10 What are things made of?

Planning page

Getting started

10.1 Properties of matter page 206
- Activities page 207
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Main ideas
- Chapter 10 crossword

Review
- Chapter 10 test

Essential Learnings for Chapter 10

Essential Learnings	References		
	Student book (page number)	Workbook (page number)	Teacher Edition CD (Assessment task)
Knowledge and understanding *Natural and processed materials* Changes in physical properties of substances can be explained using the particle model	pages 214–218 pages 223–226	pages 81–82	Assessment task 10 A particle model
Ways of working Draw conclusions that summarise and explain patterns, and that are consistent with the data and respond to the question	Activities page 207 Investigate 25 page 219 Activities pages 223–224	page 82	
Evaluate data, information and evidence to identify connections, construct arguments and link results to theory	pages 214–218 pages 223–226		
Communicate scientific ideas, explanations, conclusions, decisions and data, using scientific argument and terminology, in appropriate formats	Investigate 25 page 219 Activity page 226	Exercise 3 page 78 pages 81–82	

QSA *Science Essential Learnings by the end of Year 9*

Vocabulary

compressed
condensation
contraction
density
diffusion
evaporation
expansion
particle
plasma
pressure
processed
properties
solidification
solidify
sublimation
synthetic
theory

Focus for learning

Discuss the properties of everyday solids, liquids and gases (page 205).

Equipment and chemicals (per group)

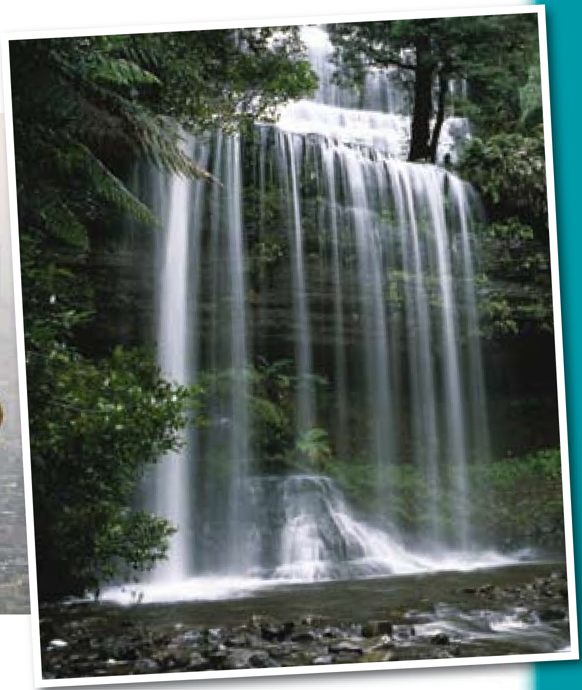
Activities page 207	drinking glass, tissue, electronic balance (class use), plastic syringe
Investigate 24 page 209	100 mL measuring cylinder, balance, piece of wire, 2 small objects—one that floats (eg wooden block) and one that sinks (eg marble)
Activity page 211	peanut-shaped starch packing beads
Activity page 217	20–30 small ball bearings, petri dish lid or flat glass dish. For a class activity, use an overhead projector.
Investigate 25 page 219	250 mL beaker, crushed ice, thermometer (–10 to 110 °C) or datalogger and temperature probe, burner, tripod, gauze and heatproof mat, stopwatch, stirring rod, retort stand and clamp, stopper with hole to hold thermometer in clamp, graph paper
Activity page 223	**A:** 250 mL beaker, drinking straw, crystal of potassium permanganate, tweezers **B:** (class demonstration): 50 mL beaker, 500 mL beaker, concentrated HNO_3, pieces of Cu
Activity page 224	class demonstration: ball and ring apparatus, flask (conical or round), glass tubing inserted in a rubber stopper, large plastic bowl

10 What are things made of?

Getting Started

Use the three photos on this page to help you to answer these questions.

- Which of the things in the photos are solids? Which are liquids? Which are gases?
- Can you change the shape of solids, liquids and gases?
- Can you compress a solid, that is, squeeze it into a smaller volume? Can you do this for liquids and gases?
- What do solids, liquids and gases have in common?



Starting point

Write the words *solids*, *liquids* and *gases* on the board as the headings of three columns. On one side of the board write a list of jumbled up everyday substances/materials which are either solids, liquids or gases. Ask students to say which list each belongs to and fill in the table.

Ask students to brainstorm and make their own lists of solids, liquids and gases. Alternatively, ask each student to give an example (making sure they state whether it is a solid, liquid or gas) and fill in the table, or have another student do so. Brainstorming is an effective strategy because it helps the students draw on their experience and creativity.

Generate discussion questions from the lists. Ask the students where they would place a material like plasticine: is it a solid or a liquid? (A solid remains in the same shape unless changed by external forces.)

Start the lesson with an investigation. Have an iceblock in a beaker large enough for the students to see. Students are familiar with ice, water and steam. Ask questions like:

- Is it a solid, a liquid or a gas?
- How do you know it is a solid?
- What makes it a solid?
- What does it look like; feel like?
- How can it be turned into a liquid?
- How is a liquid different from a solid?

This could be turned into a Think/Pair/Share (page 126), group brainstorming or roundtable activity.

Students should realise that temperature is an important factor in determining the state of a substance. Room temperature is considered to be 20 °C.

Hints and tips

- Have some examples on the bench of each state of matter to show or to be passed around the room. For a gas you could have a sealed container of air.
- It may be appropriate here to revise the difference between mass and weight (page 83).
- 'Silent surveys' are a useful tool to help classroom management, particularly if you do not want a discussion. Simply ask the students to put their hand up in silence for their response to a survey question.

10.1 Properties of matter

What is matter?

Everything around you is made up of **matter**—the desk, your shirt, the water in a swimming pool, the hair on your head, even the air you breathe. Most matter can be classified into one of three main groups: solids, liquids and gases. These are usually called the three **states of matter**.

Solids, liquids and gases have two important properties—they all have *mass* and they all take up space. To find the mass you use a balance. To find the amount of space occupied by something you measure its *volume*. So all matter has mass and occupies space.

Solids

Solids include such things as steel girders, this book, and most of the objects you can see. They all have mass and occupy space. The shape of most solids cannot easily be changed, and nor can their volume. Powders are also solids but their shape can be changed.

Liquids

Water, milk and oil are all examples of matter in liquid form, and they all have mass. The volume of a quantity of liquid does not change, but its shape can. For example, pour some milk from a carton into a glass. The volume of the milk doesn't change, but its shape does. And if the milk is spilt, it has another shape (Fig 4).

Gases

The air around us is a gas. In fact, it is a mixture of gases, mainly nitrogen and oxygen. Other common gases are helium and carbon dioxide. All these gases have mass and occupy space. Gases do not have a fixed shape or volume. A gas fills its container, no matter what the shape or size of the container. For example, helium gas fills a metal gas cylinder. The gas can be let out through the tap to fill balloons of various shapes and sizes. If the balloon bursts, the gas will escape and spread out into the air. Gases can also be compressed (squeezed into a smaller volume like the helium in the cylinder). You cannot do this with liquids and solids.

Fig 5 Gases do not have a fixed shape or volume.

Fig 4 The volume of a liquid does not change, but its shape may.

Learning experience: solids

Here is a way to explain that a powder is a solid. Hold up a beaker of powdered chalk or icing sugar. Do a 'silent survey' asking who thinks this is a solid, liquid or gas. Ask students to write down a reason for their choice. Do the same thing with a whole piece of chalk or a lump of icing sugar. (It may be possible to derive a suitable definition of a solid.)

Repeat the process, but with crushed chalk or icing sugar, making sure it is not yet a powder. If you put all the pieces back together would you have the same material? (Students should realise it is still a solid only in smaller pieces.)

Completely crush chalk or sugar into a powder and repeat the process. Now hold up the original sample and ask if anyone's first response is different from their last. (The individual pieces don't change shape but collectively the powder can change shape.)

Learning experience: liquids

To illustrate a liquid changing shape but not volume, place a drop of food dye in the bottom of a beaker then fill it with water so the class can see the water changing shape. Measure the volume. Now pour the beaker of coloured water into another larger beaker and again measure the volume.

Learning experience: gases

To illustrate a gas changing shape and volume, have a student blow up a balloon to only three-quarters of its capacity. Poking and pulling shows how it changes shape. Squashing it compresses the air and decreases its volume.

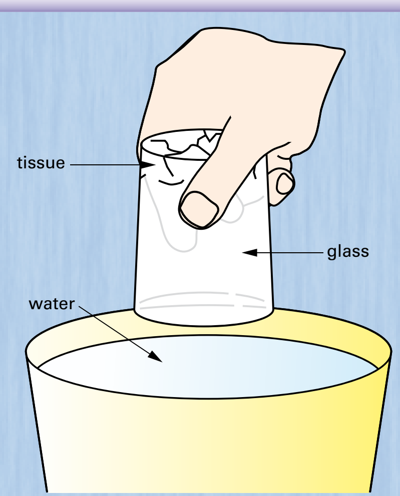
Activities

A Crumple a tissue, and fit it tightly into the bottom of a glass. Push the glass, mouth down, into a large container of water until most of the glass is under water.

What do you observe?

Pull the glass out of the water and check whether the tissue is wet.

Write an inference to explain your observations.



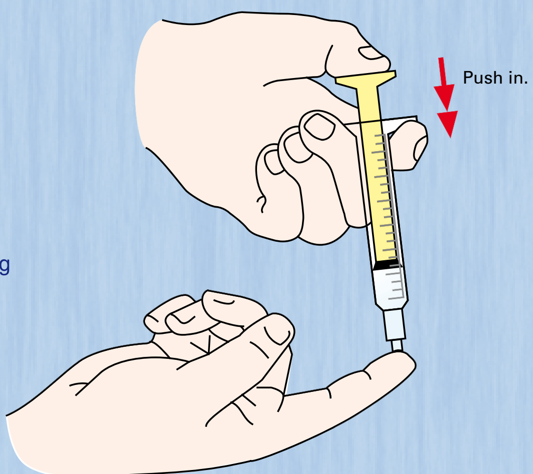
B Use a balloon and an electronic balance to test whether air has mass.

C Place your finger over the end of a syringe containing air. Try to push the plunger in.

Can air be compressed?

Draw some water into the syringe.

Can water be compressed?



