CBSE Test Paper 02

Chapter 11 Thermal Properties of Matter

1. If the substance is in the form of a long rod, then for small change in temperature, ΔT, the fractional change in length, Δl/l, is **1**
   a. directly proportional to log ΔT
   b. directly proportional to ΔT
   c. inversely proportional to ΔT
   d. inversely proportional to log ΔT
2. The coefficient of volume expansion is n times coefficient of linear expansion where n equals **1**
   a. 4
   b. 2
   c. 3.0
   d. 5
3. In an experiment on the specific heat of a metal, a 0.20 kg block of the metal at 150^{o} C is dropped in a copper calorimeter (of water equivalent 0.025 kg) containing 150 cm^3 of water at $27^{o}C$. The final temperature is $40^{o}C$. Compute the specific heat of the metal. **1**
   a. 0.43 J $g^{-1}K^{-1}$
   b. 0.37 J $g^{-1}K^{-1}$
   c. 0.40 J $g^{-1}K^{-1}$
   d. 0.46 J $g^{-1}K^{-1}$
4. A water heater is operated by solar power. If the solar collector has an area of 6.00 m^2 and the power delivered by sunlight is 550 W/ m^2, how long does it take to increase the temperature of 1.00 m^3 of water from $20.0^{o}C$ to $60.0^{o}C$? **1**
   a. 50.7 ks
   b. 54.7 ks
   c. 56.7 ks
   d. 52.7 ks
5. The triple points of neon is 24.57 K. Express this temperatures on the Celsius and

Fahrenheit scales **1**

a. $-208.58^{o}C = -355.44^{o}F$

b. $-238.58^{o}C = -315.44^{o}F$

c. $-248.58^{o}C = -415.44^{o}F$

d. $-218.58^{o}C = -335.44^{o}F$

6. The earth without its atmosphere would be inhospitably cold. Why? **1**
7. Why an ice box is constructed with a double wall? **1**
8. Metal disc has a hole in it. What happens to the size of the hole when disc is heated? **1**
9. On a hot day, a car is left in sunlight with all the windows closed. After some time, it is found that the inside of the car is considerably warmer than the air outside. Explain, why? **2**
10. 100 g of water is super cooled to –10°C. At this point, due to some disturbance mechanized or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze? [$S_w = 1cal/g/^{\circ}C$ and $L^W_{fusion} = 80cal/g$] **2**
11. a. Why the brake drums of a car are heated when it moves down a hill at constant speed?
    b. Why pendulum clocks generally go faster in winter and slow in Summer? **2**
12. 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. **3**
13. Two vessels A and B of different materials but having identical shape, size and wall thickness are filled with ice and kept at the same place. Ice melts at the rate of 100 g m in"1 and 150g min^{-1} in A and B, respectively. Assuming that heat enters the vessels through the walls only, calculate the ratio of thermal conductivities of their materials. **3**
14. 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} K^{-1}. **3**
15. A body cools from 80 °C to 50 °C in 5 minutes. Calculate the time it takes to cool from 60 °C to 30 °C. The temperature of the surroundings is 20 °C. **5**

Answer

1. b. directly proportional to $\Delta \mathrm{T}$

Explanation: $\alpha = \frac{\Delta l}{l \times \Delta T}$

$\frac{\Delta l}{l} = a\Delta T$

2. c. 3.0

Explanation: $\alpha = \left(\frac{\Delta l}{l}\right)\frac{1}{\Delta T}$ and $\gamma = \left(\frac{\Delta V}{V}\right)\frac{1}{\Delta T}$

Volume V = L^3

expanded length = $L(1+\alpha\Delta T)$

expanded Volume =

$[L(1+\alpha\Delta T)]^3 = L^3(1+\alpha^2\Delta T^2+2\alpha\Delta T)(1+\alpha\Delta T)$

very small term is neglected

expanded volume = $V(1+3\alpha\Delta T)$

$\Delta V = 3\alpha V\Delta T$

$\gamma = \left(\frac{\Delta V}{V}\right)\frac{1}{\Delta T} = \frac{3\alpha V\Delta T}{V}\frac{1}{\Delta T}$

$\gamma = 3\alpha$

3. a. 0.43 J $\mathrm{g}^{-1}\mathrm{K}^{-1}$

Explanation: Heat lost by the metal = Heat gained by the water and calorimeter system

$m_1c_1\Delta T_1 = (m_1+m_2)c_2\Delta T_2$

$200 \times c_1 \times 110 = (150+25) \times 4.186 \times 13$

$c_1 = \frac{175 \times 4.186 \times 13}{200 \times 110}$

$c_1 = 0.43Jg^{-1}K^{-1}$

4. a. 50.7 ks

Explanation: $Q = ms\Delta T$

$P = \frac{W}{t} = \frac{ms\Delta T}{t}$

$t = \frac{ms\Delta T}{P} = \frac{1000 \times 4186 \times 40}{550 \times 6}$

= 50700\sec = 50.7K\sec

5. c. $-248.58\ ^\circ C = -415.44\ ^\circ F$

Explanation: $\frac{T_C - 0}{100 - 0} = \frac{T_F - 32}{212 - 32} = \frac{T_K - 273.15}{373.15 - 273.15}$

$\frac{T_C}{100} = \frac{T_F - 32}{180} = \frac{T_K - 273.15}{100}$

$T_K = 24.57K$

after solving

$T_C = -248.58\ ^\circ C$

$T_F = -415.44\ ^\circ F$

6. Due to greenhouse effect, the presence of atmosphere prevents heat radiations received by earth to go back. In the absence of atmosphere radiation will go back at night making the temperature very low and inhospitable.

