PARTICLE MODEL 2

2.1 There are three states of matter

2.2 Scientists' understanding of matter has developed over thousands of years

2.3 The particle model explains matter

2.4 The particle model can explain the properties of matter

2.5 Increasing kinetic energy in matter causes it to expand

What if?

M&Ms

What you need:

M&Ms (red is best), 250 mL beaker

What to do:

1 Pour 100 mL of water into the beaker.
2 Place one M&M in the centre of the beaker.
3 Allow the water and the red M&M to settle.
4 Time how long the colour takes to reach the walls of the beaker.

What if?

» What if the water were warm? Would the colour move faster or slower
» What if the water were chilled?
» What if you stirred the water?

2.1 There are three states of matter

Matter is the name given to all substances. There are three major states of matter – solid, liquid and gas. Solids, liquids and gases are all around us. Steel, concrete, wood and plastic are all solids. Water and cooking oil are liquids. Carbon dioxide is a common gas – you can see it as bubbles in soft drinks. Air is a mixture of gases. The smell of a barbecue is caused by gases that leave the food as it is being cooked. Many substances can be found in more than one state.

Solids, liquids and gases

Water is the most common substance that we experience in its different states of matter. Solid water is ice. We are all familiar with liquid water, and water as a gas is known as water vapour. In the freezer, liquid water solidifies into ice. On a cold night, frost (solid) forms water vapour (gas) in the air. On a warm day, puddles (liquid) will evaporate to become water vapour.

Although the ocean and iceberg shown in Figure 2.2 may look and behave very differently, they are both different forms of water. The ocean is liquid and the iceberg is solid. There is also water vapour, which is a gas, in the air. Clouds are made of small liquid water droplets. All of these different states of water are made of the same 'building blocks', or water particles.

Often substances can be described as just one state. However, some substances seem to be made of more than one state of matter. Sometimes we can see the states of a mixture, such as in honeycomb confectionary, which is a combination of solid, liquid and gas. But other times it is difficult to tell the state of mixtures. How would you classify slime or jelly?

Figure 2.1 A glass of iced lemonade contains the three states of matter.

Figure 2.2 Solid water floats on liquid water.

EXPERIMENT 2.1: COMPARING STATES OF MATTER
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EXPERIMENT 2.1A: THREE STATES OF WATER
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Figure 2.3 Honeycomb is a combination of solid and gas. Or is it?

Figure 2.4 Liquid water. When most of us think of water, we think of the **liquid** form that comes out of our taps. Liquid water sits at the bottom of cups and flows smoothly over surfaces. Water can fit into containers of all shapes and sizes. It is flexible.

Change of state

The temperature that causes water to become a solid is called its **freezing temperature**. If heat is added back to the solid water, the ice melts. This temperature is called the **melting point**.

The process of making a gas from water is called **evaporation**. The temperature at which the gas or vapour starts to form is called the **boiling point**. If heat is removed from the steam, the gaseous water slows its movement until it once again forms liquid water. This process is called **condensation**.

Figure 2.5 Solid water. When heat is removed from liquid water, the movement of the water slows. The water has been **solidified**. This is the **solid** form of water called ice. Like all solids, ice holds its shape even when it is tipped from a container.

Figure 2.6 Gas water. When heat is added to liquid water, the water starts to move faster. Eventually it becomes a gas called **water vapour**. The gas has much more energy than a liquid or solid. It does not sit at the bottom of a container. Instead it moves freely around the whole container.

