

# 8 Chemical change

Chemical reactions are happening everywhere. Chemical reactions in your body digest food, decay your teeth and much more. Chemical reactions occur in batteries to provide electricity, in the oven when you bake a cake, in your hair when it is bleached or coloured, and in your car when it burns fuel. Explosions are very fast chemical reactions.

## Think about reactions

- Why does a half-eaten apple go brown?
- How is an explosion different from other chemical reactions?
- Why does a spoonful of sugar dissolve more quickly than a sugar cube?
- What makes a nail rust?
- Why is the Sydney Harbour Bridge continually being painted without a break?
- What is a backdraught and what causes it?
- What is the difference between soaps and detergents?
- What makes Lycra® so special?
- Why is recycling so important?

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# YOUR QUEST

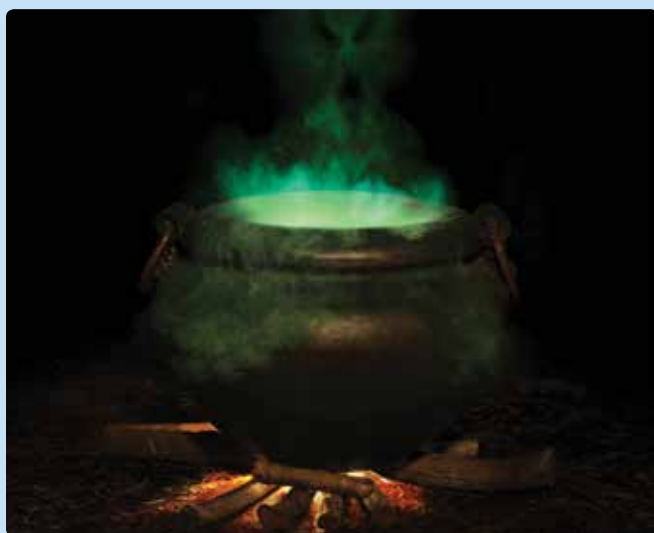
## What is a chemical reaction?

What is a chemical reaction — and how do you know whether a chemical reaction has taken place?

### THINK

Check out the images on this page and answer the questions based on what you already know about chemical reactions.

The boiling liquid in the pot below is changing colour. It began as a mixture of reds, yellows and blues and, after stirring, is changing into a dangerous-looking green soup.

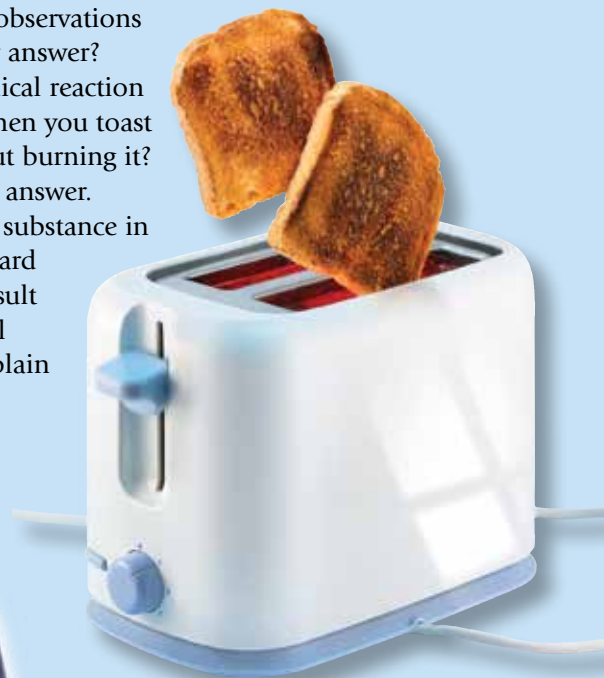


- 1 Write down your opinion about whether or not a chemical reaction is taking place.
- 2 Explain how you know whether a chemical reaction has taken place.
- 3 Is there a chemical reaction taking place underneath the pot? Explain your answer.
- 4 Clouds are forming above the pot. Is this evidence of another chemical reaction? Explain your answer.



It was a long, tough and hot cross-country race. Just as well this runner drank lots of water along the way.

- 5 Runners in long-distance races sweat heavily. The water lost due to sweating evaporates from the skin. Is this evaporation an example of a chemical reaction? Explain your answer.
- 6 Does a chemical reaction take place when you burn toast? What observations support your answer?
- 7 Does a chemical reaction take place when you toast bread without burning it? Explain your answer.
- 8 Is the frozen substance in the man's beard below the result of a chemical reaction? Explain your answer.



Oh, no! The toast is burnt again!

Antarctic weather is freezing — REALLY freezing!

# Patterns, order and organisation: Physical and chemical properties

Thousands and thousands of different substances are used in the objects that surround you. Each substance shown below has physical and chemical properties that make it useful for a particular purpose.

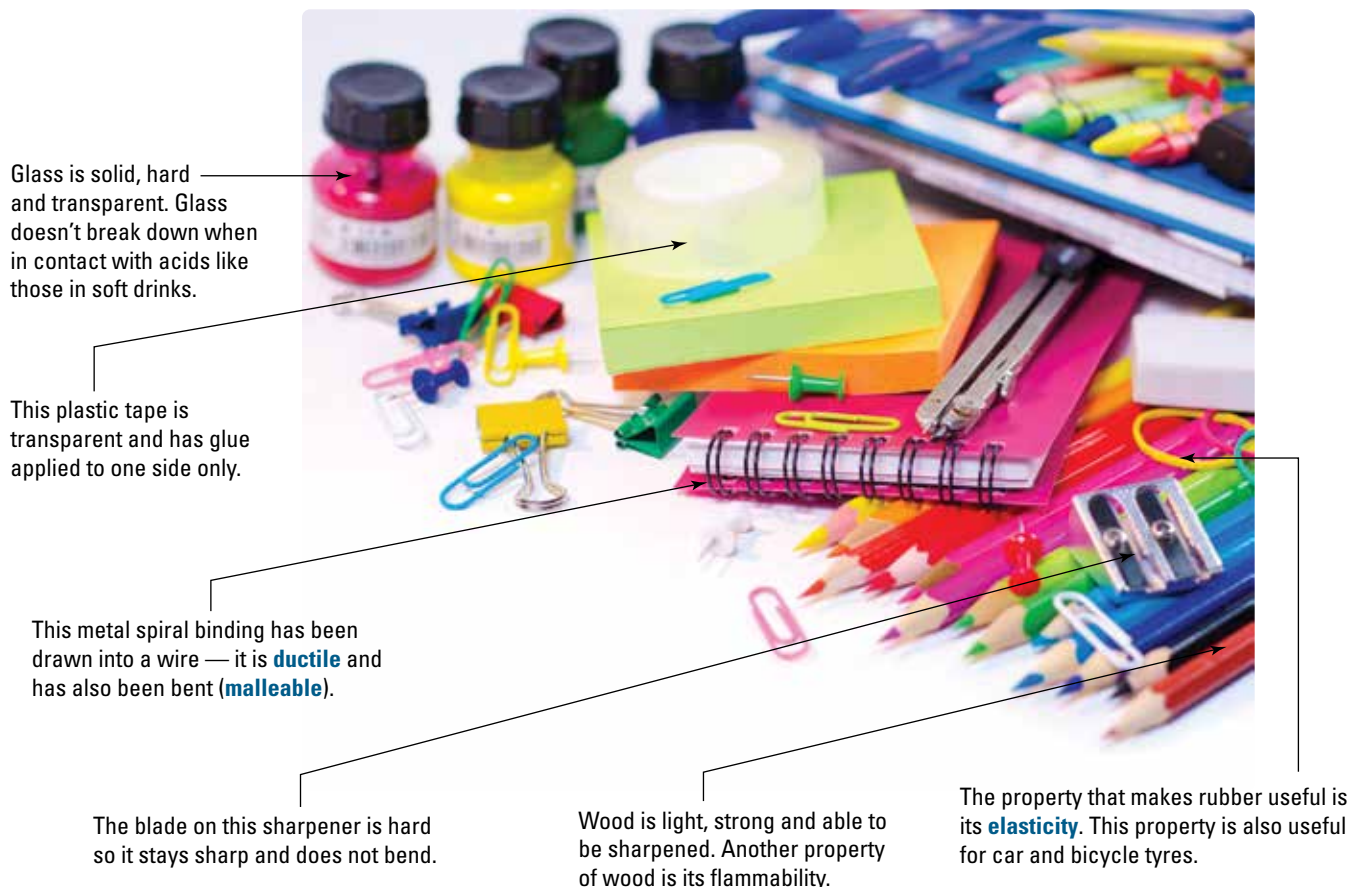
## Physical or chemical?

The properties of most substances fall into two categories — physical or chemical. **Physical properties** are those that you can either observe using your five senses — seeing, hearing, touching, smelling and tasting — or measure directly. Examples include colour, size, shape, texture, temperature, malleability and ductility, but there are many, many more.

**Chemical properties** are those that describe how a

substance combines with other substances to form new chemicals or how a substance breaks up into two or more different substances. Examples of chemical properties include **flammability**, **reactivity** and **toxicity**.

- Flammability is an indicator of how easily a substance catches fire. When a substance burns, it creates new substances.
- Reactivity is a measure of how easily a substance combines with other substances to produce new substances.
- Toxicity refers to the danger to your health caused when poisonous substances combine with chemicals in your body to produce new substances and damaging effects.



## INVESTIGATION 8.1

### Checking out properties

**AIM** To describe the physical properties of a variety of substances

**Materials:**

a range of small items that might include a tennis ball, a table-tennis ball, a table-tennis paddle, a dishwashing sponge, assorted fabrics (for example, wool from a jumper, nylon socks and stockings, polyester, cotton), a magnifying glass or lens, a roll of sticky tape, a candle, paper clips, small springs, polystyrene cups, foam rubber, aluminium foil, a clear plastic bottle of dishwashing detergent, a bottle of perfume

### METHOD AND RESULTS

- ▶ Work in groups of three or four so that you can discuss the properties. Work on one item at a time.

- 1 For each item, list all its physical properties that you can think of. Some items will consist of more than one substance. In those instances, list the physical properties of each substance.
- 2 For each physical property of each substance in the item, explain how that property makes the substance useful for its purpose.

### DISCUSS AND EXPLAIN

- 3 List tests that you could perform to discover some of the chemical properties of the substances in some of the items.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Most metals can be described as ductile and malleable. How does each of these properties make metals useful?
- 2 Which of the two categories of properties can be directly observed with your five senses?
- 3 Some substances have the chemical property of toxicity. What does this mean?

### THINK

- 4 What property of leather makes a soccer ball easy to grip?
- 5 List the properties of the packaging of potato chips.



