

CBSE Test Paper 01
Chapter 11 Thermal Properties of Matter

1. Molar Specific Heat capacity has units of **1**
 - a. W/m.K
 - b. J/mol.K
 - c. J.ohm/sec.K²
 - d. J/kg.K

2. 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 = $1.70 \times 10^{-5} \text{ K}^{-1}$. **1**
 - a. $1.24 \times 10^{-2} \text{ cm}$
 - b. $1.44 \times 10^{-2} \text{ cm}$.
 - c. $1.34 \times 10^{-2} \text{ cm}$
 - d. $1.54 \times 10^{-2} \text{ cm}$

3. A student eats a dinner rated at 2000 Calories. He wishes to do an equivalent amount of work in the gymnasium by lifting a 50.0-kg barbell. How many times must he raise the barbell to expend this much energy? Assume that he raises the barbell 2.00 m each time he lifts it and that he regains no energy when he drops the barbell to the floor. **1**
 - a. 8.14×10^3
 - b. 8.74×10^3
 - c. 8.54×10^3
 - d. 8.34×10^3

4. A spray can containing a propellant gas at twice atmospheric pressure (202 kPa) and having a volume of 125 cm^3 is at 22°C. It is then tossed into an open fire. When the temperature of the gas in the can reaches 195°C, what is the pressure inside the can?

Assume any change in the volume of the can is negligible. **1**

- a. 260 kPa
- b. 300 kPa
- c. 290 kPa
- d. 320 kPa

5. A steel railroad track has a length of 30.000 m when the temperature is 0.0°C. Suppose that the ends of the rail are rigidly clamped at 0.0°C so that expansion is prevented. What is the thermal stress set up in the rail if its temperature is raised to 40.0°C? $\alpha_{\text{steel}} = 11 \times 10^{-6} (\text{°C})^{-1}$ $Y_{\text{steel}} = 20\text{GPa}$ **1**

- a. $8.4 \times 10^6 \text{ N/m}^2$
- b. $8.1 \times 10^7 \text{ N/m}^2$
- c. $9.1 \times 10^7 \text{ N/m}^2$
- d. $8.8 \times 10^6 \text{ N/m}^2$

6. Why the temperature above 1200°C cannot be measured accurately by a platinum resistance thermometer? **1**

7. Stainless steel cooking pans are preferred with extra copper bottom. Why? **1**

8. Each side of a cube increases by 0.01% on heating. How much is the area of its faces and volume increased? **1**

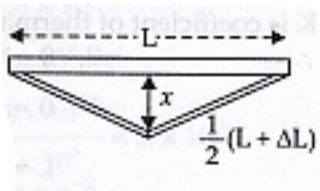
9. Calculate the heat of combustion of coal when 10 g of coal on burning raises the temperature of 2 litres of water from 20° C to 55° C. **2**

10. An iron ring of diameter 5.231 m is to be fixed on a wooden rim of diameter 5.243 m both initially at 27°C. To what temperature should the iron ring be heated so as to fit the rim? (Coefficient of linear expansion of iron is $1.2 \times 10^{-5} \text{ K}^{-1}$) **2**

11. What do you mean by molar specific heat of a substance? What is its SI unit? **2**

12. A 'thermacole' icebox is a cheap and efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox 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 h. The outside temperature is 45 °C, and co-efficient of thermal conductivity of thermacole is $0.01 \text{ J s}^{-1}\text{m}^{-1}\text{K}^{-1}$. [Latent heat of melting of ice = $335 \times 10^3 \text{ Jkg}^{-1}$] **3**

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14. What is calorimetry? Briefly explain its principle. **3**
15. A rail track made of steel having length 10 m is clamped on a railway line at its two ends (Figure).



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 $\alpha_{steel} = 1.2 \times 10^{-5} / ^\circ\text{C}$. **5**

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Answer

1. b. J/mol.K

Explanation: $Q = nC\Delta T$

$$C = \frac{Q}{n\Delta T}$$

2. b. 1.44×10^{-2} cm.

