

Chapter 5

Three States of Matter

We learnt that matter has three states: solid, liquid and gas.



Iron can melt under high temperature conditions. What is the difference between its solid and liquid states?



5.1

Properties of Three States of Matter

Like water, all matter can exist in three states: solid, liquid and gas. What kinds of properties do these three states of matter have?

Lesson 1 Shape of The Three States of Matter

Shape is one of the properties of matter. Is the shape of solid, liquid and gas similar or different?



How is the shape of the three states of matter similar or different?



Activity : Observing the shape of a stone, water and air

What We Need:

➔ a stone, water, three balloons



What to Do:

1. Put the stone into the balloon and tie the top of the balloon. Fill the second balloon with water and blow up the third balloon. Tie the mouth of the balloons.
2. Press the stone, water and air in the balloons and observe the changes in their shape.
3. Based on your observations, think about the following questions:
 - (1) What happened to the shape of the stone, water and air when you pressed them?
 - (2) What shape do solid, liquid and gas have?
 - (3) How similar or different is the shape of the three states of matter?
4. Share your findings with your classmates. Discuss how the shape of the three states of matter is similar or different.

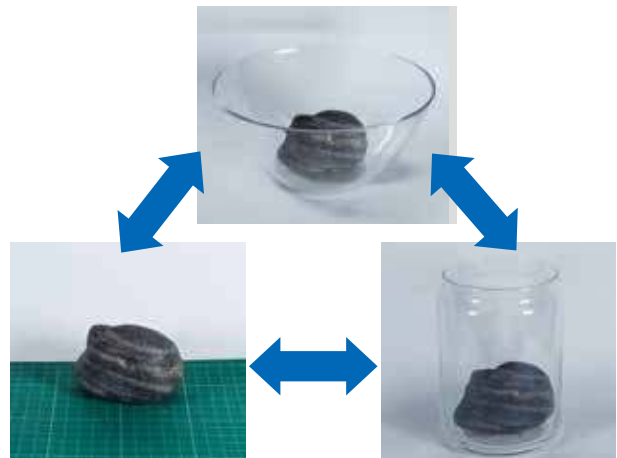


Summary

Solid, liquid and gas have specific characteristics in terms of their shape.

1. Solid

A solid has a **definite shape**. The shape of solid remains the same whether it is pressed or placed into different containers. For example, a stone will keep its shape wherever we press it or put it on a desk, in a glass or in a box. This means that the shape of a solid does not change. A solid has a definite shape.



A solid does not change its shape wherever it is placed in different place.

2. Liquid

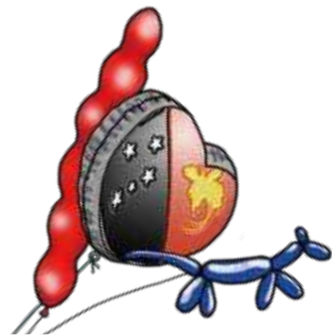
Liquid has **no definite shape**. Liquid changes its shape when it is pressed. Liquid also changes its shape to match the shape of the containers. For example, liquid takes the shape of the glass when it is poured into a glass. Liquid also changes its shape when it is spilled on a table. A liquid has no definite shape.



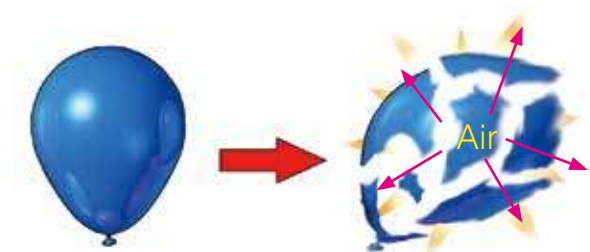
A liquid changes its shape to match the shape of the containers.

3. Gas

Gas has **no definite shape**. Gas changes its shape as it takes the shape of the container. If we fill the different shaped balloons with air, the air expands to fill the balloons and takes on different shapes. If the balloons burst, air will escape and spread out.



A gas expands to fill the balloons and takes on the different shapes.