Why are potato chip bags pumped full of air?  
Why is foil often used for the packaging?  
Could a different material be used?

- 6 List at least two physical properties that you can describe using your sense of hearing.

- 7 Three chemical properties are listed on the previous page — can you think of another one? Explain that chemical property using an example.
- 8 Look at the image on the previous page. Choose three items and explain how the properties of the materials make them suitable for their purpose.

### IMAGINE

- 9 Imagine that you are designing a spacecraft that will take astronauts to the Moon and back. List the properties that the outer surface of the spacecraft would need to have. Include at least two chemical properties.

### INVESTIGATE

- 10 Road bike frames for serious and competitive cyclists are made from aluminium, carbon fibre or a combination of both. Find out:
  - (a) what properties both aluminium and carbon fibre have that make them suitable for the frames of road racing bikes
  - (b) which properties make aluminium bikes more suitable than carbon fibre for some purposes. (Note that cost is not a property!)



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sheet

8.1 Properties of materials

# Time for some changes

## Chemical changes

When you hard-boil an egg, a **chemical change** takes place. At about 100 °C the eggwhite and yolk undergo chemical changes that alter their chemical make-up. Bonds between atoms or molecules are broken or new bonds between these particles are formed. Unlike cooling melted chocolate, which brings about another physical change, cooling the egg will not change it

back to its raw state. In fact, most chemical changes are difficult to reverse.

When paper is burnt, it combines with oxygen to form ash and smoke. This is a chemical reaction, because new substances are formed. Burning gas in a Bunsen burner is also a chemical change. The methane gas burns with oxygen in the air to form two new substances: carbon dioxide and water vapour. During this chemical reaction heat is also produced.



When a glass is placed over a candle, initially it continues to burn, using up the oxygen in the glass and producing carbon dioxide.



A few seconds later, all the oxygen is used and the candle goes out.

## How does a candle burn?

When you try to light a piece of solid wax it melts, but does not burn. If solid wax doesn't burn, how does a candle burn? Is it the string wick that is in the middle of the candle that burns? String will burn, but it doesn't burn like a candle does. How then does a candle burn?

When you light the wick of a candle, the wax at the top of the candle melts. The molten wax is drawn up the wick just as water soaks into a paper towel.

As the liquid wax flows up the wick and gets closer to the heat of the flame it **evaporates**. The wax vapour mixes with oxygen in the air and burns.

### INVESTIGATION 8.2

#### A burning candle

**AIM** To observe and describe the changes that take place when a candle burns

##### Materials:

|                |         |
|----------------|---------|
| safety glasses | candle  |
| jar lid        | matches |
| heatproof mat  |         |

#### METHOD AND RESULTS

- ▶ Place a jar lid on a heatproof mat.
- ▶ Light a candle and allow a drop of wax to drip onto the lid. Place the candle on the drop of wax and fix it to the lid.
- 1** Observe the candle and write down as many observations of the burning candle as you can.
- ▶ Discuss your observations with others in your group.
- ▶ Blow out your candle and you will see a white vapour rising from the top of the wick.

**CAUTION** Do not smell the vapour directly. Fan the odour to your nose with your hand.

- ▶ To confirm that the white vapour is not smoke, carry out the following test: Relight the candle. Once it is burning properly, blow it out. Quickly light the top of the vapour trail. The flame should run down the vapour to the wick and relight the candle.

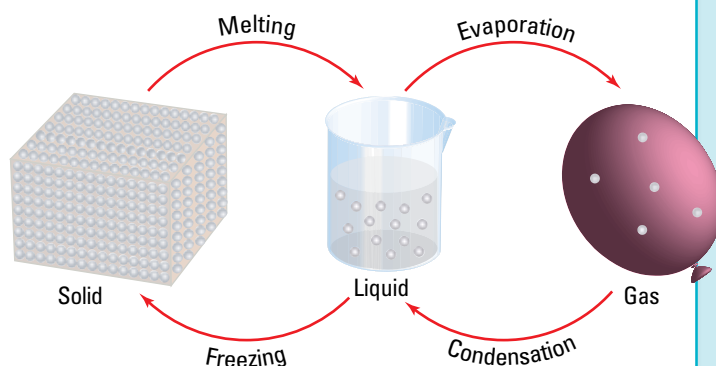
#### DISCUSS AND EXPLAIN

- 2** How far is the flame from the solid wax?
- 3** The solid wax forms a little pool of liquid wax around the wick. Why does this happen?
- 4** Describe the odour of the vapour that is present after the candle is blown out.
- 5** Draw a diagram of a candle and its flame. Label this diagram to explain how a candle burns.
- 6** Explain why lighting the wax vapour causes the candle to relight.

If you enjoy eating chocolate you'll know that it's not so easy to eat on a hot summer's day. Energy transferred from the hot air surrounding the chocolate causes it to melt. The chocolate changes **state** from solid to liquid. The chocolate's change in state is reversible. The melted chocolate can be cooled and solid chocolate will form again.

## Physical changes

The changes to the chocolate described above are **physical changes**. Melting, evaporation, condensation and freezing are all physical changes. Changes of state are reversible physical changes.



Changes of state are reversible physical changes.

Changes in the shape or size of a substance are also physical changes. These are not always reversible. For example, if you drop an egg, its shape is changed forever. But when you stretch an elastic band, it can quickly return to its original shape when you let it go.

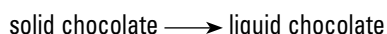
A physical change does not break any bonds between the atoms of a substance, nor does it create any new bonds. No new substances are formed.

## Describing change

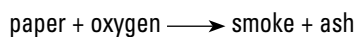
In a burning candle, there are both physical and chemical changes. The melting of the solid wax to form liquid wax and the evaporation of liquid wax to form wax vapour are physical changes. The burning of the wax vapour is a chemical change. The wax vapour reacts with oxygen in the air to form new substances including carbon dioxide and ash.

Physical and chemical changes can be described using word equations.

Melting chocolate can be described by the equation:



The burning of paper can be described by the equation:



## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 What is the difference between a physical and a chemical change?
- 2 Describe two examples of a physical change.
- 3 Describe two examples of a chemical change.
- 4 Match the word with the definition.

|                             |              |
|-----------------------------|--------------|
| Change from solid to liquid | Freezing     |
| Change from gas to liquid   | Melting      |
| Change from liquid to solid | Condensation |
| Change from liquid to gas   | Evaporation  |

- 5 Which type of physical change can always be reversed by heating or cooling?

### THINK

- 6 Copy and complete the table below.

| Observation                             | Physical or chemical change |
|-----------------------------------------|-----------------------------|
| Water freezing to form snow             |                             |
| A cake cooking                          |                             |
| Lighting the gas on the stove           |                             |
| Petrol evaporating at the petrol pump   |                             |
| Lighting a match                        |                             |
| Steam condensing on the bathroom mirror |                             |
| Melting gold to cast gold bars          |                             |
| Dynamite exploding                      |                             |
| Bleaching a stain                       |                             |
| Dissolving eggshell in acetic acid      |                             |

- 7 Write two word equations to describe the changes of state that take place when a candle burns.
- 8 Write a word equation to describe the chemical change that takes place when a candle burns.
- 9 When you hard-boil an egg, the inside of the egg gets hard. Why is this a chemical change and not a physical change?

### CREATE

- 10 Candles are a good example of both physical change and chemical change. Write a poem about a candle burning.

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8.2 Changing states

# Chemical reactions

A **chemical reaction** is a chemical change in which a completely new substance is produced.

Almost all the products you use or wear each day are made by chemical reactions, from cosmetics to concrete, plastics to paper, glass to graphite, stainless steel to shampoo, fibres to food additives, margarine to medicines and many, many more.

## Feeling hungry?

A hamburger is an incredible mixture of chemicals. Every part of it has been produced by chemical reactions. The most important chemical reaction in growing the lettuce is photosynthesis, in which the reactants are carbon dioxide and water. The products are glucose (a type of sugar) and oxygen. That chemical reaction cannot take place without light and a chemical called chlorophyll, which gives plants their green colour. In fact, none of the other components of the hamburger could be grown or produced without photosynthesis.

The substance used to make cheese is the product of a chemical reaction in which a protein in cow's milk called casein reacts with acetic acid when heated. Acetic acid is found in orange and lemon juice and is more commonly known as vinegar.

## Reactants and products

The substances that you begin with in a chemical reaction are called the **reactants**; the substances that are produced are called the **products**. When you wash the dishes, a chemical reaction occurs between the detergent and the mess on the dishes. When you shampoo your hair, some of the chemicals in the

shampoo react with the greasy substances on your scalp that contain dust, dirt and tiny organisms such as bacteria that can make your hair unhealthy.

## Where's the evidence?

You can usually tell whether a chemical reaction has taken place by identifying one or more of these clues:

- a **precipitate** (cloudiness caused by a solid substance) appears in a liquid or gas
- an odour is detected
- bubbles appear
- there is an increase or decrease in temperature
- light is emitted or a flame appears
- there is a change in colour.

However, the only way to be certain that a chemical reaction has taken place is to identify one or more new chemical products.



The bright yellow precipitate in this flask is a product of the chemical reaction that takes place when colourless solutions of lead nitrate and potassium iodide are mixed together.



When water is added to dried copper sulfate, it turns blue — but has a chemical reaction taken place? No reaction has occurred since the solid turns white again when dried.

### WHAT DOES IT MEAN?

The word **product** comes from the Latin word **productum**, meaning 'thing produced'.

## Chemical reaction experiments

Before you start each of the following four investigations, design a suitable table for recording your observations.

As you perform the experiments:

- 1 Make a note of the appearance of each of the reactants you start with.
- 2 Carry out the experiment and observe carefully to detect any changes that occur.
- 3 Describe the changes that take place and products of the reaction.

### INVESTIGATION 8.3

#### Heating copper carbonate

**AIM** To observe and record the chemical reaction that occurs when copper carbonate is heated

**Materials:**

Bunsen burner, heatproof mat and matches  
safety glasses  
test tube, test-tube rack and test-tube holder  
spatula  
copper carbonate powder

#### METHOD AND RESULTS

- ▶ Pour 2 spatulas of copper carbonate into the test tube.
- ▶ Using the test-tube holder, heat the test tube in the Bunsen burner flame. Remember to move the test tube in and out of the flame and point it away from people.
- ▶ Stop heating when the copper carbonate has changed colour.

- 1 Record your observations.