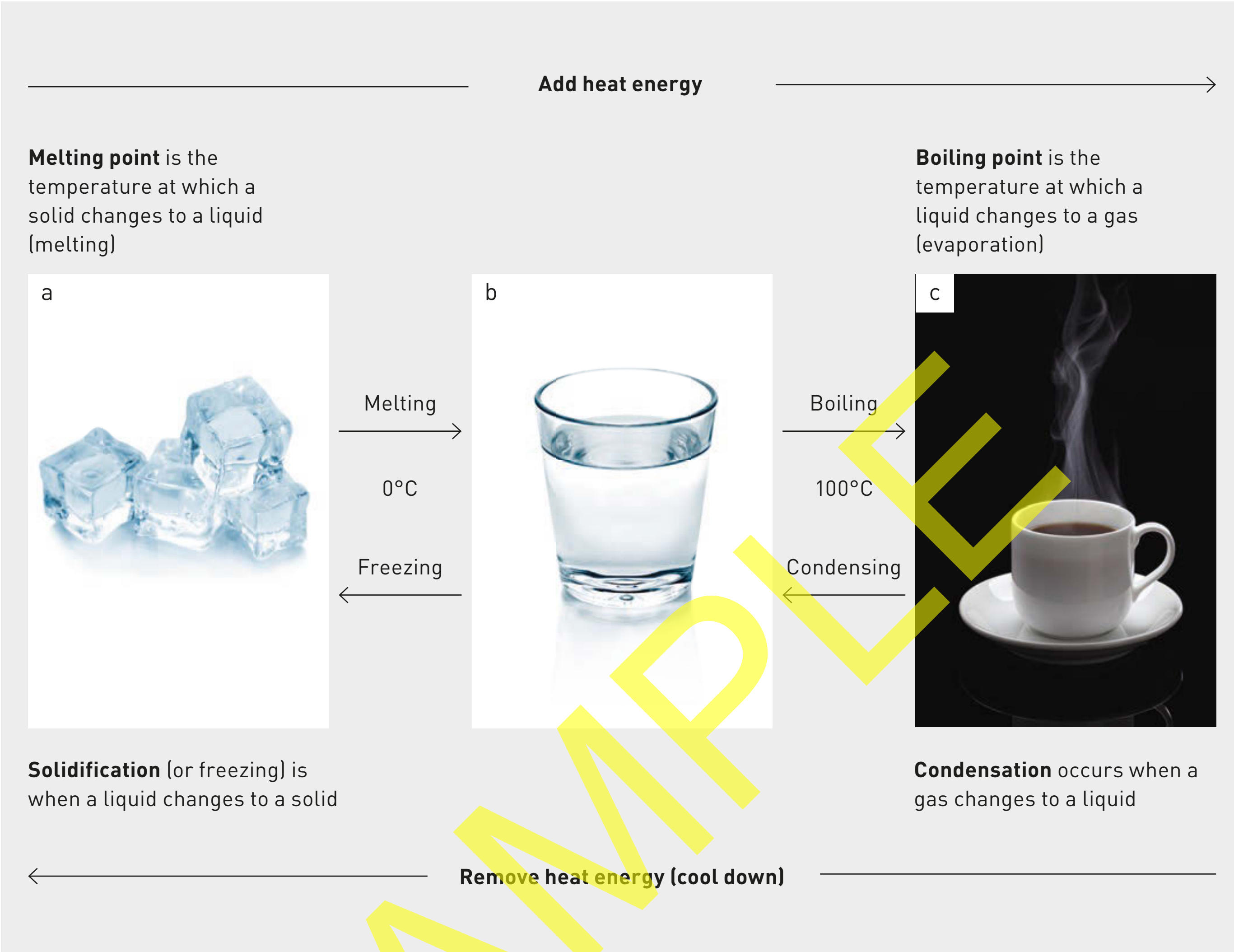


Figure 2.7 Adding or removing heat energy can change the state of water.

Describing matter

The properties of a substance are the characteristics that make it unique. Solids, liquids and gases have unique properties. Solids do not change their shape and cannot be compressed. Liquids cannot be compressed and change their shape to fit the container holding them. Gases completely fill the container holding them and can be compressed. Some substances are important to us because of particular properties. For example, one property of water is that is can be used to dissolve many other substances. This makes water useful for cleaning clothes, cooking and experiments in a chemistry laboratory.

The properties of substances can be divided into two groups: physical and chemical properties.

Physical properties are what we can observe and measure without changing the substance into something else. Examples of physical properties are colour, texture, boiling point, density, heat capacity and how easily the substance can dissolve other substances or be dissolved itself.

Chemical properties are what a substance does in a chemical reaction. Examples include bubbling, permanent colour change and permanent change of state.

Table 2.1 Properties of water.

PHYSICAL PROPERTY	VALUE
Melting point	0°C
Boiling point	100°C
Colour	Colourless
Density	1.00 g/mL at 25°C

Figure 2.8 You can sometimes see condensation when you breathe out on a cold morning. The water gas in your breath becomes a fine liquid when it hits the cold air, making what is commonly called 'dragon breath'.

Check your learning 2.1

Remember and understand

1 Group the following substances according to their state of matter as a solid, liquid or a gas, or even a combination of states: ice cream, chocolate bar, clouds, thick smoke, glass, honey, cake or bread, mashed potato, paper, peanut butter (smooth), cling wrap, play dough, sand, steam, slime.

2 Describe what happens to water when it:

a evaporates

b condenses

c freezes.

3 By applying heat to liquid water, what could happen to its state?

4 What is meant by a property of a substance?

5 Why are the properties of matter so important to us?

6 What are the similarities and differences between physical and chemical properties?

Apply and analyse

7 What is the:

a melting point of water?

b boiling point of water?

8 Refer to the table below. Which substance has the:

a lowest melting point?

b highest melting point?

c lowest boiling point?

d highest boiling point?

SUBSTANCE	MELTING POINT (°C)	BOILING POINT (°C)
Water	0	100
Iron	1535	2750
Lead	327	1750
Mercury	–39	357
Table salt	805	1413
Oxygen	–219	–183
Nitrogen	–210	–196

9 Decide whether the following properties are physical or chemical: the ability to be hammered into flat sheets (malleability), the ability to explode, the amount of vapour released at different temperatures.

10 Select a common substance, such as cling wrap or vinegar. Name some of the physical properties of this substance.

Evaluate and create

11 A student claimed a frozen drink bottle was leaking because condensation had formed on the outside of the container. How would you explain to the student where the condensed water came from?

