

4

More About Solids, Liquids and Gases

All matter is made up of tiny particles, which may be molecules or atoms (metals, for example, are made up of atoms). For the sake of simplicity, we will call the particles of matter 'molecules' in this chapter. The characteristics of a substance are determined by the type of molecules it is made up of. For example, a substance made up of large (heavy) molecules is heavier (has a greater density) than one made up of smaller molecules.

Molecules of matter exert attractive forces on each other. This means any two molecules of a substance that are close to each other attract each other with some force. This **intermolecular force** is called **cohesive force** in the case of molecules of the same substance. To 'cohere' means to stick together. The tendency of molecules to stick together due to the attractive force between them is called **cohesion**.

GENERAL PROPERTIES

The general properties of solids, liquids and gases and the temperatures at which they melt, boil, etc., depend largely on the cohesive forces between their molecules.

Solids

The cohesive force that binds the molecules of a solid is very strong. Hence, the molecules can neither move away from each other nor change their positions relative to each other. This is why the shape and size (volume) of a solid do not change easily. Solids are said to be **rigid**, which means they retain their shape even when a force is applied. This is particularly useful in the construction of buildings, bridges, and so on.

The **molecules of matter are in constant motion**. In a solid, the molecules only vibrate about the same position, somewhat the way we jog in place. When a solid is heated, the molecules vibrate with greater energy, which shows as a rise in temperature. The molecules also gain enough energy to move apart a little, which results in expansion.



Fig. 4.1 The fact that metals are used in construction is an application of the rigidity of solids.

The more a solid is heated, the more energetically its molecules move. In other words, the more its temperature rises. Then there comes a point when the molecules become energetic enough to change their positions relative to each other. That is when a solid melts. The temperature at which this occurs depends on the strength of the cohesive force that binds the molecules of a solid. In general, the cohesive force that binds a metal is stronger than that which binds a nonmetal, so metals have a higher melting point than nonmetals.



Fig. 4.2 The cohesive force in ice is much weaker than that in iron. Hence, ice melts at 0°C , while iron melts at 1535°C .

Liquids

The cohesive force between the molecules of a liquid is not as strong as that between the molecules of a solid. Hence, the molecules can change their relative positions, though they cannot move away from each other. This is why a liquid can flow and change its shape, though its volume remains the same. The volume of a liquid does not change even when it is under pressure because its molecules cannot move closer together. This is why a liquid is **incompressible**.

The fact that the volume of a liquid does not change under pressure means that its density also does not change with pressure. However, liquids expand considerably when they are heated. Hence, the density of a liquid decreases when it is heated. This, as you may remember, helps to set up convection currents in a liquid. The warmer, lighter part of a liquid rises, while the colder, denser part of a liquid sinks.

Gases

The cohesive force between the molecules of a gas is almost negligible. Hence, the molecules are free to move as they please. In other words, the distances between them as well as their relative positions can change. This means the volume as well as the shape of a gas can change. The molecules of a gas move freely and fill up any space (volume) that is available to them. They can also be compressed into



Fig. 4.3 Melting snow is carried by rivers from the mountains to the plains because liquids flow.

a small space. Thus, only the mass of a gas remains constant. Its volume and density depend on its container. Its pressure too depends on the size of its container, as we will discuss in the section on pressure.

SURFACE OF A LIQUID

You have learnt that the molecules of a liquid attract each other with a force called cohesive force. This makes the surface of a liquid behave in an interesting manner. Any molecule inside a liquid is attracted equally on all sides by neighbouring molecules, so the net force on it is zero. In other words, molecules inside a liquid are not pulled in any particular direction. Molecules on the surface of a liquid, however, experience a net downwards pull, since there are no molecules pulling them upwards (Figure 4.4). This makes the surface of a liquid tend to contract in a manner similar to a stretched rubber sheet. Just as a stretched rubber sheet is in a state of tension, we assume that the surface of a liquid is in a state of tension. This tension acting on the surface of a liquid is called **surface tension**. It is defined as **the force acting per unit length of an imaginary line on a liquid surface**. Its SI unit is **newton per metre**. As an example, the surface tension of water is about 0.07 newton per metre.

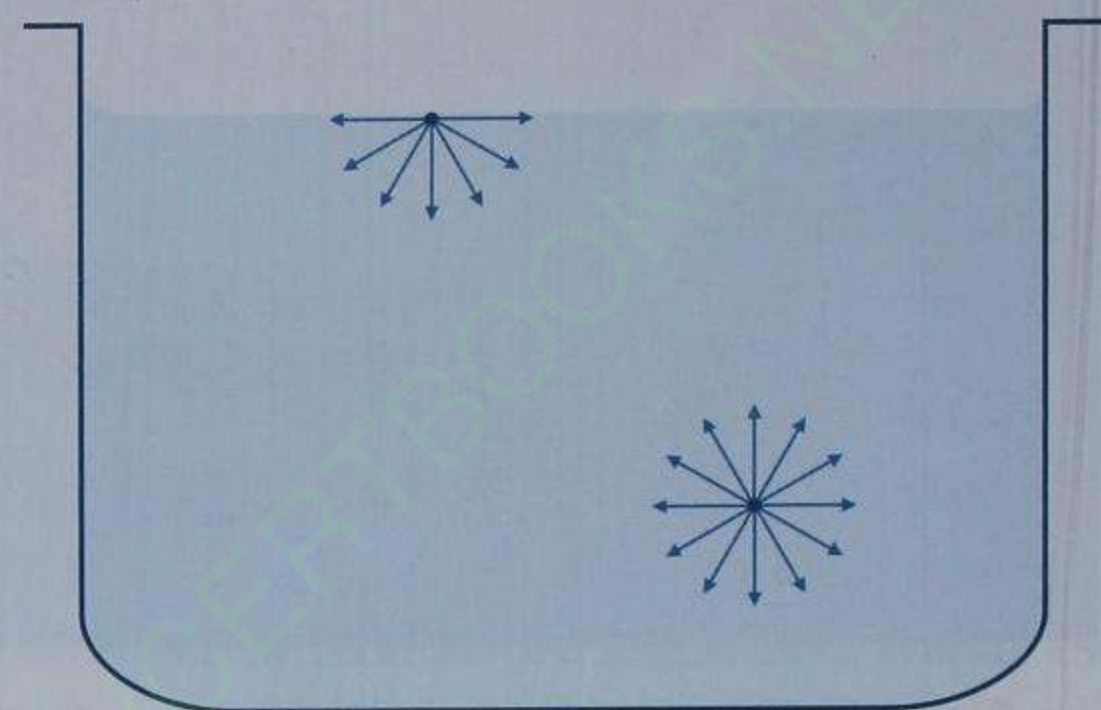
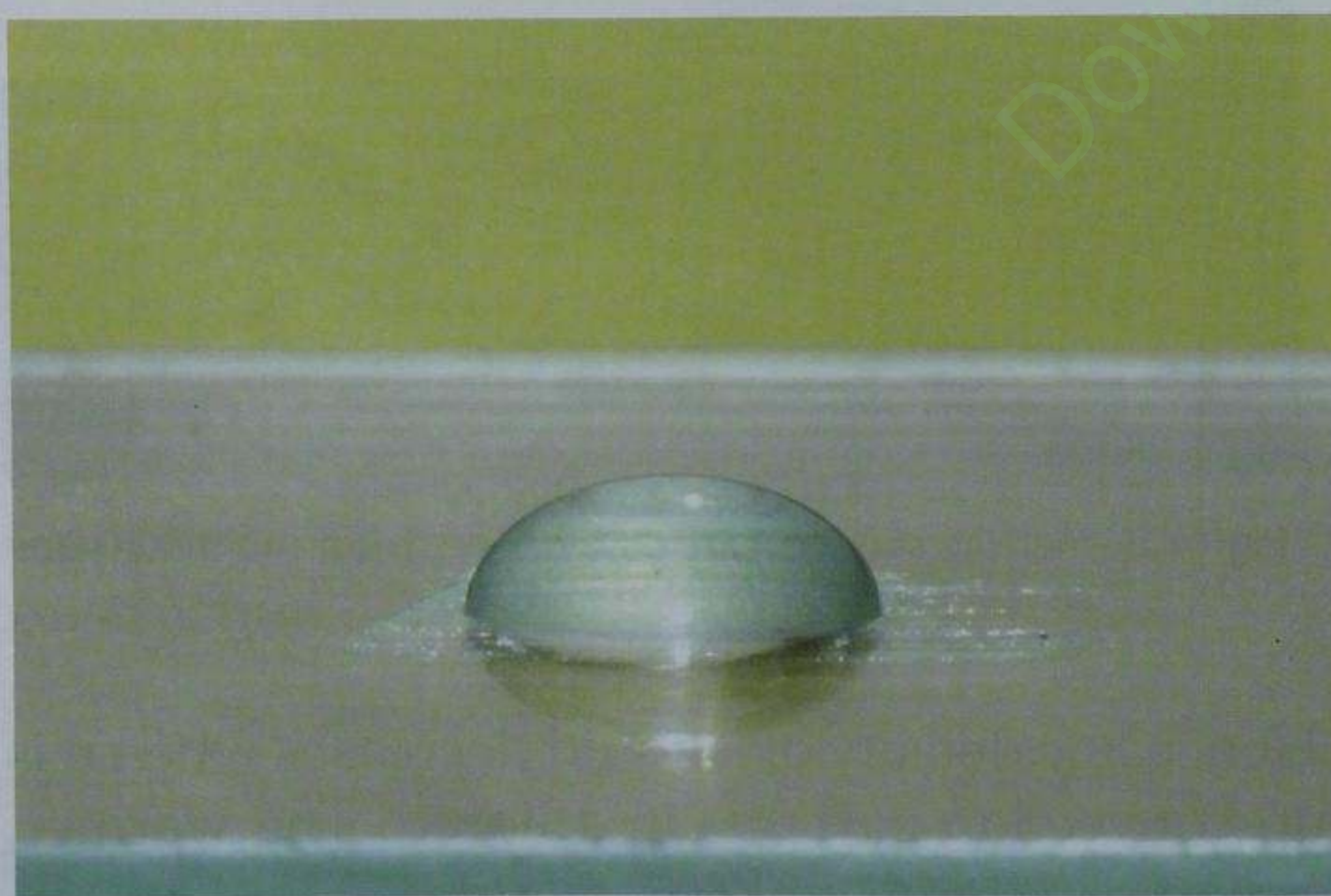


Fig. 4.4 Molecules on the surface experience a net downwards pull.

