4

Heat

SYLLABUS

1. (a) The effects of heat : rise in temperature (revision of thermometer, Celsius scale); fire (flammable/non-flammable substances), change of state (revision of terms : melting, solidification, boiling, condensation, evaporation, sublimation), expansion.
   (b) Equal lengths of different solids expand by different amounts when heated equally.
   (c) Equal amounts of different liquids expand by different amounts when heated equally.
   (d) Some applications in everyday life.
2. (a) Transfer of heat — conduction, convection and radiation.
   (b) Conductors and insulators.
   (c) Convection currents in liquids and gases.
   (d) Absorption and reflection of radiant heat — polished and dark bodies.
   (e) Everyday applications
   (f) The thermos flask

Caution : Train students to take simple precautions against burn injuries/fires.

- Simple improvised experiments to show conduction and convection (E).
- Examining and drawing a labelled diagram of a thermos flask (E).
- Compound bar, unequal expansion of different liquids (D).

A. EFFECTS OF HEAT AND CHANGE IN STATE

WHAT IS HEAT ?

In our day-to-day life, we use the terms hot, cold, warm, etc. During summers, we often say that today is a hot day while in winters we say that last evening, it was very cold. When we feel cold, we take something hot like tea or coffee and when we feel hot, we take something cold like cold drink, ice cream, etc. When we touch hot water, we feel warm and when we touch an ice cube, we feel cold. This happens because when we touch hot water, energy flows from hot water to our hand and when we touch ice cube, energy flows from our hand to the ice cube.

This transfer of energy from one body to another is due to the difference in temperature of the two bodies and this difference is due to the amount of heat possessed by each body.

The energy that transfers from one body to another due to a temperature difference between them is called **heat**. The direction of this energy transfer is always from a body at higher temperature to a body at lower temperature.

When you rub both your palms together vigorously, you feel warmth in the palms. Here, friction generates heat. The rubbing of palms involves a form of energy. This shows that heat is a form of energy.

James Joule was the pioneer in describing about heat. He showed how kinetic energy possessed by an object can also be converted into heat energy. Similarly, various other forms of energies can be converted into heat energy. When a candle burns in the air, chemical energy is converted into heat. In an electric bulb, electrical energy is converted into light and heat. In the same way heat energy can be converted into other forms of energy.

For example, when iron is heated, it becomes red hot and emits light. Here heat converts into light. In a steam engine, heat is converted into mechanical energy. Heat can also be converted into electricity through special devices. This is done in thermal power plants.

SOURCES OF HEAT

The main sources of heat are (i) Fire (ii) Sun, (iii) Electricity.

(i) Fire

We all know that fire was known to man since Stone Age or even before. They had the concept of making fire by igniting a dry mass of leaves with the help of two dry sticks or stones rubbed together vigorously. Fire as

Fig. 4.1 Fire as a source of heat

known to man, initially, was used protection from cold, to frighten the wild beasts, to melt copper and iron and to make weapons and tools for himself.

We use fire to cook our food. This fire we get from common fuels such as, wood, kerosene, coal, cooking gas, *etc*. The heat produced by burning fuels like diesel, petrol, *etc.*, is used to drive engines and run vehicles and also to produce electricity.

Thus, we can now say that fire is one of the major sources of heat.

Gradually, it was realised that fire could cause damage to property and also loss of life. This came the need to differentiating inflammable substance from non-flammable substances.

Inflammable Substances : Those substances which can easily catch fire are called inflammable substances. The best examples one can imagine are those of petrol, liquiefied petroleum gas (LPG), synthetic fibres, wood, dry grass, paper, *etc.*

Non-flammable Substances : Those substances which are fire resistant up to a large extent of temperature are called non-flammable substances. For example, water and sand are the best known fire resistant substances *i.e.* non-flammable substances.

Knowledge bank

Molecules of solid, liquid or gas stop vibrating at very low temperature called absolute zero, equivalent to –273°·16°C.

ACTIVITY 1

To show that heat can be transferred from one body to another.

Method : Take one page of paper and a piece of cloth. Keep the page on the piece of cloth on a table. Now, switch on your electric iron. When the iron gets heated press the paper using the iron for about 30 seconds. Now, remove the iron. Touch the paper by one hand and the cloth with the other. You will find that both the things are hot.

It shows that heat is transferred from one body to other.

Precautions From Fire

While handling fire either in the kitchen or elsewhere and to avoid burn injuries, one must observe the following precautions :

1. Do not wear synthetic clothes near the fire.
2. Make sure that there is no leakage of gas in the pipes or from the regulator of the cooking gas.
3. Avoid inflammable articles near electrical gadgets, circuits or cooking gas.
4. If unluckily a person suffers from burn injuries, it would be best to pour water on the injuries as first aid. Water helps to remove the heat from the burnt part most efficiently.

(ii) Sun

The sun is a major and natural source of heat on the surface of earth. All living organisms on the earth get heat mainly from the sun. This heat makes the water to evaporate from ponds, rivers and oceans. The evaporated water condenses in the higher atmosphere to form clouds and these clouds give us rain. Plants synthesize their food from sunlight.

(iii) Electricity

We get heat from electricity in various forms. In winter, we heat our rooms with a room heater, we use a geyser to heat water, we use microwave oven, induction oven, toaster, *etc.*, in our kitchen. In all these electrical gadgets, electricity is used to produce heat.

It is also of immense interest to note that contrary to the earlier beliefs, heat energy is contained not only in hot bodies but also in cold bodies whose temperature is more than absolute zero temperature. Sir Humphry Davy of England in 1799 rubbed two pieces of ice in vacuum at temperature below the ice-point and noticed that the ice did melt. This further proves the fact that heat is produced due to the motion of particles.

TEMPERATURE

Temperature is a measure of energy level due to the motion of individual atoms and molecules in a gas, liquid or solid.

- If an object has a high temperature (hot object), its constituent particles are moving around or vibrating energetically *i.e.* at high speed.
- If an object has a low temperature (cold object), its constituent particles are moving around or vibrating slowly *i.e.* at low speed.

Thus, **"the temperature of a body is a measure of the degree of hotness or coldness of that body."**

When two bodies at different temperatures are brought in contact with each other, heat energy flows from the hot body to the cold body until both the bodies reach the same temperature. This is known as the **Principle of Calorimetry**. According to this principle

Heat lost by hot body = Heat gained by cold body

When we have to cool a glass containing hot milk, we place it in a tumbler containing cold water as shown in Fig. 4.2. In this process, the heat starts flowing from the glass containing hot milk to the cold water and thus the hot milk starts losing its heat.

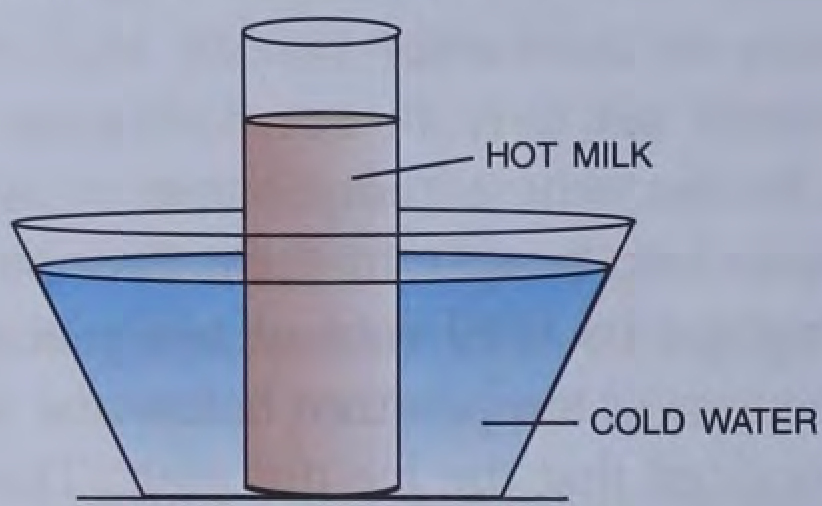


Fig. 4.2 Flow of heat

Measurement of Temperature

The temperature is generally measured in degree celsius. It is denoted as °C.

There is another unit of temperature *i.e.* degree Fahrenheit, which is denoted as °F.

The S.I. unit of temperature is kelvin (K).

The temperature of a body is measured by means of a *thermometer*. The most common type of thermometer is mercury thermometer. It works on the principle : "*The length of liquid (mercury) column rises with the rise in temperature, due to thermal expansion.*"

In the previous class, you learnt how to measure temperature of a body using a thermometer.

ACTIVITY 2

To observe if the sense of (body) touch can be used as a reliable technique to measure temperature.

- Take three vessels A, B and C.
- Fill vessel A with ice cold water, vessel B with normal tap water and vessel C with warm water.
- Now dip your right hand in vessel A and left hand in vessel C, as shown in Fig. 4.3(a).
- What do you observe now ?

You will observe that your right hand in vessel A feels cold while your left hand in vessel C feels warm.

- Now put both your hands in vessel B, as shown in Fig. 4.3(b).
- What do you observe now ?

You will feel that your right hand feels warm while your left hand feels cold. But actually the water in vessel B is neither hot nor cold.

This proves that your sense of touch cannot measure temperature correctly.

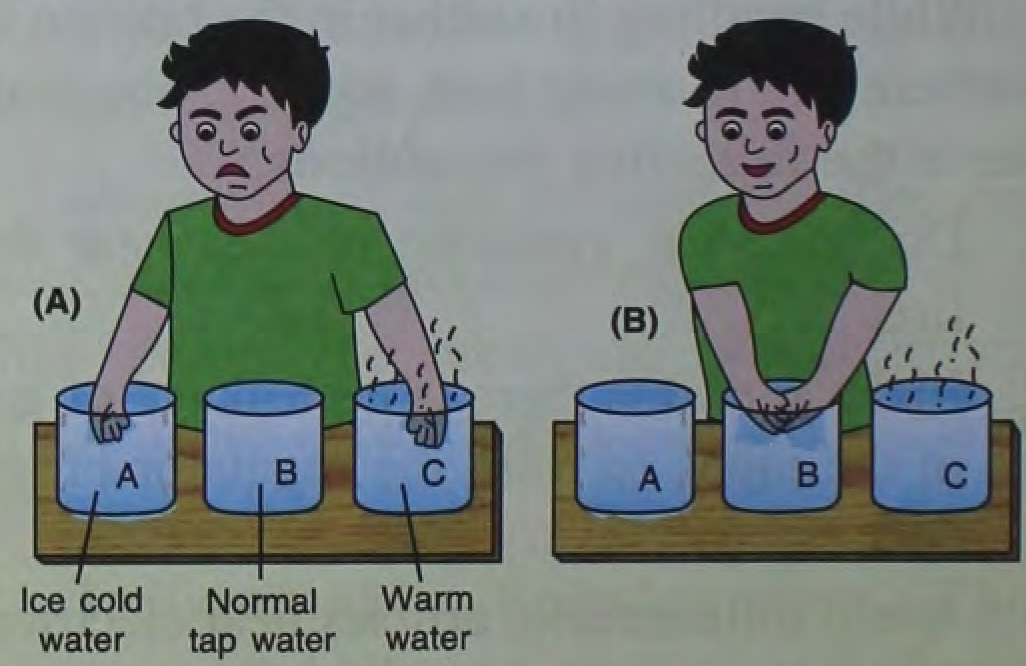


Fig. 4.3 Feeling hotness and coldness of water

Qualities of a Good Thermometer

The following are the basic qualities of a good thermometer :

1. The thermometer bulb should be thin-walled so that the liquid inside the bulb can quickly attain the temperature of the body in contact.

