Measurement and Effects of Heat

EXERCISE [PAGE 103]

Exercise | Q 1.1 | Page 103

Whom should I Pair with?

Group A	Group B
a. Temperature of a healthy human body	296 K
Boiling point of water	98.6°F
Room temperature	0° C
Freezing point of water	212°F

Solution:

Group A	Group B
a. Temperature of a healthy human body	98.6°F
b. Boiling point of water	212°F
c. Room temperature	296 K
d. Freezing point of water	0°C

Exercise | Q 2.1 | Page 103

Who is telling the truth?

The temperature of a substance is measured in joules.

Solution: Sentence a is lying as heat energy is measured in joules.

Exercise | Q 2.2 | Page 103

Who is telling the truth?

Heat flows from an object at higher temperature to an object at lower temperature.

Solution: Sentence b is telling the truth as heat energy flows from an object at higher temperature to an object at lower temperature.

Exercise | Q 2.3 | Page 103

Who is telling the truth?

Joule is the unit of heat.

Solution: Sentence c is telling the truth as joule is the unit of heat.

Exercise | Q 2.4 | Page 103

Who is telling the truth?

Objects contract on heating.

Solution: Sentence d is lying as objects expand on heating.

Exercise | Q 2.5 | Page 103

Who is telling the truth?

Atoms of a solid are free.

Solution: Sentence e is lying as atoms of a solid are closely packed because of force attraction between them.

Exercise | Q 2.6 | Page 103

Who is telling the truth?

The average kinetic energy of atoms in a hot objects is less than the average kinetic energy of atoms in a cold objects.

Solution: Sentence f is lying as the average kinetic energy of atoms in a hot objects is greater than the average kinetic energy of atoms in a cold objects.

Exercise | Q 3.1 | Page 103

You will find if you search.

A thermometer is used to measure _____ .

Solution: A thermometer is used to measure **temperature**.

Exercise | Q 3.2 | Page 103

You will find if you search.

The apparatus used to measure heat is called a _____.

Solution: The apparatus used to measure heat is called a **calorimeter.**

Exercise | Q 3.3 | Page 103

You will find if you search.

Temperature is the measures of the _____ Kinetic energy of the atoms in a substance.

Solution: Temperature is the measures of the average kinetic energy of the atoms in a substance.

Exercise | Q 3.4 | Page 103

You will find if you search.

The heat contained in a substannce is the measures of the _____ kinetic energy of atoms in the substance.

Solution: The heat contained in a substance is the measures of the total kinetic energy of atoms in the substance.

EXERCISE [PAGE 103]

Exercise | Q 2 | Page 103

Nishigandha kept a vessel containing all the ingredients for making tea in a solar cooker. Shivani kept a similar vessel on a stove. Whose tea will be ready first and why?

Solution: Shivani's tea will be prepared first.

In Shivani's case, the intensity of the flame in contact with the vessel is very high due to which the flow of heat will be faster. Thus, the time taken by the tea to reach its boiling point will be less. Hence, tea will be prepared fast.

In case of Nishigandha, the intensity of radiation reaching the vessel is not as high as compared to stove's flame. Thus, the flow of heat will be slower in this case due to which more time will be taken to reach the boiling temperature of the tea. Hence, tea will be prepared at slower rate.

Exercise | Q 3.1 | Page 103

Write brief answers.

Describe a clinical thermometer. How does it differ from the thermometer used in laboratory?

Solution: Clinical thermometer is used in homes. It has a glass tube with a bulb at one end and the other end closed. This bulb and some part of the tube is filled with thermometric liquid, such as mercury or alcohol. The rest of the volume of the tube has vacuum in it. There is a kink near the end of the glass tube which prevents the falling back of the thermometric liquid once it is removed from the hot body under observation.

It is basically used to measure the temperature of humans. A clinical thermometer has a temperature range of only 35 ºC to 42 °C.

Exercise | Q 3.2 | Page 103

Write brief answers.

What is the difference between heat and temperature ? what are their units.

Solution:

Heat	Temperature
It is a form of energy which causes in us the sensation of hotness or coldness.	It is measure of the degree of hotness or coldness of an object.
It is measured in joules (J).	It is measure in kelvin (K), Celsius (ºC) and Fahrenheit (ºF)

Exercise | Q 3.3 | Page 103

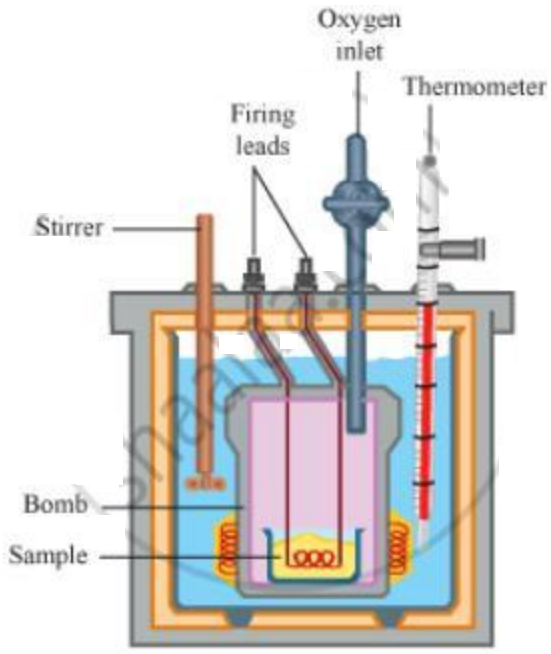
Write brief answers.