If the balloon bursts, the air will escape.

Lesson 2

Volume of Three States of Matter

Solid has a definite shape but liquid and gas have no definite shape. How about the volume of solid, liquid and gas?



What characteristics of volume do the three states of matter have?



Activity : Heating and cooling water and air

What We Need:

- ➡ cold water, hot water, plastic bottle with its cap, straw, balloon, two bowls, removable adhesive

What to Do:

1. Stretch the mouth of the balloon over the top of an empty bottle. Place the bottle in the bowl of hot water for a minute and observe the size of the balloon. Then place the same bottle into a bowl of cold water for a minute and observe the size of the balloon. Record your observations.
2. Next, make a hole on the top of the bottle cap, big enough for a straw to fit through. Put a straw through the cap and seal around the hole in the cap using removable adhesive. Fill the bottle with water and screw on the bottle cap. Put the bottle in the bowl and pour hot water onto the bottle. Observe the water in the straw and record your observations.
3. Share your results with your classmates.



Be very careful when handling hot water!



Discussion

Based on your results, think about the following questions.

1. What happened to the size of the balloon when the empty bottle was heated and cooled? Explain why.
2. What happened to the water in the straw when hot water was poured on the bottle? Explain why.

Summary

Solid, liquid and gas expand when heated. They contract when cooled. The increase in volume of matter due to an increase in temperature is called **thermal expansion**.

1. Solid

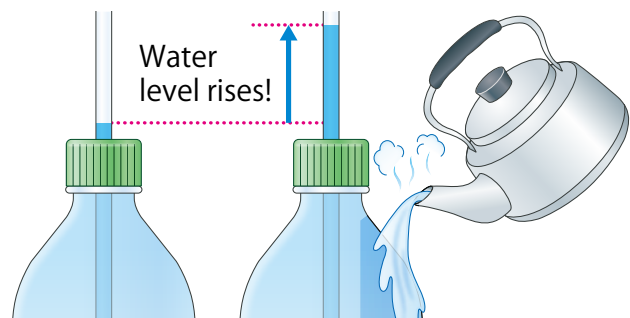
Solid expands very little when heated. Most large bridges include metal parts which look like two metal combs. There are spaces between these metal parts that allow the bridge to change length without breaking. If the bridge material expands and the bridge gets longer, the parts move closer together. If it contracts, they move further apart.



Metal parts allow the bridge to change length.

2. Liquid

Liquid expands a little more than solid. When hot water is poured on the bottle filled with water, the water inside the bottle becomes warmer and expands.



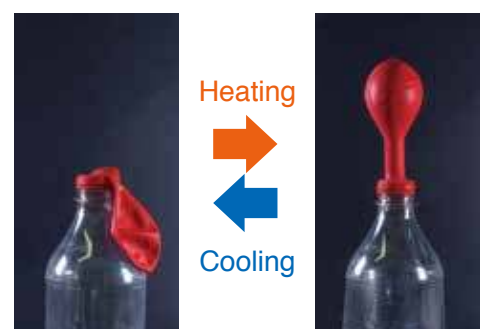
Water level rises when hot water is poured.

As a result of this the water level in the straw rises.

The volume of water increases.

3. Gas

Gas expands a lot more when heated. As the air inside the bottle heats, the balloon begins to expand. This is because the air inside the bottle expands and it spreads out into the balloon.



As the air inside the bottle is heated, the balloon begins to expand.

Lesson 3

Change in State of Matter 1: Solid and Liquid

Water can change its state by heating and cooling. How about other matter?



How does matter change its state from a solid to a liquid?