2. The stem of the thermometer must be made of thick glass so that it does not break easily.
3. The capillary bore should be narrow so that the liquid moves through a large length in the stem even if there is a small increase in the volume of liquid in the thermometer.
4. The liquid used in the thermometer should be such that it can expand uniformly with the rise in temperature and even for a small rise in temperature, it should expand uniformly. This will help in calibration of the thermometer.
5. The liquid should have a low freezing point and high boiling point so that the instrument can be used over a wide range of temperature.
6. The liquid should be opaque so that it is visible through the glass.
7. The liquid should be practically non-volatile so that its expansion is not affected by its vapour pressure.
8. The liquid should have low specific heat capacity. Lower the specific heat capacity lesser the heat it will absorb from the body to expand.
9. The liquid should be available in pure state.
10. The liquid should not stick to the glass.

There are various types of thermometers that are made up of liquid, gas and those which work on electricity. Here, we shall restrict ourselves to liquid thermometers only.

Liquid thermometers : Thermometers in which liquid is used as a thermometric substance are called **liquid** thermometers. The two most commonly used thermometric liquids are mercury and alcohol.

Advantages of using mercury : Mercury is used as a thermometric liquid because of the following advantages :

1. It does not stick to the glass, therefore readings are more accurate.
2. It is an opaque and shiny liquid and hence it is easily visible through the glass.
3. Its expansion is uniform at all temperatures.
4. It has a low freezing point (–39°C) and a high boiling point (357°C). Therefore, it can be used over a wide range of temperatures.
5. It is easily available in pure state.
6. It is a non-volatile liquid and hence vapours are not formed in the empty part of the thermometric tube.

Advantages of using alcohol as a thermometric liquid : Following are the advantages of using alcohol as a thermometric liquid.

1. Its freezing point is –139°C and hence can measure very low temperatures.
2. It has a fairly even expansion or contraction over a large range of temperatures (about six times more than mercury).
3. Although alcohol's visibility through the glass is not very clear, this difficulty is removed by adding a dye to it.

However, alcohol cannot be used to measure very high temperatures because it starts boiling at 78°C.

Disadvantages of using water : Water cannot be used as a liquid in a thermometer due to the following reasons :

1. It sticks to the glass.
2. It is transparent, so it is difficult to read the level through the glass.
3. It is volatile and hence vapours apply a pressure on the surface thereby affecting the reading.
4. It is a poor conductor of heat.
5. Its expansion is not uniform over a wide range of temperatures.
6. It freezes at 0°C and boils at 100°C and hence the range is not very wide.
7. Its specific heat capacity is high which means it will absorb more amount of heat from the object which is kept in contact with the thermometer.

Making of a Mercury Thermometer

The making of a mercury thermometer consists of the following three steps :

(1) Construction (2) Marking the lower fixed point and the upper fixed point (3) Calibration *i.e.* temperature scale.

Construction : A thermometer is made up of a cylindrical stem with a bulb at one end. The inner wall of the bulb is connected to a capillary tube. The other end is initially open.

Filling of mercury in the capillary tube

A clean and hard capillary tube about 30 cm long is taken. To this tube, a cylindrical bulb is connected at one end and the other end is kept open. A small glass funnel is connected to the tube with the help of a short rubber tube. The tube is placed vertically with its bulb in an oil bath as shown in Fig. 4.4. Some mercury is poured into the funnel and the oil bath is heated. During heating, the air of the bulb expands and escapes out in the form of bubbles through the mercury in the funnel. The tube is taken out from the oil bath and allowed to cool. The air in the bulb contracts and a little amount of mercury goes down into the bulb through the capillary tube.

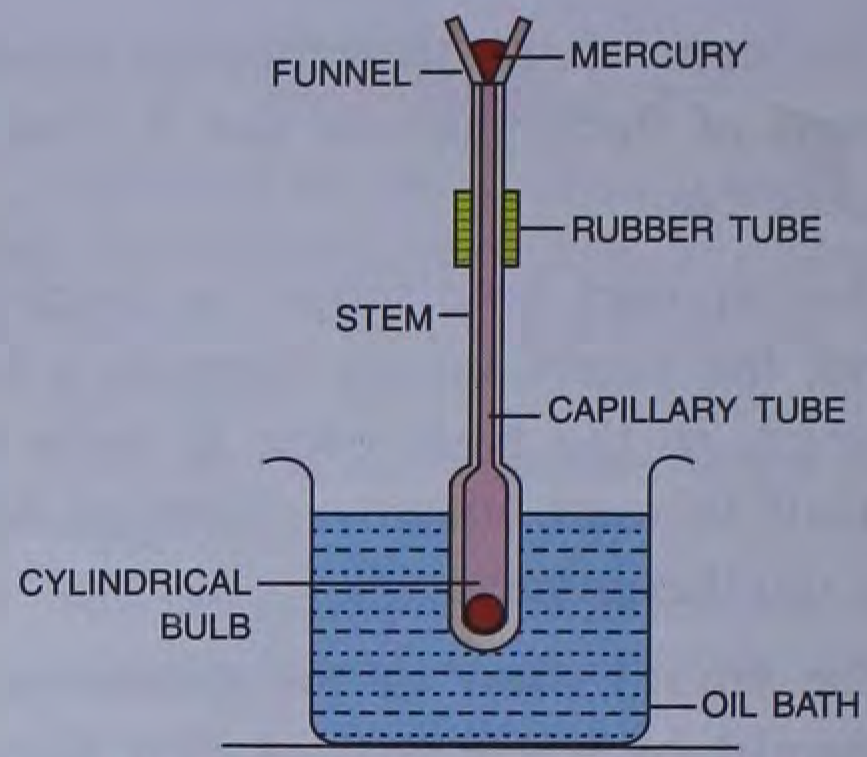


Fig. 4.4 The capillary tube being filled with mercury

The tube is again heated in the oil bath and the process is repeated a number of times till the bulb is completely filled with mercury. The funnel and the rubber tube are then removed from the capillary tube. The bulb is then heated to a temperature higher than the maximum temperature to be measured by the thermometer. The top open end of the capillary tube is then sealed by heating the end over a gentle bunsen flame.

Calibration of the thermometer

Lower fixed point and upper fixed point :

Keep the bulb of the thermometer in ice at 0°C (See Fig. 4.5). Ensure that the temperature of ice is continually maintained at 0°C. This is achieved by arranging the bulb of the thermometer in a funnel so that the portion of ice which melts may flow out. On keeping the bulb in ice at 0°C, the temperature of the bulb and the mercury inside it decreases. As a

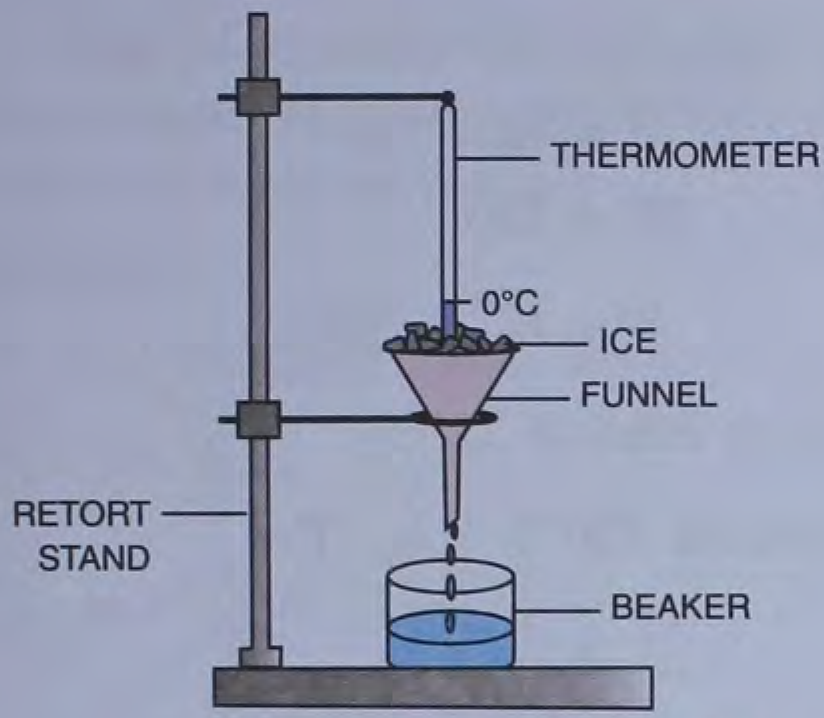


Fig. 4.5 Lower fixed point

result, the mercury starts contracting (or decreasing in volume) till the temperature of the mercury in the tube is also 0°C. When the temperature of the mercury in the tube is 0°C, it stops contracting and its level becomes fixed. Mark this position of the mercury level as 0°C. This is known as *lower fixed point.*

Now the instrument (capillary tube with bulb) is kept inside an arrangement called *hypsometer* (not actually shown in Fig. 4.6). In the figure, we consider only a round bottom flask. The flask is partially filled with water and is then heated so that the water in it boils. Steam gets accumulated in the flask, above the water. The bulb of the thermometer is kept in contact

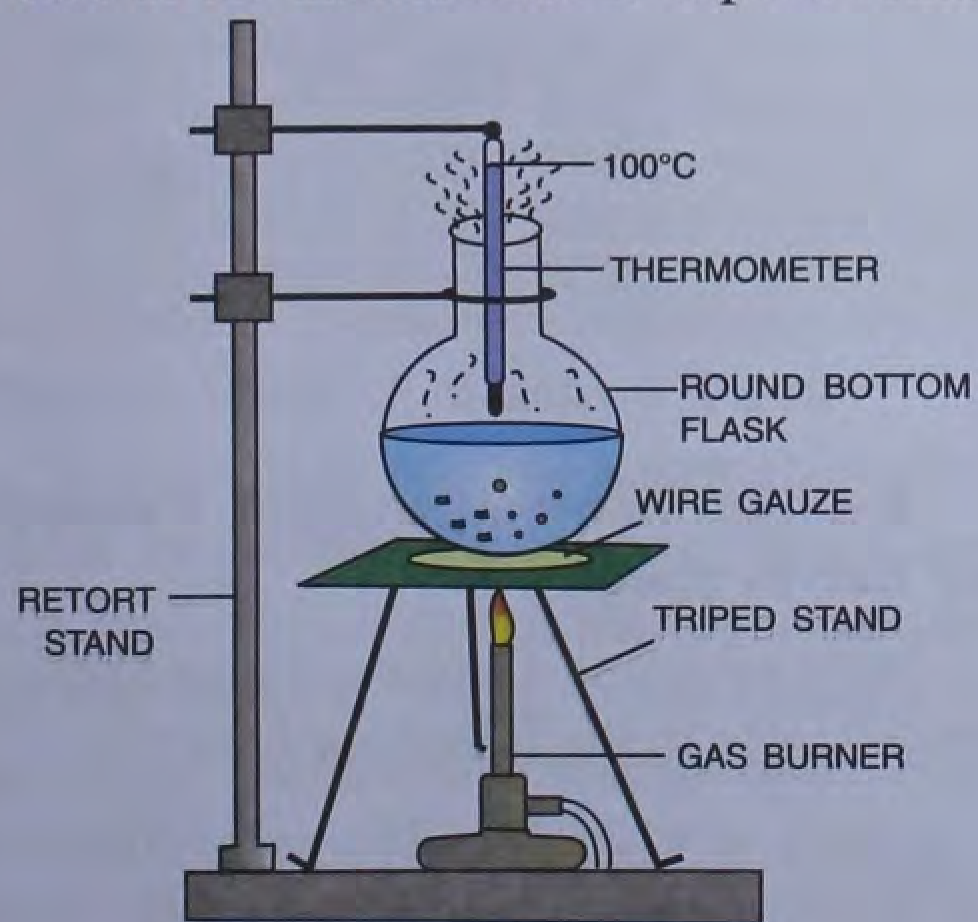


Fig. 4.6 Upper fixed point

with this steam. As the bulb is in contact of steam at 100°C, temperature of the bulb and mercury inside it rises. As a result of this the mercury starts expanding till the temperature of the mercury is same as the temperature of steam *i.e.*, 100°C. On attaining this temperature, the mercury stops expanding and its level becomes fixed. This point (level) is marked as 100°C and is known as the *boiling point of water*. This is known as *upper fixed point*. Now the gap between the lower and upper fixed points is divided into 100 equal parts; each part gives 1°C. This is called the calibration of a thermometer.