D To summarise what you know about solids, liquids and gases, copy the following table. Complete it by putting a ✔ or a ✘ in each box.

State of matter	Properties of matter				
	Have mass	Occupy space	Fixed shape	Fixed volume	Can be compressed
solids	✓				
liquids	✓				
gases	✓				

Activities notes

- At this point it is advisable to remind students of the definition of an observation (page 12) and an inference (page 24).
- The electronic balance is a very sensitive piece of equipment. Make sure that it is correctly 'zeroed' each time before weighing.
- In order to find the mass of air, the balance must be very sensitive (0.001 g) and set up on a fixed bench, preferably in a case to exclude air movement. It is a good idea to ask a reliable student to use the balance, and check that it is used properly to prevent damage.
- Count the number of syringes you hand out and make sure you get them all back at the end of the class.

Hints and tips

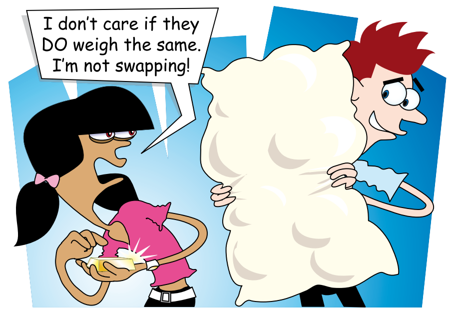
- Don't assume students remember how to determine the volume of something. Revise volume and mass, and the appropriate units. Note: 1 mL = 1 cm^3.
- You can use Archimedes' principle to determine the volume of any irregularly shaped object by placing it in water and measuring the volume of water displaced.
- Water is most dense at 4 °C. As it freezes it expands, so ice is less dense than water and floats.

Homework

- Ask students to explain why sharks sink and why swimming helps to keep them afloat. Students may choose to draw a cartoon or diagram to help with their explanation.
- Ask students to compile a table of three or more substances which sink in water and three or more which float in water. They will need to find out the density of each substance in g/cm^3. If they are using the internet, students should use Australian websites so they don't meet non-SI units.

Density

An important property of matter is its **density**. Which is heavier, a kilogram of feathers or a kilogram of gold? The answer is neither—they both have the same mass. The difference is that a one kilogram bar of gold would be about the size of a Mars bar, while one kilogram of feathers would fill a very large pillow. The mass of the gold is packed into a much smaller volume than the feathers. A small volume of gold has a large mass. We say that gold is much more *dense* than feathers.



Similarly, iron is denser than wood. Suppose you have a 1 cm cube of iron and a 1 cm cube of wood. Both cubes take up the same amount of space, so they both have the same volume (1 cubic centimetre). However, their masses are very different. The iron cube has more mass packed into one cubic centimetre. The density of iron is therefore greater than the density of wood. Density is how much mass is packed into a measured volume. It is usually measured in grams per cubic centimetre (g/cm^3).

The table at the top of the page shows the densities of some common substances. Notice that the density of water is 1 g/cm^3, and that gases are much less dense than solids and liquids.

Anything will float in water if its density is equal to or less than the density of water, that is 1 g/cm^3. For example, a piece of pine wood (density 0.4 g/cm^3) floats in water, but a piece of granite (density 2.7 g/cm^3) sinks. Fruit and vegetables sometimes float and sometimes sink. For those that float, the lower their density the more they stick out above the water. You can try this at home with a bowl of water.

Table of densities (g/cm^3)

Substance	Density	
helium gas	0.00018	FLOAT IN WATER
air	0.0013	
carbon dioxide gas	0.002	
polystyrene foam	0.1	
cork	0.2	
pine wood	0.4	
petrol	0.7	
polythene plastic	0.9	
ice	0.9	
water	1.0	
sea water	1.03	SINK IN WATER
aluminium	2.7	
granite	2.7	
iron	7.8	
nickel	8.9	
lead	11.3	
gold	19.3	
osmium	22.5	

Humans, like most animals, float in water, but only just. This is because we are mostly water. However, we have a layer of fat under our skin, and this has a density less than water. There are also air spaces, such as lungs, inside our bodies. Sharks are unusual in that they are denser than water. If they don't keep swimming they sink to the bottom.

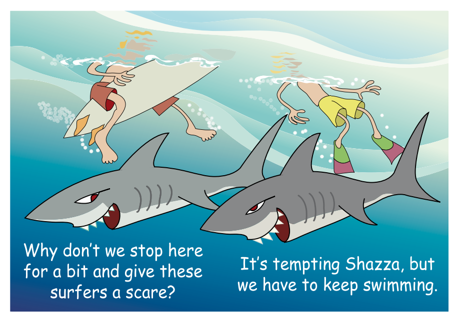


Fig 9 Anything will float in water if its density is equal to or less than the density of water.

Learning experience

Ask a set of 'Quick Questions' on the material already covered. Students only need to record answers. Spend no more than 5 to 10 minutes doing this. This is a useful tool to use at the start of any lesson.

Learning experience

As each student enters the room, give them a printed word card. Ask them to write a definition of the word on their card. Choose students to read out their definition—make sure each word has been properly defined. (Suggested words: *solid*, *liquid*, *gas*, *matter*, *mass*, *volume*, *float*, *sink*.) For help with writing definitions, see *Science World 1 Workbook* pages 42–43.

Learning experience: sink, float or mix?

Have on the bench a large glass measuring cylinder about one-third full of glycerine. Fill a beaker with some coloured water. Before pouring the water in with the glycerine, get the students to make a prediction and ask them to justify their prediction. Will it sink, float or mix? Demonstrate what happens. Ask the students to observe what happens and to give an inference.

Measuring density

To find the density of something you must first measure its mass and volume. You then divide the mass by the volume to find the density.

$$\text{density (g/cm}^3\text{)} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

Measuring the volume of a regular solid such as a cube is easy, but how would you measure the volume of an irregularly shaped object such as your body? The secret is to drop the object into water, and measure the volume of water it displaces (pushes out). This method was discovered by Archimedes in Greece about 250 BC. In Investigate 24 you can use this method to find the density of a small object.

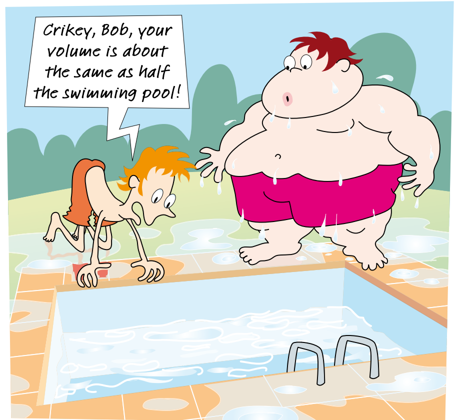


Fig 10 One way to measure your volume

Investigate 24 MEASURING DENSITY

Aim

To measure the density of two different objects.

Materials

- measuring cylinder, 100 mL
- balance
- piece of wire
- 2 small objects—one that floats (eg wooden cube) and one that sinks (eg marble)

Planning and Safety Check

Read the six steps carefully and draw up a data table like the one below.

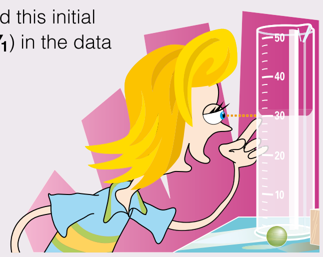
Method

1 Using the balance, find the mass of each object. Check with your teacher if you have forgotten how to do this.

Record the masses in the data table.

2 About half fill the measuring cylinder with water. It is best if you fill it to a set mark, say 30 mL. Make sure the *bottom* of the meniscus (the curved water surface) is exactly on the mark.

Record this initial volume (V_1) in the data table.



Object	Mass (g)	Initial volume of water, V_1 (mL)	Final volume of water, V_2 (mL)	Volume of object $V_2 - V_1$ (cm^3)	Density (g/cm^3)

Hints and tips

It is helpful to give an example, such as the one below, of how the formula is used to calculate the density of a substance. You may find it useful to provide a half-page handout on calculating densities that students can stick into their notebooks. Use easily divisible numbers if calculators are not available.

A gold nugget has a mass of 38.6 g and a volume of exactly 2 cm^3

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$= \frac{38.6}{2} = 19.3 \text{ g/cm}^3$$

Since this is the same density as in the table (page 208), the nugget must be pure gold.

Lab notes

- It's a good idea to have several balances set up around the lab for ready access and supervision.
- Remind students how to read the volume of a liquid in a measuring cylinder (page 30).
- Students will need calculators here.
- It is better for students to use plastic measuring cylinders to minimise breakages. If using glass cylinders, tell students to be careful when dropping the marble or ball bearing into the cylinder—if it breaks it can be messy and expensive. It is best to hold the cylinder on an angle and let the marble slide down the side.
- Remember to use the wire to hold down polystyrene and other things that normally float.

Hints and tips

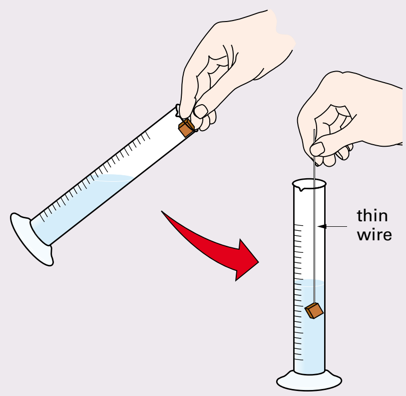
Demonstrate how to calculate the density of an object using the method described in Investigate 24. Use a large glass measuring cylinder to enhance the visual learning aspect. Demonstrating the technique before the students attempt to do it reinforces the procedure.

Lab note

- Make sure you allow time to go through the Discussion questions with the class, particularly question 3.

3 Holding the cylinder at an angle, carefully slide in the first object. If it floats you will have to hold it under the water with a piece of wire, as shown.

Record the water level in the cylinder with the object completely under water (***V*₂**).



4 Take the object out of the cylinder, and repeat Steps 2 and 3 for the other object.

Record the water level for the second object.

5 Calculate the volume of each object by subtracting the initial volume of water (V_1) from the final volume (V_2).

Record your results in the data table. (Note: 1 millilitre = 1 cubic centimetre.)

$$\textbf{volume of object} = V_2 - V_1$$

6 Calculate the density of each object using the formula:

$$\textbf{density} = \frac{\textbf{mass of object (g)}}{\textbf{volume of object (cm}^3\textbf{)}}$$

Give your answer to the nearest 0.1 grams per cubic centimetre.

