

# 1 The nature of matter

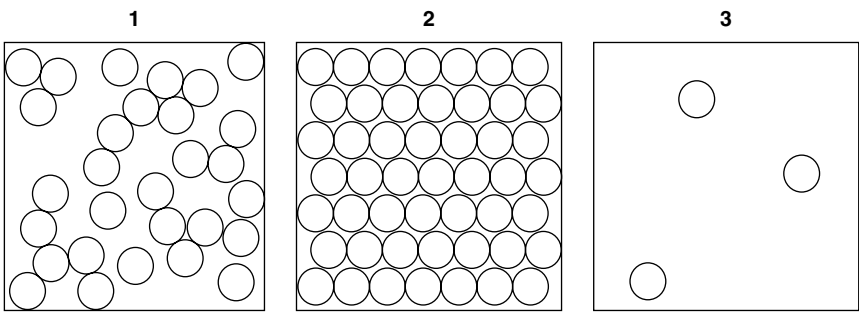
**This unit covers:**

- ☐ the physical states of matter and their basic properties
- ☐ changes between physical states of matter
- ☐ the kinetic particle theory
- ☐ filtration and distillation

**Exercise 1.1 The three states of matter**

This exercise discusses the basic properties of the different states and the changes of state brought about by changing temperature. It will develop your confidence in using the terms involved. It will help you discuss comparisons between the states.

- 1 Look at the following diagrams showing how the particles are arranged in a solid, liquid and gas. Use the diagrams, and your previous knowledge, to help you fill in the gaps left in the following table.



Physical state	Volume	Density	Shape	Fluidity
solid	has a fixed volume	.....	has a definite shape	does not flow
liquid	has a fixed volume	moderate to high	no ..... – takes the shape of the container	generally ..... .....
gas	no ..... ..... – expands to fill the container and can be compressed	.....	no definite shape – takes the shape of the container	flows easily



Complete the comparisons below using words given in the list. Each word should be used only once.

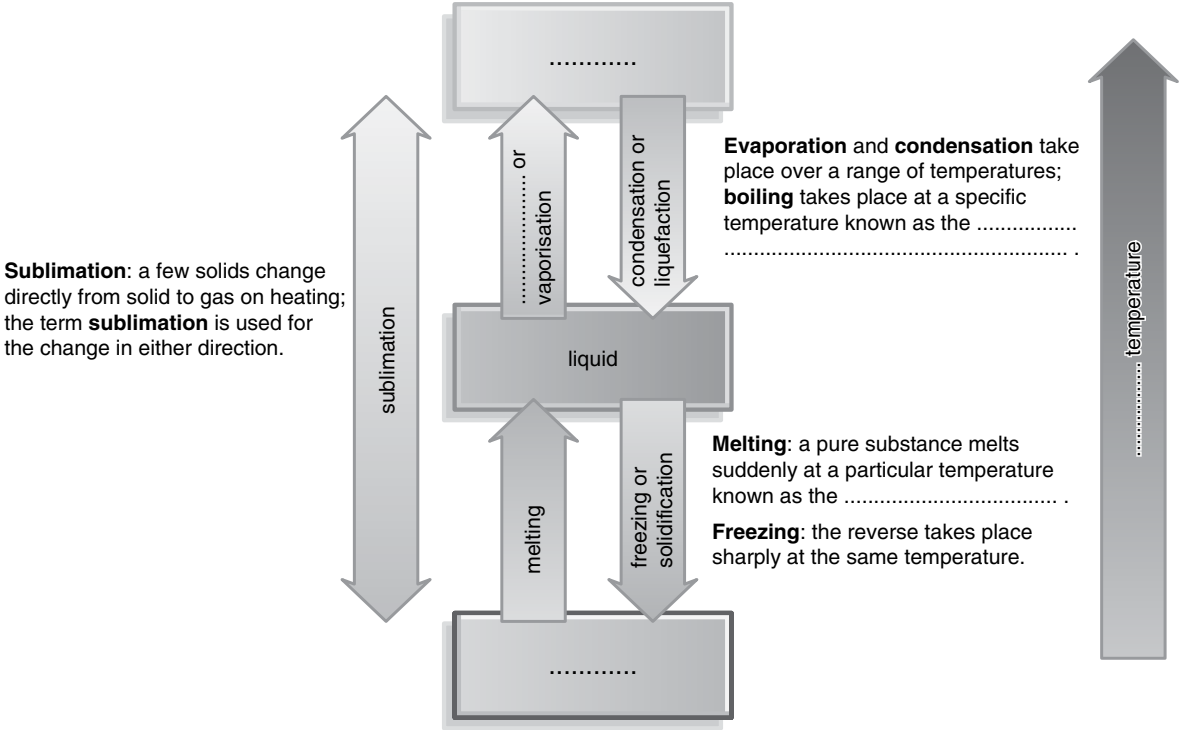
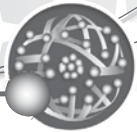
**fixed      lower      expands      higher      fluid**  
**more      compressed      pressure**

- a** Most solid substances have a ..... density than the liquid or gas.
  - b** The density of a gas is ..... than that of the liquid state.
  - c** The volumes of a solid and a liquid are ..... while a gas ..... to fill the container it is in.
  - d** Both gases and liquids are ..... states.  
A gas is ..... fluid than a liquid.
  - e** Solids and liquids have a fixed volume which is not changed by increasing the pressure. However, gases can be ..... by increased .....
- 2 a** Read the following description and use the information from it to complete the labelling of the diagram that follows.

