We have learnt in class VI that kinetic energy is the energy of any matter in motion. The small particles that make up matter are constantly moving. They have kinetic energy. The kinetic energy of particles in matter is called **thermal energy**. When thermel energy is transferred, it is known as heat. The word thermal means 'heat'.

Heat is the thermal energy that flows from an object. Heat flows from an object at higher temperature to an object at lower temperature. In this chapter, we shall learn about different modes of heat transfer.

8.1: Transfer of Heat

Imagine your teacher has brought packets of dates to distribute in your class. The teacher has three options.

Option 1: The teacher can give a packet of dates to first student and ask him/her to pass it to the next student and then next student passes it further. In this way, each one of you will receive a packet without moving from your place.

Option 2: The teacher can ask students to line up and come to his table one by one. After receiving the packet every student moves back to his/her seat.

Option 3: The teacher can just throw a packet towards each one of you without any movement on your part. Much the same way heat energy transfers from a hot body to a cold body.

The transfer of heat energy from one object to the other is called **transmission of heat**. Heat energy transfers in three ways, i.e. conduction, convection and radiation.

8.2: Conduction

If one end of a metal spoon is heated with a flame, the other end will also get heated up after a while (Fig.8.1). The heat energy is transferred from one end of the spoon to the other without the actual movement of particles (atoms or molecules) of the spoon. Such a mode of transmission of heat is called **conduction**. It resembles the example given above in option 1.

Fig. 8.1: Heat from the candle flame also warms the part of the spoon in the hand due to conduction.

The transfer of heat through matter without the actual movement of particles from their position is called conduction. Conduction occurs in solids, liquids and gases, but solids usually conduct heat better than liquids or gases.

In solids, the particles are held very close to each other. They vibrate constantly. When we heat one part of a solid, the particles gain heat energy and start vibrating faster. During their vibration they bump into nearby particles and also cause them to vibrate fast. In this way, the particles of hot part of a solid transfer heat to those in the colder parts.

Extend Your Thinking
Why does conduction not occur at all in a perfect vacuum?

Activity 8.1 Observing Conduction

You will need:

- metal rod or knitting needle
- cork
- candle

Procedure

1. Push one end of the metal rod or knitting needle into the cork. Use the cork as a handle.
2. Light the candle. Burning candle will melt and change into liquid wax. Drop this melting wax on to the rod at three different points. Let the wax cool.
3. Heat the free end of the rod on the candle. Note the time when the wax at three different points melts.

On which point will the wax melt first?

8.3: Good and Bad Conductors

Different materials conduct heat at different rates. Materials which allow heat to flow through them easily are called **good conductors** of heat. Solids such as metals are **good conductors** of heat. Materials which do not allow heat to flow through them easily are called **bad conductors** of heat or **heat insulators**. Solids such as wood, glass, plastic, styrofoam, etc. are bad conductors of heat. All liquids (except mercury which is a liquid metal) and gases are also bad conductors of heat.

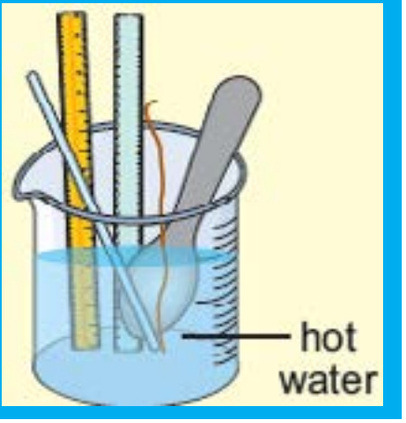
Table 8.1: Heat Conductors and Insulators

Good Conductors	Insulators
silver	air or any gas
copper	cork
aluminium	glass
iron	plastic
mercury	wood

Fig. 8.2: The metal part of the frying pan allows heat to pass through but its plastic handle does not.

Activity 8.2 **Some materials are conductors of heat and some are insulators**

Take some hot water in a beaker. Take a steel spoon, a glass rod, a plastic scale, a wooden scale and a piece of thick copper wire. Dip one end of each of these in the hot water. Wait for 2-3 minutes. Then touch the other end of each article with your fingers. Which ones become hot (conductors of heat) and which ones do not (insulators).