2.2 Scientists' understanding of matter has developed over thousands of years

Science involves developing hypotheses, testing them with reproducible experiments and modifying ideas. When an idea becomes supported by all the current evidence, then it becomes a **theory**. The particle theory of matter has been tested and refined by scientists for more than 2000 years.

Democritus

Over 2400 years ago, Democritus, a Greek philosopher, put forward the idea that that all matter is made up of particles. He proposed that if you were to cut up these particles into smaller and smaller pieces, you would eventually have tiny particles that could not be cut up any more. Democritus called these particles *atomos*, which is Greek for 'indivisible'. This is the origin of the word **atom**.

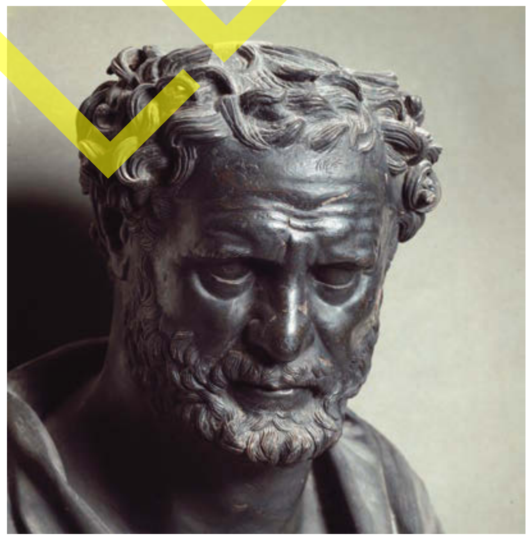


Figure 2.9 Democritus (c. 460–370 BCE) proposed that all matter is made of atoms.

John Dalton

It was not until more than 2000 years later, in the early 1800s, that the Englishman John Dalton developed Democritus's idea further. Dalton's ideas were based on the results of experiments performed by many earlier chemists. Dalton studied these results and proposed a model to explain them. His model was that matter is made of particles.

Dalton's ideas are outlined below.

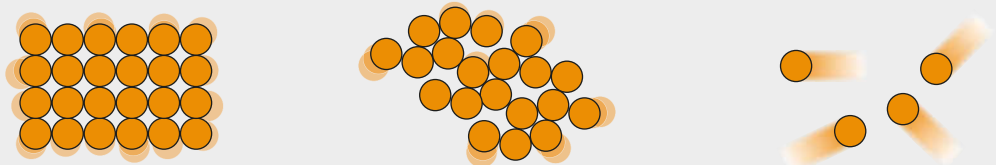
> All matter consists of tiny particles called atoms.
> Atoms cannot be created or destroyed, and are indivisible.
> All atoms of the same **element** are identical, but different from atoms of other elements.
> When atoms combine to form **compounds**, each atom keeps its identity.
> Atoms combine to form compounds called **molecules** in simple whole number ratios. For example, hydrogen and oxygen combine in a ratio of 2:1 to form water, now written as H_2O.

Figure 2.10 John Dalton (1766–1844) developed Democritus's ideas about particles.

Solids
The particles are close together. They are held in a regular arrangement and vibrate around a fixed point.

Liquids
The particles are close together, but they can move and slide over each other.

Gases
The particles are far apart and move quickly on their own. They spread out to fill the space available to them.



Modern chemistry

This new understanding encouraged scientists to find out more and more about these tiny particles, eventually leading to the branch of science now called **chemistry**.

We can add some new ideas to Dalton's list to help us explain matter.

> Particles are too small to be seen.
> Particles are always moving. When it is hotter, the particles move faster; when it is cooler, the particles move slower.
> Particles have mass.
> Particles can join to make larger particles. When they combine, their masses add together.
> There are spaces between particles.
> Forces hold particles together to stop them from separating.

All these ideas or rules explain how particles act in real substances. The real particles follow these rules in all substances.

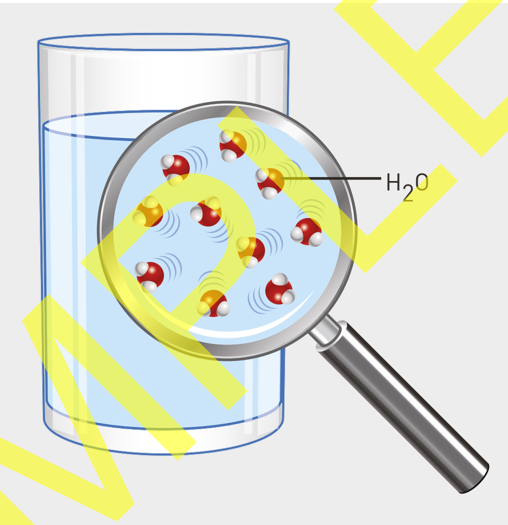


Figure 2.11 A glass of water is made of molecules. Each molecule contains two hydrogen atoms and one oxygen atom.