Activity : Heating and cooling a candle

What We Need:

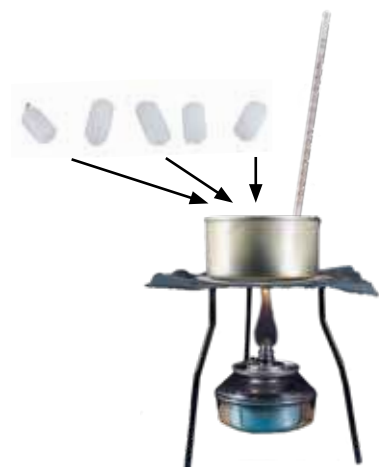
- ➔ thermometer, candle, burner, empty tin can, bowl with water

What to Do:

1. Draw a table like the one on the right.
2. Break up the candle into small pieces and put them in the empty tin can.
3. Place the thermometer in the tin and take the first reading. Heat the tin can using the burner as shown in the picture below.
4. Measure the temperature of the candle every two minutes and observe the candle until it melts completely.
5. Record the temperature and your observations in the table after every two minutes.
6. After melting, place the tin can in the bowl of water. Measure the temperature of the candle every two minutes and observe its hardness until all the candle wax hardens completely.
7. Record the temperature and your observations in the table.
8. Share your results with your classmates.

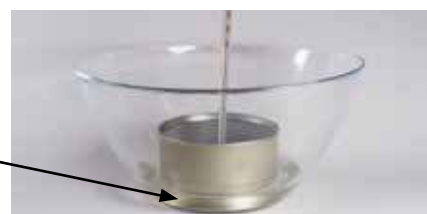


| Time (mins) | Temperature (°C) | Conditions of Candle |
|-------------|------------------|----------------------|
| 0 | | |
| 2 | | |
| 4 | | |
| 6 | | |
| 8 | | |
| 10 | | |
| 12 | | |
| ... | | |



Be careful when using the hot burner and water!

Water





Discussion

Think about the following questions based on your results.

1. What was the state of the candle before and after heating?
2. How did the state of the candle change after placing it in the bowl?
3. What was the temperature of the candle when it completely melted and hardened?
4. How does the candle change its state from a solid to a liquid and from a liquid to a solid?

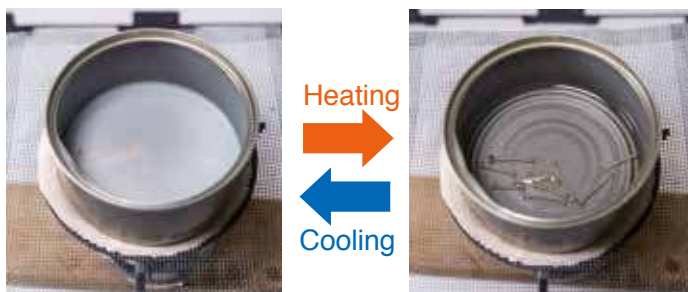
Do you remember what caused the change in the state of water, from ice to water and from water to ice?



Summary

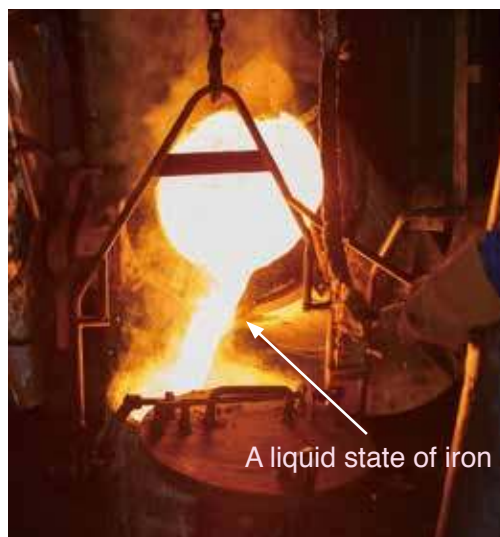
Matter can change its state from a solid to a liquid and from a liquid to a solid when it is heated or cooled. For example, a candle is a solid because it has a definite shape. When a candle is heated, it starts to melt.

A candle changes its state from a solid to a liquid by heating. When the melted candle is cooled, it hardens. A candle changes its state from a liquid to a solid when it is cooled.



A candle changes its state by heating and cooling.

