CBSE Test Paper 04

Chapter 11 Thermal Properties of Matter

1. Heat is a form of **1**
   a. energy
   b. solid
   c. liquid
   d. gas
2. The coefficient of area expansion is n times of coefficient of linear expansion. where n equals **1**
   a. 5
   b. 2
   c. 3
   d. 4
3. The temperature of a silver bar rises by 10.0^{o}C when it absorbs 1.23 kJ of energy by heat. The mass of the bar is 525 g. Determine the specific heat of silver. **1**
   a. 0.234 kJ/kg. ^{o}C
   b. 0.254 kJ/kg. ^{o}C
   c. 0.244 kJ/kg. ^{o}C
   d. 0.214 kJ/kg. ^{o}C
4. compared to glass copper expands **1**
   a. three times less
   b. five times more
   c. about the same
   d. two times less
5. A 200 cm^3 glass flask is filled to the brim with mercury at 20°C How much mercury overflows when the temperature of the system is raised to 100° C The coefficient of linear expansion of the glass is $0.40 \times 10^{-5}/^\circ C$. Cofficient of volume expansion of mercury is $1.82 \times 10^{-4}/^\circ C$ **1**
   a. 2.3 cm^3
   b. 2.5 cm^3

c. 2.7 cm^3

d. 2.9 cm^3

6. Is the bulb of a thermometer made of diathermic walls or adiabatic walls? **1**
7. Is it correct to call heat as the energy in transit? **1**
8. Calorimeters are made of metals, not glass Why? **1**
9. Briefly explain the concept of thermal equilibrium and temperature. **2**
10. 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. **2**
11. What kind of thermal conductivity and specific heat requirements would you specify for cooking utensils? **2**
12. 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. **3**
13. A brass boiler has a base area of 0.15 m^2 and thickness 1.0 cm. It boils water at the rate of 6.0 kg/min when placed on a gas stove. Estimate the temperature of the part of the flame in contact with the boiler. Thermal conductivity of brass = 109 J $s^{-1}m^{-1}$ K^{-1}; Heat of vaporisation of water = 2256×10^3 J kg^{-1}. **3**
14. 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 J g^{-1} 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. a. energy

   Explanation: Heat is the amount of energy flowing from one body of matter to another spontaneously due to their temperature difference.

2. b. 2

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

   area A = L^2

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

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

   $\alpha^2\Delta T^2$ is very small

   expanded area = $A(1+2\alpha\Delta T)$

   $\Delta A = 2\alpha A\Delta T$

   $\beta = \left(\frac{\Delta A}{A}\right)\frac{1}{\Delta T} = \frac{2\alpha A\Delta T}{A}\frac{1}{\Delta T}$

   $\beta = 2\alpha$

   So that n = 2

3. a. 0.234 kJ/kg. $^\circ$C

   Explanation: $s = \frac{Q}{m\Delta T} = \frac{1.23}{0.525\times 10} = 0.234 KJ/Kg^\circ C$

4. b. five times more

   Explanation: The coefficient of linear expansion is more for copper then that of glass.

5. c. 2.7 cm^3

   Explanation: coefficient of linear expansion of the glass

   $\gamma_S = 0.40\times 10^{-5}/^\circ C$

   Cofficient of volume expansion of mercury $a_L = 1.82\times 10^{-4}/^\circ C$

   The amount of mercury overflows

   $\Delta V = (\gamma_L - \gamma_S)V\Delta\theta$

$$\gamma_S = 3\alpha = 3 \times 0.4 \times 10^{-5} = 0.12 \times 10^{-4}$$
$$\Delta V = (1.82 - 0.12) \times 10^{-4} \times 200 \times 80 = 2.7cm^3$$

