

7 Chemical reactions

Every single living thing on Earth depends on chemical reactions — from the largest mammal, the blue whale, right down to the smallest insects. In plants, chemical reactions transform carbon dioxide and water into sugars and other nutrients such as proteins and starch. The burning of fuels to generate electricity, operate industry and transportation, and keep our homes at a comfortable temperature is a chemical reaction, as is the formation of crystals in a retort. So what are chemical reactions?

Think about chemical reactions

- How do atoms behave during chemical reactions?
- In chemical reactions, what is conserved other than energy?
- How does an icepack go cold without containing anything cold?
- What makes an airbag inflate during a car accident?
- How can you stop your stomach from burning and rumbling?
- What causes tooth decay?
- What is pickling and why is it done?
- Why does acid rain dissolve statues?
- What is the active ingredient of petrol?
- Which combustion reaction takes place in your own body?

In this chapter:

- 7.1 Rearrange those atoms 274
- 7.2 Matter and energy: Chemical reactions and energy 276
- 7.3 Acids and bases 280
- 7.4 SCIENCE AS A HUMAN ENDEAVOUR
 - Acid rain 285
- 7.5 Combustion reactions 287
- 7.6 Thinking tools: Matrixes and plus, minus, interesting charts

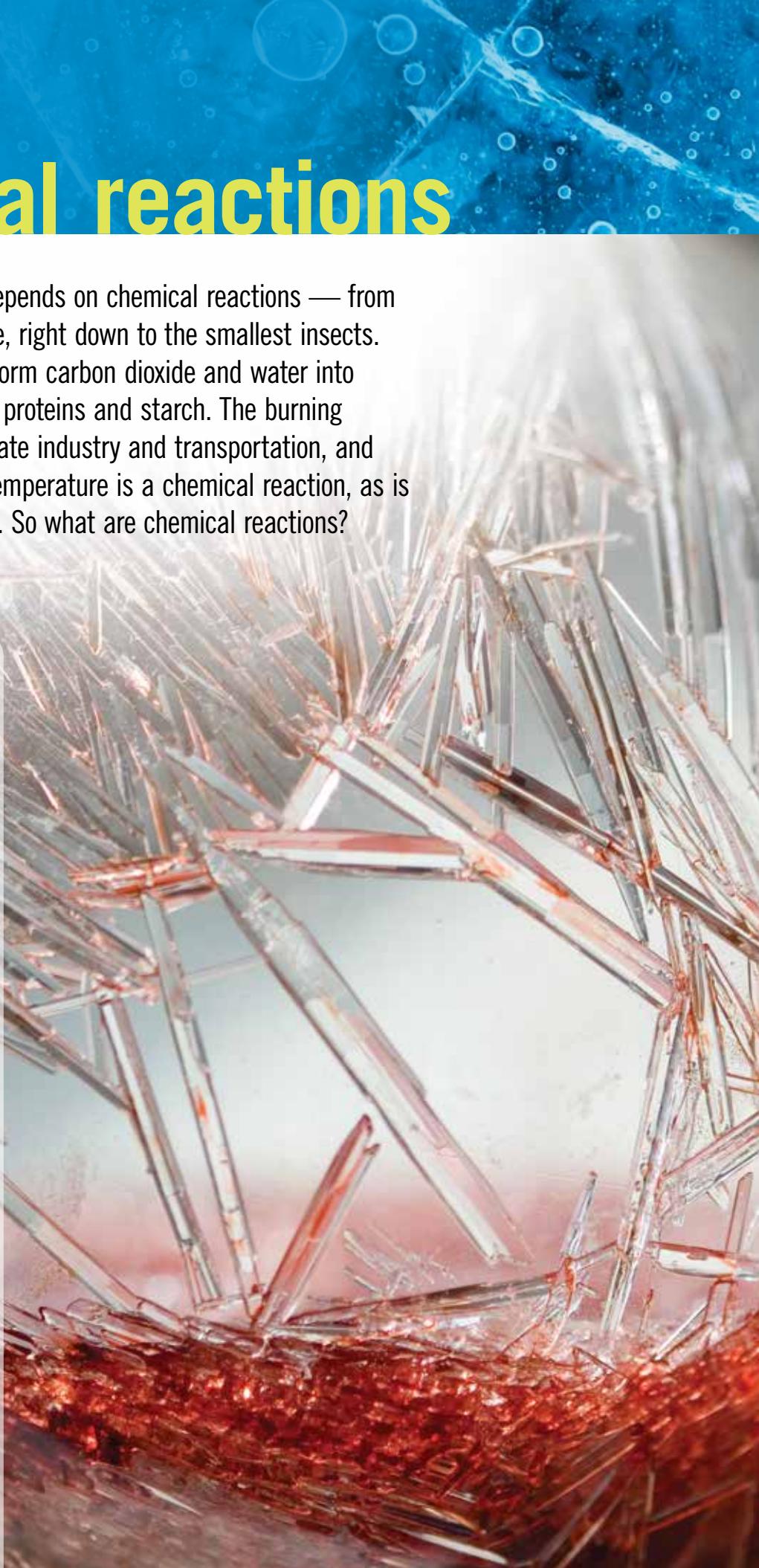
eBook plus
ONLINE ONLY

Study checklist/Digital resources 289

Looking back 290

ICT ACTIVITY projectsplus

ChemQuiz! 291



YOUR QUEST

WHAT AM I?

- ▶ You have to regularly provide me with fuel.
- ▶ The fuel burns in a chemical reaction known as combustion.
- ▶ The chemical energy stored in my fuel is transformed into mechanical energy and heat.
- ▶ The faster I go, the more fuel I need.
- ▶ I release waste products that smell and pollute the environment.



The chemistry of eating

THINK

Preparing, eating and digesting food all involve chemical reactions, many of which you already know about. Answer the following questions to find out what you already know about these important chemical reactions.

- 1 All of the food that we eat — including meat — begins with the growth of plants.
 - (a) What is the name of the chemical reaction that produces the glucose that plants produce?
 - (b) Which form of energy is necessary to allow this chemical reaction to take place?
- 2 The baking of bread makes use of a chemical reaction involving yeast and sugar. The same type of reaction is used in brewing to produce alcohol.
 - (a) What is the name of this chemical reaction?
 - (b) One of the products of this chemical reaction causes bread to rise while it is being baked. What is the name of this product?
(Hint: It's a gas.)
- 3 The chemical digestion of food occurs when chemicals in your body react with the food.
 - (a) What name is given to the chemicals that speed up these chemical reactions?
 - (b) Much of the food that you eat is broken down to glucose, which takes part in a chemical reaction that occurs in every single cell of your body. What is the name of this chemical reaction, which releases useful energy?
- 4 Overeating can make your stomach produce too much acid.
 - (a) Which type of substance is contained in the products that can be taken to reduce the discomfort and pain caused by the extra acid?
 - (b) What is the name of the chemical reaction that provides you with relief from the effects of the extra acid?

Evidence of chemical reactions

INVESTIGATION 7.1

Reflecting on a burning candle

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

Materials:

safety glasses
candle
jar lid
matches
heatproof mat

METHOD AND RESULTS

- ▶ Place the tea light on a heatproof mat.
- ▶ Light the candle.
- ▶ Observe the candle burning and answer the following questions.

DISCUSS AND EXPLAIN

- 1 Describe three physical changes that take place while the candle burns.
- 2 Make a list of as much evidence as you can that a chemical reaction has taken place.

CAUTION Do not touch the candle or flame and do not smell the vapour directly. You can fan the vapour towards your nose with your hand.

Rearrange those atoms

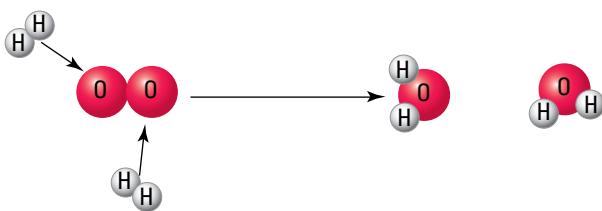
A cake rising in an oven, a bath bomb fizzing in a full bathtub, and an old car getting rusty — what do they have in common? They are all evidence of chemical reactions.

Chemical reactions take place when the bonds between atoms are broken and new bonds are formed, creating a new arrangement of atoms and at least one new substance. As the new substance is formed, observable changes take place — a change in temperature or colour, the formation of a visible gas or new solid, or perhaps even just an odour.

Reactants and products

The new substances that are formed during a chemical reaction are called the **products**. The original substances are called the **reactants**. For example, when hydrogen gas is added to oxygen gas and ignited, the new substance water is formed. The reactants are hydrogen and oxygen. The product is water. The bonds between the hydrogen atoms and oxygen atoms are broken and new bonds are formed between oxygen and hydrogen, as shown below.

