10^{-6} \text{ K}^{-1}$

28 A faulty thermometer reads freezing point and boiling point of water as  $-5^\circ\text{C}$  and  $95^\circ\text{C}$  respectively. What is the correct value of temperature as it reads  $60^\circ\text{C}$  on faulty thermometer?

- (a)  $60^\circ\text{C}$
- (b)  $65^\circ\text{C}$
- (c)  $64^\circ\text{C}$
- (d)  $62^\circ\text{C}$

29 The plots of intensity of radiation versus wavelength of three black bodies at temperatures  $T_1, T_2$  and  $T_3$  are shown. Then,

- (a)  $T_3 > T_2 > T_1$
- (b)  $T_1 > T_2 > T_3$
- (c)  $T_2 > T_3 > T_1$
- (d)  $T_1 > T_3 > T_2$

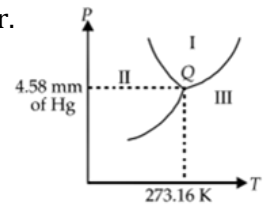


30 If the temperature of hot black body is raised by 5%, rate of heat energy radiated would be increased by how much percentage?

- (a) 12%
- (b) 22%
- (c) 32%
- (d) 42%

31 In the phase diagram shown, the point Q corresponds to the triple point of water. The regions I, II and III respectively correspond to phases

- (a) liquid, solid, vapour
- (b) solid, liquid, vapour
- (c) liquid, vapour, solid
- (d) solid, vapour, liquid

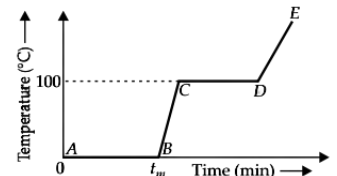


32. Which of the following statement does not hold good for thermal radiation?

- (a) The wavelength changes when it travels from one medium to another.
- (b) The frequency changes when it travels from one medium to another.
- (c) The speed changes when it travels from one medium to another.
- (d) They travel in straight line in a given medium.

33 Refer to the plot of temperature versus time showing the changes in the state of ice on heating (not to scale). Which of the following is correct?

- (a) AB represents ice and water are not in the thermal equilibrium.
- (b) At B water starts boiling.
- (c) At C all the water gets converted into steam.
- (d) CD represents water and steam in equilibrium at boiling point.

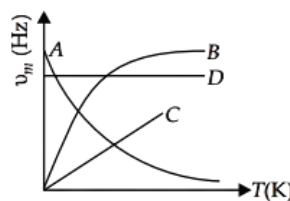


34. Three stars A, B, C have surface temperatures  $T_A, T_B$  and  $T_C$ . A appears bluish, B appears reddish and C appears yellowish. We can conclude that

- (a)  $T_A > T_C > T_B$
- (b)  $T_A > T_B > T_C$
- (c)  $T_B > T_C > T_A$
- (d)  $T_C > T_B > T_A$

35. Which one of the following is  $\nu_m - T$  graph for perfectly black body?  $\nu_m$  is the frequency of radiation with maximum intensity and  $T$  is the absolute temperature.

- (a) A  
(b) B  
(c) C  
(d) D



## Case Based MCQs

Case I : Read the passage given below and answer the following questions from 36 to 40 .

### Specific Heat Capacity

Heat capacity of a substance is defined as  $H = \frac{\Delta Q}{\Delta T} = ms$ , where  $\Delta Q$  is amount of heat supplied to the substance to change its temperature from  $T$  to  $T + \Delta T$ .

Specific heat capacity is the amount of heat per unit mass absorbed or given off to change its temperature by one unit.  $S = \frac{1}{m} \frac{\Delta Q}{\Delta T} = \frac{H}{m}$

It depends on the nature of substance and its temperature.

- 36 Which one of the following substances has highest specific heat capacity at room temperature and atmospheric pressure?  
(a) Water                      (b) Ice                      (c) Aluminium                      (d) Mercury
- 37 Heat capacity of a substance is infinite. It means  
(a) heat is given out.  
(b) heat is taken in.  
(c) no change in temperature whether heat is taken in or given out.  
(d) all of these.
- 38 Water is used as a coolant because  
(a) it has lower density.                      (b) it has low specific heat.  
(c) it has high specific heat.                      (d) it is easily available.
- 39 Calorie is defined as the amount of heat required to raise the temperature of 1 g of water by  $1^\circ\text{C}$  and it is defined under which of the following conditions?  
(a) From  $14.5^\circ\text{C}$  to  $15.5^\circ\text{C}$  at 760 mm of Hg  
(b) From  $98.5^\circ\text{C}$  to  $99.5^\circ\text{C}$  at 760 mm of Hg  
(c) From  $13.5^\circ\text{C}$  to  $14.5^\circ\text{C}$  at 76 mm of Hg  
(d) From  $3.5^\circ\text{C}$  to  $4.5^\circ\text{C}$  at 76 mm of Hg
- 40 Find the thermal capacity of 40 g of aluminum. ( $s = 0.2\text{cal/gK}$ )  
(a)  $168\text{ J}/^\circ\text{C}$                       (b)  $672\text{ J}/^\circ\text{C}$                       (c)  $840\text{ J}/^\circ\text{C}$                       (d)  $33.6\text{ J}/^\circ\text{C}$

Case : II Read the passage given below and answer the following questions from 41 to 45 .