Discussion

1 Compare your results with those found by other students. If they are different, suggest possible reasons.

2 Which object is more dense?

3 Suggest another way of finding the volumes of the objects. Try it, and check your results.

Using materials

All the materials around us are taken from or made from the Earth's natural resources. For example, we use cotton, wood and rubber from plants and wool, leather and silk from animals. We breathe the air and extract various gases from it, eg oxygen, nitrogen and argon. We use the rocks of the Earth and extract metals such as iron, copper and gold, and other useful materials like coal, oil and limestone. We eat seafood from the oceans and extract salt from seawater.

Some of these materials we use in their *natural* state. For example, a gold nugget can be made into jewellery and wool can be woven into clothing. Often we process these materials to improve or alter their properties. For example, we may treat the wool to make it shrink-resistant, and we grind up corn to make flour, which we use to make bread. These are *processed* materials.

Over the years, however, we have made many totally new materials. For example, 2000 years ago the Chinese discovered how to make paper from wood. In recent times we have made an incredible range of materials such as concrete, glass, plastics, paints and pesticides. These materials do not occur naturally, and are said to be *synthetic*.

Learning experience

Students could construct a Y-graph using the headings *natural*, *processed* and *synthetic*. Set them a challenge to write as many materials as they can under each heading. Give them a time limit.

Alternatively, if you construct a Y-graph on the board, students can take it in turns to write a material in the correct place.

Learning experience

Have a collection of some natural, processed and synthetic materials to pass around the room for the students to touch. They can try to guess which group each material belongs to.

Science in action

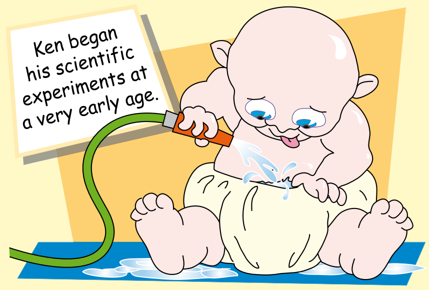
The properties of a material determine what it can be used for. Wool is used for winter clothes because it keeps your body heat in. Aircraft are made of aluminium metal because it is light. Copper is used to make electric wires because it is a good conductor of electricity, and because it can be shaped to form wire. Drills are sometimes diamond-tipped, because diamond is much harder than most other substances.

Synthetic materials are continually being developed with special properties to do particular jobs. Here are four examples.

1 Since 1996 Australia's banknotes have been made from polypropylene plastic. These last longer than paper notes, stay cleaner and are very difficult to counterfeit. They can also be recycled to make compost bins, plumbing fittings and other useful household and industrial products.

2 In 1999 CSIRO developed a new sunscreen called *Sunsorb*. It is similar to zinc cream, but because the powder it is made from is so fine, it is virtually invisible.

3 If you break open a disposable nappy, you will find a white powder called *WaterSorb*. It forms a gel when water is added to it. It can soak up a large volume of urine, keeping the baby's bottom dry. It is also used to prevent pot plants drying out.



4 Polystyrene packing beads are being replaced by ones made from wheat or corn starch. This makes sense because wheat and corn are renewable, unlike polystyrene which is made from oil and is non-renewable. These beads cause less damage to the environment since they form a suspension in water and are biodegradable.

Activity

For this activity you will need some peanut-shaped starch packing beads.

How many starch packing beads do you think will 'disappear' in two teaspoons of water?

To test this, add one starch bead at a time, stirring well to form a suspension. Observe how the beads change and how the water changes.

Could you get the beads back again? How?

WEBwatch

Go to www.scienceworld.net.au and follow the links to the websites below.

The secret of the disposable nappy

This site has an experiment to test the superabsorbent powder in a disposable nappy.

Reserve Bank of Australia

This site has information on the famous Australians on our notes, how the notes are made and recycled, and how to detect counterfeit notes.

Try searching under the trade names of some of the newer synthetic materials, eg Kevlar, Mylar, Nomex, Teflon, Tyvek. Keep notes on the properties and uses of each material you research.

Hints and tips

Investigate the meanings of the words *renewable*, *non-renewable* and *biodegradable*. Explain their meanings and get students to write a definition and example for each into their notebooks. Alternatively, have them do it as a homework activity. (See Check! 11 on page 213.)

Homework

Write an advertisement for *garden water-saving crystals*. In the advertisement, include an explanation of how they work and how they benefit the garden.

Activity notes

- Ask the school office in advance to collect a box of starch packing beads. Make sure to keep them in a dry place.
- Revisit what a suspension is (page 162).

Check!

1 In which state would a substance be if it had:
- **a** no fixed volume?
- **b** a fixed volume and shape?
- **c** a fixed volume but took the shape of its container?

2 Each of the cartoons below illustrates at least one property of matter. Which shows that:
- **a** a solid has a fixed shape?
- **b** a liquid can be made to have any shape?
- **c** a gas can be compressed?
- **d** a gas does not have a fixed volume?

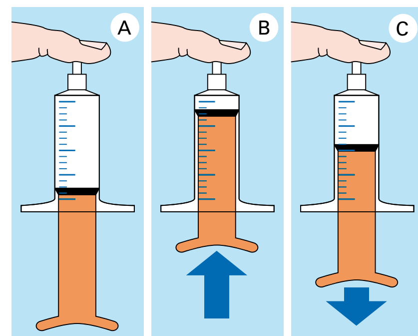
3 **a** How many kilograms are there in 2000 g, 100 000 g, 1530 g?
b How many grams are there in 2 kg, ½ kg, 6.7 kg?

4 Look at the data table below.

	mass (g)	volume (cm^3)
Object A	39	6
Object B	54	20
Object C	6	5

- **a** Which object has the greatest mass?
- **b** Which object has the greatest density?

5 Look at the diagrams below. Suppose you keep your finger over the end of the syringe, starting in position A. You push in the plunger to B, then pull it back to C. In which position is the air in the syringe most dense? Explain your choice.



6 It is easier to float in sea water than in fresh water. Use your knowledge of density to explain this.

7 A balloon filled with helium rises when you let it go. A balloon filled with carbon dioxide sinks. Explain the difference.

8 In each of these pairs, which is the object, and which is the material it is made from? Describe the properties of each substance that make the object useful. Record your answers in a table with three columns.
- **a** window / glass
- **b** styrofoam / coffee cup
- **c** plastic / ruler
- **d** aircraft / aluminium
- **e** bank note / polypropylene plastic

Check! solutions

1 a A substance with no fixed volume would be in the **gas** state.
b A substance with a fixed volume and shape would be in the **solid** state.
c A substance with a fixed volume but which took the shape of its container would be in the **liquid** state.

2 a Cartoon 4 shows that a solid has a fixed shape.
b Cartoon 2 shows that a liquid can be made to have any shape.
c Cartoon 3 shows that a gas can be compressed.
d Cartoon 1 shows that a gas does not have a fixed volume.

3 a There are 2 kg, 100 kg and 1.53 kg in these masses respectively.
b There are 2000 g, 500 g and 6700 g in these masses respectively.

4 a The object with the greatest mass is B.
b The object with the greatest density is A and it is 6.5 g/mL.

5 The air is most dense in syringe B because it is compressed into the smallest volume.

6 A substance will float in any other substance which is more dense. A greater difference in density will allow it to float more easily and salt water is more dense than fresh water.

7 A balloon filled with helium has a density less than air and will be pushed upwards. A balloon filled with carbon dioxide is denser than air and will sink to the floor.

8

Object	*Substance*	*Properties*
window	glass	transparent
coffee cup	styrofoam	insulator
ruler	plastic	transparent, flexible
aircraft	aluminium	strong, light
bank note	polypropylene	strong, easily folded

9 Classify the following materials as natural, processed or synthetic:

concrete	milk	petrol
flour	natural gas	soft drink
marble	nylon	superphosphate
marijuana	oxygen	uranium

10 Make a table listing the properties of the four synthetic materials described on page 211.

11 What is the difference between a renewable material and a non-renewable one? Give examples, in addition to the ones on page 211.

challenge

1 Many people incorrectly say that lead is heavier than steel. What should they really say?

2 Which properties allow you to distinguish between the substances in each of the following pairs?
- a steel and aluminium
- b lemonade and water
- c salt and sugar
- d wood and plastic
- e polystyrene and starch packing beads

3 Which of the following would you use to make the base for a stand-up sign outside a shop—concrete, aluminium or gold? Explain your answer in terms of the properties of the three substances.

4 a A piece of copper has a mass of 50 g and a volume of 5.6 cm^3. What is its density?
b Another piece of copper has a volume of 7 cm^3. What is its mass?

5 A rectangular block of wood has sides 8 cm by 4 cm by 5 cm. It has a mass of 120 g.
a What is its density?
b Would this block of wood float in water?

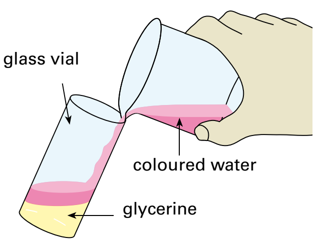
6 What is the mass of air in a room measuring 10 m × 5 m × 3 m if the density of air is 1.3 kg/m^3?

7 Suggest some uses for a plastic that dissolves in water.

8 The balloons in the photo are made of a material called Mylar. They are filled with helium gas and stay inflated for months. Suggest which properties of Mylar make it suitable for use in these special balloons.

try this

1 One-third fill a glass vial with glycerine. Carefully pour an equal volume of coloured water down the inside of the vial so that it flows gently onto the glycerine, as shown. Drop a small piece of perspex into the vial. Observe what happens, and try to explain it in terms of density.



2 Does a fresh hen's egg sink or float in water? Try it. Now add salt to the water, while stirring carefully, and observe what happens. *Explain* your observation.

A rotten egg floats in fresh water. Suggest why.

Challenge solutions

1 It is more correct to say that lead is **denser** than steel.

2 The differing properties are the:
- a colour and density
- b taste and smell
- c taste and size of the crystals
- d texture and the smell when cut
- e colour and smell.

3 It would be best to use concrete because aluminium is too light to be a base and gold is too expensive.

4 a Density is calculated by dividing the mass by the volume: M/V = 50/5.6 = 8.9 g/cm^3.
b Mass is the product of the volume and the density: D × V = 8.9 × 7 = 62.3 g.