Why metals are better conductors than non-metals?

All solids (metals and non-metals) are made of tiny particles called molecules. But, some solids conduct heat better than others. Let us put a metal and a plastic spoon in hot water. Which one is a good conductor of heat, metal or plastic? When both spoons receive heat energy, the particles (atoms or molecules) at the hot end of each spoon vibrate fast and bump into neighbouring particles. These particles transfer heat energy to next neighboring particles (Fig.8.3,8.4).

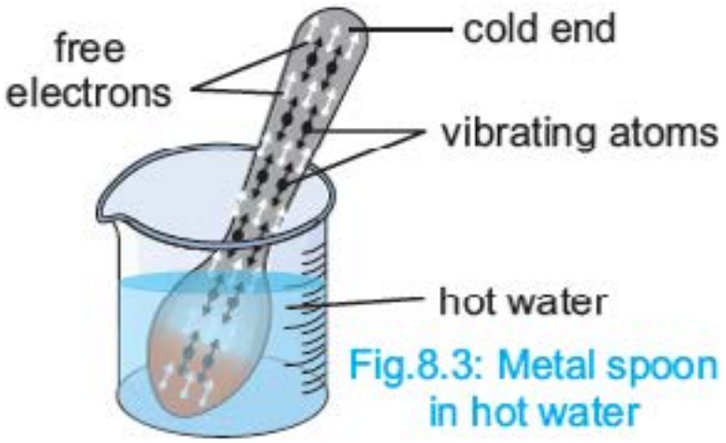


Fig.8.3: Metal spoon in hot water

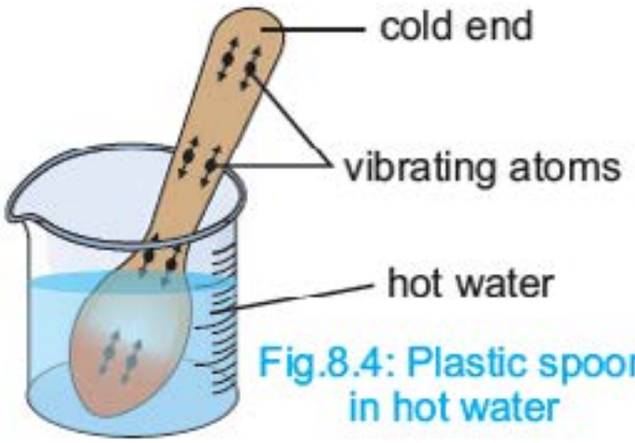


Fig.8.4: Plastic spoon in hot water

Particles in metals are packed more closely together than non-metals. Metals can transmit heat energy more readily than non-metals (wood, plastic, etc.). The presence of free electrons also speeds up the transfer of heat in metals. When the metal spoon gets heated, the free electrons gain kinetic energy and move farther towards the colder parts of the metal spoon. They bump into the atoms in the colder parts and transfer heat energy to them. In metals, heat energy is transferred from one place to another both by the vibrations of particles as well as by the movement of free electrons. That is why metals are good conductors of heat than non-metals(insulators).

Extend Your Thinking
Many fast food restaurants pack their hot sandwiches/pizzas in styrofoam boxes instead of wrapping them in ordinary paper. Why is the styrofoam used?

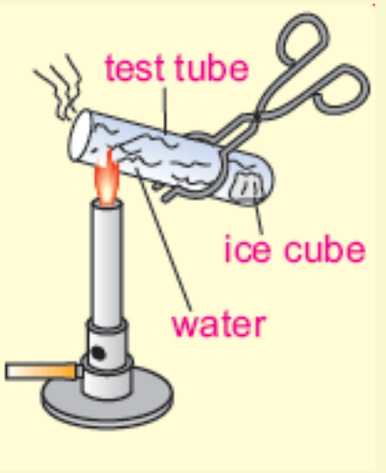
Conduction in Liquids and Gases

The process of conduction in liquids and gases is very slow as compared to solids (metals). The particles in liquids and gases are not held closely together. The particles have less chances to bump into other particles in liquids and even lesser in gases. That is why, the transfer of heat energy from fast-moving particles to neighbouring particles is slow. Water and air are bad conductors of heat.