Reading a thermometer

Let us learn how to read a thermometer. First, note the temperature difference indicated between the two bigger marks. Also note down the number of divisions (shown by smaller marks) between these marks. Suppose the bigger mark reads one degree and there are five divisions between two sucessive bigger marks. Then, one small division reads $\frac{1}{5}$ or 0·2 °C. Wash the thermometer, preferably with an antiseptic solution. Hold it firmly and give it a few jerks. The jerks will bring the level of mercury down. Ensure that it falls below 35 °C. Now place the bulb of the thermometer under your tongue. After one minute, take the thermometer out and note the reading. This is your body temperature. The temperature should always be stated in its unit, *i.e.*, °C.

TEMPERATURE SCALE

In general, we use three different scales to measure temperature. These are the Celsius scale, the Fahrenheit scale and the kelvin scale.

In order to mark thermometer with Celsius scale, the length of the thermometer between the lower fixed point and the upper fixed point is divided into 100 equal parts. The lower fixed point is marked 0°C and the upper fixed point is marked 100°C.

In order to mark a thermometer with kelvin scale, the length of the thermometer between the lower fixed point and the upper fixed point is divided into 100 equal parts. The lower fixed point is marked 273 K and the upper fixed point is marked 373 K.

To convert the Celsius scale into the kelvin scale, we have to add 273 to the Celsius scale. For example,

0°C is equivalent to (0 + 273) = 273 K.

100°C is equivalent to 100 + 273 = 373 K.

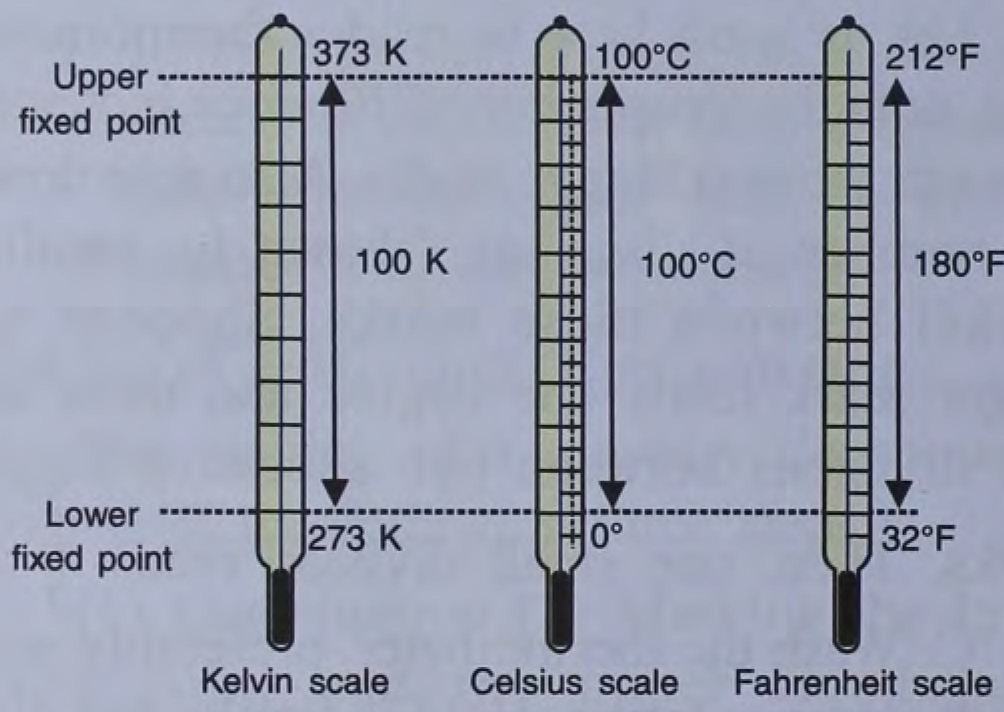


Fig. 4.7 Temperature scales of thermometers

In order to mark a thermometer with Fahrenheit scale, the length of the thermometer between the lower fixed point and the upper fixed point is divided into 180 equal parts. The lower fixed point is marked 32°F and the upper fixed point is marked 212°F. In order to convert °C into °F, we use the following equation :

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

Suppose we have to convert 0°C into °F, we put 0 in place of C and solve for F. *i.e.*

$$\frac{0}{5} = \frac{F-32}{9}$$

$$0 \times 9 = 5(F - 32)$$

$$0 = 5F - 160$$

$$5F = 160$$

$$F = \frac{160}{5} = 32°F$$

∴ 0°C is equal to 32°F.

To convert 100°C into °F.

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

$$\Rightarrow \quad \frac{100}{5} = \frac{F-32}{9}$$

$$900 = 5(F - 32)$$

$$900 = 5F - 160$$

$$900 + 160 = 5F$$

$$\text{or} \quad F = \frac{1060}{5} = 212°F$$

∴ 100°C is equal to 212°F.

To convert 98·6°F normal human body temperature into °C.

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

$$\Rightarrow \quad \frac{C}{5} = \frac{98{\cdot}6-32}{9}$$

$$9C = 5(98{\cdot}6 - 32)$$

$$9C = 493 - 160$$

$$9C = 333$$

$$C = \frac{333}{9} = 37°C$$

∴ 98·6°F is equal to 37°C.

Relation between Celcius, Fahrenheit and Kelvin scales.

We can relate Celcius, Fahrenheit and Kelvin scales in the following form :

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

Solved example : Let us find out at what temperature the readings of Celsius scale and Fahrenheit scale are equal ?

Solution :

Let the temperature be x.

$$\therefore \quad \frac{C}{5} = \frac{F-32}{9}$$

$$\Rightarrow \quad \frac{x}{5} = \frac{x-32}{9}$$

$$9x = 5(x-32)$$

$$9x = 5x - 160$$

$$9x - 5x = -160 \qquad 4x = -160$$

$$x = \frac{-160}{4} \qquad x = -40$$

Therefore, – 40°C is equal to – 40°F.

Intext Questions

1. Give few examples of inflammable substances.
2. Define temperature.
3. Write the names of various scales used in thermometers.
4. What are the lower and upper fixed points in a thermometer ?
5. There are two beakers containing water upto the same height. In one beaker the water is at 20°C and in the other it is at 20°F. Suppose a fifty paise coin is released in each beaker from the same height. In which beaker will it touch the base first ? Give reasons.

Effects of Heat

You would have come across many effects of heat on matter. On heating, snow melts while water boils and gradually vapourises. When an object is heated, many changes may take place. The simplest change is the rise in the temperature of the body. On heating, an object may slightly expand in size. It may change its state from solid to liquid or from liquid to gas. This is the most familiar effect of heat. Heat speeds up most of the chemical reactions. Heat can even kill organisms. We boil milk and water in order to kill harmful bacteria present in them.

(i) Change in temperature of the body: When a body is heated, its temperature rises and when it is cooled, its temperature falls. This change in temperature depends on the quantity of heat absorbed or given out by the body, the mass of the body and the material of the body. When heat is absorbed, the temperature of the body increases and when the heat is given out, its temperature decreases.

(ii) Change in the shape of the body : When a body is heated, it expands and when it is cooled, it contracts. This increase in size of the body due to heating is called thermal expansion. We will learn more about thermal expansion further in this chapter.

(iii) Change of State of Matter : Matter exists in *three* physical states.

• Solid • Liquid • Gas

The change in a substance from one physical state to another is called *change of state*. This can be achieved either by heating or cooling the substance. Figure 4.8 gives the entire change of states.

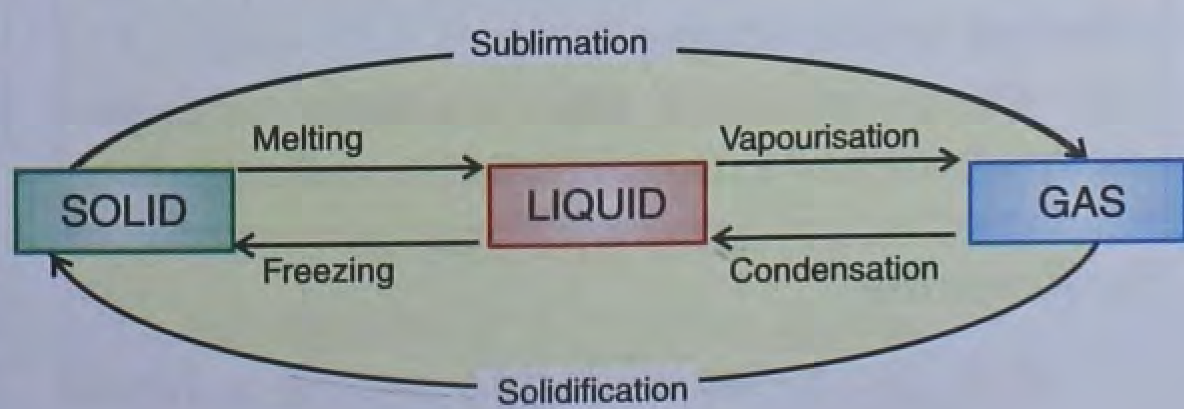


Fig. 4.8 The change of state

(a) Fusion or Melting

It is the process during which a solid changes to liquid state at a constant temperature by the **absorption of heat**. The fixed temperature at which a solid melts at normal atmospheric pressure is known as melting point. *For example*, wax melts at about 63°C, ice (solid) melts into water (liquid) at a temperature of 0°C.

ACTIVITY 3

Take about 200-300 g of crushed ice in a 500 mL beaker. Immerse a thermometer in ice and note its temperature. Heat the beaker containing the ice from below and record the temperature after every 30 seconds till the ice melts. Continue to heat the water and record its temperature every one minute for five minutes. Record your observation in following table.

Table : Melting of ice

Time	*State of matter*	*Temperature*
0 s	Solid	0°C
....	....	....
....	....	....
....	....	....
....	....	....

From the table you will note that the temperature remains at 0°C until the whole ice melts. Though heat is continuously supplied to ice during this period, its temperature does not increase. Where does that energy go ? You see that the ice melts, that is, it changes its state from solid to liquid. The heat supplied during this change is used up by the ice in changing its state from solid to liquid. Once the ice is completely melted, the temperature of water obtained begins to rise.

The temperature at which a substance changes its state from solid to liquid is called its **melting point**.

(b) Freezing

It is the process during which a liquid changes into solid state at a constant temperature by **releasing heat**. The fixed temperature at normal atmospheric pressure at which freezing of the liquid occurs is known as *freezing point*. For example, water (liquid) freezes into ice (solid) at a temperature of 0°C.

For crystalline subtance, its melting point and freezing points are the same. For example, ice melts at 0°C and water freezes at 0°C.

(c) Vapourisation or Boiling

It is the process during which a liquid changes into its vapour state at a constant temperature by the **absorption of heat**. The fixed temperature at normal atmospheric pressure at which vapourisation occurs is known as *boiling point* or *vapourisation point* of the liquid. *For example*, water (liquid) vapourises to steam (gas) at a temperature of 100°C.

