

> Chapter 1

States of matter

IN THIS CHAPTER YOU WILL:

Science skills:

- describe the key properties of the physical states of matter and the changes that take place between them
- understand the kinetic particle theory of matter and the nature of diffusion and dissolving.

English skills:

- meet and practise the verbs involved in describing changes of physical state, and the nouns resulting from those verbs
- develop the ability to construct sentences linking facts and their consequences.

Exercise 1.1 The three states of matter

IN THIS EXERCISE YOU WILL:

Science skills:

- describe the key properties of the different physical states of matter and the changes of state brought about by changing temperature.

English skills:

- look at the use of verbs and nouns when describing chemical processes.

KEY WORDS

boiling: the process of change from liquid to gas at the boiling point of the substance; a condition under which gas bubbles are able to form within a liquid – gas molecules escape from the body of a liquid, not just from its surface

evaporation: a process occurring at the surface of a liquid, involving the change of state from a liquid into a vapour at a temperature below the boiling point

fluid: a gas or a liquid; they are able to flow

matter: anything that occupies space and has mass

1 States of matter

1 a The table below shows how the particles are arranged in a solid, liquid and gas. Complete the table using information in Figure 1.1 and your own knowledge.

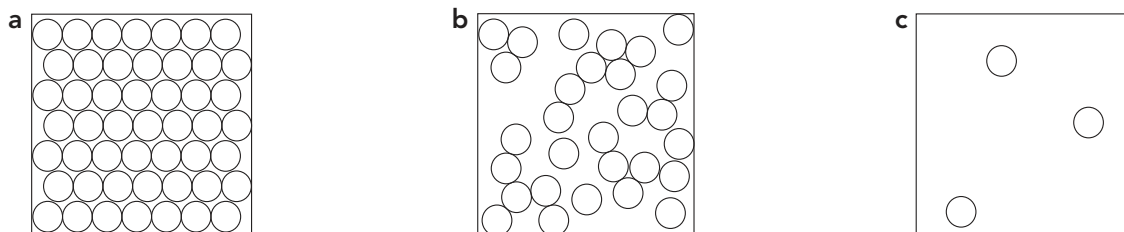


Figure 1.1: The arrangement of particles in a: a solid, b: a liquid and c: a gas.

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	does not have a – takes the shape of the container	generally
gas	does not have a – expands to fill the container and can be compressed	.....	does not have a definite shape – takes the shape of the container	flows easily

b Complete the following sentences i–v using the words below. Each word should be used only once. Note that the sentences express comparisons.

- compressed expands fixed fluid higher**
lower more pressure

- i Most solid substances have a density than their liquid or gas form.
- ii The density of a gas is than that of the liquid state.
- iii The volumes of a solid and a liquid are, but a gas to fill the container it is in.
- iv Both gases and liquids are states. A gas is **fluid** than a liquid.
- v Solids and liquids have a fixed volume which is not changed by increasing the pressure. However, gases can be by increased

