14. Thermal Energy

- Thermal energy, also called heat, is a form of energy which gives us sensation of hotness. Like other forms of energy its SI unit is Joule (J)
- Temperature is a measure of hotness of a body. It is measured in, ºF, ºC or K, with the help of a device called thermometer.
- The three scales of temperature are related as:

$$\frac{C}{100} = \frac{F-32}{180} = \frac{K-273}{100}$$

- Different types of thermometer are designed for different purposes for measuring human body temperature doctors use a clinical thermometer, for measurement of temperature of bodies in laboratory, laboratory thermometers are used, for measuring the highest and lower value of atmospheric temperature meteorologists use maximum and minimum thermometer.
- When heat is supplied to a substance and its state does not change, the temperature of the substance rises. The heat gained or lost by a substance is given by

$$Q = mc\theta$$

where m = mass, c = specific thermal capacity and θ = rise or fall in temperature.
- Specific thermal capacity of a substance (also called its specific heat) is defined as heat per unit mass per degree change in temperature. Its SI unit $Jkg^{-1}K^{-1}$.
- When heat is supplied to a substance and it changes from solid to liquid or liquid to gaseous state (or vice-versa) there is no change in its temperature. The heat supplied during change of state is called Latent heat of the substance. The Latent heat of a substance is defined as heat required to change a unit mass of substance from one state to another without change in its temperature, i.e., $L = Q/m$
- There are two types of latent heats of a substance: Latent heat of fusion and latent heat of vaporization. SI unit of latent heat is $J\ kg^{-1}$.
- The constant temperature at which a solid changes to its liquid state is called melting point and the constant temperature at which a body changes from liquid to gaseous state is called boiling point.

  Melting point and boiling point are characteristic properties of the substance. Thus the substance which melt at 0ºC and boils at 100ºC is H_2O.
- All the substances expand on heating. Expansivity of different materials is different. However, the expansivity of liquids is more than solids, where as, the expansivity of gases is very much more than even liquids.
- Solids may increase in length, in breadth, as well as, in height, on heating. Therefore we define linear expansivity of a solid as the increase in length per unit original length per degree Celsius rise in temperature i.e. $\alpha = \frac{l_2 - l_1}{l_1(\theta_2 - \theta_1)}$. Also the volume expansivity of a substance is defined as $\gamma = \frac{\nu_2 - \nu_1}{\nu_1(\theta_2 - \theta_1)}$.

  The SI unit of expansivity is per Kelvin.
- A bimetallic strip bands on heating due to difference in expansivities of the two metals it is made of. Bimetallic strips are used in temperature control devices, called thermostats.
- While laying our structures we have to make provisions for thermal expansions or otherwise our structures will be damaged or get deformed to damage other things.

Build your Understanding

- A piece of metal and a piece of wood are lying in open. On a winter morning you measure temperatures. Will you find any difference in temperature? Obviously not, because, they both might have attained the temperature of the atmosphere.

  Now, you touch the two one by one. Which of the two you feel colder? Metal piece why so? Because, metal piece conducts heat and so more heat flows from your body to piece of metal.

- How much heat is required to convert 20 g of ice at –10ºC into steam at 100ºC. Given: Specific heat of ice = 0.5 cal g^{-1} $ºC^{-1}$, Specific Heat of water = 1 cal g^{-1} $ºC^{-1}$, Latent heat of fusion of ice = 80 cal/g. Latent heat of vapourization of water = 540 cal/g. Express the result in S.I. unit.

  Ans: For this conversion heat is absorbed in the following steps:

  (i) For converting –10ºC ice into 0ºC ice,

  $$Q_1 = mc\theta = 20\text{g} \times \frac{0.5 \text{ cal}}{0°\text{C}} \times 10°\text{C}$$

  $= 100$ cal.

  (ii) for converting 0ºC ice into 0ºC water $Q_2 = mL = 20 \times 80 = 1600$ cal

  (iii) for converting 0ºC water in 100ºC water $Q_3 = mC'\theta' = 20 \times 1 \times 100 = 200$ cal

  (iv) For converting 100ºC water in 100ºC steam,

  $Q_4 = mL' = 20 \times 540 = 10800$ cal

  $\therefore$ Total heat required $= Q_1 + Q_2 + Q_3 + Q_4$

  $= 100 + 1600 + 2000 + 10800$ cal

  $= 14500$ Cal

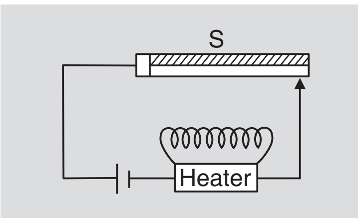
  1 Cal $= 4.18$ J

  $\therefore$ $Q = 14500 \times 4.18$ J

  $= 60610$ J

✔ Maximise Your Marks

1. The bimetallic strip in the diagram is made of iron and aluminum. Which side is iron if the circuit is broken on heating? Explain.



2. Why do liquids have two types but gases only are type of volume expansivity.

3. You have same amount of water and mercury at the same temperature. When equal size ice piece are placed in the two liquids which of them will supply more heat to ice? Explain.

★ Stretch Yourself

1. Why is the use of mercury preferred in most thermometers?
2. Give one example where we supply heat to a substance but its temperature does not rise and one example where we do not supply heat but temperature rises.
3. Why do you not use ice cold water in place of ice to cool your drinks?

? Test Yourself

1. What will be the value of 20ºC on Fahrenheit scale and Kelvin scale?
2. What will be the length of a rod of steel at 100ºC if it has a length of 1m at 0ºC. Expansivity of steel is 8×10^{-6} $ºC^{-1}$.
3. Describe an activity to show that real expansion of a liquid is greater than apparent expansion.