(d) Condensation

It is the process during which vapours change into liquid state at a constant temperature by **releasing heat**. The fixed temperature at normal atmospheric pressure at which condensation occurs is known as *condensation point* of the gas or vapour. For example, steam (gas) condenses to water (liquid) at a temperature of 100°C.

For the same substance, its vaporisation point is the same as its condensation point. For example, boiling water converts into its vapours (steam) at 100°C and steam converts into boiling water at 100°C.

(e) Sublimation

It is the process in which a solid directly converts into gaseous state without undergoing through liquid state. For example, camphor or naphthalene, ammonium chloride, iodine, etc.

(f) Solidification

It is the process in which a gas condenses directly into solid state without undergoing through liquid state. For example, conversion of carbon dioxide into dry ice.

(g) Expansion

Generally, a substance expands on heating and contracts on cooling. Water is an exception, as on heating it from 0°C to 4°C, it contracts and on further heating above 4°C it expands. When a substance is heated, its molecules start vibrating faster and the intermolecular space increases. Hence, hotter the substance, larger will be its volume. Comparatively, gases expand the most on heating while solids expand the least on heating.

Intext Questions

1. Define conduction of heat.
2. By what process of transfer of heat do we receive heat from the sun ?
3. Differentiate between a conductor and an insulator ?
4. Which of the two, distilled water or supply water, is a better conductor of heat ?

TEST YOURSELF

A. Fill in the blanks :

1. A body is at high temperature if its molecules are moving around at .... speed.
2. The degree of .... or .... of a body is a measure of the temperature of the body.
3. The lower fixed point of a thermometer is the temperature at which pure water .... while the upper fixed point of a thermometer is the temperature at which pure water ....
4. The lower fixed point on the Celsius scale is .... while on the Fahrenheit scale, it is ....
5. When a substance is heated with no rise in temperature, change of .... takes place.
6. Liquids and gases only have .... or .... expansion.
7. The volume expansion of water is .... than that of alcohol.
8. Heat is said to be transferred by .... while heat energy is transferred from the hot end to the cold end particle to particle.
9. .... is the best conductor of heat while .... is the worst.

Ans. (1) High (2) hotness, coldness (3) freezes, boils (4) 0°C, 32°F (5) state (6) volume, cubical (7) less (8) Conduction (9) Silver, Asbestos

B. Choose the correct answer.

1. Which among the following is not an inflammable substance ?
   (a) LPG (b) Wood
   (c) Water (d) Paper
2. Boiling point of water is
   (a) 95°C (b) 100°C
   (c) 200°C (d) 80°C
3. What is the range of a clinical thermometer ?
   (a) 35°C – 42°C (b) 38°C – 40°C
   (c) 30°C – 35°C (d) 40°C – 42°C

C. Short answer questions

1. State the effects of heat on a body.
2. Is the statement correct : –273°C = 0 K ? Explain.
3. Is the statement correct : –40°C = –40 K ? Explain.
4. State the expressions to relate between (i) Celsius and Fahrenheit (ii) Celsius and Kelvin
5. Define the following terms :
   (a) Melting (b) Boiling
   (c) Condensation (d) Sublimation
6. Explain why on a cold day the metallic handle of a door feels colder than a wooden door.

7. Give *two* examples each of good conductors of heat and poor conductors of heat.

D. Long answer questions

1. Draw a neat labelled diagram of a thermometer and explain the marking of the lower and upper fixed points.
2. Convert 100°F into Celsius and Kelvin scales. **Ans.** 37·8°C, 310·8 K
3. Convert 10 K into °C. **Ans.** –263°C
4. The temperature of a body rises from 90°C to 100°C. What is the rise in temperature in (i) °F (ii) K ? **Ans.** (i) 18°F (ii) 10 K
5. A mercury thermometer is transferred from boiling water to a glass of hot milk. The mercury level falls to three-fourth of the distance between the upper and lower fixed points. Calculate the temperature of milk in (i) °C (ii) °F (iii) K. **Ans.** (i) 75°C (ii) 167° F (iii) 348 K

B. THERMAL EXPANSION OF SOLIDS AND LIQUIDS

Thermal Expansion of Solids

We know that solids have definite shape and size. Therefore, the length, area and volume of a solid increases when we heat it. The following experiments demonstrate the expansion of substances on heating.

ACTIVITY 4

Take an iron ball and a ring such that the ball is just able to pass through the ring. Set the apparatus as shown in Fig. 4.9. Heat the ball for sometime and then try to pass it through the ring. The ball will not pass through. However, on cooling, it again passes through the ring. What are the reasons ?

It happens so because the ball expands on heating. But on cooling, it passes through the ring because on cooling, the ball contracts. This experiment shows that solids expand on heating and contract on cooling.

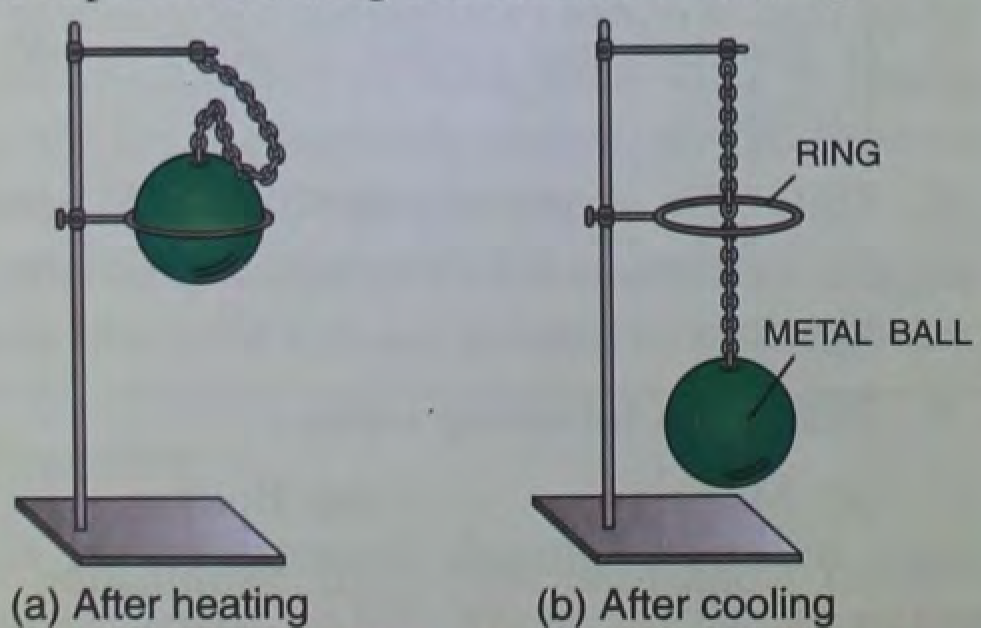


Fig. 4.9 Ball and ring experiment to show that solids expand on heating

ACTIVITY 5

Take a metal rod and set up an apparatus as shown in Fig. 4.10. Fix one end of the rod and keep the other end free but it touches to a pointer. Now heat the rod. You will see that the pointer starts moving. Why does this happen ?

It is because of the expansion of the metal rod. When the rod expands, it elongates along the free end which pushes the pointer.

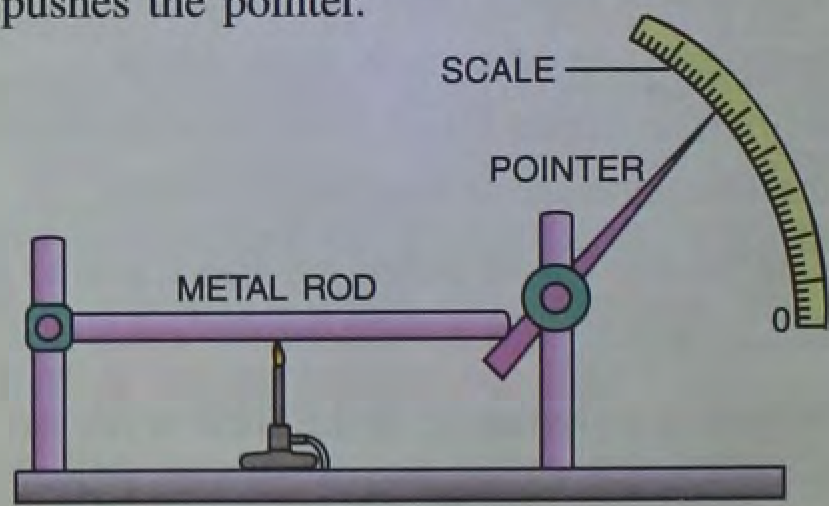
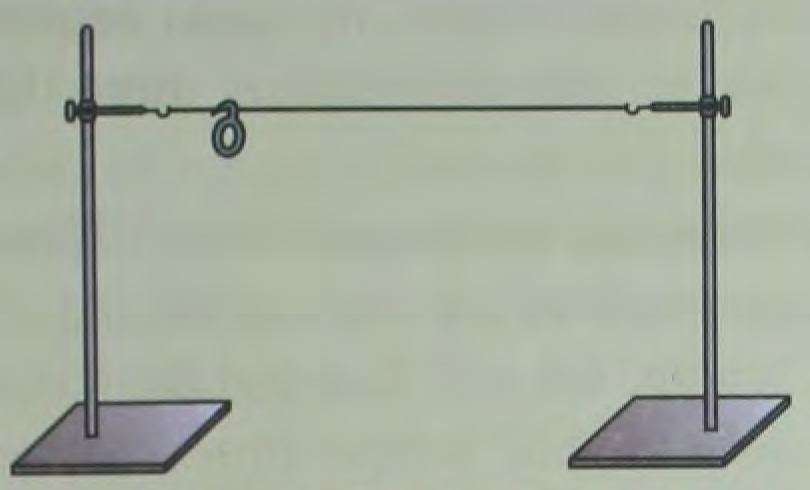


Fig. 4.10 Metals expand on heating

ACTIVITY 6

Take a piece of iron wire and slip a curtain ring (metallic) through the wire. Stretch the wire between two clamp stands, as shown in Fig. 4.11(a). The wire should be tight in between the two stands.

Now take the ring to the end of the wire and heat the other end. What do you notice ? The ring will gradually move towards the middle of the wire. This happens because the wire when heated expands and becomes loose. As a result there is a depression in the middle of the wire, due to which the ring slips to the middle region (see Fig. 4.11(b)).



(a) Before heating wire is straight

(b) After heating wire sags.

Fig. 4.11

Practical Applications of Thermal Expansion of Solids

1. In the construction of bridges, some space has to be left to allow the metal to expand during a rise in temperature. Hence, while constructing a bridge, one end is kept fixed while the other end is mounted on a roller so as to compensate for the expansion or contraction when change in temperature takes place.

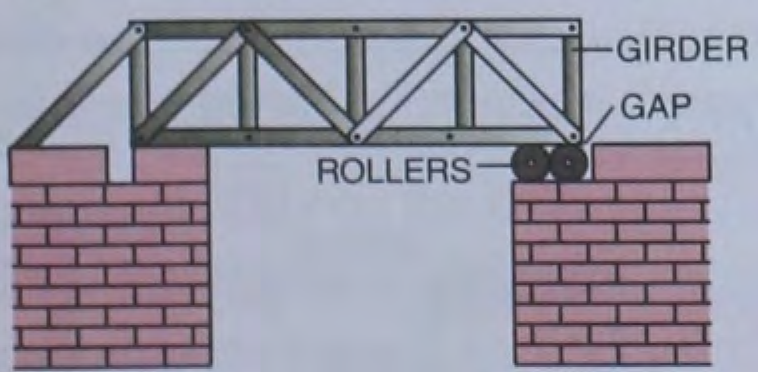


Fig. 4.12 Gap for the expansion in a bridge

2. While laying rail tracks, small gaps are always left in between the tracks. This is done to compensate for the expansion with the rise in temperature, otherwise they would bend outwards.