### INVESTIGATION 8.4

#### Magnesium metal in hydrochloric acid

**AIM** To observe and describe the chemical reaction between magnesium and hydrochloric acid

**Materials:**

heatproof mat  
safety glasses  
test tube and test-tube rack  
1 cm piece of magnesium ribbon  
dropping bottle of 0.5M hydrochloric acid

#### METHOD AND RESULTS

- ▶ Put the magnesium in the test tube.
- ▶ Add 20 drops of hydrochloric acid to the test tube.

**CAUTION** The test tube may become quite hot

- 1 Record your observations.

### INVESTIGATION 8.5

#### Sodium sulfate and barium chloride

**AIM** To observe and describe the chemical reaction between sodium sulfate and barium chloride

**Materials:**

heatproof mat  
safety glasses  
test tube and test-tube rack  
test-tube holder  
dropping bottle of 0.1M sodium sulfate solution  
dropping bottle of 0.1M barium chloride solution

#### METHOD AND RESULTS

- ▶ Add 20 drops of the sodium sulfate solution carefully to the test tube.
- ▶ Add 20 drops of the barium chloride solution carefully to the test tube.

- 1 Record your observations.

#### DISCUSS AND EXPLAIN

- 2 What observation provides evidence that a chemical reaction has taken place? Explain your reasoning.

### INVESTIGATION 8.6

#### Steel wool in copper sulfate solution

**AIM** To observe and record the chemical reaction between steel wool and copper sulfate

**Materials:**

heatproof mat  
safety glasses  
test tube and test-tube rack  
glass stirring rod  
1 cm ball of steel wool  
dropping bottle of 0.5M copper sulfate solution

#### METHOD AND RESULTS

- ▶ Put the steel wool in the test tube, using the glass stirring rod to push it gently to the bottom of the test tube.
- ▶ Add copper sulfate solution to the test tube to a depth of 2 cm.

- 1 Record your observations.

#### DISCUSS AND EXPLAIN

- 2 What observation provides evidence that a chemical reaction has taken place?



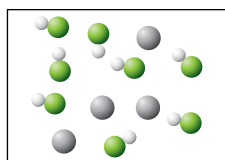
Safety glasses should always be worn during experiments involving chemical reactions.

## Writing word equations

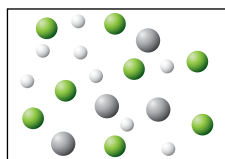
Each of the chemical reactions in Investigations 8.3–8.6 can be described by a chemical word equation. In each case the reactants are on the left side of the equation and the products are on the right side.

- When magnesium metal reacts with hydrochloric acid, hydrogen gas and magnesium chloride are formed:

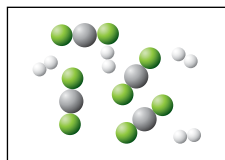
magnesium + hydrochloric acid  $\longrightarrow$  hydrogen + magnesium chloride



1. Magnesium is placed into hydrochloric acid.



2. Bonds between hydrogen and chlorine atoms break.



3. New bonds form. Chlorine atoms bond to magnesium atoms to form molecules of magnesium chloride, while hydrogen atoms bond together to form molecules of hydrogen gas.

### KEY

● Chlorine atom    ● Hydrogen atom    ● Magnesium atom

2. Heating copper carbonate forms copper oxide and carbon dioxide:

copper carbonate  $\xrightarrow{\text{heat}}$  copper oxide + carbon dioxide

Although heat is required for this chemical reaction to take place, it is not a substance and therefore is not a reactant. It is written above the arrow for this reason.

3. Sodium sulfate and barium chloride in solution react to form solid barium sulfate and sodium chloride, which remains dissolved in the solution:

sodium sulfate solution + barium chloride  $\longrightarrow$  solid barium sulfate + sodium chloride solution

4. Steel wool (which is made of iron) dissolves in copper sulfate solution to form iron sulfate solution and copper metal:

iron + copper sulfate solution  $\longrightarrow$  iron sulfate solution + copper

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Write down four observations that could provide evidence that a chemical reaction has taken place.
- 2 When magnesium metal reacts with hydrochloric acid, hydrogen gas and magnesium chloride are formed.
  - (a) What are the products?
  - (b) What are the reactants?
- 3 What is the only real proof that a chemical reaction has taken place?

### THINK

- 4 Write word equations for the following chemical reactions.
  - (a) Octane gas is burnt with oxygen in a car engine to produce carbon dioxide and water.
  - (b) Sodium metal reacts with chlorine gas to form sodium chloride.
  - (c) Hydrogen gas and oxygen gas combine to form water.
  - (d) Zinc metal dissolves in hydrochloric acid to form hydrogen gas and zinc chloride.
- 5 Explain why the reaction that takes place when copper carbonate is heated is called a decomposition reaction.
- 6 Explain why the tomato, cheese, bread and meat in a hamburger cannot be grown or produced without photosynthesis.
- 7 Describe the evidence that one or more chemical reactions takes place when meat is grilled.

### CREATE

- 8 Performing some chemical reactions can be dangerous. Design a safety poster for one of the experiments you have done.
- 9 Choose one of the materials below and find out how it is manufactured. Write a report about the chemical reactions used in its production.
  - Glass
  - Soap
  - Margarine
  - Paper
  - Nylon
  - Polyethylene

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8.3 Physical and chemical changes  
8.4 Describing chemical changes

# Fast and slow reactions

## Explosions

Explosions are chemical reactions that take place very quickly. Explosions also release a lot of heat, light and noise. In less than 10 milliseconds, a dynamite blast in a large mine can produce 5 billion litres of gas and release 20 billion joules of energy — enough energy to tear any rock apart.

In contrast, the chemical reactions that cause concrete to set are very slow. It can take several days for concrete to set hard. Rusting is another example of a slow chemical reaction.

The **reaction rate** is a measure of how quickly a chemical reaction occurs. How can the rate of a reaction be changed to make a slow reaction happen quickly or make a fast reaction slow down?

### WHAT DOES IT MEAN?

The word *explosion* comes from the Latin word *explosio*, meaning 'driven off by clapping or hooting'.

## Speeding up a reaction with heat

Heating a substance adds energy to its particles. They move more rapidly and collide more frequently. When they collide, bonds between the particles are broken and new ones are more easily formed with the particles of other substances. Heating substances, therefore, usually causes the rate of a chemical reaction to increase.

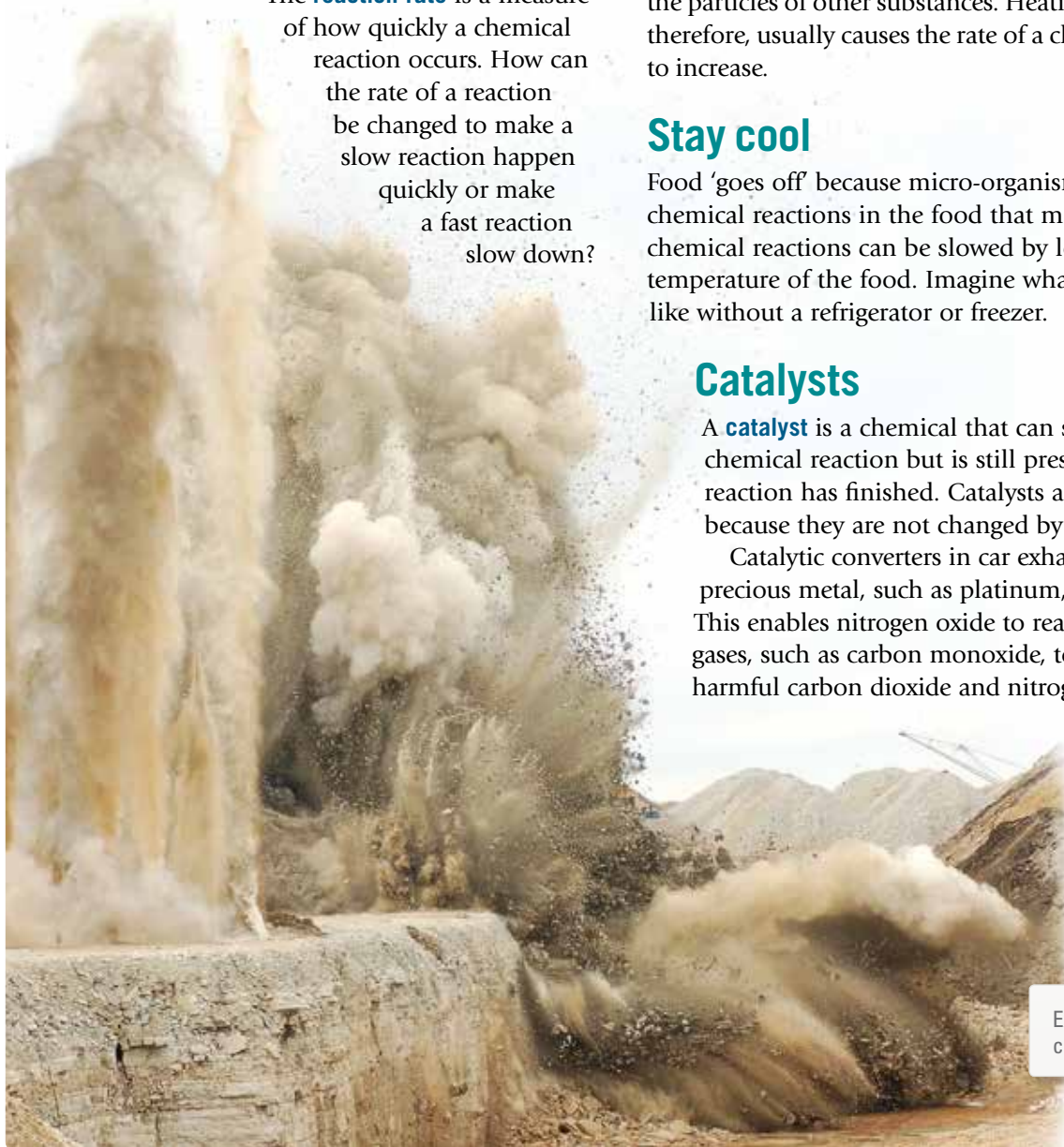
## Stay cool

Food 'goes off' because micro-organisms cause chemical reactions in the food that make it rot. These chemical reactions can be slowed by lowering the temperature of the food. Imagine what life would be like without a refrigerator or freezer.

## Catalysts

A **catalyst** is a chemical that can speed up a chemical reaction but is still present once the reaction has finished. Catalysts are not reactants because they are not changed by the reaction.

Catalytic converters in car exhausts use a precious metal, such as platinum, as a catalyst. This enables nitrogen oxide to react with toxic gases, such as carbon monoxide, to form the less harmful carbon dioxide and nitrogen gases; this reaction would not occur in the absence of the catalyst.