Check your learning 2.2

Remember and understand

1 What was the major difference between the ideas proposed by Democritus and Dalton?

2 How is an 'idea' different from a 'theory'?

Apply and analyse

3 Consider a school assembly. Everyone is sitting quietly in their seats in rows. When the assembly finishes, there is a crowd at the doors pushing to go through them to leave. When outside, the students run off in all directions as fast as they can. Explain which parts of this analogy represent a solid, a liquid and a gas.

4 Some people use analogies or models to compare states of matter. What states do the following situations most closely represent?

a A swarm of bees crawling over each other.

b A thousand tennis balls tidily arranged in a large cardboard box.

c Eggs in trays in a large egg container.

d A school of fish darting in all directions as they avoid a predator.

2.3 The particle model explains matter

Matter is made of extremely small particles called atoms, which are difficult to visualise because they are so tiny. If we imagine the atoms as being tiny balls, then we are using a model or an analogy. By imagining how the balls would behave if the substance were melting, dissolving or heated, we are comparing the atoms to the balls. This is the **particle model of matter**.

The kinetic theory of matter

The particle model of matter is always true. Every observation and every experiment can be explained with this model.

In the particle model of matter, the particles are always moving. The word 'kinetic' refers to the energy of anything that is moving. Therefore particles always have **kinetic energy**. The faster they move, the more kinetic energy they have. For this reason, the particle model can also be called the kinetic theory of matter.

Figure 2.12 Some of the energy in storms comes from the condensation of vapour into liquid, which we see as rain.

Particle energy

The movement of people and particles is related to their kinetic (movement) energy.

- When people are sitting quietly, they have little kinetic energy. This is like a solid, where the particles only vibrate.
- In a crowd, people are standing and moving around and have more kinetic energy. This is like a liquid, where the particles jostle about. Particles in a liquid have more kinetic energy than particles in a solid.
- When people are running, they have much more kinetic energy. This is like a gas, where the particles move fast and on their own. Particles in a gas have the highest amount of kinetic energy.

Using the kinetic theory of matter

The kinetic theory of matter can be used to explain many of the observations and measurements that we make about the substances around us.

Mass is the amount of matter in a substance and is measured in kilograms (kg).

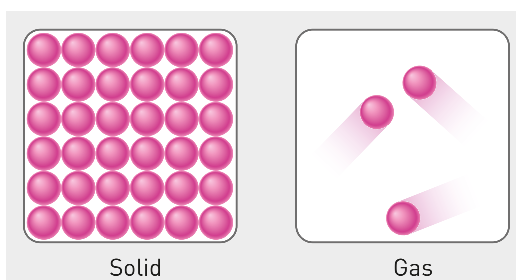


Figure 2.13 A container of a solid has more particles than the same container of gas.

CHALLENGE 2.3A: MODELLING MATTER
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CHALLENGE 2.3B: MAKING A CUPPA
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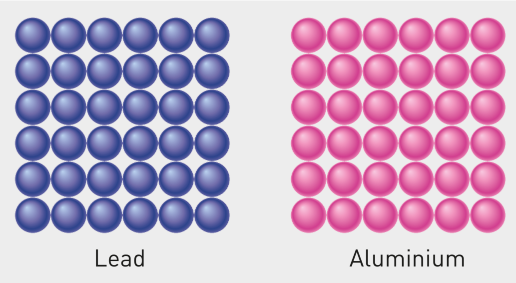

Figure 2.14 Lead atoms have a greater mass than aluminium atoms.

Mass depends on the number of particles and the mass of each individual particle.

A particular volume of solid or liquid has a greater mass than the same volume of gas because it has more particles in it. For example, a container of liquid nitrogen is much heavier than the same-sized container of nitrogen gas. This is because the liquid nitrogen has more particles in it than the fast moving gas particles.

A piece of lead has a much greater mass than the same-sized piece of aluminium. Both are metals that are made of atom particles that are packed closely together. The difference is the mass of each atom particle. Lead atoms have a greater mass than aluminium atoms.

Diffusion

When the lid is taken off a bottle of perfume, the smell of the perfume spreads throughout the room. This occurs without any breeze or wind and is called **diffusion**. Another example of diffusion is tea spreading out from a tea bag in a cup of hot water. Stirring the cup of tea will mix the particles and speed up the rate of diffusion.

Diffusion occurs fastest in gases. This is because the particles in gases are moving freely and quickly and there is plenty of space between them. The particles in a gas will spread out quickly and take up the space available.

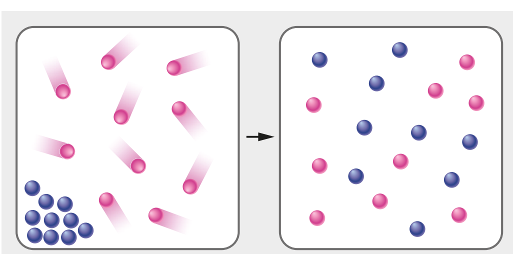

Figure 2.15 Before (left) and after (right) diffusion in a gas.

In liquids, the particles jostle against each other. They do not move far before colliding with another particle. As a result, particles in a liquid do not move very far or very fast. Diffusion in liquids is slow.