When heat is added to a solid, its temperature will rise to a certain point where the solid starts to melt. This point is called the **melting point**. When heat is removed from the liquid, its temperature drops to a certain point where the liquid starts to freeze. This point is called the **freezing point**. The melting and freezing point of water is 0°C .



Iron starts melting at about $1\,500^{\circ}\text{C}$.

Lesson 4

Change in State of Matter 2: Liquid and Gas

Water can change its state from water to water vapour by heating and from water vapour to water by cooling. How about other matter?



How does a matter change its state from a liquid to a gas?



Activity : Change in state of ethanol

What We Need:

- ➔ ethanol, zip lock bag, tray, hot and cold water



What to Do:

1. Draw a table like the one shown below

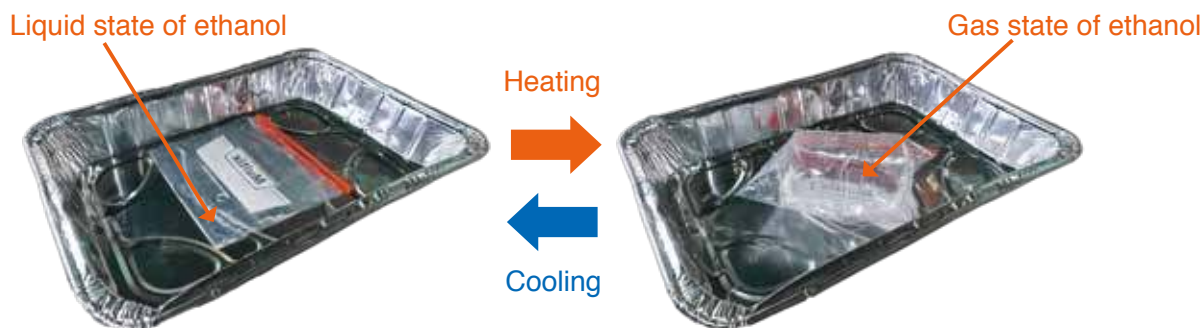
| | What is happening to the zip lock bag and ethanol? |
|------------------------------|--|
| Before pouring the hot water | |
| After pouring the hot water | |
| After pouring the cold water | |

2. Pour 5 mL of ethanol into the zip lock bag, zip it firmly and observe.
3. Place the zip lock bag in the tray and pour hot water onto it. Observe the zip lock bag and the ethanol in it. Record your observations in the table.
4. Pour cold water onto the zip lock bag. Observe the zip lock bag and the ethanol. Record your observations in the table.
5. Think about the following questions based on your observations:
 - (1) What happened to the zip lock bag and the ethanol after pouring the hot water? Explain why.
 - (2) What happened to the zip lock bag and the ethanol after pouring cold water? Explain why.
 - (3) How did the ethanol change its state?
6. Share your findings with your classmates.



