CHEMISTRY

Mixing, Dissolving and Separating

Ideas you have met before

Carrying out experiments

Scientists gather evidence by carrying out experiments. For the evidence to be useful, the experiment has to be designed and carried out carefully. Results and observations need to be recorded so that patterns can be seen and conclusions drawn.

Heating a liquid

If we heat water enough it will boil and turn into steam. Steam is a gas that, if it cools down, will turn back into a liquid.

Drying involves evaporation, which occurs faster with heat and the movement of air.

Dissolving

Some materials – such as salt and sugar – can dissolve in water. We say that these are soluble.

Other materials – such as sand – do not dissolve in water. We say that these are insoluble.

Separating mixtures

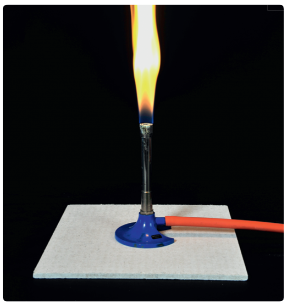
If something has been mixed with water but has not dissolved, we can separate it by using a filter or a sieve.

This method can be used to remove sand and gravel from water, but filtering does not remove soluble substances such as salt.

In this chapter you will find out

Using laboratory equipment

- A Bunsen burner can be used to supply heat to speed up a chemical reaction or to cause a change of state.
- Measuring the mass before and after a reaction helps us to understand some important ideas in chemistry.

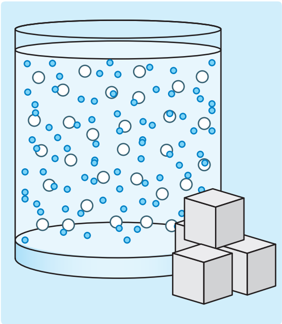


Distillation

- If we heat a liquid it will evaporate, turning into a vapour (gas). If we then cool the vapour, it will turn back into a liquid.
- If we heat different liquids, we find that they boil at different temperatures.
- We can use this information about boiling points to separate mixtures of liquids. The process is called distillation and is used to make perfume and also fuels such as petrol.

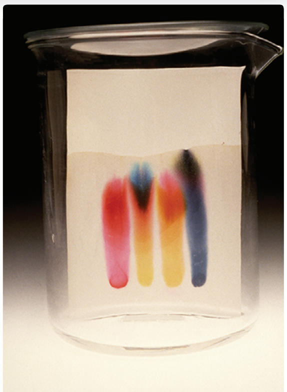
Solubility

- When substances dissolve we can explain the process by thinking about the particles they are made of.
- Dissolving often happens more quickly at higher temperatures because of the extra energy of the particles.
- Solutions are very useful.



Chromatography

- Soluble substances can be made to travel up filter paper by adding a solvent.
- If we do this with coloured dyes or inks, we find that the different colours in the mixture move different distances.
- This technique is called paper chromatography and can be used to separate mixtures and identify chemicals.



193885_P086_121.indd 87 09/12/2013 15:07

Working safely in a laboratory

We are learning how to:

- Recognise and reduce risks when working in the laboratory.
- Name and select appropriate equipment.

Many activities that we do are risky – such as crossing the road or playing sport. That does not mean we do not do them, but it is important that we take precautions to reduce the likelihood of injury.

FIGURE 1.3.2a: Head protection makes rollerblading safer, but no less fun.

Staying safe

In many sports – such as cycling, cricket and horse riding – athletes are encouraged to wear head protection. Some jobs require employees to wear special clothing, head, ear or eye protection to minimise the **risk** of injury and keep them safe. Safety is very important in a science **laboratory**.

1. State three jobs that require workers to wear hard hats.

2. Why do doctors and nurses often wear gloves?

3. a) What safety equipment is the rollerblader wearing?

b) List other safety equipment that a competing rollerblader might wear, and how it would protect him/her.

Safety in the laboratory

Ignoring **hazards** can lead to accidents and people being injured. If we identify and reduce the risk of these hazards then we can work safely. Hazards in the laboratory can come from chemicals, glass equipment or hot objects. The way we behave can also affect the risks to ourselves and to others. Wearing safety goggles is important when performing experiments to protect your eyes from splashes and objects that may splinter or produce sparks.

FIGURE 1.3.2b: Students in this laboratory are NOT safe.

4. How many hazards can you identify in Figure 1.3.2b?
5. How could the risk from these hazards be reduced?
6. Write your top ten safety rules for working safely in the laboratory.

Laboratory apparatus

The laboratory, like a kitchen, contains equipment for heating, measuring, mixing and pouring. However, the names for the equipment are different. It is important to use the correct scientific names for practical **apparatus** so that other scientists can copy your methods to compare and verify the results.

Scientists use a **Bunsen burner** to heat substances to very high temperatures. Knowing how to use the burner safely is very important to reduce the risks of injury and fire.

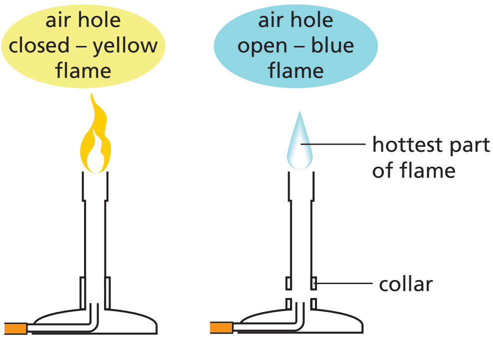


FIGURE 1.3.2c: The flame on a Bunsen burner can be controlled.

A Bunsen has two colours of flame depending on how much air is mixed with the methane gas before it is burned, as shown in Figure 1.3.2c. This is controlled by moving the collar to open and close the air hole at the base. We always leave Bunsen burners with the air hole closed when they are not being used.

7. If you were using a Bunsen burner to heat a liquid in a beaker, why would it be best to:
   - **a)** use a glass beaker, rather than a plastic one?
   - **b)** use a tripod and gauze?
8. Explain how the following apparatus reduces risks in laboratory experiments:
   - **a)** test-tube rack
   - **b)** clamp and stand.
9. Explain how you could reduce the risks when heating a substance in a boiling tube.
10. Give as many advantages as you can for using a heatproof bench mat while heating substances directly in a flame using tongs.

Did you know...?

25 000 children under 5 years old attend hospital in the UK every year after being accidentally poisoned by substances in their own home.

(*Royal Society for the Prevention of Accidents*)

Key vocabulary

risk
laboratory
hazard
apparatus
Bunsen burner

SEARCH: school laboratory safety rules

Chemistry

Recording experiments

We are learning how to:

- Represent scientific experiments clearly.
- Make and record accurate measurements.

Symbols and simple diagrams can accurately represent an object, message or procedure, without requiring the skills of an artist.

Representing apparatus

It is important to be able to represent how an **experiment** has been carried out clearly so that others can understand what has been done. This can be achieved using a simple, common series of 2D images.

An evaporating basin, for example, is represented with a simple 2D **line diagram** (see Figure 1.3.3b). Notice that there is no top line. This shows that the dish is open and has no lid or cover.

You can use the same style of diagram to show how to set up all the apparatus for an experiment.

1. Why are simple 2D diagrams used to represent equipment?
2. Why do scientists use an arrow to represent a Bunsen burner?

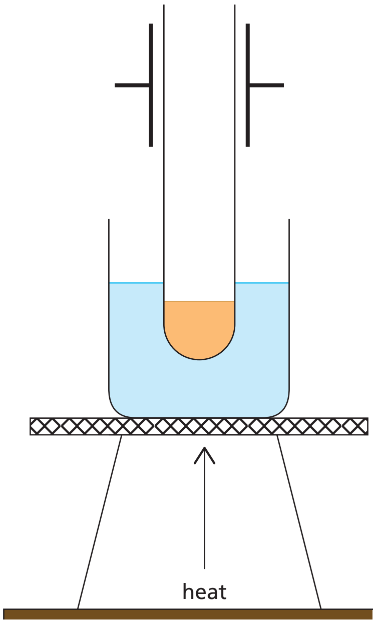


FIGURE 1.3.3a: This type of 2D diagram can be drawn to illustrate apparatus.

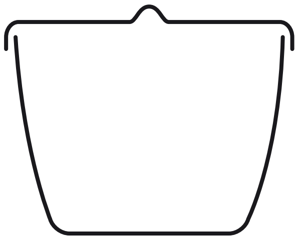


FIGURE 1.3.3b: An evaporating basin and a simple 2D diagram representing it

Measuring accurately

Measuring cylinders come in different sizes – for example 10 cm^3, 25 cm^3 – so that you can choose the one that most closely matches the volume you are **measuring**. This makes measurements more *accurate* by helping you measure closer to the volume needed.

FIGURE 1.3.3c: Measuring cylinders of different sizes

Liquids are not as easy to measure as they may seem because they do not form a straight line at the surface. The surface curves downwards – this is called a **meniscus**. Scientists use the bottom of the meniscus to make their readings. They do this at eye level so that they can be sure that they are reading the position and scale accurately.