ACTIVITY

Smear a sheet of glass or any glass surface with Vaseline. Use a dropper or toothbrush to put small drops of water on the surface. You will see that the water forms spherical drops instead of spreading out. The smaller the drops, the more spherical they will be. The reason why this happens is surface tension. Surface tension makes a small amount of liquid contract or draw itself into a small ball.



(a)



(b)

Fig. 4.5 Droplets of water (a) on a sheet of glass and (b) on a leaf

Meniscus

So far we have discussed only cohesive force, or the force of attraction between the molecules of a liquid. However, this is not the only force experienced by the molecules of a liquid. They are also

attracted by the molecules of the container (or any surface) they are in contact with. This force, which acts between the molecules of a liquid and those of the surface it is in contact with, is called **adhesive force**. 'Adhesion' means sticking. Adhesive force makes a liquid stick to the surface, or wet the surface, it is in contact with. You may have noticed that water sticks to any surface it comes into contact with, including your skin.

ACTIVITY

Dip part of a thin glass or plastic tube in water (you could use a thin straw or a part of a gel pen refill). Close the top with a finger and pull the tube up a little. Some water will be drawn up into the tube. Notice the surface of the water in the tube. It will be curved. In fact, if you look carefully, you will notice that the surface of water in any container has this shape—a little higher at the edges than at the centre.

The curved surface of a liquid in a container is called a **meniscus** (a Greek word that means crescent). It forms because the attraction (adhesive force) between the molecules of the liquid and the molecules of the container pulls up the part of the liquid surface that is in contact with the container.

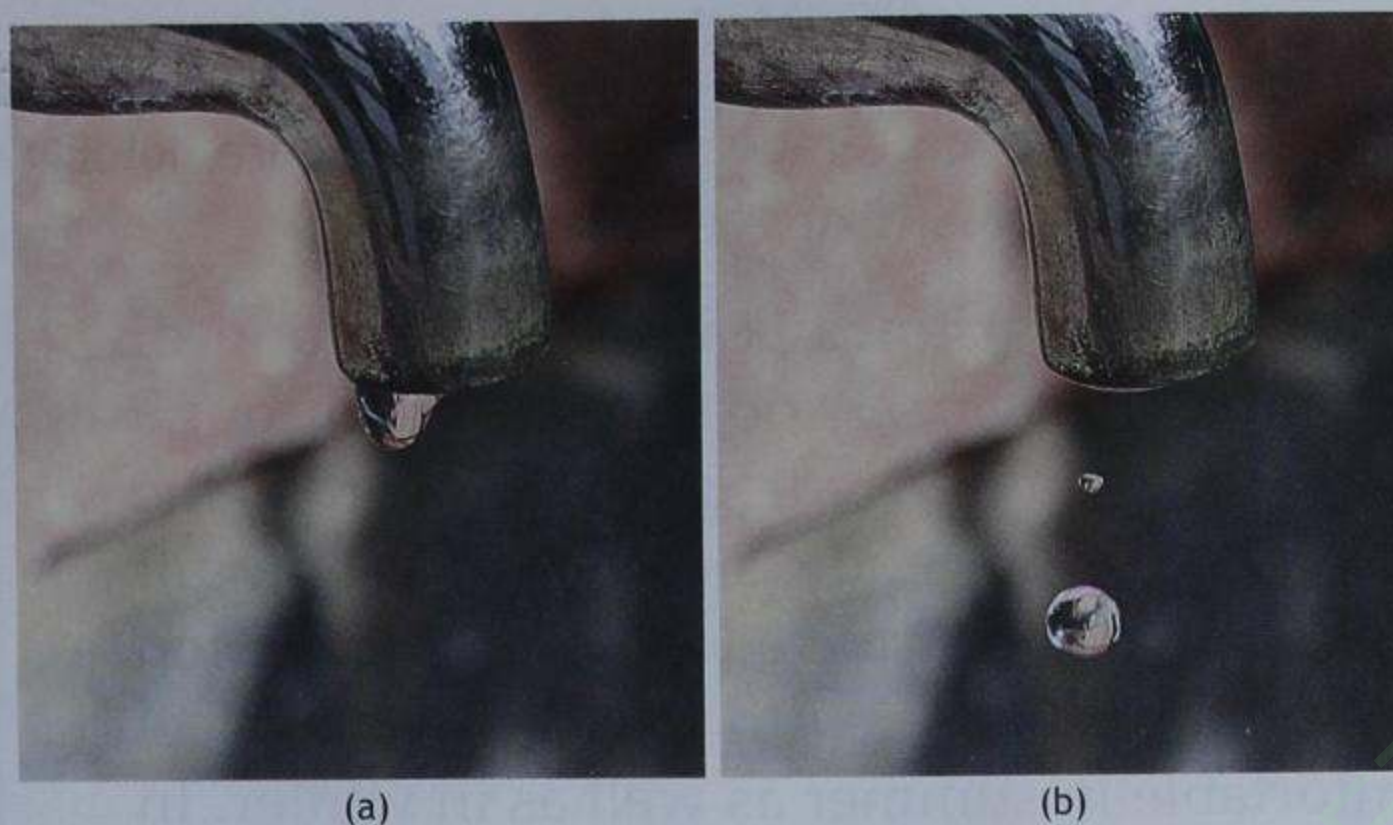


Fig. 4.6 (a) Adhesive force makes a drop of water stick to a tap. (b) Cohesive force makes it contract into a sphere as it falls.

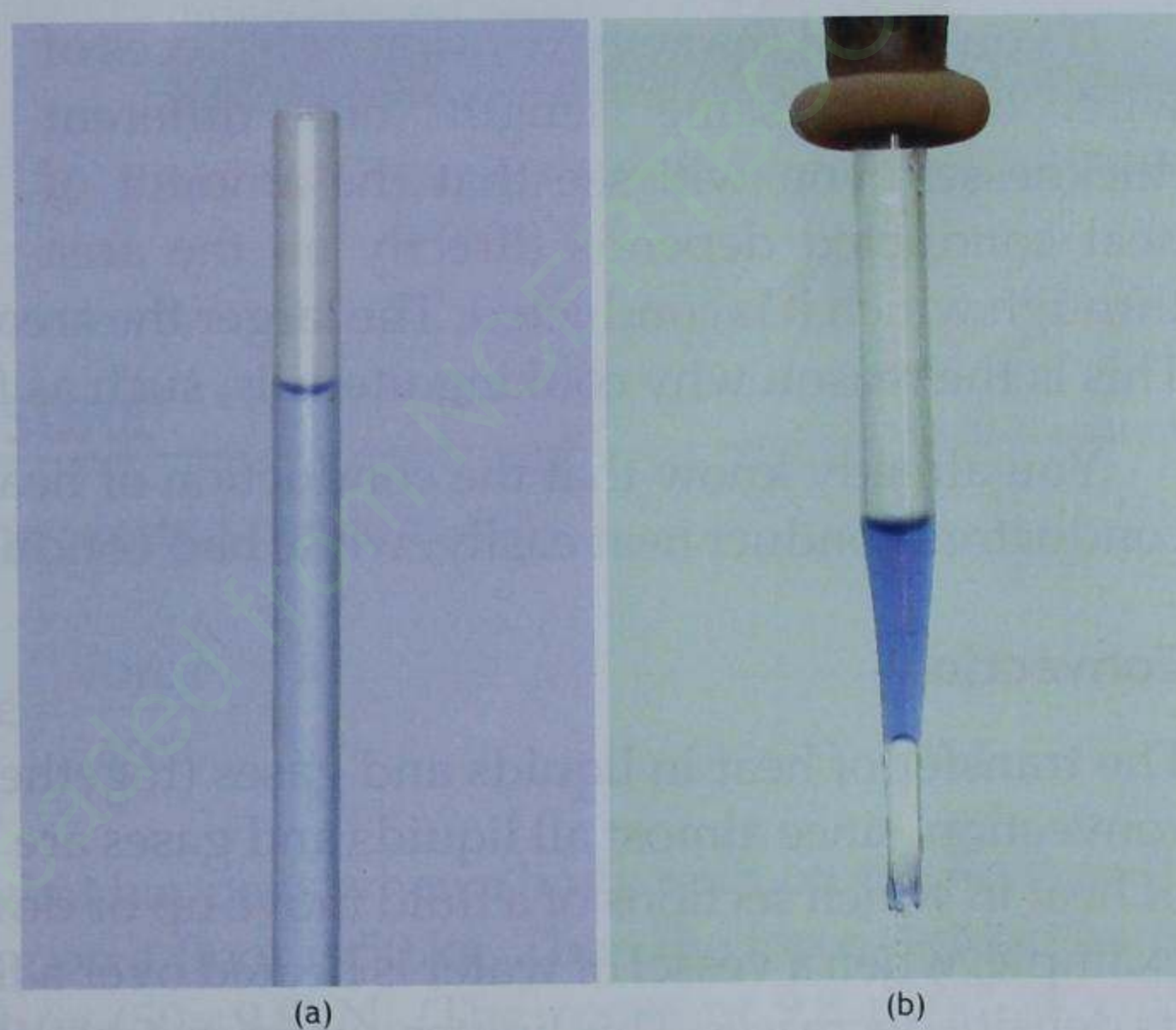


Fig. 4.7 The meniscus (a) in a narrow tube and (b) in a dropper

TRANSFER OF HEAT

In your previous class you have learnt that heat can be transferred by three processes called conduction, convection and radiation. We will now discuss conduction and convection in greater detail.