LANGUAGE TIP

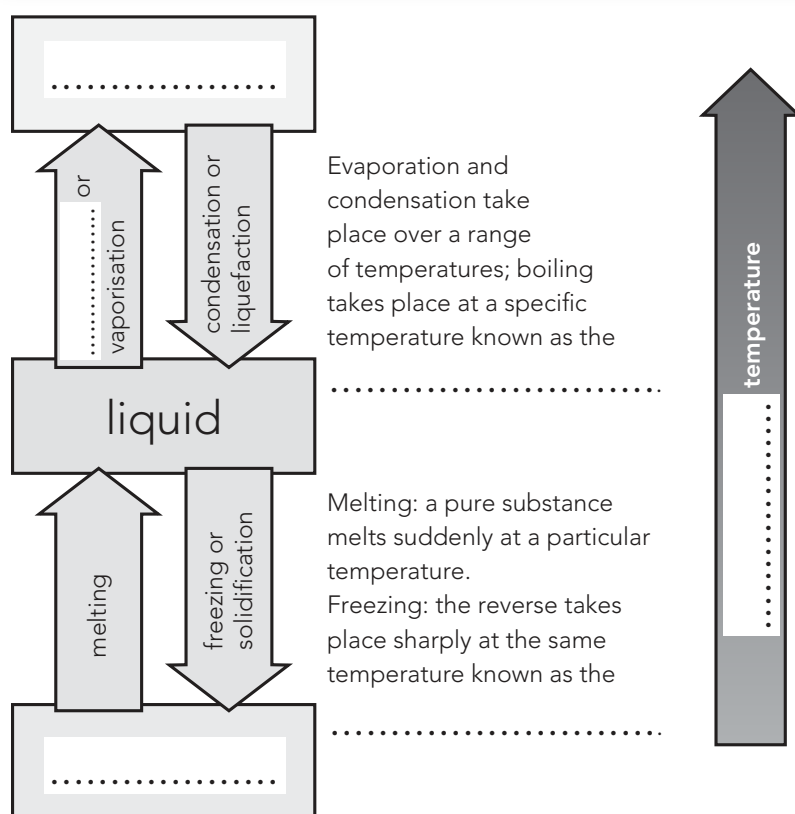
You can compare things using comparative adjectives with *than*. Short adjectives become comparative when you add *-er*; longer adjectives become comparative by adding *more* before them. (See Chapter 8.)

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2 a Read the following passage, then complete the labels in the diagram.

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

If a liquid is left alone, it will slowly evaporate. It becomes a vapour or gas. **Evaporation** can happen at any temperature, but 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 volatile.



b Write a suitable title for the diagram.

.....

LANGUAGE FOCUS

When you describe the action of a substance changing state, or of an agent (e.g. a person) carrying out an action, you use a verb. For example, the verb *to filter*:

The salt crystals were filtered from the solution using filter paper.

When you look for a verb in a dictionary, you will often find it with *to* before it, but you frequently do not need to use the *to*.

The names of the processes taking place are nouns:

Maya carried out the filtration using filter paper and a funnel.

Note that most nouns describing processes end in *-ation*. If the verb ends in *-e*, change the *-e* to *-ation*. However, with some verbs, particularly verbs ending in *-fy* (e.g. *solidify*), you need to change the *-y* to *-ication*.

The product of the change is also a noun:

Maya collected the filtrate in a conical flask.

3 Complete the table with the correct forms of the words.

Verb	Noun – name of process	Noun – product of process
to condense	.....	.....
to	evaporation	vapour
to .....	.....	crystals
to precipitate	.....	precipitate
to	solidification	solid

Exercise 1.2 Explaining physical processes

IN THIS EXERCISE YOU WILL:

Science skills:

- investigate changes of state based on the key ideas of scientific observation, explanation and definition.

English skills:

- use linkers *so*, *because* and *which suggests that* to link scientific facts with consequences and hypotheses.

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LANGUAGE FOCUS

Compare these sentences:

- 1 *The melting point of ice is 0°C, so it becomes liquid at higher temperatures.*
- 2 *Ice becomes liquid at temperatures higher than 0°C because it is above its melting point.*

The melting point of ice is 0°C = a fact.

It becomes liquid at higher temperatures = a consequence, result or logical conclusion.

If the fact is before the consequence, use *so*.

If the consequence is before the fact, use *because*.

Sometimes a fact gives us an idea for a new theoretical explanation, or hypothesis. If so, we can link the fact and the hypothesis using *which suggests that*:

Fact		Hypothesis
┌──────────┐	┌──────────────────────────┐	
└──────────┘	└──────────────────────────┘	
Liquids are fluid, <i>which suggests that</i> the particles in liquids can move around.		

- 4 The following sentences **a–g** consist of two parts. For each sentence, decide which part expresses the fact and which part expresses the consequence, then complete each sentence using *because*, *so* or *which suggests that*. Here is an example to help you:

Iron is denser than water, so a block of iron sinks when placed on the surface of water.

- a Ice floats on water,, unusually, liquid water is denser than solid water (ice).
- b Ethanol is more volatile than water, it will evaporate more quickly than water at the same temperature.
- c A gas spreads out to fill its container the particles of a gas can move around freely.
- d A liquid can be poured from one beaker to another a liquid is fluid and can flow from one place to another.
- e A gas can be compressed when pressure is applied, there is space between the particles in a gas.