Notice that the hydrogen and oxygen atoms that were present in the reactants are also present in the product. There is no gain or loss of atoms. They have simply been rearranged.



This reaction can be represented by a word equation as shown: oxygen + hydrogen → water.

A burning question

The idea of atoms rearranging themselves may seem obvious now, but two hundred years ago it was not. It was thought, for example, that when a candle burned the wax simply vanished. In other words, it was thought that matter could disappear.

In the eighteenth century, French nobleman Antoine Laurent Lavoisier showed that although a candle seems to disappear as it burns, there is as much mass present after it has completely burned as there was

before. The apparent loss of mass was caused by gases moving into the atmosphere. Lavoisier's ideas led to the development of the **Law of Conservation of Mass**, which states that matter can be neither created nor destroyed during a chemical reaction. The diagram and word equation below left is a simple representation of the Law of Conservation of Mass.

Lavoisier also provided evidence for the **Law of Constant Proportions**, which states that a compound, no matter how it is formed, always contains the same relative amounts of each element.

For example, carbon dioxide (CO_2) always contains the same relative amounts of carbon and oxygen (about 27 per cent of the mass is made up of carbon). It does not matter whether the carbon dioxide forms from the

reaction of sherbet in your mouth or from the reaction in the engine of a car, this proportion is fixed because every molecule of CO_2 is formed by the bonding of one carbon atom with two oxygen atoms. This law helped to shape our understanding of the way atoms bond together. In fact, after his unfortunate execution during the French Revolution, Lavoisier became known as the Father of Modern Chemistry.



Starting the ball rolling

Simply placing two chemicals together does not always mean they will react. For example, hydrogen and oxygen react violently, yet a mixture of these two gases can be stored indefinitely if kept cool in a secure container. Energy must be supplied to start the reaction. Sometimes only a small amount of energy is needed to start (or initiate) the reaction. Heat transferred from the surroundings may be enough.

INVESTIGATION 7.2

Conserve that mass!

AIM To compare the mass of the products of a chemical reaction with the mass of its reactants

Materials:

safety glasses
250 mL conical flask
4 Alka-Seltzer tablets
1 balloon
Matches
an electronic balance
100 mL measuring cylinder
water

METHOD AND RESULTS

CAUTION Wear safety glasses.

- ▶ Place the conical flask on the balance and pour in 100 mL of water.
- 1 Place two tablets alongside the conical flask and record the total mass.
- ▶ Remove the flask from the balance and drop the tablets into the water.
- 2 When the reaction is complete, weigh the flask and record the mass.
- ▶ Rinse out the flask thoroughly and again add 100 mL of water.
- ▶ Place two tablets inside the balloon. You may need to break the tablets into pieces to do this.
- ▶ Stretch the neck of the balloon over the conical flask, being careful not to drop the tablets into the water. The balloon should be flopped over, resting against the side of the flask.
- 3 Place the conical flask and balloon onto the balance and record the total mass.
- ▶ Lift up the top of the balloon and drop the tablets into the water in the conical flask.
- 4 When the reaction is complete, weigh the flask and record the mass. **Do not remove the balloon.**
- 5 After you have recorded the mass, remove the balloon. Light a match and test the gas in the conical flask. Record your observations.
- 6 Describe what happened during the reaction.

DISCUSS AND EXPLAIN

- 7 Which gas do you think filled the balloon?
- 8 Comment on your results of the total mass before and after each reaction. Explain your answer.
- 9 Why do you think it took a long time for the Law of Conservation of Mass to be developed?

Energy may also be supplied by an electric current, a beam of light or a Bunsen burner flame. This energy is needed to begin the process of breaking the bonds in the reactants, which allows the atoms to rearrange and form new bonds in the products.

In this case, the word equation is modified to show the word 'heat' written over the reaction arrow:



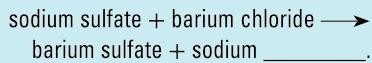
UNDERSTANDING AND INQUIRING

REMEMBER

- 1 What name is given to chemicals that:
 - (a) react in a reaction
 - (b) are formed in a chemical reaction?
- 2 What happens to the atoms in substances that take part in chemical reactions?
- 3 State the Law of Conservation of Mass and explain in your own words what it means.
- 4 State the Law of Constant Proportions and explain how it applies to carbon dioxide.
- 5 Energy can be required to start a reaction. List three possible sources of this energy.

THINK

- 6 A piece of paper is weighed on an accurate balance and then burned, leaving a pile of ashes. The ashes are collected and weighed on the same balance.
 - (a) Would you expect the mass of the ashes to be the same as the mass of the paper before it was burned?
 - (b) Explain your answer in terms of the products produced.
- 7 Explain why, when a piece of steel wool burns, the mass of the blackened material is greater than the original mass of the steel wool.
- 8 A chemical reaction is described by the following word equation:



Identify the second product.

INVESTIGATE

- 9 Find out more about Antoine-Laurent Lavoisier, his work and why he lost his head during the French Revolution.

eBook plus

work sheet

→ 7.1 Combustion

Matter and energy: Chemical reactions and energy

When fuels such as petrol are burned in motor vehicles, energy is released and used to keep the vehicle in motion. Burning is a chemical reaction in which fuel reacts with oxygen, producing carbon dioxide, water and several other products.

The energy released comes from the rearrangement of atoms. There is less energy stored in the chemical bonds in the products than there was in the reactants. Chemical reactions that release energy are called **exothermic** reactions.

Chemical reactions in which energy is absorbed from the surroundings are called **endothermic** reactions. There is more energy 'stored' in the chemical bonds of the products than there was in the reactants.



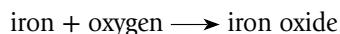
The energy that keeps this motorcycle moving comes from an exothermic chemical reaction.

WHAT DOES IT MEAN?

The words **exothermic** and **endothermic** come from the Greek words *exo*, meaning 'out', *endo*, meaning 'in', and *therme*, meaning 'heat'.

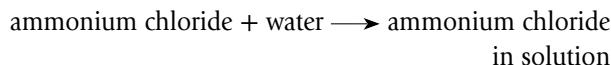
Hot stuff

Portable hand warmers, commonly used by skiers and campers, become hot when shaken due to an exothermic chemical reaction in which energy is released to the surroundings. One type of hand warmer contains iron, water, salt and sawdust. When the contents of the packet are shaken quickly, the powdered iron reacts with oxygen to form iron oxide. During this chemical reaction, some of the **chemical energy** of the substances is transformed into heat energy which is transferred to the hands, increasing their temperature. We can show this chemical reaction with a word equation:



As cold as ice

Athletes use instant icepacks to treat injuries. The icepack may consist of a plastic bag containing ammonium nitrate or ammonium chloride powder and an inner bag of water. Squeezing the bag breaks the weaker inner bag and immediately causes the powder to dissolve in the water. The **chemical process** that takes place absorbs energy from the injured area, thus lowering its temperature. It is therefore an endothermic chemical process. We can describe this chemical process with a word equation:



INVESTIGATION 7.3

Exothermic and endothermic processes

PART 1 IS FOR TEACHER DEMONSTRATION ONLY

AIM To investigate some exothermic and endothermic processes

Materials:

safety glasses
bench mat
4 large test tubes and test-tube rack
10 mL measuring cylinder
Balance
thermometer (-10°C to 110°C)
stirring rod
magnesium ribbon
sandpaper
0.5 mol/L hydrochloric acid
lithium chloride
sodium thiosulfate
potassium chloride

METHOD AND RESULTS

Construct a table like the one below in which to record the temperature changes as the five chemical processes described take place.

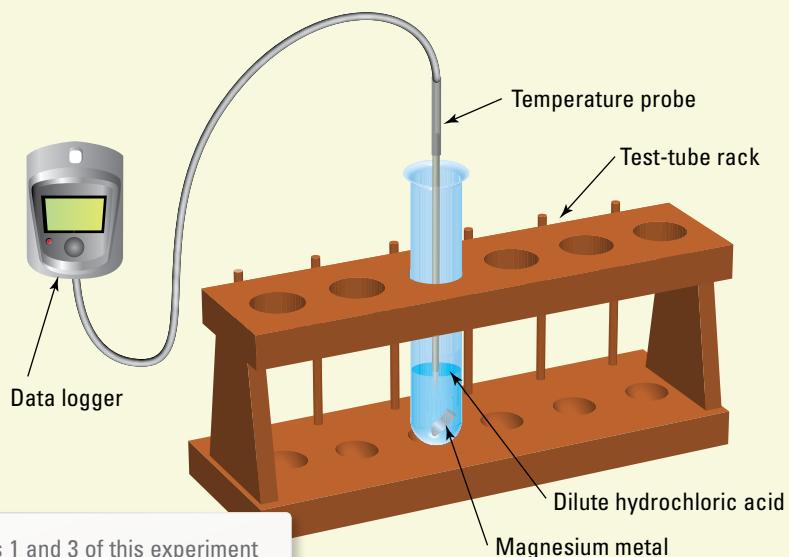
Part 1: Magnesium in hydrochloric acid

- ▶ Pour 10 mL of 0.5 mol/L hydrochloric acid into a test tube in a test-tube rack. Place a thermometer in the test tube and allow it to come to a constant temperature. Record the temperature of the solution.
- ▶ Clean a 10 cm piece of magnesium ribbon using the sandpaper until it is shiny on both sides. Coil the magnesium ribbon and place it into the test tube of hydrochloric acid.
- ▶ Observe the temperature of the solution as the magnesium reacts with the hydrochloric acid.