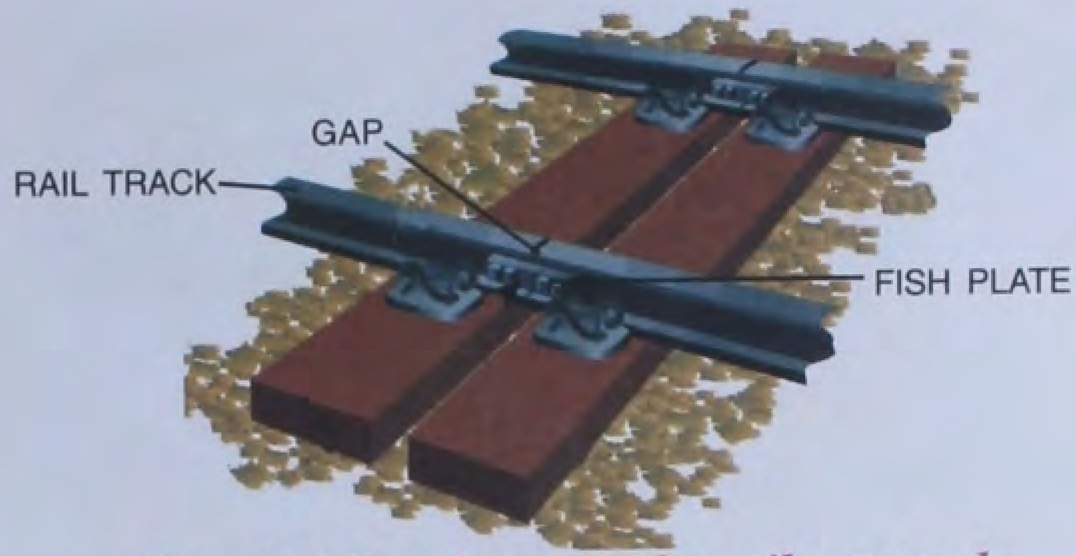
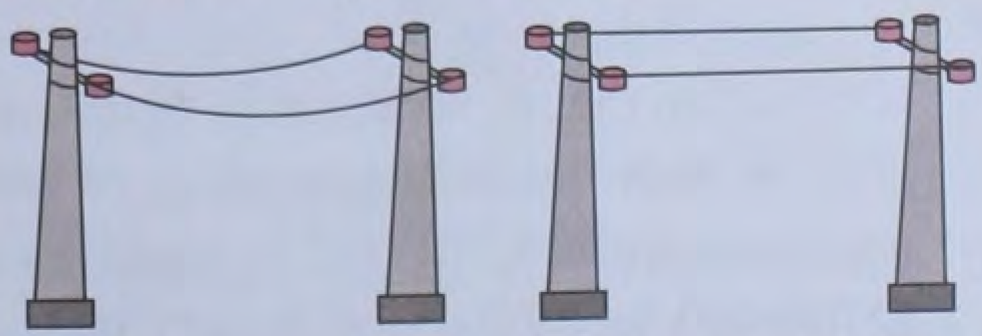


Fig. 4.13 Gap between the railway tracks

3. A rivet is a small steel cylinder used for fastening two metal plates. The two metal plates to be joined together are placed one over the other and a hole is made into them. The rivet is slightly smaller and thinner than the hole. The rivet is heated to red hot so that it expands and then put into the hole. The two ends of the rivet are then beaten to round them off. When the rivet cools, it contracts and fits firmly on the two metal plates and joins them securely. Rivets are used in collapsable gates, locks, bridges made of steel etc.

4. Telephone and electric wires are always left loose (sagging) between the two poles so as to cope with the contraction of the metallic wires in winters, otherwise they would become tight and break (see Fig. 4.14).



(a) Electric wires in summer (b) Electric wires in winter

Fig. 4.14 Electric wires are kept loose for the contraction in winter

5. The iron rim of a bullock cart wheel is made slightly smaller than the wooden wheel. The rim is heated as a result of which it expands. This heated rim is

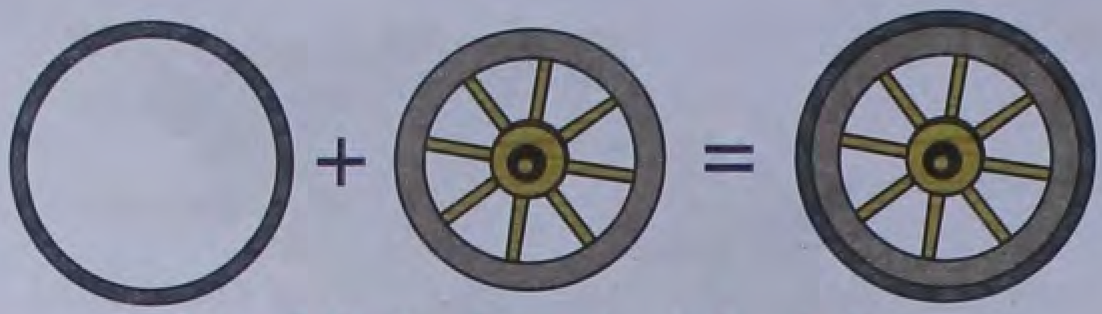


Fig. 4.15 An iron rim is heated to fit it on a wooden wheel

slipped on the wooden wheel and immediately cold water is sprinkled on it. It contracts and thus becomes tight fit over the wooden frame. This is done to increase the life of the wheel.

6. When hot tea or milk is poured into a thick glass tumbler, it often cracks because thick glass is a poor conductor of heat. On pouring hot tea or milk, the inner surface of glass expands more than the outer surface. This unequal expansion leads to cracking of the glass tumbler.
7. Platinum wire are fused in the glass rod but not other wires. The reason is that glass and platinum expand or contract by almost the same amount but other metals expand or contract more than glass. So after heating when they are cooled, other metals will contract more than glass and hence will loosen up from the glass or will expand and break the glass.
8. In appliances where expansion or contraction due to variation in temperature is to be kept minimum, an alloy of nickel and iron called 'invar' is used as it's expansion or contraction is very less.

Linear Expansion

When a solid (rod or wire) is heated, linear expansion takes place, *i.e.*, length increases. This increase depends on three factors.

(i) **Original length of the rod :** If we heat two rods of the same metal but of different lengths by same amount, the longer rod will expand more than the shorter rod.

(ii) **Increase in temperature :** If we heat two rods of the same metal and of same length, we will find that the rod heated to a higher temperature will expand more than the rod heated to a lower temperature.

(iii) **Material of the rod :** If we heat two rods of same length but of different metals, say one of copper and the other of iron, we will find that the copper rod expands more than the iron rod even though both the rods are heated equally.

Thus, equal lengths of different solids expand by different amounts when equally heated.

ACTIVITY 7

Consider a compound bar (a bimetallic strip) as shown in Fig. 4.16. The bars are made of brass and iron of equal lengths and riveted together. Observe what happens when the compound bar is heated. Can you explain the shape of the compound bar on heating ?

Brass expands more than iron on heating. The coefficient of linear expansion of brass is about 1·5 times more than that of iron. Thus, when compound bar is heated, it acquires a curved shape as shown in the figure.

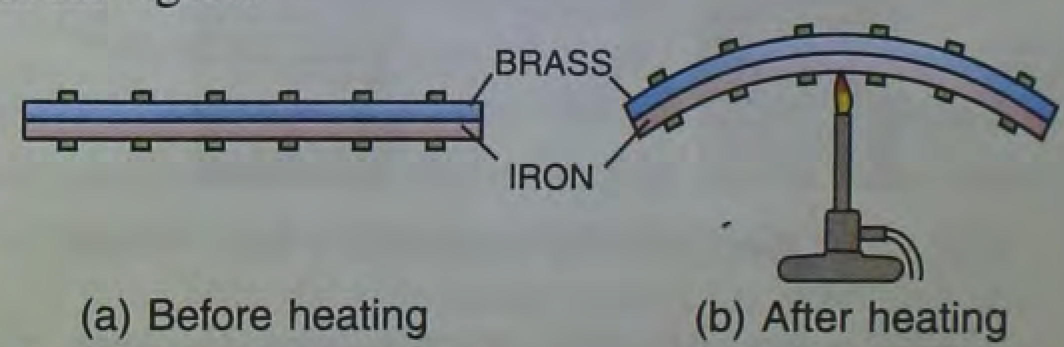


Fig. 4.16 Different solids expand differently in length

Thermal Expansion of Liquids

Generally, liquids expand more on heating than solid Water shows anomalous expansion when heated from 0°C to 4°C. Above 4°C, it expands unlike any other liquid. This unusual behaviour of water is known as **Anomalous Expansion of Water**. To demonstrate the expansion of liquids, we can perform the following experiment.

ACTIVITY 8

Take some coloured water filled in a flask as shown in Fig. 4.18. Pass a narrow tube into it through a stopper which is tightly fixed into the flask so that a little amount of water will rise into the narrow tube. Note the level of the water in the narrow tube. Now heat up the flask. You will see that the water level starts rising in the narrow tube. If you cool the liquid, the level will start coming down. This happens because on heating, the liquid expands and on cooling, it contracts.

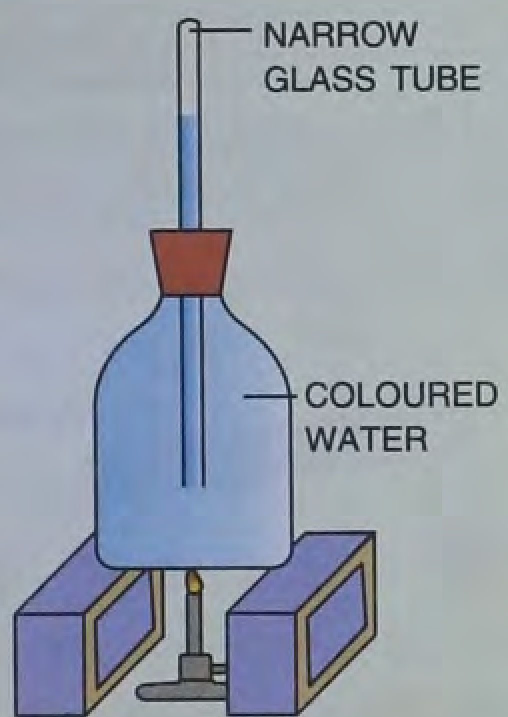


Fig. 4.17 Liquids expand on heating and contract on cooling

Equal Volumes of Different Liquids Expand by Different Amounts When Heated Equally

The volume or cubical expansion of a liquid depends mainly on the nature of the liquid *i.e.* different liquids have different coefficients of cubical expansions. Let us conduct the following activity to know this fact.

ACTIVITY 9

Take four identical vessels (say spherical flasks of same size), A, B, C and D. In each flask, fix a capillary glass tube through a rubber stopper. Fill equal volumes of water, kerosene, alcohol and ether, respectively in the 4 vessels at the same temperature. Now dip them in a hot water bath to ensure uniform heating. All the four liquids will get heated as a result of which they will expand and rise in the capillary tubes. The liquid that shows greater rise in the tube has greater coefficient of volume expansion. In Fig. 4.18, it is seen that expansion in ether is the maximum while in water, it is the minimum. This proves that the coefficient of cubical expansion of ether is more than that of alcohol, kerosene and water. Hence, we conclude that different liquids expand by different amounts when heated equally.