Activity 8.3 **Water is a bad conductor of heat.**

Water and most other liquids except mercury are bad conductors. To show this:

1. Wrap an ice cube in wire gauze and drop it in a test tube almost filled with water. It will settle down.
2. Hold the test tube and heat it near the neck with a Bunsen flame/ spirit lamp.



Observe

Soon the water in the upper part of the test tube will start to boil, but the ice at the bottom melts very slowly. It shows that water is a bad conductor of heat.

8.4: Everyday Applications of Conduction of Heat

Conduction plays an important role in our lives.

1. Cooking utensils, electric kettle, iron, soldering iron, etc. are made of metals to conduct heat quickly. Their handles are made of plastic or wood which are bad conductors.
2. Birds have feathers which keep their bodies warm because feathers are bad conductors of heat (Fig.8.5).
3. Woolen clothes and blankets slow down the transfer of heat. It so happens because the wool traps air in it. The air is a bad conductor of heat.
4. Ice is covered with jute rugs to reduce its melting speed. Jute is a bad conductor of heat.
5. An insulating material (e.g. styrofoam) is filled between the double walls of a refrigerator. It reduces the transfer of heat across the walls of the refrigerator.
6. Double-pan windows are used in buildings to slow the transfer of heat. Air between the two layers of glass acts as an insulator.
7. Thermos bottles use air or a vacuum to slow the transfer of heat by

Fig. 8.5: Birds have feathers which are bad conductor of heat.

Fig. 8.6: Polyester is a poor conductor of heat. It can keep our body warm during winter

Tidbits

- The plastic water cooler and hot pots have double walls. The styrofoam and air between the walls reduce transfer of heat by conduction.

8.5: Convection

Unlike particles of solids, particles in liquids and gases move from one place to another. Take a beaker and put small pieces of paper in it. Fill half of the beaker with water. Heat the beaker by a spirit lamp. We shall see that pieces of paper rise to the top of water, move sideways and sink to the bottom. The water in the beaker also gets warm. The molecules of water absorb heat energy from the bottom of the beaker and rise to the top. Other surrounding molecules of water come to the bottom to absorb heat energy.

The transfer of heat in which molecules of a medium actually move to the source of heat energy to absorb heat and then move away from it, is called **convection**.

Convection occurs in liquids and gases only because their molecules can move freely. The molecules of a solid are held closely together. They cannot move freely, therefore, convection is not possible in solids.

The upward and downward movement of molecules of water or air is called a **convection current**.

Fig.8.7: Motion of the paper pieces in water is due to convection of heat.

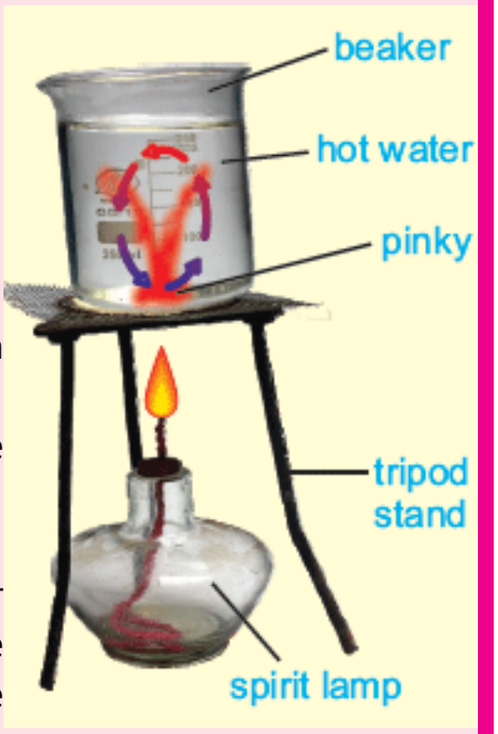
Animation 8.2 : Metals Convection
Source & Credit : carleton

Activity 8.4

Convection in Liquids

You will need

- a beaker
- water
- tripod stand
- spirit lamp
- potassium permanganate crystals (pinky)



Procedure:

1. Fill the beaker two-thirds with water.
2. Place the beaker on a tripod stand.
3. Place a crystal of potassium permanganate (pinky) at the bottom of the beaker gently using a straw.
4. Now, heat the water by placing the spirit lamp just below the crystal. What did you observe?