Conduction

Conduction is the process of transfer of heat from one part of a material (or object) to another without any movement in the material. It is of significance only in solids, though it does occur (to a very small extent) in liquids and gases as well. When one part of a solid is heated, the molecules of that part gain energy and vibrate more vigorously. In doing so, they push and pull the molecules of the adjacent colder part. These molecules then start vibrating more energetically. Thus, energy flows from the hotter to the colder part of the solid.

ACTIVITY

Take two pieces of a metal wire, one twice as long as the other. Hold one end of each and put the other end into a flame. Gradually the ends you are holding will become warm. You will notice that the shorter wire gets warmer than the longer wire.

The activity shows that **the conduction of heat depends inversely on the distance through which it is transferred**. In other words, the greater the distance, the smaller is the amount of heat that is conducted. This is the reason why old houses with thick walls feel comfortable in summer as well as in winter. In summer, the thick walls allow less heat to enter from outside. In winter, they allow less heat to leave the house.

If you repeat the activity using two pieces of wire of the same length but different thicknesses, you will see that **the amount of heat conducted depends directly on the area through which it is conducted**. The larger the area, the greater is the amount of heat that is conducted. This is the reason why cooking utensils, such as frying pans, have a large base.

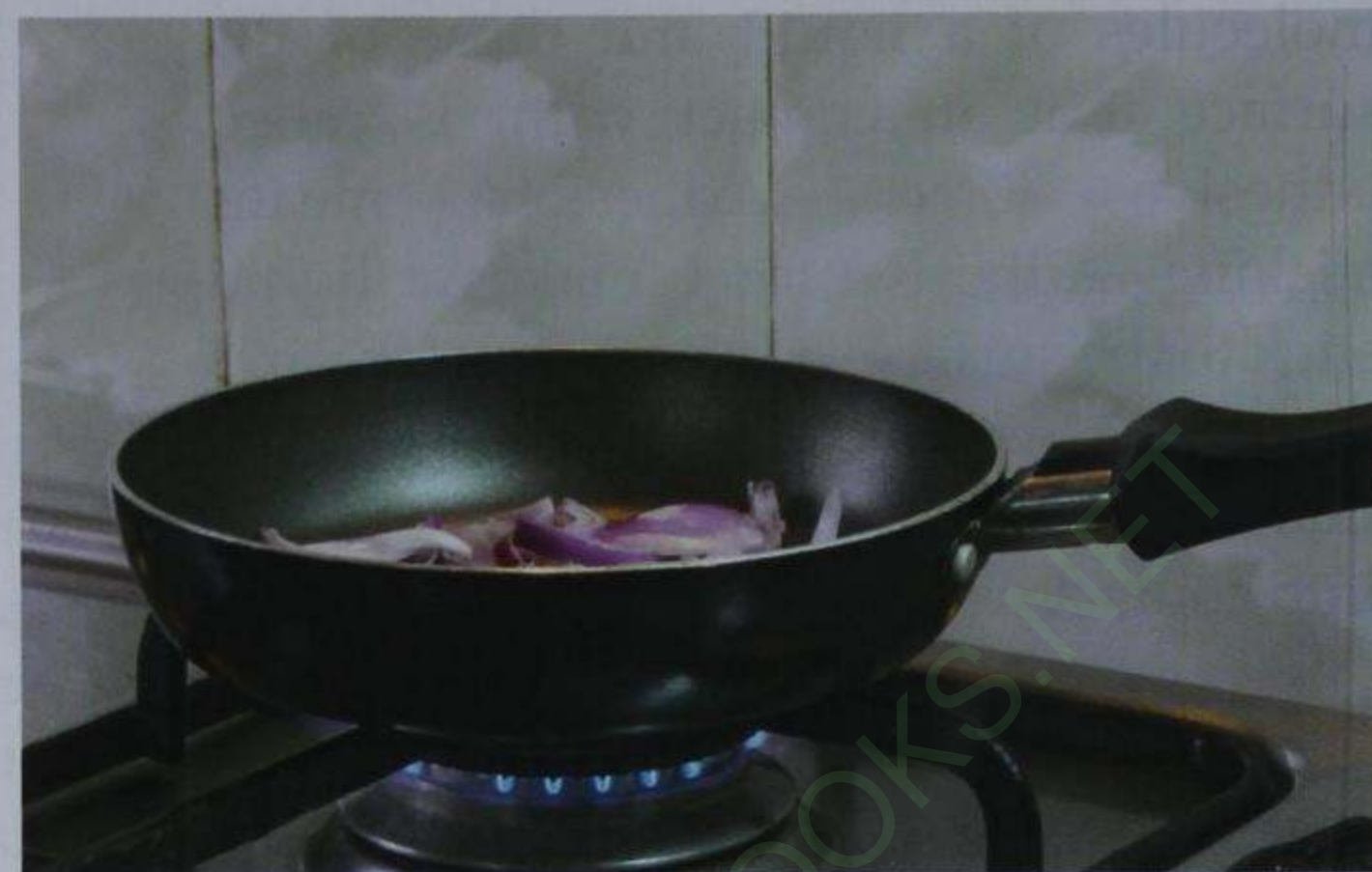
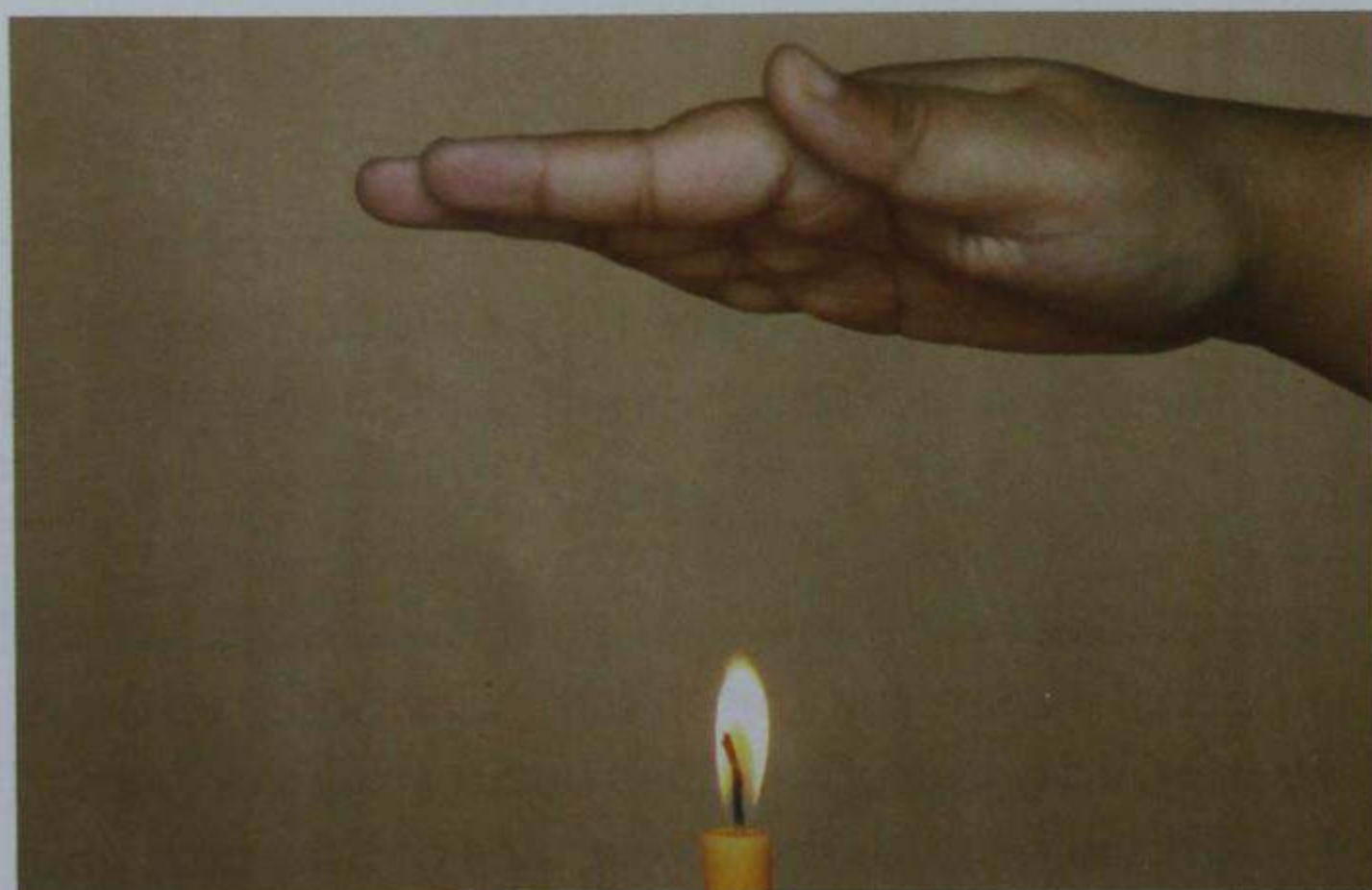


Fig. 4.8 The wide base of a frying pan allows it to absorb heat easily.