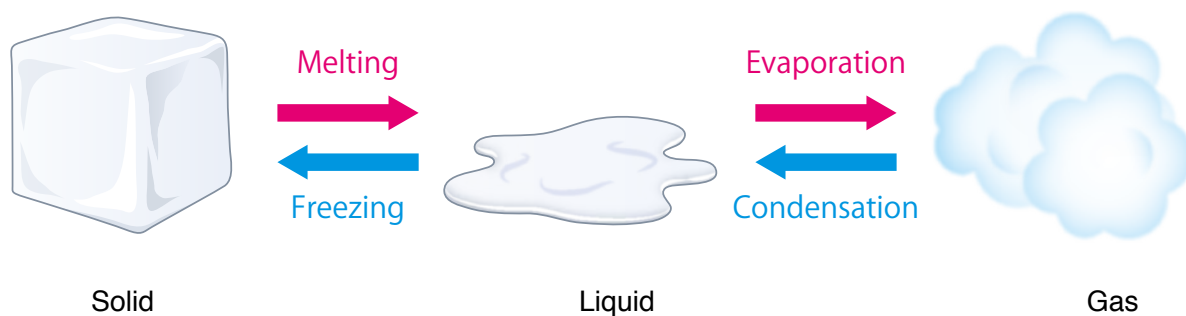
Summary

Matter can change its state from a liquid to a gas and from a gas to a liquid when it is heated or cooled. For example, ethanol is a liquid. When ethanol in a zip lock bag is heated, the zip lock bag expands and the amount of liquid ethanol decreases. This means that the ethanol changes its state from a liquid to a gas. The temperature at which a liquid changes into a gas is called the **boiling point**. When a gas state of ethanol in the zip lock bag is cooled, the zip lock bag shrinks and the amount of liquid ethanol increases. This means that the gas state of ethanol changes its state from a gas to a liquid.



Ethanol changes its states by heating and cooling.

All matter can be solid, liquid or gas depending on their temperature. Matter changes its state by heating or cooling. When heat is added to matter, it changes its state from a solid to a liquid or from a liquid to a gas. The process that causes a matter to change from a solid to a liquid is called **melting**. The change of state from a liquid to a solid is called **freezing**. When heat is removed from matter, it changes its state from a gas to a liquid or from a liquid to a solid. The change of state from a liquid to a gas is called **evaporation**. The change of state from a gas to a liquid is called **condensation**.



Matter can be a solid, liquid or gas depending on its temperature.

Shape of the Three States of Matter

| | | |
|---|---|--|
| | | |
| <p>Solid has a definite shape which does not change even if it is pressed or placed anywhere.</p> | <p>Liquid has no definite shape. It changes its shape when pressed or placed in different kinds of container.</p> | <p>Gas has no definite shape. It changes its shape as it takes the shape of the container.</p> |

Volume of Three States of Matter

- ☒ Solid, liquid and gas expand when heated and contract when cooled.
- ☒ Thermal expansion is the increase in volume of matter due to the increase in its temperature.

| Volume of Matter when Heated | | |
|------------------------------|--|--|
| Solid | Liquid | Gas |
| Solid expands very little. | Liquid expands a little more than solid. | Gas expands greater than liquid and solid. |

Changes in States of Matter: Solid and Liquid, Liquid and Gas

- ☒ Matter can change from one state to another by heating and cooling.
- ☒ All matter can be solid, liquid or gas depending on their temperature.



- ☒ The melting point is the point in which solid starts to melt when the temperature rises.
- ☒ The freezing point is the point in which liquid starts to freeze when the temperature drops.
- ☒ The melting and freezing point of water is 0°C .
- ☒ The boiling point is the temperature at which a liquid changes into a gas.

Q1. Complete each sentence with the correct word.

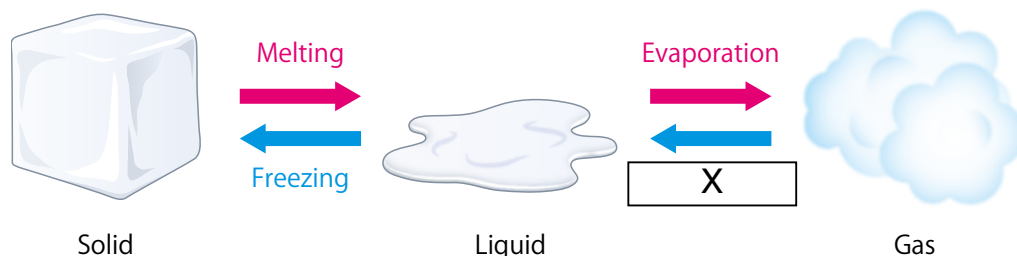
- (1) The three _____ of matter are solid, liquid and gas.
- (2) Unlike liquid and gas, _____ has a definite shape.
- (3) Gas changes its _____ as it takes the shape of different kind of containers.
- (4) The melting and freezing point of water is _____ °C.

Q2. Choose the letter with the correct answer.

- (1) Solid, liquid and gas _____ when they are heated.
 - A. contract
 - B. expand
 - C. disappear
 - D. burst
- (2) Which of the following is a property of liquid?
 - A. All liquids have colour.
 - B. Liquid never expand when it is heated.
 - C. Liquid has a definite shape.
 - D. Liquid increase its volume when its temperature increases.