Balances can measure mass to different numbers of decimal places. The more decimal places there are the more precise the measurement is and the more *sensitive* the balance is to very small differences in mass.

3. Explain your choice of equipment to make the following measurements:

a) 6 cm^3 **b)** 23 cm^3 **c)** 10 g

d) 42.40 g **e)** 20 °C **f)** 62 s

4. Why is it important to choose the appropriate measuring equipment?

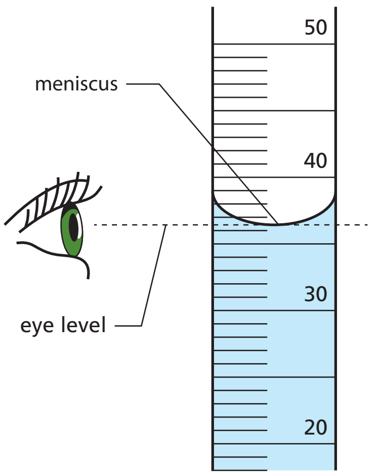


FIGURE 1.3.3d: Reading the meniscus at eye level

Reporting results

Results are recorded in tables with headings, units and **data**. If the mass was measured on a balance with one decimal place, all the data should be reported with one decimal place, including the average result.

Mass of powder	Volume of gas (cm^3)		
	First experiment	Repeated experiment	Average
1 g	5	7	6
10 g	90	95	92.5
5 g	27	23	25

FIGURE 1.3.3e: Example of a results table

5. Say why you think the table in Figure 1.3.3e is a good one and how it could be improved.

6. Write a checklist that your class could use to make sure that your results are recorded accurately.

7. The same 100 cm^3 measuring cylinder was used to make all the measurements in the table. How might this have affected the results?

Did you know...?

The meniscus in mercury curves upwards. So, when you read the temperature on a thermometer, you should read the top of the meniscus at eye level.

Key vocabulary

experiment

line diagram

measuring

meniscus

data

Recognising materials, substances and elements

We are learning how to:

- Recognise the difference between materials, substances and elements.
- Identify elements by their names and symbols.
- Explain what is meant by a chemically pure substance.

Chemistry is the study of the structure, properties and uses of materials. Materials are combinations of substances that are made of basic building blocks – the chemical elements.

Elements and compounds

For a scientist, a **material** is anything made of matter or particles. Most materials are made up of combinations of chemical substances, called **compounds**.

Compounds are made up of different **elements**. Elements are the chemical building blocks of materials – each is made up of only one type of atom. Each element is identified by a unique **symbol**, which always begins with a capital letter. Table 1.3.4a lists some common elements and their symbols.

Some elements have symbols based on their old names, such as iron (ferrum), gold (aurum) and copper (cuprum).

1. What is the chemical symbol for carbon?
2. Explain why CO and Co are not the same thing.

Pure or not?

When elements combine in a compound, sometimes they form a **molecule**. A water molecule is made up of two hydrogen (H) atoms and one oxygen (O) atom. We write this as H_2O.

Chemically **pure** water contains only H_2O molecules. Bottled water contains other substances – for example, magnesium (Mg) and calcium (Ca). It is not the same as pure water.

3. Which elements make up the sugar called glucose ($C_6H_{12}O_6$)?
4. Describe the difference between chemically pure water and so-called 'naturally pure' bottled water.

FIGURE 1.3.4a: Orange juice may contain over 10 different compounds, including water, sugar and vitamins.

TABLE 1.3.4a

Name of element	Symbol
hydrogen	H
oxygen	O
carbon	C
cobalt	Co
iron	Fe
gold	Au
copper	Cu
calcium	Ca

5. Explain why calcium carbonate, $CaCO_3$, is a pure substance but not an element.

6. Why do you think that we call substances like orange juice and bottled water *pure*?

Elements in the body

Almost 99 per cent of the mass of your body is made up of only six elements, but these are combined in different ways. Blood contains water, salts and an iron-containing compound called haemoglobin. Bones and teeth are made from compounds that contain calcium and phosphorus.

In total, your body contains around 28 different elements (Table 1.3.4b) whose atoms combine in various ways to create the different substances that you are made of.

TABLE 1.3.4b

Elements in the human body	Make up (%)
oxygen	65
carbon	18
hydrogen	10
nitrogen	3
calcium	1.5
phosphorus	1.0
potassium	0.35
sulfur	0.25
sodium	0.15
magnesium	0.05
copper, zinc, selenium, molybdenum, fluorine, chlorine, iodine, manganese, cobalt, iron	0.70
lithium, strontium, aluminium, silicon, lead, vanadium, arsenic, bromine	trace amounts

7. Explain why blood is not a pure substance but haemoglobin is.

8. Draw a graph to represent the 10 most abundant elements in your body. Include the symbols.

Did you know...?

Before recorded history, many elements were in use but only in the form of their compounds. It was not until the late 1700s that pure elements started to be isolated and identified.

Key vocabulary

material

compound

element

symbol

molecule

pure

Understanding water

We are learning how to:

- Recognise the importance and different sources of water.
- Explain the differences between types of water.

Approximately 70 per cent of the Earth is covered by water. It exists in oceans, rivers, glaciers and falls from the sky as rain and snow. We rely on it to drink and wash, but also to grow food and to transport us from place to place. It literally sustains life on our planet.

FIGURE 1.3.5a: Much of the Earth is covered by water.

Would you drink seawater?

Seawater tastes salty because of the minerals and salts dissolved in it. Seawater is a **mixture**. It contains substances dissolved from rocks and the atmosphere. Some elements and compounds can be extracted from it and are used to make other things including chlorine, bromine and iodine.

1. Why is seawater described as a mixture?
2. Suggest an easy way of proving that there are substances dissolved in seawater.

What is in our water?

Because **water** is good at dissolving substances, natural sources of water on Earth are mixtures. Even bottled mineral water is not pure water because it contains substances that have been dissolved from the rocks surrounding it. These are not harmful and, in fact, can be good for us.

Some tap water contains a lot of calcium compounds that sometimes appear as a white substance in kettles when the water is boiled – this is called **limescale**. Some of our tap water has fluoride added because it is good for our teeth. Other substances, such as chlorine compounds, are added to kill bacteria and make the water safe to drink.

	(mg/l)
Calcium (Ca)	181.0
Chloride (Cl^-)	57.5
Bicarbonate (HCO_3^-)	239.0
Fluoride (F^-)	0.5
Lithium (Li)	0.2
Magnesium (Mg)	53.5
Nitrate (NO_3^-)	2.2
Potassium (K)	2.5
Silica (SiO_2)	7.5
Sodium (Na)	36.1
Strontium (Sr)	3.2
Sulfate (SO_4^{2-})	459.0

FIGURE 1.3.5b: Bottled water includes substances such as calcium. So does tap water.

3. Name two chemicals that might be added to water when it is being prepared to be supplied to us.
4. If there is calcium in the water we drink, how might it have got there?
5. Suggest why drinking water supplied in different parts of the country might taste slightly different.

The need for clean water

Not all countries around the world have access to clean, safe water. In some parts of Africa, for example, many people die due to lack of water or from diseases caught from drinking dirty water. Some African countries are hot, barren and have had significant periods of drought where crops fail and food is scarce. By drilling wells deep underground and providing methods for cleaning and **purifying** water, the lives of people in these areas can be transformed.

FIGURE 1.3.5c: People need clean water.

Our water is recycled. We collect and use rainwater in reservoirs – even the water we flush or wash away is collected and cleaned, and then returned to the main water supply. In order to recycle water effectively, an understanding of chemistry is vital. If too much or the wrong chemical is used, many people would be affected and could be poisoned or become ill from bacteria in the water.

6. Why is a supply of clean water so critical?
7. What is the difference between clean water and pure water?
8. Suggest why the supply of clean water is improved:
   a) in parts of Africa by drilling deep wells
   b) in many countries by building reservoirs.

Did you know...?

Water, H_2O, should be a gas at room temperature, like hydrogen sulfide, H_2S. However, there are special forces between water molecules that hold them together more strongly than molecules in similar compounds.

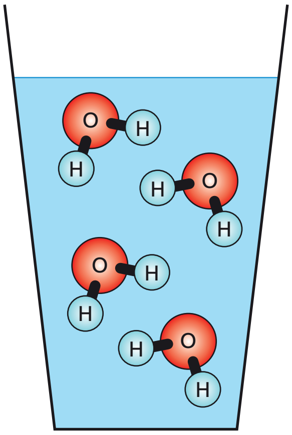


FIGURE 1.3.5d: Water is a special case.

Key vocabulary

mixture
water
limescale
purifying

Dissolving

We are learning how to:

- Explain the terms solvent, solution, solute and soluble.
- Identify factors that affect dissolving.
- Explain the difference between a dilute solution and a concentrated solution.

Limestone caves are amazing places. Stalactites grow down from the roof and, where the water drips down and hits the cave floor, stalagmites grow upwards. They grow only a few centimetres every hundred years as water slowly deposits the minerals it dissolved when passing through the limestone rock.