You already know that the conduction of heat also depends on the nature of the material. Good conductors conduct heat easily, while bad conductors do not.

Convection

The transfer of heat in liquids and gases (together called fluids) takes place almost entirely through convection, since almost all liquids and gases are bad conductors. **Convection is the mode of transfer of heat in which sections of a fluid move up or down due to changes in density with temperature**. For example, when a vessel of water is heated over a flame, the water near the bottom becomes warm and its density decreases. This lighter, warmer part then moves up, comes in contact with the cooler layers and cools down. It then sinks, is heated by the flame, and moves up again.



(a)



(b)

Fig. 4.9 (a) If you place your hand above a flame, you will feel the heat carried by the rising air. (b) However, if you place it by the side of the flame, you will not.

Convection is the mode of transfer of heat in gases as well. If you place your hand a little above a lighted candle, you will feel the heat carried by the rising stream of hot air. However, if you keep your hand at the same distance by the side of the flame, you will not feel the warmth because air is a poor conductor.

Convection plays a major role in weather phenomena, for example, the almost daily rainfall in equatorial regions. In these regions, the almost direct rays of the sun heat the ground rapidly. The air near the ground gets heated and rises. The rising air cools, and the water vapour present in it forms clouds. Cooler air from above sinks, gets heated and rises again to form more clouds. The clouds bring rain, usually in the afternoon.

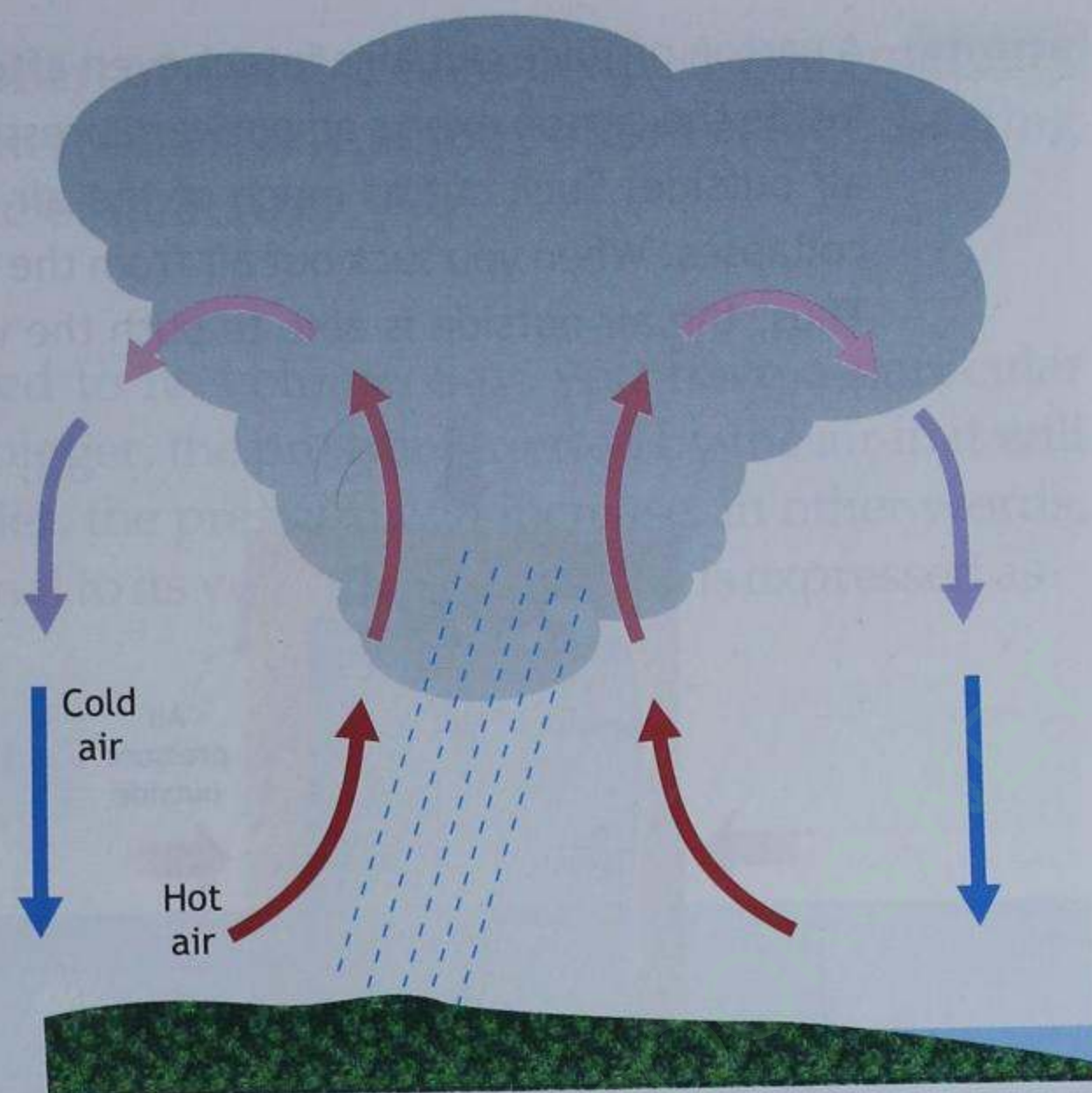


Fig. 4.10 Equatorial rainfall results from convectional currents.

PRESSURE

You have learnt in Class 6 that pressure is the force exerted per unit area.

$$\text{Pressure} = \frac{\text{force}}{\text{area}}$$

The SI unit of pressure is N/m^2 . Let us recall what happens when a body rests on the floor or any other surface. Suppose the mass of a carton resting on a floor is 50 kg. Then the force exerted by the carton on the floor is equal to its weight, which is $(50 \times 9.8) \text{ N}$. (The constant 9.8 m/s^2 is g , the acceleration due to gravity, as you know.) If this weight acts on an area of 1 m^2 , the pressure exerted by the carton is 490 N/m^2 .

You know that gases and liquids also have mass. Hence, it should not surprise you that they too exert pressure. Let us study the pressure exerted by gases in general, and that exerted by air in particular.

Pressure Exerted by Gases

The gases that make up the atmosphere exert pressure on us and on everything on the earth, including the surface of the earth. This is called **atmospheric pressure**. Remember that air does not only press downwards. It exerts a pressure in all directions. This, in fact, is true of all gases. **All gases exert pressure equally in all directions**. Thus, the air in a room exerts equal pressure on the floor, ceiling and the walls. Similarly, the gas in a balloon exerts equal pressure on all sides of the balloon.

Since the density of air decreases as one climbs higher, atmospheric pressure decreases with height. It is the highest at sea level, being about 10^5 N/m^2 . This means the atmosphere exerts a force of 10^5 N over every square metre of the earth. Why do we not feel this huge pressure acting on us? That is because the pressure inside our body is equal to the atmospheric pressure. If it were not for this, our body would cave in.

ACTIVITY

A carton of juice remains intact even after you have sucked out all the drink from it. This is because the air inside the carton exerts an outward pressure on the walls that is equal to the inward pressure exerted by the air outside. Suck out as much of the air (from an empty carton) as you can. You will find that the carton collapses. When you suck out air from the carton, the pressure inside becomes less than the pressure outside. Thus, the air outside is able to push the walls in.



Fig. 4.11 (a) An empty carton is filled with air, so the pressure inside is balanced by the pressure outside. (b) When air is sucked out, the carton caves in because of the higher pressure outside.

Measurement of pressure

Different instruments are used to measure the pressure exerted by air. **Barometers** are used to measure atmospheric pressure, while **pressure gauges** are commonly used to measure the pressure of air in the tyres of vehicles. Barometers can be of different types. The **Fortin barometer**, designed by Nicolas Fortin, works on the principle that under normal conditions, atmospheric pressure can support a mercury column of height 76 cm. This was discovered by an Italian scientist called Toricelli. He found that when a tube containing mercury was inverted over an open trough of mercury [Figure 4.12(a)], the height of mercury in the tube was always 76 cm. This is because the pressure exerted by air on the surface of mercury is equal to the pressure exerted by a column of mercury of height 76 cm.