In solids, the particles are locked into position. The particles vibrate, but cannot move to a new location. So, the particles in a solid cannot spread out and diffusion does not occur in solids.

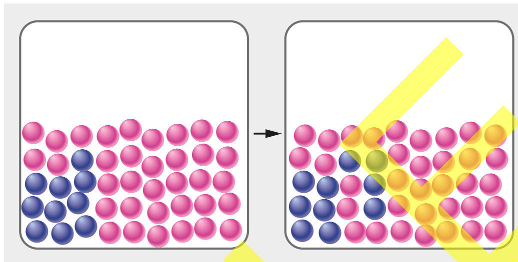

Figure 2.16 Diffusion is slow in liquids.

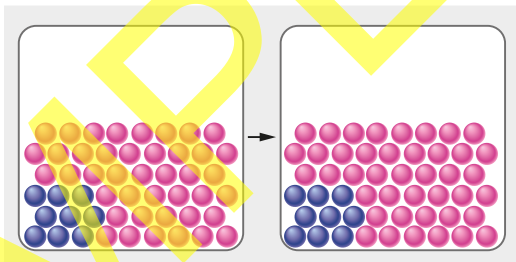

Figure 2.17 Solids don't diffuse.

Check your learning 2.3

Remember and understand

1. Is there any difference between the particle model of matter and the kinetic theory of matter? Explain your answer.
2. What is the meaning of 'kinetic' in the kinetic theory of matter?
3. Rank the states solid, liquid and gas in order of energy content, from highest to lowest.
4. What is meant by 'mass'?
5. How does the kinetic molecular theory (or particle model) of matter explain the different masses of different substances?
6. Why does a lump of lead have a greater mass than a lump of wood?
7. How does the kinetic molecular theory of matter explain diffusion in:
   a. liquids?
   b. gases?

2.4 The particle model can explain the properties of matter

Understanding how particles move can help us to explain the physical properties of matter. This includes how much force the substance can withstand (strength), its ability to scratch other objects (hardness), its thickness (viscosity), how much it can be compressed (compressibility) and the number of particles in a certain volume (density).

Figure 2.18 Reinforced concrete combines the tensile strength of steel with the compressional strength of concrete.

Strength

The idea of strength can be considered in different ways. A rubber band is easily stretched, but what about a piece of wire? Different wires made of different metals will break if stretched. **Tensile strength** is a measure of the flexibility of the links or bonds between the particles. The bonds between the particles in steel are stronger than the bonds between tin particles. Another type of strength is compressional strength. Substances that can withstand large forces without being crushed have a high compressional strength.

Hardness

Hardness is the ability of a substance to scratch another substance. An iron nail will scratch a plastic ruler because the iron is harder than plastic. However, the iron nail will not scratch glass because the iron is softer than glass. The order of hardness is glass, then iron, then plastic.

Hardness is not the same as strength. A very hard substance may shatter easily. If this happens, the material is described as 'brittle'. The particle model of matter explains hardness in terms of the forces that hold the particles together. The particles in hard substances are held together very strongly and it is difficult to separate them. In plastic, the particles are not held together as strongly and can be removed or scraped off. Therefore, plastic is not a hard substance.

There is a connection between hardness and melting. Substances that are hard have strong forces (bonds) between their particles. These strong forces mean that for hard substances to melt, a lot of heat energy is needed. These substances usually have a high melting temperature.

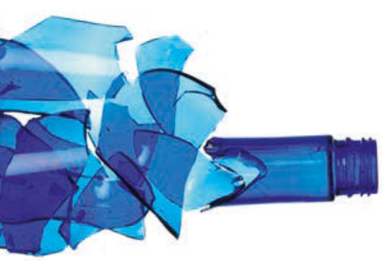

Figure 2.19 Glass is a hard, but brittle, substance.

Viscosity

Viscosity is the thickness or 'gooiness' of a liquid. It describes how easily the particles move around each other. Viscous liquids are hard to pour. Water has a low viscosity, cooking oil is more viscous and honey is very viscous. Engine oils used in engines have different viscosities.

Figure 2.20 Engine oils are labelled with viscosities.

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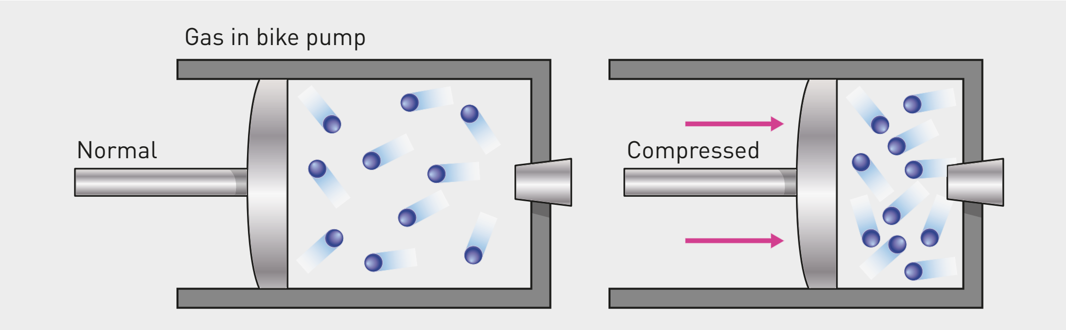

Figure 2.21 Compression reduces the space between particles.