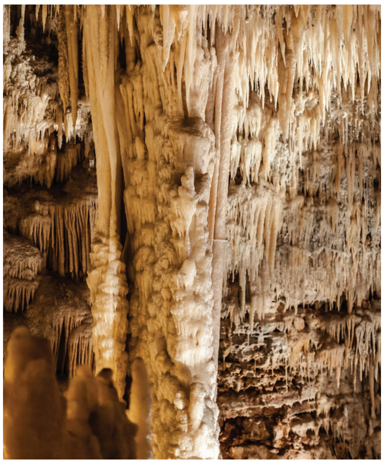


FIGURE 1.3.6a: Even rocks dissolve.

Do you take sugar?

If you stir sugar into a cup of tea or coffee the crystals disappear – they dissolve. The water is called the **solvent** and the mixture is called a **solution**. The sweeter the taste, the more sugar has dissolved. Substances that dissolve are described as **soluble**.

1. Why does sugar disappear when you stir it in tea?
2. How do you know that the sugar is still there in the drink?
3. What is a solution?

FIGURE 1.3.6b: The sugar seems to disappear but the tea tastes sweet.

Different sugars

Different kinds of sugar all contain sucrose, which is extracted from plants like sugar cane or sugar beet. Although the size of the crystals varies, the sucrose molecules ($C_{12}H_{22}O_{11}$) are all the same.

If you use a beaker containing water you can see how easily sugar dissolves. A solid that dissolves is called a **solute**. Not all types of sugar dissolve in water at the same speed.

FIGURE 1.3.6c: Does the type of sugar affect how it dissolves?

193885_P086_121.indd 96 09/12/2013 15:07

TABLE 1.3.6: The rate at which different types of sugar dissolve

Sugar type	Mass used (g)	Volume of water (cm^3)	No. of stirs to dissolve it all
caster	1.50	100	20
white cubes	1.50	100	75
granulated	1.45	100	42
brown sugar	1.50	100	58

Look at the experiment results in Table 1.3.6 to answer these questions.

4. What were the solute and the solvent?
5. Put the sugar types in order of size of their sugar pieces, starting with the largest. What do you notice about how they dissolved?
6. Explain why the experiment was a fair test.

Did you know...?

The artificial sweetener aspartame is 250 times sweeter than sucrose. However, a natural sweet protein called thaumatin, found in the West African katemfe fruit, is 3000 times sweeter than sucrose!

Dissolving sugar

Sugar lumps are made of sugar crystals packed together. Each of these crystals contains many tiny sugar molecules. The solution in the glass in Figure 1.3.6d contains a mixture of water molecules (solvent) and sugar molecules (solute).

The water molecules are much smaller than the original sugar crystals and are able to break down the crystals into sugar molecules. The movement of the water molecules helps to separate and spread the sugar molecules throughout the solution.

The separated molecules are so small that they seem to have disappeared into the water. The mass of sugar dissolved in a particular volume of water is called the **concentration**. If there is a lot of sugar in the water it is a concentrated solution; if there is only a little it is a dilute solution.

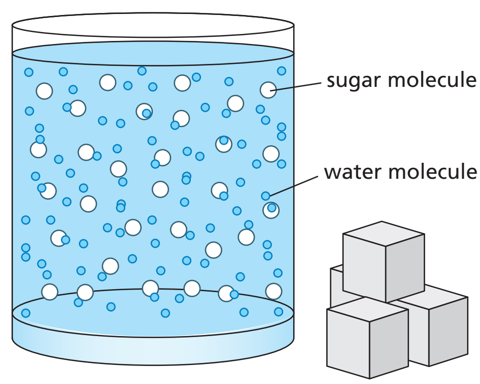


FIGURE 1.3.6d: What happens when sugar dissolves?

7. Explain, using the correct scientific terms, why sugar dissolves.
8. Why does stirring make the sugar dissolve faster?
9. Will icing sugar dissolve faster than caster sugar? Explain your answer.
10. Draw a diagram like the one in Figure 1.3.6d to show the difference between a concentrated solution and a dilute solution.

Key vocabulary

solvent
solution
soluble
solute
concentration

193885_P086_121.indd 97 09/12/2013 15:07

Separating mixtures

We are learning how to:

- Recognise the differences between substances and use these to separate them.

If you put different objects together, such as different fruits in a bowl, toys in a box or sweets in a bag, you have a mixture. Simply picking out one object separates it from the mixture. You can have mixtures of elements and compounds too. These are not so easy to separate.

Using size to separate mixtures

Gravel and rocks can be removed from sand by sieving. This separation depends on the size of the holes in the sieve. However, if the sand was mixed with water, this method would not work. A **filter** would be needed instead.

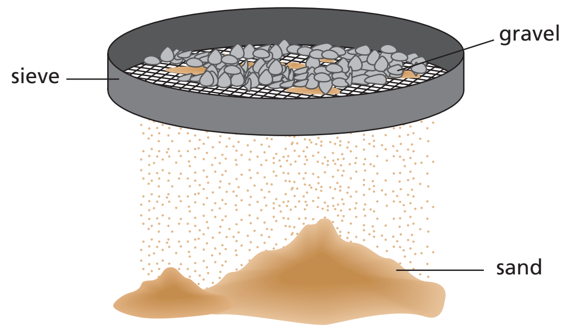


FIGURE 1.3.7a: Using a sieve

Filters are often made of paper or cloth with very small holes that are difficult to see without a microscope. Filters are often used to remove the solids when making coffee. Tea bags act as filters, whereas a tea strainer acts as a sieve. Air and fuel filters are used in cars to remove particles that would damage the engine.

1. What is the difference between a filter and a sieve?
2. Explain how filters and sieves are helpful when making tea and coffee.

Being different

Mixtures can be separated by finding differences between the substances. For example, there are only three metals that are attracted by a magnet – iron, cobalt and nickel. We can use this difference to separate these magnetic metals from mixtures.

FIGURE 1.3.7b: The physical property of magnetism can be used to separate magnetic from non-magnetic materials.

TABLE 1.3.7

Rules for mixtures	
1	Mixtures can be separated by physical methods.
2	Mixtures only have the properties of the things in the mixture.
3	Mixtures of elements can be made using different amounts of each one.
4	No chemical change occurs when making mixtures.

3. Would all of a mixture containing iron filings and lead powder be magnetic?

4. If nickel chloride were mixed with lead, could you use a magnet to separate them? Explain your answer.

5. Use the rules in Table 1.3.7 to explain why mixtures can be separated using known differences between the substances.

Separation by filtration

In the laboratory, filter paper can be used to separate solids from liquids – this process is called **filtration**. Substances that do not dissolve are described as **insoluble**. Filtration helps to separate soluble and insoluble solid substances.

Liquids like oil and water do not mix. The oil does not dissolve in the water to make a solution. These liquids are described as **immiscible**. The lighter oil floats on top of the water, and even if you shake the mixture, the two layers will reappear as the two liquids separate again.

The way these two liquids behave means that a separating funnel can be used to split them up. The water layer can be removed using the tap at the bottom, leaving the oil layer behind.

6. Choose a method to separate flour and rice.

7. Explain why a bottle of salad dressing made from vinegar and olive oil must be shaken before use.

8. Explain why filtration would not separate sugar and water.

9. Create a key or flow diagram to help explain which method of separation to use for a mixture.

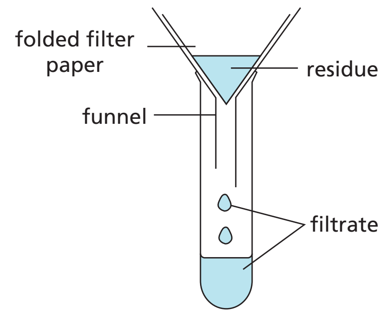


FIGURE 1.3.7c: Separating mixtures by filtration

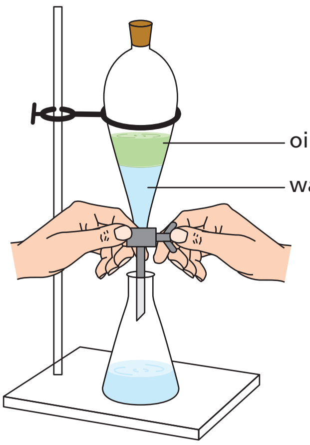


FIGURE 1.3.7d: Using a separating funnel to separate immiscible liquids

Did you know…?

The components of blood can be separated by spinning the blood really fast in a centrifuge. This causes the red blood cells to separate from the plasma because they are denser and sink to the bottom.

Key vocabulary

filter
mixture
filtration
insoluble
immiscible

Chemistry

Dissolving and evaporating

We are learning how to:

- Separate a soluble substance from water.
- Form crystals from solutions.
- Explain solubility.

Gemstones, such as amethyst, are crystal that formed deep in the Earth's crust. Water dissolved salts and as this solution cooled over thousands of years, the precious crystals formed.

FIGURE 1.3.8a: Amethyst crystals formed naturally by the processes of dissolving and evaporating.