Explain the construction of a calorimeter. Draw the necessary figure.

Solution: A device used for heat measurement is called a calorimeter.

Construction of a Calorimeter

- It consists of a metallic vessel and stirrers. They are made of copper or aluminium.
- The vessel is then kept inside a wooden jacket which contains heat-insulating materials.
- The outer wooden jacket acts as a heat shield, and reduces the heat loss from the inner vessel.
- The outer jacket has an opening through which a mercury thermometer is inserted into the calorimeter.



Exercise | Q 3.4 | Page 103

Write brief answers.

Explain why rails have gaps at specific distances.

Solution: All solids expand on heating. As rails are made up of steel, these also expand in summers and contract in winters. These expansion and contraction can cause sagging and bending of rails which could derail the trains running on them. Thus, the rails have been provided with gaps at specific distance so as to prevent this bending of rails. These spaces get closer in summers and wider in winters.

Exercise | Q 3.5 | Page 103

Write brief answers.

Explain with the help of formulae the expansion coefficients of liquid and gas.

Solution: The formula for liquid expansion or gas is

$V_2 = V_1 (1 + \beta \Delta T)$
or

$$\beta = \left(\frac{V_2 - V\_1}{V_1} \right) \frac{1}{\triangle T}$$

From the above formula, we can say that

- the volumetric expansion coefficient of a liquid (β) is defined as the fractional change in the volume of the liquid per degree Celsius (or kelvin) change in temperature.
- the volumetric expansion coefficient of a liquid (β) is defined as the fractional change in the volume of the gas per degree Celcius (or kelvin) change in temperature at constant pressure. So, β is the constant pressure volumetric expansion coefficient in case of gas.

Exercise | Q 4.1 | Page 103

Solve the following example.

What must be the temperature in Fahrenheit so that it will be twice its value in Celsius?

Solution: Let the temperature in Celsius be T.

So, the temperature in Fahrenheit = 2T

Now,

$$F = 32 + \frac{9}{5} C$$

$$\Rightarrow 2T = 32 + \frac{9}{5} T$$

$$T = 160° C$$

$$\Rightarrow \text{Temperature in Fahrenheit} = 2T = 320° F$$

Exercise | Q 4.2 | Page 103

Solve the following example.

A bridge is made from 20 m long iron rods. At temperature 18°C, the distance between two rods in 0.4 cm. Up to what temperature will the bridge be in good shape?

Solution: Length of the iron rod = 20 m = 2000 cm at 18°C
Distance between the length of two rods, = 0.4 cm Temperature coefficient of linear expansion of iron = $11.5 \times 10^{-6} ° C^{-1}$

The bridge will be in good shape till both the rods expand by 0.2 cm as the temperature is increased. Let at temperature T, both the rods expand by 0.2 cm i.e. the total expansion is 0.4 cm.
Using formula for linear expansion of solids, we have

$$\frac{\triangle l}{l} = \alpha_l \triangle T$$

$$\Rightarrow \frac{0.4}{2000} = 11.5 \times 10^{-6} \times (\mathrm{T} - 18)$$

$$\mathrm{T} = 18 + \frac{0.4}{2000 \times 11.5 \times 10^{-6}} = 35.4^{\circ}\mathrm{C}$$

Exercise | Q 4.3 | Page 103

Solve the following example.

At 15°C the height of Eifel tower is 324 m. If it is made of iron, what will be the increase in length in cm, at 30°C?

Solution: Height of Eifel tower = 324 m = 32400 cm at 15°C

Temperature coefficient of linear expansion of iron = 11.5×10^{-6} ° C^{-1}

Change in temperature = 30°C - 15 °C = 15°C

Change in length = Δ l

Using formula for linear expansion of solids, we have

$$\frac{\triangle l}{l} = \alpha_l \triangle \mathrm{T}$$

$$\Rightarrow \frac{\triangle l}{32400} = 11.5 \times 10^{-6} \times 15$$

$$\triangle l = 32400 \times 11.5 \times 10^{-6} \times 15 = 5.6\mathrm{cm}$$

Exercise | Q 4.4 | Page 103

Solve the following example.

Two substances A and B have specific heats c and 2 c respectively. If A and B are given Q and 4Q amounts of heat respectively, the change in their temperatures is the same. If the mass of A is m, what is the mass of B?

Solution: Let the mass of B M.
Let the change in temperature be T for both the bodies, A and B.
The amount of heat in a body is given as

Q = m × c × Δ T

For body A,

Q=m × c × T

$$\Rightarrow T = \frac{Q}{mc} \quad \text{....(i)}$$

For body B,

4Q=M × 2c × T

$$\Rightarrow M = \frac{4Q}{2c \times T}$$

From (i) , $T = \frac{Q}{mc}$

$$\Rightarrow M = \frac{4Q}{2c \times \frac{Q}{mc}} = 2m$$

Exercise | Q 4.5 | Page 103

Solve the following example.

When a substance having mass 3 kg receives 600 cal of heat, its temperature increases by 10°C. What is the specific heat of the substance?

Solution: Let the specific heat capacity of the substance be c.

Given: Mass of the substance, m = 3 kg = 3000 g

Heat given to the substance, Q = 600 cal

Increase in temperature of the substance = 10°C

Now, the amount of heat in a body is given as

$$Q = m \times c \times \triangle T$$

$$\Rightarrow c = \frac{Q}{m \times \triangle T} = \frac{600}{3000 \times 10} = 0.02 \text{ cal } g^{-1\,\circ} C^{-1}$$