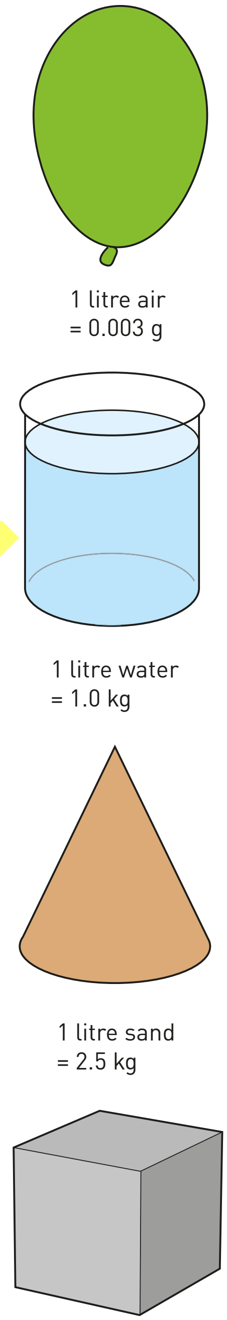

Figure 2.22 Density compares the mass of objects of the same volume.

Compressibility

Compressibility refers to the ability of a substance to be squashed or compressed. You can test for compressibility when substances are in a plastic syringe.

If you put your finger over the end of a syringe, you can compress the air inside it. However, if you replace the air with water, you cannot compress the water. Similarly, if you filled the syringe with sand, you would not be able to compress it.

In solids and liquids, there are no empty spaces between the particles, so it is not possible to compress the particles closer together. Solids and liquids are said to be **incompressible**. Gases, like air, can be compressed. This is because the particles are spread out and there is space between them.

Density

One way of comparing the 'heaviness' of two substances is to compare their densities. Density describes the number of particles and how tightly packed they are. The density of a substance will affect its properties, such as its ability to float.

One litre of water is heavier than one litre of air. We say that water has a greater density than air. Sand has a greater density than water or air, but a lower density than lead.

The particle model of matter explains density in terms of both the mass and the closeness of the particles. Gases always have low densities because there is a lot of empty space between the particles. Solids normally have high densities because there is no space between the particles.

The densities of some common substances are given in Table 2.2.

Table 2.2 Densities of some common substances.

SUBSTANCE	DENSITY (G/CM³)
Air	0.001
Foam rubber	0.05
Wood	0.3
Oil	0.75
Water	1.0
Glass	2.6
Steel	7.8
Iron	7.8
Copper	8.9
Lead	11.3
Gold	19.3
Mercury	13.6

Check your learning 2.4

Remember and understand

1 Prepare a table and list the physical properties mentioned in this chapter and their meanings.

Apply and analyse

2 Rank the following in order of compressibility: solid, liquid, gas.

3 If you placed a highly viscous liquid, such as oil, into a water pistol, what would be the effect? Explain your reasoning.

4 What would happen to a polished wooden table if you rubbed it with sand? Explain by using the idea of hardness.

5 Why do gases have a much lower density than solids and liquids?

2.5 Increasing kinetic energy in matter causes it to expand

When you heat matter, you are passing on energy to the particles. This means the particles start moving faster. The kinetic (movement) energy of the particles increases. This can be used to explain melting and boiling. The **melting point** and **boiling point** are the temperatures at which a substance melts and boils, respectively.


Figure 2.23 Vaporisation explains steam rising from soup.

Heating particles

Gold is usually a solid at room temperature (20°C). Like all solids, the particles in gold are packed tightly together. When solid gold is given heat energy, the gold particles start vibrating faster and faster. When the temperature reaches 1064°C the particles have enough kinetic energy to move around each other, just like the particles in a liquid. The gold has melted.

If you continue heating the gold, the particles continue to gain kinetic energy, move faster and take up more space. Eventually, when the temperature reaches 2807°C, the gold particles have enough kinetic energy to break free from the other gold particles, and move off on their own as a gas.

This process can happen in reverse. If the temperature is reduced, the particles will move more slowly. The attraction to other particles will now keep the particles close together. The gas has condensed into a liquid.

As the particles in a liquid lose energy, their movement slows. Eventually they are held in place by other particles and do not have enough energy to move on their own – they become particles locked into a solid. The liquid has solidified or frozen.

Remember that the main difference between a hot and a cold substance is the kinetic energy in the particles.

The differences in the movement of hot and cold particles can be seen in a beaker of water. As the particles move around, they cause diffusion. If the particles move faster, then diffusion should occur faster.


Figure 2.25 Solidification occurs when a substance cools.