Explosions are fast chemical reactions.

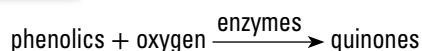
This reaction in a catalytic converter can be shown as:



The catalysts in living things are called **enzymes**. Enzymes in the human body help to digest the food you eat more quickly.

Apples and other fruits go brown because chemicals in them, called phenolics, react with oxygen in the air. The brown chemical products are called quinones. Enzymes in the fruit speed up the

reaction. The chemical word equation for this reaction is:



Apples go brown when phenolics react with oxygen in the air. Enzymes speed up the reaction.



Granular sugar dissolves faster than a sugar cube because it has a larger surface area.

or more oxygen by fanning the fire. To make the stain disappear more quickly, you could add more bleach.

Another solution is to increase the surface area of the reactants so that they can mix more easily. In the case of the camp fire, you can chop the wood or use smaller pieces of twigs and leaves. To help the tablet dissolve, you could crush it.

## Altering the reactants

No doubt you have been in situations where you wanted to increase the rate of a chemical reaction. Perhaps you wanted a camp fire to burn faster, a tablet to dissolve or a stain to be removed more quickly. What would you do in each case to make the reaction faster?

One solution is to add more reactant. In the case of the camp fire you can add more wood,

Effect of amount of reactants: The more reactants, the more particles take part in the reaction. Fanning a fire adds oxygen and increases the rate of burning.

Effect of surface area: To make a fire burn more quickly, the wood can be chopped into smaller pieces. This allows a greater surface area of wood to come into contact with the oxygen.

The effects of amount of reactants and surface area on the rate of reaction

### INVESTIGATION 8.7

#### The effect of temperature on a reaction

**AIM** To investigate the effect of temperature on the rate of a chemical reaction

##### Materials:

safety glasses  
test-tube holder  
heatproof mat  
Bunsen burner  
matches

marble chips  
dropping bottle of 1M  
hydrochloric acid  
test tube  
test-tube rack

##### METHOD AND RESULTS

- ▶ Carefully slide one or two marble chips to the bottom of the test tube.
- ▶ Add 1M hydrochloric acid to half-fill the test tube.
- ▶ Observe the reaction.

- ▶ Now gently heat the test tube and observe the reaction.

- 1 Has a chemical reaction occurred? Describe the evidence that you observed.

##### DISCUSS AND EXPLAIN

- 2 What effect did heating the test tube have on the rate of this reaction?
- 3 In this chemical reaction, the calcium carbonate that makes up the marble chips reacts with the hydrochloric acid to produce calcium chloride, water and carbon dioxide gas.
  - (a) List the reactants.
  - (b) List the products.
  - (c) Write a word equation for this chemical reaction.
- 4 Suggest a different method of increasing the rate of reaction.

## HOW ABOUT THAT!

Have you ever had a composite resin filling in your tooth? The dentist uses blue light or ultraviolet (UV) radiation to set this type of filling. The visible or UV light speeds up the reactions that cause the materials in the filling to harden. Without the UV light, you would be waiting for hours for this type of filling to set.



UV light can speed up the setting of a composite resin filling.

## INVESTIGATION 8.8

### Changing the rate of reaction

**AIM** To investigate the factors that affect the rate of chemical reactions

#### Materials:

|                               |                        |
|-------------------------------|------------------------|
| safety glasses                | mortar and pestle      |
| heatproof mat                 | spatula                |
| test tubes and test-tube rack | 0.5M hydrochloric acid |
| white chalk                   | 1M hydrochloric acid   |
|                               | measuring cylinder     |

#### METHOD AND RESULTS

Hydrochloric acid reacts with chalk to produce carbon dioxide gas, water and calcium chloride.

- ▶ Place a small amount of chalk in a test tube and add enough hydrochloric acid to cover it. Observe the chemical reaction.
  - ▶ Discuss with your partner how you could use this reaction to demonstrate one of the hypotheses below.
    - (a) Increasing the concentration or amount of reactants will speed up a chemical reaction.
    - (b) Increasing the surface area of reactants will speed up a chemical reaction.
    - (c) Decreasing the concentration or amount of reactants will slow a chemical reaction.
- 1 Design your experiment and write down the method.
  - 2 Predict the results you would expect to obtain that would support the hypothesis you chose.
  - ▶ Perform the experiment.
  - 3 Prepare a report of your findings.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 What is the rate of a reaction?
- 2 State five different methods of changing the rate of a reaction.
- 3 How does heating increase the rate of a reaction?
- 4 What is a catalyst?
- 5 How do you know that a catalyst is not a reactant?
- 6 What is an enzyme?

### THINK

- 7 Does a refrigerator stop food from rotting or does it just slow the rotting? Explain your answer.
- 8 What is the point of adding catalysts to washing powders?

- 9 Which will dissolve more quickly — a sugar cube or the same amount of sugar in a teaspoon? Explain your answer.

### CREATE

- 10 Write and act out a short dramatic performance to show how a piece of chalk takes longer to react with an acid than the same amount of crushed chalk.

### INVESTIGATE

- 11 Change the temperature, concentration and surface area in the **Reaction rates** interactivity in your eBookPLUS to see how they affect the rate of a reaction; then decide how the rates of particular reactions could be changed. **int-0230**
- 12 Test your ability to identify different types of reactions by completing the **Time Out: 'Reactions'** interactivity in your eBookPLUS. **int-0759**

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8.5 Speeding up reactions

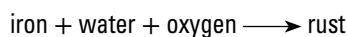
# Rusting out

**Rusting** is an example of **corrosion**. Corrosion is a chemical reaction that occurs when substances in the air or water around a metal 'eat away' the metal and cause it to deteriorate.

There are many examples of corrosion: silver tarnish; the green film that forms on copper or brass objects; and, the most common one, the rusting of iron. Corrosion causes enormous damage to buildings, bridges, ships, railway tracks and cars.

## Rust

**Rust** is the flaky substance that forms when iron corrodes. Iron reacts with water and oxygen in the air to form iron oxide and other iron compounds that make up the familiar red-brown substance known as rust. Rusting is a slow chemical reaction that can be represented by the following word equation:



Even strong buildings and bridges that are made from steel, an alloy of iron, are weakened by rusting. The Sydney Harbour Bridge, for example, is continually painted to protect it from moisture and the air, which would cause its steel girders to rust. Ships and cars are also constructed largely of steel. Despite the strength of steel, it needs to be protected from the corrosive effects of the environment.

The Sydney Harbour Bridge is continually painted to protect it from moisture and the air, which would cause its steel girders to rust.



### INVESTIGATION 8.9

#### Observing rusting

Steel wool is made from iron. You can observe rusting of the iron in steel wool by performing the following experiment.

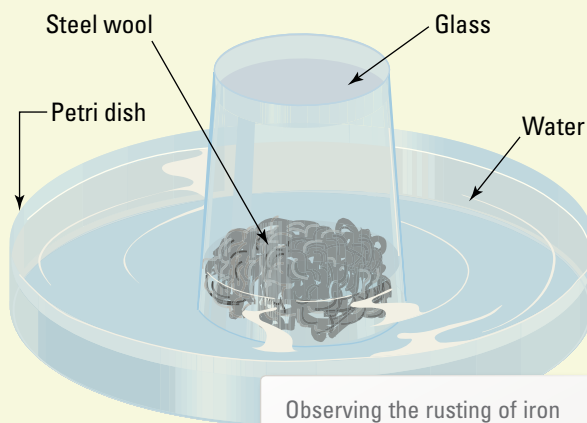
**AIM** To observe and describe the rusting of steel wool

#### Materials:

Petri dish  
water  
steel wool (without any soap)  
small glass  
permanent marker

#### METHOD AND RESULTS

- ▶ Pour some water into the Petri dish.
  - ▶ Place the steel wool in the middle of the Petri dish.
  - ▶ Cover the steel wool by placing the glass over it upside-down.
  - ▶ Mark the level of the water on the outside of the glass with a permanent marker.
  - ▶ Leave for several days, adding water as required to keep the level at the mark on the glass.
- 1 Construct a table in which you can record your observations over several days.



#### DISCUSS AND EXPLAIN

- 2 What did you observe about the level of water inside the glass? Can you explain why this happened?
- 3 Write down a word equation for the chemical reaction that occurred inside the glass.

## Speeding up rusting

Some substances in the environment make rusting happen much more quickly. One of the most effective of these is salt. Steel dinghies that are used in the ocean rust much faster than those that are used only in fresh water. This is because the salt in the sea water speeds up the reaction between oxygen in the air and the iron in the steel.

Some chemicals released from factories also increase the rate of rusting. A CSIRO study conducted in Melbourne found that rusting rates were high near airports and sewage treatment plants.

Rusting is much slower in dry environments like deserts, where the rainfall is nearly zero and there is very little water vapour in the air.

### HOW ABOUT THAT!

In the Mojave Desert of Southern California, hundreds of unused aircraft are stored out in the open air. Due to the dry air, rusting occurs extremely slowly. As a result, some of the aircraft are still structurally sound after being exposed in the open air for about 20 years.



### INVESTIGATION 8.10

#### Investigating the corrosion of different metals

**AIM** To investigate the corrosion of a variety of metals

**Materials:**

small strips of a range of metals such as copper, aluminium, zinc and magnesium

sandpaper  
other equipment approved by your teacher

#### METHOD AND RESULTS

- ▶ Design and carry out an investigation to study the resistance of a selection of different metals to corrosion. Ensure that appropriate variables are controlled. Before commencing, clean the metal strips with sandpaper to ensure that any coatings already caused by corrosion are removed.
- 1 Write a report on your investigation that includes your aim, method, results (including a table), discussion and a clear conclusion listing the metals in order of resistance to corrosion, from most resistant to least resistant. Include the answers to the questions below in your discussion.

#### DISCUSS AND EXPLAIN

- 2 Identify the independent and dependent variables in your investigation.
- 3 Name the variables that you controlled.
- 4 Suggest how you might be able to improve or speed up the investigation.

## Rust protection

The layer of rust that forms on an iron object flakes off the metal, allowing air and moisture to get through to the iron below. This causes more rusting to occur and eventually the iron becomes a heap of rust. It is important to protect iron and steel from corrosion, especially if they are part of a bridge or the hull of a ship.

There are several ways to protect iron and steel from rusting. One way is to prevent oxygen or moisture from contacting the metal. This is called **surface protection**. The metal can be protected by coating it with paint, plastic or oil. If the surface protection becomes scratched or worn off, the metal below can be attacked by moisture and oxygen, and rusting will occur. Examine the painted surface of an old car. Wherever the paint has chipped off you will find that corrosion has occurred and rust can be seen.

