CHEMISTRY

Explaining Chemical Changes

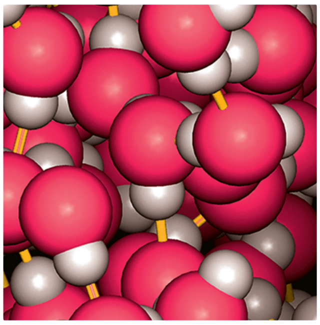
Ideas you have met before

The particle model

Matter is made of particles, and we can describe these particles in terms of atoms and molecules.

We can represent atoms and molecules in particle pictures.

During a chemical change, atoms and molecules are rearranged. This can be shown using particle pictures.



Chemical changes

Changes can occur when materials are mixed. Some of these changes are non-reversible – these are called chemical changes, or chemical reactions.

Mixing bicarbonate of soda with vinegar and making toast are chemical changes – you cannot get the original materials back.

The new materials made in chemical changes can be useful.

Burning

Burning materials (such as wood, wax and gas) produces new materials.

Burning is usually a chemical change. Burning is also known as combustion.

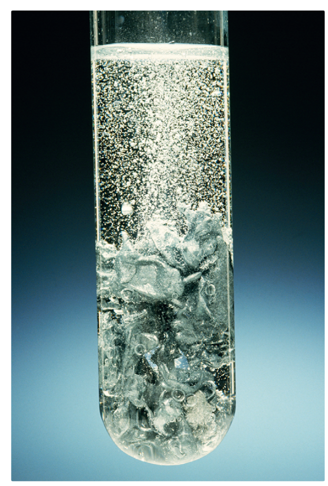
In this chapter you will find out

Acids, alkalis and indicators

- We use acids in our everyday lives, such as in food and batteries.
- We use alkalis in our everyday lives, such as in cleaning products and medicines.
- Some acids and alkalis are hazardous.
- We can make and use indicators to show how acidic or alkaline a substance is.
- The pH scale is an important measure of the level of acidity and alkalinity of a substance.

Reactions of acids and alkalis

- Acids react with metals, with carbonates and with alkalis.
- In these reactions the particles are rearranged – we can show this using diagrams, equations and other models.
- A neutral substance is one with pH 7. It is made when an acid and an alkali exactly neutralise one another.
- Neutralisation reactions can be useful for our health.



Combustion

- We can control combustion by understanding what is needed for substances to burn.
- Combustion changes the atmosphere because of the new products that are formed.
- Air pollution from combustion can cause rain to become acidic and cause environmental problems.

Exploring acids

We are learning how to:

- Recognise acids used in everyday life.
- Describe what all acids have in common.
- Identify the hazards that acids pose.

Acids are often thought of as dangerous substances. Indeed, many acids *are* dangerous and we must take precautions when handling them. However, we come across many acids in our daily life that are useful and not dangerous at all.

Useful acids

If you look around your kitchen, you may find some **acids** to eat or drink.

Citrus fruits such as lemons and oranges contain citric acid. Vinegar, which is used to pickle foods or to flavour chips, contains ethanoic acid. Fizzy drinks contain carbonic acid. Tea contains tannic acid.

Acids also have industrial uses. Sulfuric acid is used in car batteries and in making fertilisers. Nitric acid can also be used in making fertilisers and in paints.

1. List some examples of acids that we have in our homes.
2. Describe two acids that may be used to make fertilisers.
3. Suggest what taste acids have in common.

FIGURE 2.4.2a: Which acid is found in each of these?

Considering the hazards

Concentrated acids, such as concentrated sulfuric acid, are extremely dangerous. These acids are **corrosive** – this means that the acid can destroy skin and attack metals if spilled.

The types of acid that are often used in science lessons are dilute acids – this means that they have had water added to them. Dilute acids are not as dangerous as concentrated acids. They are not corrosive but may be an **irritant** to the skin. Your skin might become red and blistered if some acid was spilled on it.

Acids that are found in food and drink, such as in lemons and vinegar, are extremely weak and dilute. This is why they are safe to eat and drink, whereas dilute hydrochloric acid is not. However, they may still sting if they get into a cut.

4. Explain why is it better to use images on hazard labels, rather than words.
5. Suggest why you usually use dilute acids in school practical experiments, rather than concentrated acids.
6. Describe the precautions that you should take when working with an acid that displays the hazard symbol.
7. Explain why concentrated acids are more dangerous than dilute acids.

What do acids have in common?

Some acids taste sour. Some acids are weak enough that we can eat or drink them. Some acids would burn your skin. However, one thing that *all* acids have in common is that they contain the element **hydrogen**. We can show this by looking at the chemical formulas of acids:

Hydrochloric acid, HCl – this shows that the acid contains hydrogen and chlorine.

Sulfuric acid, H_2SO_4 – this shows that the acid contains hydrogen, sulfur and oxygen.

FIGURE 2.4.2d: Which element do all of these acids contain?

8. The chemical formula for nitric acid is HNO_3. Which elements does nitric acid contain?
9. A sour-tasting substance is found to contain the elements oxygen, sulfur and hydrogen. Suggest whether or not this is an acid and explain your reasoning.

FIGURE 2.4.2b: 'Corrosive' hazard sign

FIGURE 2.4.2c: 'Harmful' hazard sign, which is used for substances that are not corrosive but are irritants.

Did you know…?

Your stomach contains hydrochloric acid, which helps to digest food and kill bacteria. You can feel this acid burning your throat slightly when you vomit.

Key vocabulary

acid

corrosive

irritant

hydrogen

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Exploring alkalis

We are learning how to:

- Recognise alkalis used in everyday life.
- Describe what all alkalis have in common.
- Identify the hazards that alkalis pose.

Many of the cleaning products that we use have something in common – they all contain an alkali. It is the alkali that gives soap, shampoo and washing powder a soapy feeling. We have alkalis all around us and life would be very different without them.

FIGURE 2.4.3a: Many cleaning products contain an alkali.

Useful alkalis

Some **alkalis** are harmful. However, many alkalis are harmless and are very useful.

Many cleaning products – such as bleach, oven cleaner, disinfectant and washing powder – contain alkalis. Toiletries such as soap, shampoo and toothpaste also contain an alkali. Even some medicines such as indigestion remedies contain alkalis.

When you bake a cake, you use baking powder to ensure that the cake is light and fluffy. Baking powder contains an alkali called sodium hydrogencarbonate (sodium bicarbonate). Without it, your cakes would be like biscuits!

1. Name some alkaline cleaning products.
2. Name two alkalis that are safe to put in your mouth and two that are not.
3. Suggest how your life would change if there were no alkalis.

What do alkalis have in common?

Most alkalis feel **soapy** to touch. Soap forms because the alkali reacts with fats on your skin. However, some alkalis are too harmful to put on your skin. The common feature of all alkalis is that they contain **hydroxide** particles (chemical symbol OH).

Sodium hydroxide, NaOH, is the alkali used in many cleaning products, such as oven cleaners. Calcium hydroxide, $Ca(OH)_2$, is an alkali used by gardeners when their soil is too acidic. Both of these products would be harmful if you swallowed

FIGURE 2.4.3b: Which alkali does baking powder contain?

them. Magnesium hydroxide is the weak alkali found in many indigestion remedies.

4. What is the common feature of all alkalis?
5. Which elements are contained in:
   a) calcium hydroxide?
   b) sodium hydroxide?
6. Suggest what the chemical formula for magnesium hydroxide is.

Dangerous alkalis

Many of the alkalis in our homes are dangerous. The most dangerous alkalis include oven cleaners and caustic soda (to unblock drains). These substances are corrosive – they both contain the alkali sodium hydroxide.

FIGURE 2.4.3c: Which alkali do both of these products contain?

Other alkalis are classed as an irritant, rather than corrosive. Examples are bleach and disinfectant.

Alkalis are often more dangerous than acids given the same hazard classification. This is because it can be hard to rinse an alkali from the skin because it becomes soapy.

7. Bleach often has 'irritant' written in braille on the bottle. Suggest why this is important.
8. Draw the hazard symbol that would be found on a bottle of bleach.
9. Bleach contains sodium hydroxide and another chemical, sodium hypochlorite. Bleach is dangerous, but caustic soda is even more dangerous. Suggest why.

Did you know...?

In the past, stale urine was used as a source of the alkali ammonium hydroxide. It was used to bleach and clean clothes – it was even used in toothpaste!

Key vocabulary

alkali

soapy

hydroxide

Using indicators

We are learning how to:

- Use indicators to identify acids and alkalis.
- Analyse data from different indicators.
- Compare the effectiveness of different indicators.

