CHAPTER 4

Mixtures

Have you ever wondered ...

- where bubbles in a soft drink come from?
- where sugar goes when you stir it into tea?
- how recycled garbage is separated?
- where clean tap water comes from?

LS

After completing this chapter you should be able to:

- describe the differences between pure substances and mixtures
- identify examples of pure substances and mixtures
- identify the solvent and solute in solutions
- investigate and use filtration, decantation, evaporation, crystallisation, chromatography and distillation
- compare separation methods used in the home
- discuss the recycling of greywater and blackwater
- investigate everyday applications of filtering, sorting waste materials, reducing pollution, extracting products from plants, separating blood products and cleaning up oil spills
- describe how water use and management relies on technology
- investigate how science and technology have allowed us to treat water in industry and at home
- discuss issues relating to water use and management.

AB 4.1

MODULE 4.1

Types of mixtures

Most of the substances that you deal with every day are not pure substances; they are mixtures. The air you breathe is a mixture, as are an artist's paints and the water you get from a tap.

What is a mixture?

A **pure substance** is one that is made up of only one type of substance. For example, pure water is made of only water and refined sugar is made up of only sugar. In science, a **mixture** is any substance that:

- is made from two or more pure substances that have been stirred together
- can be separated back into its original pure substances.

Paints, soft-drinks, air and seawater are examples of mixtures.

Solutions

Watch carefully as sugar is stirred into water and the solid sugar will seem to disappear! The sugar has dissolved. The sugar breaks up into tiny particles that are too small to see. These particles then spread throughout the water. Although these sugar particles cannot be seen, if you taste the water the sweetness of the liquid tells you the particles are still there. This is what is meant when something is said to **dissolve**. A substance that dissolves like this is described as **soluble**. A substance that does not dissolve is described as **insoluble**.

When things mix really well, like when sugar dissolves in water, the mixture is known as a **solution**. When you stir sugar into water, you make a sugar solution.

AB 4.2 Prac 1 p. 146

PROBLEM

Can you undo water pollution?

YES

SUPPLIES

- small 500mL bucket of polluted water (including kitchen oil, food packaging)
- strainer, tongs, cardboard, wool, spoon, fabric, coat hanger, feathers, sponges, cotton balls

PLAN & DESIGN Design the solution. What information do you need to solve the problem? Draw a diagram. Make a list of materials you will need and steps you will take.

CREATE Follow your plan. Draw your solution to the problem.

IMPROVE What works? What doesn't? How do you know it solves the problem? What could work better? Modify your design to make it better. Test it out.

REFLECTION

1 What areas of STEM did you work in today?
2 What career is this activity related to?
3 If another student was to do this task, what advice would you give?

Solutes and solvents

When you make a solution, the substance that dissolves is known as the **solute**. In a sugar solution, the sugar is the solute. The substance that dissolves the other one is the **solvent**. So in this case the water is the solvent.

The soft drink in Figure 4.1.1 has sugars, preservatives and flavourings dissolved in water. There is also carbon dioxide gas dissolved in it to give the drink its bubbles. This shows that solutes don't always need to be solid. Table 4.1.1 shows other types of solutions made by combining solvents with solutes.

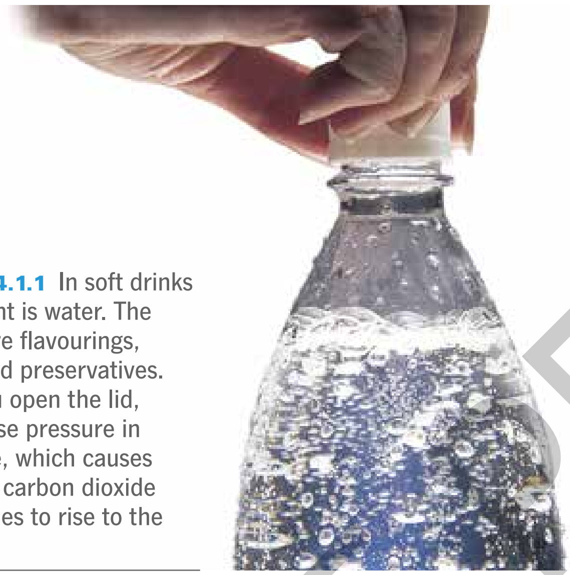


FIGURE 4.1.1 In soft drinks the solvent is water. The solutes are flavourings, sugars and preservatives. When you open the lid, you release pressure in the bottle, which causes dissolved carbon dioxide gas bubbles to rise to the surface.

TABLE 4.1.1 Common types of solutions

Type of solution	Examples
solid dissolved in a liquid	grease dissolved in petrol, sugar dissolved in water
liquid dissolved in another liquid	liquid detergent dissolved in water, oil dissolved in petrol
gas dissolved in a liquid	oxygen gas dissolved in water, oxygen gas dissolved in blood
gas dissolved in another gas	oxygen gas, carbon dioxide gas and water vapour dissolved in the other gases of the air

Most of the solutions you will meet in science and at home are aqueous solutions. An **aqueous solution** always has water as its solvent. Sugar dissolves in water, so a sugar solution is classified as an aqueous solution. Likewise, soft drink is an aqueous solution of sugars, preservatives, flavouring and carbon dioxide.

A particular solute will dissolve in some solvents and not in others. For example, grease will not dissolve in water but will dissolve in methylated spirits, petrol, turpentine and the fluids used by drycleaners. Particular solvents will dissolve some substances and not others. For example, water will dissolve detergent, but not oil. You can see this in Figure 4.1.2.

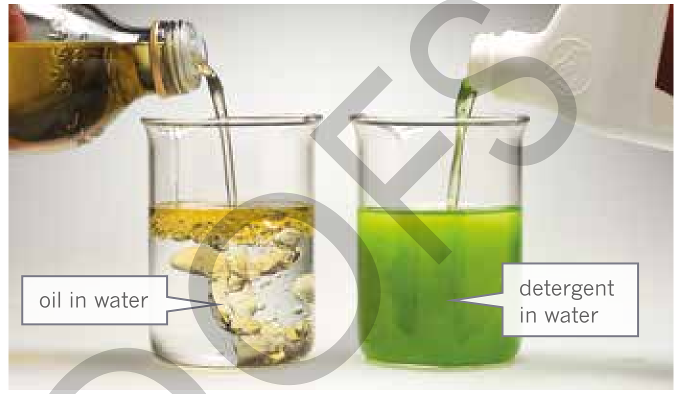


FIGURE 4.1.2 Oil will not dissolve in water but detergent will dissolve in water.

Solution or not?

Light passes easily through a solution, allowing you to see through it. This is one way of telling whether a mixture is a solution or not. Solutions are transparent (see-through). You can describe solutions such as this as 'clear', meaning you can see through them.

Solutions can be colourless, looking much like water. Other solutions are coloured. For example, blue copper sulfate solid dissolves in water to form a blue-coloured solution. You know that a solution has been formed because you can see straight through it. You can see its preparation in Figure 4.1.3.

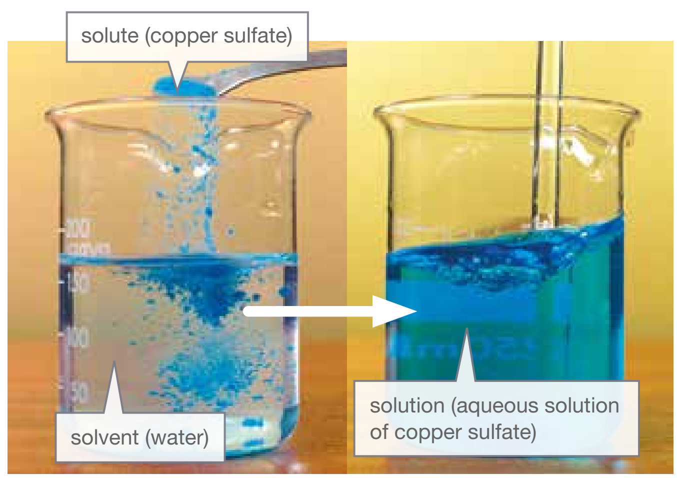


FIGURE 4.1.3 Preparation of an aqueous solution of copper sulfate

Colourless and clear are not the same. Clear means that you can see though it. Colourless means it is not coloured. Figure 4.1.4 helps explain these different meanings.

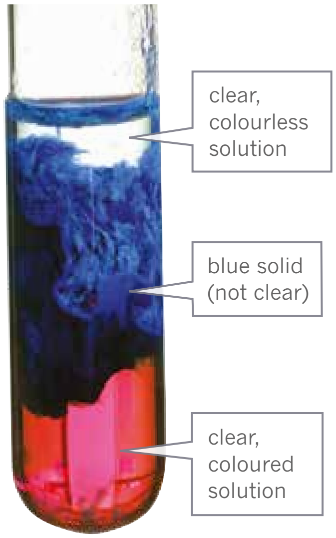


FIGURE 4.1.4 Solutions can be coloured or colourless and are always transparent. You can see through them.

Concentrated, dilute and saturated solutions

A solution is said to be **concentrated** if there is a lot of solute dissolved in the solvent. If there is only a little solute in the solution, then it is a **dilute** solution. Four spoonsful of sugar dissolved in a swimming pool will produce a dilute solution. In contrast, four spoonsful of sugar in a cup of tea will make it concentrated. A concentrated solution and a dilute solution are shown in Figure 4.1.5.

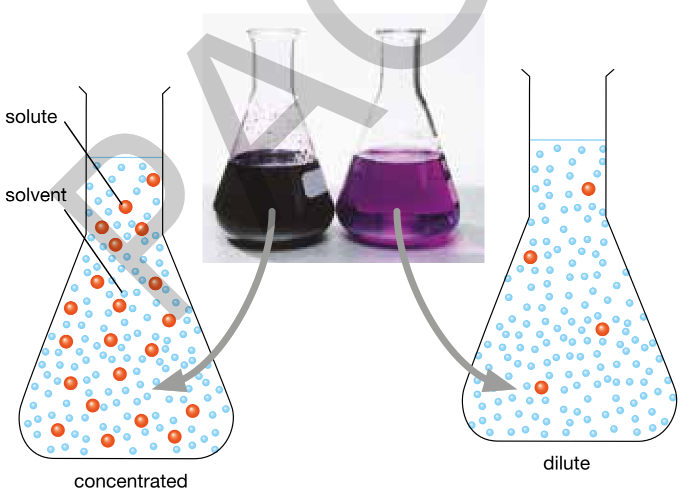


FIGURE 4.1.5 Concentrated solutions have a lot of solute dissolved in them while dilute solutions have very little.

Imagine you took a glass of water and kept adding spoonsful of salt to it, stirring each time. You would find that eventually the salt would stop dissolving. When a substance will no longer dissolve in a solvent, the solution is said to be **saturated**. Any undissolved solute then falls to the bottom as sediment. This is shown in Figure 4.1.6.

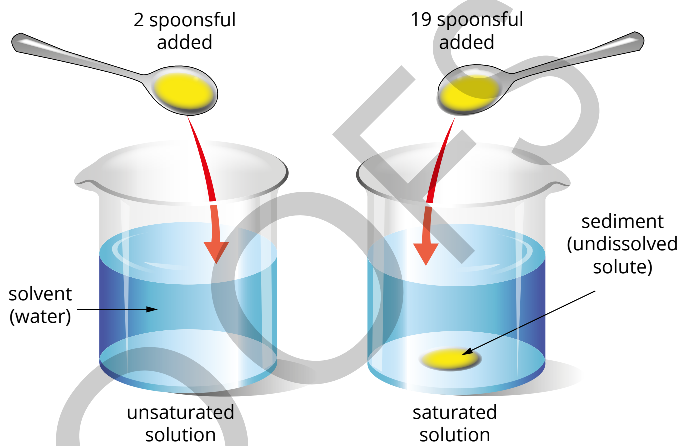


FIGURE 4.1.6 The concentration of a saturated solution is so high that no more solute will dissolve.

An example of saturation is seen in saltwater lakes sometimes found near the sea and in the outback. The concentration of the salt in the lakes increases as water evaporates. Eventually, the lake becomes saturated and solid salt is deposited (left behind) around the edges of the lake (see Figure 4.1.7).

FIGURE 4.1.7 Salt deposits around the edges of Lake Gairdner in South Australia

Prac 2 p. 147
Prac 3 p. 148
AB 4.3

Suspensions

Sand does not dissolve when it is mixed into water. Instead it stays solid and spreads throughout the water. This type of mixture is called a **suspension**. In suspensions, substances like sand do not dissolve but **disperse** (spread) through a liquid or gas. Figure 4.1.8 shows dust floating in the air. This is another example of a suspension. Usually, the suspended particles are too large and heavy to stay in suspension and will fall and settle if left undisturbed. Sand mixed into a beaker of water will, after a while, settle on the bottom of the beaker. In the same way, dust in the air eventually drops to cover floors and other surfaces. Table 4.1.2 lists some different types of suspension.