Temperature effects

One way to help things dissolve is to increase the temperature of the water. This is why we wash clothes in warm water. Any **soluble** stains in the clothes will dissolve better at a higher temperature. The mass of solute that dissolves in a solvent at a particular temperature is called its **solubility**.

Look at the data in Table 1.3.8. The results show the mass of sugar (sucrose) that can dissolve in 100 cm^3 of water.

TABLE 1.3.8: Dissolving sugar in water at different temperatures

Temperature of water (°C)	0	20	40	80
Mass of sucrose that can dissolve (g)	180	200	240	600

1. What does the data in Table 1.3.8 tell you about the solubility of sucrose at different temperatures?
2. How could you display this data to show the pattern more clearly?
3. Estimate the mass of sucrose that will dissolve at 60 °C.

Did you know…?

These amazing natural gypsum crystals were found 300 metres underground in a mine in Mexico in 2000. They have grown undisturbed for thousands of years. Some are as long as 12 metres.

FIGURE 1.3.8b Naica gypsum crystals

193885_P086_121.indd 100 09/12/2013 15:07

Making crystals

Heat can also be used to separate soluble substances from their solutions. When the solvent evaporates it leaves behind the solid solute – this is called **crystallisation**. If this process happens quickly, small **crystals** of the solute will form. However, if the evaporation happens slowly, bigger crystals can grow.

Crystallisation happens most efficiently when the solution is **saturated**. This means that there is as much solute dissolved in a solvent as possible. If any more solute is added to a saturated solution it will not dissolve. As the solvent cools, the crystals start to form. The solubility of substances depends on the temperature of the solvent.

4. What is a ‘saturated’ solution?

5. Describe how you could grow salt crystals.

6. Why do you think that the crystals start to form as the solvent cools?

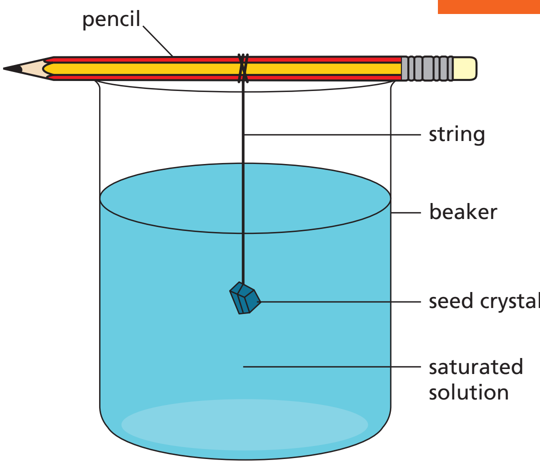


FIGURE 1.3.8c: You can grow your own crystals.

Using graphs

Substances dissolve more in hot water because the water molecules have more energy and move faster. They can break down the crystals and separate the solute molecules more quickly. Solubility also depends on the type of solute. The graph shows the change in solubility of different salts with temperature.

7. Look at Figure 1.3.8d. Which salt is most soluble at 60 °C?

8. If 50 g of potassium nitrate were added to water at 20 °C, would it all dissolve? How do you know?

9. What would you see if a solution containing 50 g of sodium chloride was cooled from 100 °C to 40 °C?

10. How much sodium nitrate would you need to add to 100 g of water at 50 °C to make a saturated solution?

11. Using your knowledge of dissolving, explain why there is a connection between the temperature of a solvent and the solubility of a salt.

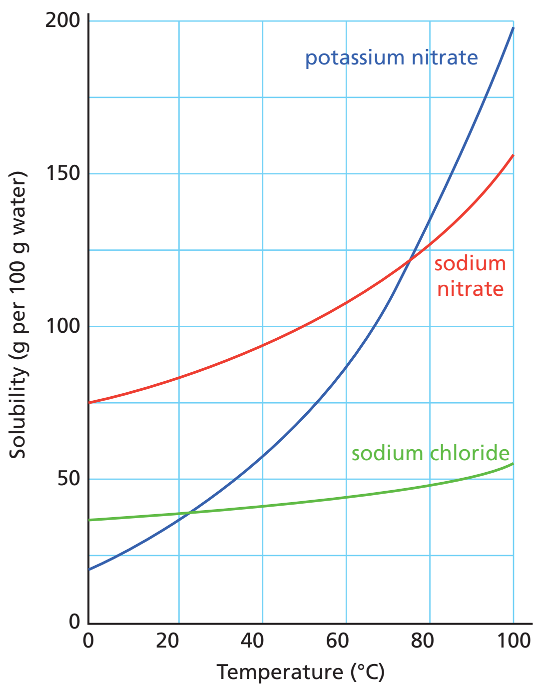


FIGURE 1.3.8d: Solubility graph

Key vocabulary

soluble
solubility
crystallisation
crystal
saturated

Extracting salt

We are learning how to:

- Identify sources of salt and describe how it is extracted.
- Recognise the uses and importance of salt.
- Obtain pure salt from a mixture.

Salt has always been valuable to flavour and preserve food. The chemical name for salt is sodium chloride. We can make chlorine from salt. Chlorine is used to make drinking water safe by killing harmful bacteria.

FIGURE 1.3.9a: Salt crystals

Sea salt

People have obtained **salt** from seawater and salt lakes for thousands of years. The Romans in Britain trapped seawater in shallow ponds. As the water **evaporated**, salt (**sodium chloride**) crystals were left behind. This method is still used in some countries, such as Australia and India. If the seawater is taken from an area that is not polluted, the crystals of sea salt are pure enough to use in cooking.

1. Give two uses for salt.
2. Name one chemical that is made from salt and explain how it is used.
3. How did the Romans obtain salt in Britain?
4. Why do you think the evaporation method of extracting salt is still used in Australia but not in Britain?

FIGURE 1.3.9b: India is the world's third largest salt producer, after China and the USA.

Rock salt

In winter you often see lorries spreading salt and grit on the roads. The salt makes the ice melt and the roads are made safer. This kind of salt is called **rock salt**. The rock salt is mined from the ground and broken into a powder, which makes it easier to spread on icy roads.

Rock salt is not pure salt. It is a natural mixture of salt and insoluble materials like clay. Most rock salt is brown, but it can be yellow or red depending on the clay it is mixed with.

You can purify rock salt yourself. Because the salt is soluble but the sand is not, water can be used to help separate the substances. The insoluble materials can be filtered off using a funnel and filter paper, and the remaining solution evaporated to obtain the salt.

193885_P086_121.indd 102 09/12/2013 15:07

5. Give two reasons why rock salt and grit are used on icy roads and pavements.
6. What gives rock salt its colour?
7. What is meant by an ‘insoluble material’?
8. Describe how you would separate pure salt from rock salt.

Mining salt

In Cheshire, people have obtained salt from **brine** pits since the 17th century. Brine is salty water. Because salt is soluble in water but rocks are not, water is used to mine the salt. This is called solution mining.

Water is pumped down one of the pipes to dissolve some of the salt underground. The brine is then pumped up and water is evaporated to leave pure, white salt crystals. However, removing the salt from under the ground leaves large holes. The land above can sink into these holes, destroying buildings.

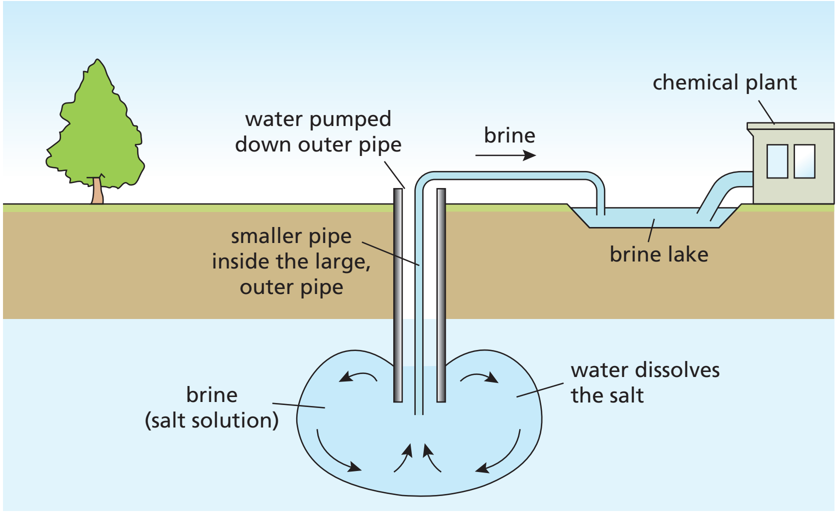


FIGURE 1.3.9c: Using solution mining to extract salt

9. What are the differences between rock salt and the salt extracted by solution mining?
10. Explain, in as much detail as you can, why solution mining is a better source of salt for cooking than rock salt.
11. What are the advantages and disadvantages of solution mining?

Did you know…?

The concentration of salt in the Dead Sea, between Jordan and Israel, is so high that you can float very easily on the water surface. However, only specially adapted microorganisms can survive in it.