Figure 4.12(b) shows the Fortin barometer. The leather bag at the bottom contains mercury. The level of the mercury in the tube can be seen through a glass window. It rises and falls with the atmospheric pressure, and can be read

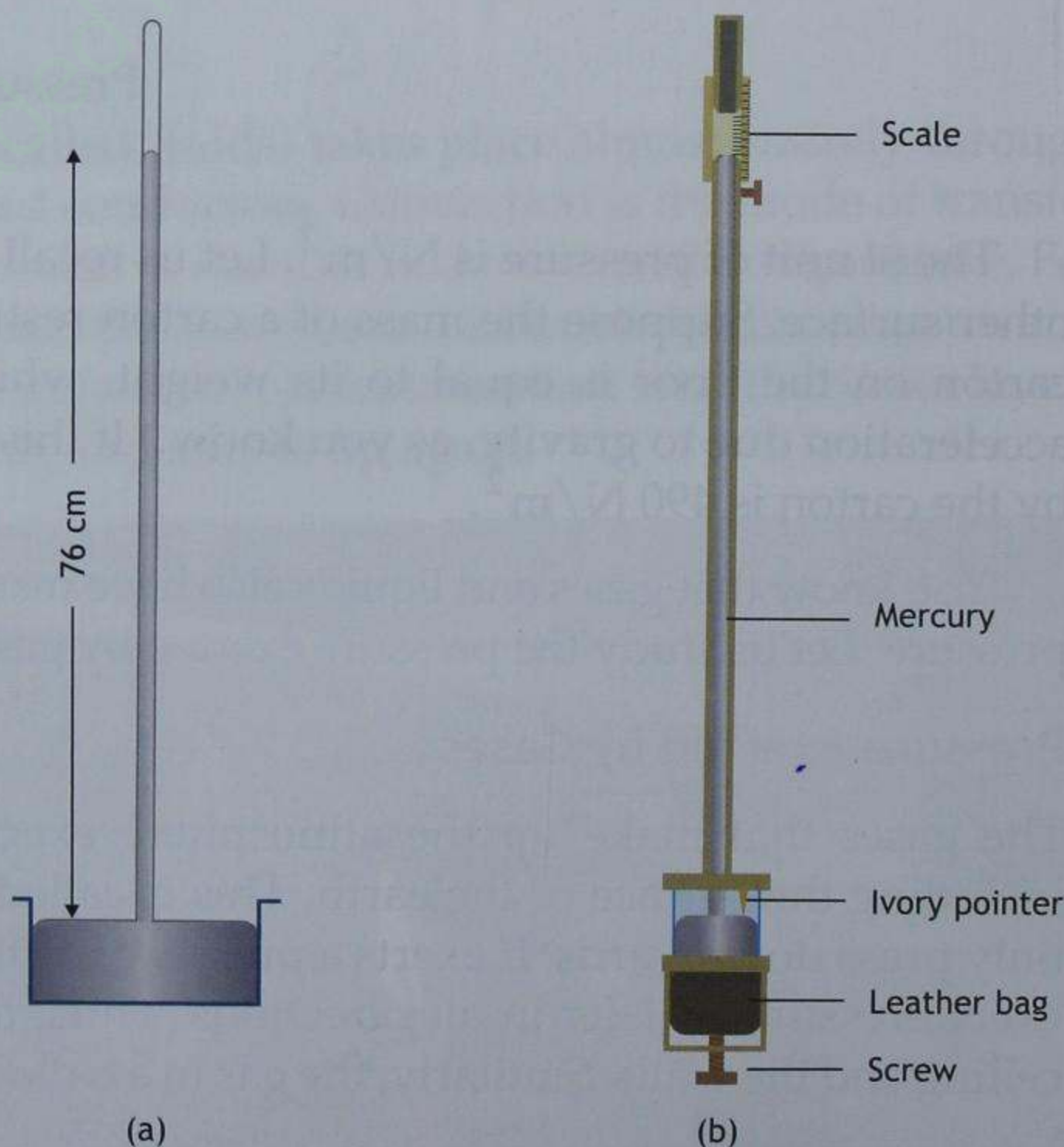


Fig. 4.12 (a) Under normal conditions, the pressure exerted by air supports a mercury column of height 76 cm. (b) A Fortin barometer works on this principle.

accurately on the scale alongside. The space above the mercury in the tube is filled with mercury vapour. The zero mark of the scale is at the tip of the pointer. The screw at the bottom is for adjusting the leather bag so that the pointer just touches the surface of mercury.

Pressure and volume

The pressure of a (particular mass of) gas is closely related to its volume. Say, you have a particular amount (mass) of gas in a balloon. If you make the balloon bigger, the pressure exerted by the air in it will decrease. On the other hand, if you make the balloon smaller, the pressure will increase. In other words, **the pressure of a (certain mass of) gas is inversely proportional to its volume.** The relation is expressed as

$$pV = \text{constant}$$

This may become clearer if you consider what happens to the molecules of a gas when the gas is compressed into a smaller space. A particular mass of gas has a particular number of molecules. When its volume decreases, the molecules get crowded into a smaller space and the pressure increases. On the other hand, when the volume increases, the molecules spread out and the pressure decreases.

You can achieve a similar effect by pumping out or pumping in gas while keeping the volume fixed. When you pump out gas, the molecules remaining inside the fixed volume spread out, and the pressure decreases. This is what happened when you sucked out some air from the empty carton. On the other hand, when you pump more gas into a fixed volume, the molecules get more crowded and the pressure increases.

This pressure–volume relationship finds many applications in our life.

1. When the handle of a bicycle pump is pushed down, a piston inside the pump moves down and compresses the air inside it. This means the volume of the air decreases. Hence, its pressure increases, and it is able to force its way into the tube (inside the tyre).
2. When we breathe in, the ribs move outwards and the diaphragm moves downward. This increases the volume of the thoracic (chest) cavity and decreases the pressure inside. As a result, atmospheric air comes in through the nostrils and wind pipe into the lungs.
3. When we use a straw to drink, we first suck out the air in the straw. This decreases the pressure in

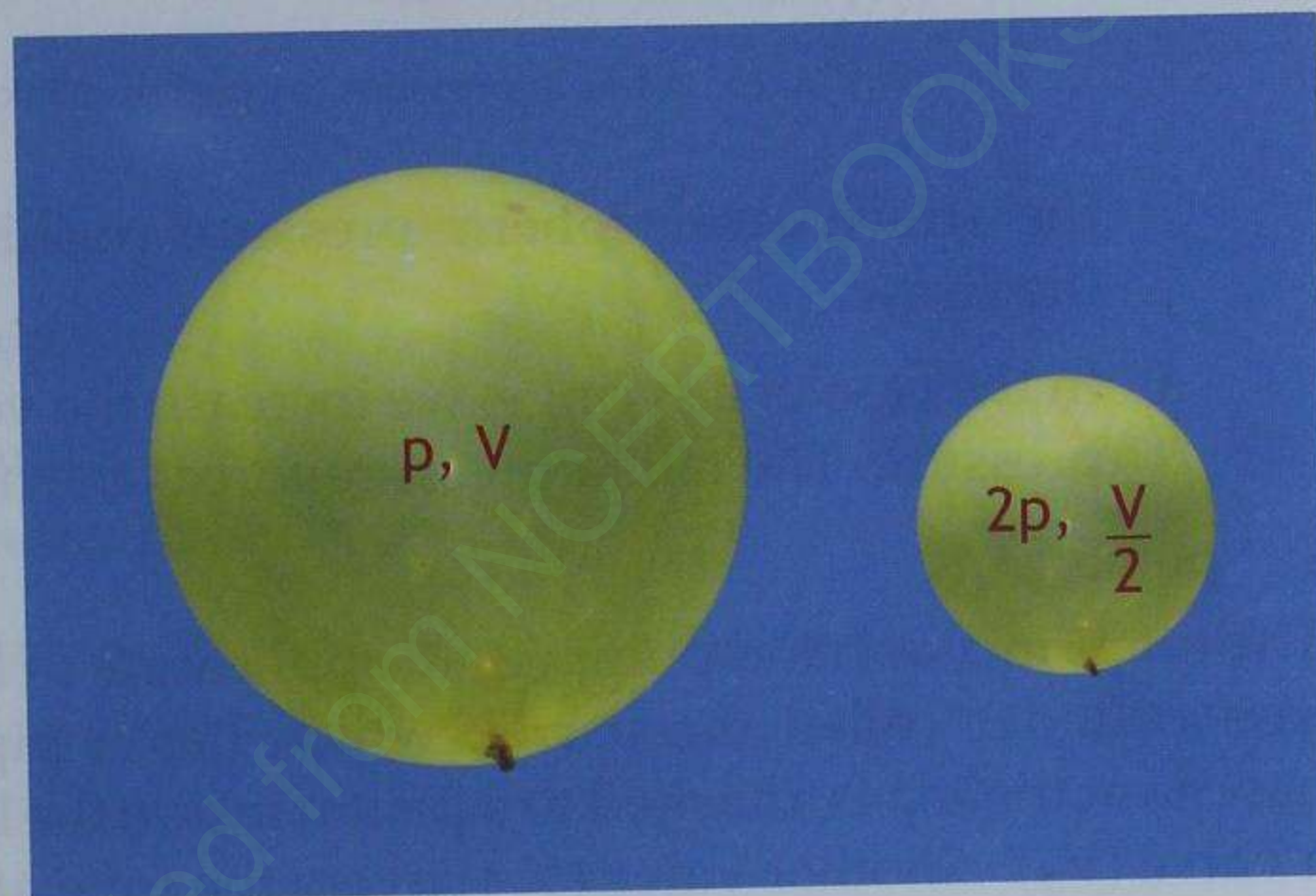


Fig. 4.13 If the volume of a gas is halved, the pressure is doubled.



Fig. 4.14 When the handle is pushed down, air gets compressed and pressure increases.