TABLE 4.1.2 Types of suspensions

Type of suspension	Examples
solid suspended in a liquid	muddy water, sand in water
solids suspended in a gas	sand blown about in the air by the wind
liquids suspended in another liquid	oil paints, many medicines

FIGURE 4.1.8 Dust floating in the air forms a suspension of a solid (dust) in a gas (air). Eventually, the dust will settle onto the furniture and floor.

AB 4.4

SciFile

Shake your bottle

Mylanta is an antacid liquid that eases heartburn. Like many medicines, it needs to be shaken up before you take it. If you don't, then one of the important ingredients might remain as a sediment on the bottom of the bottle and so you would receive an incorrect dose.

Working with Science

GREEN CHEMIST

Dr Deanna D'Alessandro

Green chemistry is a new and exciting field that aims to find environmentally responsible ways of making and using chemicals. Dr Deanna D'Alessandro works at the University of Sydney developing materials that create solutions for environmental problems. Dr D'Alessandro works in a laboratory with a team of scientists and students. One of her projects is developing materials called metal-organic frameworks that work like sponges, soaking up liquids and gases. These materials can be used to capture gases from the atmosphere, such as carbon dioxide or methane, or store hydrogen to fuel cars. Dr D'Alessandro is excited about making discoveries that can solve problems in the real world.

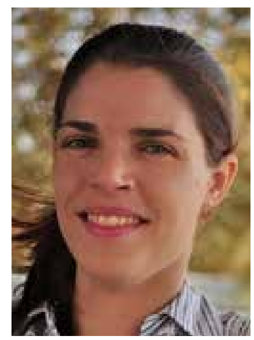


FIGURE 4.1.9 Dr Deanna D'Alessandro

To become a green chemist, you will need a Bachelor of Science, majoring in chemistry. After your degree, you can work in the industry or continue studying and become a researcher. A keen eye for detail, love of solving problems and curiosity about the world around you are great qualities to have as a green chemist.

Review

1. Why is green chemistry an important area of research in today's world?
2. What other types of scientists might a green chemist work with?

MODULE **4.1** # Review questions LS

Remembering

1 Define the terms:
   a mixture
   b dissolves
   c soluble
   d aqueous
   e dilute.

2 What term best describes each of the following?
   a a substance that will not dissolve in a liquid
   b a clear mixture in which a substance dissolves in water
   c a mixture that has a lot of substance dissolved in it
   d a mixture that cannot dissolve any more of a substance
   e a mixture in which a fine powder does not dissolve but separates out to form a sediment.

3 List two examples each of a solute, a solvent and a solution.

4 What are four types of solution? Give an example of each.

5 List three types of suspension and give an example of each.

6 Name a solvent that will dissolve:
   a sugar
   b grease.

Understanding

7 Cooking oil breaks into lots of small droplets when added to water, but seems to 'disappear' when added to detergent. Explain why.

8 Mylanta is an antacid liquid used to relieve 'heartburn'. Why do you think the label tells you to shake the bottle well before using it?

9 Outline how you could show that a sugar solution is just saturated.

10 What types of mixtures might be present in a polluted water sample such as that used in in the STEM 4 Fun activity on p.139?

Applying

11 A chef dissolved salt in boiling water that he was going to use to cook pasta. Identify whether the salt, water or salty water was the:
   a solute
   b solvent
   c aqueous solution.

Analysing

12 a Compare a concentrated glass of cordial with a dilute glass of cordial.
   b What would the two solutions taste like?

13 Compare a sugar solution with a suspension of sand in water.

14 Classify each of the following as a solution or a suspension.
   a cordial in water
   b carbon dioxide gas in lemonade
   c clouds
   d food colouring in water
   e dust in air
   f smoke from a car exhaust.

Evaluating

15 Fiona found that 10 mL of water tasted just as sweet whether she mixed 5 teaspoons or 10 teaspoons of sugar into the liquid. Propose an explanation for this.

16 Figure 4.1.10 shows milk being poured into salt water.
   a Identify which substance is the solution.
   b Justify your answer.

FIGURE 4.1.10

MODULE 4.1

Review questions

17 Vitamin C is soluble in water. Vitamins A, D and K are soluble in oils. Chefs recommend that:

- vegetables are not soaked in water before or during cooking
- steaming or microwaving is better than boiling.

One reason for these recommendations is to stop heat destroying the vitamins. Propose another reason.

18 Solutions are transparent. This means that there are no particles in the solution big enough to reflect or scatter the light as it passes through. Figure 4.1.11 shows two test-tubes A and B that contain different mixtures. Green and red lights are shone through both.

a Identify the test-tube that contains a solution.

b Justify your choice.

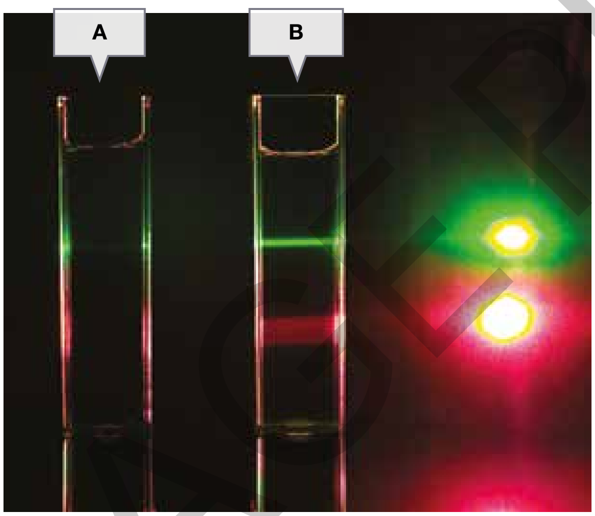


FIGURE 4.1.11

19 Figure 4.1.12 shows beams of sunlight passing through foggy air.

a Identify whether the air is a solution or a suspension.

b Justify your answer.

FIGURE 4.1.12

20 Two students, Dean and Erin both tested how well copper sulfate crystals dissolved in water. Dean used tap water, while Erin used distilled water. They each added copper sulfate a spoonful at a time, stirring each time to see if it dissolved. Dean used copper sulfate from a fresh jar, while Erin used recycled copper sulfate from other experiments. They each counted the number of spoons they added until the solutions became saturated.

a Predict whether Dean and Erin are likely to get the same result.

b Evaluate whether this is a fair test.

c What do you think Dean and Erin could have done to improve their experiments?

MODULE 4.1

Practical investigations

1 • Soluble and insoluble substances

Processing & Analysing

Evaluating

Purpose

To investigate what substances will dissolve in water and kerosene.

Timing 45 minutes

Materials

- ½ spatula copper carbonate ($CuCO_3$)
- ½ spatula copper sulfate ($CuSO_4$)
- 1 spatula table salt (NaCl)
- cooking oil in dropping bottles
- 6 mL kerosene

- 6 medium-sized test-tubes with stoppers to fit
- test-tube rack
- marking pen or sticky labels
- spatula

SAFETY

A Risk Assessment is required for this investigation.

Copper sulfate and copper carbonate are toxic so do not touch, sniff or taste them.

Kerosene is flammable and should be kept away from naked flames. Wear safety glasses and rubber gloves at all times to avoid contact with your skin and eyes. Avoid inhaling fumes by doing the activity in a well-ventilated area.

Procedure

1. Copy the table in the Results section into your workbook.
2. Place the test-tubes in the rack. Use the marking pen or sticky labels to number them 1 to 6.
3. Add about 5 cm of tap water to test-tubes 1 to 4. Pour 3 cm of kerosene into test-tubes 5 and 6.
4. Add different solutes to the different test-tubes as shown in Figure 4.1.13.
5. Place a stopper in each test-tube. Shake each of the test-tubes for about 1 minute. Place all the test-tubes in the test-tube rack and record what you see.
6. Do not tip anything down the sink. Return all test-tubes and liquid to your teacher.

Results

1. Record your observations in the following table. Give your table a title.

Test-tube number	Solvent	Solute	Observation
1	water	copper carbonate	
2	water	copper sulfate	
3	water	salt	
4	water	oil	
5	kerosene	oil	
6	kerosene	salt	

Review

1. How did you tell if a solution formed? What signs did you look for?
2. In which test-tubes did a solution form?
3. Name the substances that were insoluble in:
   a. water
   b. kerosene.
4. Identify the substance that is:
   a. a solvent of salt but not of oil
   b. a solvent of copper sulfate but not copper carbonate.

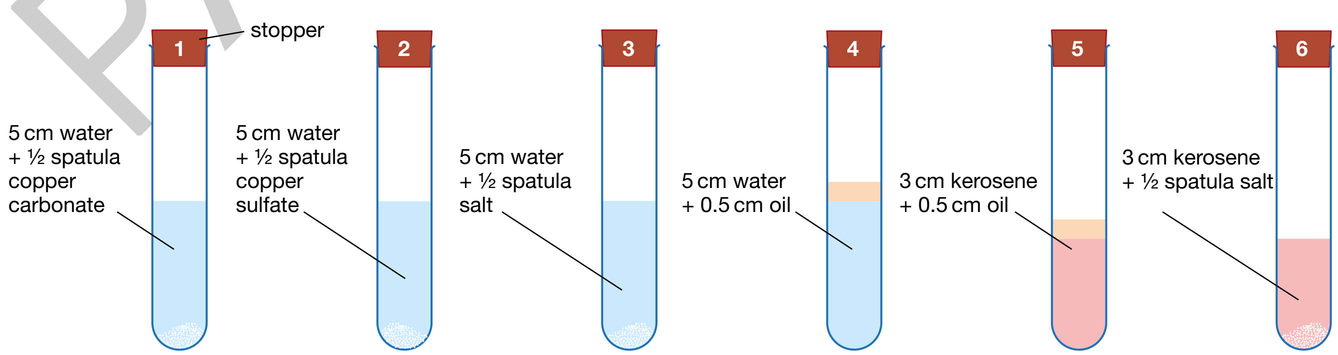


FIGURE 4.1.13

MODULE 4.1 Practical investigations

• STUDENT DESIGN •

2 • Dissolving and surface area

Planning & Conducting

Evaluating

Purpose

To test whether breaking up a solute into smaller particles can change how fast it dissolves.

Hypothesis

Which do you think will dissolve faster—a whole Sugarine® tablet or a crushed Sugarine tablet? Before you go any further with this investigation, write a hypothesis in your workbook.

Timing

45 minutes

SAFETY

A Risk Assessment is required for this investigation.

Materials

- 2 Sugarine tablets
- 2 test-tubes and stoppers
- paper patty case
- 1 metal spoon
- Method for timing the reaction such as a stopwatch, smart phone or tablet to film the experiment and then review to check the time. (optional)

Procedure

1. Design an experiment that will test whether a crushed Sugarine tablet dissolves faster or slower than a whole Sugarine tablet. Figure 4.1.14 might give you some ideas on how to do this.

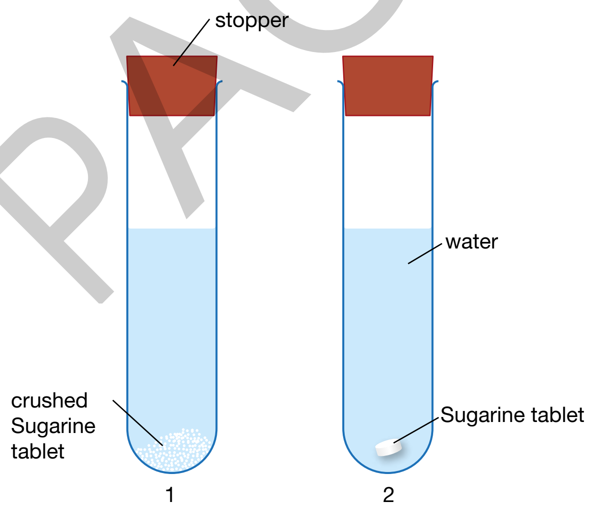


FIGURE 4.1.14

2. Write your procedure in your workbook.
3. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

- Crush the tablets in the patty case to stop them spreading
- You should use the same size test-tubes with the same amount of water in each.
- You only need to find out which tablet dissolves faster—you do not need to find the exact time each tablet takes to dissolve.

Results

Record which tablet (whole or crushed) dissolved first. If you measured the time taken for each to dissolve, then record the times as well.

Review

1. List the variables that you controlled (kept constant) during this experiment.
2. Which variable did you change?
3. a. Construct a conclusion for your investigation.
   b. Assess whether your hypothesis was supported or not.
4. In this investigation, it was not necessary to measure the length of time it takes for the two tablets to dissolve. Explain why.
5. You sometimes take an aspirin tablet or capsule when you have a bad headache. Capsules contain roughly the same amount of aspirin as a tablet. However, a capsule has its aspirin as small particles held in a shell that dissolves when you swallow it.
   a. Which would you choose to relieve your headache faster – a capsule or a tablet?
   b. Justify your choice.

MODULE

4.1 Practical investigations

• STUDENT DESIGN •

3 • Investigating dissolving

Planning & Conducting

Questioning & Predicting

Purpose

To investigate how things dissolve.