The traffic indicators on a car tell other vehicles when the car is going to turn. Indicators in science can show us whether a substance is an acid or an alkali. Nature is full of natural indicators and we can make use of these indicators in many ways.

What are indicators?

An **indicator** is a substance that has different colours in an acid and in an alkali. One example of an indicator is **litmus**. Litmus solution turns *red in acid* and *blue in alkali*. If a solution is neither an acid nor an alkali, we say it is **neutral.**

Litmus paper is sometimes easier to use than litmus solution. Blue litmus paper turns red in an acid; red litmus paper turns blue in an alkali.

FIGURE 2.4.4a: What colour is litmus in a neutral solution?

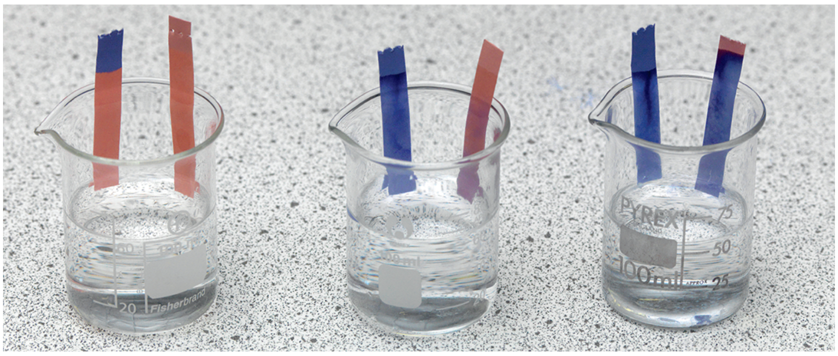

FIGURE 2.4.4b: Litmus paper is easy to use.

1. Describe what an indicator is.
2. Describe the colour changes of litmus solution in an acid and an alkali.
3. Draw a table to show the colours in acid, alkali and neutral of:

   a) red litmus paper **b)** blue litmus paper.

Uses of indicators

Most flower, fruit and plant parts that are red, blue or purple can be used as an indicator. This is because these parts of a plant contain chemicals called anthocyanins that change colour in acids and alkalis. The real purpose of these chemicals is to preserve nutrients in the winter. However, we can use these chemical indicators in other ways.

Gardeners can use indicators to test soils. This is useful because some plants prefer acidic soils while others prefer alkaline soils. Home swimming pools should be kept at around neutral. Indicators can be used to check that water has not become acidic or alkaline. Industries can use indicators to check that the liquid waste that they dispose of is not acidic or alkaline. For example, photographic industries use indicators in this way.

4. Describe three uses of indicators.

5. Explain why most red, purple or blue flowers can be used to make indicators.

FIGURE 2.4.4c: Most red and purple flowers can be used to make an indicator.

What does the indicator show?

A group of students made indicators from different plants. They then checked the colour change of each indicator in acid and alkali. They recorded their results.

TABLE 2.4.4: Which is the most useful indicator?

Plant used to make indicator	Colour of indicator	Colour in acid	Colour in alkali
red cabbage	purple	red	green
beetroot	red	red	purple
cherries	red	red	blue

6. An indicator made from red cabbage turned green in an unknown liquid. Explain what this tells us.

7. An indicator made from beetroot stayed red when added to another unknown liquid. Does this mean that the unknown liquid is an acid?

8. Compare the results given by each of the indicators. Suggest which is the most useful indicator.

Did you know...?

Baking powder can also be used as an indicator. It does not show any colour change but it does fizz when added to an acid, but not when added to an alkali or to water.

Key vocabulary

indicator

litmus

neutral

Chemistry

Using universal indicator

We are learning how to:

- Describe what the pH scale measures.
- Measure and record pH values.
- Identify the advantages of universal indicator.

Some acids, such as sulfuric acid, are corrosive and can burn the skin. Other acids, such as orange juice, are so weakly acidic that we can drink them. Sometimes we need to know how strong or weak an acid is. We cannot make a strong acid weak by diluting it – even dilute sulfuric acid, which we use in school laboratories, is still a strong, harmful acid. But concentrated orange juice is not corrosive or harmful!

FIGURE 2.4.5a: Orange juice contains a weak acid.

Are all acids the same?

If oven cleaner got on your skin, it would burn. This is because it contains a **strong alkali**. Soap also contains an alkali but you can of course put this safely on your skin. This is because soap contains a **weak alkali**.

Sulfuric acid is used when preparing skeletons because it can remove flesh from bones – it is a **strong acid**. Ethanoic acid is found in vinegar – it is a **weak acid**.

1. Give an example of a:

a) strong acid **b)** weak acid
c) strong alkali **d)** weak alkali.

2. Explain why we can put vinegar and orange juice in our mouths, but not sulfuric acid.

FIGURE 2.4.5b: Oven cleaner contains a strong alkali, sodium hydroxide.

Using universal indicator

Most chemical indicators just tell us whether a substance is an acid or an alkali. **Universal indicator** turns a range of different colours. The colour depends on whether the substance is an acid or an alkali *and* on how strong or weak it is. Each colour is given a **pH number**.

On the pH scale:

- neutral solutions are pH 7
- acidic solutions are lower than pH 7
- alkaline solutions are higher than pH 7

Did you know…?

The pH scale was invented in 1909 by a Danish chemist, Søren Sørensen. It is thought that 'pH' may stand for 'power of hydrogen', linked with the fact that all acids contain hydrogen.

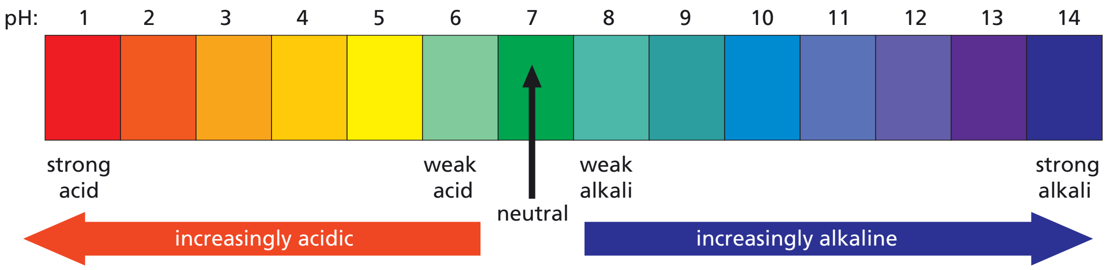

FIGURE 2.4.5c: The pH scale ranges from pH 1 to pH 14.

3. Universal indicator is added to a liquid and it changes to yellow. State the pH of the liquid.

4. Describe what happens to the strength of an acid as the pH number decreases.

5. Describe what happens to the strength of an alkali as the pH number increases.

Comparing indicators

Litmus indicator turns red in acid and blue in alkali. Red cabbage indicator turns red in acid and purple in alkali.

Universal indicator is a mixture of several different indicators. This means that it gives a full range of predictable colours, depending on the strength of the acid or alkali.

TABLE 2.4.5: Universal indicator shows the strength of different acids and alkalis.

Substance	pH	Acidic or alkaline?
hydrochloric, nitric and sulfuric acids, and car battery acid	**0–1**	strongly acidic
phosphoric acid	**1–2**	acidic
citrus fruit, such as lemons and oranges; vinegar	**4**	acidic
distilled water	**7**	neutral
egg, hand soap	**8**	alkaline
ammonia	**11**	alkaline
oven cleaner	**12**	alkaline
caustic soda, paint stripper	**13–14**	strongly alkaline

6. Describe what colour litmus indicator would turn if added to:

a) hydrochloric acid

b) vinegar.

7. Explain the advantages of using universal indicator over litmus or red cabbage indicator.

Key vocabulary

strong/weak alkali

strong/weak acid

universal indicator

pH number

Exploring neutralisation

We are learning how to:

- Describe examples of neutralisation.
- Use indicators to identify chemical reactions.
- Explain colour changes in terms of pH and neutralisation.

The pain of a nettle sting can be eased by rubbing the sting with a dock leaf. Nettles contain a weak acid and dock leaves contain a weak alkali. The alkali 'cancels out' the acid. This is called neutralisation and there are many other examples around us.

FIGURE 2.4.6a: Why does a dock leaf help with a nettle sting?

Did you know...?

Bee stings are acidic and are treated by neutralising the acid with a mild alkali, such as bicarbonate of soda. Wasp stings are slightly alkaline and are treated by neutralising with an acid, such as vinegar. Therefore, it is important to know what has stung you.

