



N4

BrightRED
PUBLISHING

National 4 CHEMISTRY

BrightRED Study Guide

Curriculum for Excellence

N4

CHEMISTRY



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NATIONAL 4 CHEMISTRY**

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CHEMICAL CHANGES AND STRUCTURE

REACTION RATES

The speed or rate of a chemical reaction is a measure of how fast the reaction occurs.

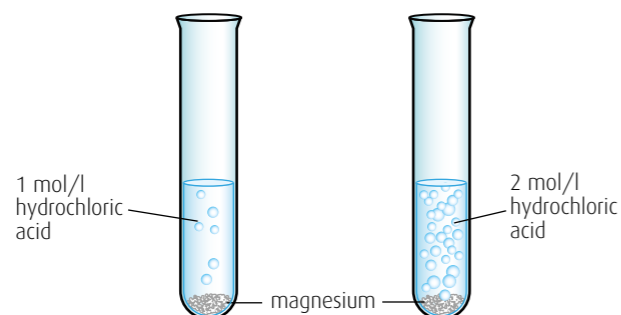
Different reactions have different rates. For example, the formation of crude oil from the remains of sea organisms is a very slow reaction while the burning and explosions which happen in fireworks are very fast reactions.

VARIABLES AFFECTING THE RATE OF A REACTION

The reaction between magnesium metal and dilute hydrochloric acid is often used to study reaction rates. This reaction releases bubbles of hydrogen gas.

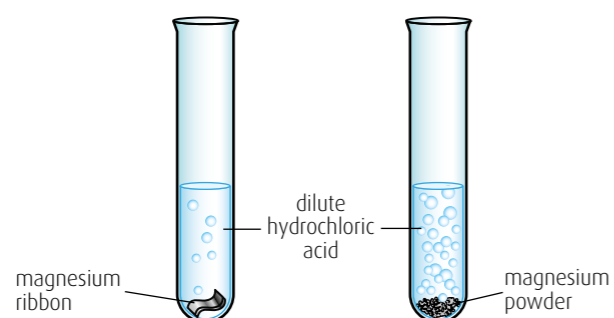
Concentration

In general, increasing the **concentration** of the reactants will lead to an increase in reaction rate.



Particle size

In general, increasing the **surface area** of a reactant will increase the rate of a reaction. Magnesium powder will react much faster with dilute hydrochloric acid than a piece of magnesium ribbon of the same mass.



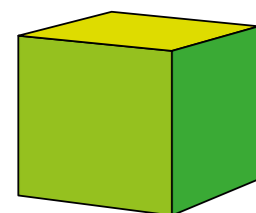
Crude oil – reactions took millions of years



Burning fireworks – reactions are over in seconds



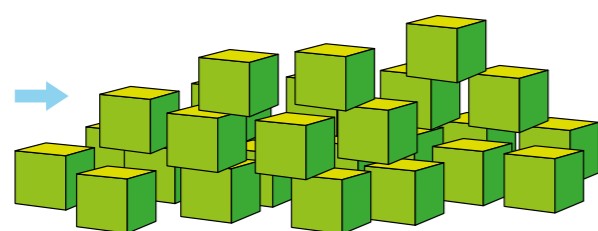
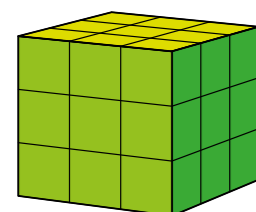
Magnesium reacting with dilute hydrochloric acid



Consider a cube with a side length of 3 cm.

Each face has an area of 9 cm^2 (3×3) and since there are 6 faces the total surface area of the cube will be 54 cm^2 .

Now split this cube into 27 little cubes. The total surface area is now 162 cm^2 .



DON'T FORGET

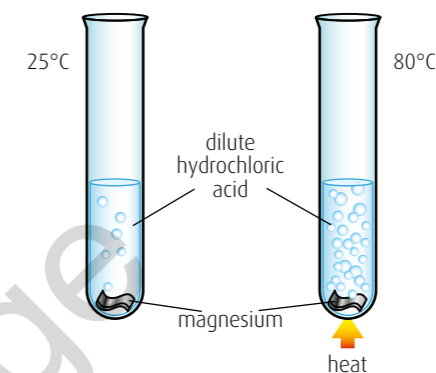
The concentration of a solution is measured in moles per litre, mol/l. A 2 mol/l solution is twice as concentrated as a 1 mol/l solution.