mercury overflows = 2.7cm^3

6. Adiabatic walls does not allow to pass heat into mercury of bulb and diathermic allows to conducts heat through it. So in the bulb of thermometer diathermic walls are used.
7. Yes, it is perfectly correct to call heat as the energy in transit because it is continuously flowing on account of a temperature difference between bodies or parts of a system.
8. Calorimeters are made of metals, not glass because metals are good conductors of heat and have low specific heat capacity.
9. Two systems are in a state of thermal equilibrium if all parts of the two systems are at the same temperature.Thus, the temperature is a property which determines whether the two given systems will be in thermal equilibrium or not.
10. For neon Triple point $T = 24.57K$
    $\therefore T_c = T(\mathrm{K}) - 273.15$
    $= 24.57 - 273.15 = -248.58^o C$
    $T_F = \frac{9}{5}T_C + 32 = \frac{9}{5} \times (-248.58) + 32 = -415.44^\circ\mathrm{F}$
    For carbon dioxide Triple point, $T = 216.55\ K$
    $\therefore \quad T_C = T(K) - 273.15 = 216.55 - 273.15 = -56.6^\circ\mathrm{C}$
    $T_F = \frac{9}{5}T_C + 32 = \frac{9}{5} \times (-56.6) + 32 = -69.88^\circ\mathrm{C}$
11. A cooking utensil should have-
    i. Low specific heat so that it immediately attains the temperature of the source.
    ii. High conductivity, so that it can conduct heat through itself and transfer it to the contents quickly.
12. K = C + 273.15
    and C/5 = (F - 32)/9
    Where, K is Kelvin , C is Calcius and F is Fahrenheit.
    For 24.57 K
    In calcius ,
    C = 24.57 - 273.15
    C = -248.58° C

In Fahrenheit ,

-248.58/5 = (F - 32)/9

F = -248.58 × 9/5 + 32

= -414.44°F

For 216.55 K,

in Celsius ,

C = 216.55 - 273.15

= -56.6°C

In Fahrenheit,

-56.6/5 = (F - 32)/9

F = -56.6×9/5 + 32

= -69.88°F

13. Base area of the boiler, A = 0.15 m^2

Thickness of the boiler, l = 1.0 cm = 0.01 m

Boiling rate of water, R = 6.0 kg/min = m/t

With mass, m = 6 kg

and time, t = 1 min = 60 s

Thermal conductivity of brass, K = 109 J $s^{-1}m^{-1}$ K^{-1}

Heat of vaporization, L = 2256×10^3 J kg^{-1}

The amount of heat flowing into water through the brass base of the boiler is given by (mathematical equation comes from the definition of thermal conductivity):

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

Where,

T_1 = Temperature of the flame in contact with the boiler

T_2 = Boiling point of water = 100°C

Heat required for boiling the water:

θ = mass of the water × latent heat of vaporisation = m×L ....(ii)[As, there occurs only change in state, the latent heat of vaporisation comes into account]

Equating equations (i) and (ii), we get:

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

$$\Rightarrow T_1 - T_2 = \frac{mLl}{KAt}$$

$$\Rightarrow T_1 - T_2 = \frac{6 \times 2256 \times 10^3 \times 0.01}{109 \times 0.15 \times 60}$$

$\therefore T_1 - T_2$= 137.98°C

$\Rightarrow T_1 = T_2 + 137.98 = 237.98^\circ C$ (As, T_2 = boiling point of water =100°C)

Therefore, the temperature of the part of the flame in contact with the boiler is 237.98°C.

14. Power of the drilling machine, P = 10 kW = 10×10^3 W =10^4 W

    Mass of the aluminum block, m= 8.0 kg = 8000 g

    Time, t = 2.5 min = 2.5 $\times$ 60 = 150 s

    Specific heat of aluminium, c= 0.91 J $g^{-1}K^{-1}$

    Let rise in the temperature of the block after drilling = δT

    Total energy of the drilling machine = $P \times T$

    $= 10 \times 10^3 \times 150 = 1.5 \times 10^6 J$

    As only 50% of the energy is useful as per the question

    so useful energy , $\Delta Q = \frac{50}{100} \times 1.5 \times 10^6 = 7.5 \times 10^5 J$

    But $\Delta Q = mc\Delta T$

    $\therefore \Delta T = \frac{\Delta Q}{mc}$

    $= \frac{7.5 \times 10^5}{8 \times 10^3 \times 0.91}$ = 103°C

    Therefore, temperature of block increases by 103^0 C in drilling for 2.5 minutes.

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

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

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

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

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

$\log_e \frac{80-20}{50-20} = -300K$
$\frac{2.3026}{K}\log_{10} 2 = -300$
$\frac{-2.3026}{300}\log_{10} 2 = K$ ....(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.