Hypothesis

Once you have decided which investigation to perform, write a hypothesis in your workbook.

Timing 45 minutes

Materials

Students to choose from:

- sugar
- copper sulfate ($CuSO_4$)
- salt
- 3 varieties of liquid dishwashing detergent
- source of grease (such as oil)

SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that will answer **one** of the following questions.
   - Can sugar and copper sulfate both dissolve in the same container of water?
   - Is the amount of salt that can dissolve in water more or less than the amount of sugar that can dissolve in the same volume of water?
   - Can copper sulfate dissolve in a saturated solution of salt?
   - Are all dishwashing liquid detergents equally good at dissolving grease?

2 Write your procedure in your workbook. Include a diagram of your design for your experiment

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

4 Dispose of all residues from experiments as directed by your teacher.

Results

Record your results and observations in your workbook.

Review

1 Construct a conclusion for your investigation.

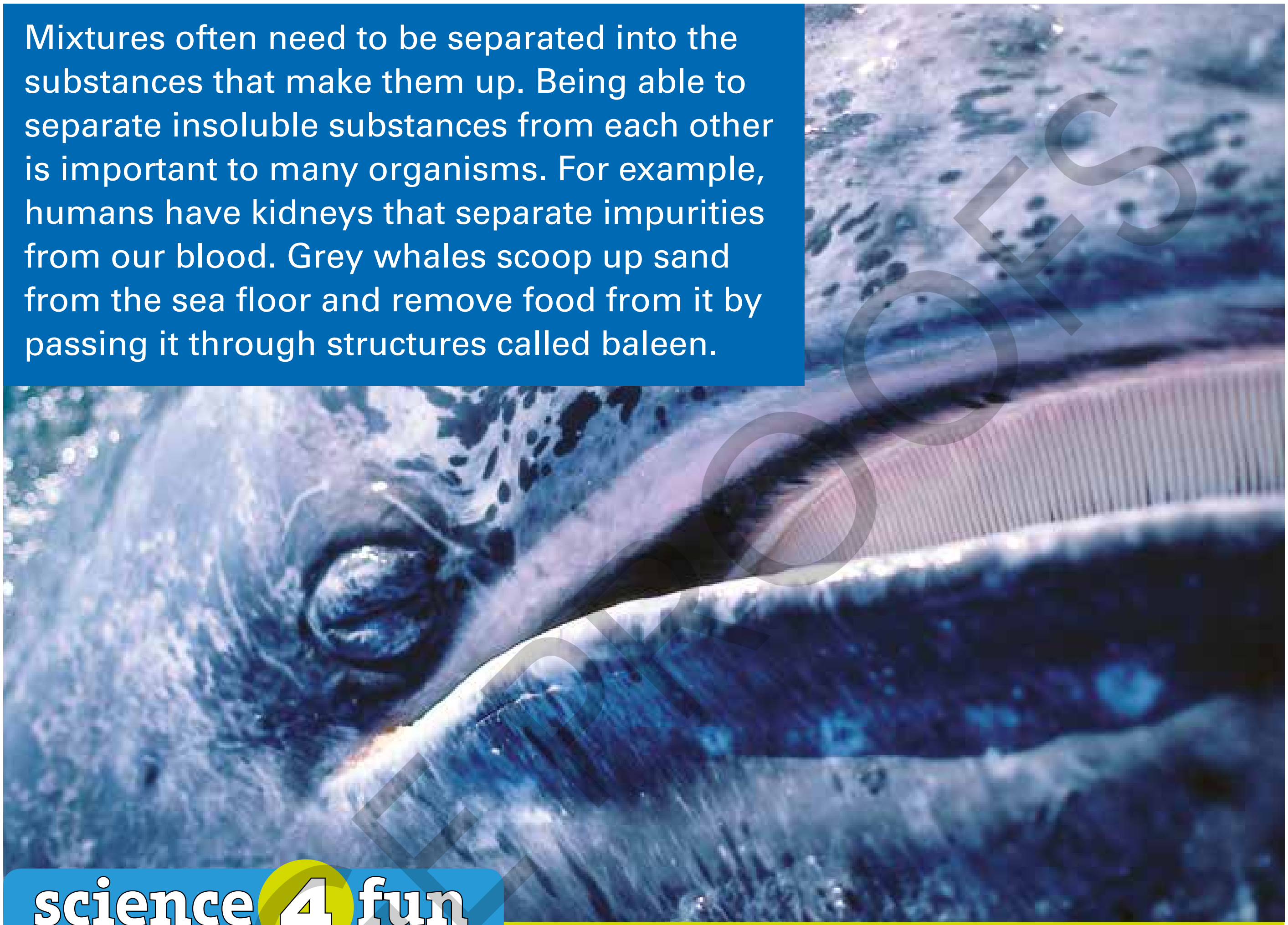
2 Assess whether your hypothesis was supported or not.

FIGURE 4.1.15 Copper sulfate crystals

MODULE 4.2

Separating insoluble substances

Mixtures often need to be separated into the substances that make them up. Being able to separate insoluble substances from each other is important to many organisms. For example, humans have kidneys that separate impurities from our blood. Grey whales scoop up sand from the sea floor and remove food from it by passing it through structures called baleen.



science 4 fun

Panning for gold

YES

Could you find gold?

Collect this ...

- metal bowl or old cereal bowl (shallow with gently sloping sides)
- fairly clean sand or loam soil
- small metal objects such as nails or washers
- bucket of water or hose

Do this ...

1. The small metal objects are your 'gold'. Mix them up with the soil and put the mixture in the bowl.
2. Half fill the bowl with water.
3. Hold the bowl with a hand on each side. Move the bowl around in a circular motion to swirl the water through the soil. The soil should start lifting up into the water.
4. Let the water wash over the sides of the bowl as you move it around. The aim is to wash some of the soil out of the bowl with the water.
5. Keep adding water and swirling the soil around so it is gradually removed from the bowl. You should see the 'gold' collecting on the bottom of the bowl.
6. See how pure you can get the 'gold'. You may have to practise to improve your technique.

Record this ...

Describe what happened.

Explain why you think this happened.

Magnetic separation

Your recycle bin at home contains a mixture of solids. It probably contains steel cans, glass jars, aluminium cans, paper, cardboard, plastic bottles and packaging. After collection, this mixture needs to be separated so that the different substances can be recycled and then re-used.

Magnets are a convenient way of separating any rubbish made of iron or steel. Iron is always attracted to magnets. As steel is made from more than 95% iron, it too is attracted to magnets. Magnets also attract the metals nickel and cobalt, but do not attract other metals such as aluminium, copper or gold or substances such as plastic, paper or glass.

Magnetic attraction allows iron and steel to be easily removed from piles of rubbish, leaving the non-magnetic materials behind. One way in which magnets are used to separate rubbish is shown in Figure 4.2.1. Magnetic separation is also used in the mining industry and in the scrap metal business.

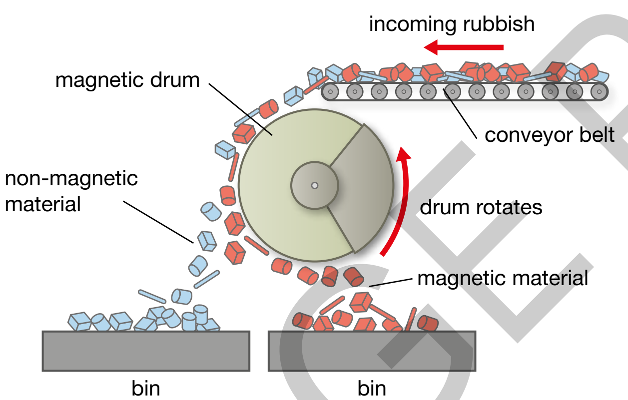


FIGURE 4.2.1 A rotating drum can be used to separate magnetic materials from rubbish.

FIGURE 4.2.2 Panning for gold uses gravity separation.

Gravity separation

Not all mixtures contain a collection of solids like those in your recycle bin. Many mixtures are suspensions which contain insoluble solids dispersed through a liquid. **Gravity separation** uses gravity to separate heavier substances from a suspension. The heavier particles sink to the bottom of the container. Gold panning uses gravity separation. As Figure 4.2.2 shows, the heavier and denser particles drop to the bottom of the pan, allowing the lighter, less dense mud and water to be poured off. Hopefully, gold will be down among those heavier particles!

Decantation is a type of gravity separation that lets suspensions of solids or liquids separate naturally. The top layer can then be poured or scraped off. After vegetables are cooked in a saucepan of water, the water is poured off. This is decanting. If a bottle of wine is left standing up for a long time, sometimes sediment collects at the bottom of the bottle. If you pour the wine into a glass container (decanting), the sediment remains behind in the bottle.

Decantation can separate:

- oil and water—water sinks to the bottom with a layer of oil on top
- leaves and soil—soil falls to the bottom, with leaves on top
- rocks and water—rocks sink to the bottom with water covering them.

Decanting is used in many industries. Figure 4.2.3 shows how decanting can be used in science laboratories.

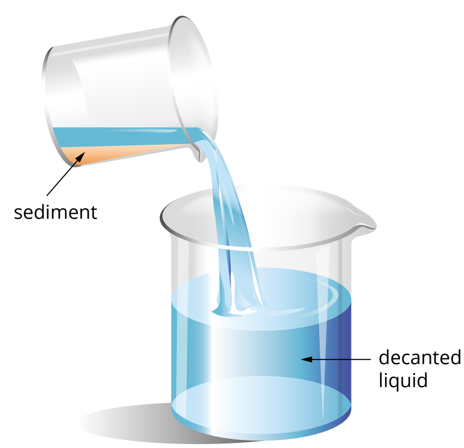


FIGURE 4.2.3 Decanting pours off the liquid to leave the solids behind.

Sieving

A sieve is a barrier with holes in it. Small solid particles can get through, but large ones cannot. The process is called sieving. Sieves are common in the kitchen. For example, lumps of flour are removed before baking by sifting the flour through a sieve called a flour sifter. A colander is a sieve that strains water from cooked vegetables and pasta and the wire basket in Figure 4.2.4 strains hot oil from the chips once cooked.

FIGURE 4.2.4 The wire basket chips are cooked in is a type of sieve.

Sieves are also used in industry and their holes can be graded to a specific size for the job they do. For example, a fishing net may be able to catch large fish but allows smaller fish and water to pass through. Sieves are used to separate apples into different sizes and are used in mining to ensure that only rocks of the correct size enter a rock crusher.

Filtration

Filtration, also known as filtering, is a widely used method of separating solids from liquids.

Filtration uses a **filter**. A filter is like a sieve in that it is a barrier with many, many small holes in it. These holes are smaller than the particles being separated and so these particles get caught in the filter. However, smaller particles pass straight through. Filters can take different forms, such as a mesh of fine fibres (like cotton wool) or even a rock that has fine pores (small holes). The larger particles that are trapped in the filter are known as the **residue**. The smaller particles (usually water) that pass through the filter are known as the **filtrate**.

SciFile

Human filters

Your kidneys filter your blood removing wastes and producing urine. Your whole blood supply passes through your kidneys in about 1 hour. This means your blood has passed through your kidneys about 24 times in a day. From this you make about 1 litre of urine.

Filters are commonly used in everyday life. Filters are used to separate coffee grounds from filter coffee. Likewise, tea bags are a type of filter that allows water to move through them while keeping the tea leaves in the bag. Filters remove fluff from the water in washing machines and leaves from swimming pools. In cars, filters remove dirt and metal particles from the oil lubricating its engine and transmission.

Filters can also be used to separate solids from gases. The face mask shown in Figure 4.2.5 is a filter that separates dust from air. A similar filter is used in most vacuum cleaners. The filtered, clean air is then blown back into the room. Air conditioners, clothes dryers and air cleaners use filters to ensure the air is clean and free of dust and fluff.

Filters are also used in the laboratory. Several different methods are used, but the most common uses filter paper.

FIGURE 4.2.5 Builders, painters and plasterers work in dusty environments so they often wear face masks to stop dust entering their airways.

STEM 4.2 AB 4.5

SkillBuilder

Folding a filter paper

There are two methods to fold filter paper. The conical fold is shown in Figure 4.2.6.

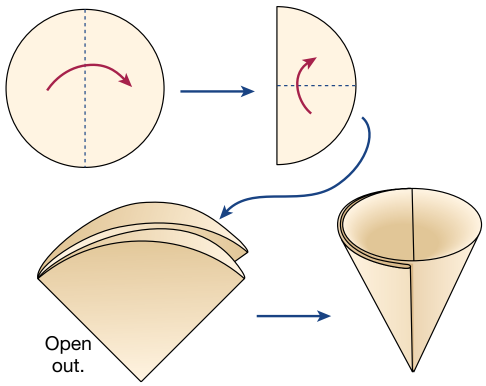


FIGURE 4.2.6 How to make a conical fold for filter paper

The other method of folding is called fluting. This is shown in Figure 4.2.7.