Mixing acids and alkalis

As we add an alkali to acid, the molecules in the acid and alkali react. The resulting solution becomes less acidic (the pH increases) as we add more alkali. It is almost as if the alkali 'cancels out' the acid. This reaction between acids and alkalis is called **neutralisation**.

If we add just the right amount of alkali, the solution will become exactly neutral.

1. Describe what is meant by 'neutralisation'.
2. Describe what happens to the pH of an acidic solution as an alkali is added. Explain your answer.
3. Describe what would happen to the pH of an alkaline solution if an acid were added.

Neutralisation in action

4.6

There are examples of neutralisation reactions all around us. Our saliva is alkaline and it neutralises some of the acid made by bacteria in our mouth. We also neutralise the acid by using toothpaste, which is also alkaline. Heartburn is caused by acid from the stomach. Antacid tablets contain an alkali that neutralises the acid. Industries such as textile and paper factories produce lots of alkaline liquid waste. This is neutralised with acid before it is disposed of.

4. Explain why alkaline waste from industries must be neutralised before it is released into lakes and rivers.

5. Summarise some applications of neutralisation in a table. For example:

Situation	Neutralised by
stomach acid	antacid tablets

FIGURE 2.4.6b: The alkali in toothpaste neutralises acid that could decay the teeth.

Demonstrating neutralisation

We can use indicators to demonstrate neutralisation in action. If universal indicator is added to an alkali, it turns purple. If some acid is then added, the colour changes. If the solution becomes neutral, the solution would eventually be green.

We can use a technique called **titration** to mix acids and alkalis precisely. This allows us the see a whole range of colour changes.

A burette allows an acid to be added to an alkali gradually. If the acid is added slowly enough, the neutral point (pH 7) can be seen. This point is indicated by the solution turning green.

6. Describe the colour changes that would be seen in the conical flask as the solution changed from a strong alkali to neutral.

7. Suggest what would be seen if more acid was added after the neutral point was reached. Explain your answer.

8. Explain the benefits of using a burette, rather than dropping pipettes, to add the acid.

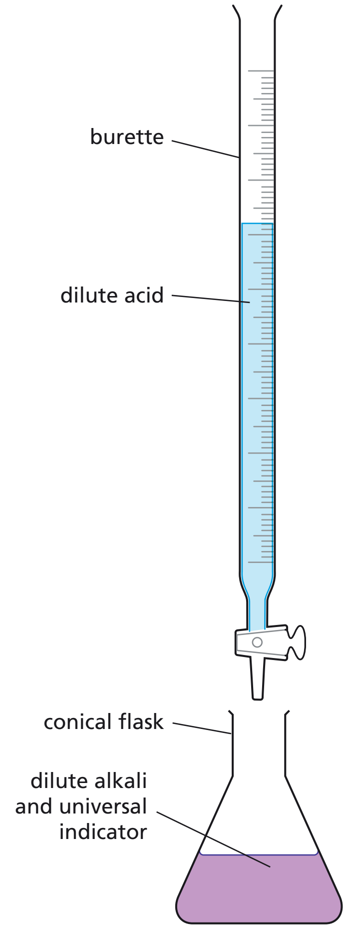

FIGURE 2.4.6c: Titration can be used to carry out a neutralisation reaction precisely.

Key vocabulary

neutralisation

titration

Explaining neutralisation

We are learning how to:

- Recall the equation for a neutralisation reaction.
- Explain how water is made during a neutralisation reaction.
- Apply a model to explain neutralisation.

Acids and alkalis 'cancel each other out'. We see a change in colour of indicator when we mix them. This change is a chemical reaction, with new products being formed. A model may help us to understand what is happening during the reaction.

Making water

All acids contain hydrogen, so the symbol H will appear in the formula – for example, hydrochloric acid is HCl. All alkalis contain both hydrogen and oxygen so the formula will have both O and H. We call this combination 'hydroxide' – for example sodium hydroxide is NaOH. When acids and alkalis are mixed a *chemical reaction* takes place, with new products being formed.

The hydrogen and the hydroxide combine to form water, H_2O. **Water** is a product of neutralisation.

Acids have a low pH and alkalis have a high pH. Water is **neutral**. Therefore there is a change in pH as we mix acids and alkalis.

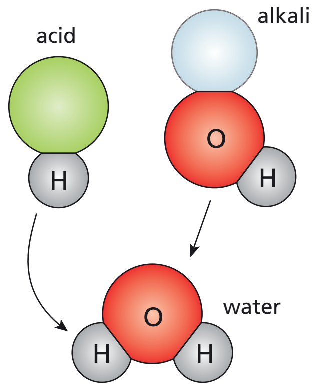

FIGURE 2.4.7a: H in acid and OH in alkali combine to form water, H_2O.

1. Name one of the new products formed when acids and alkalis mix.
2. Describe what combines from each of the acid and the alkali to form water.
3. Suggest the pH of pure water.

The neutralisation equation

Water is just one of the products of neutralisation. The other product is a **salt**. The type of salt produced depends on the acid and alkali that were reacted. We can describe neutralisation using an **equation**:

acid + alkali → salt + water

For example, if hydrochloric acid is neutralised with the alkali sodium hydroxide, the salt produced is sodium chloride.

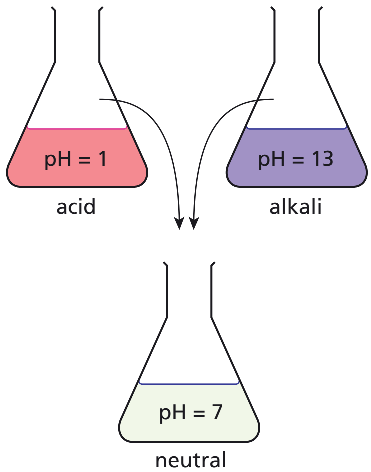

FIGURE 2.4.7b: Neutralisation

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4. Write the general equation for neutralisation.
5. Name the product of neutralisation that:
   a) is always the same
   b) depends on the acid and alkali used.
6. Describe the two new products that are formed when hydrochloric acid is mixed with sodium hydroxide

A model for neutralisation

In science, models are often useful for helping us to understand something that we cannot see or touch. We cannot see or touch the individual molecules in an acid and an alkali – so, it can be difficult to understand the reactions that are going on.

In Figure 2.4.7c, hydrogen is shown as a red brick and oxygen is shown as a yellow brick. The rest of the acid is shown as black bricks and the rest of the alkali is shown as blue bricks.

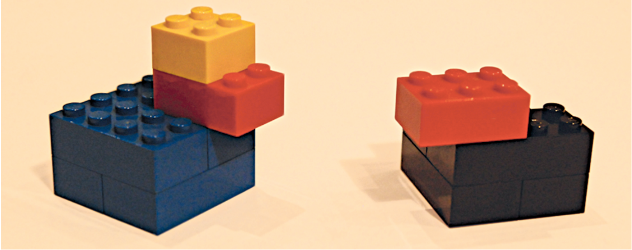

FIGURE 2.4.7c: Which bricks represent the acid?

7. Explain why models, such as this one, are used in science.
8. Using the building bricks model, draw:
   a) the water produced
   b) the salt produced.
9. Another type of model uses circles to represent atoms and molecules. Use the model in Figure 2.4.7d to draw the products of the reaction between hydrochloric acid (HCl) and sodium hydroxide (NaOH).

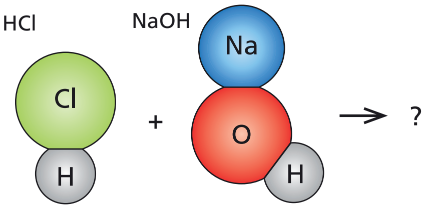

FIGURE 2.4.7d: What are the products of this reaction?

Did you know…?

Pure water is neutral. However, our drinking water is usually slightly acidic or slightly alkaline. This is because this water contains dissolved minerals and gases.

Key vocabulary

water
neutral
salt
equation

Understanding salts

We are learning how to:

- Name examples of salts.
- Describe the uses of common salts.
- Predict the reactants used in and the salts made by different neutralisation reactions.

We usually think of 'salt' as something that we add to food. The scientific name for this type of salt is sodium chloride. However, there are many more types of salt, each with different uses.

Salts and their uses

A **salt** is made in a neutralisation reaction, along with water. The most common salt is sodium chloride. It has many uses – flavouring food, treating icy roads and as a food preservative. Sodium chloride is essential in the human body. In industry, sodium chloride is used to produce chlorine, hydrogen and sodium hydroxide and each of these then have important uses.

Magnesium chloride is used in the manufacture of cement and can also be used to absorb dust in places such as excavation sites. Iron sulfate is used by gardeners to kill moss on lawns. Calcium sulfate is used to make plaster of Paris to treat fractures.