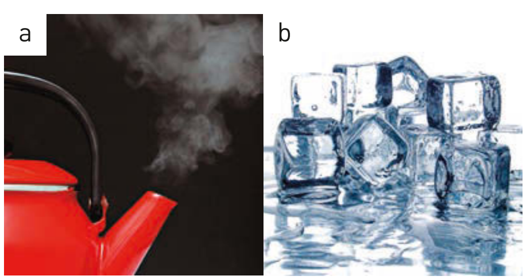

Figure 2.24 (a) The boiling point of water. (b) The melting point of ice.

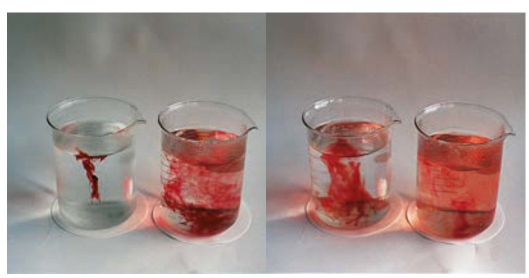
Figure 2.26 Diffusion occurs faster in hot water (right beaker) than in cold water (left beaker).

EXPERIMENT 2.5A: EFFECT OF HEAT
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EXPERIMENT 2.5B: FROM ICE TO STEAM
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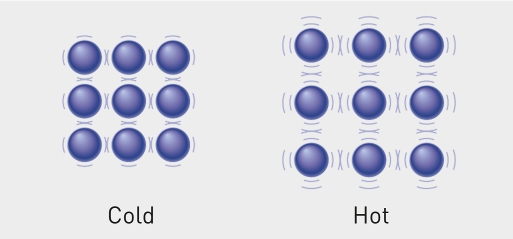

Figure 2.27 In a hot solid, the particles vibrate harder, faster and wider than in a cold solid.

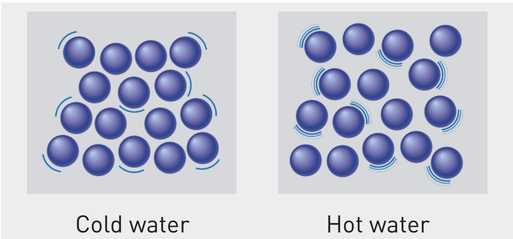

Figure 2.28 In a hot liquid, the particles jostle around faster and take up more space than in a cold liquid.

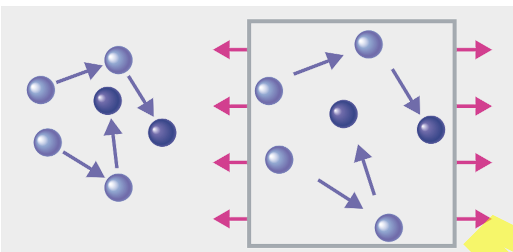

Figure 2.29 In a hot gas, the particles move faster, and collide with each other harder, than in a cold gas.

Heat causes expansion

All objects and substances expand (increase in size or volume) as their temperature increases. These objects contract (shrink) back to their original size when they are cooled back to their original temperature. The expansion is only small – approximately 10 mm in a 30 m bridge – but it is very important for the strength of the object. Expansion effects are seen in bridges, railway tracks and large buildings.

Applying heat energy causes the particles in the liquid or gas to gain more energy. The particles jostle more and speed up. As they move around faster, they take up more space and push the other particles further apart.

Expansion and contraction have many important applications such as liquid-in-glass thermometers. When an alcohol thermometer is placed in your mouth, the heat from your body passes to the liquid inside the thermometer, causing it to expand and move up the tube. Thermometers are filled with red- or green-coloured alcohol, but not the type of alcohol in alcoholic drinks.

Figure 2.30 An expansion joint in a suspension bridge.

Figure 2.31 Train tracks would buckle in the heat without tiny gaps between them.

Check your learning 2.5

Remember and understand

1 Draw a diagram similar to that shown in Figure 2.32. Add labels to show the energy changes between states.

2 How does the movement of particles change as they get hotter?

3 What is the difference between the terms 'expand' and 'contract'?

4 When hot objects cool, do they return to their original size?

Apply and analyse

5 What precautions are taken with railway tracks and bridges to ensure that they do not buckle and bend on a hot day?

6 How can you be sure that when a solid is heated and expands, the increase in size is not caused by more particles (atoms) being added?

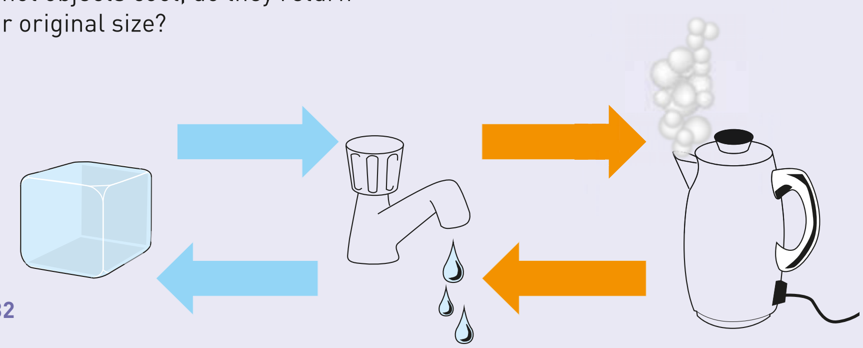

Figure 2.32

* REVIEW

2

Remember and understand

1 What are the three common states of matter?

2 Select one word to replace each phrase.
   a The spreading out of a substance such as a dye or smell.
   b The ability of one substance to scratch another substance.
   c The ratio of the mass divided by the volume.