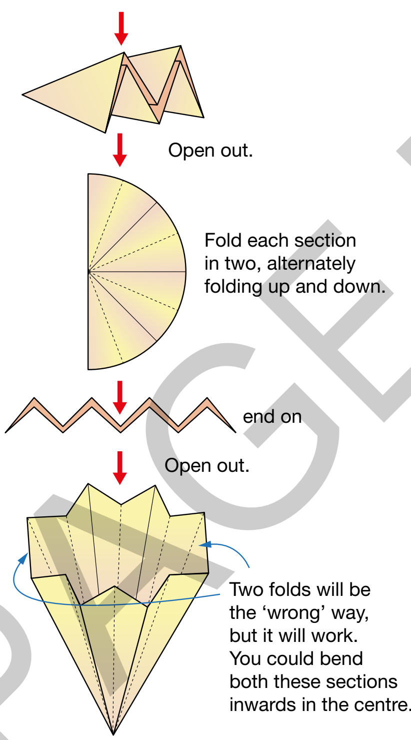


FIGURE 4.2.7 How to fold a fluted filter paper

Fluting increases the surface area of paper in contact with the liquid that is being filtered. This speeds up filtering because it provides more spaces for the liquid to escape through. This is useful when filtering fine suspensions that can block holes in the filter paper.

SkillBuilder

How to filter

To filter, set up the equipment as shown in Figure 4.2.8.

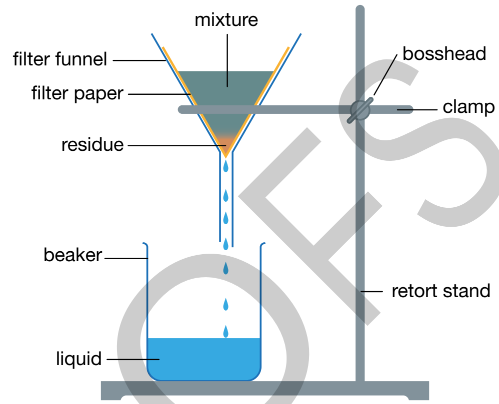


FIGURE 4.2.8 A retort stand and clamp is being used here but special filter stands can be used instead.

Some things to remember when filtering are:

- Solids will enter the filtrate if you let the liquid go over the top of the paper
- The paper will break if you touch the filter while filtering.

AB 4.5

Prac 1 p. 156

Prac 2 p. 157

Centrifuging

A simple **centrifuge** is shown in Figure 4.2.9. It has chambers arranged around the rim of a spinning tub. Any tiny particles suspended in the liquid are forced to the sides and then to the bottom of each chamber. The spinning process is called centrifuging.

FIGURE 4.2.9 A simple centrifuge is used to separate substances in the laboratory.

A common use of a centrifuge is in the spin cycle on a washing machine, in which the clothes are spun very fast in the bowl. Figure 4.2.10 shows how this works. Water is forced out of the clothes and through the holes in the bowl. It then drains away and is pumped out of the machine. In a similar way, salad spinners are used in the kitchen to dry washed lettuce.

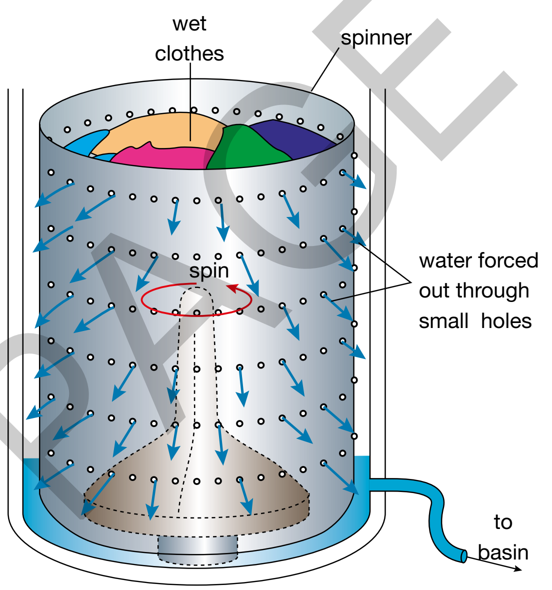


FIGURE 4.2.10 A washing machine spin cycle acts as a simple centrifuge.

There are many other designs for centrifuges. Some very complicated ones are used in mining. Centrifuging is also widely used in laboratories.

Centrifuging blood

Blood and its parts are very important in health care. After a serious accident or during surgery, people might need to receive a transfusion of whole blood. Sometimes only parts of blood are needed, such as red or white blood cells or liquid plasma (Figure 4.2.11). Whole blood can be separated into these parts by centrifuging. These parts can then be used directly or further separated to treat particular health conditions.

Plasma is used to treat burns patients. Some other conditions don't require plasma but instead need particular chemicals extracted from it. For example, chemicals called clotting factors are extracted from plasma to treat people who have haemophilia. Patients with this disease can bleed to death because their blood does not clot (thicken) to seal a cut.

Patients with anaemia have insufficient red blood cells in their blood. They can be given whole unseparated blood but this can stress their heart if they also have heart problems. Instead, they are given transfusions of red blood cells because these place less stress on the heart.

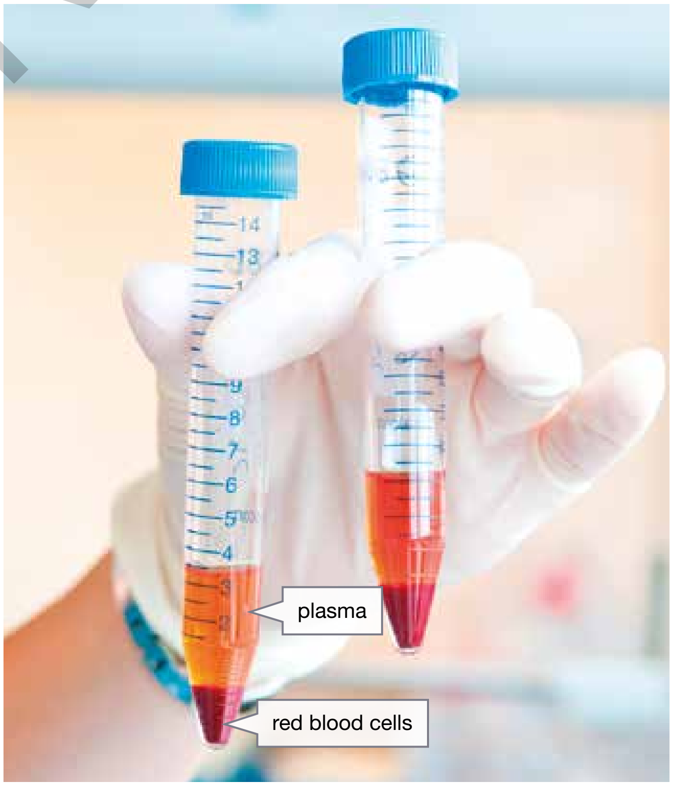


FIGURE 4.2.11 Blood that has been centrifuged separates out into layers.

AB 4.6
Prac 3 p. 157

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Ocean bins

Two surfers from Perth have come up with a smart way to get rubbish out of marine environments. Andrew Turton and Pete Ceglinski grew up surfing. Their love of the ocean inspired them to clean it up and the idea for the Seabin came to life.

Ocean pollution

Ocean pollution is a growing environmental problem. Ocean pollution is shown in Figure 4.2.12. Scientists have estimated that around 8 million tonnes of plastic rubbish goes into the oceans every year. It is thought that up to 245,000 tonnes of plastic is currently floating on the ocean surface. As well as plastic, there is also pollution from oil spills, sewage and toxic chemicals. This pollution is having serious impacts on ocean life, human health and use of the ocean. Ways to combat ocean pollution include improving waste management and increasing efforts to capture and dispose of ocean pollution.

The Seabin solution

The Seabin is a floating bin that sucks rubbish into it like a vacuum cleaner (Figure 4.2.12). The bin is attached to a pier where a pump works to suck water and rubbish into a mesh bag, trapping the rubbish.

The reusable mesh bag is easily lifted out and the rubbish disposed of. The water flows out of the bottom of the bin, up through the water pump and back into the ocean. A filter can be attached to the pump to separate oil from the seawater. Fish and other marine animals swim below the water that is sucked through the Seabin so are not likely to be captured. The diagram in Figure 4.2.13 shows the simple set up of the Seabin.

The Seabin collects anything that floats near it, such as plastic bags, bottles, paper and oil. The inventors hope to recycle the plastic rubbish collected by the Seabins, and turn it into material to make more Seabins! The Seabin can operate all day, every day of the year.

REVIEW

1. Why are inventions like the Seabin so important?
2. The Seabin can remove oil from seawater. What properties of oil and water allow them to be separated?
3. What other ways can science and our understanding of water and pollutants help to remove rubbish from the oceans?

MODULE

4.2 Review questions

Remembering

1 Define the terms:
  a sieve b gravity separation.

2 What term best describes each of the following descriptions?
  a sieve with many small holes in it
  b a machine with chambers spun at speed around an axle.

3 List examples of sieving and filtering around your home.

4 What is an example of centrifuging that is used at home?

5 What are two methods that can be used to separate a:
  a solid from another solid?
  b solid from a liquid?
  c liquid from another liquid?

6 Draw a diagram that shows how to set up equipment for filtration.

Understanding

7 Outline how magnetic separation can be used to separate magnetic and non-magnetic metals from household rubbish.

8 Explain why particles of gold fall to the bottom of the pan when panning for gold.

9 a Describe what a paper filter would look like if you could magnify it enough.
  b Explain how filter paper works to filter out particles.

10 Filtration will not separate sugar from water. Explain why.

11 Construct a table in which you:
  a list each of the five methods of separation in this module
  b describe how each method works
  c specify an example where it may be used.

Applying

12 Identify a method of separation that could be used for the following situations.
  a You want fine clean sand without any sticks or stones from the soil in your garden.
  b You drop nails into the sand in your backyard.
  c You drop hundreds-and-thousands into the flour a baker is using for a cake.
  d The gravel border along the driveway is covered by bark, and leaves and fine sticks are mixed with the gravel.
  e Your tea bag breaks in your cup of tea.

13 Compare:
  a gravity separation and centrifuging
  b sieving and filtering
  c the two methods of folding filter papers.

Analysing

14 Car air cleaners are structured as shown in Figure 4.2.14.
  a Compare the air cleaner with a fluted filter paper.
  b Describe why this design is effective as an air cleaner.

FIGURE 4.2.14

Evaluating

15 Propose a reason why vehicle air, fuel and oil filters need to be changed regularly.

16 Some washing machines do some test spins before starting the spin-dry cycle. After doing this, the machine may not spin the clothes but instead agitate them back and forth for a while, before trying another test spin. Propose a reason why the machine has been designed to do this.

Creating

17 Design an experiment to test whether cold water from a refrigerator filters faster than warm tap water.
  a Which do you think will filter faster?
  b Draw a diagram(s) to show how you intend to carry out your experiment.
  c Describe the procedure you intend to use.
  d Identify the independent variable, dependent variable and controlled variables.
  e How will you make sure the test is fair?

18 In the laboratory, you are given a mixture of sugar, sand and gravel. Design a way of separating these three substances.

MODULE 4.2

Practical investigations

1 • Comparing filters

Questioning & Predicting

Processing & Analysing

Purpose

To compare conical and fluted filter papers.

Hypothesis

Which filters faster—a conical filter paper or a fluted filter paper? Before you go any further with this investigation, write a hypothesis in your workbook.

SAFETY

A Risk Assessment is required for this investigation.

Copper carbonate is toxic so do not touch, sniff or taste it.

Timing 45 minutes

Materials

- 1 spatula sand
- 1 spatula copper carbonate ($CuCO_3$)
- 1 spatula
- 2 funnels
- 4 filter papers
- 4 × 100 mL beakers
- 2 stirring rods
- 2 stopwatches or timers
- retort stand, bosshead and clamp or filter stand

Procedure

1 Place two funnels in the clamp or filter stand. Place a beaker under each funnel to collect the liquid.

2 Fold one filter paper into a conical shape and the other into the fluted shap eas shown in the Skill builder 'Folding a filter paper' on page 152 and in Figure 4.2.15. Place each filter in a funnel.

3 Collect one spatula of sand and place it in 40 mL of water in a beaker. Repeat for the other beaker.

4 Read the Skill builder 'How to Filter' on page 152. Make sure you understand how to filter before continuing.

5 Now pour the contents of one beaker into the conical filter paper. Start the timer as soon as the first water goes into the conical filter paper.

6 Pour the same amount of water from the other beaker into the fluted paper. Start the second timer as soon as the water goes into the fluted filter.

7 Add more of the sand and water mixture to each filter paper until all of the liquid has been filtered. Stop the timer when the filter stops filtering. Leave any remaining sand in the beaker. Note the time taken for each filter, and how clear the filtrate is.