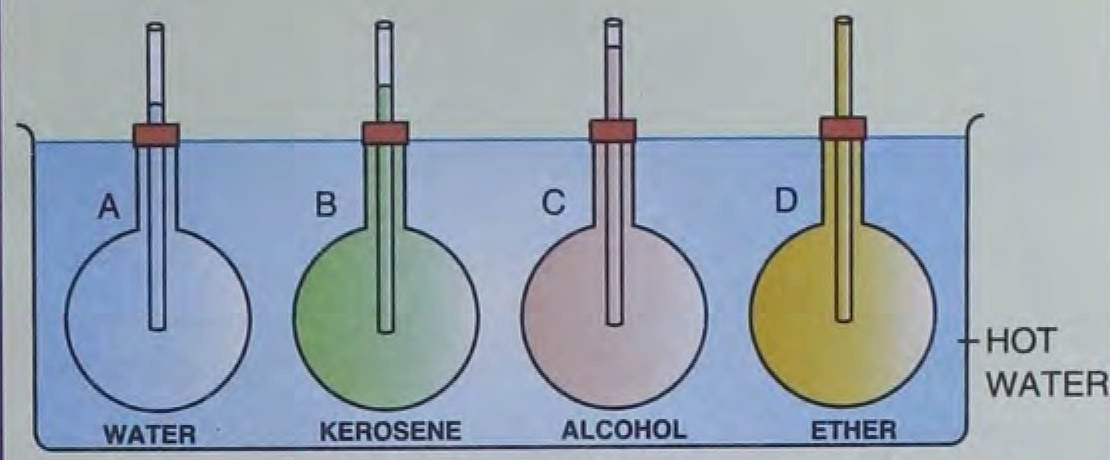


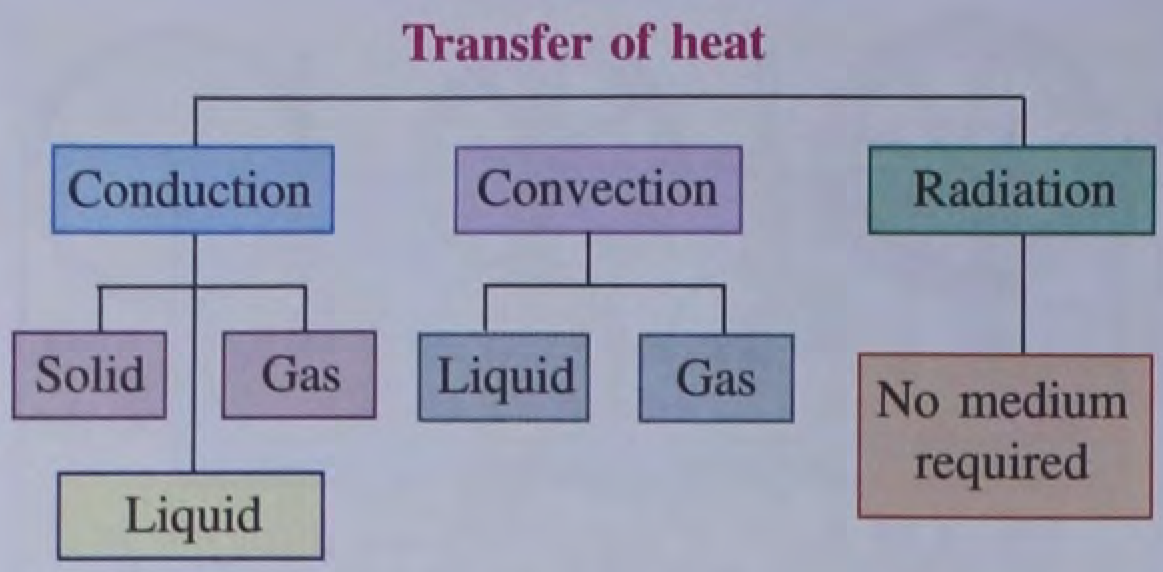
Fig. 4.18 Rates of expansion are different in different liquids

Intext Questions

1. What is the normal temperature of the human body ?
2. What happens in the process of sublimation ?
3. Why are telephone wires kept loose ?
4. Give an example of expansion.

TRANSFER OF HEAT

Whenever there is a difference in temperature between two bodies or between a body and its surroundings, heat energy flows from the body of higher temperature to the body of lower temperature. The flow of heat energy from hot body to cold body can take place in three different ways : (i) conduction (ii) convection and (iii) radiation.



ACTIVITY 10

Take a metal rod and dip it into a beaker containing water which is heated on a hot plate. In this process, we see that there are three ways in which heat is travelling. Firstly, the hot plate gives off the heat into the surrounding air by radiation. Secondly, the water in the beaker moves around by convection with the warm water rising up and cold water sinking down. Lastly, the heat moves along the rod by conduction, from the heated end to the cooler end. Thus, this activity shows three modes of transfer of heat.

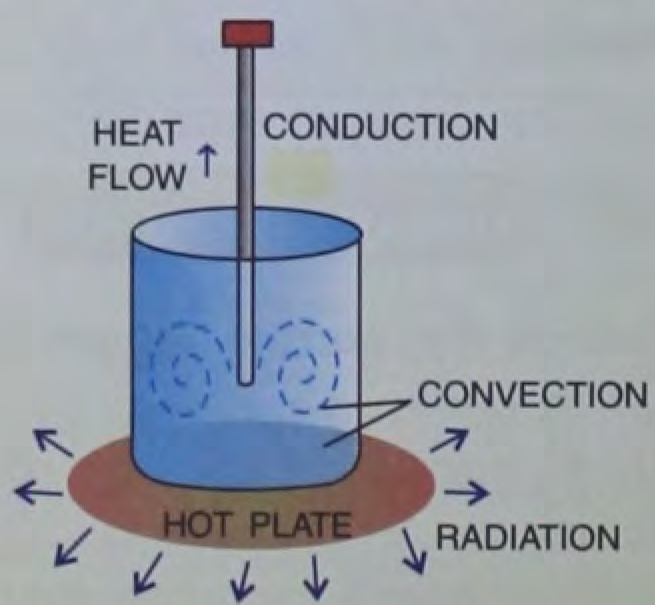


Fig. 4.19 An experiment to show how heat travels in different mediums

(i) Conduction

If one end of an iron rod is placed on fire, the other end will soon become warm. During this process, the particles of the rod in contact with fire gain heat energy. This heat energy is transmitted to the subsequent sections of the rod. This successive transmission of heat from particle to particle (hot end to cold end) is the basis of the conduction process.

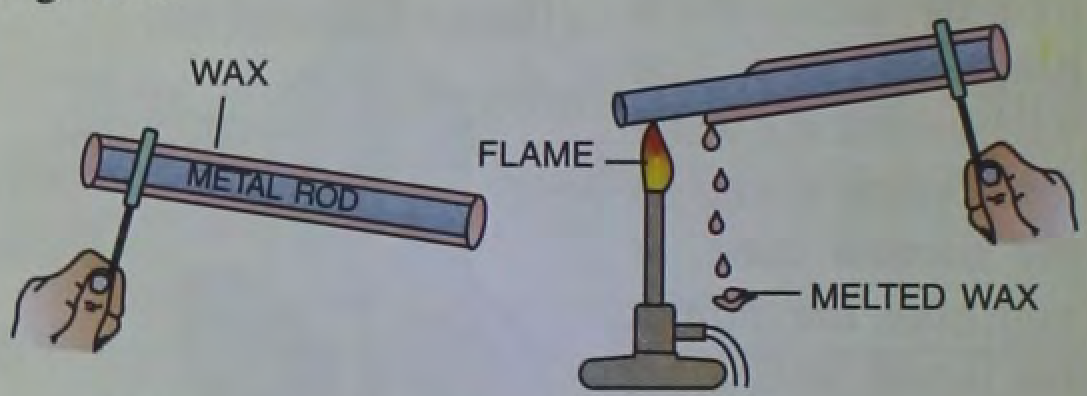
Conduction of heat is thus defined as the flow of heat energy through matter from hot end to cold end without any movement of the molecules of matter as a whole.

Conduction takes place mainly through solid objects but it can take place through liquids and gasses also.

Let us perform the following activities :

ACTIVITY 11

Take a metal rod and coat it uniformly with wax. Using a flame, heat one end of the wax coated rod. See Fig. 4.20.



(a) Wax coated on a metal rod *(b) On heating the rod wax melts*

Fig. 4.20

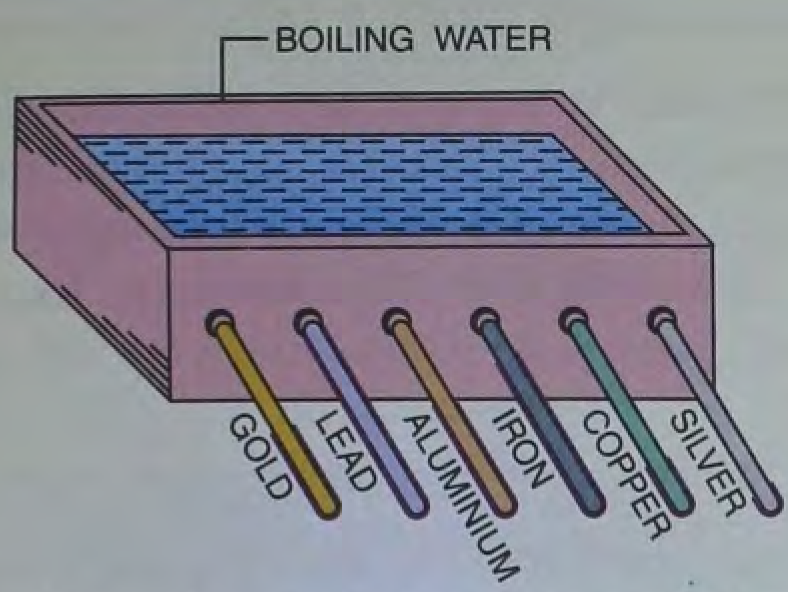
It will be observed that on heating the rod the wax coating will start melting and will melt upto greater length if the rod is heated for a longer time.

ACTIVITY 12

To show that different metals conduct heat at different rates.

Figure 4.21. shows rods of different metals but exactly of same size and shape. One end of each road is fitted into the holes on the side of a trough (Ingen-Hauz's experiment).

The other end of each metal rod projecting outside the trough is coated completely and uniformly with wax. Fix a small match stick at the tip of each metal rod projected outside the trough, with the help of wax. Now fill the trough with



boiling hot water which heats the end of each rod in the trough to the same temperature. The heat starts flowing from the hot end to the cold end, where the match sticks have been fixed with the help of wax. As the temperature of the far ends reach the melting point of wax, the match sticks start dropping off. The match sticks on silver rod drops first showing that silver is the best conductor of heat followed by copper, gold, aluminium, iron and lead.

Conductors and Insulators

Substances through which heat is easily conducted are called *good conductors* of heat. Metals are good conductors of heat *e.g.* silver, gold, copper, iron, aluminium, brass, steel, etc. are good conductors of heat

Substances through which heat is not easily conducted are bad or poor conductors of heat. Substances such as glass, wood, distilled water, wax, plastic, air, *etc.*, are poor conductors of heat. Ebonite and asbestos are the worst conductors of heat and are called *insulators*.

Since metals contain a large number of free electrons, which act as carriers of heat energy, the thermal conductivity of metals is very high.

Mercury is a liquid good conductor. Mica is a good conductor of heat but bad conductor of electricity. Gases are comparatively poorer heat-conductors. Since atoms are far apart in the case of gases, they conduct heat poorer than liquids and solids.

ACTIVITY 13

Take some water in a long test tube. Wrap some ice-cubes in a wire gauze and gently drop them into the test tube. Due to the wire gauze wrapped on it, the ice-cubes become heavy and sink to the bottom. Now heat the test tube gently near its mouth. It is seen that as the water at the top boils (Fig. 4.22), the ice-cubes at the bottom remain unaffected. This clearly shows that water is a poor conductor of heat.