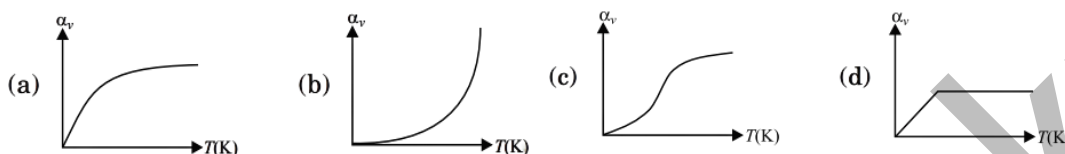
### Thermal Expansion:

The increase in the dimensions of a body due to the increase in its temperature is called thermal expansion. Thermal expansion is present in solids, liquids and gases. In the case of solids, the increase will be in length, area and volume. In liquids and gases, only expansion in volume is possible as they do not possess any fixed shape. In the case of gases, the state of a gas at any instant is dependent on its volume, pressure and temperature. Hence a gas can be heated at constant volume or at constant pressure. The property of thermal expansion of substance is different for different substances and it also depends on the state of the substance viz, solid, liquid or gas.

Relation between  $\alpha$ ,  $\beta$  and  $\gamma$

The three coefficients of thermal expansion are related as  $\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$ .

- 41 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 the same (d) none of these
- 42 Which of the following graphs correctly shows variation of coefficient of volume expansion of copper as a function of temperature?



- 43 Two spheres  $A$  and  $B$  are made of the same material and have the same radius. Sphere  $A$  is hollow and sphere  $B$  is solid. Both the spheres are heated to the same temperature. Which of the following is correct?  
 (a)  $A$  expands more than  $B$ . (b)  $A$  expands less than  $B$ .  
 (c) Both the spheres expand equally. (d) Data is insufficient.
- 44 The coefficient of volume expansion of liquid is  $\gamma$ . The fractional change in its density for  $\Delta T$  rise in temperature is  
 (a)  $\gamma\Delta T$  (b)  $\frac{\Delta T}{\gamma}$  (c)  $1 + \gamma\Delta T$  (d)  $1 - \gamma\Delta T$
- 45 If  $\alpha$ ,  $\beta$  and  $\gamma$  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)  $\frac{\beta}{\alpha} = \frac{\gamma}{\beta}$

### Assertion & Reasoning Based MCQs

For question numbers 46-55, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

- (a) Both  $A$  and  $R$  are true and  $R$  is the correct explanation of  $A$   
 (b) Both  $A$  and  $R$  are true but  $R$  is NOT the correct explanation of  $A$   
 (c)  $A$  is true but  $R$  is false  
 (d)  $A$  is false and  $R$  is also false

46 **Assertion (A)** : The density of water is maximum at  $4^\circ\text{C}$ .

**Reason (R)** : The volume of water decreases while heating from  $0^\circ\text{C}$  to  $4^\circ\text{C}$ .

47. **Assertion (A)** : The coefficient of volume expansion has dimension  $\text{K}^{-1}$ .

**Reason (R)** : The coefficient of volume expansion is defined the change in volume per unit volume per unit change in temperature.

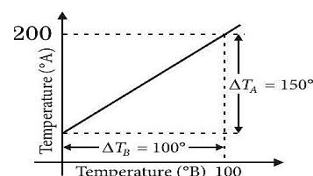
48. **Assertion (A)** : When a solid iron ball is heated, percentage increase in its volume is largest.

**Reason (R)** : Coefficient of superficial expansion is twice that of linear expansion where as coefficient of volume expansion is three time of linear expansion.