8 Repeat steps 1–7 with new filter papers, but this time use copper carbonate instead of sand.

9 Dispose of all residues from experiments as directed by your teacher.

Results

1 Record the appearance of the filtrate, for both the sand and the copper carbonate.

2 Record the time it took for all of the liquid to pass through each filter.

Review

1 Compare the rate at which the two differently folded filter papers filtered each of the mixtures.

2 Construct a conclusion for your investigation.

3 Assess whether your hypothesis was supported or not.

4 Propose a reason why one folding method was better than the other.

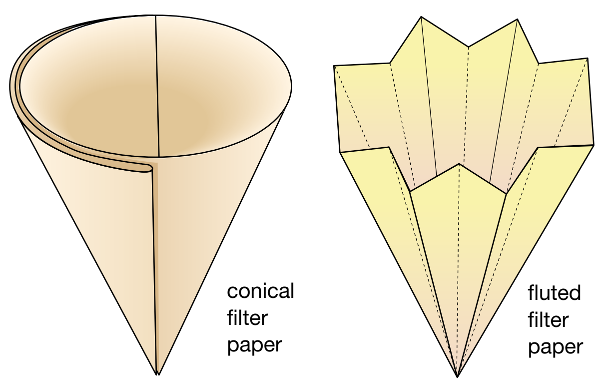


FIGURE 4.2.15

MODULE
4.2 Practical investigations

• STUDENT DESIGN •

2 • Separating solids

Planning & Conducting
Processing & Analysing

Purpose

To separate a mixture of sand, gravel, iron filings and salt.

Timing 45 minutes

Materials

- 1 spatula sand
- 1 spatula gravel
- 1 spatula of iron filings
- 1 spatula table salt
- water
- 100 mL beaker
- 4 spatulas
- magnet (wrapped in plastic)
- equipment including filter paper, funnels, beakers
- fly wire 20 cm square
- electronic scales

SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 Use different spatulas to measure out one spatula each of sand, gravel, iron filings and salt.
2 Weigh each sample separately using the electronic scales and record the mass of each.
3 Combine all four substances together in a beaker.
4 Design a method to separate these four solids from each other so that you recover all four substances.
5 Write your procedure in your workbook.
6 Make sure you weigh each component once you have separated it at the end. Compare this with the initial mass and total, to see how accurate and careful your separation techniques have been.
7 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and how you can minimise those risks. Show your teacher your procedure and risk assessment If they approve, then start work.

Hints

- Make sure the magnet stays covered in its plastic.

Review

Construct a report using the headings listed in Module 1.4.

• STUDENT DESIGN •

3 • Oil spills

Planning & Conducting
Evaluating

Sorbents are materials that can soak up substances. Sorbents are commonly used to soak up oil that has spilled into the sea, rivers or lakes.

Purpose

To compare three different sorbents that could be used to clean up oil spills.

Hypothesis

Which sorbent do you think will soak up more oil—paper towel, cotton balls or a sponge? Before you go any further with this investigation, write a hypothesis in your workbook.

Timing 45 minutes

Materials

- 50 mL cooking oil
- detergent (for cleaning up)
- equal masses of cotton balls, paper towel and kitchen sponge
- 3 plastic cups
- 2 wide-mouth jars
- tweezers
- access to timer

SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 Carefully read the list of materials provided.
2 Design a method that will allow you to compare how well cotton balls, paper towel and a kitchen sponge absorb cooking oil that has been mixed with water.
3 Write your procedure in your workbook.
4 Before you start any practical work, assess your procedure. List any risks it might involve and how you can minimise those risks. Show your teacher your procedure and risk assessment. If they approve, then start work.

Review

1 Construct a conclusion for your investigation.
2 Assess whether your hypothesis was supported or not.
3 Construct a report using the headings listed in Module 1.4.

MODULE 4.2 Practical investigations

STEM INQUIRY

Stones and beans don't mix

Background

Nutritionists recommend that our diet should contain legumes. These foods are a good source of protein, dietary fibre and various vitamins and minerals. Many legumes grow close to the ground and include foods such as chickpeas, navy beans (used in canned baked beans), lentils and peanuts (also known as ground nuts).

When legumes are harvested, occasionally small stones from the field can accidently enter the food. This is a big problem for companies that package legumes. If a stone is mistaken for a legume, this could result in someone breaking a tooth.

Problem

An organic food store wants you to design a technique in order to separate small stones from one type of legume. Your task is to use your understanding of separating techniques to outline the process that the organic food store should use to remove stones before they sell the legumes.

Procedure

1 In a small group (3-4 students), design a system to separate small stones from one type of legume.

2 Write your procedure in your workbook and show your teacher. If they approve your plan, then collect your equipment and carry out the experiment.

Hints

In your initial investigation of the materials:

- What are the properties of dried legumes and stones?
- What happens if you put a magnet next to a stone or dried legume?
- What equipment and materials do you have access to?

Materials

- 200 g of one type of dried legume
- 20 g of various small stones

Equipment

- water
- sieves
- magnets
- weighing balances
- plastic containers
- rulers
- and equipment that you have in your science laboratory such as funnels, measuring cylinders and beakers.

Engineering design process

- Identify the problem that needs solving.
- Brainstorm solutions to identify the different separation techniques and which ones might apply to this task.
- Before you commence your investigation you must conduct a risk assessment and write down safety measures that you will follow to keep yourself and other students safe. (see Activity Book for a template)
- Summarise your investigation in a scientific report including the Purpose, Hypothesis, Materials, Procedure, Risk Assessment, Results (including data presented in tables and / or graphs), Discussion and Conclusion.

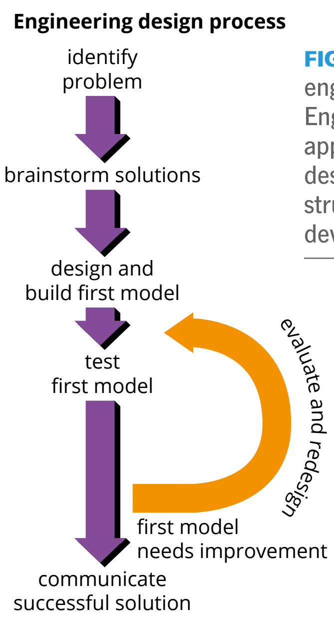


FIGURE 4.2.16 Following the engineering design process. Engineering involves the application of science to design, build, test and maintain structures, machines and devices.

MODULE

4.3 Separating soluble substances

The soluble substances in a solution are far too small to settle or be trapped in filter papers. Different methods are therefore needed to separate them from the solvent they are dissolved in. In the photo a separation method called chromatography is being used to separate pigments in black dyes.

STEM 4 fun

PROBLEM

Can you use black marker and white paper to create a colourful butterfly?

YES

SUPPLIES a range of different black markers and pens, dropper, straws, plastic or paper cups, water, methylated spirits, different white paper including filter paper, tissue paper, copy paper

PLAN & DESIGN Design the solution. What information do you need to solve the problem? Draw a diagram. Make a list of materials you will need and steps you will take.

CREATE Follow your plan. Draw your solution to the problem.

IMPROVE What works? What doesn't? How do you know it solves the problem? What could work better? Modify your design to make it better. Test it out.

REFLECTION

1 What field of science did you work in? Are there other fields where this activity applies?
2 What did you do today that worked well? What didn't work well?

Chromatography

Chromatography is a process that can separate a mixture by making it move through another substance. This substance could be a gel, column of liquid or strip of paper, like that as shown in Figure 4.3.1. When a piece of paper with ink on it is placed in water, the water will move up the paper. Water is the solvent. As the water moves up the paper, it dissolves the dyes from the ink and carries the colours with it as it moves higher up the paper. The process is called chromatography.

Chromatography works because different substances in the dyes have different levels of attraction to the paper. Substances that are strongly attracted to the paper are harder for the solvent (water) to move along, so these substances do not move very far. Weakly attracted substances move the furthest along the paper. In this way, the different substances in the dye are separated.

Chromatography is very important in industry. It is used to find out what is in oil and gas, and to identify chemical pollutants in water samples taken from rivers or the sea.

Chromatography is also used by pharmaceutical manufacturers to analyse plants and animals for possible useful medical drugs and to test the quality of their products.

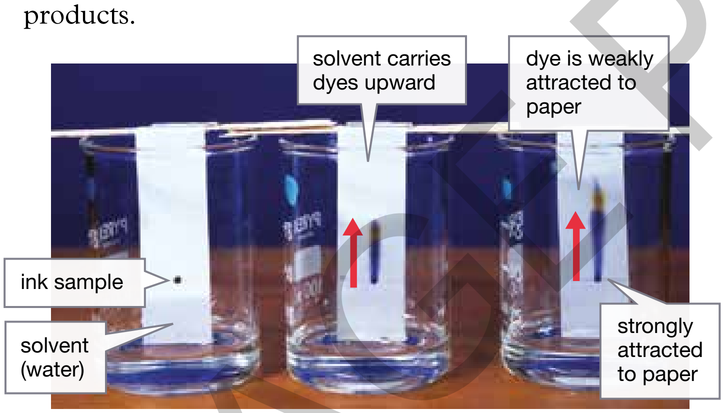


FIGURE 4.3.1 Paper chromatography separates mixtures such as inks and dyes.

SciFile

Lawbreakers beware!

Chromatography can catch you out! It can help catch drug cheats in sports by identifying banned drugs in urine. Chromatography can also be used to identify the ink used to write a letter, and that ink can be matched to your pen.

science 4 fun

Candy crystals

NO

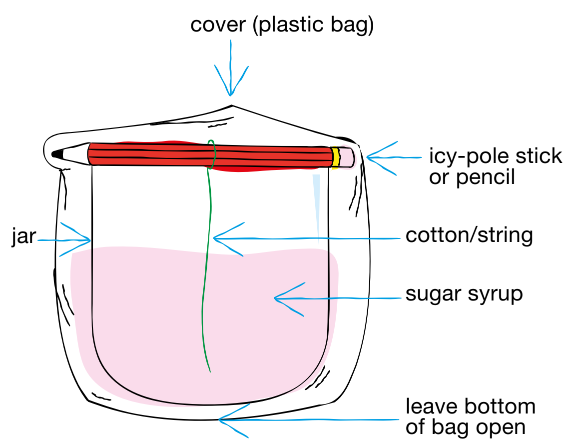
Can you grow big candy crystals?

Collect this ...

- sugar (sucrose)
- water
- food colouring (optional)
- flavouring (optional)
- clean glass jar
- clean cotton or string
- pencil or icy-pole stick
- metal saucepan
- stove

Do this ...

1 Pour 3 cups of sugar and 1 cup of water into the saucepan.
2 Heat, stirring constantly, until all the sugar has dissolved. Try not to boil the solution. A few drops of food colouring and ½ teaspoon of flavouring can be added, but this may slow your crystal formation.
3 Cool the sugar syrup in the refrigerator until it is at about room temperature.
4 Soak the string in the syrup and then hang it to dry in the air.
5 Set up your equipment as shown in the diagram.



6 You can eat the candy after the week. Do not eat the string.

Record this ...

Describe what happened.

Explain why you think this happened.

Evaporation

When pools of water lie on a road, or wet clothes are placed on the washing line, the sun will heat up the water. As the water heats, it changes state and becomes a gas, a process known as **evaporation**. As more of the water evaporates, the pool of water or wet clothes will become dry. Water evaporates at any temperature above 0 °C. Water does not have to be boiling to evaporate. However, evaporation speeds up at higher temperatures. This explains why clothes dry more quickly on a hot day than a cold one.

If the water has any solute dissolved in it, then evaporation will leave that solute behind. For example, sea water is an aqueous solution of salt dissolved in water. After swimming in the sea, the water on your skin evaporates, leaving a thin layer of salt behind.

Evaporation is used in kitchens at home and in restaurants. For example, when cooks make a sauce or gravy, they heat the mixture so that water evaporates (Figure 4.3.2). As the mixture loses water, the sauce gets thicker and its flavour gets stronger.

FIGURE 4.3.2 Evaporation removes the water from sauces making them thicker and richer.

Evaporation is commonly used in the laboratory to separate a solvent from its solute. The solution can be left in the air to evaporate using the heat of the room, but a Bunsen burner or hotplate speeds the process up. The solute is left behind in the evaporating dish, while the solvent (usually water) is lost to the air. This means that you can only collect the solute.

Crystallisation

The solute left behind by evaporation often forms crystals. You can see some different crystals in Figure 4.3.3. Crystals have distinctive shapes because the solute particles lock into one another like pieces of a jigsaw.

As the solvent evaporates, the solution becomes more and more concentrated. Eventually the solution becomes so concentrated that it is saturated. The solute particles start to lock in with one another, and the crystals grow as more of the solvent evaporates. This process is called **crystallisation**. Smaller crystals form when the solvent evaporates quickly. In contrast, larger crystals form when the solvent evaporates slowly.