All chemical substances can exist in three different forms (or **physical states**) depending on the conditions. These different **states of matter** are known as **solid**, **liquid** and **gas**. Changing the temperature conditions can change the state in which the substance exists. Increasing the temperature will eventually cause most solids to melt. This temperature at which a solid melts is the **melting point** of that substance. The substance has now become liquid.

If a liquid is left to stand, it will slowly evaporate. It becomes a vapour or gas. This evaporation can happen at any temperature. However, if the temperature is increased enough, it will reach a point where the liquid boils. Bubbles of gas form in the liquid and this temperature is the **boiling point**. Some substances evaporate and boil very easily. They are said to be volatile. At normal pressures very few substances can pass from the solid state directly to a gas. This is known as **sublimation**.

Liquids and gases can both *flow* and adjust to the shape of their container. They are said to be *fluid*. They can be poured into and out of the container. Liquids and gases are called *fluids*.



- b** Write a title that describes what this diagram is illustrating.  
.....
- c** What do you think will happen if we increase the temperature of a liquid?  
I think that if we increase the temperature of a liquid .....  
.....



### Exercise 1.2 Explaining physical processes

This exercise will develop your familiarity with the key ideas of scientific observation, explanation and definition. It will also further increase your confidence in talking about changes of state.

Compare these two sentences:

Ice becomes liquid at temperatures higher than 0 °C *because* it is above its melting point.

The melting point of ice is 0 °C so it becomes liquid at higher temperatures.

‘Ice becomes liquid at certain temperatures’ is an observation. ‘The melting point of ice is 0 °C’ is the explanation – it tells us why we see ice becoming liquid at temperatures higher than 0 °C. If we give the observation first, we use the word *because* to join it to the explanation. If we give the explanation first, we use the word *so* to join it to the observation.

observation *because* explanation

explanation *so* observation

Sometimes an observation can give us an idea for a *new* theoretical explanation, or *hypothesis*. Then we can link the observation to the idea using ‘*which suggests that*’:

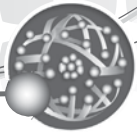
liquids are fluid *which suggests that* the particles in liquids can move around

observation *which suggests that* hypothesis

- 1** The following sentences are made up of two parts. Some sentences contain an observation and its explanation. Others contain an observation which suggests a hypothesis. Complete each sentence by writing either *because*, or *so*, or *which suggests* between the two parts. Here is an example to help you:

Puddles of water disappear after the rain has stopped .....*because*..... water evaporates into the air.

- a** Iron is denser than water ..... a block of solid iron sinks when placed on the surface of water.
- b** Ethanol is more volatile than water ..... it evaporates more quickly than water.
- c** A liquid can be poured from one beaker to another ..... a liquid is fluid and can flow from one place to another.
- d** A gas spreads out to fill its container ..... that the particles of a gas can move around freely.



- e** Water evaporates more quickly the higher the temperature ..... puddles disappear quickly on a warm day.
- f** A solid object has a fixed shape .....that the particles in a solid are held in fixed positions.
- g** A gas can be compressed when pressure is applied .....that there is space between the particles in a gas.

Some of these observations are the basis of the kinetic particle theory of matter. We will consider that theory further in the next exercise.

- 2** The following statements *define* certain terms used in connection with changes of state. All the terms have been used in this unit already.

The word *define* is a command word often used at the start of certain exam questions. It means you must answer with a short, but complete, meaning of the term. Look closely at your syllabus to see which ideas are usually asked to be defined.

It is worth learning these definitions rather than trying to make them up in the exam.

Definitions often use the words **which** or **that** to link the parts of the definition together. For example, Melting is the process **that** takes place when a solid turns into a liquid.

- a** Complete these first examples by pairing up the two parts of the sentence. Put the letter that goes with each number in the box provided beneath the table. The first example has been done for you. Once you have completed the exercise, write out the whole sentence for each definition in your notebook to help you remember it.

<b>1</b>	Freezing is the process ...	<b>A</b>	... <i>that</i> can flow from one place to another.
<b>2</b>	Fluids are substances ...	<b>B</b>	... <i>which</i> a solid turns into a liquid.
<b>3</b>	The melting point is the temperature at ...	<b>C</b>	... <i>that</i> turns a liquid into a gas.
<b>4</b>	Boiling is a process ...	<b>D</b>	... <i>that</i> turns a liquid into a solid.