- 49 **Assertion (A)** : A beaker is completely filled with water at  $4^{\circ}\text{C}$ . It will overflow, both when heated or cooled.  
**Reason (R)** : There is expansion of water below and above  $4^{\circ}\text{C}$ .
- 50 **Assertion (A)** : Thermal conductivity depends on nature of material of the wall.  
**Reason (R)** : When temperature difference across the two sides of a wall is increased, its thermal conductivity increases.
- 51 **Assertion (A)** : Snow is better insulator than ice.  
**Reason (R)** : Snow contains air packet and air is good insulator of heat.
52. **Assertion (A)** : A body with large reflectivity is a poor emitter.  
**Reason (R)** : Poor absorbers of heat are poor emitters.
- 53 **Assertion (A)** : For a perfectly black body, absorption coefficient and emission coefficient is one.  
**Reason (R)** : Perfect absorbers are perfect emitters.
- 54 **Assertion (A)** : Greater is the coefficient of thermal conductivity of a material, smaller is the thermal resistance of a rod of that material.  
**Reason (R)** : Thermal resistance is the ratio of temperature difference between the ends of the conductor and rate of flow of heat.
- 55 **Assertion (A)** : In the upper part of the atmosphere the temperature of air is of the order of 1000 K, even then it is quite cold there.  
**Reason (R)** : The heat density of upper atmosphere is very high.

### Very Short Answer Type Questions (VSA)

1. The graph between two temperature scales  $A$  and  $B$  is shown in figure. Between upper fixed point and lower fixed point there are 150 equal division on scale  $A$  and 100 on scale  $B$ . What is the relationship for conversion between the two scales?



2. Two identical rectangular strips, one of copper and the other of steel, are riveted to form a bimetallic strip. What will happen on heating?
3. Thermal conductivity of air is less than that of felt but felt is a better heat insulator in comparison to air. Why?
4. The temperature on a Fahrenheit scale is  $98.6^{\circ}\text{F}$ ? What is the corresponding temperature on a Kelvin scale?
5. The temperature gradient in a rod 0.5 m long is  $40^{\circ}\text{C}$  per metre. The temperature of the hotter end is  $30^{\circ}\text{C}$ . What is the temperature of its colder end?
6. 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.
7. How does running hot water on a jar lid loosen it?

8. 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?
9. Why are we advised to store medicines below  $86^{\circ}\text{F}$  ?
10. Specific heat of aluminium metal is  $24.4 \text{ J/moleK}$ . Express the specific heat in  $\text{J/kgK}$ .

### Short Answer Type Questions (SA-I)

11. Two absolute scales  $A$  and  $B$  have triple points of water defined to be  $100A$  and  $250B$ . What is the relation between  $T_A$  and  $T_B$  ?
12. The volume of a metal block changes by  $0.12\%$ , when it is heated through  $40^{\circ}\text{C}$ . Find the coefficient of linear expansion for material of block.
13. Show that the coefficient of area expansions,  $(\Delta A/A)/\Delta T$ , of a rectangular sheet of the solid is twice its linear expansivity,  $\alpha_1$ .
14. A lead bullet strikes against a fixed steel plate with a velocity  $200 \text{ m s}^{-1}$ . If the impact is perfectly inelastic and the heat produced is equally shared between the bullet and the target, what is the rise in temperature of the bullet? (specific heat capacity of lead =  $125 \text{ J kg}^{-1} \text{ K}^{-1}$ )
15.  $0.15 \text{ kg}$  of ice at  $0^{\circ}\text{C}$  is mixed with  $0.30 \text{ kg}$  of water at  $50^{\circ}\text{C}$  in a container. Find the resultant temperature. Given the Latent heat of fusion of ice =  $3.35 \times 10^5 \text{ J/kg}$  and  $c_{\text{water}} = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$ .
16. Two rods  $A$  and  $B$  of different materials are welded together as shown in figure. Their thermal conductivities are  $K_1$  and  $K_2$ . Find the thermal conductivity of the composite rod.



- 17 The density of water at  $20^{\circ}\text{C}$  is  $998 \text{ kg/m}^3$  and at  $40^{\circ}\text{C}$  is  $992 \text{ kg/m}^3$ . Find the coefficient of volume expansion of water.
- 18 The specific heat of many solids at low temperatures varies with absolute temperature  $T$  according to the relations  $S = DT^3$ , where  $D$  is a constant. What is the heat energy required to raise the temperature of a mass  $m$  of such a solid from  $T_1 = 20 \text{ K}$  to  $T_2 = 30 \text{ K}$ ?
- 19 Draw experimental curves between wavelength  $\lambda$  and intensity of radiation  $E_\lambda$  emitted by a black body maintained at different constant temperatures.
- 20 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	$1.250 \times 10^5 \text{ Pa}$	$0.200 \times 10^5 \text{ Pa}$
Normal melting point of sulphur	$1.797 \times 10^5 \text{ Pa}$	$0.287 \times 10^5 \text{ Pa}$

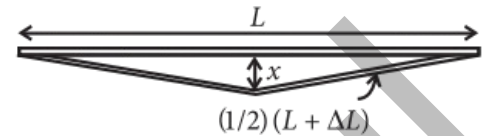
- (a) What is the absolute temperature of normal melting point of sulfur as read by thermometers  $A$  and  $B$ ?