Explanation

When water is heated, the water near the flame gets hot. Hot water rises up. The cold water from the sides moves down towards the source of heat. This water also gets hot and rises. Water from the sides moves down to take its place. This process continues till the whole water gets heated. This mode of heat transfer is known as convection.

Activity 8.5 — Convection in Gases

You will need

- a box with two holes at the top (convection box)
- paper/cloth
- matchbox
- candle
- plastic sheet

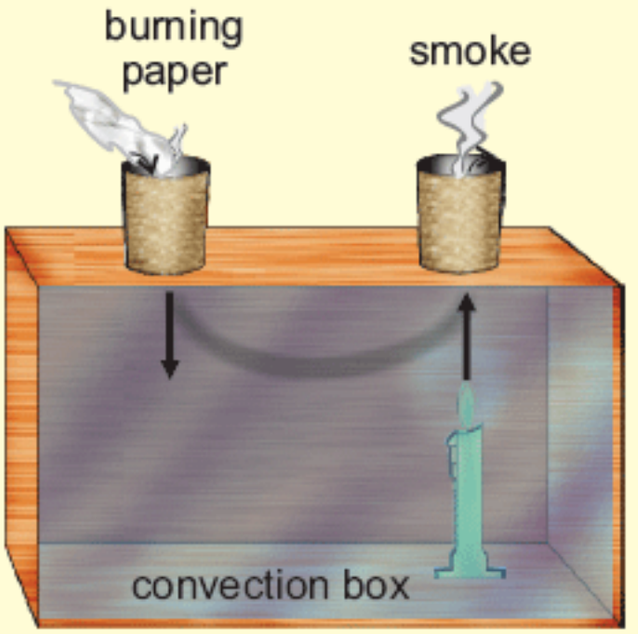
Procedure

1. Light a candle and place it under one of the holes in the convection box.
2. Bring a burning piece of paper/cloth near the hole other than the candle.

Observe the path of the smoke in the convection box.

What happens?

As the warm air weighs less than the surrounding air, it rises out of the hole above. The cooler and heavier surrounding air enters the box through the other hole to take the place of the air which left the box. This movement of air in and out of the holes due to the difference in weights, sets up a convection current.



8.6: Winds and Ocean Currents

We know that convection is the transfer of heat by the actual movement of theparticles in materials. Winds and ocean currents are examples of effects of convection. The heat of the Sun heats up the surface of the Earth and the air near it also gets hot. The air expands and gets lighter. So, it rises up and cool air from the neighbouring regions moves in to fill its space.

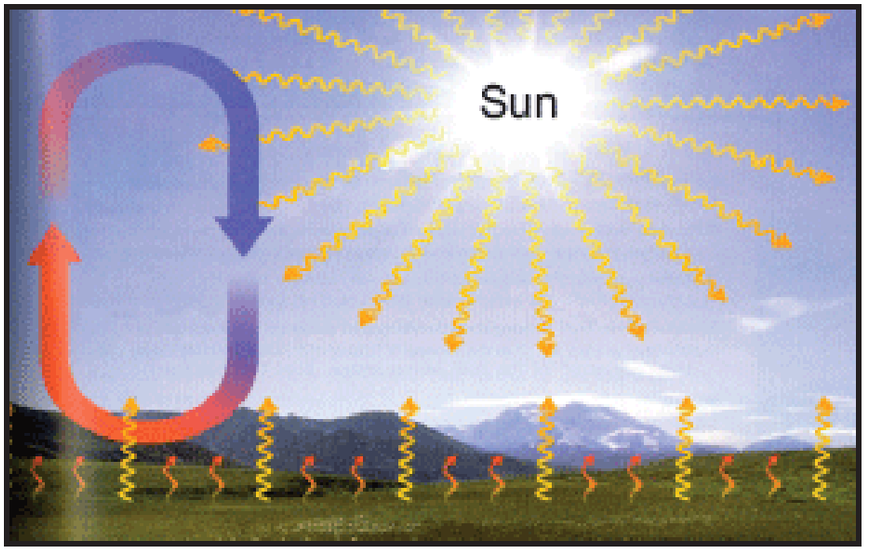


Fig.8.8: Convection causes winds.