7. To minimise the heat loss, an ice box is made of double wall and the space in between the walls is filled with some non-conducting material to provide heat insulation.

8. Expansion is always outward, therefore the hole size increased on heating.

9. Glass transmits about 50% of heat radiation coming from a hot source like the sun but does not allow the radiation from moderately hot bodies to pass through it. Due to this, when a car is left in the sun, heat radiation from the sun gets into the car but as the temperature inside the car is moderate, they do not pass back through its windows. Hence, inside of the car becomes considerably warmer.

10. Water mass = 100 g

At $-10^{o}C$ ice and water mixture exists.

Heat required (given out) by - $10^\circ C$ ice to $0^\circ C$ ice = $ms\Delta t$

$= 100 \times 1 \times [0 - (-10)]$

$Q = 1000\text{cal}$

Let gm of ice melted Q = ml

$m = \frac{Q}{L} = \frac{1000}{80} = 12.5g$

So, there is m = 12.5 g water and ice in mixture. Hence temperature of mixture remains $0^\circ C$.

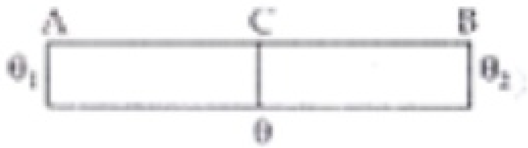
11. a. When the car moves downhill, the decrease in gravitational potential energy is converted into work against force of friction between brake shoe and drum which

appears as heat.

b. Time period of pendulum $T = 2\pi\sqrt{\frac{l}{g}}$ or $T \propto \sqrt{l}$

In winter l becomes shorter so its time period reduces, i.e. the pendulum takes less time to complete an oscillation, so it goes faster. In summer l increases resulting in increase in time period, i.e. the pendulum takes more time for a complete oscillation, so the clock goes slower.

12. As the temperature of rod varies from θ_1 to θ_2 from one end to another. So mean temperature of rod, $\theta = \frac{(\theta_1+\theta_2)}{2}$



So rate of flow of heat from A to C to B are equal

$\because \theta_1 > \theta > \theta_2$

From defination of thermal conductivity we get,

$\therefore \quad \frac{d\theta}{dt} = \frac{KA(\theta_1-\theta)}{L_0/2}$ (A = area of cross-section of the rod, L_0 = length of the rod)

$again,\ \frac{d\theta}{dt} = \frac{KA(\theta-\theta_2)}{L_0/2}$ (since same amount of heat flows from A to B via C in unit time)

K is coefficient of thermal conductivity of the material of the rod.

$\therefore \theta_1 - \theta = \theta - \theta_2$

$\therefore \theta = \frac{\theta_1+\theta_2}{2}$

Hence the final length of the rod,

$L = L_0(1+\alpha\theta) = L_0\left[1+\alpha\left(\frac{\theta_1+\theta_2}{2}\right)\right]$

13. Suppose m_1 and m_2 be the masses of ice melted at the same time (t = 1 min) in vessels A and B, respectively.

The amounts of heat flowed into the two vessels will be

$Q_1 = \frac{K_1A(T_1-T_2)t}{x} = m_1L$

$Q_2 = \frac{K_2A(T_1-T_2)t}{x} = m_2L$

where L is latent heat of ice.

Dividing Equation (i) by Equation (ii)

$\Rightarrow \frac{K_1}{K_2} = \frac{m_1}{m_2} = \frac{100\text{g}}{150\text{g}} = \frac{2}{3} = 2:3$

14. Here, Length of steel tape at 27°C (L_o) = 1m or 100 cm

temperature Change(ΔT) = 45° - 27° = 18°C

Coefficient of linear expansion of steel (a) = 1.2 × 10^{-5} /°C

Length of steel tape at 45°C ,

Use expansion formula,

$$L = L_o(1 + a\Delta T)$$

= 100(1 + 1.2 × 10^{-5} × 18)

= 100 (1.000216)

= 100.0216 cm

So, length of 1 cm at 45°C = 100.0216/100 = 1.000216 cm

So, length of 63cm at 45°C = 1.000216 × 63 = 63.0136 cm.

15. By Newton's law of cooling, the rate of cooling is given by:

$$-\frac{dT}{dt} = K\left(T - T_0\right)$$

$$\frac{dT}{K(T-T_0)} = -Kdt \text{ .....(1)}$$

Where,

T - Temperature of the body

T_0 -Temperature of the surroundings

T_0 = 20°C

K is a constant

t = 5 min = 300 sec (t is the time in which the temperature of body falls from 80°C to 50°C)

Integrating equation (1), we get:

$$\int_{50}^{80} \frac{dT}{K(T-T_0)} = -\int_{0}^{300} Kdt$$

$$\left[\log_e(T - T_0)\right]_{50}^{80} = -K[t]_0^{300}$$

$$\log_e \frac{80-20}{50-20} = -300K$$

$$\frac{2.3026}{K}\log_{10} 2 = -300$$

$$\frac{-2.3026}{300}\log_{10} 2 = K \text{ ....(ii)}$$

Let t' is the time in which temp of body changes from 60^0 C to 30^0 C

Hence, we get:

$\frac{-2.3026}{K}\log_{10}\frac{60-20}{30-20}$ = t'

$\frac{-2.3026}{t'}\log_{10}4 = K$ ....(iii)

From equations (ii) and (iii) by equating the value of K, we get:

$\frac{-2.3026}{t}\log_{10}4 = \frac{-2.3026}{300}\log_{10}2$

on solving

t = 300 $\times$ 2 = 600 sec = 10 min

Therefore, it takes 10 minutes to cool the body from 60°C to 30°C temperature.