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>D</b>			

Each of the following statements defines the meaning of the term or word stated. However, the words of the definition have been scrambled. Sort out the words in the correct order and write the definition in the space provided.



Here is an example to help you:

**Boiling point**

the temperature at which bubbles of gas are formed throughout a liquid and the liquid boils.  
The temperature at which bubbles of gas are formed throughout a liquid and the liquid boils.

**b volatile**

a word used to describe a liquid that has a low boiling point and easily evaporates.

.....

.....

**c freezing**

the reverse of the process of melting, also called solidification.

.....

.....

**d evaporation**

the process by which a liquid turns into a gas below its boiling point.

.....

.....

**e sublimation**

the process by which a solid turns directly into a gas.

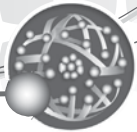
.....

example: carbon dioxide is a solid.

.....

**3** The following table summarises the trends in the properties of the different states of matter. Complete the table by crossing out the incorrect word in each case.

Property	Solid	Liquid	Gas
density	increases / decreases	_____→	_____→
compressibility (the ability to change its volume at constant temperature)	increases / decreases	_____→	_____→
fluidity (the ability to flow)	increases / decreases	_____→	_____→

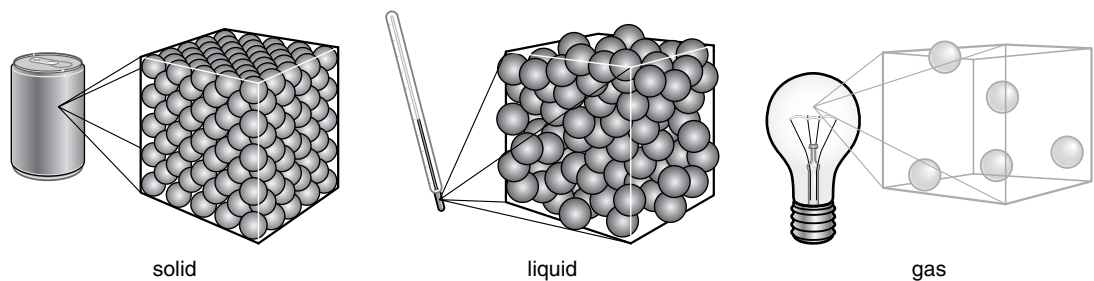


Exercise 1.3 The kinetic particle model

This exercise will help you when describing the nature of the different states and the changes between them.

The kinetic particle model helps us to understand the different states of matter. All substances are made up of *particles*, which can be atoms or molecules (see Unit 2). The model describes the organisation and movement of these particles in the three states of matter.

- 1 The following diagrams show the organisation of the particles in the three physical states of matter. Below the diagrams are descriptions of how the particles are organised and move. Follow the instructions to complete each description.



- a Complete this description of a **gas** by deleting the incorrect words.

The particles in a gas are spread far apart in *fixed/random* positions. Their arrangement is totally *regular/irregular*. The particles are *able/unable* to move around freely; they can collide, or bounce off each other.

In the sentence in part **a** above, we see two prefixes. A prefix is a group of letters that come before a root word. In this case, the root words are *able* and *regular*. The prefixes are *ir-* and *un-*. These two prefixes both mean **not**.

*Ir-* is mainly used with adjectives where the root begins with the letter 'r'; irregular, irrelevant and so on.

*Un-* is used with verbs, adjectives and adverbs; untested, uninteresting, unexpectedly.

Prefixes always change the meaning of the word. There are some more examples in Unit 2.

- b Complete this description of a **liquid** by writing the correct words on the lines. You can use the description of a gas above as a model.
- The particles in a liquid are packed ..... together. Their arrangement is ..... The particles are ..... to move around freely, though they always stay in contact with each other.





- c** Complete this description of a **solid** by completing the sentences. You can use the descriptions of a gas and a liquid above as models.
- The particles are .....
- Their arrangement is .....
- The particles are .....; they can only vibrate in their fixed positions.
- The kinetic particle theory also explains the changes taking place when a substance is heated and changes state.
- 2 a** Complete the following descriptions of what is happening to the movement of the particles as a solid substance is heated. Choose the best word from the alternatives given. Cross out the incorrect word of the pair suggested.

As the **volume/temperature** rises the particles in a liquid **lose/gain** more energy and move around **faster/slower**. Some particles can escape from the surface; this is **evaporation/condensation**. The temperature increases until the **boiling point/evaporation point** is reached. At this point the particles have enough energy to break the forces holding the liquid together. Gas **bubbles/drops** form in the liquid and the liquid **steams/boils**.

As a solid is heated the particles **rotate/vibrate** more **strongly/weakly**. At the **condensation point/melting point** the particles have enough **energy/power** to break the forces holding them in one place. Now they can **move/step** past each other. And so we see that the solid **freezes/melts** and turns to **liquid/vapour**.