Key vocabulary

salt
evaporate
sodium chloride
rock salt
brine

Chemistry

Understanding distillation

We are learning how to:

- Use distillation to separate substances.
- Explain why distillation can purify substances.

Distillation is used in making perfumes, fuels (such as petrol) and alcoholic drinks (such as vodka). It is an important separation process involving heating and cooling.

FIGURE 1.3.10a: Condensation is one of the processes involved in distillation.

Heating and cooling

On a cold day water **vapour** from a bath or kettle can **condense** on a cold surface. It cools down and turns back to water. This is what happens in **distillation**. Liquid mixtures can be separated using distillation.

1. Name three substances that are made using distillation.
2. Why does steam turn into liquid water when it touches a window?

Catching steam

When water boils it is hard to catch all of the water vapour because it mixes into the air. In distillation the vapour is cooled, which allows it to be collected as a liquid.

2000 years ago Greek scientists, known as alchemists, invented a way to distil liquids. A copper 'still' trapped the hot vapour, cooling it and condensing it back to a liquid. It was so successful that the design was on sale until 1860.

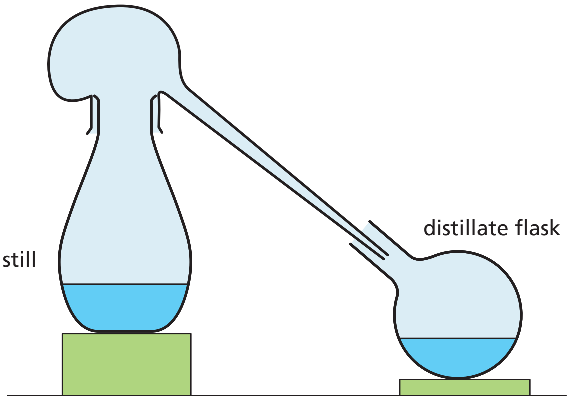


FIGURE 1.3.10b: An early distillation method

The distillation apparatus that we use today is based on the same principle of heating and cooling. The major improvement is the **Liebig condenser**, which is a double glass tube, shown in the apparatus in Figure 1.3.10c. The hot vapour from the boiling liquid flows through the inner tube, while cold water runs though the outer tube. This keeps the inner glass tube cold and condenses most vapours easily. The liquid collected at the end is called the distillate.

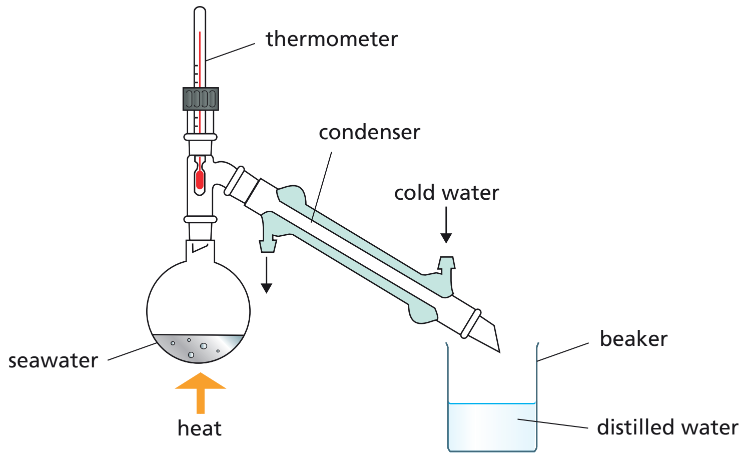


FIGURE 1.3.10c: Distillation apparatus using a Liebig condenser

3. Why is the alchemists' method a better method of separation than just heating a mixture of liquids?
4. Why is the Liebig condenser better than the alchemists' equipment?
5. Explain the safety checks you would use to separate a mixture safely.

Distilling mixtures

There are two changes of state in distillation. First, a liquid is evaporated by heating and then the cooled vapour condensed back to a liquid. When salty water is heated, only the water (solvent) changes state and the salt (solute) is left behind. The water produced is called distilled water.

Different liquids boil at different temperatures – for example, ethanol boils at 78 °C and water at 100 °C. This means that mixtures of liquids can be separated using distillation. A thermometer at the top of a distillation flask shows the temperature of the vapour being condensed and hence identifies the substance being separated. Distillation is an effective way of **purifying** alcohol or increasing the concentration of alcoholic drinks. It is also useful for separating flammable liquids like petrol and diesel because the vapours never come into direct contact with the flame.

6. Why is distillation a better way to separate salt and water than crystallisation?
7. Why is a thermometer important in distillation?
8. Why is distillation a good method for separating petrol and diesel?
9. Explain how water and ethanol are separated.

Did you know…?

Steam distillation is used to obtain essential oils from plants such as herbs and flowers. The products are used in aromatherapy, flavourings in foods and drinks, and as scents in perfumes, cosmetics and cleaning products.

Key vocabulary

vapour

condense

distillation

Liebig condenser

purify

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.

How hard is your water?

Some people have hard water coming out of their taps. It does not really do them any harm, but it can cause problems. A good way to tell if the water is hard in the area where you live is to look inside your kettle at home – in a hard-water area you will see limescale there. It looks like a creamy coloured fur but if you touch it the 'fur' is actually quite hard. You can also tell if you go to wash your hands – the soap will not form much lather in the water, but will tend to form a scum instead.

FIGURE 1.3.11a: Limescale in a kettle

Water is hard if it has minerals dissolved in it that contain calcium or magnesium. Some dissolved chemicals cause the hardness to be temporary. These chemicals can be removed by boiling and the water becomes soft. Calcium bicarbonate or magnesium bicarbonate cause temporary hardness. However, if there is calcium sulfate or magnesium sulfate in the water the hardness is permanent – boiling the water will not remove it.

As well as forming deposits on the inside of kettles, the chemicals in hard water can also cause harm to central heating systems, dishwashers and washing machines by clogging them up.

Now, you might wonder how these chemicals get into the water. After all, water falls as rain and rain is considered to be soft – it contains few chemicals. Actually, rain water is slightly acidic (this is natural and, unlike the acid rain caused by pollution, not a problem). The way that water becomes hard is by running over chalk or limestone. Limestone, for example, contains calcium carbonate and the rainwater reacts with this.

Not everybody has hard water though, and in a number of areas it is soft, depending on where the water comes from. The water in Birmingham, for example, comes from reservoirs in the Elan Valley in Wales, which is a soft-water area. Soft water lathers with soap quite easily and does not cause deposits. However, it is not all good news for people in soft-water areas – some people prefer the taste of hard water.

FIGURE 1.3.11b: A limestone landscape

193885_P086_121.indd 106 09/12/2013 15:07

Task 1: Is your water hard?

Is the water in your area hard? How do you know? People can often taste the difference between hard water and soft water. How can water taste different?

Task 2: Temporary or permanent?

What sort of problems does hard water cause? How does water become hard? What is the difference between temporary hard water and permanent hard water? What causes that difference?

Task 3: Soluble or insoluble?

Limescale is calcium carbonate. Is it soluble or insoluble? How do you know? How could you demonstrate this? What about calcium bicarbonate?

Task 4: Calcium carbonate

Calcium carbonate is made up from the elements calcium, carbon and oxygen and is written as the chemical 'formula' $CaCO_3$. Which symbols represent each element? How can you tell from this formula that each molecule consists of five atoms?

Task 5: Calcium hydrogen carbonate

Calcium bicarbonate has the formula $Ca(HCO_3)_2$. Which elements does it contain? Why do you think it is called calcium *bi*carbonate? Its modern name is calcium hydrogen carbonate. Why is this more useful?

193885_P086_121.indd 107 09/12/2013 15:07

Finding out what air is made of

We are learning how to:

- Describe the composition of air.
- Separate gases from air.

Your body is very effective at separating things out from air. Air is a mixture of gases and small particles of dust, pollen and pollutants. Hairs and mucus in your nose help in removing dust and pollen.

FIGURE 1.3.12a: Particles in the air can affect our health.

Up in the air

Two **gases** make up 98 per cent of the air – nitrogen (N_2) and oxygen (O_2) are diatomic. Nitrogen is not a very reactive gas – however, oxygen is needed to burn fuels for heat, to make electricity and for car engines to run. When oxygen reacts with other elements, compounds called oxides are formed. Carbon dioxide (CO_2) is produced when carbon compounds are burned in air. Animals breathe out carbon dioxide.

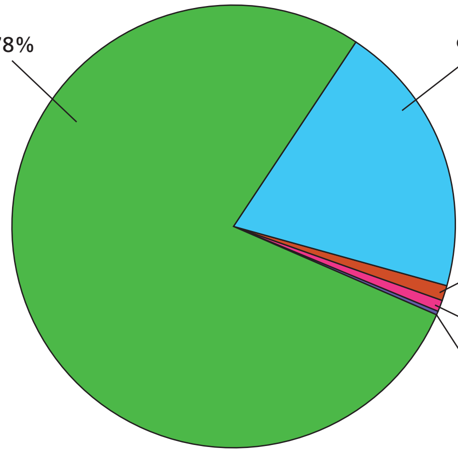


FIGURE 1.3.12b: Air is a mixture.