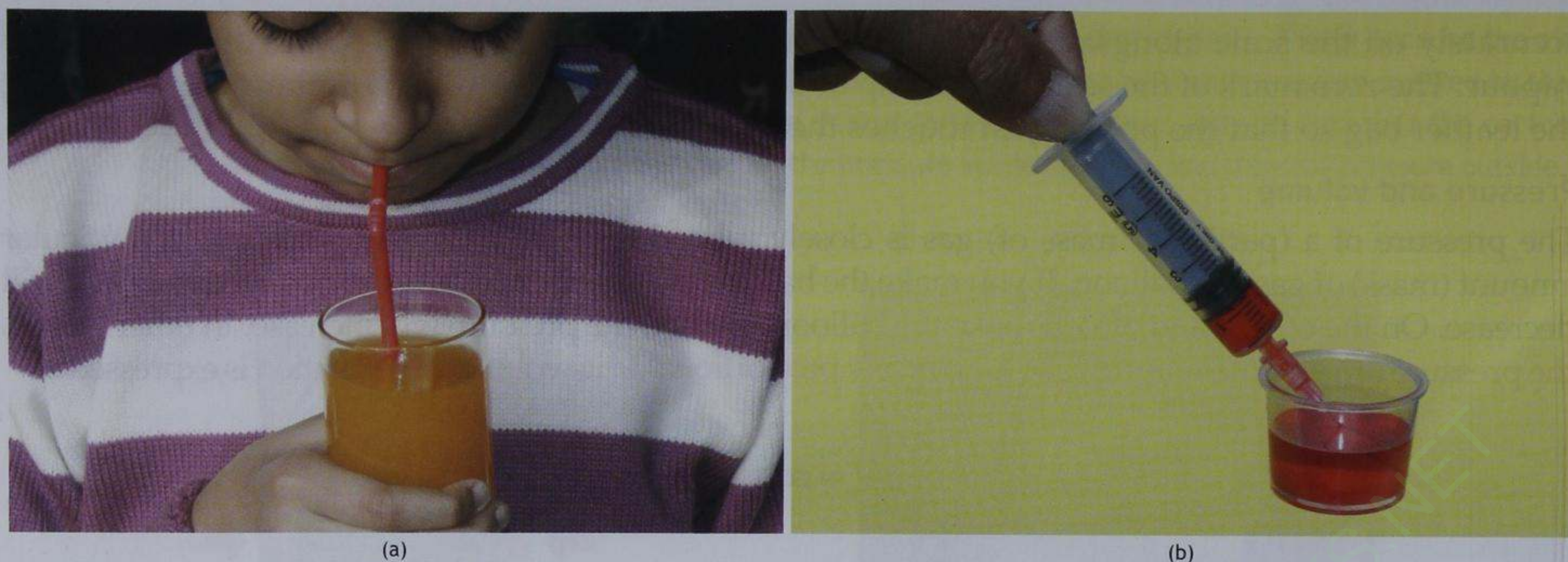


Fig. 4.15 A fall in pressure (a) pushes drink into a straw and (b) draws fluid into a syringe.

the straw. Atmospheric pressure pushing down on the drink then forces the drink up the straw.

4. In the case of a syringe, we increase the volume by pulling out the piston, which reduces the pressure. The fall in pressure forces the medicine into the syringe.

Lift pump

The lift pump, or hand pump, is an application of the principle we have been discussing. It has a fixed iron cylinder called the barrel, which has a pipe dipping into the underground water. A long handle at the top is attached to a piston inside the barrel. The piston has an opening that is covered by a valve (V_2). Another valve (V_1) covers the tube at the bottom of the barrel. Both the valves can only move upwards.

When the piston is moved up, the volume of the air below it increases and its pressure decreases. This makes V_1 open and water flows into the barrel. Next, when the piston is moved down, V_1 closes and the water in the barrel forces open V_2 and collects above the piston. When the piston moves up the next time, the water above it flows out of the spout and the region below it gets filled up with water again.

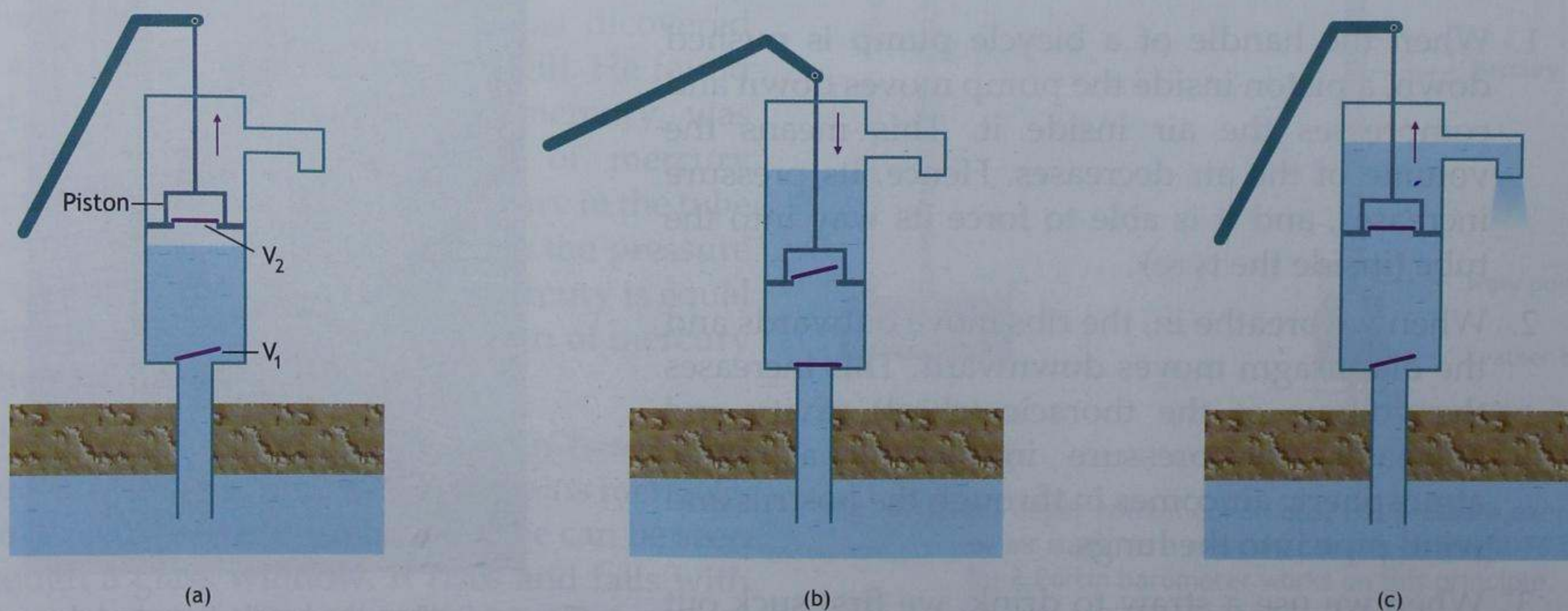


Fig. 4.16 How a lift pump works

Pressure Exerted by Liquids

Consider a vessel of liquid of cross section A and height h .

The volume of the liquid = Ah .

Suppose the density of the liquid is d .

Then the mass of the liquid = Ahd .

The force exerted by the liquid = $Ahdg$.

The pressure exerted by the liquid

$$= \frac{\text{Force}}{\text{Area}} = \frac{Ahdg}{A} = hdg.$$

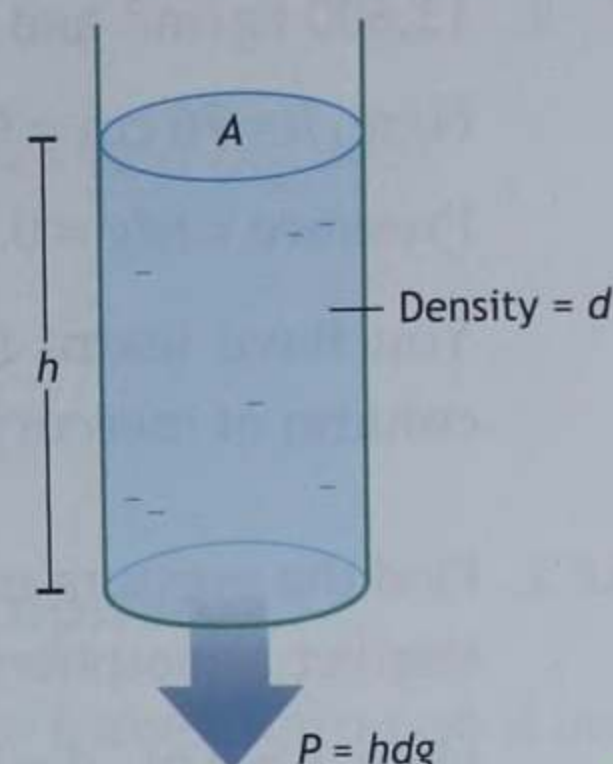


Fig. 4.17 The pressure exerted by a column of liquid depends on its height.

This brings us to some very interesting points about the pressure exerted by liquids.

1. The pressure exerted by a column of liquid depends on its height.
2. The pressure at all points at the same horizontal level in a liquid is the same. For example, the pressure at a particular depth under the sea is the same, everywhere.
3. A liquid exerts pressure equally in all directions. Suppose the pressure at a particular level under the surface of a liquid is P . The liquid will exert this pressure on any surface at this level, which may be the walls of the vessel or the bottom.

ACTIVITY A simple activity will make these things clear. Pierce four holes down the side of a plastic bottle. Stick a strip of adhesive tape over the holes. Fill the bottle with water and place the bottle in the sink or in a large vessel. Peel off the tape. The jet of water from the lowest hole will travel the farthest because pressure increases with depth (or height of the column of water).

If you make four holes at the same height, you will notice that all the jets travel the same distance from the bottle. This is because the pressure is the same at all points at the same level of a liquid.