Another way to protect iron from rusting is to coat it with a layer of zinc. This is called **galvanising**. Zinc is a more reactive metal than iron, and in the presence of moisture and oxygen the zinc layer corrodes, leaving the iron unaffected. Many roofing materials and garden sheds are made from galvanised iron. You can also buy galvanised nails.

## INVESTIGATION 8.11

### Rusting and salt water

**AIM** To investigate the effect of salt water on the rate of rusting

**Materials:**

test tubes and test-tube rack  
measuring cylinder  
iron nails  
water  
salt (sodium chloride)

#### METHOD AND RESULTS

- ▶ Design an experiment to test the effect of the saltiness of water on the time taken for an iron nail to rust.
- ▶ Propose a hypothesis.
- ▶ Discuss your experimental design with a partner. You will need to consider which conditions must be kept the same and which condition will be varied.
- ▶ You will need to set up a control test tube. Find out what the purpose of a control is.

- 1 Write down your method. It should be clear enough for someone else to follow without any help.
- 2 Construct a table in which to record your observations over the next few days.

#### DISCUSS AND EXPLAIN

- 3 What effect did salt have on the time taken for the iron nail to rust?
- 4 Was your hypothesis supported?
- 5 How do your results compare with those of others in your class?
- 6 Write a report of your findings.



This wrecked car has rusted quickly because of its proximity to the sea.

## Rusting can be useful

Not all rusting is bad. From a pharmacy you can buy hand warmers, which are commonly used by skiers and campers. These packages will produce heat when you shake them. The contents of the packet include powdered iron, water, salt and sawdust. When the packet is shaken vigorously, the iron rusts quickly, which produces heat.

### HOW ABOUT THAT!

City councils face problems caused by the action of dogs on metal lampposts. The corrosive properties of the dogs' urine rusts the steel of the lampposts a few centimetres above the ground.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 What is corrosion?
- 2 What is rusting?
- 3 What is surface protection?
- 4 What is galvanised iron and what advantage does it have over iron?

### THINK

- 5 Why does rusting occur faster in coastal regions than in areas further away from the sea?
- 6 How can galvanising protect iron from rusting when the zinc coating corrodes more quickly than the iron?
- 7 Suggest why the powdered iron in hand warmers used by skiers and campers rusts much more quickly than an iron nail.

### INVESTIGATE

- 8 Corrosion is found in many places. Survey your school for rust spots. Write a report about your findings.
- 9 If you have access to an old car, survey it carefully and record all its rust spots. Why are some parts of the car more likely to rust?
- 10 Aluminium corrodes quite quickly, yet it is used to make soft drink cans. Find out why aluminium cans are not corroded by the drinks they store.
- 11 Use the **How rust works** weblink in your eBookPLUS to watch a video about rust and the corrosion of iron.

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work  
sheet

8.6 Rusting

# Burning is a chemical reaction

**Burning** is a chemical reaction. It involves the combination of oxygen with a fuel and always produces heat and gases. Reactions that involve combination with oxygen are examples of **oxidation** reactions.

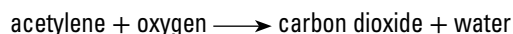
There are many other oxidation reactions. The rusting of iron to form iron oxide is an oxidation reaction. Rusting could correctly be described as a very slow type of burning reaction.

## Burning fossil fuels

When a **fossil fuel** reacts with oxygen, heat is produced, along with carbon dioxide and water vapour. Fossil fuels are fuels formed from the remains of living things. Petrol, natural gas, coal, wood and even paper are fossil fuels.

## The oxyacetylene torch

To obtain temperatures as high as 3000 °C — hot enough to melt iron and weld metals — acetylene fuel is mixed with pure oxygen in an oxyacetylene torch.



An oxyacetylene torch is used in construction work.

## The car engine

Burning is also known as **combustion**. Car engines work by the combustion of petrol or gas in the cylinders. A mixture of air and fuel is drawn into

each cylinder and ignited by a spark from the spark plug. The fuel reacts rapidly with oxygen in the air. The resulting explosion pushes the piston, which turns the drive shaft. The products of the reaction, carbon dioxide and water vapour, leave the car engine through the exhaust pipe.

### HOW ABOUT THAT!

A backdraught occurs when a fire in a closed room dies down because it has been starved of oxygen, but flammable gases continue to stream out of the hot materials in the room. When a door to the room is opened, air is quickly drawn inside, restoring the supply of oxygen and allowing the fire to reignite. The resulting fire consumes all the flammable gases in a few seconds and produces sufficient heat to ignite any remaining materials in the room. This is very dangerous to firefighters.

## Rocket fuels

Liquid and solid fuels are used in the NASA rocket program. When these fuels are burnt, they provide sufficient thrust to place a rocket in orbit hundreds of kilometres from Earth. Liquid hydrogen and liquid oxygen react to power the rocket's main engines.



Most of the thrust required to place the rocket in its desired orbit comes from chemical reactions in the solid fuel, which is located in the solid rocket boosters. In space, liquid fuel such as hydrazine is oxidised to produce an enormous volume of gas. As the gas is released, the rocket is thrust forward. By controlling the direction of the thrust, it is possible to steer the rocket.



Oxidation reactions provide the thrust to launch a rocket.

### INVESTIGATION 8.12

#### Burning magnesium

**AIM** To observe and record the combustion of magnesium

**Materials:**

|                |                                          |
|----------------|------------------------------------------|
| safety glasses | 2 cm piece of                            |
| tongs          | magnesium ribbon                         |
| sandpaper      | Bunsen burner, heatproof mat and matches |

#### METHOD AND RESULTS

- ▶ If the magnesium ribbon is dull, use the sandpaper to remove the dull layer.
- ▶ Hold the magnesium ribbon with tongs in the Bunsen burner flame.

**CAUTION** Do not look directly at the flame — eye damage may occur.

- ▶ After burning the magnesium metal, observe the product that remains.
- 1 Describe the magnesium metal before burning.
  - 2 During burning, the magnesium reacted with the oxygen in the air by combining with it to form magnesium oxide. Describe the magnesium oxide.

#### DISCUSS AND EXPLAIN

- 3 How do you know that a chemical reaction has taken place?
- 4 Write a word equation for the chemical reaction.

### INVESTIGATION 8.13

#### Burning paper

**AIM** To observe and record the combustion of paper

**Materials:**

safety glasses  
Bunsen burner, heatproof mat and matches  
tongs  
gas jar  
limewater  
paper  
deflagrating spoon

#### METHOD AND RESULTS

- ▶ Place 10 mL of limewater in the bottom of the gas jar.
- ▶ Put a ball of scrunched-up paper into the deflagrating spoon.
- ▶ Light the paper and lower it into the gas jar.
- ▶ When burning has stopped, remove the deflagrating spoon and cover the jar.
- ▶ Shake the gas jar and observe the colour of the limewater.

- 1 What happened to the limewater?

#### DISCUSS AND EXPLAIN

- 2 What gas was given off by the burning paper?
- 3 Which other substance or substances were produced by the reaction?

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Define the term 'burning'.
- 2 What evidence is there that burning is a chemical reaction?
- 3 What is a fossil fuel? List three examples of fossil fuels.
- 4 List and describe three examples of useful oxidation reactions.
- 5 Write a word equation for each of the three examples listed in question 4.
- 6 Is rusting an example of burning? Explain.

### THINK

- 7 Complete this word equation:  
fuel + \_\_\_\_\_ → \_\_\_\_\_ + water vapour
- 8 Name at least one fuel that is not a fossil fuel.
- 9 What are the three different one-word names given to the chemical reactions in which fuels react with oxygen?

- 10 Space agency scientists and engineers are constantly searching for better rocket fuels. List the properties that they are looking for. Also, list the properties that are undesirable.

### CREATE

- 11 Choose one fuel from the list below and prepare a poster on its use. Include in your poster details of where the fuel comes from, what it is used for, and a word equation for its oxidation reaction.
  - methane • butane • kerosene • diesel
  - ethanol • propane • lignite • acetylene

### INVESTIGATE

- 12 Fire has always been present in Australia and is a major cause of change in the environment. Find out how Australian Aboriginals have traditionally used fire to benefit themselves and the environment.

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work  
sheet

8.7 Combustion

# A new breed of materials

The scientists and engineers who develop new plastics for spacesuits that allow astronauts to walk in space need a knowledge of chemistry to create materials that are strong, light and heat resistant. Developing new materials for a particular purpose requires an assessment of the required properties and an understanding of chemical reactions.

The spacesuits worn by astronauts when they are walking in space contain many layers of materials developed by scientists and engineers.



## Fantastic plastic

Metals, paper and ceramics have been used for thousands of years. But **plastics** have been around for less than 100 years. Plastics are synthetic (manufactured) materials that can be easily moulded into shape. Some plastics are flexible and soften when they are heated. They can be easily moulded into products such as milk and fruit juice containers, rubbish bins, spectacle lenses, electrical insulation and laundry baskets. Others are quite hard and rigid. These plastics are used to make items such as toilet seats, electrical switches, bench tops and outdoor furniture. Most plastics are the products of chemical reactions with crude oil, from which petrol and bitumen are also produced, as the main reactant.

### WHAT DOES IT MEAN?

The word *plastic* comes from the Greek word *plastikos*, meaning 'able to be moulded'.

### HOW ABOUT THAT!

Australia was the first country in the world to use only plastic notes for currency. The notes are more difficult to forge and last much longer than the old paper notes.

## The clothes you wear

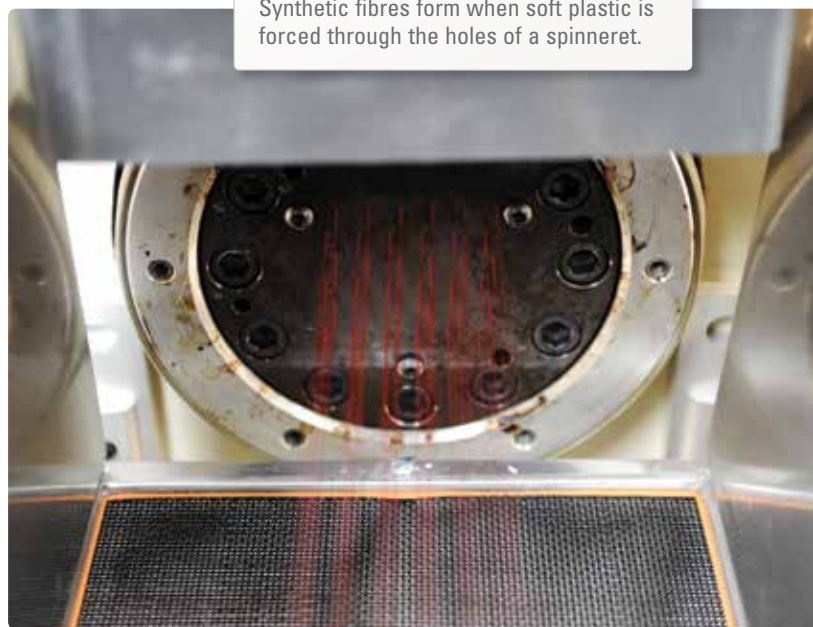
Until the development of nylon in 1938, just in time to make parachutes for World War II, the world relied almost completely on fabrics made from **natural fibres** such as wool, cotton, linen and silk.