1. Which are the two most common gases in the air?
2. What name is given to any compound formed from a reaction involving oxygen?
3. Give two ways that carbon dioxide can be released into the air.

193885_P086_121.indd 108 09/12/2013 15:07

Air pollution

The particles and gases produced by burning fuels are released into the air. The pollution this causes has short- and long-term health effects. The daily air quality index (DAQI) tells us how much pollution there is in the air and DEFRA, the government body that produces it, provides health advice. This information is vital, for example, for people with lung problems or asthma.

The **air pollution** information is based on hourly results taken from over 120 automatic monitoring systems across the UK. They detect fine particles and gases such as sulfur dioxide and nitrogen oxides that can irritate our lungs.

1	2	3	4	5	6	7	8	9	10
Low			Moderate			High			Very high

FIGURE 1.3.12c: Daily air quality information is displayed using this scale. (DEFRA)

4. Why is the DAQI information important for children with asthma?

5. Why are so many automated monitoring stations in the UK taking readings every hour?

6. Which pollutants are measured and where do they come from?

Boiling cold?

Most gases have **boiling points** significantly lower than 0 °C. Therefore to separate oxygen from the other gases in air, the distillation process has to take place at very low temperatures. The cryogenic distillation process can produce high-purity gases by pushing the molecules closer. This also means that the gases take up less space. Air is **compressed** and cooled to very low temperatures and the liquid air is allowed to heat up slowly in a fractionating column. Oxygen oils off at –183 °C and the purified gas is stored under pressure.

7. Newborn babies sometimes need to breathe pure oxygen. How is pure oxygen obtained?

8. Why does cryogenic distillation use more energy than normal distillation?

9. Why are gases like oxygen and compressed air stored in pressurised containers?

Did you know…?

'SCUBA' stands for 'self-contained underwater breathing apparatus'. The tanks contain compressed air to allow divers to breathe underwater.

FIGURE 1.3.12d: Scuba divers use tanks of compressed air.

Key vocabulary

gas

air pollution

boiling point

compressed

Exploring chromatography

We are learning how to:

- Use chromatography to separate dyes.

Chromatography is one of the most important separation methods used to identify unknown substances. There are many types of chromatography – some use liquids and some use gases. Chromatography is used by scientists to detect drugs and explosives and to identify dyes and paints.

FIGURE 1.3.13a: Separation by chromatography

Separating colours

Black ink is not just a black colour mixed with water. Black ink is a **mixture** of colours. Filter paper and water can be used to **separate** these colours. This method of separation is called **paper chromatography**. Figure 1.3.13a shows what happens when the colours are separated. Drops of water (solvent) are added to the middle of the paper where the ink spot is placed.

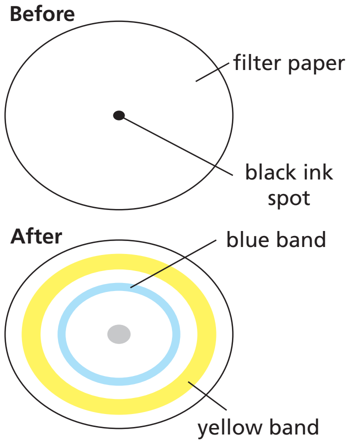


FIGURE 1.3.13b : Separating ink colours

1. What evidence is there that black ink is not pure?
2. What causes the ink to spread across the filter paper?
3. What is chromatography?

Examples of chromatography

If you cut a section of the filter paper, it can act as a wick. By dipping this wick into water, the liquid is drawn up through the ink and the colour begins to separate all on its own. The resulting pattern of colours is a **chromatogram**.

This method shown in Figure 1.3.13c is called ascending paper chromatography, because the water soaks up from the base carrying the colour spots with it. Some colours move faster than others, which is why the colours separate.

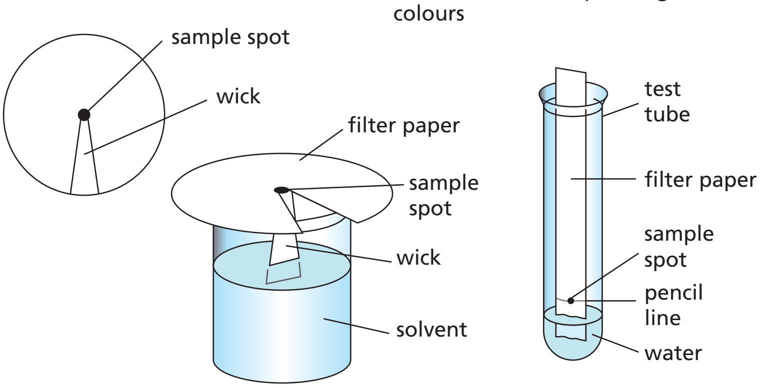


FIGURE 1.3.13c: Other methods of chromatography

You can use chromatography for colourless mixtures, but must develop the chromatogram by spraying the paper with a chemical to make the spots visible, or using an ultraviolet (UV) light to look at the spots.

4. What do we call the pattern of spots on the paper?
5. Why is the line drawn in pencil and not in ink?
6. Why would paper chromatography be no good for separating salt from water?

Making comparisons

If the same conditions are used, the distance that a coloured **dye** travels up the paper is always the same. This is how chromatography can be used to identify unknown substances. The distance that the dye travels from the original spot on the pencil line at the base, compared to the distance travelled by the solvent (solvent front) can be calculated. This is called the R_f or retardation factor.

R_f = distance travelled by dye ÷ distance travelled by solvent

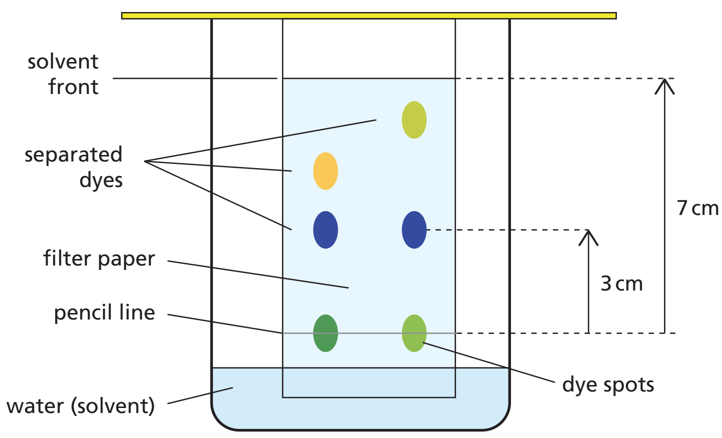


FIGURE 1.3.13e: Chromatogram to compare two dyes

7. Why is the starting line above the water level in the beaker?
8. If two brands of blue dye gave identical spot patterns, what could you conclude?
9. What conclusions can you draw from the chromatogram in Figure 1.3.13e?
10. Some dyes are invisible in normal light and only show up in ultraviolet light. This is how security inks work. How could you use chromatography with a set of security inks?

Did you know…?

You can separate pigments in leaves by chromatography using alcohol as the solvent. Chlorophylls are green pigments that help plants make food via photosynthesis. The yellow pigment separated here is carotene, which is found in carrots and is used as a food colouring (E160a).

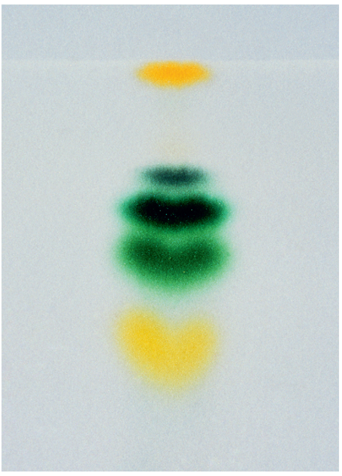


FIGURE 1.3.13d: A plant pigment chromatogram

Key vocabulary

mixture
separate
paper chromatography
chromatogram
dye

193885_P086_121.indd 111 09/12/2013 15:07

Using chromatography

We are learning how to:

- Use chromatography to identify unknown substances.
- Draw conclusions from evidence.

Solving crimes requires scientists to produce high-quality evidence that the court will believe and use to prove guilt or innocence. This means that forensic scientists have to be very careful and repeat their experiments to be sure that their evidence is reliable and accurate.

FIGURE 1.3.14a: The recovered car provided clues.

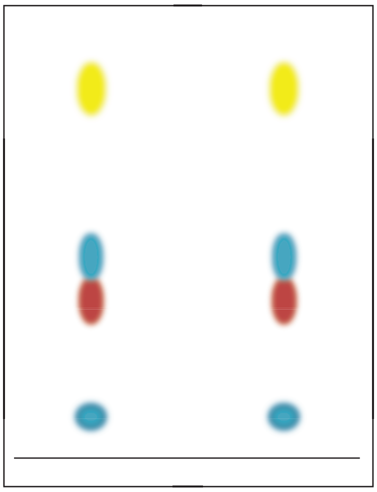
Major crime solved

A series of burglaries and break-ins at jewellery stores has netted a gang of criminals thousands of pounds. Unfortunately for them they were careless. Fast driving caused accidents that left traces of car paint at several of the crime scenes. One of the robbers left graffiti messages scrawled on the wall, taunting the police to catch them.