The rising warm air reaches upper colder layers of the air and cools down. Cool heavy air sinks to the Earth in cold regions to blow again to take the place of the rising air. Thus, convection currents are setup and the wind-system goes on.

Ocean currents are also set up due to convection of heat. Water of the hot regions of an ocean gets hot, it expands and gets lighter, but water in the colder regions remains cold and heavy. Hot water moves along the surface of the ocean towards the colder regions. The cold water flows below the surface of the ocean towards the hot regions. In this way, ocean currents are set up.

Convection and Gliding Flight of Birds

Convection currents also take place in atmosphere. The heat from the Sun warms the air near the ground. The warm air expands and becomes lighter in weight. As warm air rises, colder air rushes in to fill its place near the ground. This process continues. Birds like eagles, hawks, vultures and gulls take advantage of this phenomenon. They enjoy gliding. During gliding flight a bird does not move its wings, but glides on air currents. A lot of energy of birds is saved during gliding

8.7: Everyday Applications of Convection Currents

We can observe the use of convection currents in our surroundings.

1. **Household ventilation** can make our house cool. The air which we breathe out is warmer and lighter. It moves up in the room to go out of the ventilators near the top side of the walls. Fresh and cool air enters the room through windows and doors.
2. In a **domestic water Heater**, water is heated in the boiler by gas burner or heating coil. The hot water expands and becomes lighter in weight. This water rises and flows into the upper part of the water heater. To take the place of hot water, cold water from storage tank (cistern) falls to the lower part of the water heater to become hot. We take the hot water from the tap attached to the water heater, convection currents help in the continuous supply of hot water.
3. An **air conditioner** also uses convection currents cool a room. Air conditioners are installed near to the ceiling. The fan of an air conditioner blows cool dry air. The cool air is heavier in weight, so it sinks. The warm air of the room rises because it becomes lighter in weight. The air conditioner draws this warm air to make it cool. In this way, the air circulates again and again till desired temperature is reached.

Tidbits

In an oven, the heater is placed at the bottom. The convection current transfersheat to all the parts of the oven.

8.8: Radiation

The transfer of heat energy from a hot body to a cold body directly, without heating the space in between the two bodies is called radiation. When we sit in the sun or in front of a heater, we feel warmth. Heat energy reaches us by radiation. This heat cannot reach us by conduction because air is a bad conductor of heat. Similarly, this heat cannot reach us by convection, as the hot air rises upward, rather than sideways. If we put a cardboard or a plastic sheet between us and the source of heat, we no longer feel warmth. So, we can say that heat from the Sun or a heater reaches us by radiation which requires no medium (Fig.8.10).

Extend Your Thinking
Why is radiation the only type of heat transfer by which the Sun's energy can move to the Earth?

Fig.8.9: Convection currents heat up water in a water heater.

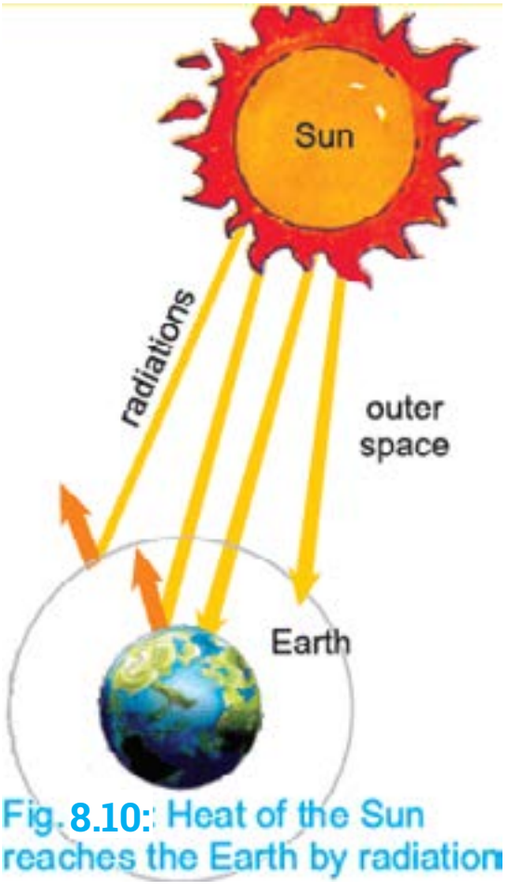


Fig. 8.10: Heat of the Sun reaches the Earth by radiation

8.9: Experiments on Radiation and Absorption

Objects absorb and radiate heat at the same time. Whether all objects absorb and radiate heat equally? To study it let us perform some activities.