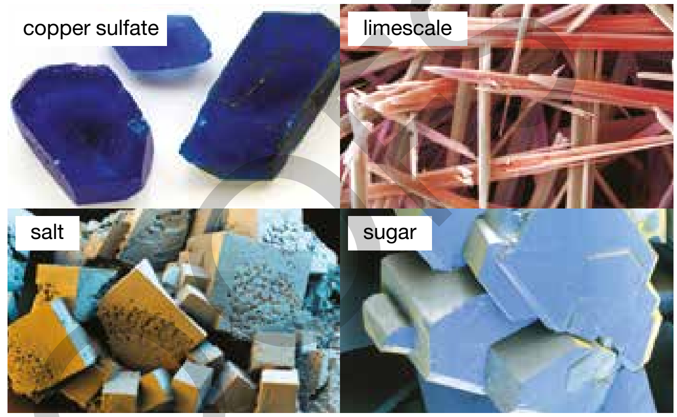


FIGURE 4.3.3 Crystals come in a variety of different shapes. They form because the solvent evaporates, leaving solute crystals behind.

Evaporation and crystallisation are used in industry to remove soluble substances from solutions and to purify substances. For example, salt producers make salt by using the heat from the Sun to evaporate water from pools of salt water. This leaves crystals of salt behind to be collected (Figure 4.3.4).

FIGURE 4.3.4 Salt crystals recovered from sea water have been scraped into piles.

Crystallisation is also used in industry to purify substances such as pharmaceuticals (medical drugs). A solution may have unwanted substances dissolved in it as well as substances that are wanted. The unwanted substances are called **impurities**.

The particles of impurities generally do not have the same shape as the solute particles. So if you crystallise the solute, the impurities will not have the right shape to lock into the growing crystals (Figure 4.3.5). Instead, the impurities stay in solution and the crystals formed stay pure.

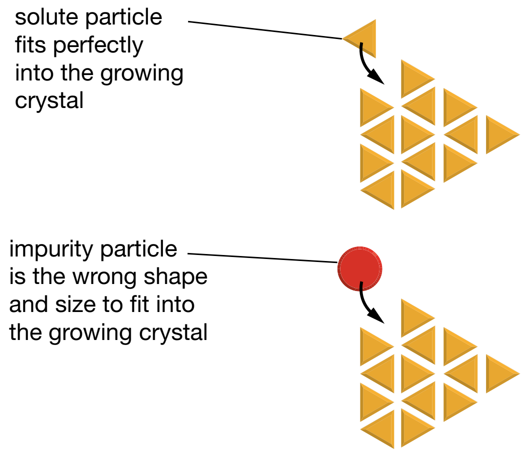


FIGURE 4.3.5 Impurities have the wrong shape to lock into crystals. Crystallisation is often used to purify substances such as medical drugs.

Distillation

Evaporation is the process in which a liquid turns into a gas. Condensation is the opposite: a gas cools to form a liquid. **Distillation** uses both evaporation and condensation to separate substances.

Evaporation loses the liquid solvent to the atmosphere, but sometimes you need to keep the liquid as well. In distillation, the gas is condensed back into a liquid so that it can be collected. If the solvent is water, distillation first evaporates off the water. Distillation then cools the water vapour so that it condenses back into liquid water. The apparatus that converts the gas back to the liquid is called the condenser. Figure 4.3.6 shows a special apparatus called a Liebig condenser that is often used in the laboratory.

SciFile

Smelling nice

The oldest written records of perfume being made by steam distillation date to around 1000 CE. The Persian scientist Avicenna is said to have invented the process to make rose water. There is now a perfume named Avicenna in his honour.

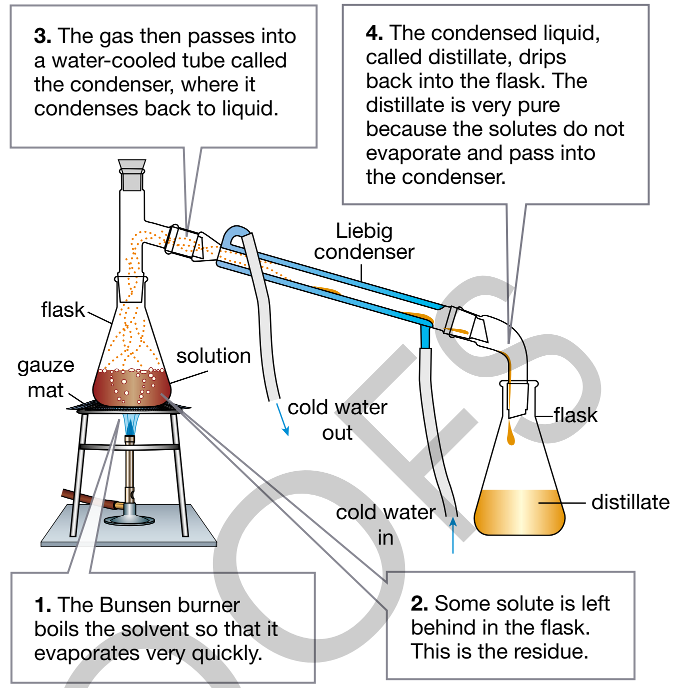


FIGURE 4.3.6 Distillation is often carried out in the laboratory using a Liebig condenser.

Distillation is able to separate several liquids from each other if they have different boiling points. For example, alcohol has a boiling point of 78°C while water boils at 100°C. These two liquids can therefore be separated by distillation. When the mixture reaches 78°C, the alcohol evaporates leaving the water behind. The alcohol vapours then condense back into liquid alcohol inside the condenser. After all the alcohol has evaporated, the mixture's temperature will increase and the water will evaporate when it reaches 100°C. When this water vapour reaches the condenser it too condenses back into its liquid form. Whatever solute was dissolved in the original solution is left behind.

As well as separating solutions in laboratories, distillation is used in:

- producing alcoholic drinks such as vodka and bourbon
- separating crude oil into petrol, diesel, lubricating oils and other components
- removing impurities from drinking water
- separating oxygen, nitrogen and argon from air for industrial use
- perfume manufacture.

Prac 1 p. 164 | AB 4.7 | AB 4.9

MODULE 4.3

Review questions

Remembering

1 Define the terms:
   a evaporation   b impurities.

2 What term best describes each of the following?
   a the separation of ink by water moving up paper
   b solute left behind after the solvent has evaporated.

3 Match the following separating methods with its correct description. Choose from A, B or C.
   a chromatography   c distillation
   b evaporation
   A a process using evaporation and condensation to separate and recover both solute and solvent
   B a process that can separate a mixture by making it move through another substance like a paper strip
   C a process in which heat changes a liquid into a gas, allowing recovery of the solute but not the solvent

4 Name the separation process used to:
   a separate different coloured substances from food colouring or ink
   b collect salt crystals from seawater
   c make alcoholic drinks like gin and whisky.

Understanding

5 Explain the process by which chromatography can separate substances.

6 Explain the process by which distillation can separate a solute and a solvent and allow you to recover both substances.

7 You are making copper sulfate crystals in the laboratory by evaporating water from a solution of copper sulfate. Describe how you could:
   a make the crystals rapidly
   b form larger crystals by evaporating the water slowly.

Applying

8 Identify a separation method that could be used for each of the following purposes:
   a to purify water from a washing machine enough to drink it
   b to recover the sugar from a bag that you accidentally dropped into a saucepan of water while you were cooking.

9 Draw a diagram that shows how crystallisation stops impurities from becoming part of a growing crystal.

Analysing

10 If you are lost in the bush and have no drinking water, you can make a 'bush still' to try to collect some.
   a Compare the 'bush still' shown in Figure 4.3.7 with distillation apparatus.
   b How can this be considered an example of distillation?

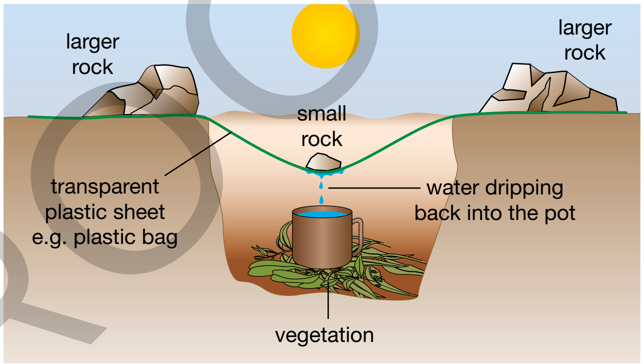


FIGURE 4.3.7

11 Compare evaporation of water and boiling of water.

Evaluating

12 a Identify the process used in the STEM4fun on page 159 to separate the colours in marker pen inks.
   b What do you think would happen if you swapped the tissue paper with paper that attracted the colouring more strongly.
   c Justify your answer.

14 A whisky maker wants to concentrate the alcohol in his mixture. Alcohol boils at 78°C and water boils at 100°C. If you were the whisky maker, would you choose evaporation or distillation? Justify your choice.

15 When you dry your bathers after swimming in the sea, they are crisp with salt. However, if you rinse them in fresh water first, they dry clean and salt-free. Propose a reason why the two methods of drying produce such different results.

16 When evaporating a solution to produce pure crystals of a solute, there are also impurities left behind. Design an experimental method to separate the impurities and the crystals.

MODULE 4.3 Practical investigations

1 • Slow and fast evaporation

Questioning & Predicting

Communicating

Purpose

To grow salt (sodium chloride) crystals and compare their sizes when formed by fast and by slow evaporation.

Hypothesis

Which do you think will produce larger crystals—slow cooling or fast cooling? Before you go any further with this investigation, write a hypothesis in your workbook.

SAFETY

A Risk Assessment is required for this investigation.

Tie long hair back. Turn the Bunsen burner flame to yellow when it is not being used. Allow equipment to cool before packing it away.

Timing 45 minutes

Materials

- 2 × 50 mL salt (sodium chloride) solution OR 2 × 50 mL concentrated alum (potassium aluminium sulfate) solution

- 2 evaporating basins
- 100 mL beaker
- Bunsen burner, bench mat, tripod and gauze mat or hotplate

Procedure

Slow evaporation

1 Pour 50 mL of your solution into one of the evaporating basins until it is about one-quarter full. Set it aside somewhere in the room where it will not be disturbed. Observe what happens over the next day or so.

Fast evaporation

2 Collect about 50 mL of solution in your beaker, and set up the equipment as shown in Figure 4.3.8. Do not turn on the Bunsen burner or hotplate yet.

3 Pour the solution into your evaporating basin until it is about half full.

4 Heat the solution with a hot flame with the Bunsen burner airhole about half open, watching carefully that material does not 'spit' out of the basin. If it does spit, close the collar on the Bunsen burner a little, or use the gas hose to move the Bunsen burner carefully in and out of the tripod. If you are using a hotplate then start with high heat and then turn it down as the solution starts to evaporate.

5 When only a small pool of the liquid is left, turn the Bunsen burner or hotplate off. The rest of the liquid will evaporate with the heat left in the basin.

6 Allow the basin to cool for several minutes.

Review

1 Describe the crystals formed by fast and slow evaporation.

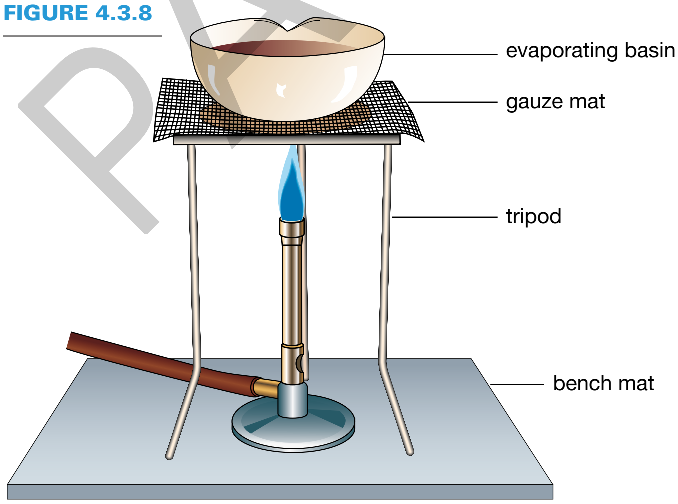
2 a Construct a conclusion for your investigation.

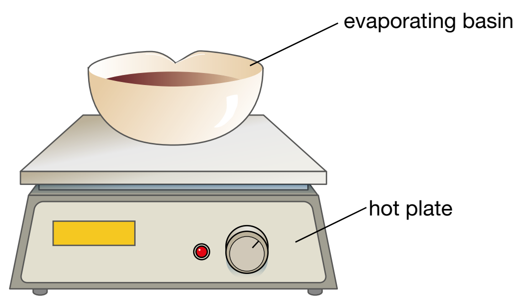
b Assess whether or not your hypothesis was supported.

3 Figure 4.3.8 shows the equipment used in this prac in three dimensions (3D). Construct a scientific diagram that shows it in two dimensions (2D).

4 Use the results of this prac to help you explain why salt crystals often form around the edges of salt lakes.

FIGURE 4.3.8





MODULE 4.3 Practical investigations

STEM INQUIRY

Do leaves contain the same colours?