The police **forensic** team used the **reliable** technique of **chromatography** to prove that they had arrested the right gang. The paint left at the crime scenes matched that on the criminals' car perfectly.

Chromatograms of the ink from the wall also exactly matched a set of marker pens found in the gang leader's home and provided the **accurate evidence** needed.

1. What did the forensic scientists deduce after making the chromatogram (Figure 1.3.14b) of the car paint found at the scene?
2. How could they make their conclusion more reliable?
3. Is it sufficient evidence to find that the paint on a car matches that at the scene of the crime?



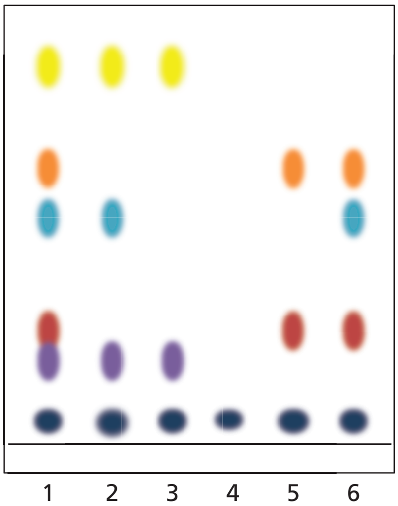
1 Crime scene paint
2 Suspect car paint

FIGURE 1.3.14b: Chromatogram of paint samples

Considering the evidence

Figure 1.3.14c shows a chromatogram using ink from the graffiti messages and ink from four of the pens in a set found in the suspect's home. Consider the evidence from Figure 1.3.14c and answer the following questions.

4. What evidence is there that the graffiti ink was a mixture?
5. How does the evidence from the chromatography prove that the graffiti was drawn by the suspect?
6. Explain how the forensics team could make sure that their evidence was reliable and accurate.



Analysis of ink
1. Crime scene graffiti
2. Suspect pen ink 1a
3. Suspect pen ink 1b
4. Suspect pen ink 2a
5. Suspect pen ink 2b

FIGURE 1.3.14c: Chromatogram of ink samples

Special separation

Samples of DNA gathered at crime scenes can be used to identify and eliminate suspects. The sample is treated with special chemicals and then injected into a gel. When an electric current passes through the gel, the components of the DNA separate and spread, just like the ink on the chromatography paper. This is called electrophoresis. The pattern that the DNA produces is unique to an individual person, like a fingerprint.

Scientists can use DNA 'fingerprints' to find out who you are related to. Your DNA fingerprint contains aspects of the DNA patterns of each of your parents.

7. Explain how DNA fingerprinting is similar to chromatography.
8. What are the differences between chromatography and electrophoresis?
9. What precautions would forensic scientists have to take when gathering and testing DNA evidence?

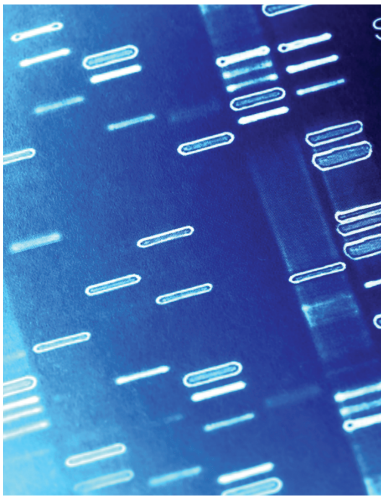


FIGURE 1.3.14d: DNA fingerprinting can help to rule suspects in or out.

Did you know...?

'Chroma' is the Greek word for colour.

Key vocabulary

forensic
reliable
chromatography
accurate
evidence

Finding the best solvent

We are learning how to:

- Choose the best solvent.
- Recognise hazards when using solvents.

Most graffiti artists use spray paints that cannot be washed away with water. To remove spray paint, a different solvent is needed to dissolve the paint.

FIGURE 1.3.15a: Some graffiti has become famous.

Solvent choice

There are many materials like spray paint and oil that are **insoluble** in water, so we need other **solvents** to **dissolve** them. For example, petrol is a very good solvent for oily stains and spray paint, but it is too dangerous to use because it is very flammable. Scientists use **hazard** symbols to highlight the risks of chemicals like solvents, see Table 1.3.15.

1. Why can we not simply wash away graffiti with water?
2. Which solvent would you choose to remove:
   a) nail polish from glass?
   b) ballpoint pen mark from a shirt?
   c) emulsion paint from paint brushes?
3. What hazards are involved when using solvents other than water?

FIGURE 1.3.15b: You can buy special stain removers.

TABLE 1.3.15: Properties of solvents

Solvent	It can dissolve	Hazards
water	sugar, food colours, emulsion paint	none
alcohol (ethanol)	ballpoint pen ink, perfume, herbs, spices	
acetone (propanone)	nail polish	
white spirit	grease, oil paint	

Careful choice

Tar stuck to the paint of a car is insoluble in water and difficult to remove. If you try to clean it off with solvents like acetone or white spirit, they will not only remove the tar, but also the paint on the car.

The choice of solvent is very important and must be selected by careful testing and checking. This is important for clothing too. If you use the wrong solvent you could damage the dyes and fabric.

4. What are the advantages and disadvantages of using tar and stone chippings on road surfaces?
5. Why might there be a problem in removing tar from a car?
6. Explain why there is a need to buy different stain removers when removing stains from clothing.

Clean and smelly

Dry cleaning uses a solvent called tetrachloroethene (C_2Cl_4) instead of water. The clothes are washed in the solvent at 30 °C before being tumbled in warm air (60 °C) to remove it. All the vapours produced are cooled and the condensed solvent is collected. Dry cleaners can recycle nearly 100 per cent of the solvent. This is important because the solvent is classified as highly toxic as well as harmful to the environment.

Alcohols like ethanol can dissolve colours, flavours and odours to make scented products like perfume. Alcohol evaporates easily, which is why perfume or aftershave dries so quickly on your skin. Liquids that evaporate quickly are described as **volatile**. This property allows us to smell substances, but it can also make solvents more dangerous. This is because the substances are more flammable and can enter the lungs quickly when they are vapours.

7. How is the dry-cleaning solvent recycled?
8. Why is it important that dry cleaners recycle as much solvent as possible?
9. What are the advantages and disadvantages of using a volatile solvent?

Did you know ...?

Metals can dissolve in each other to form alloys. Dentists used to use mercury alloys for fillings in teeth. Now most fillings are made from ceramics that avoid the possible harmful effects of metal alloys in your mouth.

FIGURE 1.3.15c: Perfume evaporates easily.

Key vocabulary

insoluble
solvent
dissolve
hazard
volatile

Modelling mixtures and separation

We are learning how to:

- Explain what happens to mass during dissolving.
- Use a circle model to explain dissolving and separation.

Architects use drawings and models to show how new buildings might look. These models are smaller, simpler copies of the real thing. Similarly, we can use a scientific **model** to help explain observations in science.

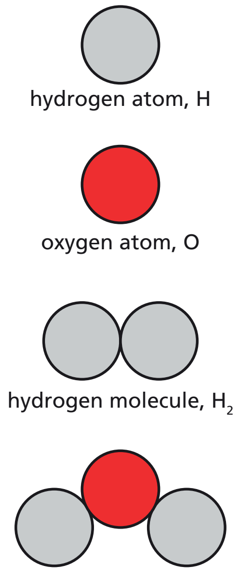


FIGURE 1.3.16a: Atoms and molecules represented by the circle model

Circle models of substances

A circle model helps us to understand the composition of substances. Each circle represents an **atom**. Different colours represent different atoms. When atoms bond together they form a **molecule**. If a molecule contains different types of atom it is called a compound. If a substance only contains one type of atom or molecule it is **pure**. Mixtures can contain any number or type of different atoms or molecules.

1. Why are circle models useful?
2. Draw circle models to represent:
   a) one atom
   b) a molecule consisting of two identical atoms
   c) a molecule consisting of two different atoms
   d) a mixture of different molecules.

Conservation of mass

When salt dissolves in water the crystals seem to disappear, but they are still there, mixed with the water molecules. This can be proved by measuring the mass of the substances. No atoms are lost and no new atoms are added. This is called the **Law of Conservation of Mass**.

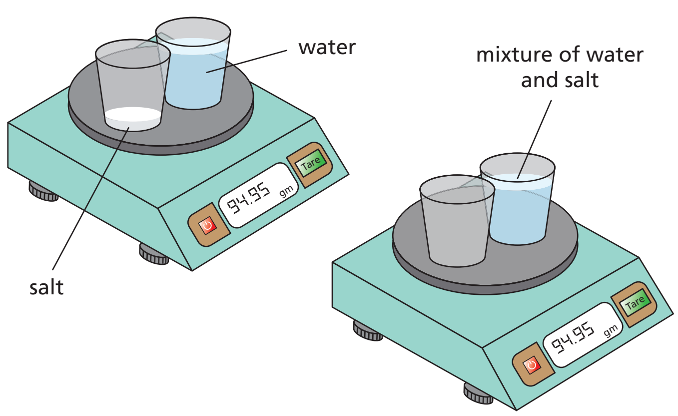


FIGURE 1.3.16b: The mass of water and salt on the first balance is the same as the mass of the mixture on the second balance.