5 The volume of the block of wood is 8 × 4 × 5 = 160 cm^3.
a The density is M/V = 120/160 = 0.75 g/cm^3.
b Yes, it will float in water because its density is less than water (= 1).

6 The volume of air in the room is 10 × 5 × 3 = 150 m^3. If the density of air is 1.3 kg/m^3 then M = D × V = 1.3 × 150 = 195 kg. This is more than you or your teacher could carry.

7 Some good uses for plastic that dissolves in water are slow release fertiliser, shopping bags that will not otherwise disappear in the soil and little packets of jelly crystals or cordial mix.

8 Mylar is a material which will not allow the helium atoms to pass through it, unlike the rubber in normal balloons. This means that the Mylar balloons will stay inflated for months.

Homework

The egg test in *Try this* could be done at home.

9 The natural materials are milk, natural gas, marble, marijuana and oxygen.

The processed materials are petrol, flour, soft drink, superphosphate and uranium.

The synthetic materials are concrete, nylon and perhaps the soft drink if it contains artificial sweetener.

10

Material	Properties
polypropylene	stay cleaner, last longer, recyclable
Sunsorb	very fine and almost invisible
WaterSorb	soak up large amounts of liquid
wheat starch beads	soluble and biodegradable

11 A renewable material is one which is easily produced again or possibly recycled. The wheat starch beads are a good example. Non-renewable materials are those that are not easy to produce again or be recycled once they have been used. An example is petroleum fuel.

Hints and tips

Doing a demonstration reinforces concepts about energy. You need to put ‘energy in’ when heating a substance and changing its state from a solid → liquid → gas. Do one of the suggested learning experiences below with your class.

10.2 Solid–liquid–gas

The three different states of matter can be changed from one to another by adding or removing heat. These changes are called **changes of state**.

If you heat a solid it will form a liquid. For example, ice melts to produce liquid water. Metals such as iron and gold also melt if you heat them enough.

Fig 18 Solid gold melts at about 1000°C. The liquid gold can then be poured into moulds.

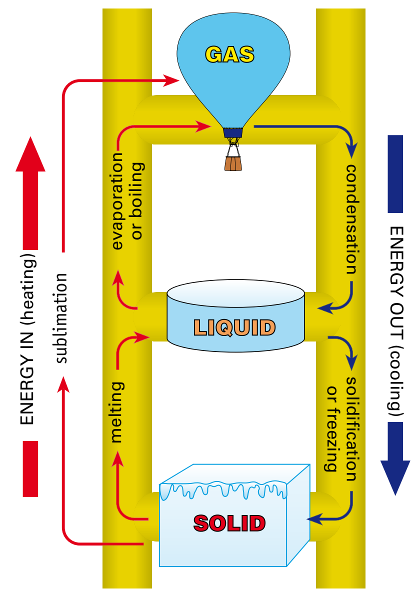
Heating also causes *evaporation* of liquids to produce gases. For example, when water is heated it evaporates to form water vapour, which is a gas. The hotter the water gets, the more quickly it evaporates. When bubbles of water vapour appear in the water it is said to be *boiling*. The water vapour forms more quickly, and is now called steam. This occurs at 100°C, the boiling point of water. Water can evaporate at any temperature, but boiling occurs only at the boiling point.

Cooling causes gases to condense and form liquids. For example, steam is invisible, but when it meets cooler air it forms a cloud. This is because the steam condenses to form tiny droplets of water. A similar thing happens in the bathroom when you have a hot shower. Some of the hot water evaporates and changes into water vapour. Because the air in the bathroom is cooler, the water vapour condenses to form tiny drops of water which float in the air and ‘fog up’ the mirror. Similarly, as water from the Earth’s surface evaporates it forms water vapour. As this water vapour rises it becomes cooler and may condense to form clouds and perhaps rain.

Cooling also causes water to freeze or *solidify*. This occurs naturally when snow and hail form. We use the same process to make ice blocks and ice-cream. Molten metal can be poured into moulds to solidify into various shapes (see Fig 18).

Some solids do not change to a liquid when they are heated. Instead they turn straight into a gas in a process called *sublimation*. For example, ‘dry ice’ is solid carbon dioxide. When it sits on the bench it soon warms up and changes directly into gaseous carbon dioxide, which is invisible.

Another way to look at changes of state is to think of the three states of matter as rungs on an energy ladder. To change state by climbing up the ladder, energy must be added to the matter—it must be heated. To change state by going down the ladder, energy must be taken from the matter—it must be cooled.



Learning experience

In a beaker, have an iceblock set up over a Bunsen burner, ready to heat. (The iceblock could be coloured for effect.) Do not light the burner. While you are explaining changes of state, the ice should start to melt. When you get to the section on evaporation and boiling, ask the class what could be done to cause the water in the beaker to change its state from a liquid to a gas. Light the burner and heat the water. Wear safety glasses and don’t overheat the beaker as it may crack.

Learning experience

Obtain some dry ice (solid CO_2) and show how it changes state from a solid to a gas (sublimation). Remember not to touch the ice with your fingers or they may stick to it! Students get quite excited by this display. It is certainly worth the effort of obtaining some dry ice.

The particle theory

More than 2000 years ago in ancient Greece a philosopher called Democritus suggested this hypothesis: *all matter, living and non-living, is made of tiny particles too small to be seen*. His idea was that if you kept cutting something into smaller and smaller pieces you would eventually come to the smallest possible particles—the building blocks of matter. He used the word *atomos* (which in Greek means 'cannot be divided') to describe these tiniest particles. This is where the word **atom** comes from. (You will learn about atoms in *ScienceWorld 2*.)

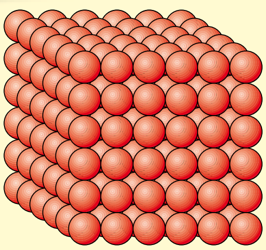
Since then scientists have done many tests with matter, and the results have always agreed with Democritus' hypothesis. Such a hypothesis that is supported by many experimental results is called a **theory**. So the hypothesis that matter is made up of tiny particles too small to see is now called the **particle theory** of matter.

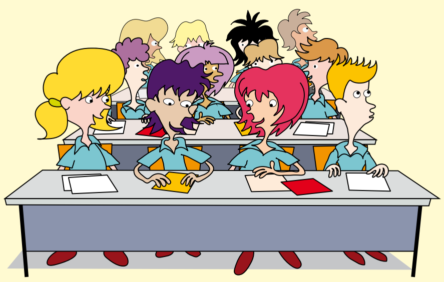
This particle theory can be used to explain the properties of solids, liquids and gases.

The particle theory of matter

1. All matter is made up of tiny particles too small to see.
2. There are spaces between the particles.
3. There are attractive forces between particles. The weaker these forces are, the further apart the particles are.
4. The particles are always moving.
5. At high temperatures the particles move faster than they do at low temperatures.

Solids





The particles in a solid (eg steel) are packed tightly in a fixed pattern. There are strong forces called **chemical bonds** holding them together, so they cannot leave their positions. The only movements they make are tiny vibrations to and fro.

We cannot see these invisible particles, but we can use a **model**. For example, we can represent the particles by the students in your class. When everyone is sitting down, the class is a model for a solid.

The word model has a special meaning in science. It is not the latest model car or a fashion model. It is a way of representing something that is too small to be seen, or too large or complicated to be studied easily. A model is not the real thing. It is only a representation that helps you understand or explain something.

Hints and tips

Cut a piece of paper in half, then in half again, and so on. Eventually the pieces will be too small to see.

Hints and tips

In the first printing of *ScienceWorld 1* there was an error in the last sentence in the second paragraph. The last line reads 'the **particle theory** of matter'.

Learning experiences

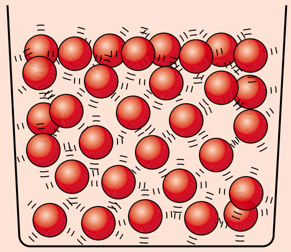
1. Write the particle theory of matter on the board for students to copy into their notebooks, but do it as a 'fill in the gaps' exercise.
2. Students could draw a cartoon to illustrate the particle theory.

Assessment task

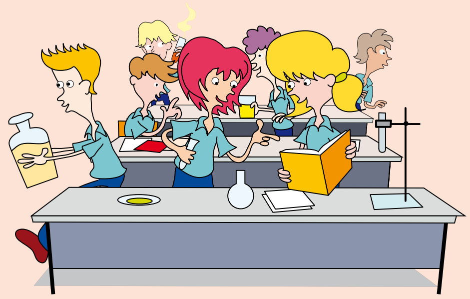
This would be a good time to set Assessment task 10: A particle model, found on the CD.

HEAT

Liquids



The particles in a liquid (eg water) can move about and slide past each other. They are still close together but are not in a fixed pattern. The forces (bonds) that hold them together are weaker than those in a solid.



When the students are moving about busily doing practical work, the class is a model for a liquid.

HEAT

Gases

The particles in a gas (eg air) are far apart, and they move about very quickly. There are still attractive forces between them but they are very weak. The particles collide with each other and the walls of the container, and bounce off in all directions.

When the lesson is over students go in many different directions. Some may stay in the room, while others go to different parts of the school.

Learning experience

Students could 'role play' the states of matter either as a whole class or in groups. This could be acted out at the end of the lesson so they can 'float out of class' modelling a gas.

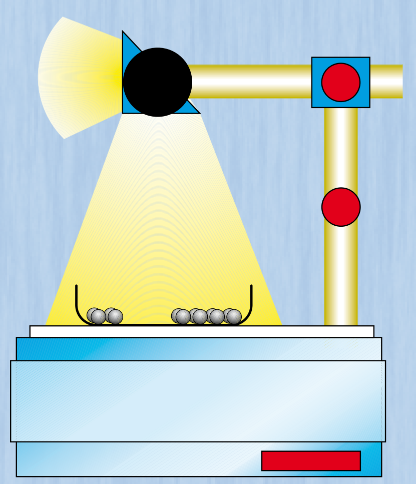
Activity

1 Make a model for matter by putting some ball bearings in a flat dish or box.
What do the ball bearings represent? What does the dish or box represent?
Draw the arrangement of the ball bearings.
What state of matter does this represent?

2 Shake the dish gently so that the ball bearings move about.
Describe the new arrangement of ball bearings.
What state of matter does this represent?

3 Shake the dish vigorously.
Describe the new arrangement. What state of matter does it represent?

Your teacher may demonstrate this model using a dish on an overhead projector.