Activity 8.6 A good absorber of heat is a good radiator of heat.

You will need:

- black-coloured can
- silver-coloured can
- laboratory thermometer
- cold water
- hot water

Procedure

1. Fill two thirds part of each can with cold water.
2. Put a thermometer in each can and record temperatures.
3. Place both cans in bright sunlight.

Observe and record the temperature of each can after about 10 minutes.
The temperature of water in black can is higher because it has absorbed more heat from the Sun.

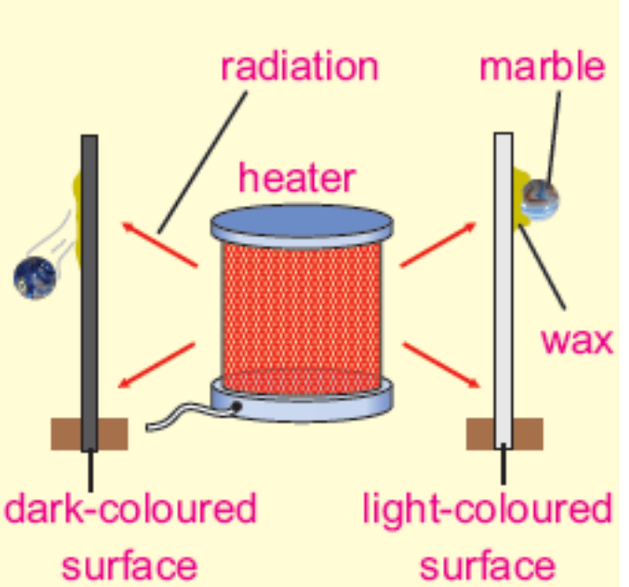
4. Again fill the cans with hot water and place thermometers in them. Record temperature of water in each can.
5. Place both cans in a shady place. Observe and record the temperature of each can after some time.

In which can did the water cool faster?

Activity 8.7 A good absorber of heat is a good radiator of heat.

You will need:

- an electric heater
- two marbles
- wax
- a metal plate with rough, dark coloured surface
- a metal plate with shiny, smooth, light coloured surface



Procedure

1. Stick a marble on each plate with the help of wax.
2. Place the heater between the two metal plates so that each plate receives the same amount of heat from the heater.
3. Switch on the heater.

Observe the marbles stuck on the plates.

Things to think

Why did the marble stuck on the plate with rough, dark coloured surface drop first?

Science, Technology and Society

In hot countries, houses are painted with light-coloured paints. The light colour of the paint absorbs little heat and reflects most of the radiation from the Sun. What colour of paint would you suggest for the houses in very cold countries?

8.10: Good and Bad Radiators and Absorbers of Heat

Experiments have proved that good absorbers of heat are also good radiators of heat. Black surfaces are good absorbers and good radiators of heat, while shiny surfaces are bad absorbers and bad radiators of heat (Fig.8.11, 8.12).

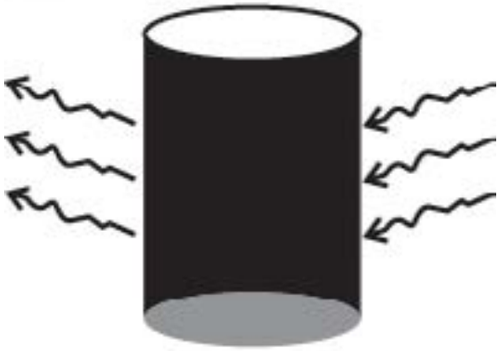


Fig. 8.11: A black, dull surface

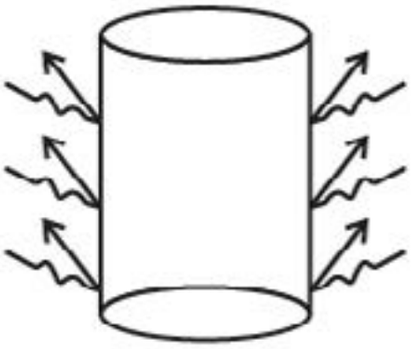


Fig. 8.12: A white, shiny surface

Tidbits

Since shiny surfaces are bad emitters of radiation, shiny teapots and utensils can keep food or tea warm for a longer time than black ones. In addition, shiny containers can keep cold liquids cool for a longer time than black containers.