Background

Simon enjoys walking home from school in April when there are many autumn leaves on the ground. He had always wondered why leaves change colour in autumn so collected a few leaves of different colours and took them to his science class the following day. Simon's science teacher thought this was a very good question and asked if anyone in the class might know the answer? A couple of students thought that it might be due to the leaves dying since they no longer had access to water via the tree branches. Simon's teacher explained that leaves are normally green in colour due to a pigment called chlorophyll which is important in the process of photosynthesis. When leaves start to change colour in autumn, the chlorophyll breaks down and other colours that were also present in the leaf can later be observed.

Problem

Simon's class wanted to find out the range of different colours that could be found in leaves. Simon's teacher asked the class to use their knowledge of separating mixtures using the technique of chromatography to see if they could answer this question.

Procedure

1 Design and conduct a valid experiment that will separate the different colours contained in an autumn leaf.

2 Write your procedure in your workbook and show your teacher. If they approve your plan, then collect your equipment and carry out the experiment.

Hints

In your investigation:

- Many of the pigments in leaves are water soluble.
- Suitable solvents could include ethanol (methylated spirits) or acetone (nail polish remover).

Materials

- Leaves of different colours from the same or different trees

Equipment

- chromatography or filter paper
- beakers
- mortar and pestle
- methylated spirits
- acetone

Engineering design process

- Identify the purpose
- Identify the independent, dependent and controlled variables and only change one variable at a time.
- Based on your purpose and the controls and variables, write a hypothesis for this experiment.
- Before you commence your investigation you must conduct a risk assessment and write down safety measures that you will follow to keep yourself and other students safe. (see Activity Book for a template)
- Summarise your experiment in a scientific report including the Purpose, Hypothesis, Materials, Procedure, Risk Assessment, Results (including data presented in tables and / or graphs), Discussion and Conclusion.

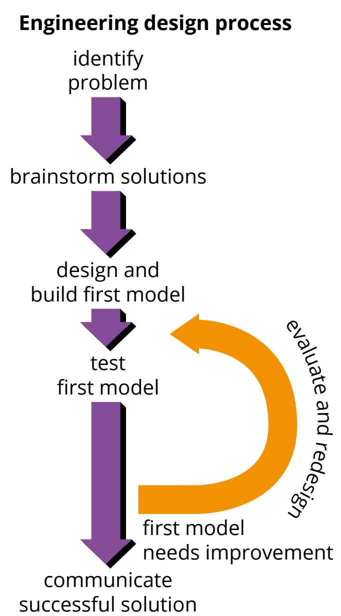


FIGURE 4.3.9 Following the engineering design process. Engineering involves the application of science to design, build, test and mainten structures, machines and devices.

MODULE 4.4 Purifying water

Drought in much of Australia has forced us to find ways to save water. One solution is to recycle water, cleaning dirty water and then using it again. Water can be cleaned using separating techniques such as filtration and distillation. New methods of providing clean water are also being developed. Some of these methods can produce drinking water from toilet water or seawater.

science 4 fun

Cleaning water

Can dirt clean water?

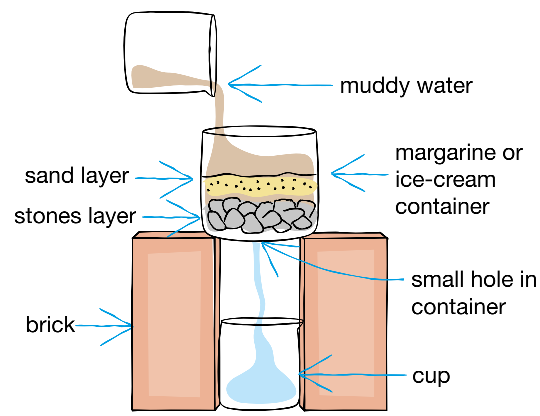
YES

Collect this ...

- some fairly clean sand
- some small stones like blue metal or road gravel
- bucket of muddy water
- ice-cream or margarine container
- some bricks or rocks for a stand
- 3 cups to catch liquid

Do this ...

1. Make a small hole in the bottom of your ice-cream or margarine container.
2. Set up your equipment as shown.
3. Pour some muddy water in and let it pass through into the container at the bottom. Put this sample aside.
4. Repeat step 2, but instead of setting the sample aside, pour it through the sand and stones again.
5. Continue pouring the collected sample through the sand and stones until the sample you collect at the bottom has little suspended mud in it.



6. Compare this final sample with the original sample you set aside.

Record this ...

Describe what happened.

Explain why you think this happened.

The need for water

Water is the most important substance needed for life. It is essential, because without it all living things die.

As humans, we need more water than just for drinking (see Figure 4.4.1). We need water to grow our food. We also use water as a solvent that dissolves:

- soap and detergent in our showers, sinks and carwashes
- sugars and flavourings in soft drinks and fruit juices
- chemicals used in industry, in the preparation of foods, medicines, fertilisers, paints, adhesives and paper
- minerals underground in a process called leach mining.

FIGURE 4.4.1 Water is used as a solvent in industry to make many products such as medicines, dyes, drinks and fertilisers.

Water also dissolves minerals in rocks and many of these are needed by plants for their growth. These minerals are also needed by animals that eat the plants.

SciFile

Too much water

It is possible to drink too much water. A man in the UK died after drinking about 7 litres of water in a short period. Excessive amounts of water like this can cause a condition where sodium is flushed out of the body and brain cells are damaged.

Is water pure or a mixture?

The term *water* means different things to different people. To scientists, water is a pure chemical with the chemical formula H_2O. However, to everyone else, water is what comes out of a tap and is found in rivers, lakes, swimming pools, rain and the sea.

In these cases, water is not pure but is an aqueous solution with H_2O as its solvent, or a suspension H_2O. Sometimes it's both. For example, seawater is both an aqueous solution and a suspension, containing water, dissolved salt, floating particles like sand, and living things like seaweed, bacteria and fish. Seawater also has dissolved oxygen in it, which is used by all the organisms that live there, and dissolved carbon dioxide, which is used by seaweed.

Water in rivers and lakes contains dissolved oxygen, as well as bacteria and possibly particles of dirt, forming a muddy suspension (Figure 4.4.2). Swimming pools contain dissolved chlorine or other treatment chemicals.

FIGURE 4.4.2 The mixing of these two rivers shows that one (left) is relatively clear while the other (right) has a lot of mud floating in it as a suspension.

Tap water is a mixture of many substances. Some of these enter the water naturally through contact with soil and rock. Others are added deliberately by water authorities to protect public health. What is in your water depends on the source of the water, and how it was treated.

Water treatment

Water that is obtained from dams, rivers and aquifers is never pure. It also contains other substances. Most of these substances come from the rocks and soil that the water passes over.

These unwanted substances can cause health and other problems if not removed before the water is used. For example, rubbish washed from gutters into rivers, dams and lakes encourages microscopic disease-causing bacteria to grow in the water. Likewise, pollutants might be toxic. The high salt content of groundwater rusts away hot water systems and washing machines, often causing them to burst. Clay and other sediments can also block pipes and clog motors.

Drinking water

Water fit to drink is called **potable water**, while water unfit to drink is known as non-potable. Water from dams and groundwater goes to a treatment plant before it is supplied as potable water to homes and businesses.

There are five stages of water treatment as shown in Figure 4.4.3. These stages are:

1 Flocculation—The fine solid particles like clay are separated out of the water. Chemicals called flocculants are added to make the tiny clay particles clump together.

2 Sedimentation—after an hour the water passes into a sedimentation tank where these clumps settle to the bottom.

3 Filtration—The water is pumped through filters to remove any remaining particles.

4 Sterilisation—Chlorine is added to kill micro-organisms like bacteria.

5 Fluoridation—Fluoride is added to reduce the chance of tooth decay.

Water filters like the one shown in Figure 4.4.4 can be used to remove impurities. and added chemicals from potable water. Generally this is not needed in Australia.

Prac 1
p. 175

FIGURE 4.4.4 Some people use filters to clean their water of impurities.

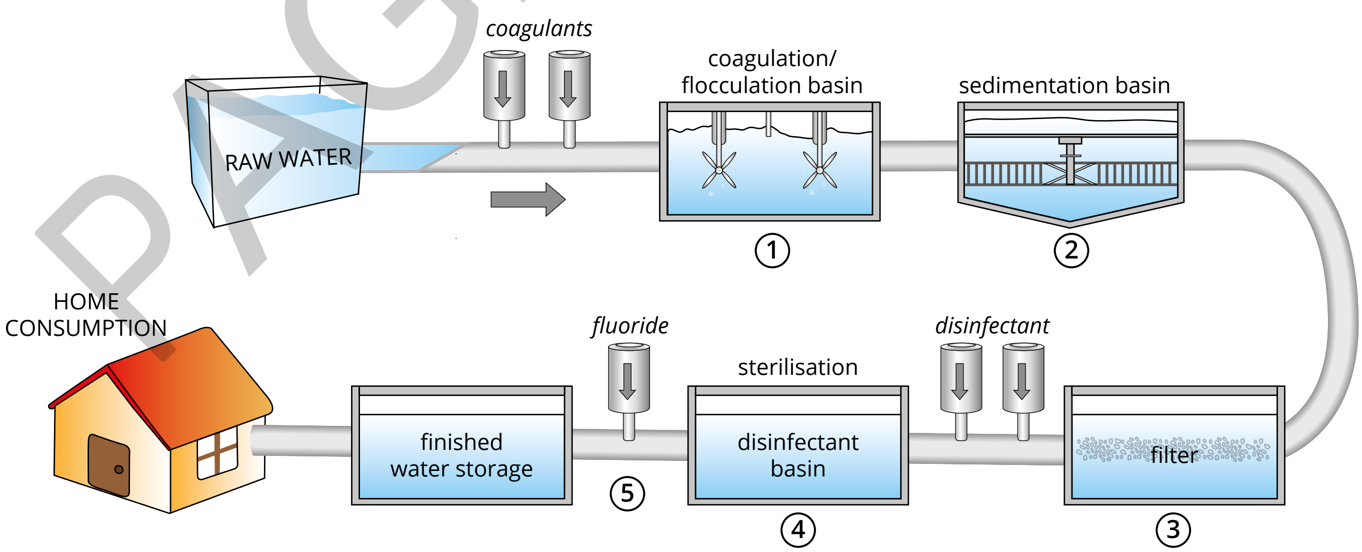


FIGURE 4.4.3 Drinking water treatment plant

Desalination

Dams, lakes and groundwater may not be able to supply all of Australia's needs in the future. This is because the water in them comes from rainfall, and rainfall is declining in many parts of the country. Another source of drinking water is salt water, such as seawater or water from salt lakes or salty rivers. Before we can drink this, the salt must be removed. **Desalination** is the process of removing salts such as sodium chloride from the water.

Desalination can be achieved by distillation, but distillation in this form doesn't work well on a large scale. The desalination process is also quite expensive. Another process of removing salt from seawater is via reverse osmosis. This too is expensive as it requires a lot of energy. Reverse osmosis places salt water is placed under high pressure, which forces it through a very fine filter or membrane. The membrane has microscopically small holes that only the water particles pass through. The salt is left behind. In this way the salt is separated from the water. A reverse osmosis plant is shown in Figure 4.4.5.

FIGURE 4.4.5 Reverse osmosis desalination plants have been built near Perth, Sydney, Melbourne and the Gold Coast to treat seawater and make it into drinking water.

Wastewater treatment

Wastewater is any water that has been used and disposed of because it is no longer clean. This includes all water disposed from homes, shops, offices and factories and the runoff from roads, gardens and irrigation. **Sewage** is wastewater from kitchens, bathrooms, toilets and laundries.

Sewage can be classified as:

- **blackwater**—this is wastewater that comes from toilets and kitchens. This wastewater contains urine, faeces (poo), toilet paper and anything else that gets thrown down the toilet. Blackwater also includes food wastes washed down the sink and wastewater from dishwashers.