- 1 Record the final temperature of this solution.

Part 2: Lithium chloride in water

- ▶ Pour 10 mL of water into a test tube in a test-tube rack. Place a thermometer in the water in the test tube and allow it to come to a constant temperature.



Parts 1 and 3 of this experiment can be demonstrated with the aid of a data logger.

- 2 Record the temperature of the water.
▶ Use a balance to weigh 2 g of lithium chloride, add it to the water in the test tube and stir gently.
▶ Observe the temperature of the solution as the lithium chloride dissolves in the water.

- 3 Record the final temperature of this solution.

Part 3: Sodium thiosulfate in water

- ▶ Repeat part 2 above using 2 g of sodium thiosulfate instead of lithium chloride.

Part 4: Potassium chloride in water

- ▶ Repeat part 2 above using 2 g of potassium chloride instead of lithium chloride.
- 4 Complete the table by calculating the change in temperature resulting from each process. Use + or - signs to indicate whether the temperature decreased or increased.

DISCUSS AND EXPLAIN

- 5 Which processes were exothermic and which were endothermic?
6 Which one or more of the chemical processes above was a chemical reaction? How do you know?

Exothermic and endothermic processes

Chemical process	Initial temperature ($^{\circ}\text{C}$)	Final temperature ($^{\circ}\text{C}$)	Change in temperature ($^{\circ}\text{C}$)

Although the chemical bonds are broken in this process, it is not a chemical reaction because a new substance is not formed.

Endo or exo?

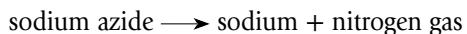
Whether energy is absorbed or released during a chemical reaction can be observed by comparing the temperature of the substances before the reaction with their temperature after the reaction.

Airbags

Airbags have saved many people from death or serious injury in car accidents. When an airbag inflates, it creates a cushion between the occupant's body and the windscreens, dashboard and other parts of the inside of the car. Airbags, which are made from nylon, may be concealed in the steering wheel, dashboard, doors or seats.

The rapid inflation of an airbag is the result of an explosive exothermic chemical reaction. The reaction is triggered by an electronic device in the car that detects any sudden change in speed or direction of the car. The bag fills with a harmless gas. When the occupants move forwards or sideways into the bag, they push the gas out of the airbag through tiny holes in the nylon. The airbag is usually totally deflated by the time the car comes to rest.

One of the chemical reactions commonly used in airbags produces a massive burst of nitrogen gas. In older airbags, the nitrogen was released when the toxic chemical sodium azide (NaN_3) decomposed:



Other chemicals, including potassium nitrate, were present to react with the potentially dangerous sodium metal that was produced. In newer airbags, sodium azide has been replaced with less toxic (and less expensive) chemicals.



Airbags inflate as a result of an explosive chemical reaction.

Alfred Nobel — an explosive career

Alfred Nobel is probably most famous for bequeathing his fortune to establish the Nobel Prizes in Physics, Chemistry, Medicine, Literature and Peace. However, Nobel made his fortune inventing **dynamite** and developing the use of explosives in the 1860s.

Alfred Nobel was born in Sweden in 1833. He was educated in Russia. Nobel was fluent in several languages and interested in literature, poetry, chemistry and physics. In Paris he met a young Italian chemist, Ascanio Sobrero, who had earlier invented **nitroglycerine**, a highly explosive liquid. Alfred Nobel became very interested in nitroglycerine and saw its potential in the construction industry. When he returned to Stockholm in Sweden he tried to develop nitroglycerine as an explosive. Several explosions, including one in 1864 in which Nobel's younger brother was killed, made the authorities realise that nitroglycerine was extremely dangerous.

Alfred Nobel had to move his laboratory out of Stockholm's city limits and onto a barge anchored on a nearby lake. He was determined to make nitroglycerine safe to work with. He discovered that mixing nitroglycerine with silica would turn the liquid into a paste that could be shaped into rods suitable for inserting into drilling holes. In 1866 he patented this material under the name dynamite.

Dynamite is mainly used in the mining and construction industries. Huge areas of rock can be broken apart because the chemical reaction involved in dynamite's explosion releases large amounts of energy and gas, which can exert great pressure. Explosives can release enough energy to cause a small earthquake.

The invention of dynamite could not have come at a better time than the middle of the nineteenth century. New mines were being opened to supply coal for heating and steam engines, iron and other building materials. Railways were being laid all over the world and passes had to be blasted through the mountains.



Alfred Nobel bequeathed his fortune to establish the Nobel Prizes.

Over the years, Alfred Nobel set up factories and laboratories in more than 20 countries.

Alfred Nobel died in 1896 and when his will was opened it came as a surprise that the interest earned by his \$9 million fortune was to be used for the establishment of the Nobel Prizes. The prizes were to be awarded 'for the good of humanity' in the fields of chemistry, physics, physiology or medicine, literature and peace.

Explosion: ... the act of exploding; a violent expansion or bursting with noise, as of gunpowder or a boiler ...

(*The Macquarie Dictionary*)

... loud noise caused by this ... rapid or sudden increase ...

(*The Australian Pocket Oxford Dictionary*)



UNDERSTANDING AND INQUIRING

REMEMBER

- 1 How are exothermic reactions different from endothermic reactions?
- 2 In a chemical reaction in which energy is absorbed from the surroundings, where does the extra energy go?
- 3 Explain why the chemical process that takes place in an icepack containing ammonium chloride is not a chemical reaction.
- 4 Explain how an airbag works.
- 5 Write a word equation to describe one chemical reaction that occurs to inflate an airbag.
- 6 What was Alfred Nobel's most famous invention?
- 7 Describe how an explosive is able to split large volumes of rock.

THINK

- 8 Are the chemical reactions described below exothermic or endothermic?
 - (a) Dilute hydrochloric acid is added to dilute sodium hydroxide in a test tube. They react to produce sodium chloride and water. After the reaction, the test tube feels very warm.
 - (b) As garden compost decomposes, the compost heap gets warmer.
 - (c) Barium hydroxide and ammonium thiosulfate solutions are mixed and the temperature drops enough to freeze water.
- 9 Instant hot compresses are used by athletes to warm torn muscles. They relieve pain and speed up the healing process. The hot compresses contain calcium chloride powder and an inner bag of water. When the inner bag

bursts, the calcium chloride dissolves in the water and releases energy.

- (a) Is the chemical process that takes place in the compress endothermic or exothermic?
 - (b) How does the energy stored in the chemical bonds of the product compare with the energy stored in the chemical bonds of the calcium chloride and water?
 - (c) Write a word equation to describe this chemical process.
- 10 Are explosions endothermic or exothermic reactions? Explain your answer.
 - 11 Why do you think that Alfred Nobel donated his entire fortune to reward those who worked for the 'good of humanity'?
 - 12 In exothermic chemical reactions, energy is released. Why is energy not included in the chemical equations that describe the reactions?

INVESTIGATE

- 13 Find the names of some Australians who have been awarded the Nobel Prize. Choose one Australian scientist who has won the Nobel Prize and write a short biography about him or her. Include in your biography information on when they were awarded the Nobel Prize and the work that they did to receive such a prestigious award.
- 14 Use a yearbook or the internet to find out who won the most recent Nobel Prizes for Chemistry, Physics and Medicine. Write a short biography about one of the laureates. (The winners of Nobel Prizes are referred to as laureates. The Nobel Prizes are announced in October of each year.)

Acids and bases

Chemical reactions involving acids and bases play an important role in our lives. They occur in the kitchen, in the laundry, in the garden, in swimming pools and even inside the body.

Acids

Acids are **corrosive** substances. That means they react with solid substances, ‘eating’ them away. Acids have a sour taste — in fact, the word ‘acid’ comes from a Latin word meaning sour. Some acids, such as the sulfuric acid used in car batteries, are dangerously corrosive. The acids in ant stings and bee stings cause pain. Others, such as the acids in fruits and vinegar, are safe — even pleasant — to taste.