Teacher note: It is possible to buy special magnetic marbles for this activity.

Explaining melting

We can use the particle theory to explain changes of state. When a solid is heated, its particles gain more energy and vibrate more. This makes the solid expand—get bigger. At the melting point the particles vibrate so much that they break away from their positions. When this happens the solid becomes a liquid.

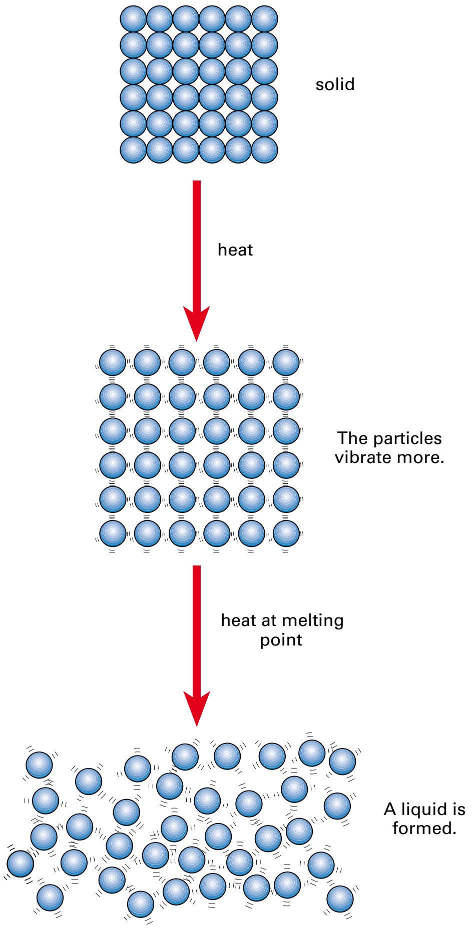


Fig 24 The particle theory can be used to explain the melting of a solid.

Hints and tips

The following analogy is a useful way of explaining melting to students. Take a large lump of frozen peas out of the freezer and place it into a beaker with a small amount of water in it. While heating the beaker, ask students to explain what the peas breaking away is analogous to. The more heat is added, the more peas break away from the lump until they are all free.

Learning experience

Give the students a one-minute challenge to see who can write down as many common or everyday solids as they can which melt at low temperatures—less than 50 °C (butter, ice, ice-cream).

Learning experience

Students could make plasticine models. For a liquid model, balls of plasticine could be placed in a beaker, and for a gas, balls could be placed on a sheet of paper.

Hints and tips

Present to the class some interesting facts about liquids. For example, did you know that liquids do not burn; it is their vapour which does? For example, with burning oil spills, the liquid oil isn't alight but the vapour given off is.

Activity notes

- It is important here not to use too many ice cubes (better to use just one or two) because when they melt, the watch glass will overflow and this will be confusing to the observer.
- It is most efficient to have about 50 mL water in the beaker.

Animation

Students should view the **Particle theory** animation on the CD.

Homework

Ask students to compile a dot-point summary of the unit so far. This can be added to later and used as a revision tool for tests or examinations.

Explaining boiling

When a liquid is heated, its particles have more energy and move faster. They bump into each other more energetically and bounce further apart. This makes the liquid expand. At the boiling point, the particles have enough energy to break the bonds holding them together. They break away from the liquid and form a gas.

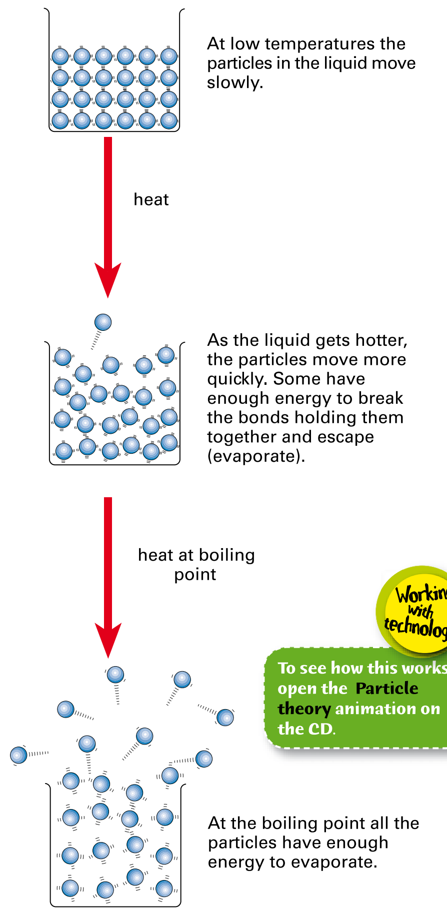


Fig 25 The particle theory can be used to explain the evaporation and boiling of a liquid.

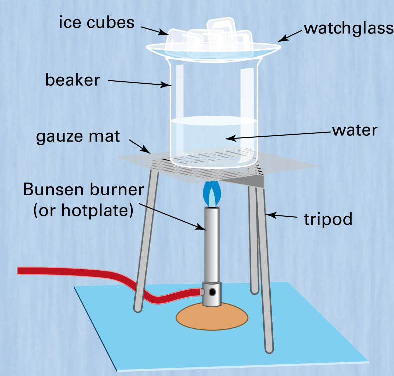
Working with technology

To see how this works, open the **Particle theory** animation on the CD.

Activity

Set up the apparatus shown below and observe carefully what happens.

- Where does evaporation occur?
- Where does condensation occur?
- Where does water exist in:
  - **a** a solid state?
  - **b** a liquid state?
  - **c** a gaseous state?



Science in action

If you are fascinated by the weather, you may be interested in becoming a *meteorologist*. Meteorologists study how water evaporates from the Earth's surface to form water vapour which rises into the atmosphere where it condenses to form tiny water droplets which we see as clouds.

Meteorologists analyse and interpret weather data collected around Australia, including satellite photos. They then prepare weather reports for TV and newspapers, and issue warnings for storms, cyclones, floods and droughts. They work in field stations throughout Australia and its territories, from the tropics to Antarctica.

Learning experience

Using what they have learned from the Activity, students could make a poster or draw a flow diagram to explain cloud formation.

Learning experience

If the class has access to computers, they could search the internet for tables of melting and boiling points of substances.

Investigate

25 MELTING AND BOILING

Aim

To measure and graph the temperature as ice melts to water and then boils.

Working with technology

Materials

- small beaker, eg 250 mL
- crushed ice
- thermometer (–10 to 110°C) or datalogger and temperature probe
- burner, tripod, gauze and heatproof mat
- stopwatch
- stirring rod
- retort stand and clamp
- stopper with hole to hold thermometer in clamp
- graph paper

For information on using dataloggers, open the ICT skillsheet on the CD.

Planning and Safety Check

Read through the Method.

- What safety precautions will be necessary?
- Which is the independent variable and which is the dependent variable? How do you know which is which?

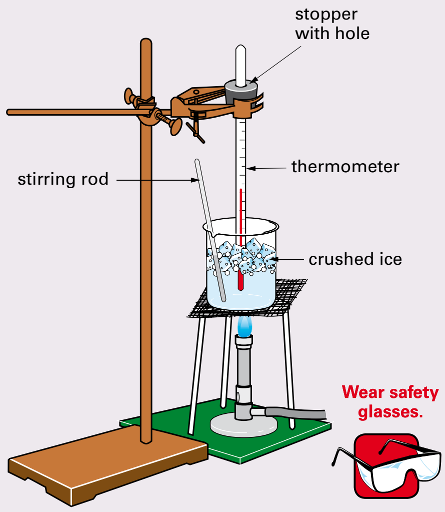
Design a data table, with columns for the two variables to be measured.

Method

1. Set up the apparatus as shown.
2. Half-fill the beaker with crushed ice, and measure its temperature. (Remember to wait until the reading is steady.)

   Record the temperature of the ice in your data table.
3. Light the burner and adjust it to a medium flame. Put it under the beaker and immediately start timing.
4. Measure the temperature every minute. Use the stirring rod to stir gently before each reading. Continue your measurements until the water has been boiling for 3 or 4 minutes.

   Record the data in the data table.



5. Graph your results or print them from the datalogger.

Discussion

1. What caused the ice to melt?
2. What did you notice about the temperature as the ice melted?
3. What did you notice about the temperature as the water boiled?
4. Your graph has two flat sections joined by a slope. What does it mean where the graph is flat? On the graph, mark when the ice is melting. Also mark where the water is boiling.
5. Use your graph to find the temperature of the water 10 minutes after you started heating.
6. Predict the temperature of the water 10 minutes after it started to boil.
7. The temperature did not increase while the ice was melting and while the water was boiling—even though there was a constant supply of energy from the burner. Use the particle model to explain where that energy was going.

Lab notes

- Avoid using mercury thermometers in case of breakages. Remind students of how to handle thermometers (page 31). If you use mercury thermometers, make sure you know the clean-up procedure in case of breakage.
- Thermometers are fragile instruments and care is vital.
  - Do not hit them with the stirring rod.
  - Do not leave them lying on the bench where they can roll off.
  - Clamp them securely so they do not fall into the beaker.

Check! solutions

1

solid $\underset{\text{freezes}}{\overset{\text{melts}}{\rightleftarrows}}$ liquid $\underset{\text{condenses}}{\overset{\text{evaporates}}{\rightleftarrows}}$ gas

2 a The melting point of ice is the temperature when it changes from a **solid** to a **liquid**.
b The melting point of ice is **0 °C**.
c The boiling point of water is the temperature when it changes from a **liquid** to a **gas**.
d The boiling point of water is 100 °C.

3 a The substance formed is a liquid.
b The substance formed is a solid.
c The substance formed is a liquid.
d The substance formed is a gas.

4 a When dew forms on the grass **condensation** is occurring.
b When a bottle of perfume is opened **evaporation** is occurring.
c When a puddle of water disappears **evaporation** is occurring.
d When moth balls disappear **sublimation** is occurring.
e When lava forms rock, **solidification** is occurring.

5

Change of state	*Heating*	*Cooling*
a solid to liquid	✓	
b liquid to gas	✓	
c gas to liquid		✓
d liquid to solid		✓
e solid to gas	✓	

6 a True.
b True.
c False. To change a liquid to a gas you have to **heat** it.
d False. Solids have a definite shape because their particles are **not** free to move around.
e True.
f False. If water boils for a long time its temperature will **not** rise above 100 °C.
g True.
h False. The particles of a gas are so far apart that they only attract each other with **weak** forces.
i False. The particles of a solid only move by **vibrating**.