1. Describe four uses of sodium chloride.
2. List three other examples of salts and describe their uses.
3. Write a definition of a salt.

FIGURE 2.4.8a: There are many types of salts, with far more uses than making your food tasty!

Making predictions

The salt made during a neutralisation reaction can be predicted.

The first part of the name of the salt comes from the alkali, usually from the metal in the alkali. For example, the alkali sodium hydroxide forms salts that start with 'sodium', whereas magnesium hydroxide forms salts that start with 'magnesium'.

The second part of the name of the salt comes from the acid. Table 2.4.8 summarises the ends of the salt names for each of the common acids.

TABLE 2.4.8: The acid used tells us the end of the salt name.

Acid used in neutralisation	forms salts that end in…
hydrochloric acid	chloride
sulfuric acid	sulfate
nitric acid	nitrate

So, if nitric acid is neutralised by copper carbonate, the salt formed will be called copper nitrate.

4. Suggest what the first part of the name of the salt will be if the alkali used is calcium carbonate.
5. Predict the name of the salt formed in a neutralisation reaction between hydrochloric acid and sodium hydroxide.
6. Write an equation for the reaction between hydrochloric acid and magnesium hydroxide.

Bases and neutralisation

A **base** is any substance that neutralises an acid to produce a salt and water. An alkali is a soluble base – one that dissolves in water. Therefore, all alkalis are bases, but not all bases are alkalis. Copper oxide is an example of a base. Sodium hydroxide is an example of a base that is also an alkali.

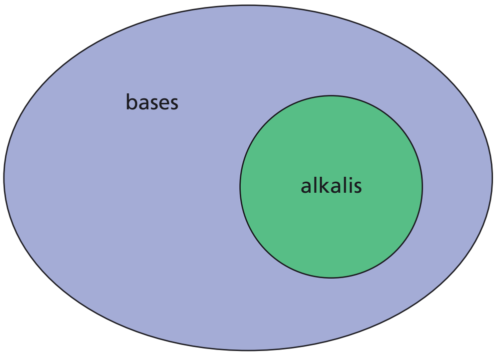

FIGURE 2.4.8b: All alkalis are bases, but only soluble bases are alkalis.

7. Explain the difference between a base and an alkali.
8. Explain why copper oxide is a base, whereas sodium hydroxide is also an alkali.
9. Write an equation for the reaction between an acid and a base. Compare this with the reaction of an acid and an alkali.

Did you know…?

Sodium chloride lowers the melting point of ice. When it is added to icy roads, the ice melts at a lower temperature than it would ordinarily. The ice melts to make the roads less dangerous.

FIGURE 2.4.8c: Why is salt spread on icy roads?

Key vocabulary

salt

base

Chemistry

Exploring the reactions of acids with metals

We are learning how to:

- Describe the reaction between acids and metals.
- Explain the reaction between acids and metals.
- Compare the reactivities of different metals.

Most metals react with acids. The way that a metal reacts varies, depending on its reactivity. Some metals are so reactive that we would never add some acid to them in the laboratory.

Reacting acids with metals

A **chemical reaction** is one in which new products are made. There are clues that we can look for to spot a chemical reaction. These include:

- bubbles of gas being given off
- a change in temperature
- a colour change
- a change in mass.

When we add an acid to most metals, we see bubbles. This is because a gas is produced during the reaction. We may also feel the test tube getting warmer. These observations are both evidence that a chemical reaction has taken place.

1. Describe some of the observations that tell us that a chemical reaction is taking place.
2. Describe two signs that the reaction between an acid and a metal is a chemical reaction.
3. Explain why bubbles are produced during reactions.

What are the new products?

Acids react with most metals. Just like when acids react with alkalis, a **salt** is formed. However, water is *not* formed, unlike in neutralisation. Instead, a gas is formed – gas is **hydrogen**. You can test for hydrogen gas because it burns with a 'pop'. If you put a lighted splint into the top of the test tube in which an acid and metal are reacting, you will hear a 'pop' sound. This is because the flame ignites the hydrogen and it explodes.

FIGURE 2.4.9a: How can you tell that a chemical reaction is taking place between the acid and magnesium?

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We can summarise the reaction between acids and metals using an equation:

acid + metal → salt + hydrogen

The salt produced depends on the type of acid and the metal used. For example, if you react nitric acid with copper metal, copper nitrate is the salt formed.

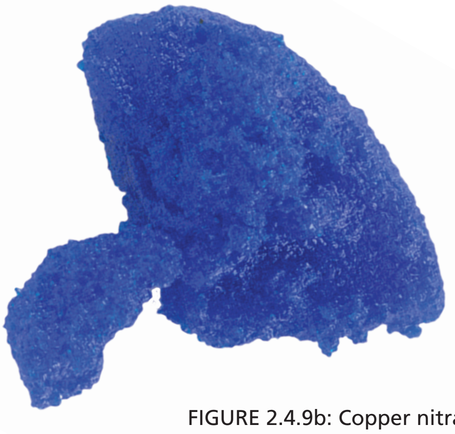
FIGURE 2.4.9b: Copper nitrate

4. Write an equation for the reaction between nitric acid and copper metal.
5. Write an equation for the reaction between hydrochloric acid and magnesium metal.
6. Explain why we should not put a flame near a large amount of hydrogen gas.

Comparing reactivity

A group of students reacted hydrochloric acid with some different metals. They recorded their observations about the **reactivity** of the acid with the metals.

Metal	Observations when acid added
zinc	some bubbles
magnesium	vigorous bubbling
iron	a few bubbles
copper	no bubbles

FIGURE 2.4.9c: Results of reactions between hydrochloric acid and some metals

7. Order the metals in terms of reactivity, going from most to least reactive.
8. The teacher told the students that calcium was too reactive to use in this experiment. Suggest what may be seen if acid was added to calcium.
9. Write a word equation for each of the reactions.

Did you know…?

Precious metals such as gold, silver and platinum do not react with acids. They are so unreactive that they stay as pure metals. This is one reason that they are used to make jewellery.


FIGURE 2.4.9d: Precious metals are unreactive.

Key vocabulary

chemical reaction
salt
hydrogen
reactivity

Exploring the reactions of acids with carbonates

We are learning how to:

- Describe the reaction between acids and carbonates.
- Explain the reaction between acids and carbonates.
- Write word equations for the reactions between acids and carbonates.

Some rocks, such as limestone, contain a metal carbonate – limestone contains calcium carbonate. Limestone reacts with acids in a predictable way, and as new products are formed the limestone is eroded.

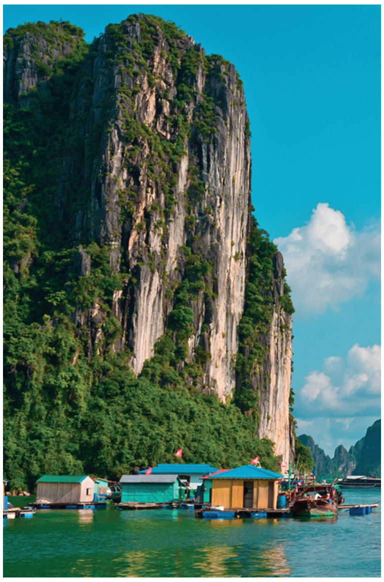

FIGURE 2.4.10a: Limestone is mainly calcium carbonate.

Evidence for a reaction

If an acid is mixed with a metal **carbonate**, fizzing is seen. This fizzing is caused by bubbles of a gas made during the reaction.

The gas produced when acids react with a metal carbonate is **carbon dioxide**. You can carry out a test to prove that this gas is carbon dioxide. Carbon dioxide gas turns **limewater** cloudy. If the gas produced during a reaction between an acid and a metal carbonate is bubbled into limewater, the limewater turns cloudy.

1. Name the most common metal carbonate found in rocks.
2. Explain why some rocks fizz when some acid is added to them.
3. Describe how you can prove that the gas made when acids and metal carbonates react is carbon dioxide.

FIGURE 2.4.10b: Limewater is used to test for carbon dioxide.

Summarising the reactions

Carbonates react with an acid to produce a salt and water. The reaction also makes another product – carbon dioxide gas. The reaction between acids and carbonates can be summarised in an equation.

acid + metal carbonate → salt + water + carbon dioxide

As with neutralisation and acid–metal reactions, the type of salt produced depends on the types of acid and metal carbonate reacted. For example, if hydrochloric acid is reacted with calcium carbonate, the salt produced is calcium chloride. If hydrochloric acid is reacted with copper carbonate, the salt produced is copper chloride. Water and carbon dioxide are always produced during these reactions.