WHAT DOES IT MEAN?

The word *acid* comes from the Latin word *acidus*, meaning ‘sour’.

Bases

Bases have a bitter taste and feel slippery or soapy to touch. Some bases are very corrosive, especially caustic soda (sodium hydroxide). Caustic soda will break down fat, hair and vegetable matter and is the main ingredient in drain cleaners. Other bases are used in soap, shampoo, toothpaste, dishwashing liquid and cloudy ammonia as cleaning agents. Bases that can be dissolved in water are

called **alkalis**. Some common acids and bases are listed in the tables on the following page.

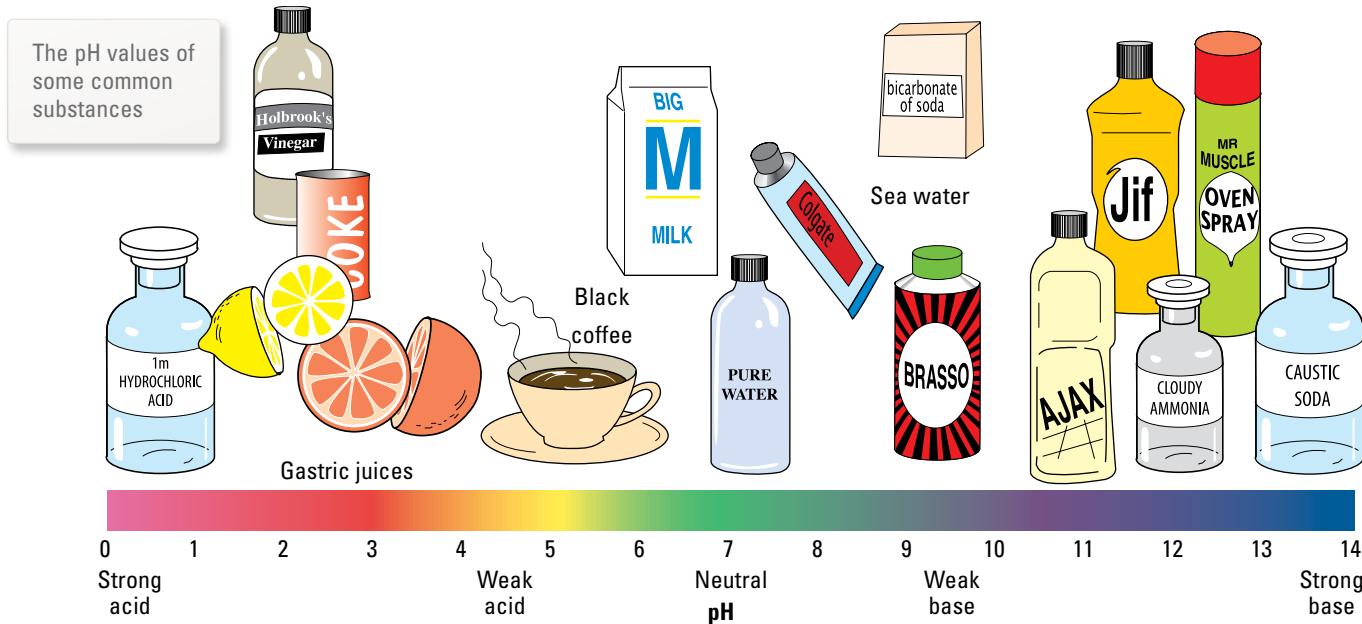
Giving an indication

Acid-base **indicators** are substances that can be used to tell whether a substance is an acid or a base. The indicators react with acids and bases, producing different colours in each. Two commonly used indicators are litmus, which turns red in an acid and blue in a base, and bromothymol blue, which turns yellow when added to an acid and a bluish-purple when added to a base.

The pH scale

You can describe how acidic or basic a substance is by using the numbers on the **pH scale**. The pH scale ranges from 0 to 14. Low pH numbers (less than pH 7) mean that substances are acidic. High pH numbers (more than pH 7) mean that substances are basic. If a substance has a pH of 7, it is said to be neutral — neither acidic nor basic. This is shown on the pH scale below.

Acids and bases can be graded from strong to weak. For example, a strong acid has a very low pH (pH 0 or 1) and a strong base has a very high pH (pH 13 or 14). The pH of a substance can be measured using a pH meter or a special indicator called **universal indicator**. Universal indicator is a mixture of indicators and it changes colour as the strength of an acid or base changes. The colour range of universal indicator is shown on the next page.



Neutralisation

When an acid and a base react with each other, the products include water and a salt. Such a reaction is called a **neutralisation** reaction. These reactions can be very useful. They can relieve pain caused by indigestion or the stings from wasps, bees and ants. They can be used to change the pH of soil to make it more suitable for growing particular plants. Neutralisation reactions are also used in cooking and to keep swimming pools and spas clean.

To neutralise means to stop something from having an effect. To stop the properties of acids from having an effect, a base can be added to it. Similarly, to stop a base from having an effect, an acid can be added. So, the pain caused by the acidic sting of an ant can be relieved by adding a weak base, such as sodium bicarbonate (baking soda). The pain caused by the base in the sting of a wasp can be relieved by adding a weak acid such as vinegar.

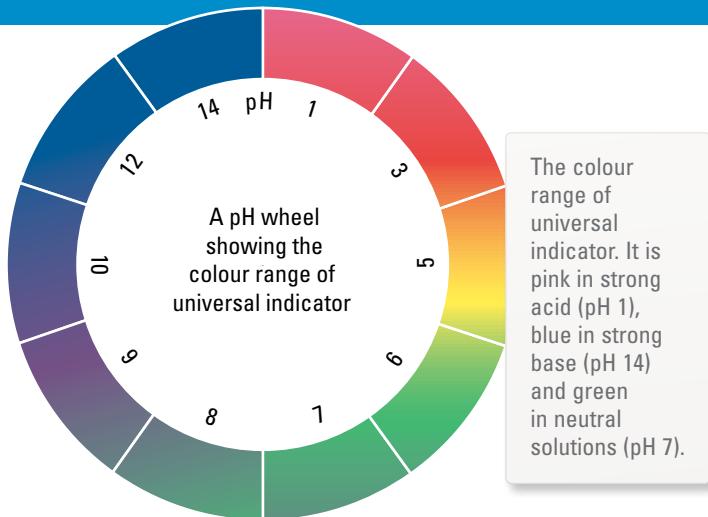
The word equation for a neutralisation is:



Sometimes, a gas is produced as well as a salt and water. For example, when hydrochloric acid is neutralised with sodium hydroxide, the products are water and the salt sodium chloride. When hydrochloric acid is neutralised with sodium bicarbonate, the products are the salt sodium chloride, water and carbon dioxide gas.

Common acids and bases

Acid	Uses
Hydrochloric acid	<ul style="list-style-type: none">To clean the surface of iron during its manufactureFood processingThe manufacture of other chemicalsOil recovery
Nitric acid	<ul style="list-style-type: none">The manufacture of fertilisers, dyes, drugs and explosives
Sulfuric acid	<ul style="list-style-type: none">The manufacture of fertilisers, plastics, paints, drugs, detergents and paperPetroleum refining and metallurgy
Citric acid	<ul style="list-style-type: none">Present in citrus fruits such as oranges and lemonsUsed in the food industry and the manufacture of some pharmaceuticals
Carbonic acid	<ul style="list-style-type: none">Formed when carbon dioxide gas dissolves in water; present in fizzy drinks
Acetic acid	<ul style="list-style-type: none">Found in vinegarThe production of other chemicals, including aspirin
Base	Uses
Sodium hydroxide (caustic soda)	<ul style="list-style-type: none">The manufacture of soapAs a cleaning agent
Ammonia	<ul style="list-style-type: none">The manufacture of fertilisers and in cleaning agents
Sodium bicarbonate	<ul style="list-style-type: none">To make cakes rise when they cook



The colour range of universal indicator. It is pink in strong acid (pH 1), blue in strong base (pH 14) and green in neutral solutions (pH 7).

Neutralisation in the garden

Neutralisation reactions are used in many situations around the home. A sting from an ant or a bee is very painful as it contains an acid — formic acid. This can be neutralised by a base such as soap. A wasp sting is painful because it contains a base and can be treated by applying an acid such as vinegar. It is important to know what has bitten you so that the correct substance can be used to neutralise the sting.