3 In which of the three major states of matter do the particles have the most energy? Explain your reasoning.

4 How does the particle model explain the following properties?
   a strength
   b hardness
   c viscosity
   d compressibility
   e density

5 Where did the word 'atoms' come from?

6 What is the difference between mass and matter?

Apply and analyse

7 When you are boiling water, the volume of the water is reduced as it evaporates. Does this mean that the density of the water changes?

8 Use the kinetic theory of matter to explain why the pressure inside car tyres will increase on a hot day.

9 What is the difference between solidification and freezing?

10 Explain how a thermometer determines difference in temperature.

Evaluate and create

11 Many people have ideas they think will explain observations and events in science. For an idea to become a theory, it must be able to explain a range of observations. The idea must also be supported by evidence and/or observations.
   a Can you suggest what evidence would have been required to support the idea that all substances are made of atoms?
   b It is found that a substance cannot be broken down into a more simple substance. How could you use the kinetic theory of matter to explain this observation?

Figure 2.33 Exhaling clouds!

12 Design a way to draw or model the following.

a the melting point of a material

b the boiling point of a material

c the density of a material

d the kinetic energy of a particle as it heats up

e diffusion

13 You should now realise that the structure and properties of a substance can be explained by the particles that make up the substance. Explain the following observations by referring to the arrangement and/or the movement of the particles within the substance. You can use labelled diagrams to improve your answers.

a Water left in an open bottle will gradually evaporate and, if the temperature of the water increases, the water will evaporate more quickly.

b Mercury is a unique substance because it is the only metal that is liquid at room temperature, and it even gives off a vapour (which makes it very dangerous because this vapour can be breathed into our lungs).

c Polythene can be produced in two different forms, high-density polythene (HDPE) or low-density polythene (LDPE). If the particles in both HDPE and LDPE are the same, suggest how the structure of the two substances would be different.

d When you heat a piece of polythene it will melt. While it is liquid, it can be formed into a different shape and when it cools the polythene will stay in this new shape.

e We can see steam, but we cannot see water vapour.

Research

14 Choose one of the following topics for a research project. Present your research in a format of your own choosing, giving careful consideration to the information you are presenting.

> **State of the matter**
>
> The changes between the states of matter have many uses. Research some of these uses and their impact on our society. Some ideas are how refrigeration and air conditioning work; making moulds and casts, such as chocolate, iron and aluminium castings; obtaining medical-grade oxygen and nitrogen from the air; how the energy changes that occur during evaporation of water and the subsequent condensation of water vapour into rain affect thunderstorms and cyclones.

> **People matter**
>
> The discovery of air pressure is a long and interesting story. Research the background of Evangelista Torricelli, Blaise Pascal and Otto von Guericke. For example, Otto von Guericke built a large water thermometer in the front of his house and made the Magdeburg hemispheres. Two opposing teams of eight horses, working like a tug-of-war, could not pull the hemispheres apart.

* KEY WORDS

2

atom
smallest particle of matter that cannot be created, destroyed or broken down (indivisible)

boiling point
the temperature at which a liquid becomes a gas

chemical property
how a substance behaves in a chemical reaction, e.g. how it reacts with acid

chemistry
branch of science that deals with matter and changes that take place within it

compound
substance made up of two or more different types of atoms bonded together, e.g. water

compressibility
ability of a substance to be compressed (squashed); gases can be compressed but solids and liquids cannot

diffusion
spontaneous spreading out of a substance through a liquid or gas, e.g. the diffusion of perfume in air

element
pure substance made up of only one type of atom, e.g. oxygen, carbon

hardness
how easily a mineral can be scratched; measured on the Mohs hardness scale

incompressible
when a substance cannot be compressed; solids and liquids are incompressible

kinetic energy
energy of motion or moving objects

mass
amount of matter in a substance, usually measured in kilograms

matter
anything that has mass and volume

melting point
the temperature at which a solid becomes a liquid

molecule
group of two or more atoms that are bonded together, e.g. a water molecule

particle model of matter
theory that all matter is made up of very tiny particles

physical property
can be measured or observed without changing a substance into something else, e.g. colour, boiling point

tensile strength
a measure of the flexibility of the links or bonds between the particles in a substance

theory
explanation of a small part of the natural world that is supported by a large body of evidence

viscosity
a measure of how slowly a liquid changes its shape; the thickness of a liquid

volume
how much space an object takes up, usually measured in litres