FIGURE 2.4.10c: Would pure calcium carbonate react faster or slower than pieces of rock?

4. Write an equation for the reaction between hydrochloric acid and calcium carbonate.

5. Write an equation for the reaction between sulfuric acid and copper carbonate.

6. Suggest how the reaction would change if you used powdered calcium carbonate, rather than a lump of rock. Explain your answer.

A changing mass

When an acid and a metal carbonate react in an open container, the carbon dioxide produced escapes into the air. The mass in the container decreases. You can plot a graph to show how the mass changes over time.

The reaction is fastest at the start and the mass falls quite quickly. As the acid and the carbonate is used up, the reaction slows down and the graph becomes less steep. When all of the acid or carbonate has reacted, the graph levels off.

7. Describe when the mass is changing most quickly.

8. Explain why the graph eventually levels off.

9. Suggest what the graph would look like if the volume of gas was measured, rather than the mass.

Did you know...?

Shells contain a high proportion of calcium carbonate. An acid will react with these shells and erode them. You can test this by leaving egg shells standing in vinegar.

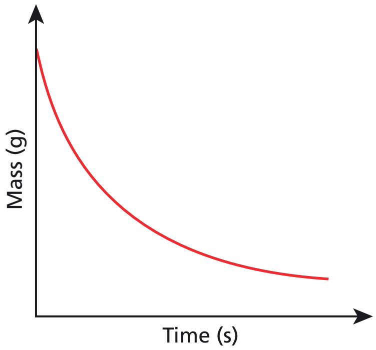

FIGURE 2.4.10d: How the mass changes over time

Key vocabulary

carbonate

carbon dioxide

limewater

Applying key ideas

You have now met a number of important ideas in this chapter. This activity gives an opportunity for you to apply them, just as scientists do. Read the text first, then have a go at the tasks. The first few are fairly easy – then they get a bit more challenging.

Ever-changing urine

When we visit the doctor, we may be asked to provide a sample of urine. This sample can be used to test for the presence of substances that should not be there, such as sugar and protein. However, the pH of urine is also sometimes measured. This can give medical professionals some clues about what may be wrong with us and how to treat the condition.

The normal pH of urine ranges from 5 to 8, with pH 7.5 being the average. The pH of human urine varies during the day, typically being lower first thing in the morning than at night. Certain conditions can cause the pH of urine to be unusually low or unusually high. For example, high urine pH can be caused by kidney failure or cystitis (a urinary tract infection). Low urine pH can be caused by untreated diabetes or starvation.

The pH of a patient's urine can help to decide which treatment may be best. For example, antibiotics are more effective in treating conditions where the urine is alkaline.

The foods that we eat can affect the pH of our urine. For example, fruits such as cranberries, wine and meat lower the pH. On the other hand, foods such as bananas, chocolate and spinach increase the pH of urine. Certain medications can also affect urine pH. For example, potassium citrate, used to treat kidney stones, can considerably decrease the pH whereas bicarbonate of soda, used to treat indigestion, increases the pH.

FIGURE 2.4.11a: A urine sample can provide important information about health.

FIGURE 2.4.11b: Turkey and cranberries make urine more acidic; green beans make it more alkaline.

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Task 1: Considering the pH

Draw a pH chart. Label the chart to show the approximate pH of urine taken from a healthy patient, a patient with untreated diabetes or starvation, and a patient with untreated kidney failure or cystitis. What colour would a doctor expect to see if universal indicator was used with each sample?

Task 2: Preparing patients for the test

Explain why patients may be asked to stop taking some medicines before they provide a urine sample. Give some examples to explain your answer. How long before the test would you suggest that the medication is stopped? Can you identify any risks with this?

Task 3: Summarising effects on pH

Draw a table to summarise the effects of different conditions, medicines and foods on the pH of urine. Can you add any more examples?

Task 4: Considering the effects of foods

Suggest whether cranberry juice is an acid or an alkali. Explain why cranberry juice is often recommended for patients suffering with cystitis.

Suggest whether chocolate makes urine acidic or alkaline. Can you suggest a drink that could be taken with chocolate to reduce its effect on the pH of urine?

Task 5: Sizing up the effects

Explain why some foods and medicines have a greater effect on how acidic or alkaline the urine is. For example, hydrochloric acid supplements have a bigger effect on pH than wine or cranberries do.

Task 6: Representing the reactions

Wine contains citric acid. Kidney stones are solid lumps of precipitate that form in the kidneys of some people. These may then (painfully) be passed in urine. One chemical in these stones is calcium carbonate. Write a word equation for the reaction between these chemicals.

Discuss why wine may not be effective (or recommended) to remove kidney stones in the body.

Chemistry

Investigating the effectiveness of antacids

We are learning how to:

- Design an investigation to compare the effectiveness of indigestion remedies.
- Analyse data to identify a suitable indigestion remedy.

Heartburn indigestion is caused by acid from the stomach irritating the upper digestive tract. For those who suffer regularly, treatments are available to neutralise this acid. But are some remedies more effective than others?

The need for antacids

The human stomach contains strong hydrochloric acid, with a pH of approximately 1. The role of this acid is to enable the digestion of proteins in the stomach and also to prevent many bacteria from surviving in the stomach. Sometimes the muscle leading from the oesophagus to the stomach can open and the acid moves up along the digestive tract. A burning sensation is then felt in the chest and throat as the acid irritates the lining of the oesophagus. This is called **indigestion** or **heartburn**.

1. Describe what type of acid is found in the stomach and comment on its strength.
2. Describe two reasons why we have acid in the stomach.
3. Explain what heartburn is and what causes it.

Alkalis in action

One of the main treatments for heartburn involves neutralising the acid from the stomach. Medicines that do this are called **antacids**. Antacid remedies contain substances, such as calcium carbonate, aluminium hydroxide and sodium hydrogencarbonate (baking soda). These substances neutralise acids, as alkalis do. However, they do not dissolve in water, as alkalis do, and are known as **bases**. Bases react with acids in a **neutralisation** reaction.

acid + base → salt + water

Because the both salt and water are neutral, antacids reduce the acidity of the stomach acid.

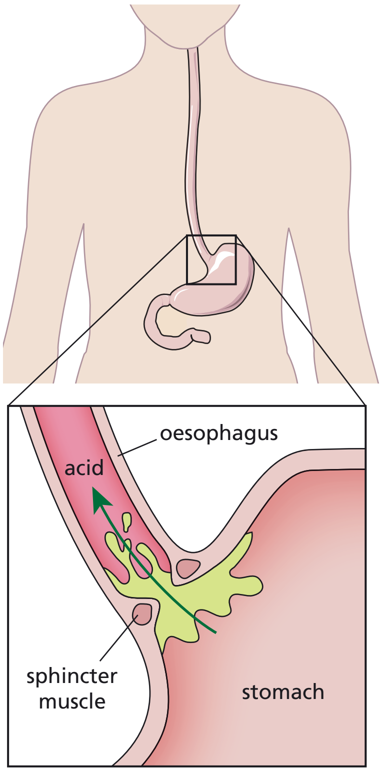

FIGURE 2.4.12a: What causes heartburn?

4. List some of the main ingredients found in heartburn remedies.
5. Explain how antacids reduce the acidity of stomach acid.
6. Suggest the effect of antacid remedies on the pH of stomach acid.

FIGURE 2.4.12b: Which bases are found in this remedy?

Which remedy?

A group of students wanted to compare the effectiveness of different commercial antacid remedies. They first added universal indicator to a beaker of hydrochloric acid to check that it was a strong acid (pH 1). They added the recommended dose of each antacid to the acid. The students observed any colour change and noted how long any change took.

TABLE 2.4.12: Results of tests on antacid remedies

Antacid remedy	Colour of universal indicator at end	Change in pH	Time taken for change
'Acid-ban' tablets	yellow	from pH 1 to pH 6	9 minutes
'Acid-ease' liquid	yellow	from pH 1 to pH 6	3 minutes
'Banish burn' tablets	red-orange	from pH 1 to pH 4	5 minutes

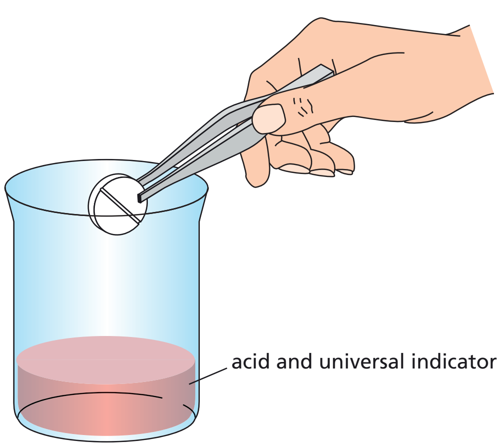

FIGURE 2.4.12c: Antacid remedies were added to acid.