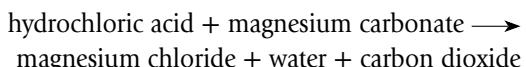
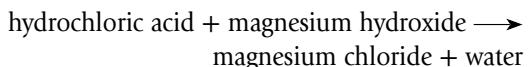
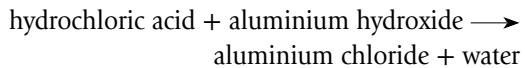
Some plants grow better in acidic soils, while other plants grow best in basic soils. If a soil is too acidic, it can be neutralised with a base such as lime. The added lime can make the soil less acidic, neutral or basic, depending on how much is added.

If the soil is too basic, ammonium sulfate can be added to the soil. This reacts with the soil to produce an acid, which helps to neutralise the bases in the soil. These neutralisation reactions in your garden can help your plants to grow by providing soil with the most suitable pH.

Indigestion

The hydrochloric acid in your stomach helps to break down the food you eat. It is a very strong acid, with a pH of less than 1.5. But if you eat too quickly, or eat too much of the wrong food, the contents of your stomach become even more acidic. You feel a burning sensation because of the corrosive properties of the acid.

To relieve the pain of indigestion, you can take antacid tablets. The active ingredients in antacid tablets are weak bases such as aluminium hydroxide, magnesium carbonate and magnesium hydroxide, which neutralise the acid. The cause of the relief you experience can be described by chemical word equations such as:



One product of this last reaction is carbon dioxide gas. You burp to get the gas out of your stomach.

Acids and bases in the kitchen

Some foods, such as pickles, chutney and tomato sauce, last a long time without refrigeration because they contain acids that prevent the growth of micro-organisms that would cause them to spoil. Others, such as onions and beetroot, are preserved by storing them in vinegar, which is also known as acetic acid. This process of preserving food is called **pickling**.

The base sodium bicarbonate is more commonly known as baking soda. When it reacts with an acid, the products are a salt, water and carbon dioxide. Self-raising flour is a mixture of an acid and baking soda. When water or milk is added to self-raising flour, the acid and base react together. The carbon dioxide produced causes the mixture to rise when it is heated.

Two ingredients in pancakes are buttermilk (an acid) and baking soda. When the two are mixed, a salt, water and carbon dioxide are produced. The bubbles of carbon dioxide get larger as the mixture is heated, causing the mixture to rise.

Swim safely

When chlorine is added to a swimming pool, it reacts with the water to produce hypochlorous acid. This acid kills bacteria and algae, keeping the pool water safe for swimming. All the chemicals in a swimming pool, when combined, need to have a pH in the range of 7.2–7.8 for a clean, hygienic pool and safe swimming.

If the pH falls below 7.2, the micro-organisms will still be killed but the swimmers will get red and stinging eyes, and the water may become corrosive and damage pool fittings. A base such as sodium carbonate (soda ash) or sodium bicarbonate (bicarbonate of soda) would have to be added to neutralise the excess acid.

If the pH rises above 7.8, bacteria and algae will grow and the water will be unfit for swimming. To reduce the pH, an acid such as sodium hydrogen sulfate would have to be added to neutralise the excess base.

Corrosive acids

Acids are corrosive. They can dissolve metals, eat away marble statues, destroy the enamel of your teeth and kill bacteria.

Because acids are corrosive, they can be very harmful. Strong acids can burn your skin and eat away clothes. If an acid is spilt on the floor, a basic powder, such as sodium bicarbonate, should be used to neutralise the acid. All spills in the science lab should be reported to your teacher.

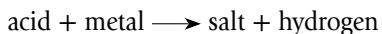
Acid can destroy the enamel on your teeth. Teeth are protected by a 2 mm thick layer of enamel made of hydroxyapatite. After a meal, bacteria in the mouth break down some of the food to produce acids such as acetic acid and lactic acid. Food with a high sugar content produces the most acid. The acids produced by the bacteria can dissolve the enamel coating of the tooth. Once this protective coating is destroyed, the bacteria can get inside the tooth and cause tooth decay. The best way to prevent this chemical reaction between tooth enamel and acid from happening is to clean and floss your teeth after every meal and avoid eating sugary foods.

HOW ABOUT THAT!

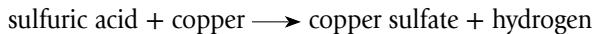
The fizzy sensation that you get when you eat sherbet is due to an acid–base reaction. The sherbet consists of sodium bicarbonate and citric acid. Both of these substances are in powdered form in the sherbet and do not react with each other. When they dissolve in the saliva of your mouth a reaction takes place, producing carbon dioxide gas and hence the fizzing.

Acids and metals

When an acid reacts with a metal, the products are a salt and hydrogen gas. The word equation for an acid–metal chemical reaction is:



For example, when sulfuric acid (hydrogen sulfate) reacts with copper, the products are copper sulfate and hydrogen. The chemical word equation for this reaction is:



INVESTIGATION 7.4

Antacids in action

AIM To investigate the neutralising action of an antacid

Materials:

Petri dish
electronic balance
spatula
antacid powder
0.1 mol/L hydrochloric acid
250 mL conical flask
100 mL measuring cylinder
methyl orange indicator
white tile or white paper

METHOD AND RESULTS

- 1 Measure and record the mass of the Petri dish.
- 2 Add a small amount of antacid powder to the dish and record the mass of the antacid and Petri dish.
- 3 Calculate the mass of the powder.
- 4 Add 50 mL of the dilute hydrochloric acid to the 250 mL flask.

- ▶ Add 3 drops of methyl orange indicator.
- ▶ Place the flask mixture on the white tile (or paper) and use the spatula to slowly add antacid from the Petri dish bit by bit. Swirl the flask to mix. Stop adding antacid when the colour changes from red to orange.
- 4 Measure and record the mass of the Petri dish and its contents (the unused antacid).
- 5 What was the mass of the antacid powder?
- 6 What colour change occurs when the methyl orange indicator is in the acid?
- 7 By subtraction, calculate the mass of antacid used to neutralise 50 mL of dilute hydrochloric acid.

DISCUSS AND EXPLAIN

- 8 How does your result agree with other groups in your class? Suggest reasons for the similarities or differences between your results.
- 9 Use your results to calculate how much antacid you would need to neutralise 500 mL of dilute hydrochloric acid.

INVESTIGATION 7.5

Reaction of acids with metals

AIM To investigate the chemical reactions of an acid with a range of metals

Materials:

safety glasses
bench mat
test tubes and test-tube rack
pieces of metal such as copper, iron, zinc, magnesium, aluminium
dropping bottle of 2 mol/L hydrochloric acid solution
rubber stopper
matches

METHOD AND RESULTS

When an acid reacts with a metal, a salt is formed and hydrogen gas is given off. You can test for hydrogen gas by holding a lighted match at the mouth of the test tube. If the gas is hydrogen, it will explode and make a ‘pop’ sound.

- ▶ Place a small piece of one of the metals in a test tube.
- ▶ Add the acid to the test tube to a depth of 1 cm.

- ▶ Observe the chemical reaction.
- ▶ Test for hydrogen gas by holding a rubber stopper over the end of the test tube for a few seconds and then placing a lighted match at the mouth of the test tube.

CAUTION Do not push the stopper into the test tube firmly. Just hold it in the top of the test tube for a few seconds.

- 1 Record your observations.
- 2 Repeat the test with other metals.

DISCUSS AND EXPLAIN

- 3 When zinc metal reacts with hydrochloric acid, zinc chloride and hydrogen gas are formed. Write a word equation for this reaction.
- 4 When the lighted match produces a ‘pop’, the hydrogen gas is reacting with the oxygen in the air to form water. You may have noticed the water form at the top of the test tube after you performed the match test. Write a word equation for this chemical reaction.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Use a two-column table to describe the properties of acids and bases.
- 2 What common property do some acids and bases have when they come into contact with solid substances?
- 3 Describe the difference between a base and an alkali.
- 4 Which type of substance has a pH value:
 - (a) less than 7
 - (b) more than 7
 - (c) equal to 7?
- 5 Explain why the chemical reaction between an acid and a base is called neutralisation.
- 6 Which substance is produced in all neutralisation reactions?
- 7 Explain how self-raising flour helps cakes rise.
- 8 Which acid is present in your stomach to help you digest food?
- 9 How does an antacid relieve the pain of indigestion?
- 10 Why does soap relieve the pain of an ant sting?
- 11 Why do foods that are high in sugar cause so much tooth decay?
- 12 Identify two products of every chemical reaction between an acid and a metal.

USING DATA

- 13 A pH meter is used to measure the pH of 5 different substances. The results are as shown in the table below:

Substance	pH value
A	6.0
B	12.0
C	3.0
D	7.0
E	8.0

- (a) Which substance is most likely to be:
 - (i) orange juice
 - (ii) milk?
- (b) Which substance could be:
 - (i) a weak base
 - (ii) pure water
 - (iii) vinegar
 - (iv) a strong base?
- (c) Which two of the substances would you expect to be the most corrosive?