(b) What do you think is the reason behind the slightly difference in answers of thermometers A and B? (The thermometers are not faulty). What further procedure is needed in the experiment to reduce the discrepancy between the two readings?

### Short Answer Type Questions (SA-II)

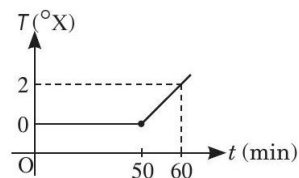
21 A rail track made of steel having length 10 m is clamped on a railway line at its two ends. On a summer day due to rise in temperature by  $20^{\circ}\text{C}$ , it is deformed as shown in figure.

Find  $x$  (displacement of the centre) if coefficient of linear expansion of steel is,  $\alpha_{\text{steel}} = 1.2 \times 10^{-5} \text{ }^{\circ}\text{C}^{-1}$ .



22 Define the terms heat capacity and water equivalent. Give their CGS and SI units.

23 A calorimeter contains 10 kg of water and some ice. Variation of temperature with time, when the calorimeter is heated over a slow burner is as shown in graph. Ignoring heat absorbed by calorimeter, find the amount of ice present.



24 Differentiate between three modes of heat transmission.

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

26. Find the ratio of heat required to raise the temperatures of two copper spheres of radii  $r_1$  and  $r_2$  ( $r_1 = 2.5r_2$ ) through 1 K.

27. (a) Calorimeters are made of metals not glass. Why?

(b) What is calorimetry?

(c) Which has the highest specific heat capacity: hydrogen or water?

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

29. (a) On what factors does the amount of heat flowing through a body [conductivity] depend? Obtain the expression for the heat conducted.

(b) Define coefficient of thermal conductivity. Write its SI unit. (c) Define thermal conductivity.

30. During summers in India, one of the common practices to keep cool is to make ice balls of crushed ice, dip it in flavored 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.

31. What is the effect of pressure on melting point of a substance? What is the regelation. Give its one practical application.

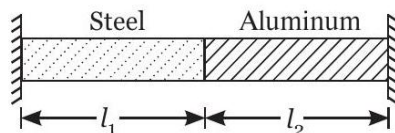
### Long Answer Type Questions (LA)

32. Explain why?

- A body with large reflectivity is a poor emitter?
- A brass tumbler feels much colder than a wooden tray on a chilly day?
- The Earth without its atmosphere would be inhospitably cold?
- Heating systems based on circulation of steam are more efficient in warming a building than those based on circulation of hot water?

33. What is meant by coefficient of linear expansion, superficial expansion and cubical expansion? Derive the relationship between them.

34. Two rods one of steel and other of aluminium is equal to cross-sectional area are joined together and the free ends are fixed between two rigid supports as shown in the figure.



Temperature of surroundings is increased by  $100^\circ\text{C}$ . If displacement of joint rods is  $(N^2/10)\text{mm}$ , then find the value of  $N$  with the help of following table.

Metal	Coefficient of expansion $\alpha(^{\circ}\text{C}^{-1})$	Young's modulus $Y(\text{Nm}^{-2})$	Length $l(\text{m})$
Steel	$\times$	$20 \times 10^{10}$	
Aluminium	$2.4 \times 10^{-5}$	$7 \times 10^{10}$	7

35. According to Stefan's law of radiation, a black body radiates energy  $\sigma T^4$  from its unit surface area every second where  $T$  is the surface temperature of the black body and  $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$  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  $10^3 \text{ K}$  and can be treated as a black body.

- Estimate the power it radiates.
- If surrounding has water at  $30^\circ\text{C}$ , how much water can 10% of the energy produced evaporate in 1 s? [ $s_w = 4186.0 \text{ J kg}^{-1} \text{ K}^{-1}$ ,  $L_v = 22.6 \times 10^5 \text{ J kg}^{-1}$ ]
- If all this energy  $U$  is in the form of thermal 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?

**ANSWER****Multiple Choice Questions:**

01. (c) 02. (d) 03. (c) 04. (b) 05. (a) 06. (b) 07. (b) 08. (c) 09. (b) 10. (d) 11. (c) 12. (d) 13. (c)  
14. (a) 15. (a) 16. (b) 17. (a) 18. (c) 19. (a) 20. (a) 21. (a) 22. (c) 23. (a) 24. (a) 25. (a) 26. (b)  
27. (d) 28. (b) 29. (d) 30. (b) 31. (a) 32. (b) 33. (d) 34. (a) 35. (c)

**Case Based MCQs:**

36. (a) 37. (c) 38. (c) 39. (a) 40. (d) 41. (a) 42. (c) 43. (c) 44. (a) 45. (b)

**Assertion & Reasoning Based MCQs:**

46. (b) 47. (a) 48. (a) 49. (a) 50. (c) 51. (a) 52. (a) 53. (a) 54. (b) 55. (c)