7. Explain why it was important to start with acid of pH 1.
8. Describe which remedy is the most effective. Explain your answer as fully as possible.
9. Another student suggests that the experiment is repeated using crushed 'Acid-ban' tablets, rather than whole tablets. Suggest how this will affect the time taken to change the pH.

Did you know...?

Even before the chemistry was understood, acid-neutralising remedies were recommended for heartburn. One remedy was to chew limestone rock. We now know that limestone contains the base calcium carbonate.

Key vocabulary

indigestion
heartburn
antacid
base
neutralisation

Chemistry

Understanding the importance of acids and alkalis

We are learning how to:

- Classify common useful chemicals as acids or alkalis.
- Explain the importance of acids and alkalis in everyday life.
- Explore common misconceptions about acids and alkalis.

Acids and alkalis are all around us. Some are useful directly, whereas others are useful in making other products in industry. Our lives would be very different without the range of acids and alkalis that we have access to.

More unusual uses of acids and alkalis

Acids and alkalis are important in ways that are not always obvious. Hydrofluoric acid is used to etch glass. It is suitable for this because the acid dissolves glass without changing the colour of the glass.

Citric acid is commonly used to make medicines taste nicer. It is also used in cigarette papers to make them burn more slowly. Many face cleansers are slightly alkaline, as are soaps. Skin toners, which are designed to be used after cleansers, are slightly acidic. This returns the skin to its preferred pH.

1. Describe two uses of citric acid.
2. Explain why hydrofluoric acid is a suitable choice of acid for glass etching.
3. Describe the type of reaction taking place on the skin when cleanser is used followed by toner.

FIGURE 2.4.13a: Hydrofluoric acid is used to etch glass.

Acids and alkalis in industry

Acids and alkalis are an essential part of many industries.

The most common use for nitric acid is in making **fertilisers**. However, nitric acid can also be used to make explosives and nylon. Sulfuric acid is also used on a large scale to make fertilisers. Sulfuric acid has many more industrial uses than any other acid.

Alkalis, such as sodium hydroxide, are used as a reactant in making many other products including soap, paper and ceramics.

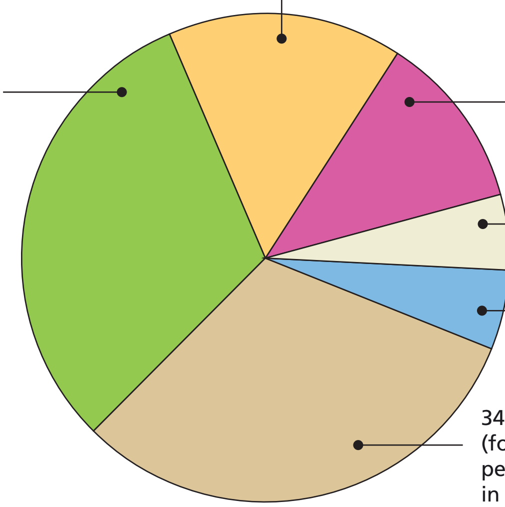

FIGURE 2.4.13b: Sulfuric acid has more applications than other acids.

4. State the biggest single use for sulfuric acid in industry.
5. Describe a use that both sulfuric acid and sodium hydroxide have in common.
6. Suggest why the production of fertilisers is so important.

Exploring common misconceptions

You can see the results of some reactions of acids and alkalis, such as a change in the colour of an indicator or the production of some bubbles of gas. However, you cannot actually *see* what is going on in the reactions in terms of the particles in the acids and alkalis. With abstract concepts like this there are usually **misconceptions** – common ideas that people share that are actually inaccurate.

TABLE 2.4.13

Idea	Why this is a misconception…
All metals react with acids to produce hydrogen gas	This is not true because copper metal does not react with some acids
Acids are corrosive	This is not true because we eat some acids, such as citric acid and ethanoic acid
A gas is always produced in a chemical reaction	

7. Explain what is meant by an 'abstract' idea.
8. Explain why the third idea in Table 2.4.13 is also a misconception.
9. Explain how models may help to understand abstract ideas.

Did you know…?

Boric acid is used in nuclear power stations as a medium in which to store waste. Used rods from the plant are cooled in boric acid as the acid absorbs some of the dangerous radiation.

FIGURE 2.4.13c: Boric acid is used to store nuclear waste.

Key vocabulary

fertiliser

misconception

Exploring combustion

We are learning how to:

- Explain the terms fuel and combustion.
- Recall what is needed for combustion.
- Analyse the fire triangle and apply it to putting out fires.

When you burn candles on a birthday cake or sit around a campfire, you do not often think about the science behind it. Burning is a chemical reaction, forming new products. If you understand the process, you can also learn how to put out fires.

What is combustion?

When you burn wood or coal, new products are made. The reaction is also irreversible – you cannot get the wood or coal back. This means that burning is a **chemical reaction**.

In order to start a fire, you need a **fuel** to burn. A fuel is any material that can be burned to release energy. Examples of fuels are wood and coal. Burning also needs oxygen. Without oxygen, a fire would go out.

The scientific name for burning is **combustion**.

FIGURE 2.4.14a: Coal and wood are examples of fuels.

1. Describe two reasons why burning is a chemical reaction.
2. Describe what is meant by:

   a) combustion **b)** fuel.
3. Explain why a fire burns more brightly if you fan the flames with air.

Did you know...?

You could not light a fire on the Moon. This is because there is no oxygen gas on the Moon.

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The fire triangle

We can summarise what is needed for combustion using the **fire triangle**.

If any of the three components of the fire triangle are missing, combustion cannot happen. You can use this information when you are trying to light a fire or put a fire out.

When lighting a barbeque, a match may be used as the source of heat to start the fire. The fuel used in a barbeque is often charcoal (made from charred wood). As long as oxygen is available, the charcoal will then burn. When you need to put out the barbeque fire, you could:

- prevent oxygen from reaching the fire by covering it with a blanket
- remove the heat by throwing water over the fire
- not add any more charcoal.

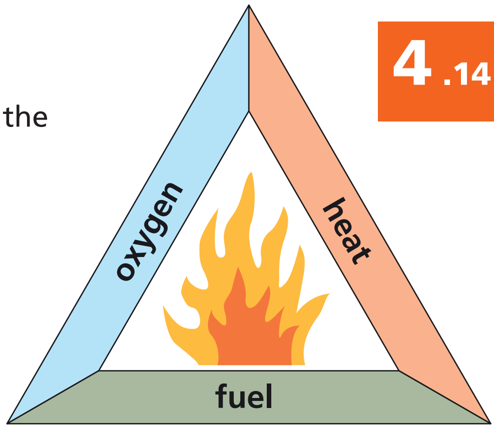

FIGURE 2.4.14b: A fire triangle shows us the things that are needed for burning.

4. If a camper builds a fire using wood and starts the fire by rubbing flint and steel together, describe the:

a) source of heat **b)** fuel.

5. Use the fire triangle to explain why the following actions put out a fire:

a) turning off the gas supply to a Bunsen burner
b) throwing water on a campfire.

Applying the fire triangle

If you float a candle under a jar in water, the water forms a seal. The candle is in a closed environment. The candle burns but eventually goes out. This is because the oxygen in the jar is used up in the burning reaction and cannot be replaced.

FIGURE 2.4.14c: Why does the flame go out?

6. Identify the fuel in this candle experiment.

7. Predict what will happen to level of water both inside and outside the bell jar after the candle goes out.

8. Suggest how the size of the jar would affect how long the candle burns for.

Key vocabulary

chemical reaction
fuel
combustion
fire triangle

Chemistry

Understanding combustion and the use of fuels

We are learning how to:

- Identify applications of combustion reactions.
- Identify fuels used in different applications.
- Compare the energy content of different fuels.

We use combustion reactions every day, from cooking the food that we eat to heating the homes that we live in. Even the electricity that we use often relies on combustion.