DON'T FORGET

Crushing a lump of a solid will decrease the particle size of the lump but increases the surface area. Smaller particles have a larger surface area.

Temperature

In general, increasing the **temperature** of a reaction will increase the reaction rate.

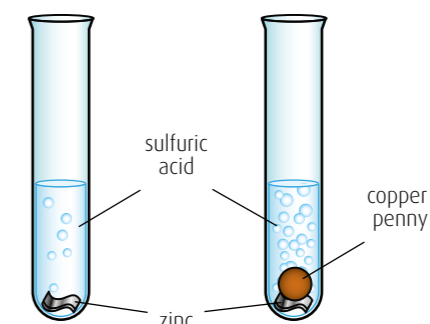


Catalysts

A **catalyst** is a substance which speeds up a reaction, but is chemically unchanged at the end of the reaction.

At the end of the reaction it is the same substance and it has the same mass as at the start of the reaction.

Consider the reaction between zinc metal and dilute sulfuric acid. The hydrogen gas produced can be seen as bubbles in the reaction mixture.



Copper metal acts as a catalyst for this reaction.

THINGS TO DO AND THINK ABOUT

- Explain each of the following in terms of reaction rates.
 - Milk stays fresher for longer if it is kept in the fridge.
 - Large carrots take longer to cook than small carrots.
 - Charcoal on a barbecue glows more brightly when air is blown onto it.
- Outline the steps necessary to prove that the copper penny is not used up in the reaction of zinc with sulfuric acid.
- The table below shows the conditions used for six experiments in an investigation into the rate of reaction between magnesium and dilute hydrochloric acid.

Reaction	A	B	C	D	E	F
Concentration of hydrochloric acid (mol/l)	0.1	0.2	0.5	0.1	0.2	0.5
Temperature (°C)	20	20	20	30	30	30
Form of magnesium	ribbon	powder	powder	powder	ribbon	powder

- In which experiment will the reaction be quickest?
- Which two experiments should be compared to investigate the effect of temperature on the rate of the reaction?
- In which experiment is the reaction slowest?

DON'T FORGET

Usually chemical reactions are supplied with heat energy to increase their rate. However, other forms of energy, such as light, can also be used. Photosynthesis is an example of this.

DON'T FORGET

When carrying out experiments to identify which factor is affecting the rate of a reaction, it is very important that only one variable is changed at a time to ensure a fair comparison is made. For example, when investigating temperature, only the temperature should be changed. Other variables like concentration and particle size should remain the same.

NATURE'S CHEMISTRY

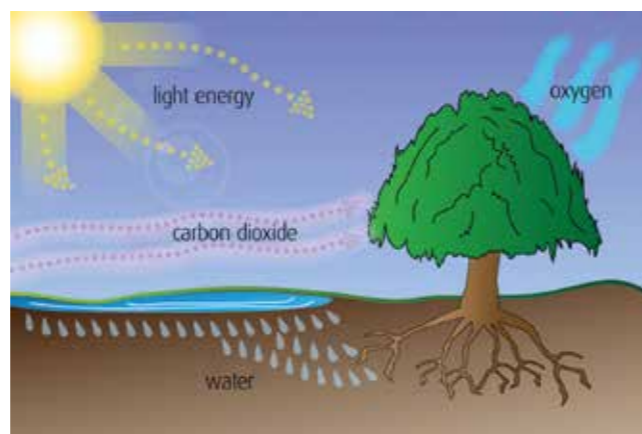
FUELS

WHAT IS A FUEL?

A **fuel** is any substance that is burned to produce heat.

There are many different types of fuel. One of the first fuels used by humans was wood.

Like many fuels, the energy stored within wood comes from the Sun. The trees capture the energy from the Sun during photosynthesis. The energy is used to make a chemical called glucose.



Some of this energy is turned to heat when the wood is burned



Chemicals in the wood have energy stored in them

Glucose is then used to make other chemicals to allow the tree to grow. One of the main chemicals found in trees is cellulose – a chemical which is made by bonding together thousands of glucose units.

These bonds act as a store for some of the energy that was captured during photosynthesis. When the wood is burned some of the energy stored in the bonds in the chemicals is released as heat.

DON'T FORGET

Combustion is another word for burning. During combustion, the elements in a fuel will react with oxygen.

EXAMPLES OF FUELS

Any fuel has energy from the Sun stored within chemical bonds. There are many examples of these.



TASK

The picture above shows some of the different types of fuel that we use. There are many different types of fuel and all of them are burned to release some of the chemical energy that is stored inside them. How many different fuels can you name?