Explanation: Change in diameter

$$\Delta l = \alpha l \Delta T = 1.70 \times 10^{-5} \times 4.24 \times (227-27) = 1.44 \times 10^{-2} \text{ cm}$$

3. c. 8.54×10^3 times

Explanation: Total no. of times he lift barbell = Total energy/energy in lifting barbell once

$$= \frac{Q}{mgh} = \frac{2000 \times 4.2 \times 10^3}{50 \times 10 \times 2} = 4.2 \times 10^3 \text{ times}$$

4. d. 320 kPa

Explanation: $P \propto T$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$P_2 = \frac{468 \times 202}{295} = 320 \text{ kPa}$$

5. d. $8.8 \times 10^6 \text{ N/m}^2$

Explanation: Thermal Stress = $Y\alpha\Delta\theta$

$$= 20 \times 10^9 \times 11 \times 10^{-6} \times 40 = 8.8 \times 10^6$$

6. The temperature above 1200°C cannot be measured accurately by a platinum resistance thermometer because platinum begins to evaporate above 1200°C .
7. The copper bottom allows more heat to flow into the pan because the thermal conductivity of copper is much larger than that of steel. Therefore, it helps in cooking the food faster.
8. As each side of a cube increases by 0.01% on heating. This results in increased in the area of faces by 0.02% and the volume by 0.03%.

9. As per question mass m of 2 litres of water = 2 kg and we know that specific heat of water $C = 4200 \text{ J kg}^{-1} \text{K}^{-1}$

\therefore The heat energy required to raise the temperature of water from 20°C to 55°C

$$Q = mc(T_2 - T_1)$$

$$= 2 \times 4200 \times (55 - 20) = 2.94 \times 10^5 \text{ J}$$

As this much heat is produced by combustion of $m_0 = 10\text{g}$ of coal, hence heat of combustion of

$$\text{coal} = \frac{Q}{m_0} = \frac{2.94 \times 10^5 \text{ J}}{10\text{g}} = 2.94 \times 10^4 \text{ J g}^{-1} = 2.94 \times 10^7 \text{ J kg}^{-1}.$$

10. From the definition of coefficient of linear expansion, $d_2 = d_1[1 + \alpha\Delta t]$

$$\Rightarrow 5.243 = 5.231[1 + 1.2 \times 10^{-5} (T - 300)]$$

$$\therefore \left[\frac{5243}{5231} - 1 \right] = 1.2 \times 10^{-5} (T - 300)$$

$$T = 191 + 300 = 491 \text{ K} = 218^\circ \text{C}$$

11. Molar Specific heat

It is defined as the amount of heat energy required to raise the temperature of 1 *mole* of that substance through 1K (or 1°C).

$$\therefore \text{Molar specific heat } C = \frac{1}{\mu} \frac{\Delta Q}{\Delta T}$$

where ΔQ = the amount of heat energy required to raise the temperature of per moles of the given

substance through ΔT .

Its SI unit is $\text{J mol}^{-1} \text{K}^{-1}$.

12. Side of the given cubical ice box, $s = 30 \text{ cm} = 0.3 \text{ m}$

Thickness of the ice box, $l = 5.0 \text{ cm} = 0.05 \text{ m}$

Mass of ice kept in the ice box, $m = 4 \text{ kg}$

Time gap, $t = 6 \text{ h} = 6 \times 60 \times 60 \text{ s}$

Outside temperature, $T_1 = 45^\circ \text{C}$

Inside temperature, $T_2 = \text{temperature of ice} = 0^\circ \text{C}$

Coefficient of thermal conductivity of thermacole, $K = 0.01 \text{ J s}^{-1} \text{m}^{-1} \text{K}^{-1}$

Latent heat of melting of ice, $L = 335 \times 10^3 \text{ J kg}^{-1}$

Let m' be the total amount of ice that melts in 6 h.

Total amount of heat lost, θ in 6 hrs by the food (mathematical form of the equation comes from the definition of the thermal conductivity):

$$\theta = \frac{KA(T_1 - T_2)t}{l}$$

Where, A = Total surface area of the box = 6 × Surface area of each surface of the box =

$$6s^2 = 6 \times (0.3)^2 = 0.54\text{m}^2$$

$$\therefore \theta = \frac{0.01 \times 0.54 \times (45) \times 6 \times 60 \times 60}{0.05} = 104976\text{J}$$

But $\theta = m'L$, from the definition of latent heat of melting of ice.

$$\begin{aligned} \therefore m' &= \frac{\theta}{L} \\ &= \frac{104976}{335 \times 10^3} = 0.313\text{kg} \end{aligned}$$

Mass of ice left = Mass of ice initially kept inside the box - Mass of ice melted in 6hrs = 4 - 0.313 = 3.687 kg

Hence, the amount of ice remaining after 6 h is 3.687 kg.