THINK

- 14 Write word equations for the reactions between:
 - (a) hydrochloric acid and sodium hydroxide
 - (b) hydrochloric acid and sodium bicarbonate
 - (c) sulfuric acid (hydrogen sulfate) and sodium hydroxide.
- 15 When you add buttermilk (an acid) to baking soda (a base) in a mixing bowl, does the pH increase or decrease? Explain your answer.
- 16 Antacid tablets contain a base, which neutralises the excess acid in your stomach and relieves the pain. When you take an antacid tablet, would you expect the pH value in your stomach to increase or decrease? Explain your answer.
- 17 A stinging-nettle plant may contain an acid that is injected into your skin when you touch it. Describe how you could show that the plant does contain an acid.
- 18 Write a word equation to describe the chemical reaction between hydrochloric acid and calcium carbonate.
- 19 Why is it that the acids in the food and drink you consume do not damage your stomach?
- 20 When you add lime to a soil that is too acidic, are you increasing or decreasing the pH?

INVESTIGATE

- 21 Find the websites of two antacid products such as Gaviscon®, Mylanta®, Eno® or Alka-Seltzer®.
 - (a) Research and report on:
 - (i) the ingredients of the product or products
 - (ii) the claims made about each of their antacid product or products
 - (iii) advice and warnings
 - (iv) side effects.
 - (b) Find a medical site that provides information about antacids, including side effects.

Comment on the adequacy of the advice on each of the two companies' websites.
- 22 On the packet of one brand of baking soda, there is a claim that you can deodorise your entire house by sprinkling it on your carpets and leaving it for a few minutes before vacuuming.
 - (a) Suggest how the baking soda could have this deodorising effect.
 - (b) Investigate other claims made on baking soda packaging and design some experiments to test one or more of the claims.
- 23 Play the **pH rainbow** in your eBookPLUS and drop liquids into their correct position on the pH scale. **int-0101**

eBookplus

work
sheet

7.3 Acids and bases

Acid rain

Every year, acid rain causes hundreds of millions of dollars worth of damage to buildings and statues.

The photographs below show the damage that has been caused to a statue over sixty years. Forests, crops and lakes are also affected by acid rain which is blown in from industrial areas.

These photographs were taken in 1908 (left) and in 1969 (right). You can see the damaging effects of acid rain on this statue.



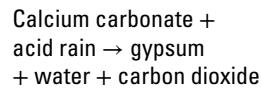
What causes acid rain?

Rain is normally slightly acidic. As clouds form and rain falls, the water reacts with carbon dioxide in the atmosphere to form very weak carbonic acid. If concentrations of sulfur dioxide and nitrogen oxide are high, these gases react with the water in the atmosphere to produce sulfuric, nitric and other acids.

When this rain falls, it is far more acidic than it would normally be and is known as acid rain. If the acid rain falls as snow, acid snow can build up on mountains. When this snow melts, huge amounts of acid are released in a short period.



When acid rain eats into buildings and statues, it is reacting with calcium carbonate in the marble or limestone.



Acid rain damages the cells on the surface of leaves and affects the flow of water through plants. It also makes plants more likely to be damaged by frosts, fungi and diseases. In northern Europe, entire forests have died as a result of acid rain.

Acid rain collects in streams, rivers and lakes, making the water more acidic. Acid rain causes the pH of lakes to fall. Some aquatic plants and animals cannot tolerate these acidic conditions and die.



eLesson



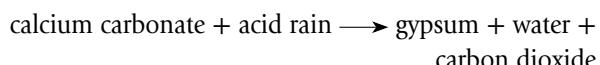
The rain is burning!

See some of the destruction that acid rain has caused on Earth. Learn why acid rain is created and how we can stop it from occurring.

eles-0065

can live in it. Acid rain causes the pH of the lake to fall. Some aquatic plants and animals cannot tolerate these acidic conditions and die. It is not only the acidic water that can kill the aquatic life. Acid rain reacts with soil, releasing minerals, which may contain elements such as aluminium. The aluminium is washed into the streams, rivers and lakes and poisons the aquatic plants and animals.

When acid rain eats into buildings and statues, it is reacting with calcium carbonate in the marble or limestone.



The gypsum formed by acid rain on a statue is a powdery dust (calcium sulfate), which is washed away by the rain. As this chemical reaction continues, the statue is slowly eaten away.

Solving the problem

The problem of acid rain and all the damage that it causes can be solved only by reducing the release of acidic gases into the air. Some ways of doing this include:

- looking for alternative ways of producing electricity
- encouraging people to use public transport or to car pool.

INVESTIGATION 7.6

Investigating acid rain

AIM To investigate the effect of pH of acidic water on the growth of seeds

Materials:

empty milk cartons
potting soil
distilled water
measuring cylinder
vinegar (or 0.1 mol/L hydrochloric acid solution)
seeds (e.g. lucerne, peas, cress, beans)
universal indicator

METHOD AND RESULTS

- ▶ Cut the milk cartons so that they are about 10 cm high. These will make suitable containers for growing the seeds, 5 seeds per container.
- ▶ Test the effect of water with different pH values on the growth of the seeds. To ensure that your tests are fair, you will need to keep everything the same in your experiment, except the one thing that you are varying. In this case you are varying the level of acidity (pH) of the water that you are putting on the plants.

DISCUSS AND EXPLAIN

- 1 Prepare a report on your investigation. This could be a written report, a video, a wall chart or an oral presentation.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 What is acid rain and how is it caused?
- 2 Why is rain slightly acidic even without air pollution?
- 3 Describe two different ways in which acid rain can harm the plants and animals in streams and lakes.
- 4 Complete this word equation: acid rain + calcium carbonate →

THINK

- 5 Motor vehicles make a large contribution to the acid rain problem. Most of them use fuel that releases acidic nitrogen oxides when it is burned. Write an account of some ways in which motor vehicle pollution could be reduced over the next thirty years.

CREATE

- 6 Write a newspaper article about the devastation caused by acid rain.

- 7 Design a wall chart that would explain how acid rain is formed and the damage that it can cause.

IMAGINE

- 8 Imagine that you live near a factory or power station that is producing acidic gases and causing harm to the environment. You wish to be elected onto the local government board to try to stop this problem. Write a speech that you could give at an election meeting.

INVESTIGATE

- 9 Use the library to find out which countries are most affected by acid rain.
- 10 Find out some of the ways that damage caused by acid rain could be stopped or at least reduced.

eBook plus

work sheet

→ 7.4 Acid rain

Combustion reactions

Some of the most spectacular chemical reactions to watch, including fireworks and the launching of spacecraft, are **combustion** reactions.

Combustion reactions are those in which a substance reacts with oxygen and heat is released. Burning is a combustion reaction that produces a flame. The substance that reacts with oxygen in a combustion reaction is called a **fuel**.

Fossil fuels

Fossil fuels such as natural gas, petrol and coal have formed from the remains of living things. They are compounds of hydrogen and carbon called **hydrocarbons**. The products of the combustion of fossil fuels always include carbon dioxide and water. Because of impurities in fossil fuels, these are not the only products of their combustion. In some cases various dangerous gases, including carbon monoxide, are also produced.

Cooking with gas

The **natural gas** used in gas stoves and ovens contains methane, a colourless, odourless and highly flammable gas. Natural gas formed millions of years ago from the remains of plants and animals and became trapped under rock. Its lack of colour and odour makes it very dangerous if there is a leak, so gas suppliers add chemicals that do have an odour so that the methane can be detected in the event of a leak or if the gas is accidentally left switched on. Methane reacts with oxygen, producing carbon dioxide and water, and it burns with a blue flame. The heat needed to start the reaction is provided by a match, lighter or spark. The chemical word equation for the combustion of methane is:



Motoring along

The fuel used in most Australian cars is liquid **octane**. This is the major component of petrol, usually between 85 per cent and 95 per cent — other fuels make up the

WHAT DOES IT MEAN?