7 a Particles move fastest in the gas state.
b Particles are closest together in the solid state.
c Particles are close together but not in a pattern in the liquid state.
d The bonds between particles are the greatest in the solid state

Check!

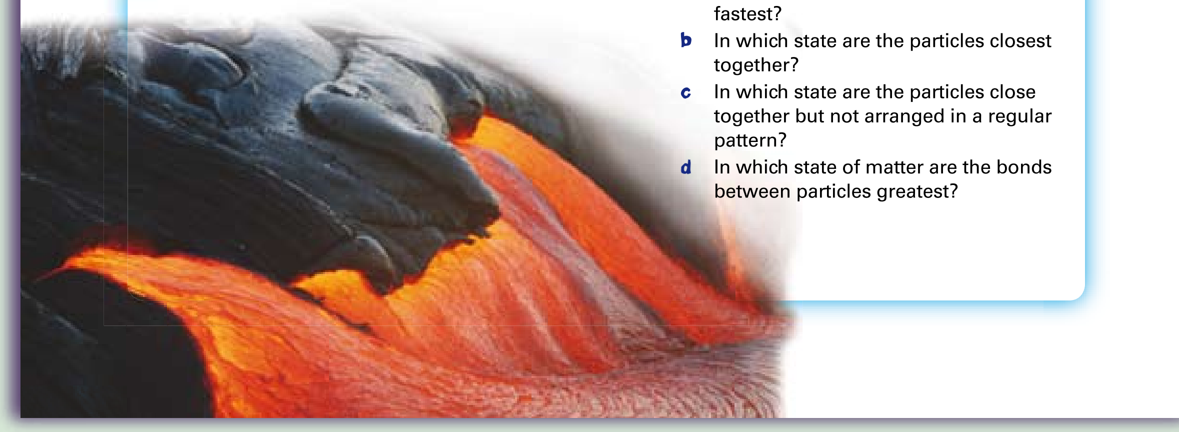
	→ ← freeze	LIQUID	→ ←	

1 Copy the diagram above. Put one word in each box and on each arrow to summarise what you know about changes of state.

2 Complete these sentences:
a The melting point of ice is the temperature when it changes from a ______ to a ______.
b The melting point of ice is ______°C.
c The boiling point of water is the temperature when it changes from a ______ to a ______.
d The boiling point of water is ______°C.

3 Choose from the words solid, liquid or gas to say what type of substance will be formed when:
a a gas condenses
b a liquid freezes
c a solid melts
d a liquid boils
Write your answers in complete sentences.

4 Name the change of state that occurs when—
a dew forms on the grass
b a bottle of perfume is opened and can be smelt on the other side of the room.
c a puddle of water on the road disappears when the sun shines.
d moth balls placed in a suitcase of clothes are gone after a few months.
e lava flows from a volcano and slowly forms a rock called basalt.



5 The table below lists five changes of state. For each change decide whether heating or cooling is needed. Copy the table and tick the correct columns.

Changes of state	Heating	Cooling
a solid to liquid		
b liquid to gas		
c gas to liquid		
d liquid to solid		
e solid to gas		

6 Indicate whether each of the following statements is *true* or *false*. If the statement is false, rewrite it so that it is true.
a Melting occurs when a solid changes to a liquid.
b All matter consists of particles.
c To change a liquid to a gas you have to cool it.
d Solids have a definite shape because their particles are free to move around.
e Water can evaporate at any temperature.
f If water boils for a long time, its temperature rises above 100°C.
g Condense is the opposite of evaporate.
h The particles of a gas are so far apart that they do not attract each other at all.
i The particles of a solid do not move.

7 a In which state do the particles move fastest?
b In which state are the particles closest together?
c In which state are the particles close together but not arranged in a regular pattern?
d In which state of matter are the bonds between particles greatest?

challenge

1 Luigi wears glasses. He finds it hard to see when he enters a hot steamy bathroom. Use what you have learnt in this chapter to explain this.

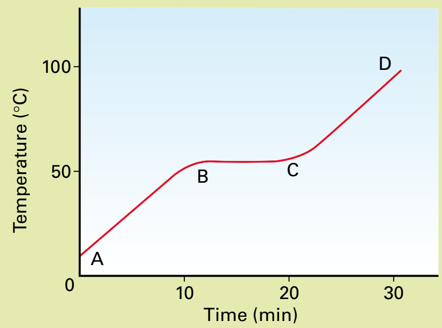
2 If gases and liquids are both made of particles, why are their properties so different? Explain in terms of particles and bonds.

3 Answer these questions in complete sentences.
- **a** How can you make the particles in a solid move faster?
- **b** What are the particles doing if a liquid is evaporating?
- **c** What can happen to a gas if its particles slow down?

4 When you cook food in a saucepan with a lid on, you may notice water on the inside of the lid. Why is this?

5 Use your knowledge of the particle theory to explain each change in the diagrams below.

6 Below is a graph showing the change in temperature over time as wax is heated.

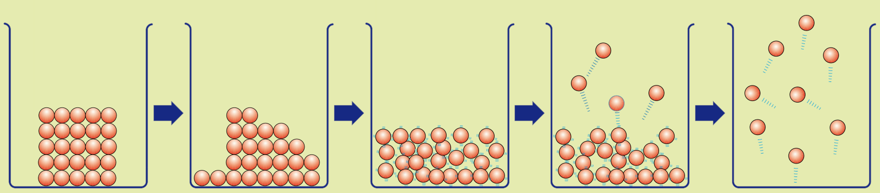


- **a** Which part of the graph shows that a change of state is taking place?
- **b** What is the melting point of the wax?
- **c** What is the state of the wax during the first 10 minutes of heating?
- **d** What is the state of the wax between C and D?
- **e** In which part of the graph are the bonds between the wax particles greatest?

7 Hexane is used as an industrial solvent. It has a melting point of –94°C and a boiling point of 69°C.
- **a** Is hexane a solid, a liquid or a gas at room temperature (20°C)?
- **b** If hexane is heated to 90°C would you expect it to be a solid, a liquid or a gas?

8 Which would evaporate more quickly: water in a flat tray, or water in an open bottle? Explain your answer in terms of the particle theory.

9 Why do clothes dry faster on a windy day than they do on a calm day?



Challenge solutions

1 Luigi finds it hard to see because the water vapour condenses on his glasses to form water droplets.

2 In gases the particles are held together by only weak bonds and they can move away from each other. This means that a gas will change volume and shape too quickly to fill the space available. In liquids the bonds between atoms are stronger and they do not move away from each other very much and will change shape but not volume.

3
- a You can make the particles in a solid move faster by heating them.
- b When a liquid is evaporating the particles are moving further apart.
- c If the particles in a gas slow down it will condense to form a liquid.

4 The water droplets form inside the lid because the steam condenses on the cooler lid.

5 From the left the particles move more and more freely because they are gaining energy by being heated. At first the regular framework changes as the matter melts. Towards the right some of the particles escape from the liquid to move into the air. This is called evaporation.

6 Using the graph:
- a The part of the graph that shows that a change of state is taking place is from B to C.
- b The melting point of the wax is approximately 55 °C.
- c The state of the wax during the first 10 minutes is solid.
- d The state of the wax between C and D is liquid.
- e The bonds are greatest at point A and as the wax is heated these bonds are weakened.

7
- a At room temperature hexane is a liquid.
- b At 90 °C hexane would be a gas.

8 Water in a flat tray will evaporate more quickly because it has a larger surface area and the particles can get into the air more easily.

9 Clothes dry more quickly on a windy day because the air moves the water vapour particles away from the clothes, allowing more water particles to evaporate.

10 a Jan's inference is the most accurate. We know glass will not allow water to pass through and that coldness cannot change to water.

b A better inference is that the water vapour in the air condenses when it comes in contact with the cold glass.

11 The dry ice 'fog' is actually fog and consists of tiny drops of water which have condensed because the dry ice has suddenly cooled the air. These are mixed with the air and carbon dioxide gas and soon warm up and evaporate to become invisible water vapour.

12 Heat is required to change a liquid to a gas. When this change occurs heat will be taken from the surroundings. In the case of perspiration, the heat comes from the clothing and skin which will therefore feel cooler.

Hints and tips

- When discussing this **Science bits** with your class, a brief explanation of what is meant by charged particles (page 233) would be useful.
- Give a brief explanation of what a magnetic field is. If you have not shown the class magnetic fields in Chapter 4, demonstrate them with an overhead projector, by placing a magnet underneath a piece of tracing paper with iron filings on it.

10 Angie wanted to keep her yoghurt cool, so she put it in a jar with some ice and screwed the lid on tightly. When she went to put it in her locker 15 minutes later, she saw that the outside of the jar was quite wet.

Everyone had a go at explaining what had happened (see the cartoon).

a Whose inference do you agree with? Why?

b Can you suggest a better inference?

11 Dry ice is sometimes used to create fog and mist on stage. If carbon dioxide is invisible, how can you see the dry ice fog?

12 On a hot day you perspire (sweat). As this perspiration evaporates it cools you. Use the particle theory to explain how evaporation produces cooling.

science bits

A fourth state of matter

We are familiar with the three states of matter we find on Earth—solids, liquids and gases. However there is a fourth state of matter called **plasma** which makes up 99% of the universe. Plasma consists of charged particles that are even further apart than the particles in a gas. You don't see much plasma on Earth because it requires very high temperatures. However the sun is made of plasma, as are all the stars.

Lightning is a type of plasma that occurs naturally on Earth. You may have seen a plasma sphere in a science centre. The glass sphere contains a gas at a very low pressure and when very high voltage passes through it, it glows and looks like 'bottled lightning'. Plasmas also occur in neon signs and fluorescent bulbs.

Because the particles in a plasma are charged, they are affected by a magnetic field. Loops of plasma erupt from the surface of the sun and follow the curved magnetic field of the sun. Scientists are experimenting with plasmas as hot as 100 million degrees. They are trying to make a fusion reaction that produces energy as the sun does. They use powerful electromagnets which create a 'magnetic bottle' to contain the super-hot plasma.

WEBwatch

To find out more about plasmas, go to www.scienceworld.net.au and follow the links to **Amazing Plasmas**.

Learning experience

Give students this alternative definition of plasma and ask them to rewrite it so that a student in a younger year level could understand it.