Animal-based products include wool from sheep and silk from silkworms. Cotton is derived from cotton bushes and linen comes from flax plants. Today, it would be impossible to provide clothing and bedding for the world's population with purely natural fibres because of the amount of land and water that would be needed for crops and sheep.

Synthetic fibres such as those used in compression sports gear have many desirable qualities that natural fibres lack, including easy care, colour-fastness and light weight.

Of the many synthetic fibres, the most widely used are **nylon** and **polyester**. Synthetic fibres are made by pushing softened plastic materials through tiny holes in a nozzle called a **spinneret**, which looks a little like a shower head.

Synthetic fibres form when soft plastic is forced through the holes of a spinneret.



Each fibre, whether natural or synthetic, has advantages and disadvantages. Some of these are outlined in the table below.

| Fibre     | Advantages                                                                         | Disadvantages                                                                       |
|-----------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Wool      | Warm in cold weather<br>Crease resistant<br>Burns slowly<br>Retains its shape well | Shrinks when washed<br>Turns yellow in sunlight                                     |
| Cotton    | Absorbs moisture<br>Soft<br>Cool in hot weather                                    | Creases easily<br>Burns quickly                                                     |
| Nylon     | Dries quickly<br>Light<br>Strong<br>Elastic                                        | Builds up static electricity<br>Melts rather than burns<br>Turns yellow in sunlight |
| Polyester | Dries quickly<br>Crease resistant<br>Resistant to many chemicals                   | Builds up static electricity<br>Melts rather than burns                             |

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#### The future of clothing

Find out about the clothing of the future.

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## HOW ABOUT THAT!

The spinneret gets its name from the organ used by spiders to spin their webs. Liquid silk flows through the spider's spinneret. It hardens into a fibre as it passes through. Most spiders have six spinnerets.

The spider pictured here has used the fibre to build an intricate web.



### INVESTIGATION 8.14

#### Putting fibres to the test

**AIM** To observe and describe the combustion of a range of fibres

##### Materials:

a range of threads of different fibres, e.g. cotton, polyester, wool, nylon, rayon  
uniformly sized fabric samples made from different fibres or blends of fibres  
equipment decided upon by the group

#### METHOD AND RESULTS

- Work in groups of three or four to complete this investigation.

- Start by listing the properties of either the fabric samples or the fibres that can be tested by experiments. Some examples to help get you started include flammability, elasticity and the ability to absorb water.
- Devise an experiment that will allow you to compare one property of threads of either different fibres or different fabric samples.
- Make a list of the equipment you will need.

- Have your experiment plan and equipment list checked by your teacher.

**CAUTION** Obtain your teacher's approval before carrying out any tests. Synthetic fibres or blends should be burned only in a fume cupboard.

- Carry out your experiment and keep a record of your measurements and observations.
- Write a report about your experiment.

#### DISCUSS AND EXPLAIN

Include answers to the following questions in the 'Discussion' section of your report.

- List the variables that you were able to control in your experiment.
- Identify any variables that you didn't feel the need to control.
- Identify the most useful properties of each of the fibres or fabrics that you tested.
- Suggest at least one improvement that you could have made to your experiment.

## The best of both worlds

Many of today's fabrics are made from blends of natural and synthetic fibres to make the best of the properties of each fabric in the blend. A blend of polyester and cotton is commonly used for shirts and dresses. The cotton helps keep the wearer cool, while the polyester reduces creasing.

Rayon is shiny, easy to dry and cool in summer. On the 'down' side it has low **durability** and is not **elastic**. Elasticity describes the ability of a material to return to its original size after being stretched. Rayon is neither a natural nor a synthetic fibre. To make it, cellulose fibres from spruce and eucalyptus trees are mixed with chemicals that soften them. The mixture is then passed through a spinneret.

## A new breed of fibres

When you watch the feats of Olympic athletes, cyclists, skiers and skaters, it's almost certain that they are wearing Lycra. Lycra is not a fabric. Lycra is the registered trademark of a synthetic fibre called spandex. Spandex was invented in 1958. Spandex is lightweight, durable, retains its shape and fits snugly. It even pulls moisture away from the wearer's skin. Spandex is very elastic. It can be stretched to up to seven times its normal length and spring back to its initial length when released. Spandex is always blended with other fibres. As little as 2 per cent of this material in a blend makes a difference to the properties of the fabric. Lycra suits usually consist of between 3 per cent and 10 per cent spandex.

## Cleaning up

Whether you're washing dishes, clothes or yourself, it's obvious that water alone is not good enough. That's because dirt, grease and oil don't dissolve in water. You need to

Cleansing agents like hair shampoo release soil, grease and oil from the scalp. Almost all hair shampoos are detergents.

use soaps or detergents which, when mixed with water, loosen or remove soil and greasy and oily substances from surfaces. The dirt and oil can then be rinsed away by the action of running water or a wash cloth.

## Comparing soaps and detergents

Soaps and detergents share many properties. Both dissolve grease and oil (a chemical property), both can be found as solids and liquids (a physical property) and both are very, very slippery (another physical property). Most soaps and detergents are biodegradable (a chemical property), which means that they will break down naturally after their journey down the plughole.

The biggest difference between soaps and detergents is the way they are made. Soaps are made from natural fats and oils. No-one is certain about when the first soap was made, but a recipe for a substance that would have resembled soap has been found in the Middle East, dating back to the Babylonian civilisation about 4800 years ago. The ingredients included ashes from fires, oils from trees and sesame seed oil. Detergents, like most plastics, are made from chemicals obtained from crude oil. They are heavily scented with fragrances to disguise the odour, and preservatives are added so that they don't spoil.

## The perils of packaging

Just about everything you buy at the supermarket comes in a package. Even if it doesn't, you usually put it in



a bag to take it home. The type of packaging needed depends on the properties of the product inside. For example, you can't package tomato sauce in a paper bag. The most commonly used materials in packaging are paper (or cardboard), plastic, metal and glass. For a consumer, it's not just the properties of the packaging that are important. At least two questions should be asked when you make a choice about buying a product:

- Is the packaging recyclable?
- Is the packaging biodegradable?

If the packaging is glass, aluminium or steel, it is probably recyclable, which can save energy and water. If it is a plastic bottle, it is also likely to be recyclable. If the packaging is not recyclable, think about whether it is **biodegradable**; that is, can it be broken down by

natural chemical reactions in the bodies of worms or other small **organisms** that live in the soil? Plastics, metals and glass are not biodegradable. If they are thrown out with other household rubbish such as food waste, they end up in rubbish tips and will not break down. This creates the need for more rubbish tips. Of course, there is a limit to how much land can be used for rubbish tips in or near major towns and cities.

Paper is mostly biodegradable. Paper packaging that has been contaminated by food or oils cannot be recycled. But at least when it gets to the rubbish tip it can be broken down in the soil. If you have a choice, choose items with packaging that is either recyclable or biodegradable.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Identify the single property that all plastics have.
- 2 From which substance found beneath the ground are most plastics made?
- 3 Where do all natural fibres come from?
- 4 Why is woollen clothing popular in winter whereas cotton clothing is popular in summer?
- 5 Why are cotton and polyester blends so commonly used for shirts and dresses?
- 6 From which group of materials are synthetic fibres made?
- 7 What is a spinneret used for?
- 8 Which fibre do Lycra suits always contain?
- 9 How do soap and detergents remove grease, oil and dirt from surfaces?
- 10 What is the major difference between soap and detergents?
- 11 Identify two properties that soap and detergents have in common.
- 12 Plastics, metals and glass are not biodegradable.
  - (a) What does this mean?
  - (b) If non-biodegradable rubbish cannot be recycled, what happens to it?

### THINK

- 13 Which properties make plastic more suitable for use in outdoor furniture than:
  - (a) wood
  - (b) metal?
- 14 Which properties of plastic currency notes make them more suitable than the old paper ones?
- 15 Which properties of nylon made it suitable for making parachutes during World War II?

- 16 Explain why rayon is neither a natural fibre nor a synthetic fibre.
- 17 Explain why Lycra is not a fabric.
- 18 How would blending with spandex change the properties of a pure cotton fabric?
- 19 Which properties make Lycra suitable for:
  - (a) the clothes of speed skaters
  - (b) toddlers' clothing
  - (c) underwear?
- 20 Why is it important to rinse your hair thoroughly after shampooing?
- 21 State the properties of the packaging that make it suitable for each of the following supermarket items.
  - (a) Tomato sauce in a glass bottle
  - (b) Tomato sauce in a red plastic bottle
  - (c) Lemonade in an aluminium can
  - (d) Lemonade in a clear plastic bottle

### IMAGINE

- 22 Make a list of at least ten items in your house made from plastic. Imagine that they could no longer be made from plastic. For each item, write down:
  - (a) the most important properties that the items must have
  - (b) which other material could be used to make them.

### INVESTIGATE

- 23 Find out why the group of chemicals known as phosphates is no longer used in most detergents.
- 24 Research and report on how each of the following materials was discovered or developed, by whom and what they are used for.
  - (a) Polyester
  - (b) Kevlar®
  - (c) PSZ (partially stabilised zirconia)

# Use it again

The material that you throw out as household rubbish is buried in landfill tips.

The food scraps that make up almost half of your household rubbish are biodegradable. They will be broken down by microbes and other decomposers in the soil such as worms. Chemical changes take place when these organisms digest the scraps, returning nutrients to the soil. You can use compost bins or compost heaps to allow this to happen in your own backyard. Even paper and cardboard break down fairly quickly in the soil.

However, materials such as plastic, glass and metals take hundreds or even thousands of years to break down. The properties of these materials allow them to be **recycled**.

## Looking after your PET

There are two very good reasons for recycling plastics:

- Plastics are non-biodegradable. That is, they are not broken down naturally by micro-organisms. Plastics add thousands of tonnes of new rubbish to the environment every year.
- Plastics are made from oil — a resource that is expensive and dwindling. The continued production of new plastic is not **sustainable**.