The word **combustion** comes from the Latin word *comburere*, meaning 'to burn'.

remainder. Octane is obtained from **crude oil** which, like natural gas, is formed from the remains of marine plants and animals that died million of years ago. The vapour

of liquid octane reacts with oxygen, producing carbon dioxide and water. The reaction is started in each cylinder of a car by a spark from a spark plug. Most of the energy released during the reaction is used to turn the wheels of the car. The chemical word equation for the combustion of octane is:



Taking off

The fuel used in jet aircraft is **kerosene**, which is obtained from crude oil. Like the octane in cars, the vapour of this fossil fuel reacts with oxygen. An electrical spark is used to start the reaction. The chemical word equation for the combustion of kerosene in a jet engine is:



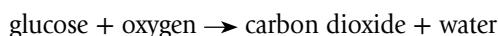
Generating electricity

Fossil fuels such as coal and natural gas are burned in power stations to generate electricity. The energy released during the combustion reaction is used to heat water to produce steam. The steam turns the blades of giant turbines, transforming its energy into electrical energy. The chemical word equation for the combustion of coal is:



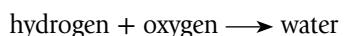
Essential combustion

A chemical reaction called **respiration** takes place in every cell of your body. Respiration is a slow combustion reaction. The energy required by your body is released when the fuel, glucose from your digested food, reacts with oxygen from the air that you breathe. The products of respiration are carbon dioxide and water. The chemical word equation for respiration is:



Blasting off

The energy to launch spacecraft is provided by a combustion reaction. The main rocket engines are fuelled by hydrogen, which reacts with oxygen in an exothermic reaction that releases enough energy to lift more than two million kilograms off the ground towards outer space. The only product of the reaction is water. The chemical word equation for the combustion of hydrogen is:



Rocket engines are fuelled by a combustion reaction with hydrogen.

Oxidation reactions

Combustion reactions are examples of **oxidation** reactions. However, strangely enough, not all oxidation reactions involve oxygen. Oxidation is now defined as the transfer of electrons from a reactant. That is what happens to fuels when they are burned in oxygen. The reaction between copper and a silver nitrate solution is an example of an oxidation reaction that does not involve oxygen. Copper is oxidised when electrons are removed from copper atoms during the reaction that produces silver metal.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 What characteristics do all combustion reactions have in common?
- 2 How are fossil fuels different from other types of fuel?
- 3 How is each of the following combustion reactions started?
 - (a) The burning of natural gas
 - (b) The combustion of octane in a car
- 4 What are the products of all combustion reactions in which fossil fuels are burned?
- 5 What is the fuel in the combustion reaction known as respiration?

THINK

- 6 Describe at least two effects on the environment of the combustion of fossil fuels.
- 7 Hydrogen and oxygen are cooled to extremely low temperatures so that they can be stored as liquids in the fuel tanks of rockets. Why is water, the product of the reaction, produced as a gas?
- 8 Respiration is the chemical reaction that takes place in every cell of your body. State two reasons it is classified as a combustion reaction.
- 9 Write a word equation for an oxidation reaction that does not involve oxygen.

INVESTIGATE

- 10 Find out how kerosene and octane are extracted from crude oil.
- 11 Find out why catalytic converters are used in cars and which chemical reactions take place within them.
- 12 Oil companies often make claims that their petrol is cleaner, more economical and provides superior performance than that of their competitors. Use the internet to investigate the following questions.
 - (a) How do the oil companies go about improving their fuel products?
 - (b) How do the oil companies try to convince consumers that their claims are correct?
 - (c) What do you think? Is there a difference between the same fuel products made by different companies or are they all the same? Use your research to back up your opinion.

CREATE

- 13 Create a poster that shows how the burning of coal is used to generate electricity. Include the chemical equation for the combustion of coal on your poster. Also include information about where the reactants come from and what happens to the products.

Matrixes and plus, minus, interesting charts

1. Write the topics in the left-hand column of the matrix.
2. Write the characteristics to be compared along the top row of the matrix.
3. If a characteristic applies to a topic, put a tick in the appropriate cell of the matrix.
4. The matrix now shows how the various topics are related.

To show similarities and differences between topics

why use?

how to ...?

In what ways are these topics similar and different?

question

Table; grid; decision chart

also called

Matrix

Topic	Feature A	Feature B	Feature C	Feature D	Feature E
1	✓		✓	✓	✓
2		✓			✓
3		✓		✓	✓
4			✓	✓	✓

example

comparison

Similarity

Both can be used to examine the key features of a topic and can help you to make a decision on something.

Plus, minus, interesting chart

Difference

PMI charts look at positive (plus), negative (minus) and interesting aspects of something. Matrixes can have a broader application.

example

Object or device	Light energy	Thermal energy	Electrical energy
Torch	✓	✓	✓
Portable stove	✓	✓	
Instant icepack		✓	

Topic/theme/idea

Plus

Minus

Interesting

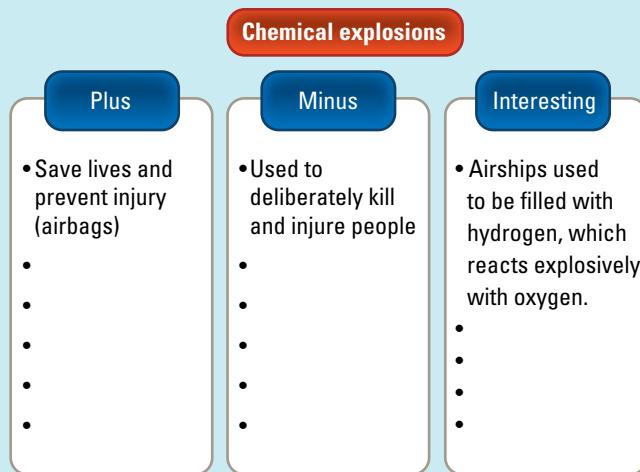
UNDERSTANDING AND INQUIRING

THINK AND CREATE

1 Copy and complete the matrix below to show which type of chemical reaction each statement refers to.

Statement	Endothermic reactions	Exothermic reactions	Neutralisation reactions	Combustion reactions
Chemical bonds are always broken.				
New chemical bonds are formed.				
Energy is released to the surroundings.				
Energy is absorbed from the surroundings.				
The Law of Conservation of Mass applies.				
A salt is always produced.				
Oxygen is always a reactant.				
One reactant is always an acid.				
Respiration in living cells is an example.				
Takes place to inflate a car airbag.				
A new substance is produced.				

2 Create your own PMI chart on chemical explosions, using the diagram below as a starting point.



3 Create a PMI chart on the use of fossil fuels.

HOW ABOUT THAT!

In 1937, a hydrogen-filled airship called the *Hindenburg* exploded violently while docking at a refuelling tower. Until recently, it was believed that hydrogen was the cause of the disaster — hydrogen and oxygen react explosively when ignited by a spark. However, scientists now claim that it was, in fact, the flammable aluminium-coated skin of the airship and a stray spark that were to blame.

Use the *Hindenburg* weblink in your eBookPLUS to listen to reporter Herb Morrison's eyewitness account of the *Hindenburg* explosion.



eBook plus

work
sheet

7.5 Airship up in flames

STUDY CHECKLIST

REACTANTS AND PRODUCTS

- identify reactants and products in chemical reactions
- describe the rearrangement of atoms of the reactants during a chemical reaction
- describe chemical reactions using word equations
- state the Law of Conservation of Mass and the Law of Constant Proportions

ENERGY IN CHEMICAL REACTIONS

- recognise that many chemical reactions must be initiated by an input of energy
- distinguish between endothermic and exothermic reactions

ACIDS AND BASES

- describe the properties of acids and bases
- distinguish between acids and bases
- describe a variety of examples of the use of acids and bases in the home, garden and industry
- investigate neutralisation reactions and describe examples of their everyday use

- investigate chemical reactions of acids with metals

COMBUSTION REACTIONS

- recognise the role of oxygen in combustion reactions
- describe a variety of examples of the use of combustion reactions
- compare combustion reactions with other oxidation reactions
- identify respiration as a combustion reaction
- describe respiration using a word equation

SCIENCE AS A HUMAN ENDEAVOUR

- describe some applications of endothermic and exothermic reactions in everyday life and athletics
- describe the role of Alfred Nobel in the development of explosives and the awarding of the Nobel Prizes
- investigate the causes and effects of acid rain
- investigate methods of preventing acid rain
- investigate the effect of the products of combustion reactions on the environment
- evaluate claims made about chemical products

eBookplus

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.

7.6 Thinking tools: Matrixes and plus, minus, interesting charts

eBookplus
ONLINE ONLY

Individual pathways

Activity 7.1

Revising chemical reactions
doc-8449

Activity 7.2

Investigating chemical reactions
doc-8450

Activity 7.3

Investigating chemical reactions further
doc-8451

eLesson

The rain is burning!

In this video lesson, you will discover the cause of acid rain and learn about the damage it can do to buildings, plants and waterways. This problem is increasing but there are practical ways to stop it. A worksheet is included to further your understanding.