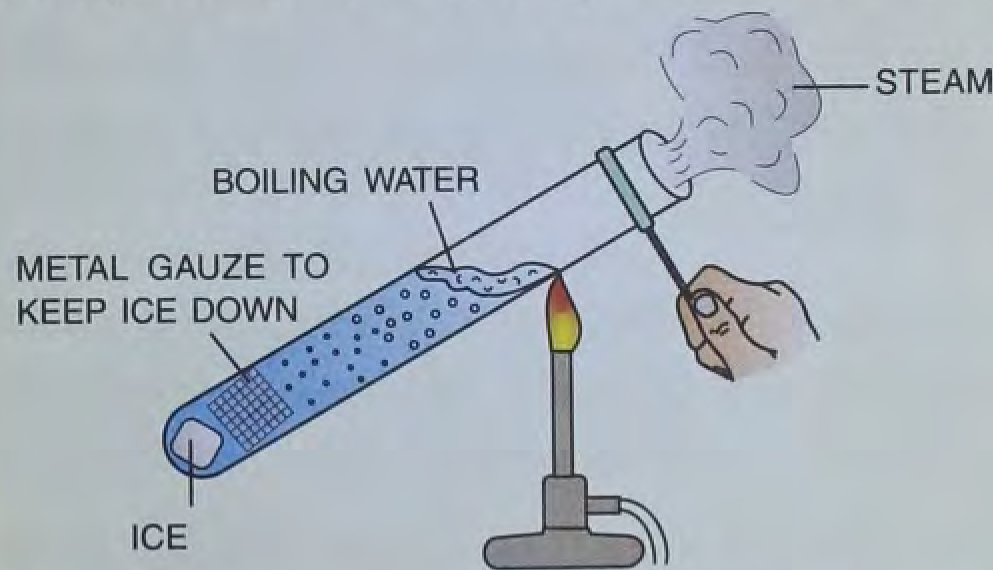


Fig. 4.22 An experiment to show that water is a poor conductor of heat

Repeat the same experiment with different liquids. You will see that the result in each case is almost the same because all liquids (other then mercury) are poor conductors of heat.

Applications of Conduction

1. Cooking utensils are made up of metals. Since metals are good conductors of heat, the handles of cooking utensils are made up of ebonite or wood. As they are poor conductors of heat, thus they do not conduct heat from the utensil to the hand. Hence, we are able to hold the utensil.
2. We wear woollen clothes in winter

because they have fine pores, which trap large amount of air in them. Since air is a poor conductor of heat, the trapped air does not allow heat to flow from our body to the surroundings.

3. Blankets keep us warm in winter. In summers, ice is wrapped in blankets to prevent it from melting. This is due to the fact that blankets have fluffy cotton or wool which trap large amount of air. Air being a poor conductor of heat does not allow heat to escape from our body in winters and in summers it does not allow the outside heat to reach the ice wrapped with blanket.
4. Quilts are used in winters to make us feel warm. Since they are made of fluffy cotton which contains large amount of air, this air does not allow heat to escape from our body to the surroundings, so we do not feel cold. This is because, air is a bad conductor of heat.
5. Coils of refrigerators and air conditioners are made of copper to conduct away heat, as copper is a good conductor of heat.
6. Mercury (a liquid metal) being a good conductor of heat is used as a thermometric liquid.
7. Hair and fur in animals are bad conductors of heat, so they keep them warm during winter by trapping air within.
8. Eskimos make igloos out of double walled snow, because double walls trap a large amount of air, which acts as an insulator and keeps the igloos warm.

ACTIVITY 14

Heat water in a small pan or beaker. Collect some articles such as a steel spoon, plastic scale, pencil, etc. and dip one end of each of these articles in hot water. Wait for a few minutes. Touch the other end. Enter your observation in the table given below:

Article	*Material with which the article is made of*	*Does the other end get hot*
Steel spoon	Metal	Yes
Plastic scale		
Pencil		

The mateirals which allow heat to pass through them easily are good conductors of heat. *For example*, aluminium, iron and copper. The materials which do not allow heat to pass through them easily are poor conductors of heat such as plastic and wood.

This shows conduction of heat by different materials.

CONVECTION

When liquids or gases are heated, certain regions become warmer than others. The warmer portion, due to expansion, become less dense than the colder portion. This makes the warmer portion rise up and the colder portion to descend down. This sets up a convection current.

Convection is thus defined as the flow of heat energy through liquids or gases from region of higher temperature to region of lower temperature by the actual movement of the liquid or the gas itself.

Convection is an effective way of bringing a hot (or a cold) fluid to a different area. Heat transfer is faster in convection than conduction.

ACTIVITY 15

Take a beaker and fill it with water up to half. Put some crystals of potassium permanganate in it. Now heat the flask and then observe the movement of the coloured solution.

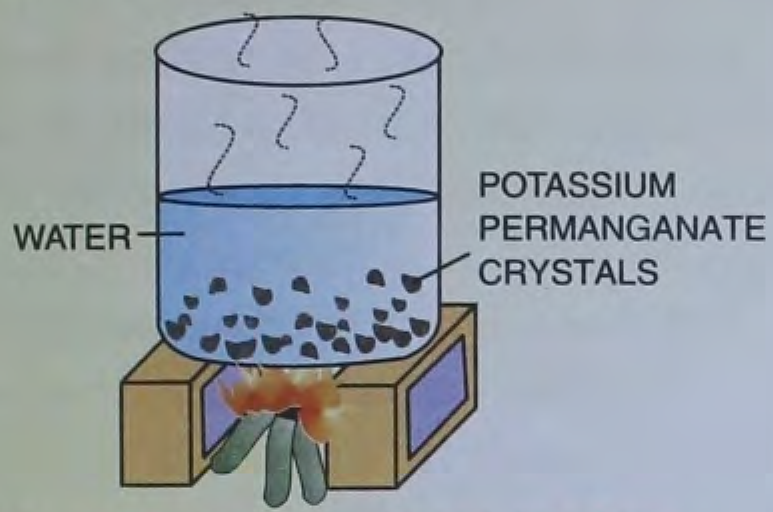


Fig. 4.22 An experiment to show convection in liquids

We observe that as soon as the flask is heated, streaks of colour start moving up and then down. This is because the water at the bottom of the flask gets heated first. Due to heat, water expands and consequently, warm water rises up and cold water comes down. This happens because the density of warm water becomes less than that of cold water. This is how heat is transferred by the actual movement of molecules of water.

ACTIVITY 16

Demonstration of convection current in gases

See the set-up in Fig. 4.23. The air in the box gets heated and rises through chimney *A*. Thus, a vacuum is

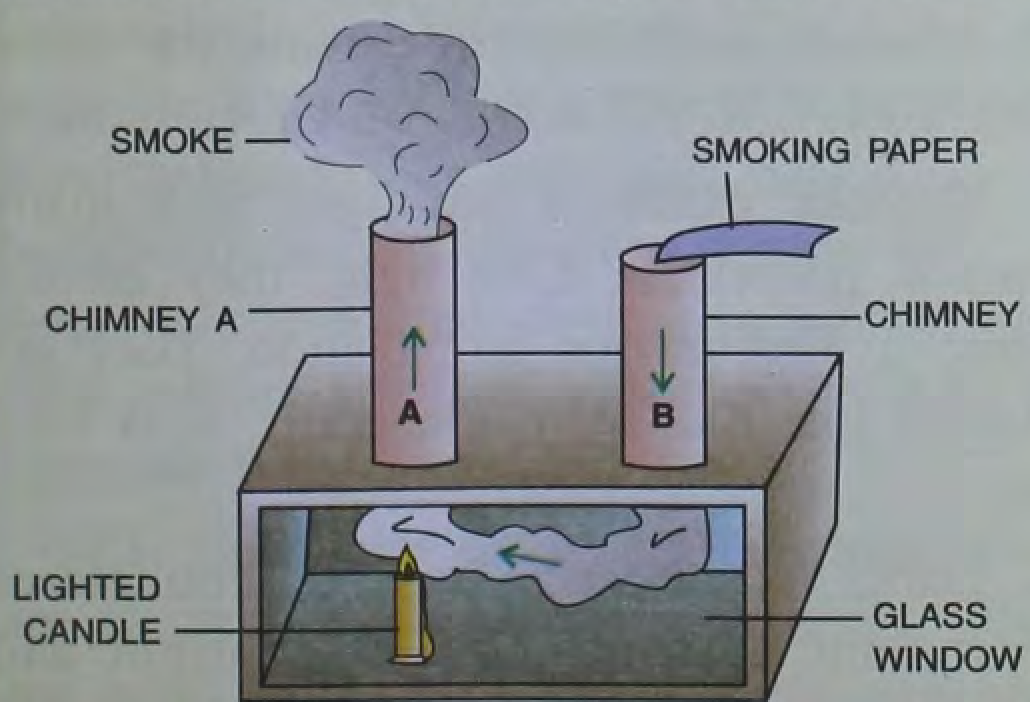


Fig. 4.23 An experiment to show convection in gases

created in the box. Now bring a smoking paper or a lighted splint near the upper end of the chimney *B*. The smoke from the smoking paper descends through chimney *B*, gets heated over the candle and rises through chimney *A*. This is how heat is transferred through the actual movement of the medium particles, in convection.

Applications of Convection

1. Formation of land and sea breezes : During the day, land gets heated faster than water. Hence, the air above the sand being warmer, rises up. The cold air above the sea being heavier takes its place. Thus, convectional currents are set up giving rise to sea breezes. To receive the cooler sea breeze, the windows of the houses in coastal area are made facing the sea.

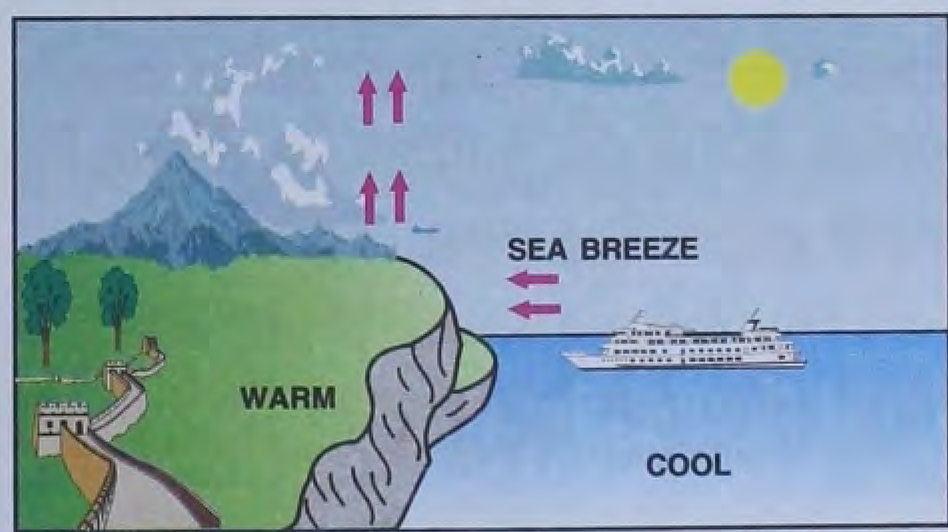


Fig. 4.24 Sea breeze during day time

At night, the sand cools faster than water. The air above the sea being warmer rises up. The cool air above the land blows towards the sea. Thus, convectional currents are set up giving rise to land breezes.

Fig. 4.25 Land breeze at night

2. Heat insulation in houses : Weather strippings are used to close small openings in windows to prevent heat loss due to convection. Also, pulling down curtains over closed window reduces heat loss, by forming a layer of still air in front of the window.