1 States of matter

- 5 The following questions discuss different terms used to describe changes of state.
- a Match the sentence halves in the following grid by drawing lines to connect the correct halves. The first one has been done for you.

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

LANGUAGE TIP

Sentences with important terms and their definitions, like the sentences in Exercise 5a, are useful to learn 'by heart'. Make a note of this type of sentence in your notebook and look at them from time to time.

- b Put the words below the terms **i–iv** in the correct order to give the definition of the term. The first one has been done for you.

i boiling point

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

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

ii volatile

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

.....

.....

iii freezing

reverse which the is process the melting of can solidification called also be and.

.....

.....

iv evaporation

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

.....

.....

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Exercise 1.3 The kinetic particle theory

IN THIS EXERCISE YOU WILL:

Science skills:

- investigate the nature of the different states and the changes between them in terms of how the particles present are organised.

English skills:

- complete a short paragraph to describe the different states and the movement of the particles in them.

KEY WORDS

kinetic particle theory: a theory which accounts for the bulk properties of the different states of matter in terms of the movement of particles (atoms or molecules) – the theory explains what happens during changes in physical state

- 6 The **kinetic particle theory** describes the organisation and movement of particles in the three states of matter (see Figure 1.2).

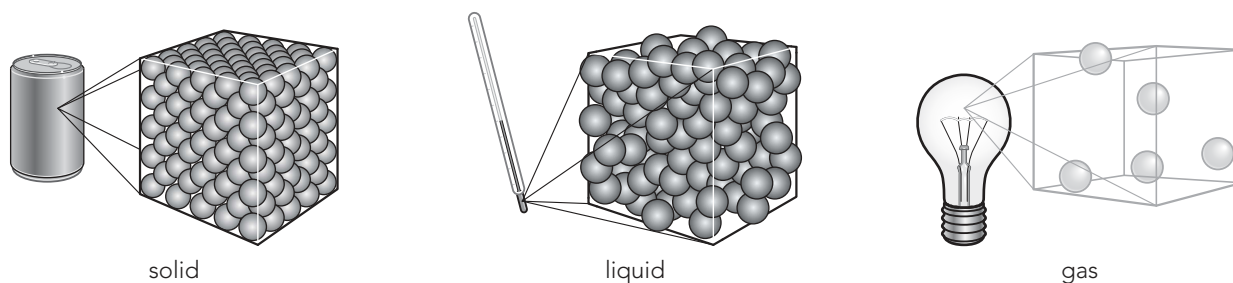


Figure 1.2: Organisation of particles in the three states of matter.

- a Circle the correct options to complete this description of a gas.
 The particles in a gas are far apart in **fixed** / **random** positions.
 Their arrangement is totally **regular** / **irregular**. The particles are **able** / **unable**
 to move around freely; they **can** / **can't** collide, or bounce off each other.
- b Complete the following description of a liquid. Use the description of a gas
 in part a as a model.
 The particles in a liquid are packed closely together. Their arrangement is
 The particles are to move around
 freely, though they can often with each other.

LANGUAGE TIP

Prefixes can help you understand words. For example, words with *un-* (*unable*, *unstable*) or *ir-* (*irregular*, *irrelevant*) mean 'not' (*not able*, *not stable*, *not regular*, *not relevant*).

7 a Circle the correct words in paragraphs **i** and **ii** to complete descriptions of what happens to the movement of the particles as a solid or a liquid is heated.

i 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**.

ii 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**.

b Use the phrases given to complete the following paragraph describing how particles change their movement and organisation when a liquid freezes.

turns into a solid **forces between particles** **lose energy**

move around more slowly **fixed positions** **freezing point**

As the liquid cools, the particles and
 The
 become stronger. At the, the particles
 become held in, and so the liquid freezes
 and

Exercise 1.4 Diffusion and dissolving

IN THIS EXERCISE YOU WILL:

Science skills:

- describe how the movement of particles in a liquid or gas results in the processes of diffusion and dissolving.