8.11: Everyday Applications of Radiation of Heat

Every object emits or radiates some amount of heat. Knowledge of radiation can help us in many ways.

1. When we sit beside a fire, the heat of fire reaches us by radiation.
2. The cooling fins at the back of our refrigerator need to radiate its heat quickly to the surroundings. Its surface is made rough and painted black (Fig. 8.13).
3. During hot summer days, it is advised to wear white or light-coloured clothes. White colour absorbs less heat than dark colours.
4. In cold areas, a greenhouse is used for better growth of plants. Radiation from the Sun passes through the glass or plastic and warms up the soil and plants. Plants and soil absorb and emit radiation and increase the temperature in the greenhouse. Plants grow well in increased temperature of the greenhouse (Fig. 8.14).

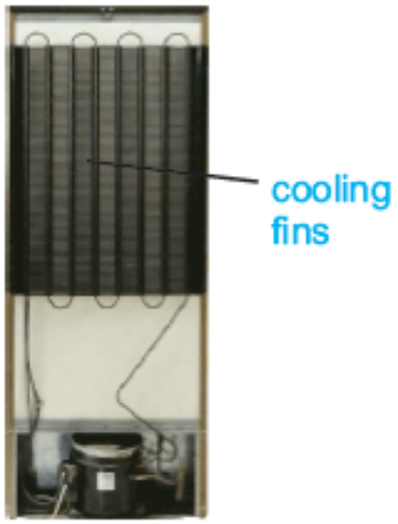


Fig. 8.13: Black cooling fins at the back of this refrigerator radiate heat quickly.

Fig. 8.14: A greenhouse

Tidbits

A blacksmith experiences all three ways of heat transfer, i.e. conduction, convection and radiation.

1. The iron in the blacksmith's forge glows red as heat is transferred to the metal from the furnace. (conduction)
2. The heat of the furnace warms the air in the blacksmith's shop. (convection)
3. The blacksmith feels the glow of heat from the furnace. (radiation)

8.12: The Vacuum Flask

The vacuum flask is a container which can keep hot things hot and cold things cold. The vacuum flask reduces the rate of transfer of heat by all the three ways, i.e. conduction, convection and radiation. The vacuum flask (thermos flask) is actually two thin glass or metal bottles, one inside the other (Fig. 8.15). Air between the glass walls is removed to create vacuum. The vacuum prevents the transfer of heat by conduction and convection. The walls of both bottles are coated with aluminium on the vacuum side. These silvered (like a mirror) and smooth glass walls prevent transfer of heat by radiation. The lid of the flask is made from a bad conductor such as cork or plastic only a little amount of heat is lost by conduction through the lid. The thin walled glass bottle is protected by fixing it in a metal or plastic container.