3. Ventilation : Ventilators are provided near ceilings in the rooms of our houses. This is because the air we breathe out is warm and rises up and leaves the room through the ventilators. Cool fresh air rushes into the room through doors and windows.

4. Refrigeration : The freezing chest of a refrigerator is always fitted near the top in a refrigerator because it cools the remaining space of the refrigerator by convection current. The air near the freezing chest cools and descends while the warmer air at the bottom rises up.

5. Smoke and gases being hot rise and escape through chimneys in industrial furnaces.

6. Room heaters and blowers heat the room by setting up convection current. They are kept on or near the floor, as hot air rises up and cool air moves down.

7. Firemen usually crawl while entering a building where fire has broken out because the hot air and smoke rise upwards.

8. Monsoon is also a convection currect set up due to difference in temperature between the sea and the land. Hot air in summer rises from the land and moisture containing cool air flows from the sea, thereby bringing rainfall on the land.

9. Birds often use convection current of air to rise high and glide effortlessly without flapping their wings.

Do You Know ?

Solar cookers utilize radiant heat energy of the sun to cook food. The inner surface is painted black so that it absorbs the solar energy better.

The heat which comes out of the hot object is called radiant heat. The extent of absorption and reflection of radiant heat depends upon

(a) the nature of surface it has.

(b) and the colour of the object.

RADIATION

"Radiation is the process of transfer of heat from a hot body to a cold body at the speed of light without affecting the intermediate medium."

Thus, heat radiation or thermal radiation can travel through vacuum. The best example of transfer of heat by radiation is the transfer of heat from the sun to the earth which travels about 15×10^7 km of space, most of which is empty, before reaching the earth.

Thermal radiations travel with the speed of light *i.e.* 3×10^8 m/s in air or vacuum.

Thermal radiation and light have many common properties. Like light, they do not require a medium for propagation. They get reflected just like light. Generally, it is seen that,

1. Dark, dull surfaces are good emitters of radiant heat energy, while bright and shiny ones are poor emitters.
2. Dark, dull surfaces are good absorbers

and poor reflectors of heat energy while bright shiny surfaces are poor absorbers and good reflectors of heat energy.

ACTIVITY 17

Take two tins, one polished bright and the other coated with black soot. Fill both the tins with equal amounts of water having same temperature. Cover them with identical lids. Place both of them in the sun. After about two hours, place two thermometers into the water in two tins. What do you observe ?

You will observe that the temperature of the water in the tin coated with black soot rises more than in the brightly polished tin.

This experiment clearly shows that the brightly polished tin has absorbed less and reflected more heat while the black soot tin has absorbed more and reflected less heat.

Applications of Radiation

1. Cooking utensils are painted black at the bottom from the outside because black surfaces are good absorbers of heat and hence cooking is fast. But, to keep the contents warm for a longer time, they are put in utensils that are polished from the inside since polished surfaces are poor emitters of heat.

2. We usually wear white or light coloured clothes in summer. This is because white or light colours are poor absorber and good reflectors of heat and thus keep our body cool during summer. Conversely, we wear dark coloured clothes in winter, since dark colours are good absorbers of heat and keep our body warm.

3. Hot water pipes and radiators of cars are painted black, since dark colours (black) are good emitters of radiant heat and hence keep the temperature within limits by radiating heat quickly.

4. Electrical room heaters have highly polished reflectors at the back side of heating element so that almost the entire heat is reflected in the desired direction of the room.

ACTIVITY 18

To prove that black bodies absorb and emit heat better than white bodies.

- Take two identical cold drink cans filled with equal amount of water.
- Paint one can black and the other white, from outside.
- Place a thermometer in each can with the bulb of the thermometer properly dipped in water.
- Now place both the cans at an equal distance from the room heater.
- Switch the heater on and let it remain on for 15 minutes.

You will observe that the temperature reading in the thermometer placed in the black can is higher than the thermometer placed in the white can. This is so because black surface is a better absorber of heat radiations than white surface.

- After switching off the heater, both the cans start emitting heat radiation to the surroundings.
- Leave them undisturbed for 10 minutes.
- Now check the readings in the thermometers. You will observe that the reading in the thermometer placed in the black can falls more rapidly than the thermometer placed in the white can. This is so because black surface is a better emitter of heat radiations than white surface.

Black bodies abosrb and emit (or radiate) more than white bodies.

A surface, which is a good absorber, is also a good radiator.

THERMOS FLASK : (DEWAR FLASK)

A special kind of a bottle used to keep hot liquids hot and cold liquids cold for a long time is called *thermos flask* or *vacuum bottle* or *Dewar flask*. It minimises the transfer of heat. Following are the features of a thermos flask :

1. Double-walled glass vessel and vacuum between the two walls prevents transfer of heat by conduction.
2. Heat transfer by convection is minimised by insulating stopper.

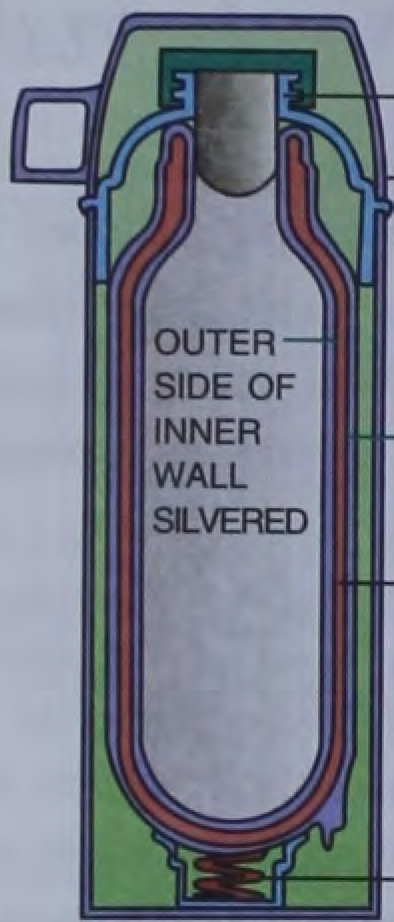


Fig. 4.26 Thermos flask

3. Heat transfer by radiation is prevented by the silvered surface of the walls. It reflects back the radiant energy that tends to escape from the bottle. The silvering of the outer surface of the inner wall makes it a poor emitter of heat while the silvering of the inner surface of the outer wall makes it a good reflector of heat which it receives from inside the flask.

   The thin glass walls at the neck may afford some heat transfer by conduction. But, this is negligible.

Example 1 : Explain why it is cool in the shade below a tree but hot a little away from it ?

Answer :

Heat radiations travel along the straight line path and heat from the sun is thus unable to reach the shade below the tree, as leaves are opaque.

Moreover air is trapped between the leaves. Air is a bad conductor of heat and hence no transfer of heat takes place from above to a region below the tree.

Example 2 : A red hot ball is suspended from the roof of a room by a thin metallic wire. Name the ways in which the ball loses heat.

Answer :

1. By conduction through the metallic wire.
2. By convection through layers of air in contact with the ball.
3. By radiation to the surroundings.

Intext Questions

1. Define conduction.
2. Why are metals called good conductors of heat ?
3. Why solids conduct heat better than liquids or gases ?
4. Why the freezing chest of a refrigerator is always fitted near the top in a refrigerator.
5. Define radiation.
6. Give an example of transfer of heat by radiation.

Differences between conduction, convection and radiation

CONDUCTION	CONVECTION	RADIATION
1. Medium is necessary for transfer of heat by conduction.	Medium is necessary for transfer of heat by Convection.	No medium is required for transfer of heat by radiation.
2. Conduction is not possible in vacuum.	Convection is not possible in vacuum.	Radiation is possible in vacuum.
3. The molecules of the medium do not leave their mean position. They transfer the heat by vibrating about their mean position.	The molecules of the medium leave their mean position and carry the heat in upward direction.	The medium does not have any role in the transfer of heat by radiation.
4. The transfer of heat can be in any direction.	The transfer of heat is in vertically upward direction.	Transfer of heat is in all directions along a straight path in the form of electromagnetic waves.
5. The process is slow.	The process is faster than conduction.	The process is fastest and the transfer of heat takes place with the speed of light, *i.e.,* 3×10^8 m/s.

TEST YOURSELF

A. Fill in the blanks :

1. Land and sea breezes occur due to transfer of heat by ....
2. Thermal radiations travel in air or vacuum with the same speed as ....

Ans. (1) Convection (2) Light.

B. Match the following :

	Column A		*Column B*
1.	Lower fixed point	(a)	Non-inflammable
2.	Sublimation	(b)	Insulation
3.	Sand	(c)	Camphor
4.	Ebonite	(d)	Metal plates
5.	Rivet	(e)	0°C

C. Choose the correct answer.

1. Which is the fastest method of heat transfer ?
   (a) Convection (b) Conduction
   (c) Radiation (d) All of these
2. Air during daytime goes
   (a) from sea to the land ?
   (b) from land to the sea ?
   (c) none of these ?

D. Short answer questions

1. Explain the following :
   (a) A tightly filled jam bottle cap can be uncapped by pouring warm water on its cap.
   (b) A thick glass tumbler is found to crack when hot tea is poured into it.
   (c) While laying of rail tracks, small gaps are left between the rails.
2. Why is a ventilator provided in a room ?
3. Define transfer of heat by convection.
4. Explain why blankets keep us warm in winter and prevent ice from melting in summer.
5. Explain why radiators of cars are painted black.
6. How are heat losses in a Dewar flask minimised.

E. Long answer questions

1. Draw a labelled diagram of a Dewar flask. State its main features.
2. Describe an experiment to show that water is a poor conductor of heat.
3. Describe an experiment to show that black or dark coloured surfaces are better absorbers of heat than bright coloured surfaces.
4. Two pins are connected to two identical rods of aluminium and iron by wax. On heating the metal rods, what do you observe ? Try to perform this experiment in your laboratory.
5. Describe an experiment to illustrate thermal expansion in solids.
6. Describe an experiment to illustrate thermal expansion in gases.
7. Using a compound metal bar, verify that equal lengths of different solids expand by different amounts on heating.
8. What are the different ways of flow of heat ?
9. Give four examples of good conductors of heat.
10. Why do we wear light coloured cotton clothes in summer ?
11. A wooden spoon is dipped in a cup of ice-cream. Its other end
    (a) becomes cold by the process of conduction
    (b) becomes cold by the process of convection
    (c) becomes cold by the process of radiation
    (d) does not become cold.

RECAPITULATION

- Heat is a form of energy that leads to the sensation of hotness or coldness.
- Temperature is the degree of hotness or coldness of a body.
- To measure temperature, we use a thermometer.
- The S.I. unit of temperature is Kelvin (K).
- The most common liquid for a thermometer is mercury.
- The temperature at which pure water freezes at normal atmospheric pressure is called freezing point of water (or melting point of ice). It is also known as the lower fixed point for a thermometer.
- The temperature at which pure water boils at normal atmospheric pressure is called the boiling point of water (or condensation point of steam). It is also known as the upper fixed point for a thermometer.
- The normal temperature of the human body is 37°C.
- The heat flows from a body at a higher temperature to a body at a lower temperature. There are three ways in which heat can flow from one object to another. These are conduction, convection and radiation.

Activities and Projects

1. Go to a doctor or your nearest health care centre. Observe the doctor taking temperature of patients. Enquire
   (a) Why the doctor dips the thermometer in a liquid before use ?
   (b) Why the thermometer is kept under the tongue ?
   (c) Whether the body temperature can be measured by keeping the thermometer at some other place than the mouth ?
   (d) Whether the temperature of different parts of the body is the same or different.
2. Go to a veterinary doctor. Discuss and find out the normal temperature of domestic animals and birds.