FOSSIL FUELS

Many of the fuels shown in the pictures on p.30 were formed from prehistoric living things that existed on the planet around 300 million years ago. These fuels are known as **fossil fuels**. Coal, oil and natural gas are all examples of fossil fuels.

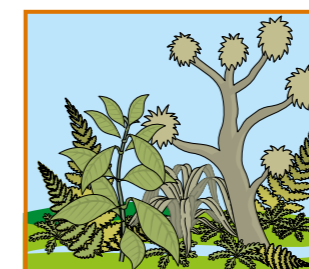
Energy from the Sun was trapped in ancient plants and trees by photosynthesis and the energy was stored in chemical bonds. Ancient animals fed from the plants and trees and so some of the energy was transferred and stored in chemical bonds in these animals. When these ancient plants and animals died, their remains decomposed and eventually turned into fossil fuels.

Fossil fuels are **finite** energy sources. This means that they will one day run out. This is because they are being used far faster than they are being formed.

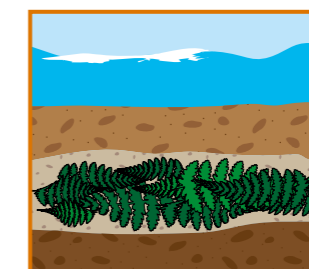
Coal

Coal is formed from dead plants. Around 300 million years ago the climate was warmer and so trees and plants grew tall. Sea levels rose and flooded the land causing swamps to form. When the trees and plants died, they fell into these swamps. There was little oxygen present in these swamps and so the trees and plants did not rot. Instead they were eventually covered with layers and layers of mud and sand.

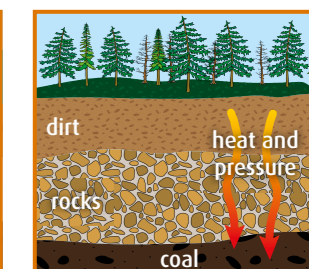
The pressure of these layers of mud and sand, combined with the heat from the Earth's crust, eventually caused the dead plants to decompose and become coal. This whole process took millions of years.



Hundreds of millions of years ago, swamps with giant plants covered the Earth.



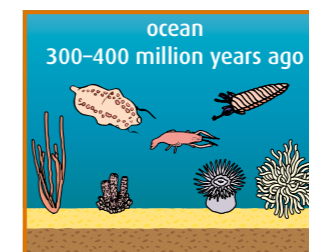
Water and soil covered the plant remains 100 million years ago.



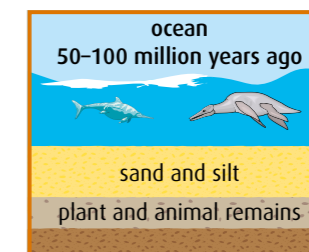
Rocks, soil and sediment created pressure and heat to form coal deep in the ground.

Oil and gas

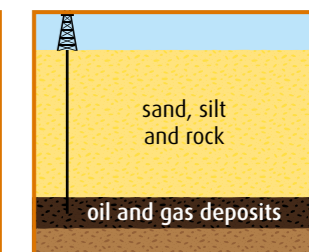
Oil and gas formed from the remains of dead sea plants and animals. These dead sea plants and animals were buried on the ocean floor and covered with layers and layers of sand and silt. Over millions of years the heat and pressure caused by burial turned them into oil and gas.



Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.



Over millions of years, these remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.



Today, we drill down through layers of sand, silt and rock to reach the rock formations that contain oil and gas deposits.

DON'T FORGET

The word 'fossil' is used for fuels such as coal, oil and natural gas because, like fossils, they are formed from the remains of living things.

THINGS TO DO AND THINK ABOUT

Peat is an important substance in Scotland's history. Try to find out some information about peat.

- How is it formed?
- How is it extracted?
- In what way is it similar to coal?
- Is it a fossil fuel?