13. Side of the given cubical ice box, $s = 30 \text{ cm} = 0.3\text{m}$

$$\text{Area of each surface of the box} = s^2 = (0.3)^2 \text{ m}^2$$

$$\text{Thickness of the icebox, } l = 5.0 \text{ cm} = 0.05 \text{ m}$$

$$\text{Mass of ice kept in the icebox, } m = 4\text{kg}$$

$$\text{Time gap, } t = 6 \text{ h} = 6 \times 60 \times 60\text{s}$$

$$\text{Outside temperature, } \theta_1 = 45^\circ\text{C}$$

$$\text{Inside temperature, } \theta_2 = 0^\circ\text{C}$$

$$\text{Coefficient of thermal conductivity of thermacole, } K = 0.01 \text{ J s}^{-1} \text{ m}^{-1}\text{K}^{-1}$$

$$\text{Heat of fusion of water, } L = 335 \times 10^3 \text{ J kg}^{-1}$$

Let 'm' be the total amount of ice that melts in 6h.

The amount of heat lost by the food, kept in the thermacole in 6 hrs (using the equation from definition of thermal conductivity):

$$Q = \frac{KA(\theta_1 - \theta_2)t}{l}$$

$$\text{Where, } A = \text{Total surface area of the box} = 6 \times \text{area of each surface} = 6 \times (0.3)^2 = 0.54 \text{ m}^2$$

$$\therefore Q = \frac{0.01 \times 0.54 \times (45) \times 6 \times 60 \times 60}{0.05} = 104976\text{J}$$

Now, if m' be the mass of melted ice, then $Q = m'L$

$$\begin{aligned} \therefore m' &= \frac{Q}{L} \\ &= \frac{104976}{335 \times 10^3} = 0.313\text{kg} \end{aligned}$$

Mass of ice left = 4 - 0.313 = 3.687 kg

Hence, the amount of ice remaining after 6h is 3.687kg.

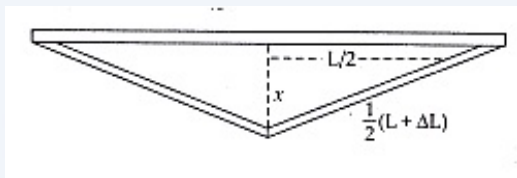
14. Calorimetry is a branch of physics that deals with the measurement of the quantity of heat being transferred from one substance to another.

The principle of calorimetry follows the law of conservation of energy. According to the principle of calorimetry, if two chemically non-reactive substances maintained at different temperatures are brought in thermal contact so as to share heat, the hotter substance transfers heat to the colder substance and the heat exchange continues till the temperature of both the substances become same. In such a situation if there is no heat energy dissipated due to radiation loss etc., then, we have

Total heat transferred from the hotter body = Total heat transferred to the colder body.

15. Coefficient of linear expansion $\alpha = 1.2 \times 10^{-5}/^{\circ}C$, initial length

$L_0 = 10\text{m}$, $\Delta T = 20^{\circ}C$ (change in temperature)



From the above figure using Pythagoras theorem, perpendicular² = hypotenuse² - base², we get

$$\begin{aligned}
 x^2 &= \left[(L + \Delta L) \frac{1}{2} \right]^2 - \left(\frac{L}{2} \right)^2 \\
 &= \frac{1}{4} [L^2 + \Delta L^2 + 2L\Delta L] - \frac{L^2}{4} \\
 x^2 &= \frac{L^2}{4} + \frac{\Delta L^2}{4} + \frac{2L\Delta L}{4} - \frac{L^2}{4} \quad (\because \Delta L^2 \ll L, \Delta L^2 \text{ is neglected}) \\
 \Rightarrow x^2 &= \frac{2L\Delta L}{4} \\
 \therefore x &= \frac{1}{2} \sqrt{2L\Delta L} \dots\dots(\text{i})
 \end{aligned}$$

Again from the definition of coefficient of linear expansion, change in length due to increase in temperature, ΔT

$$\Delta L = L_0 \alpha \cdot \Delta T = 10 \times 1.2 \times 10^{-5} \times 20 = 240.0 \times 10^{-5} \text{m}, \text{ since } \Delta L = \text{initial length at } 0^{\circ}C \times \text{coefficient of linear expansion} \times \text{increase in temperature}$$

$$\begin{aligned}
 \text{Now putting the values of } L \text{ and } \Delta L \text{ we get, } x &= \frac{1}{2} \sqrt{2 \times 10 \times 240 \times 10^{-5}} \text{ m} \\
 &= \frac{1}{2} \sqrt{10 \times 10 \times 2 \times 2 \times 2 \times 2 \times 10^{-1} \times 10^{-1} \times 10^{-4} \times 3} \text{ m} \\
 &= \frac{10 \times 4}{2} \sqrt{3} \times 10^{-2} = 20 \times .54 \times 10^{-2} = 10.8 \times 10^{-2} \text{m}
 \end{aligned}$$

$$\therefore x = 10.8 \text{cm},$$

This is the required displacement of the centre