Plastics are made from chains of molecules and are also called polymers (poly means 'many'). This chain of molecules has two repeated units.



Look closely at this photo. This is not garbage. All these things can be recycled, including cardboard, paper, egg cartons, steel cans, plastic and glass.

Household waste contains many different types of plastic, which need to be separated. The plastics industry has introduced a code system to help consumers identify recyclable plastics. The symbols shown below make the sorting of plastics before recycling easier and cheaper. Some plastics are more easily recycled than others because of differences in the structure of the chains of molecules of which they are made.



PETE

PET or PETE (polyethylene terephthalate) is used to make plastic soft-drink bottles. Most commonly known as PET, this plastic is recycled to make carpet fibre and flower tubes. Empty PET bottles completely and remove the lids before placing them in a home recycling bin. The lids are recyclable, but their small size makes the sorting process awkward.



HDPE

HDPE (high-density polyethylene) is used to make plastic milk and fruit juice bottles. This plastic is recycled to make bottles, crates, pipes, wheelie bins and playground equipment. Empty HDPE bottles completely and remove the lids before placing them in a home recycling bin.



V

Polyvinyl chloride, more commonly known as PVC, is used to make pipes, fencing and bottles containing substances other than food. It is not easily recycled and can be dangerous to your health and the environment. PVC bottles can be placed in your home recycling bin as long as the lids are removed. They are separated from the more easily recyclable plastics and sent to a separate plant for processing.



LPDE

LPDE (low-density polyethylene) is used to make wash bottles and other containers. These are recyclable and can be placed in your recycling bin. LPDE is also used to make



PP

supermarket plastic bags, which should not be placed in your home recycling bin. These bags interfere with the automatic sorting machines in recycling plants. It is best to avoid using them by using reusable bags for shopping.

PP (polypropylene) is used in synthetic fibres to make clothing, industrial fibres, car batteries, bumper bars and other car parts. Although these products are not appropriate for your recycling bin, polypropylene can be recycled for use in carpet, furniture, white goods and even polymer bank notes. Most car workshops, scrap metal dealers and service stations will accept used car batteries for recycling.





PS

Polystyrene is a very light plastic used in solid form to make plastic cutlery, toys and cases for CDs and DVDs. In its softer foam form, it is used for disposable drinking cups and packing materials. Polystyrene products should not be placed in home recycling bins. The lightness of polystyrene foam makes it difficult to sort and recycle. Although all polystyrene can be recycled, it is a very expensive process.



OTHER

Other plastics, including nylon, fibreglass and polycarbonate, are not generally recycled and should not be placed in your home recycling bin.



This compost bin is made from recycled polypropylene (PP). The compost decreases in volume as it breaks down. Almost 50 per cent of domestic waste in Australia is suitable for composting.

before they need melting down, which saves a large amount of energy.

## Saving trees

Over a million tonnes of paper, about a third of our annual consumption, is recycled in Australia. Paper is made out of fibres of the chemical cellulose and is relatively easy to recycle. Waste paper is first mixed with water to separate the fibres. Additives such as ink and adhesives are then removed, producing low-quality fibres that can be used to make cardboard and other products. Steam rollers are used to improve the quality of the finished paper. Recycling paper reduces the amount of new paper needed, saving millions of trees.

## See-through recycling

About 45 per cent of the glass packaging used in Australia is recycled. Used glass bottles, known as **cullet**, are collected and melted down in a furnace to produce new products. The overall energy saving is only 8 per cent of that used in making new glass. This is because of the high cost of collecting and melting down the bottles. In some countries, milk is sold in bottles that can be sterilised and reused up to 50 times

## And metal too!

Metals such as steel and aluminium are easily recycled as long as they can be cheaply separated from other rubbish. Steel cans, aerosol containers, jar lids and bottle tops can be recycled. The recycling of aluminium cans saves huge amounts of energy. Twenty aluminium cans can be recycled with the same amount of energy needed to produce just one new can.

### INVESTIGATION 8.15

#### Design your own waste disposal system

Your group is responsible for preparing a report on ways to improve the household waste management and disposal for the shire of Green Valley.

The shire currently collects rubbish from its 134 500 ratepayers using large green bins that are emptied by compactor trucks. The rubbish is taken to the local tip and used as landfill, at a cost to the council of \$60 per tonne. The tip is nearing capacity and will be closed within 12 months. Waste paper is collected separately by a private recycling company.

Your report could be produced in written form or as audio or video. It should address the following issues:

- 1 How will the shire encourage each household to produce less waste?
- 2 Is recycling too costly?
- 3 If recycling occurs, will recyclable wastes such as plastics, glass and metals be separated at a disposal station after collection, or collected in separate containers from households?
- 4 What measures will be used to encourage households to use compost bins?
- 5 How will the shire dispose of rubbish when the landfill site closes?

## Sorting it out

The separation of the items in your recycling bin relies on differences in their physical properties including size, weight, magnetic properties and even colour. For example, items of different weights can be separated using blasts of air or a centrifuge that works like the spin dryer of a washing machine. Steel can be separated from other metals by a large magnet.

## Special recycling programs

There are separate recycling programs for some products that cannot be placed in home recycling bins. These recycling programs are generally used to collect products containing substances that would endanger the environment or the community if they were dumped in landfill tips. For example, printer cartridges can be placed in recycling boxes at many Australia Post outlets and retail stores that sell computers and printers. Mobile phones can be left at most mobile phone outlets for recycling. Use the **Recycling** weblink in your eBookPLUS to find out where computers and other electronic equipment, white goods such as fridges and washing machines, corks, light globes and many other items are collected for recycling.

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This site also provides information about how to dispose of chemical wastes from home, school or industry. Oil, paints and unused medicines should not be placed in rubbish bins or flushed down the sink.

## You can make a difference

The three bin collection system used by many city and shire councils throughout Australia makes it very easy for you to make a difference to the environment by recycling.

During the 12 months to June 2009, Hornsby Shire in NSW recycled 18 000 tonnes of paper. That's the equivalent of:

- saving over 299 000 gigajoules of energy. That's enough to power 13 870 homes for a year!
- preventing 9032 tonnes of greenhouse gas from entering the atmosphere. That's like taking 2169 vehicles off our roads — permanently!
- saving over 298 million litres of water. That's enough to fill 119 Olympic-sized swimming pools!

Imagine the combined effect of all cities and shires Australia wide!

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 How are biodegradable substances different from those that are not biodegradable?
- 2 Where do the chemical changes that break down biodegradable waste take place?
- 3 What are the main benefits of recycling plastics?
- 4 Why are plastics such as PET now identified by a code?
- 5 What is cullet?

### THINK

- 6 The first part of the process of recycling paper involves mixing it with water. What is the major purpose of mixing the paper with water?
- 7 List three problems associated with the disposal of waste in landfill sites.
- 8 Why is only a small amount of energy saved when glass is recycled?
- 9 List two benefits of recycling aluminium.
- 10 What factors influence the decision as to whether it is worth the trouble of recycling a resource?
- 11 Ink is removed from paper when it is recycled. Is the combination of ink and paper a compound or a mixture? Explain your answer.

- 12 If a plastic bag manufacturer claimed that the bags it produced were biodegradable, what evidence would you need to be satisfied that the claim was correct?

### CREATE

- 13 Draw a poster that could be used to encourage people to do one of the following.
  - (a) Recycle all plastic products.
  - (b) Reduce their use of LDPE plastic bags.
  - (c) Separate household rubbish into different bins for more efficient recycling.
  - (d) Recycle paper used at school.
  - (e) Recycle newspaper.
  - (f) Recycle aluminium cans.

### INVESTIGATE

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- 14 Use the **Recycling** weblink in your eBookPLUS to find out how you can dispose of each of the following substances at a nearby location.
  - (a) Unwanted paint
  - (b) Used motor oil
  - (c) Unwanted and out-of-date medicines

# Target maps and single bubble maps

1. Draw three concentric circles on a sheet of paper.
2. Write the topic in the centre circle.
3. In the next circle, write words and phrases that are relevant to the topic.
4. In the outer circle, write words and phrases that are not relevant to the topic.

To identify (target) what is part of (relevant to) the topic and what is not

why use?

how to ...?

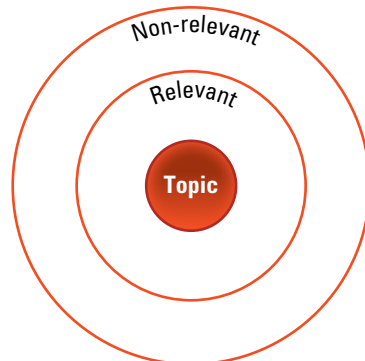
How can we find out what is relevant?

question

Circle map

also called

Target map



comparison

Similarity

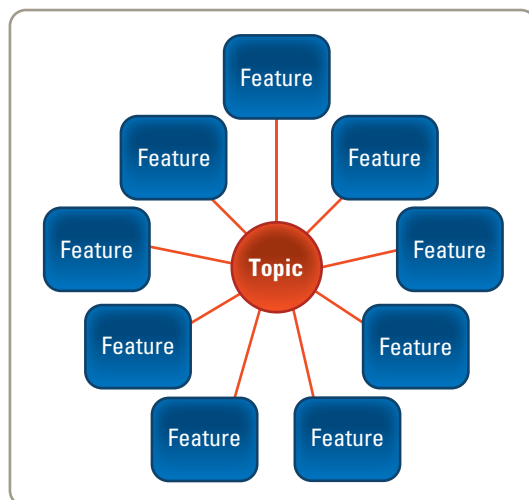
Both identify and describe the range of the content.

Difference

Single bubble maps do not identify the non-relevant material.

Single bubble map

example



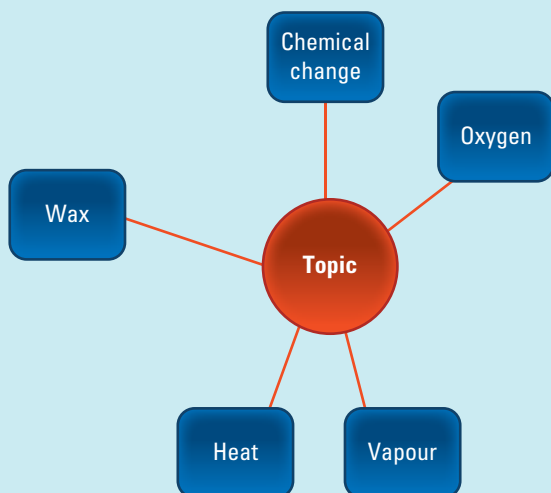
## UNDERSTANDING AND INQUIRING

### THINK AND CREATE

- 1 Use the words listed below to construct a target map about physical change.