Plasma is the fourth state of matter which is a very hot ionised gas where the number of positive ions and electrons are approximately equal, therefore virtually neutral but highly conductive.

A range of resources could be used for this task. To help students get started they could: list science words they don't understand → find their meaning → simplify meaning using words they understand → rewrite the definition → ask a student in the class to critique it.

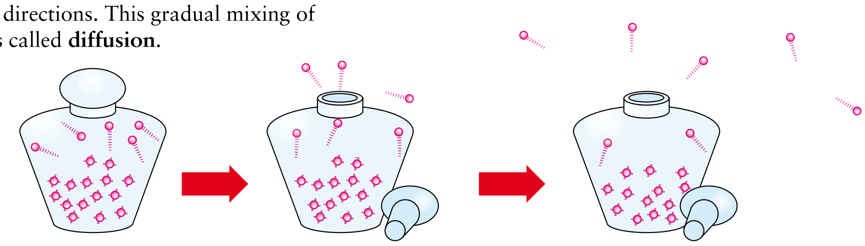
10.3 Using the particle theory

We have used the particle theory to explain solids, liquids and gases, and how they can change from one state to another. In this section we will try to use it to explain some other properties of matter.

Diffusion

If someone opens a bottle of perfume in the middle of the classroom you soon smell it in other parts of the room. The fragrance spreads through the air in all directions. This gradual mixing of substances is called **diffusion**.

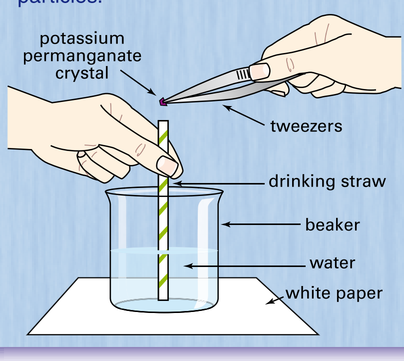
Let's explain how perfume diffuses. When the lid is on, the gas particles remain inside the bottle. When the lid is taken off, the liquid perfume evaporates easily. Since there are only weak forces between the particles, they can spread out, moving away from the crowded bottle to places where there are fewer particles of perfume. Eventually the particles spread evenly throughout the air in the room.



Activities

A Put a beaker on a sheet of white paper and half fill it with water. Let it stand for a while to let the water become perfectly still. Use a pair of tweezers to drop a single crystal of potassium permanganate (Condy's crystals) down a drinking straw as shown. Then leave the dish undisturbed overnight.

Explain what you observed in terms of particles.

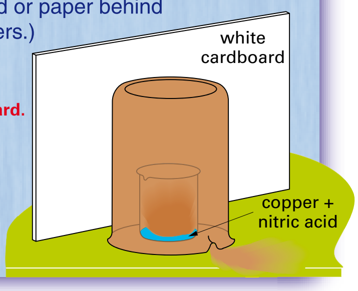


B *This activity involves the poisonous gas nitrogen dioxide and can only be done as a teacher demonstration—in a fume cupboard.*

Place a few pieces of copper in a small beaker. Pour a few drops of concentrated nitric acid on the copper and immediately cover the beaker with a larger beaker, as shown.

Observe what happens to the brown gas. (It helps to put a piece of white cardboard or paper behind the beakers.)

Use a fume cupboard.



Hints and tips

Remind students of everyday experiences with diffusion of gases. For example, after a sports lesson someone may have sprayed deodorant in the change room. A short time later the entire change room will probably smell that person's deodorant. Discuss the importance of being sensitive to the wellbeing of others as some perfumes may trigger asthma or an allergic reaction.

Activities notes

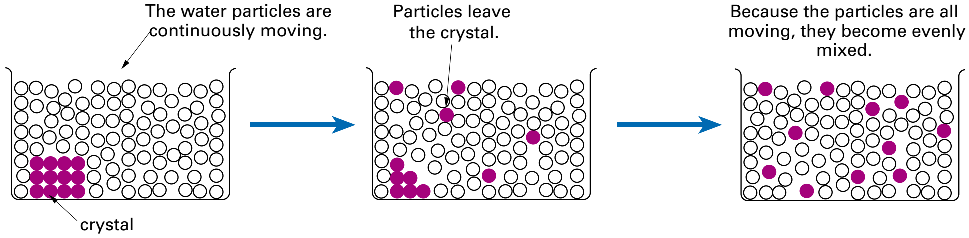
Part A

With Condy's crystals it is vital that the beaker is not moved or the diffusion pattern will be disturbed.

Part B

Nitrogen dioxide: this will need to be done in a fume cupboard where only a few students can see it at once. Some help from the lab technician would be good, so that the rest of the class can be supervised while doing other work.

As you saw in the activity on the previous page, when a crystal of potassium permanganate is placed in water, the water slowly turns purple. Both the crystal and the water are made of particles. Being in the liquid state, the water particles are moving and bump into the particles in the crystal. This causes some particles to leave the crystal and move into the spaces among the water particles, as shown below. This is the process of dissolving. As the particles continue to move, they diffuse throughout the water and the purple colour spreads evenly.

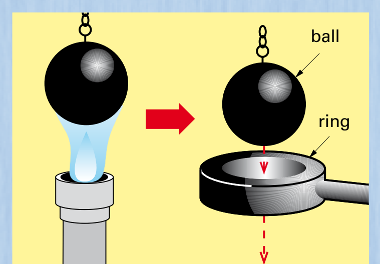


Activities

Your teacher may demonstrate the following activities. For each activity, *predict* what you think will happen, then *observe* what happens and finally *explain* what happened.

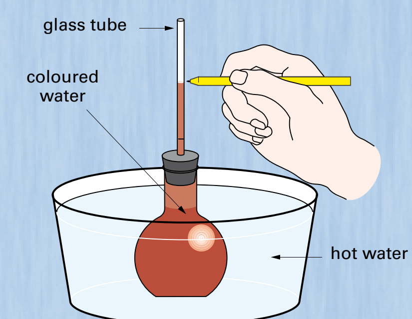
A Using a ball and ring apparatus (or other metal shapes), put the ball through the ring. Then heat the ball strongly and try to put it through the ring again.

What do you predict will happen if you heat the ring and try again? Try it.



B Fill a flask with coloured water and fit a stopper with a piece of glass tubing through it. The coloured water in the tube should reach just above the stopper. Mark this level with a marking pen. Put the flask in a container of hot water for a few minutes. Now put it in a container of *cold* water.

How could you use this apparatus to measure temperature?



C Put a balloon over the mouth of a flask. Heat the flask gently using a Bunsen burner.

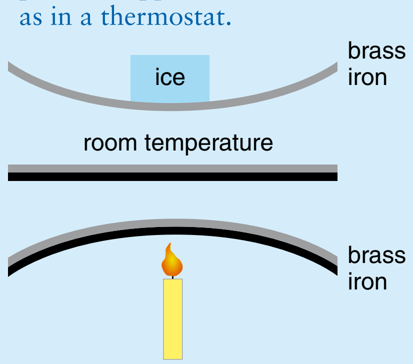
Write a generalisation to explain the results of *all three* activities.

Hints and tips

- The potassium permanganate crystals dissolving in water is an example of the diffusion of a solid in a liquid.
- Putting an Aspro Clear or Alka-seltzer tablet in water shows the diffusion of a gas through a liquid (tiny bubbles disperse in the water). Ask the class why the gas escapes out of the liquid.

Activities notes

- The chain holding the ball gets very hot. If students are doing this part of the activity, make sure they don't touch the chain.
- A bimetallic strip could be used instead of the ball and ring. Brass contracts more when cooled than iron. Brass expands more when heated than iron. Explain some practical applications of this, such as in a thermostat.



Homework

Ask students to find out what a thermostat is used for and which appliances (ovens, fridges, toasters etc) in their home have one and why. They could draw a plan of their house marking the location of each appliance which has a thermostat. Make sure they label what the appliance is.

Expansion and contraction

As you saw in the activity, solids, liquids and gases all expand (get larger) when they are heated. That is, they occupy more space. Similarly, when they are cooled they contract (get smaller) and occupy less space.

In solids the particles vibrate in fixed positions. As the solid is heated the particles absorb energy, vibrate more violently and start to bump into each other. This causes them to move further apart so that they have more room for their violent vibrations. As a result, the solid as a whole expands. When the solid is cooled, energy is lost. The particles slow down again and occupy less space (contract).

Expansion and contraction of liquids and gases can be explained in a similar way.

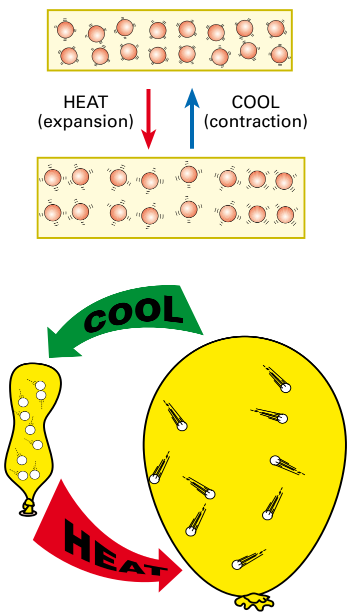


Fig 42 In the cool balloon the air particles move slowly. In the warm balloon the faster-moving particles hit the walls of the balloon more violently, pushing them out and causing the balloon to expand.

Air pressure

When Rhys pulls into the service station, he discovers his car has a flat tyre. What keeps the tyre inflated is *air pressure*. The invisible particles of air are only tiny but they move very rapidly—about the speed of a rifle bullet. These tiny bullets bombarding the walls of the tyre cause the air pressure. What has happened to Rhys is that some of the air has escaped from the tyre and there are not enough particles to give the pressure needed to keep the tyre inflated. Rhys gets the tyre fixed and pumps it up with compressed air. Now the air pressure is back to normal.

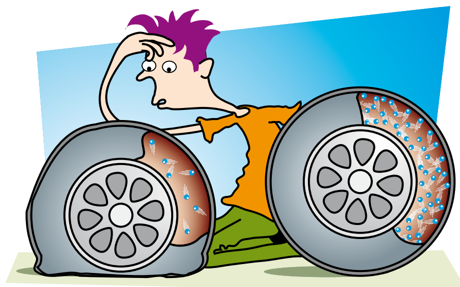


Fig 43 A flat tyre contains few air particles and the air pressure is low. An inflated tyre contains many air particles and the pressure is high.