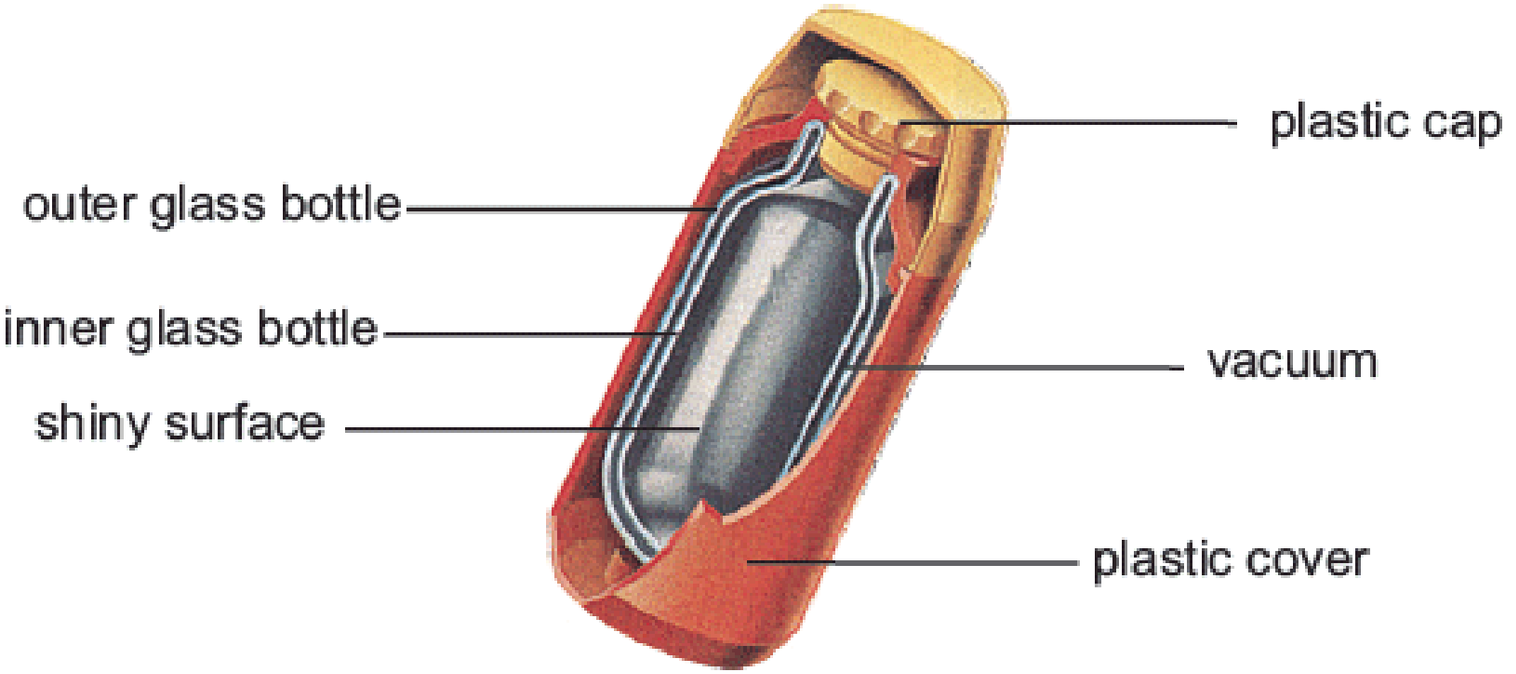


Fig. 8.15 : A vacuum flask slows the transfer of heat by conduction (plastic), convection (vacuum) and radiation (shiny surface).

Extend Your Thinking
How conduction, convection and radiation are alike and how they are different?

Key Points

- Heat is a form of energy. Heat always flows from an object at higher temperature to an object at lower temperature.
- Conduction is the transfer of heat through matter without the actual movement of particles from their positions.
- Convection is the transfer of heat in which molecules of a medium actually move to the source of heat energy to absorb heat and then move away from it.
- Radiation is the transfer of heat from a hot body to a cold body directly, without heating the space in between the two bodies.
- Conduction occurs in solids, liquids and gases. But metals are better heat conductors.
- Convection occurs only in liquids and gases.
- Radiation needs no material medium to transfer heat energy.
- Good and bad conductors of heat play very important role in our lives.
- Convection causes wind and ocean currents.
- Heat from the Sun reaches us by radiation.
- Some birds take advantage of convection currents and glide in the air for hours.
- A good radiator of heat is also a good absorber of heat.
- A vacuum flask reduces the transfer of heat by conduction, convection and radiation to keep things hot or cold.

Questions

1. Complete each of the following sentences by writing the correct term.

i The transfer of heat by movement of molecules from place to place

ii. It can maintain the temperature of drinks

iii. The transfer of heat by direct contact of molecules

iv. The surface which absorbs and radiates heat better

3. Give short answers.

i. Why do we use cooking pots made of metals?

ii. What is a convection current?

iii. Which surfaces do absorb maximum heat?

iv. Why do we use woollen clothes and blankets during winter days?

v. What is the advantage of gliding flight for a bird?