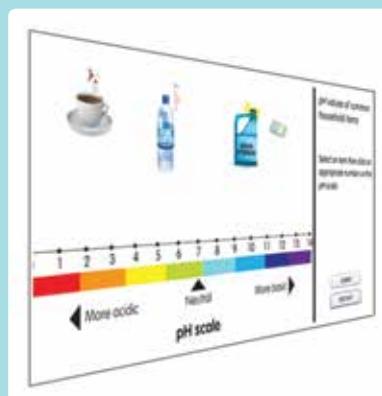


Searchlight ID: eles-0065

Interactivity

The pH rainbow

This interactivity helps you develop your knowledge of pH by challenging you to drop different liquids in their correct position on the pH scale. Instant feedback is provided.



Searchlight ID: int-0101

FOCUS activity

Access more details about focus activities for this chapter in your eBookPLUS.
doc-10654

LOOKING BACK

assessON

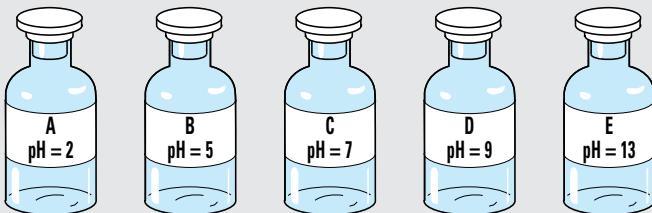
Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement. www.assesson.com.au

- 1 A particular chemical reaction can be described by the word equation:
hydrochloric acid + magnesium carbonate → magnesium chloride + water + carbon dioxide.
(a) What are the reactants in this chemical reaction?
(b) List the products of the reaction.
(c) From which compound did the atoms present in the carbon dioxide come?
(d) This is an exothermic reaction. Which substances have more energy stored in chemical bonds — the reactants or the products?
- 2 List four examples of observable evidence that a chemical reaction has taken place.
- 3 Use the Law of Conservation of Mass to explain why it is incorrect to say that when a candle burns it disappears.
- 4 State the Law of Constant Proportions.
- 5 When hydrogen reacts with oxygen in a rocket engine, a huge amount of energy is released.
$$\text{hydrogen} + \text{oxygen} \xrightarrow{\text{heat}} \text{water}$$

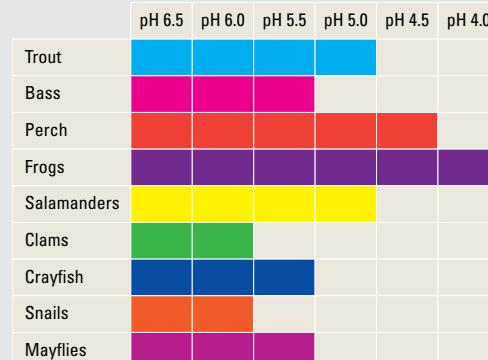
(a) Why does the word 'heat' appear above the arrow in the chemical word equation?
(b) Is this reaction endothermic or exothermic? Explain how you reached your answer.
- 6 When an instant icepack is squeezed to activate it to treat an injury, ammonium chloride dissolves in water, producing a solution of ammonium chloride. As the ammonium chloride dissolves, energy is absorbed from the injured area, causing it to become very cold.
(a) Is the production of the ammonium chloride an endothermic or exothermic process?
(b) Explain why this process is not a chemical reaction, even though chemical bonds have been broken.
- 7 Are the chemical reactions that convert the chemical energy stored in your muscles into other forms of energy endothermic or exothermic? How do you know?
- 8 Use a three-column table to sort the substances listed below into acids, bases and salts.

caustic soda	gastric juices
hydrogen chloride	antacid tablets
sodium bicarbonate	copper nitrate
sodium chloride	magnesium chloride
ammonia	fizzy drinks
lemon juice	sodium sulfate

- 9 The liquids in the bottles below are labelled with their pH. Which of the bottles is most likely to contain:
(a) distilled water
(b) a strong acid
(c) vinegar
(d) bathroom surface cleaner?



- 10 Predict the salts that would result from the neutralisation reaction between:
(a) magnesium oxide and hydrochloric acid
(b) copper (II) oxide and sulfuric acid
(c) sodium hydroxide and acetic acid
(d) sodium oxide and nitric acid?
- 11 If the water in a swimming pool has a pH that is too high for hygienic and safe swimming, which type of pool chemical should be added — an acid or a base?
- 12 What is pickling?
- 13 Complete the following chemical word equation:
acid + metal →
- 14 Outline the cause of acid rain and explain how it affects the natural environment and man-made structures.
- 15 There are at least two reactants in every combustion reaction. One of them is called a fuel.
(a) With what substance does the fuel react?
(b) Identify one product of every combustion reaction.
(c) One product of combustion reactions is not a chemical. What is it?
- 16 Identify two chemical products of combustion reactions in which fossil fuels are burned.
- 17 Identify the main reactant in each of the following fuels in combustion reactions.
(a) Natural gas
(b) Petrol
(c) Jet aircraft fuel
- 18 One combustion reaction takes place in every cell of your body.
(a) What is the name of this combustion reaction?
(b) Identify the reactants in the reaction.
(c) Identify two chemical products of the reaction.
- 19 The diagram below shows the organisms that are normally found in a particular lake and the pH of water that they are able to tolerate.



- (a) Which of these species would start to die first if the lake water started to increase in acidity?
- (b) Which of the species is the most tolerant of high acid levels in the lake? Explain.
- (c) Which species would remain if the acidity of the lake water increased until it had a pH of 5.0?

eBook plus

work sheet

7.5 Chemical reactions: Summary

ICT ACTIVITY

projectsplus

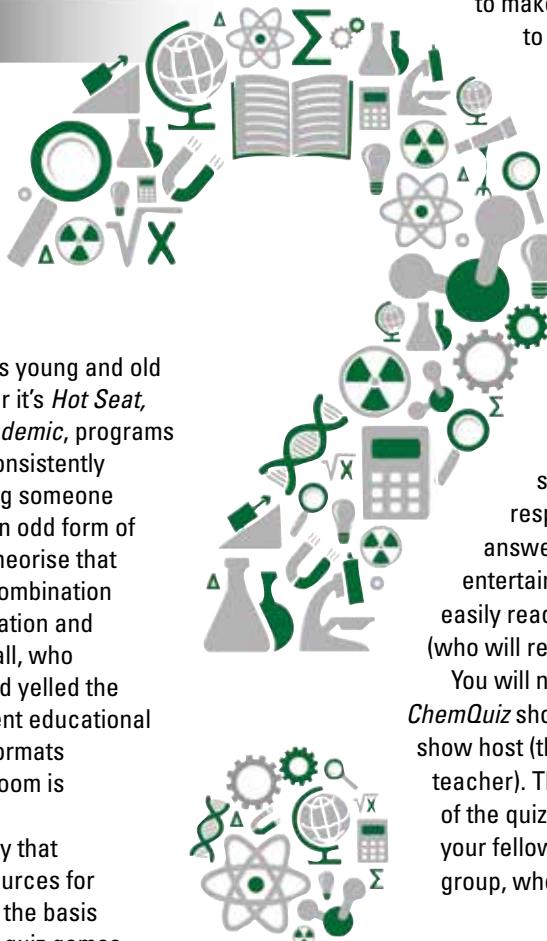
ChemQuiz!

SEARCHLIGHT ID:
PRO-0107

Scenario

You only have to have a glance at any page of your TV guide to see that Australians young and old love a good quiz show. Whether it's *Hot Seat*, *Jeopardy*, *Spit it Out* or *It's Academic*, programs with a quiz show format rate consistently well. While the idea of watching someone answer questions seems like an odd form of entertainment, psychologists theorise that their popularity arises from a combination of a desire to learn new information and a form of competition — after all, who hasn't watched a quiz show and yelled the answers at the screen? In recent educational studies, the use of quiz game formats as a teaching tool in the classroom is gaining support.

The Brain Mine is a company that specialises in educational resources for use in Science classrooms. On the basis of these educational studies of quiz games, they have decided that they would like to add a computer-based chemistry quiz show that teachers could purchase and run in their classrooms as a fun and effective way of improving student knowledge. As product developers at The Brain Mine, it is up to you and your team



to make this happen! You and your team are going to develop *ChemQuiz*, a chemistry-based quiz show in which the class teacher will act as the show host, groups of students will be the contestants and the questions (which pop up on a computer screen so that the contestants can see them) are based on chemistry skills.

Your task

Using PowerPoint, you will create a series of question screens for a quiz show that should run for about ten minutes. For each question screen, the show host must be able to reveal the correct response after a contestant has given their answer. The question screens should be entertaining and eye-catching, and should also be easily readable by the contestants and the show host (who will read the questions out as they appear).

You will need to give a demonstration of your *ChemQuiz* show with one of your group acting as the show host (the role that would normally be taken by the teacher). The show host will need to explain the rules of the quiz show at the start. The contestants will be your fellow students (preferably not those in your group, who will already know the answers!).

Process

Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group.