It is a hot day and Rhys drives non-stop for two hours to get to the beach. When he checks the tyre pressure, he finds it has gone up. There can't be any more air particles in the tyre. What has happened is that friction between the tyre and the road has caused the air inside the tyre to heat up. This means the particles have more energy and are moving faster and hitting the walls of the tyre harder. Hence the air pressure is higher. When the tyre cools down, the particles will lose energy and slow down, and the pressure will return to normal.

You have seen how the particle theory (page 215) can be used to explain changes of state, diffusion, expansion and contraction, and air pressure. You can now try to explain some other properties of matter for yourself.

Hints and tips

It is important to talk not about energy being created or destroyed, but about it being *transferred* or *transformed*. Energy being lost doesn't mean it is destroyed.

It would be worth reinforcing that pressure and force are not the same.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

The SI unit is newton per square metre and is called the pascal (Pa).

Learning experience

Set a higher-order thinking task. For example, give the following scenario: a builder didn't follow an architect's plan and forgot to put in the expansion joints in a house.

- What is expansion and contraction?
- Why are expansion joints necessary?
- What consequences may arise in different weather conditions?
- How do you think the joints are placed?
- Where do you think the joints are placed?
- Show what happens if expansion joints are put in and what happens if they aren't.
- How could the problem be fixed without pulling the house down?

It is important to allow thinking time for students to develop ideas, especially for the more creative learners.

Learning experience

At the start of the lesson have a student blow up a balloon. Put it into the laboratory fridge and take it out at the end of the lesson. It should be smaller in size, illustrating the contraction of gases with decreasing temperature.

Learning experience

Ask the students to give some examples of things in everyday life that need to allow for expansion and contraction (powerlines, railway tracks, concrete bridges and paths).

Learning experience

To illustrate the expansion of gases, take a dented ping pong ball and put it into a beaker of boiling water. You could also pose the following question: why does it help to put a pinhole in one end of an egg before you boil it?

Alternatively, try boiling about 50 mL of water in an opened aluminium drink can. Then quickly place the can upside down in water in a container so that the open top is under water.

Learning experience

Have the students do a research task to investigate the expansion of water. Their report could be written as a newsflash, an interview or media article. For very creative thinkers, they could write their article from the point of view of a fish in a pond whose home froze over. The students could investigate the following: what happens to the density of water at 0 °C, at 4 °C, greater than 4 °C and less than 4 °C?

Activity notes

- It may be useful to construct some 3-D models of different solids to help students to visualise crystalline structures.
- A piece of galvanised (zinc-coated) metal could be passed around the class. The crystal structure is quite evident.
- When you compress air (bicycle pump), you transfer energy to the molecules as the piston hits them. Hence the air warms up. (As a gas expands it cools.)

Activity

For each observation below write an inference to answer the question in terms of the particle theory. Draw a model to explain what is happening to the invisible particles.

1 Observation: *Lead is four times denser than aluminium.*

Question: How can you explain this?

2 Observation: *Add a teaspoon of sugar to a glass of water and stir.*

Question: Explain what happens.

3 Observation: *You can pour water from one container to another, but honey is much harder to pour, especially when it has been in the fridge.*

Question: How can you explain this?

4 Observation: *Crystals have a definite shape, with straight edges and sharp corners. For example, salt crystals are cubes, while quartz crystals (below) are like pointed columns.*

Question: How can you explain these different shapes?

5 Observation: *Hold your finger over the end of a bicycle pump and push in the plunger. Let go of the plunger and it moves back to where it came from.*

Question: What pushed the plunger back?

6 Observation: *Make a soap film on a frame like the one shown below. Pull the thread to stretch the film. When you release the thread the film contracts, pulling back the thin wire.*

Question: Why does this happen?

MAIN IDEAS

Copy and complete these statements to make a summary of this chapter. The missing words are on the right.

1 Matter has ______ and takes up space (its ______).
2 There are three common ______ of matter on Earth: solids, liquids and gases.
3 ______ is how much mass is packed into a measured volume.
4 Materials may be natural, processed or ______. What you use a material for depends on its ______.
5 Matter can be changed from one state to another when ______ is added or removed.
6 The particle ______ of matter states that all matter is made of particles too small to see. These particles:
- have ______ between them
- ______ each other
- are constantly ______
- move faster as the temperature increases.

attract
density
heat energy
mass
moving
properties
spaces
states
synthetic
theory
volume

Try doing the Chapter 10 crossword on the CD.

Working with technology

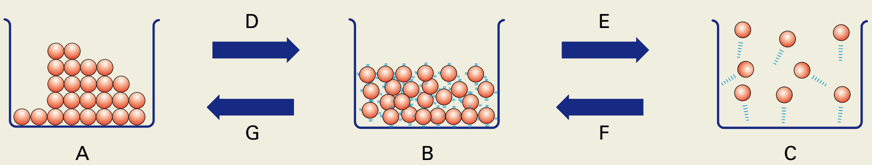
Main ideas solutions

1 mass, volume
2 states
3 density
4 synthetic, properties
5 heat energy
6 theory, spaces, attract, moving

REVIEW

1 The statement *All matter is made of particles* is:
A an observation
B an inference
C a prediction
D a generalisation

2 Copy the diagrams below and label them by replacing the letters (A–G) with one of these words: condensation, evaporation, gas, liquid, melting, solid, solidification.

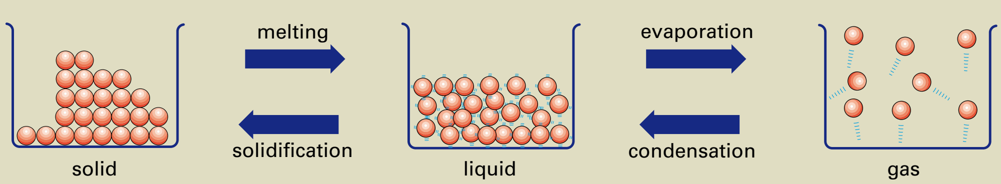


3 A substance has no fixed shape. From this information it would be correct to say that the substance is a:
A gas
B solid or liquid
C liquid or gas
D solid or gas

4 Give three examples of how the use of a substance depends on its properties.

Review solutions

1 **D**—Because the statement says *all matter*, it is a generalisation rather than an inference.
2 See the diagram at the bottom of this page.
3 **C**
4 There are several examples on page 211 but you have probably thought of others.



REVIEW

5 Mercury is a liquid with a density of 14 g/cm^3. Use the table below to find something that would sink in water but float in mercury.

Table of densities (g/cm^3)	
aluminium	2.7
lead	11.3
platinum	21.5
polystyrene foam	0.1
petrol	0.7
water	1.0

6 Archimedes was asked to find out if the crown belonging to the king of Syracuse (in ancient Greece) was made of pure gold. The king thought some silver may have been added to reduce the amount of gold needed. Archimedes decided to use his knowledge of density to solve the problem. He found the volume and mass of the crown. He also found the mass of an equal volume of pure gold. Here are his results.

volume of crown = 100 cm^3

mass of crown = 1500 g

mass of 100 cm^3 of pure gold = 1930 g

a What is the density of pure gold in g/cm^3?
b What was the density of the crown?
c Was the crown made from pure gold?

7 Write a paragraph describing the advantages and disadvantages of plastic, paper and cotton canvas for making supermarket bags. In your answer use these words: processed, non-renewable, renewable and synthetic.

8 The questions below refer to the following list of some of the possible properties of particles.

Rate of movement
A vibrating or moving very slowly
B moving around freely but slowly
C moving freely and rapidly

Spaces between particles
D very close together, almost touching
E fairly close together
F wide spaces between them

Forces between particles
G very strong bonds
H held together to some extent but free to move around
I very weak bonds

a Aluminium is a solid. Which *three* properties listed above would probably be true of its particles?
b Ozone is a gas. Which *three* properties would probably be true of its particles?
c Petrol is a liquid. Which *three* properties would probably be true of its particles?
d Steel cannot easily be compressed. Which description in *Spaces between particles* would best explain this?
e Diamond is a very hard substance. Which *two* properties above would best explain this?
f Property E in the above list can sometimes be changed to property F by:
A heating the substance
B cooling the substance
C putting it in another container
D compressing the substance

9 Use the particle theory to explain each of the following questions:
a Why do gases have much lower densities than solids and liquids?
b Why do gases condense to form liquids when cooled?

Check your answers on pages 304–305.

5 **Aluminium** (density 2.7 g/cm^3) and **lead** (density 11.3 g/cm^3) will both sink in water. And because their densities are less than the density of mercury (14 g/cm^3), they will float in mercury.

6 **a** Density of pure gold

$$= \frac{\text{mass of pure gold}}{\text{volume of pure gold}}$$

$$= \frac{1930\ \text{g}}{1000\ \text{cm}^3}$$

$$= \mathbf{19.3\ g/cm^3}$$

b Density of crown

$$= \frac{\text{mass of crown}}{\text{volume of crown}}$$

$$= \frac{1500\ \text{g}}{1000\ \text{cm}^3}$$

$$= \mathbf{15.0\ g/cm^3}$$

c No—the density of the crown is less than 19.3 g/cm^3, therefore it is not pure gold.

7 The answer should be something like this:

Shopping bags are normally made of LPDE plastic. These are cheap but are difficult to dispose of and at present cannot be recycled. However, the green shopping bags made of polypropylene can be reused many times. Plastic is a *synthetic* material made from coal. It is therefore *non-renewable*. The bags could be made from paper, a *processed* material made from wood, which is *renewable*. However, paper bags may not be as strong as plastic ones. Bags could also be made from cotton canvas. These are more expensive but can also be reused.

8 **a** **A** particlesvibrating or moving very slowly
D particles very close together, almost touching
G very strong bonds between particles
b **C** particles moving freely and rapidly
F wide spaces between particles
I very weak bonds between particles
c **B** particles moving around freely but slowly
E particles fairly close together
H particles held together to some extent but free to move around
d **D** particles very close together, almost touching
e **D** particles very close together, almost touching
G very strong bonds between particles
f **A**

9 **a** The particles in gases are much more spread out than the particles in liquids or solids. There are fewer particles packed into each cubic centimetre. Hence gases have lower densities than liquids or solids.
b When a gas is cooled its particles lose energy and don't move as quickly. They become closer together and attract each other more strongly. As a result the gas condenses to a liquid.