CHEMISTRY IN SOCIETY

METALS AND ALLOYS

METALS

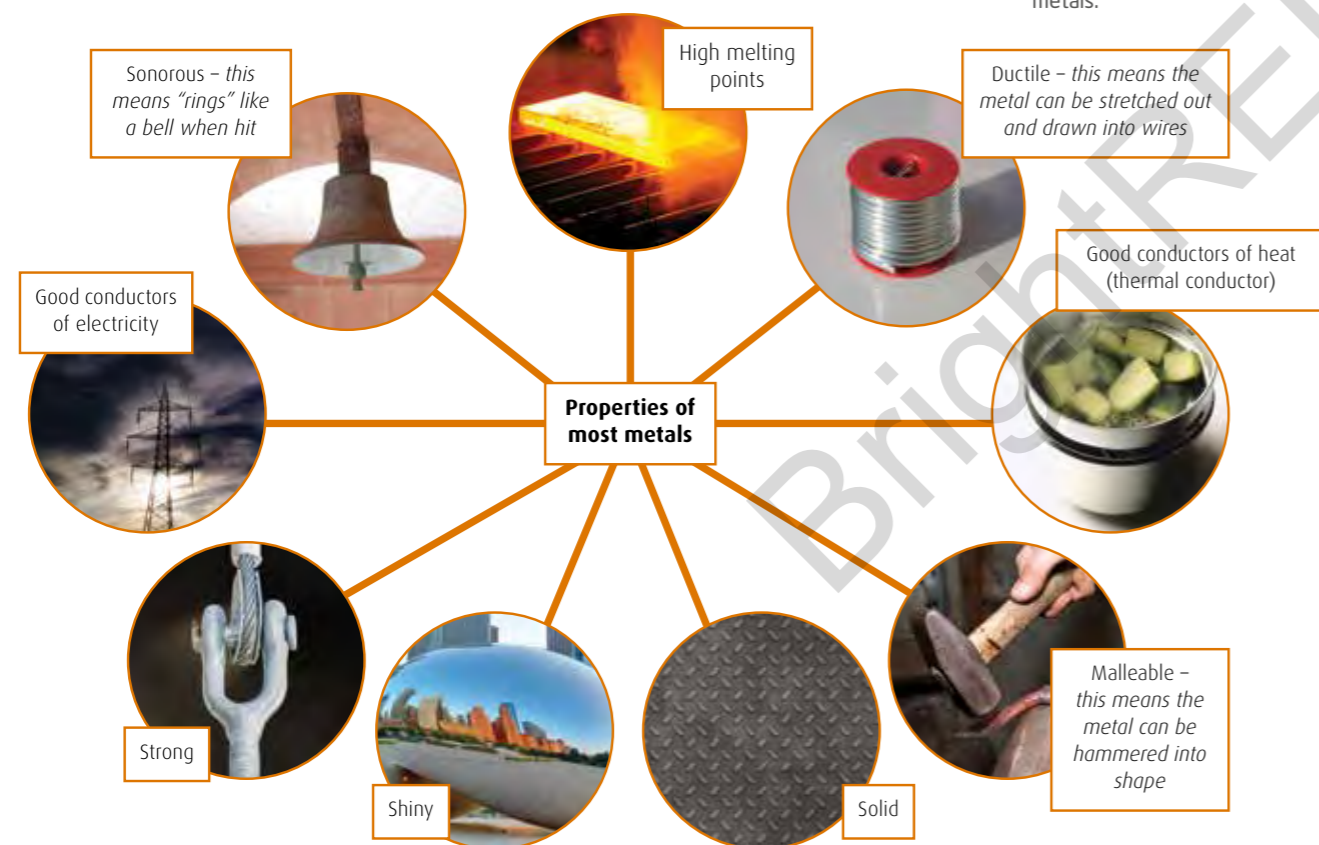
There are 118 chemical elements in the Periodic Table. Of these 118 elements, 94 are metals, which can be found on the left-hand side of the dividing step drawn on most Periodic Tables.

The image shows a standard periodic table of elements. The elements on the left side, from Lithium (Li) to Francium (Fr), are shaded in blue and labeled as 'metal'. The elements on the right side, from Boron (B) to Astatine (At), are shaded in grey and labeled as 'non-metal'. The noble gases (He, Ne, Ar, Kr, Xe, Rn) are also shaded in grey. The lanthanides and actinides are shown at the bottom of the table.

Metallurgical elements include copper, iron, magnesium, silver and gold.

PROPERTIES OF METALS

Metals are very useful materials as they have a wide variety of uses, which are linked to their properties.



Uses of metals

Copper metal is used as the material for making electrical cables because it is a good conductor of electricity and also because it is **ductile** and can be stretched into wire.

Aluminium metal is used to make bicycle frames and parts of the body of an aeroplane. This is because it is strong, light and does **not corrode**.

Silver, gold and platinum metals are used to make jewellery and coins. This is because they are **malleable**, shiny and very unreactive.