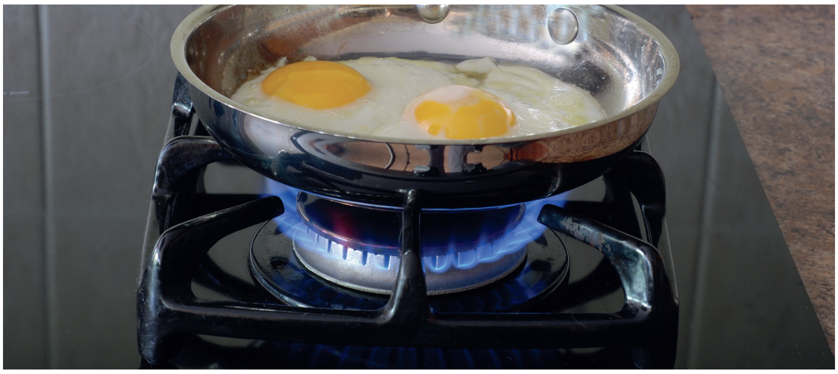

FIGURE 2.4.15a: We use combustion for cooking.

Applications of combustion

Combustion is an **exothermic** reaction. This means that the reaction releases **energy**. This energy is usually transferred as heat and sometimes also light.

Combustion is important for transportation – for example in steam engines and in the engines of cars and trucks. Fireworks are another good example of combustion in action.

Usually when you use electricity, you are relying on combustion. In power stations, fuel is burned and the heat given off is used to boil water. The steam produced is then used to drive a turbine to generate electricity. This means that you rely on combustion when turning on your lights, playing on a computer and charging up a games console.

1. Describe what an exothermic reaction is.
2. Draw a table to summarise the different uses of combustion.
3. Explain how combustion is involved in generating energy.

Did you know...?

'Spontaneous human combustion' is a phenomenon in which humans are thought to burst into flames. Some scientists believe that a spark must act as the source of heat for the burning, with fat in the body then acting as the fuel for the reaction.

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So many fuels...

In situations such as burning logs on a fire, it is easy to identify the fuel as wood. However, in other situations, such as using an electric fire to heat a room, it is not as obvious.

Electricity is not a fuel, but it is sometimes generated using a fuel. If the electricity was generated in a coal-fired power station, then the fuel used to heat the room was coal. Traditional steam engines also usually use coal as fuel.

Traditional cars use petroleum or diesel as a fuel – these both come from crude oil. Biofuels, such as ethanol, can also be used in some cars. This is an **alcohol** made from grains like barley and maize. Space rockets can be fuelled by liquid hydrogen.

FIGURE 2.4.15b: Biofuels, such as ethanol, are made from grains.

4. State the fuel used in a:

a) a steam engine

b) a log-burning fire.

5. Suggest what the fuel source is for electrical appliances such as TVs and a washing machines.

6. Many biofuel cars can only run on a mixture of ethanol and petrol in a ratio of 1:9. Explain what this means.

The best fuel for the job

A group of students wanted to compare the energy in different alcohols. They burned each alcohol and used the energy released to heat up water in a conical flask above the burner.


FIGURE 2.4.15c: How can we measure how much energy we get from this fuel?

7. Suggest what the students should measure to compare the energy released by each alcohol.

8. Explain why alcohols would not be a good choice of fuel on an open fire.

9. Suggest another factor that people may consider when deciding which fuel to use.

Key vocabulary

exothermic

energy

alcohol

Exploring the effects of burning

We are learning how to:

- Summarise combustion using an equation.
- Compare complete and incomplete combustion.
- Explain what is meant by the conservation of mass.

For combustion to take place, there needs to be oxygen. Without enough oxygen, only a partial reaction may take place. This type of reaction can be a problem because it produces more pollution.

FIGURE 2.4.16a: Complete combustion occurs when there is plenty of oxygen.

The combustion equation

Many fuels like coal, oil and gas contain the elements hydrogen and carbon – they are called **hydrocarbons.** We can summarise combustion using an equation:

hydrocarbon + oxygen → carbon dioxide + water

This reaction is called **complete combustion**. This means that there is enough oxygen to react with all of the fuel. This is an example of an **oxidation** reaction because the fuel reacts with oxygen.

Carbon dioxide is known as a 'greenhouse gas'. Any excess gas that is not used by plants forms a blanket around the Earth. Most scientists believe that burning fossil fuels is contributing to the 'greenhouse effect'.

1. Describe what is needed for complete combustion to take place.
2. Explain why combustion is also known as an oxidation reaction.
3. Describe a problem linked with production of carbon dioxide.

Did you know...?

Carbon monoxide gas can enter the blood and stop oxygen from getting to the body's cells. This can be fatal. Carbon monoxide is difficult to detect because it is odourless and colourless but carbon monoxide detectors can be used to check for leaks of the gas.

FIGURE 2.4.16b: Why do we test for carbon monoxide gas?

Incomplete combustion

If there is not enough oxygen available to react with all of the fuel, **incomplete combustion** takes place. Water is still produced, but carbon monoxide and carbon are produced instead of carbon dioxide. We can summarise incomplete combustion in this equation:

hydrocarbon + oxygen → carbon monoxide + carbon + water

Carbon monoxide is a poisonous gas. The carbon formed this way is soot. Soot is a fine black powder that can irritate the lungs and airways. Incomplete combustion also releases less energy than complete combustion.

4. Name the product that is the same in both compete and incomplete combustion.
5. Describe three reasons why complete combustion is preferred to incomplete combustion.
6. Construct a table to compare the products of complete and incomplete combustion.

Conservation of mass

A group of students investigated what happens to mass during a combustion reaction. They put steel wool into a test tube, covered the tube with a deflated balloon and then measured the mass. The balloon prevented gas from moving in or out of the tube. The tube was heated to burn the steel wool. The mass was then measured again.

Mass before: 43.48 g

Mass after: 43.49 g

The teacher told the students that the Law of Conservation of Mass says that mass can neither be created nor destroyed.

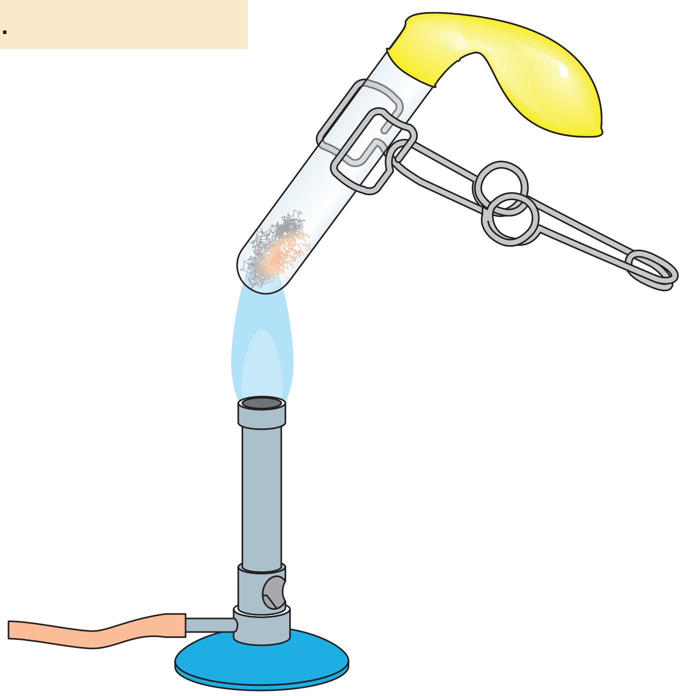

FIGURE 2.4.16c: Steel wool being heated in a closed environment

7. Explain whether the students' data supports the Law of Conservation of Mass.
8. Suggest how the students could show repeatability of the experiment.
9. Suggest what would have happened to the mass if the balloon had not been used in this investigation.

Key vocabulary

hydrocarbon

complete combustion

oxidation

incomplete combustion

Understanding acid rain

We are learning how to:

- Describe how combustion can cause acid rain.
- Describe the effects of acid rain.
- Explain the effects of acid rain.

Normal rain is slightly acidic, with a pH of approximately 5.6. However, other polluting gases can reduce the pH to 4 or lower. This is acid rain, which can damage plants, animals and even buildings. This is a worldwide problem.

How does burning affect rain?

Combustion pollutes the air with chemicals such as carbon dioxide, **sulfur dioxide** and nitrogen oxides. Sulfur dioxide is formed when the sulfur found in some fossil fuels (such as coal and oil) is oxidised during combustion. Nitrogen oxides are formed when nitrogen from the air is oxidised during combustion.

Both sulfur dioxide and nitrogen oxides are extremely soluble gases. They rise up into the atmosphere and dissolve in water to form sulfuric acid and nitric acid. These acids can then fall as **acid rain**.

Rain clouds can travel huge distances and so pollution in one part of the world may cause acid rain in another country.

Did you know...?

Much of the acid rain that falls in Scandinavia is due to pollution from the UK. The prevailing winds can carry rain clouds over huge distances before the acid rain falls.