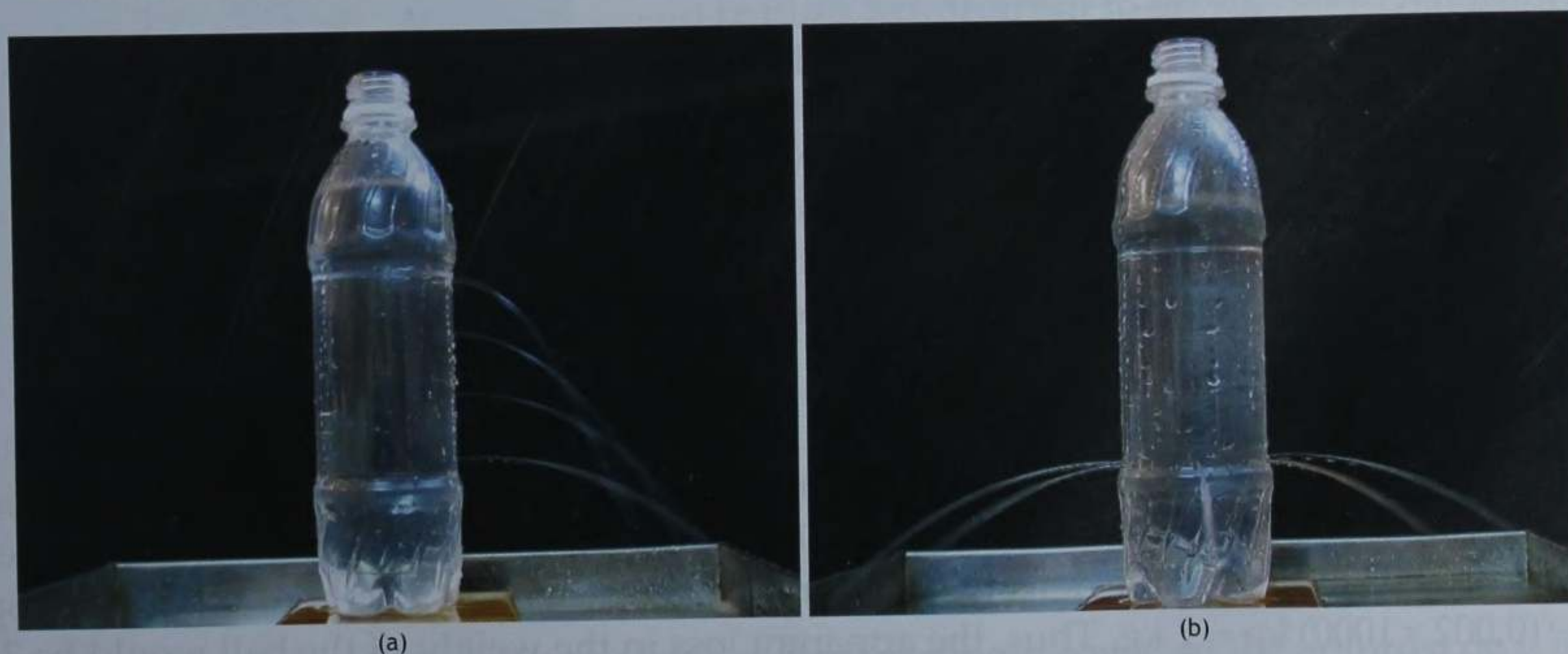


Fig. 4.18 (a) The pressure increases with depth. (b) The pressure is the same at all points at the same level.

EXAMPLE 1. Find the pressure exerted by a column of mercury of height 76 cm. The density of mercury is $13,600 \text{ kg/m}^3$ and $g = 10 \text{ m/s}^2$.

Here, $h = 76 \text{ cm} = 0.76 \text{ m}$, $d = 13,600 \text{ kg/m}^3$ and $g = 10 \text{ m/s}^2$.

Pressure = $hdg = 0.76 \text{ m} \times 13,600 \text{ kg/m}^3 \times 10 \text{ m/s}^2 = 1.03 \times 10^5 \text{ N/m}^2$.

You have learnt that under normal conditions, atmospheric pressure can support a 76-cm column of mercury. The normal atmospheric pressure is then approximately $1.03 \times 10^5 \text{ N/m}^2$.

EXAMPLE 2. Find the pressure exerted by water on the walls of a tank at a depth of 2 m below its open surface. Neglect atmospheric pressure. The density of water is 1000 kg/m^3 and $g = 10 \text{ m/s}^2$.

Here, $h = 2 \text{ m}$, $d = 1000 \text{ kg/m}^3$, $g = 10 \text{ m/s}^2$.

You know that a liquid exerts pressure equally in all directions.

Hence, the pressure on the walls = $hdg = 2 \text{ m} \times 1000 \text{ kg/m}^3 \times 10 \text{ m/s}^2 = 2 \times 10^4 \text{ N/m}^2$.

ARCHIMEDES' PRINCIPLE

ACTIVITY

Fill a glass jar or bottle with water and close it. Feel its weight. Then immerse it in water. You will find that it feels much lighter. Move it up. While it is immersed, you will be able to move it up with comparatively less effort. Then as it moves out of water, you will find that it becomes heavier.

You can repeat the activity using any solid object which does not float. You will always find that **an object feels lighter in water than in air**. It is as though somebody is pushing the object up when it is immersed in a liquid.

This upward force that acts on a body immersed in a liquid is called an **upthrust** or force of **buoyancy** (to 'buoy something up' means to keep it afloat). It is exerted by the liquid. You may have felt it while swimming. Figure 4.19 shows a swimmer. His weight is the downward force acting on him due to gravity. The other force acting on him is the upthrust exerted by water.

Man must have been aware of the upthrust exerted by water since ancient times. However, no one actually tried to measure this upthrust or the **apparent loss in weight** (the lighter feeling) due to it. It was only in the third century BC that the Greek scientist Archimedes measured it. He stated that **the apparent loss in the weight of a body immersed in a liquid is equal to the weight of the liquid displaced by it**.

Let us understand what this principle means by considering an example. Suppose a solid ball weighs 5 kg in air. When it is immersed in water, it will displace a volume of water that is equal to its own volume. Suppose the volume of the ball is 0.002 m^3 . Then the volume of the water displaced by it would also be 0.002 m^3 . Since the density of water is 1000 kg/m^3 , the weight of the water displaced would be $(0.002 \times 1000) \text{ kg} = 2 \text{ kg}$. Thus, the apparent loss in the weight of the ball would be 2 kg. In other words, the ball would weigh $(5 - 2) \text{ kg}$, or 3 kg in water. Similarly, if your weight is 45 kg in air,



Fig. 4.19 You experience an upthrust in water.

and you displace 35 kg of water when you enter a swimming pool, you will feel as if your weight is only 10 kg ($= 45 \text{ kg} - 35 \text{ kg}$).

Archimedes' principle is valid for the displacement of all fluids (gases and liquids).

Law of Flotation

When a body is in a fluid (such as water) there are two forces acting on it.

1. A force equal to its weight, acting downwards
2. A force equal to the weight of the fluid which it displaces, acting upwards

Naturally, the body will float, or remain in equilibrium, when the two forces acting on it are equal, or balance each other. In other words, **a body floats in a fluid if the weight of the fluid displaced by it is equal to its own weight**. Suppose the density of a body is d_1 and its volume is V . When it is completely immersed in a fluid of density d_2 , the forces acting on it are

$$F_1 = gd_1V, \text{ acting downwards} \quad (\because \text{mass} = \text{density} \times \text{volume})$$

$$F_2 = gd_2V, \text{ acting upwards}$$

For the body to float in the fluid, F_1 must be equal to F_2 . This means d_1 must be equal to d_2 . This brings us to something you already know. **A body floats in a fluid if its density is equal to or less than the density of the fluid.**

Boats and ships

You know that iron sinks in water because its density is much greater than that of water. Then how do boats and ships made of iron float in water? The following activity will help you understand this.

ACTIVITY Drop a lump of Plasticine into a jar of water. It will sink because its density is greater than that of water, so the weight of the water displaced by it is less than its weight. Take out the lump of Plasticine and mould it into a boat (or a bowl). If the boat is large enough, it will float.



Fig. 4.20

When you mould the Plasticine into a boat, it displaces more water, so the upthrust on it increases. This is why the boat floats. Ships and boats float for the same reason. Their hollow shape makes them

displace a large volume of water. The upthrust provided by this water keeps them afloat. In fact, the upthrust provided by the water displaced by just a part of a ship is enough to keep the entire ship afloat. This is why only a part of a ship is under water. How much of a ship is under water depends, among other things, on the density of the water. Ships go down lower in rivers than in the sea because the density of river water is less than that of sea water.

Water and ice

Why does ice float in water? For an answer do the following activity.

ACTIVITY

Fill a small cup (the cap of a bottle or the measuring cups that come with syrups will do) with water up to the brim. Put it into the freezing compartment of a refrigerator. When the water freezes, you will notice that the surface of the ice bulges upwards. This is because **water expands when it freezes**.



Fig. 4.22 Water expands when it freezes.

Since the volume of water increases when it freezes, its density must decrease (density = mass/volume). This means the density of ice is lower than the density of water. Naturally then ice floats in water, as do icebergs in the sea.

Gas balloons

Gas balloons are an example of Archimedes' principle applied to gases. These balloons are filled with hydrogen, which is much lighter than (less dense) than air. Thus, the upthrust provided by air (weight of the air displaced by the balloon) is greater than the combined weight of the balloon and the hydrogen in it. This makes such balloons move up through air.