3. What is a solution?
4. How does the mass of a solution show that the solute has not disappeared?
5. Draw diagrams, using the circle model, of a) salt and water, b) salt dissolved in water, to illustrate the Law of Conservation of Mass.
6. The same experiment was repeated, but this time the mass of the solution was lower than the original mass of the salt and water. What might have happened?

Modelling

In Figure 1.3.16c, showing filtration, the filtrate particles are drawn smaller to show that it can pass through the filter paper. Different colours are used to represent the different substances. The filtrate is a mixture of the smaller particles of two substances.

Models simplify a process to help explain how things work. You do not always need to see all the detail to understand what is happening.

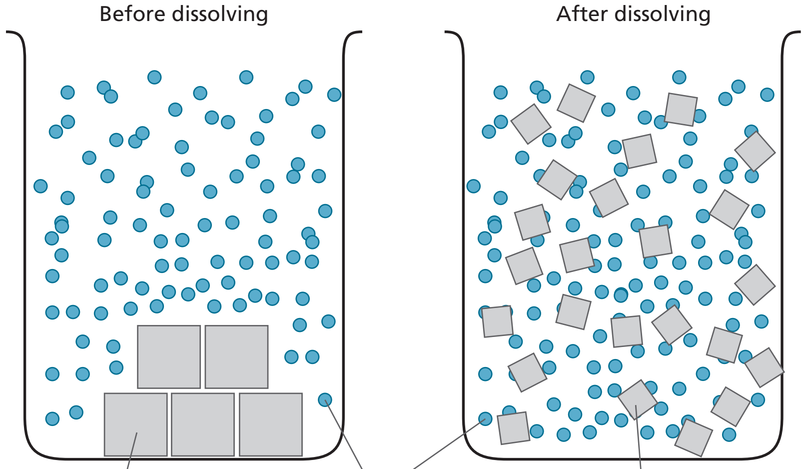


FIGURE 1.3.16d: This model shows dissolving.

7. In what ways is the model shown in Figure 1.3.16d a good one for dissolving?
8. How could this model be improved?
9. Draw a model to show:
   a) evaporation of water from salt solution
   b) separation of iron filings from sand.

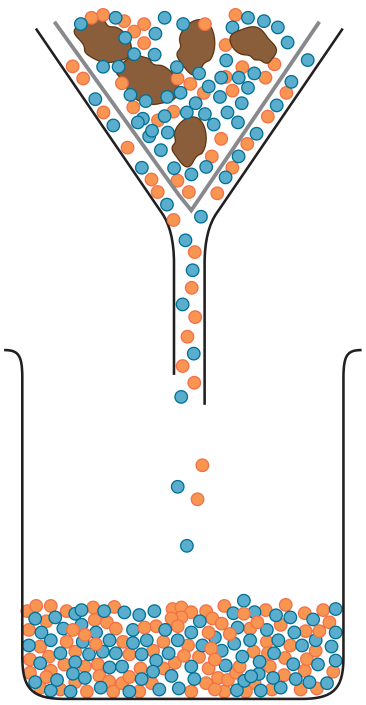


FIGURE 1.3.16c: A model of filtration

Did you know…?

Chocolate is a mixture. The ratio of cocoa, sugar, milk and fat is carefully controlled and blended so that the chocolate melts in your mouth at the right temperature.

Key vocabulary

model

atom

molecule

pure

Law of Conservation of Mass

193885_P086_121.indd 117 09/12/2013 15:07

Checking your progress

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

☐ Name and draw equipment and explain obvious laboratory risks.	☐ Select and draw apparatus accurately; explain safety precautions.	☐ Justify equipment choice and measurements; explain how to reduce risks.
☐ Use 2D images to represent a range of laboratory equipment.	☐ Use laboratory equipment safely to gather evidence.	☐ Record evidence in an effective way.
☐ Describe how to separate mixtures.	☐ Select and explain appropriate separation techniques.	☐ Explain the choice and method of separation using correct terms.
☐ Describe the process of dissolving and the effect of temperature.	☐ Describe methods for producing crystals of different sizes.	☐ Use data to draw conclusions about solubility.
☐ Understand that seawater is a mixture.	☐ Explain why most water is not pure, and why this is not necessarily a problem.	☐ Explain why contaminated water is a problem and identify what can be done about it.
☐ Identify sources and uses of salt.	☐ Describe how salt is extracted.	☐ Recognise advantages and disadvantages of salt extraction methods.

☐ Describe the process of distillation.	☐ Explain the physical processes involved in distillation.	☐ Identify the uses and advantages of distillation.
☐ Describe the composition of air.	☐ Identify sources of air pollution and their impact.	☐ Explain how distillation can be used to separate gases in air.
☐ Identify mixtures using chromatography.	☐ Explain how to separate a mixture using chromatography and interpret chromatograms.	☐ Use chromatograms to explain the composition of mixtures; compare chromatography and DNA analysis.
☐ Explain the idea of a solvent.	☐ Explain mass changes during dissolving; select solvents for different uses.	☐ Use a model to explain dissolving and separation; link the uses of solvents to their properties.

Questions

Questions 1–6

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

1. What is the chemical symbol for copper? [1]

a) Pc **b)** Co **c)** Cp **d)** Cu

2. What do we mean by an insoluble material? [1]

a) It will not dissolve. **b)** You cannot get it back after it has dissolved.
c) It dissolves other things well. **d)** It will dissolve easily.

3. Which are the two most common gases in the air? [2]

a) helium **b)** nitrogen **c)** carbon dioxide **d)** oxygen

4. Explain two ways in which you could reduce the risks when heating a substance in a test tube. [2]

5. You are trying to get a number of different stains out of your school bag. Give two reasons why you might need to use different stain removers for different stains. [2]

6. Explain how you could safely demonstrate that salt can be recovered from brine (salt water). [4]

Questions 7–12

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

7. A good way of separating a mixture of petrol and water is: [1]

a) distillation **b)** filtering **c)** crystallisation **d)** chromatography

8. Jared likes lots of sugar in his coffee. However, one day he forgets to drink it and tips the cold coffee away. He notices that the sugar has formed a sludge in the bottom of the mug, which he was surprised about because he knew he'd stirred it all in. What is the most likely explanation? [1]

a) If you leave it, sugar doesn't stay dissolved in a liquid for long.
b) Sugar is insoluble in coffee.
c) The sugar had reacted with the coffee.
d) Not as much sugar could dissolve in the cold coffee as in the hot coffee.

9. A sample of water was heated until it all evaporated and left a thin layer of white crystals behind. This proved that:

a) it was salt water **b)** it had something dissolved in it
c) it was pure water **d)** it was not fit to drink

193885_P086_121.indd 120 09/12/2013 15:07

10. Sally is trying to purify muddy water by filtering it. Which of these statements is *not* true? [1]

a) This will remove bits of silt that are floating in the water.
b) It will remove things that have dissolved in it.
c) The water will be clearer after filtering.
d) It will not remove soluble solids.

11. Marcus and Lisa are investigating how well different brands of sugar dissolve in water. Using Table 1.3.18a:

a) Explain what the results show. [2]
b) What do they have to do to make sure it is a fair test? [2]

TABLE 1.3.18a

Brand of sugar	Mass used (g)	Volume water (cm^3)	How many stirs to dissolve it all
Acme	10	100	14
Bonzo	10	100	8
Carefree	20	200	12
Delightful	20	200	7

12. Maisie has three different makes of black felt-tip pen and wonders if the manufacturers made their inks in the same way. Describe an experiment she could conduct to see if the three makes of ink all contain the same colours. [4]

Questions 13–14

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

13. James is conducting an investigation into how well a sweetener dissolves. What does the data in Table 1.3.18b tell you about the solubility of the sweetener at different temperatures? [2]

TABLE 1.3.18b

Temperature of water (°C)	20	30	40	50
Mass of sweetener that can dissolve (g)	120	135	155	180

14. A vet has been asked to find out if any of four horses, A, B, C and D, have been drugged. She takes urine samples from the four horses and arranges for a lab to prepare a chromatogram to test the samples. What do the results show? [4]

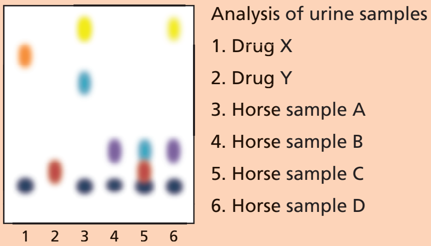


FIGURE 1.3.18: Chromatogram of horse urine samples

193885_P086_121.indd 121 09/12/2013 15:07