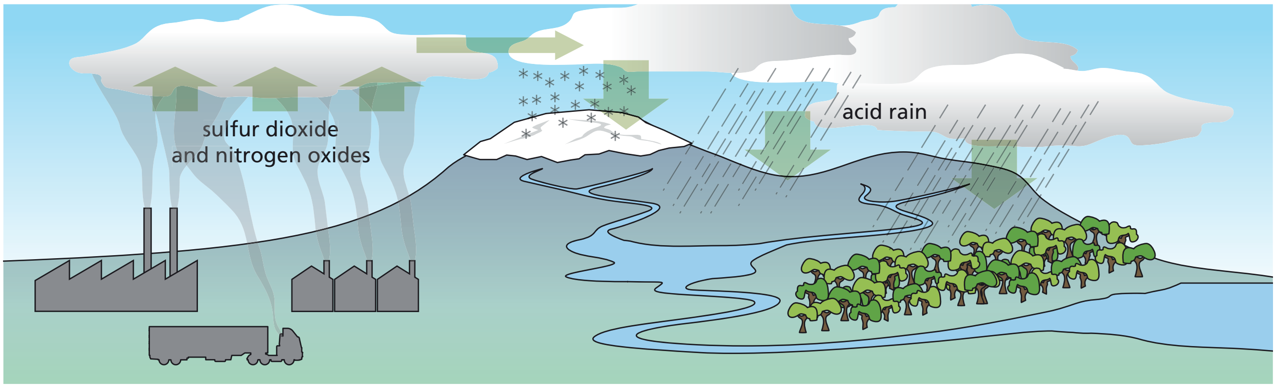

FIGURE 2.4.17a: This shows how acid rain is formed.

1. List three chemical pollutants caused by combustion.
2. Describe how sulfur dioxide gas and nitrogen oxide gases form acids in the clouds.
3. Explain how pollution produced in the UK could cause acid rain in another country.

The effects of acid rain

Acid rain can kill whole trees or even whole sections of forest. This is because:

- Acid rain can damage the leaves of plants – this means that photosynthesis cannot happen efficiently.
- Acid rain dissolves some useful nutrients from the soil and they then wash away before the plant has had time to absorb them.
- Acid rain can cause harmful chemicals, such as aluminium, to be released into the soil, which are then absorbed by the plant.

Acid rain looks and feels like normal rain. However, the chemicals that cause acid rain can be harmful to humans. This can cause respiratory diseases such as asthma and bronchitis.

Acid rain can even damage buildings and statues. This is because the acid reacts with the stone and wears it away.

4. Describe the effects of acid rain on:

a) plants
b) humans
c) buildings.

5. Suggest why forests are usually damaged slowly by acid rain.

Treatment and prevention

Acid rain would be reduced by burning less fossil fuel. To do this, we could reduce the amount of electricity that we use. We could also use alternative energy sources such as wind or solar power.

Power stations can also clean the gaseous emissions to remove sulfur dioxide. This is called 'scrubbing' and the process uses an alkali to neutralise the gas. Lakes affected by acid rain can be treated using quicklime (calcium oxide). This is an alkali that neutralises the acid rain.

6. Explain why we cannot easily stop burning fossil fuels.

7. Suggest some reasons why wind power and solar power are not used more widely.

8. Suggest how you could test the effectiveness of calcium oxide on acid rain.

FIGURE 2.4.17b: Acid rain damages the leaves of plants and they may drop off.

FIGURE 2.4.17c: Acid rain reacts with limestone in statues.

Key vocabulary

sulfur dioxide

acid rain

Checking your progress

To make good progress in understanding science you need to focus on these ideas and skills.

☐ Identify some everyday substances that contain acids and alkalis.	☐ Explain what all acids have in common and what all alkalis have in common.	☐ Evaluate the hazards posed by some acids and alkalis and know how these risks may be reduced.
☐ Give an example of an indicator and state why indicators are useful.	☐ Explain what an indicator is and analyse results when using an indicator.	☐ Compare the effectiveness of different indicators.
☐ Describe some examples of neutralisation.	☐ Describe the changes to indicators when acids and alkalis are mixed.	☐ Explain the changes to indicators in terms of pH when acids and alkalis are mixed.
☐ Recognise that water is one product of neutralisation.	☐ Explain the formation of salt and water during neutralisation, giving some examples of common salts.	☐ Predict the reactants or products of different neutralisation reactions.

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☐ Describe the observations of reactions between acids and metal, and acids and carbonate, that tell us that a chemical change is taking place.	☐ Explain the general reaction between an acid and a metal, and between an acid and a carbonate, using equations.	☐ Summarise specific reactions between acids and metals and between acids and carbonates using word equations and particle drawings.
☐ Describe what indigestion remedies are and explain how they work.	☐ Design an investigation to compare the effectiveness of indigestion remedies.	☐ Analyse data about indigestion remedies to decide which remedy is the most effective.
☐ Summarise the reactants and products of complete combustion.	☐ Compare the reactants and products of complete and incomplete combustion.	☐ Explain the Law of Conservation of Mass and how it can be proven.
☐ Describe how combustion contributes to acid rain.	☐ Describe the effects of acid rain.	☐ Explain, using an equation, the effects of acid rain.

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Questions

Questions 1–7

See how well you have understood the ideas in the chapter.

1. An example of an alkali is: [1]

   a) fruit juice **b)** vinegar **c)** nitric acid **d)** bleach

2. All acids contain the element: [1]

   a) hydrogen **b)** oxygen **c)** chlorine **d)** hydroxide

3. What is the pH of a neutral solution? [1]

   a) 1 **b)** 14 **c)** 7 **d)** 10

4. The reaction between an acid and an alkali is known as: [1]

   a) neutralisation **b)** oxidation **c)** burning **d)** combustion

5. Write a word equation for the reaction between an acid and an alkali. [2]
6. Explain why heartburn is treated using an alkali. [2]
7. Explain, using a diagram if you wish, how acid rain is produced from fossil fuels. [4]

Questions 8–14

See how well you can apply the ideas in this chapter to new situations.

8. Which salt is formed when sulfuric acid and magnesium react? [1]

   a) magnesium chloride **b)** magnesium sulfate
   c) sulfur dioxide **d)** hydrogen

9. Some students add drops of an acid onto a rock sample. They observe bubbles. What is the gas given off? [1]

   a) hydrogen
   b) oxygen
   c) carbon dioxide
   d) calcium chloride

FIGURE 2.4.19a: Dropping acid on a rock

10. A student weighed a crucible containing steel wool. He then burned the steel wool and reweighed the crucible. The mass after burning would be: [1]

    a) less than before **b)** more than before
    c) the same as before **d)** zero

11. A student wanted to prove that carbon dioxide was produced during the reaction between hydrochloric acid and calcium carbonate. What chemical could they use to show this? [1]

12. A chemical is described as feeling 'soapy'. When tested with indicator, it is shown to have a pH of 9. Explain what type of chemical this is. [2]

13. A student notices that a concentrated acid gave a more vigorous reaction with a metal than a dilute acid with the same metal. Explain why, using the idea of particles. [2]

14. A group of campers need to put a campfire out before they go to bed. Use the fire triangle to explain how they could do this. [4]

Questions 15–16

See how well you can understand and explain new ideas and evidence.

15. A student reacts different metals with hydrochloric acid. The observations are recorded in Table 2.4.19a. One of the metals is not labelled.

TABLE 2.4.19a

Metal	Observations
unknown metal	Bubbles seen, test tube became warmer
calcium	Lots of bubbles produced very quickly, test tube became very hot
zinc	Few bubbles seen

Compare the reactivity of the unknown metal with that of calcium and zinc. Explain your answer. [2]

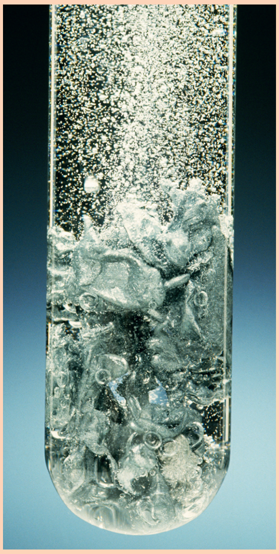

FIGURE 2.4.19b: Zinc metal reacting with hydrochloric acid

16. A group of students tried to make some indicators from different plant materials. They tested each of the solutions that they made. The results are shown in Table 2.4.19b.

TABLE 2.4.19b

Indicator	Colour in acid	Colour in alkali	Colour in neutral
A	red	blue	blue
B	red	blue	purple
C	yellow	yellow	yellow

Arrange the indicators in the order of most useful to least useful for testing the pH of a variety of different chemicals. Explain your answer. [4]