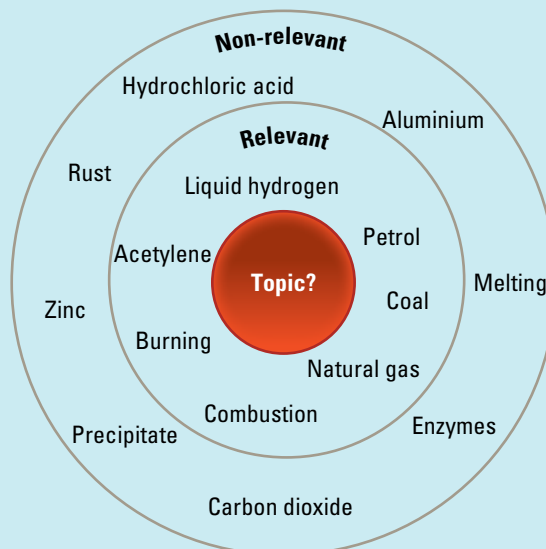
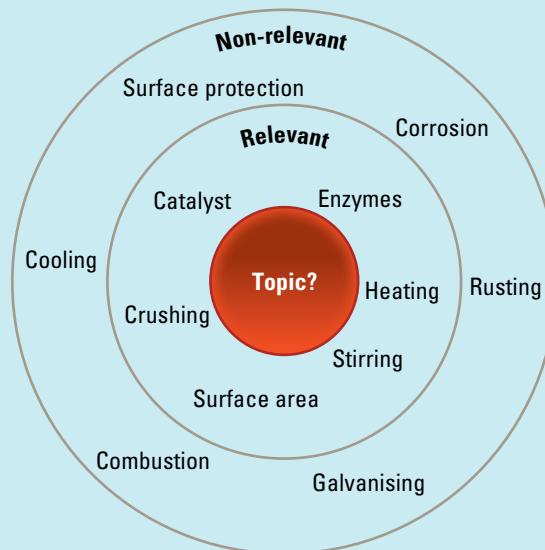
melting  
reactant  
burning  
precipitate  
catalyst  
evaporation  
rusting  
condensation  
stretching  
freezing  
explosion

- 2 The single bubble map below identifies some of the ideas associated with a burning candle.



- (a) Draw your own single bubble map about the topic 'a burning candle', adding as many additional bubbles as you can.  
(b) Construct a single bubble map that identifies clues that provide evidence that a chemical reaction has taken place.
- 3 (a) In teams, brainstorm as many single words as you can that are associated with chemical reactions.  
(b) Use the brainstorm list to create a team single bubble map on chemical reactions.  
(c) Compare your list with those of other teams and then work together to construct a class single bubble map on chemical reactions. Suggest other types of thinking tools that could be useful.

- 4 Suggest a topic for each of the target maps below.



- 5 The single bubble map below identifies some of the ideas associated with rusting.

- (a) Complete the bubble map by adding as many ideas as you can.

- (b) Use the ideas in your single bubble map to create a target map on rusting.



# STUDY CHECKLIST

## PHYSICAL AND CHEMICAL PROPERTIES

- ☐ distinguish between the physical and chemical properties of substances
- ☐ outline some examples of physical and chemical properties
- ☐ recognise that the chemical properties of a substance affect its use
- ☐ outline the benefits and disadvantages of plastics
- ☐ compare the properties and method of manufacturing soaps and detergents
- ☐ explain the difference between natural and synthetic fibres, and discuss their advantages and disadvantages

## PHYSICAL AND CHEMICAL CHANGE

- ☐ define chemical change as a change in which the bonds between atoms or molecules are broken or new bonds between these particles are formed
- ☐ distinguish between physical changes and chemical changes

## CHEMICAL REACTIONS

- ☐ define a chemical reaction as a chemical change in which a new substance is produced
- ☐ identify evidence that a chemical reaction has taken place

- ☐ distinguish between the reactants and products of a chemical reaction
- ☐ describe simple chemical reactions using word equations
- ☐ describe a variety of methods of speeding up or slowing down chemical reactions
- ☐ recognise that corrosion and burning (combustion) are chemical reactions
- ☐ describe rusting as an example of corrosion
- ☐ identify burning in oxygen as an oxidation reaction
- ☐ outline examples of the use of fuels in combustion reactions
- ☐ recall that most plastics are made from crude oil
- ☐ recall that biodegradability depends on chemical reactions within living organisms

## SCIENCE AS A HUMAN ENDEAVOUR

- ☐ investigate the use of fire by traditional Aboriginal people
- ☐ investigate the development by scientists of a variety of new materials
- ☐ distinguish between biodegradable and non-biodegradable materials
- ☐ evaluate the suitability of different types of packaging for recycling
- ☐ outline the requirements and development of systems for the collection and recycling of household waste

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## DIGITAL RESOURCES



**ANSWERS** for this chapter can be found online in your eBookPLUS.

### Online section

This section of the chapter can be found online in your eBookPLUS.

### 8.9 Thinking tools: Target maps and single bubble maps

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### Individual pathways

**Activity 8.1**  
Investigating reactions

doc-6072

**Activity 8.2**  
Analysing reactions

doc-6073

**Activity 8.3**  
Investigating reactions further

doc-6074

### eLesson

#### The future of clothing

Find out how developments in the properties of materials and fibres could affect what you'll be wearing in the future.

**Searchlight ID:** eles-0859

### Interactivities

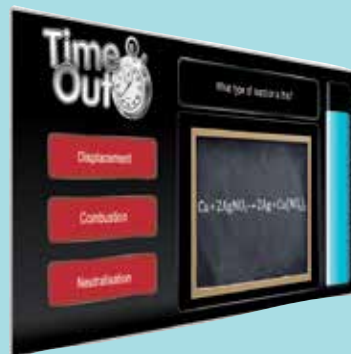
#### Reaction rates

This interactivity allows you to change the temperature, concentration and surface area of reagents to see how they affect the rate of a reaction, and then decide how the rates of a number of reactions could be changed.

**Searchlight ID:** int-0230

#### Time Out: 'Reactions'

Use this exciting interactivity to test your ability to classify different types of reactions before time runs out.



**Searchlight ID:** int-0759

- 1 List two useful properties of:
  - (a) glass
  - (b) metals
  - (c) plastics
  - (d) paper.
- 2 Explain, using examples, the difference between physical and chemical properties.
- 3 In your own words, express the meaning of each of these terms that describe the properties of substances.
  - (a) Elastic
  - (b) Ductile
  - (c) Reactive
  - (d) Malleable
  - (e) Lustrous
  - (f) Toxic
  - (g) Transparent
  - (h) Flammable
  - (i) Melting point
- 4 Identify the following as either chemical or physical changes.
  - (a) The wax on a burning candle melts.
  - (b) The wax vapour at the top of a candle wick burns with oxygen to produce carbon dioxide, water vapour and heat.
  - (c) Calcium carbonate is dissolved by hydrochloric acid to form calcium chloride, water and carbon dioxide gas.
  - (d) Hydrogen gas explodes with oxygen gas to form water.
- 5 Write word equations for each of the changes in question 4.
- 6 How do you know that:
  - (a) toasting bread is not a physical change
  - (b) rusting of a nail is not a physical change?
- 7 Some chemical reactions can be useful. Write down three examples of useful chemical reactions.
- 8 Catalysts are sometimes added to the reactants taking part in a chemical reaction.
  - (a) What is a catalyst?
  - (b) When a word equation is written to describe a chemical reaction, catalysts are not included either as reactants or products. Why?
- 9 When a lead nitrate solution is added to a potassium iodide solution, a chemical reaction takes place. A bright yellow solid appears. It is the compound lead iodide. Another compound, potassium nitrate, remains in the solution and is not visible.
  - (a) Name the reactants in this chemical reaction.
  - (b) What are the products of the reaction?
  - (c) The yellow lead iodide will eventually settle to the bottom of the flask. What 11-letter word beginning with 'p' is given to a substance that behaves like the lead iodide?
  - (d) Write a chemical word equation for the reaction.
- 10 Rusting is an example of a slow chemical reaction.
  - (a) What are the three reactants of rusting?
  - (b) What is the product of the rusting reaction?
- 11 For each of the reactions below, suggest ways that the reaction could be made to happen more quickly.
  - (a) Burning a pile of dry leaves
  - (b) Cooking potatoes
  - (c) Dissolving marble chips in acid
  - (d) Removing a stain using bleach
  - (e) Making an iron nail go rusty
  - (f) Milk going sour
- 12 Some chemical reactions can be destructive. Write down three examples of harmful chemical reactions.
- 13 Children's steel swing sets in beachside towns and suburbs rust much faster than those further from the coast.
  - (a) Explain why this happens.
  - (b) Suggest two methods of slowing down or preventing the rusting of steel swing sets.



- 14 The oxyacetylene torch shown below is used to melt metals to allow them to be joined together.
- What type of chemical reaction takes place in the oxyacetylene torch?
  - What evidence is there in the photo that a chemical reaction has taken place?



- 15 Just as chemicals can be grouped or classified, so can chemical reactions. What name is given to the following chemical reactions?
- The corrosion of iron
  - The reaction of substances with oxygen
  - Burning
- 16 The illustration below shows a camper boiling water in a billy over a camp fire.
- What physical change in the wood has taken place during the preparation of the camp fire?
  - What physical change is shown taking place?
  - What chemical change is shown taking place?
  - List two ways in which the chemical reaction taking place has been sped up.



- 17 Which properties of the plastic used to make light switches and power points make it right for the job?

- 18 What is the difference (other than their properties) between natural and synthetic fibres?
- 19 Identify each of the fibres listed below as natural, synthetic, or neither natural nor synthetic.
- Nylon
  - Cotton
  - Rayon
  - Lycra
  - Wool
  - Polyester
- 20 How are synthetic fibres such as nylon made?
- 21 Why are many garments made of a blend of two or more different fibres?
- 22 Soap and detergents can be used for the same purpose — including washing your own body.
- What is the main difference between soap and detergents?
  - What properties do soap and detergents have in common?
- 23 Which properties are essential for the packaging of the following products?
- Pool chemicals
  - Eggs
  - Soft drink
  - Peanuts
- 24 Some plastic containers are marked with this symbol.
- What substance would you expect to find in bottles made from this type of plastic?
  - What two things should you do before placing bottles made from this type of plastic in a recycling bin?
  - State two uses for this type of plastic after it has been recycled.
- 25 Describe the 'three-bin system' used by many cities and shires, and explain how it helps the environment.