English skills:

- become more familiar with the specific words used to describe diffusion and dissolving.

KEY WORDS

diffusion: the process by which different fluids mix as a result of the random motions of their particles

dissolving: a process that produces a solution of a solid or gas in a liquid, e.g. when sugar dissolves in water

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8 **Diffusion** allows substances to spread and mix; the particles move to fill all the available volume (see Figure 1.3). It is a key part of the process of **dissolving**.

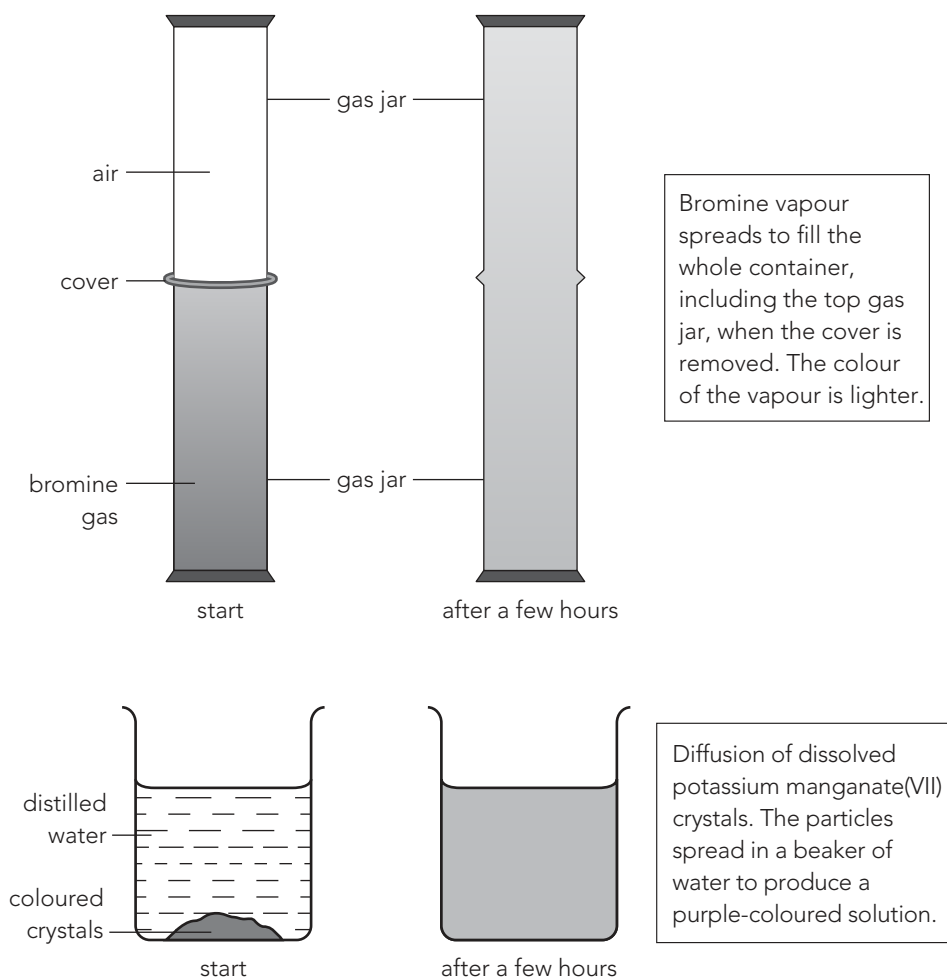


Figure 1.3: Diffusion of a gas and in a liquid.

Complete the following bullet points about diffusion.

Diffusion:

- is the process occurring when
- is a random process that can only take place in
- is much faster in
- is faster at higher

- 9 a Here are ten important words used in describing how substances dissolve.

concentrated dilute dissolved insoluble saturated
soluble solute solution solvent undissolved

Find three pairs of words with opposite meanings.

dilute *C*

.....

.....

- b Using the four words you did not use in part a, complete the following sentences.

- i A is made up of a dissolved in a
- ii When no more can be dissolved at a particular temperature, the is said to be