DON'T FORGET +

In the section on 'Chemical changes and structure' you learned that the elements can be classified as metals or non-metals.

Iron metal is used to make many different objects and building structures (fences, gates and bridges) because of its properties. Unfortunately, when iron metal reacts with air and water it corrodes to form rust on its surface, which makes it weaker and brittle.



ALLOYS

The properties of metals can be changed and improved by forming alloys. An **alloy** is a mixture of two or more elements, at least one of which is a metal.

Alloying metals produces new materials that exhibit more desirable properties. The metals that are selected for use in the alloy depend on the properties that are required in the resulting alloy.



British coins are made of alloys. A £1 coin, though gold coloured, is not made of gold because gold itself is too soft and expensive. Instead it is made from a nickel-brass alloy, which contains 70% copper, 24.5% zinc and 5.5% nickel, producing a harder coin with the desired colour.

Copper coins, such as the 1p and 2p pieces, used to be made from bronze alloys which contained copper, tin and zinc. In 1992, as a result of the increasing price of copper, the Royal Mint replaced this bronze alloy with the alloy steel, which contains iron. Steel is plated with a thin layer of copper to produce the 'copper' finish. This use of steel explains why coins made after 1992 are magnetic.

Eighteen-carat gold used for jewellery is not made from pure gold as pure gold is too soft, but is an alloy of gold mixed with copper, which produces a harder metal.



Steel, which is used for railway tracks and car body parts, is an alloy made from iron mixed with the non-metal element carbon. This produces a much stronger material, which is also less brittle than iron alone. It does, however, still corrode to form rust.

On the other hand, stainless steel, which is used to produce cutlery and kitchen sinks, is an alloy of iron, carbon and chromium. It is not only strong, but also produces a more shiny material that is more resistant to corrosion than traditional steel.



Shape memory alloys

In the 1960s a new type of alloy was developed called a shape memory alloy. An alloy of the metals nickel and titanium, it keeps the memory of its original shape. The alloy can be bent or stretched to change its shape, but will return to its original shape on heating.

Originally developed for the military and NASA, these shape memory alloys now have many everyday practical applications. They form springs in greenhouse ventilation systems so the roof panels will open and shut automatically when the temperature changes. They are also used in dental braces, as electrical components that trigger fire alarm systems and are also used to make the frames of spectacles so that even if the frames become misshapen, they can be returned to their original shape on heating.

THINGS TO DO AND THINK ABOUT

- Use a copy of the Periodic Table to identify the name of the metal from the following chemical symbols:
(a) Au (b) Cu (c) Mg (d) Ni (e) K
- Use a Periodic Table to identify the chemical symbol for each of the following metals:
(a) Zinc (b) Silver (c) Aluminium (d) Calcium (e) Iron
- Iron is the most widely used metal.
(a) Write a list of as many uses of iron that you can think of.
(b) Now put an asterisk * beside any of the uses you have identified where steel, which is an alloy of iron and carbon, might be used rather than the pure iron metal.
- The properties of different metals are linked to their uses.
Give a use for each of the following metals and identify a property for each metal that explains this use.
(a) Iron (b) Silver (c) Aluminium (d) Mercury (e) Copper

SKILLS

EVERYDAY LABORATORY SKILLS 1

One of the important parts of this course is the development of key scientific skills. As well as important practical skills, you should be given opportunities to develop problem-solving and data-handling skills. Practical skills are an important part of any science subject. In chemistry there are some basic practical techniques that are regularly used and so it is important for you to be able to carry them out correctly. Not all of the practical skills outlined in the course are dealt with here. In this guide, you have already encountered methods for measuring pH, testing for starch, testing for sugars and testing for unsaturation, following rates of reaction, electrical conductivity and cells, and flame tests.

USING A BALANCE

A balance is an essential piece of equipment in any laboratory. It is used to measure mass (how much of something there is). In the lab, the unit for mass is usually grams, g.

Some balances are used for measuring an approximate mass of a substance and will have only one decimal place. Others are used for more accurate measurements and may have four decimal places – these are called analytical balances.

Here are some important instructions to follow when using a balance.

- Ensure that the pan is clean. If the pan is dirty, then it will not be possible to take an accurate mass measurement.
- Switch on the balance using the power button.
- Wait for the display to settle. When it is ready for use it will have a reading of zero grams.
- Gently place the object being measured onto the centre of the pan. Record the reading, with units, being sure to record all the decimal places. For example, a reading of '1.50 g' would be written down as 1.50 g and not as 1.5 g.