Q3. Answer the following question.

What process of change in the state of matter is marked **X**?

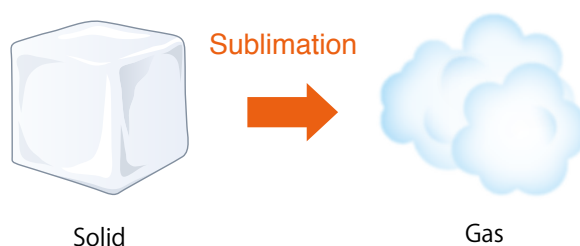


- Q4. Benny wanted to open the top of a cough mixture bottle but it was too difficult to open. The top is made of metal and the bottle is made of glass. He poured some hot water over the bottle top and then he was able to open it. What made it easier for him to open the top of the cough mixture bottle?

Do all substances change their state from solid to liquid and liquid to gas?

All substances mainly have three different states at various temperatures. The change from solid state to gas state requires the change of solid state to liquid state and liquid state to gas state.

If solids have enough vapour pressure at a particular temperature then they can change directly into air. The direct change of state from solid to gas is called **sublimation**.



Examples of Sublimation

One of the example of sublimation is dry ice. It is a solid form of carbon dioxide. Its temperature is less than -78°C . When dry ice gets exposed to air, it directly changes its state from solid to gas. When dry ice is placed in water, sublimation is accelerated and smoke like fog is created. The most common use of dry ice is to preserve food to keep it cool. This is because the temperature of dry ice is lower than ice and it does not make the food wet due to its sublimation process.

Another well-known example of sublimation is a substance known as naphthalene. Naphthalene is usually found in pesticides such as mothball. When mothballs sublime, they give off a pleasant fragrance which is also irritating to pests like cockroaches. For this reason they are used in drawers, shelves, wardrobes and suitcases in homes.



Solid state of carbon dioxide



Sublimation of carbon dioxide

5. Three States of Matter

Q1

Complete each sentence with the correct word.

- (1) Solid, liquid and gas increase its _____ when heated.
- (2) A solid has a definite _____.
- (3) The point at which solid starts to melt is called _____.
- (4) A change of state from a liquid to a gas is called _____.
- (5) Gas expands much more than solid and _____.

Q2

Choose the letter with the correct answer.

- (1) What happens when hot water is poured on a bottle filled with water?
 - A. The volume of the water will decrease.
 - B. The water in the bottle becomes warmer and expands.
 - C. The water in the bottle cools and contracts.
 - D. All water in the bottle evaporates.
- (2) Which of the following matter has no definite shape?
 - A. Oxygen and candle
 - B. Stone and water
 - C. Sand and sugar
 - D. Air and water
- (3) Which term best describes the process of change from solid to liquid?
 - A. Freezing
 - B. Evaporation
 - C. Melting
 - D. Condensation
- (4) Which of the following is the correct statement about the volume of matter?
 - A. The volume of liquid increases when it is heated.
 - B. The volume of solid decreases when it is heated.
 - C. Gas never expands when it is heated.
 - D. All matter do not change their volume when heated.

Q3

- (1) Danny observed and sketched the state of the candle as shown in the picture on the right. Classify the state of the candle near the flame as a solid, liquid or gas.



A burning candle

- (2) Study the diagram below.

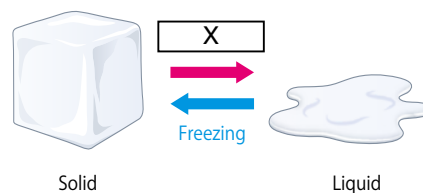


← Bowl of hot water

What will happen to the balloon when the bottle is placed into the bowl of hot water?

- (3) Explain your answer for (2).

- (4) Study the diagram shown on the right. What process is marked 'X'?



Q4

Kim placed a cup of water in a warm place. One week later, there was no water left in the cup. What happened to the water in the cup?