Fig. 4.21 The shape of boats and ships makes them float.

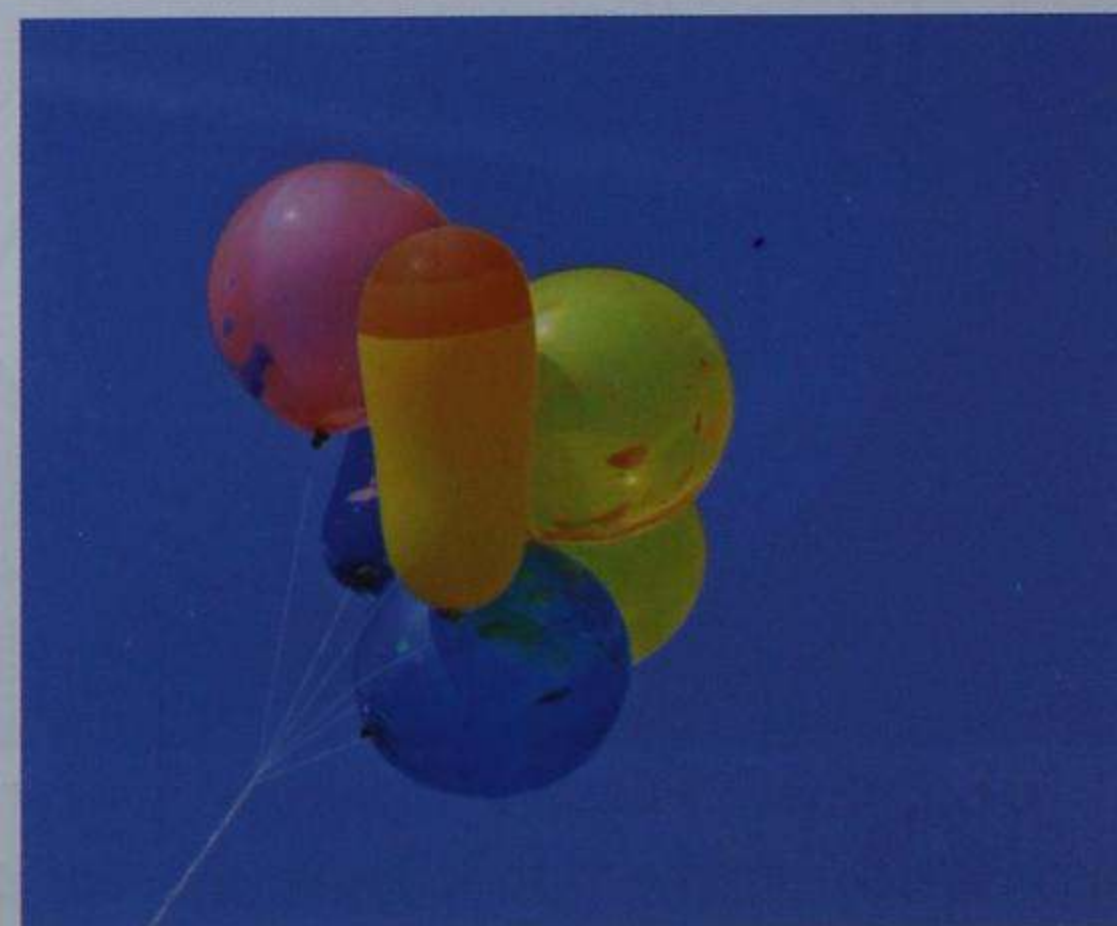


Fig. 4.23 Gas balloons move up through air because hydrogen is much lighter than air.

POINTS TO REMEMBER

- The molecules of matter attract each other. This intermolecular force is called cohesive force in the case of molecules of the same substance.
- The shape and size of a solid remains fixed due to strong cohesive force. The melting point of a solid depends on the strength of the cohesive force binding its molecules.
- The volume of a liquid is fixed but not its shape. A liquid flows and is incompressible.
- The densities of solids and liquids remain constant.
- In a gas, cohesion is negligible. Hence, a gas does not have a fixed volume or shape. The volume and density of a gas depend on the size of its container.
- Surface tension is the force acting per unit length of an (imaginary) line on a liquid surface. Its SI unit is N/m. It is responsible for the formation of liquid drops.
- Adhesion is the force of attraction between the molecules of a liquid and those of the surface it is in contact with. It makes the free surface of a liquid curve to form a meniscus.
- In thermal conduction, heat is passed on from one section of a material to another without any movement in the material. The conduction of heat depends inversely on the distance through which heat is conducted. It also depends directly on the area through which it is being conducted. Different materials conduct heat to different extents.
- Convection is the mode of transfer of heat in which sections of a fluid move up or down due to changes in density with temperature. Convection plays a central role in weather phenomena.
- Pressure is the force exerted per unit area. Its SI unit is N/m^2 .
- Atmospheric pressure decreases with height. Barometers are used to measure atmospheric pressure. The normal atmospheric pressure is taken as equal to the pressure exerted by a mercury column of height 76 cm.
- The product of the pressure and volume of a certain mass of gas remains constant. A gas exerts pressure equally in all directions.
- The pressure exerted by a column of liquid depends on its height. All points at the same horizontal level in a liquid have the same pressure. A liquid, like a gas, exerts pressure equally in all directions.
- Archimedes' principle states that the apparent loss in weight of a body when immersed in a liquid is equal to the weight of the liquid which it displaces. This is valid for liquids and gases.
- A body floats in a fluid when the weight of the fluid which it displaces is equal to its own weight. One can also say that a body floats in a fluid if its density is equal to or less than the density of the fluid.

EXERCISE

Short-Answer Questions

1. What is meant by cohesion? Explain briefly how it determines the general properties of solids, liquids and gases.
2. What is pressure? What is its SI unit?
3. Why do frying pans have a wide base?
4. Why does an object feel lighter in water than in air?

5. What causes the almost daily rainfall in equatorial regions?
6. What is a meniscus? What causes it?
7. Mention the three factors that determine the conduction of heat through a body.

Long-Answer Questions

1. Explain surface tension with an example of its effect.

2. Explain the processes of heat transfer through conduction and convection, with examples.
3. What is Archimedes' principle? Use this principle to explain how a boat made of iron floats in water.
4. Use a labelled diagram to describe the construction of a Fortin barometer.
5. Describe the construction of a hand pump, and explain its working.

Objective Questions

Choose the correct option.

1. Heat transfer in liquids and gases occurs
 - (a) mostly by conduction
 - (b) mostly by convection
 - (c) equally by conduction and convection
 - (d) by conduction in liquids and convection in gases
2. The air in a room exerts
 - (a) more pressure on the floor than on the roof
 - (b) more pressure on the floor than on the walls
 - (c) more pressure on the walls than on the roof
 - (d) equal pressure on the roof and the floor
3. The volume of water increases when it freezes to form ice.
 - (a) This is not correct.
 - (b) This explains why ice is a solid and water is a liquid.
 - (c) This explains why ice floats in water.
 - (d) This happens because the process takes place at a constant temperature
4. The two valves in a lift pump
 - (a) never move together
 - (b) always move together
 - (c) move together at certain times but not always
 - (d) move in different directions
5. In a Fortin barometer, there is some empty space above the mercury in the glass tube. This space
 - (a) contains air
 - (b) contains water vapour
 - (c) contains mercury vapour
 - (d) is a vacuum

Fill in the blanks.

1. Heat transfer in solids occurs almost entirely due to

2. A is formed at the surface of a liquid inside a narrow pipe.
3. The product of the pressure and volume of a particular mass of gas is
4. The on a body is equal to the weight of the liquid which it displaces.
5. All points at the same horizontal level in a liquid have the same
6. The pressure exerted by a column of liquid depends on its

Write true or false.

1. When any liquid changes into a solid, its density increases.
2. Thick walls of old houses reduce the conduction of heat.
3. The melting point of a solid depends on the strength of the cohesive forces binding it.
4. Normal atmospheric pressure can support a column of mercury of height 76 mm.
5. A cup is filled completely with ice. When this melts, some water will overflow.
6. Water rises in a lift pump due to atmospheric pressure.

Numericals

1. Assume that the atmospheric pressure is 10^5 N/m^2 , density of water is 10^3 kg/m^3 and $g = 10 \text{ m/s}^2$. Find the height of a column of water which will exert the same pressure as the atmosphere.
2. The density of kerosene is 800 kg/m^3 . Find the height of a column of kerosene which will exert the same pressure as the atmosphere.
3. A glass of height 15 cm is filled with milk. If the density of milk is 1.1 times that of water, find the pressure exerted by the milk at the bottom of the glass. (Neglect atmospheric pressure.)
4. A stone of volume 250 cc is completely immersed in kerosene. What will be its apparent loss of weight? (Express your answer in newtons.)
5. A solid object weighing 5 kg in air, weighs 4 kg in kerosene. Find (a) its volume and (b) its density.

Answers

1. 10 m 2. 12.5 m 3. 1650 N/m^2
4. 2 N 5. (a) 1250 cc (b) 4000 kg/m^3



The following activities will show you how surface tension actually acts like a stretched rubber sheet.

ACTIVITY

Place a needle on a piece of paper and then place the paper on the surface of some water in a bowl. When the paper gets soaked, it will sink, leaving the needle floating.

ACTIVITY

Make a loop with a smooth piece of wire. Place a piece of wire across the loop. Then dip the loop in a soap solution and take it out so that a film forms over the loop. Gently break the film on one side of the wire. The surface tension of the unbroken film on the other side will pull the wire across the loop.