There are two main methods used when weighing a substance.

1. Using the TARE (or ZERO) button

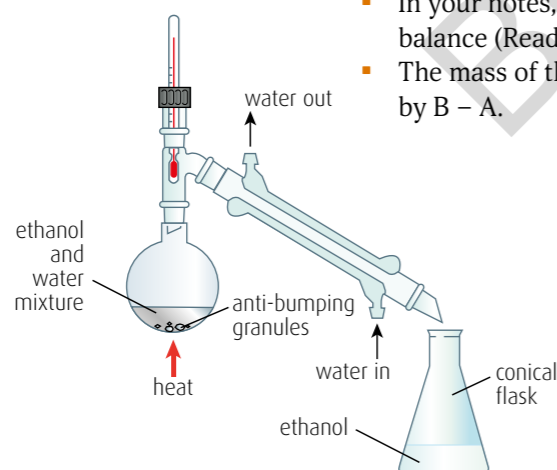
- Switch on the balance, wait for the display to settle and ensure the display reads zero grams.
- Place the beaker (or whatever is being used to contain the substance) on the balance.
- Press the TARE (or ZERO) button and wait for the display to read zero.
- Add an approximate mass of the substance.
- In your notes, record the reading on the balance.

2. Weighing by difference.

- Switch on the balance, wait for the display to settle and ensure the display reads zero grams.
- Place the beaker (or whatever is being used to contain the substance being weighed) on the balance.
- In your notes, record the reading on the balance (Reading A).
- Add the substance being weighed.
- In your notes, record the new reading on the balance (Reading B).
- The mass of the substance can then be calculated by $B - A$.

DISTILLATION

Distillation is a common technique used to separate a mixture when at least one of the substances in the mixture is a liquid. In the diagram, the mixture being separated is ethanol and water.



DON'T FORGET +

Different balances will display zero differently. A one-decimal-place balance will show 0.0 g whereas a two-decimal-place balance will show 0.00 g.

DON'T FORGET +

Make sure that all the decimal places on the display of the balance are recorded. A balance reading of 1.30 g should be recorded in this way and should not be simplified to 1.3 g.



Ethanol and water have different boiling temperatures. The boiling point of ethanol is 78°C and that of water is 100°C. Heat is supplied to the mixture until the ethanol begins to boil and turns into a gas (**evaporates**). As the ethanol vapour passes the thermometer, the temperature measured will correspond to the temperature of ethanol vapour (around 78°C). The gas then enters the **condenser** and **condenses** back into a liquid, drips down the condenser and collects in the conical flask. This liquid is called the **distillate**. In this experiment, the distillate will be ethanol.

+ DON'T FORGET

The condenser consists of an inner tube, through which the condensing gas passes, and an outer jacket. The outer jacket is connected to a tap (water is passed in at the bottom of the condenser and out at the top) and a small flow of cold water is passed through the jacket. This keeps the condenser cold and allows the gases to be condensed.

METHODS OF HEATING

In the laboratory, there are a number of methods that can be used to provide heat to a process or reaction.

The most common method of heating uses a Bunsen burner; this provides a quick and easy to control source of heating and is suitable for most school experiments.

When flammable substances are being used it is not advisable to use a Bunsen burner as the flame can cause the substance to ignite. In cases like these, sometimes boiling water from a kettle will provide enough heat.

In the distillation of ethanol, a **heating mantle** may be used to provide the heat needed to boil the mixture. A heating mantle is an electric heater specially designed to hold the



A hot-plate

round-bottomed flask holding the ethanol and water mixture. In this case, it is not safe to use a Bunsen burner as ethanol is flammable.

An alternative method of heating a flammable substance is to use an electric hot-plate. This is similar to an electric hob that you may have on your cooker at home.



An electric heating mantle – often used to heat mixtures during distillation.

THINGS TO DO AND THINK ABOUT

1. A student was weighing calcium carbonate for use in an experiment. The following results were noted.

Mass of beaker	= 109.22 g
Mass of beaker + calcium carbonate	= 114.10 g

 (a) Calculate the mass of calcium carbonate used by the student.
 (b) Describe an alternative method for weighing out this mass of calcium carbonate.
2. State the meaning of:
 - (a) distillation, (b) evaporate, (c) condenser, (d) distillate.
3. The mixtures below are to be separated by distillation. Which mixtures could be safely separated using a Bunsen burner?
 - (a) salty water or (b) cyclohexane/hexane?