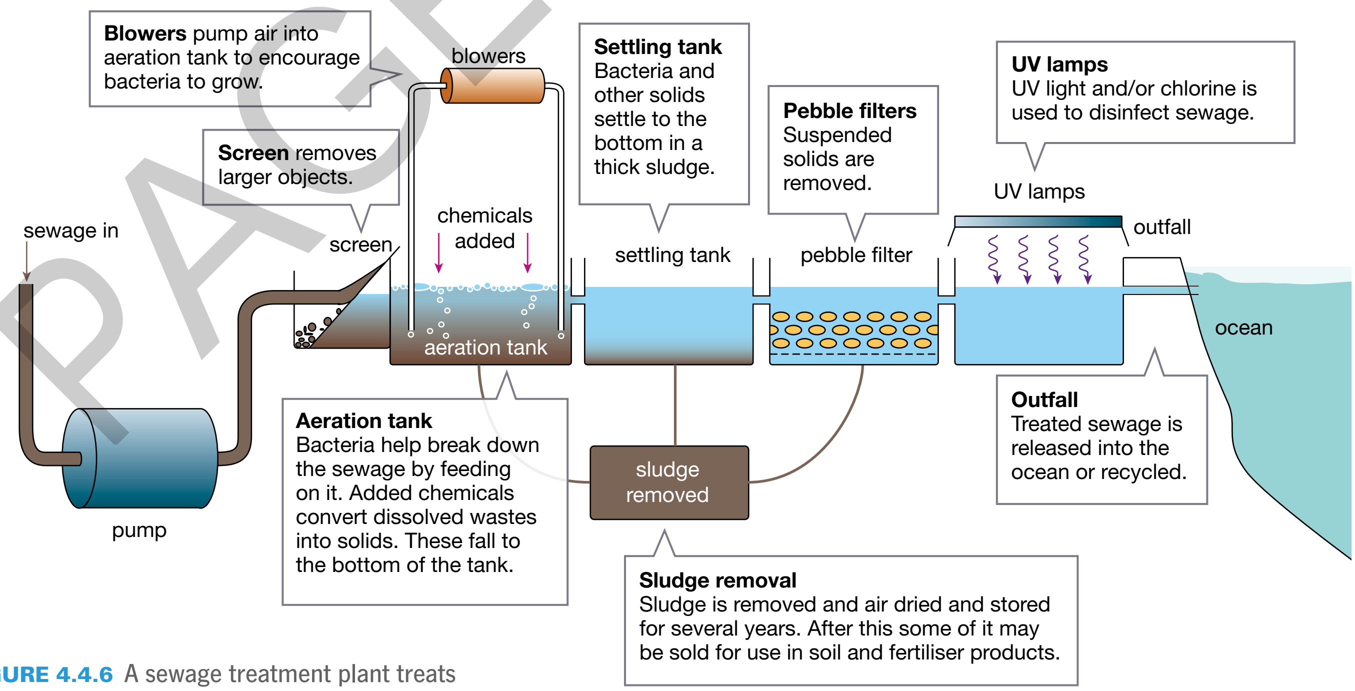


FIGURE 4.4.6 A sewage treatment plant treats sewage in a process involving several steps.

- **greywater**—this is wastewater that comes from showers, baths and laundries. It contains a large range of substances such as detergents, soaps, shampoo, grease and hair.

Due of its contents, blackwater contains many more bacteria (germs) than greywater.

The sewerage system

Most homes and businesses in cities are connected to the sewerage system. This is a system of underground pipes that carry blackwater and greywater away to a waste treatment plant. This plant then makes the water safe enough to pump into the ocean or to be used to irrigate crops and vegetable gardens. A typical sewage treatment plant is shown in Figure 4.4.6 on page 169.

Prac 2
p. 176

Septic tanks

Septic tanks are used to process sewage from houses and businesses located beyond the sewerage system, usually in the country or outer suburbs. Septic tanks are made up of a series of concrete or plastic tanks buried underground close to the building they serve. They process both blackwater and greywater and the treated water soaks through the bottom of the final tank to join groundwater in the aquifers. You can see how a typical septic tank works in Figure 4.4.7.

SciFile

The world's smelliest job?

Septic tanks have to be emptied out from time to time when the solids build up too much. The worker may have to take the lid off the tank to clear blockages. You need a strong stomach and an ability to cope with bad smells in that job.

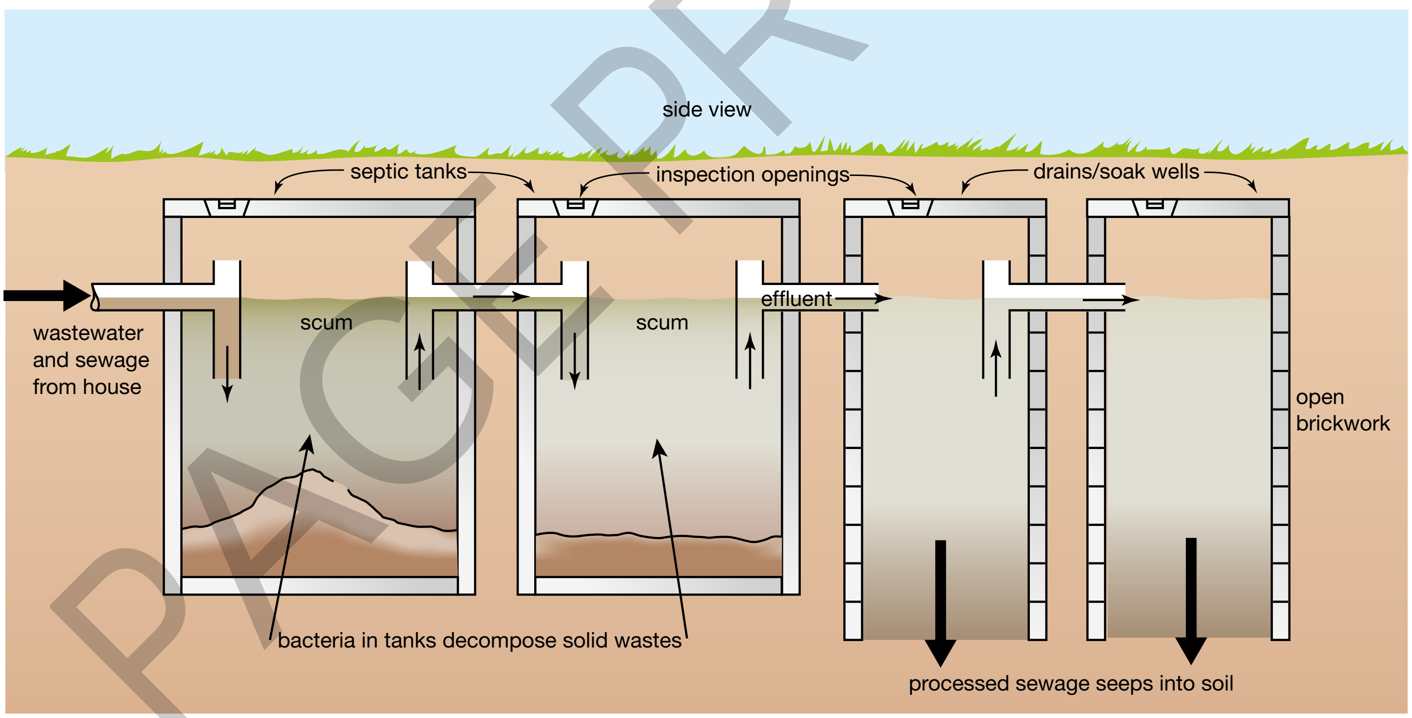


FIGURE 4.4.7 Septic tanks consist of tanks and soak wells. Processed sewage then seeps into the soil.

Greywater recycling systems

Greywater recycling systems are small systems used in homes to recycle and reuse the greywater from laundries, showers and baths. The water is cleaned and is then used in laundries, to water the garden and to flush toilets. However, the water is not clean enough to be used for drinking or washing. A plan of a greywater recycling system is shown in Figure 4.4.8. The system uses a special underground tank in which special bacteria decompose wastes in the greywater. Then the water is passed through a very fine filter to remove the bacteria and other particles and impurities. Finally the cleaned water is stored in another chamber to be re-used. Toilets and gardens use a lot of water so using greywater in these areas, saves the drinking water that would otherwise have been used.

Protecting the environment

Our water and our environment will be cleaner if we all stop putting the wrong things down the toilet or sink. Some simple actions we can all take are listed below.

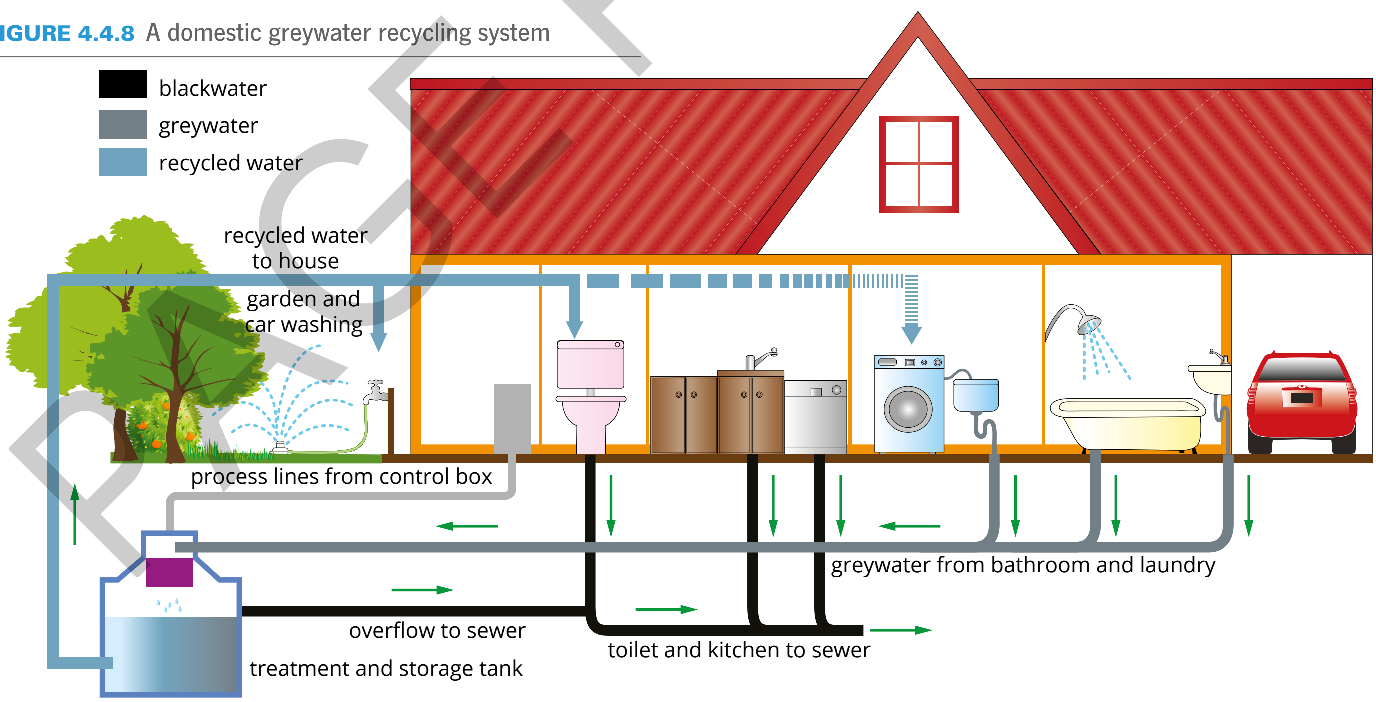
1 In the bathroom: Put medicines, nappies, women's sanitary products, razor blades and cotton buds in the bin instead of down the toilet or sink.

2 In the kitchen: Wipe the oil off pots and pans with paper towel instead of pouring excess oil down the sink. Then put the towel in the bin, along with any food scraps.

3 In the laundry: Use less detergent in the laundry. Most people use more detergent/washing powder than the manufacturer recommends. Choose detergents that are phosphate- and nitrate-free since these chemicals cause algal blooms in lakes and rivers. These blooms then produce toxic chemicals that kill fish.

4 On the street: Put rubbish in bins. Otherwise it will be washed into the rivers and into the sea via the nearest stormwater drain next time it rains.

FIGURE 4.4.8 A domestic greywater recycling system



SCIENCE AS A HUMAN
ENDEAVOUR

Use and influence of science

Drinking recycled sewage

At present in Australia, recycled sewage water is only used for irrigation of crops and public parks. However, the Australian Government has stated that it is almost certain that we will soon use recycled sewage for drinking water.

FIGURE 4.4.9 Singapore's recycled wastewater, bottled and ready to drink

Why is it being considered?

Australia is the driest inhabited continent (Figure 4.4.10). With regular droughts and an increasing population we simply do not have enough water available to meet the demand. This is why water authorities are trying to find alternative water supplies and looking for ways to reduce water usage. At the present time water usage is increasing rather than decreasing.

Should we use it?

The proposals have caused a lot of debate. For example, Toowoomba residents in south-east Queensland rejected the proposal to recycle their wastewater. One reason against using it is the 'yuk factor'. This means people don't like the thought of drinking recycled water. However, tests have shown that people cannot taste the difference between tap water, bottled water and recycled water.

FIGURE 4.4.10 Parts of Australia are very dry. Recycling sewage is a possible solution to our shortage of water.

SCIENCE AS A HUMAN ENDEAVOUR

Water authorities in Australia believe that there is no scientific or health reason against recycling wastewater for drinking. This is based on the conclusions of much scientific research. Recycled wastewater is successfully used to top up drinking water supplies in the United States, Singapore (see Figure 4.4.9) and Namibia.

How would it be done?

Recycling wastewater

Some uses of recycled wastewater are shown in Figure 4.4.11. The main proposal at present is that Australia should adopt indirect potable (drinkable water) re-use. This means first sending wastewater to a water treatment plant. There it is highly treated to make it safe. The highly treated water is then pumped back into an existing drinking water source such as a reservoir, river or aquifer. The reservoir or aquifer helps treat the water by natural processes, such as filtration by soil particles and decomposition by bacteria. Then, when the water is needed, it is pumped out of the reservoir to another water treatment plant just as at present.

Recycling sewage

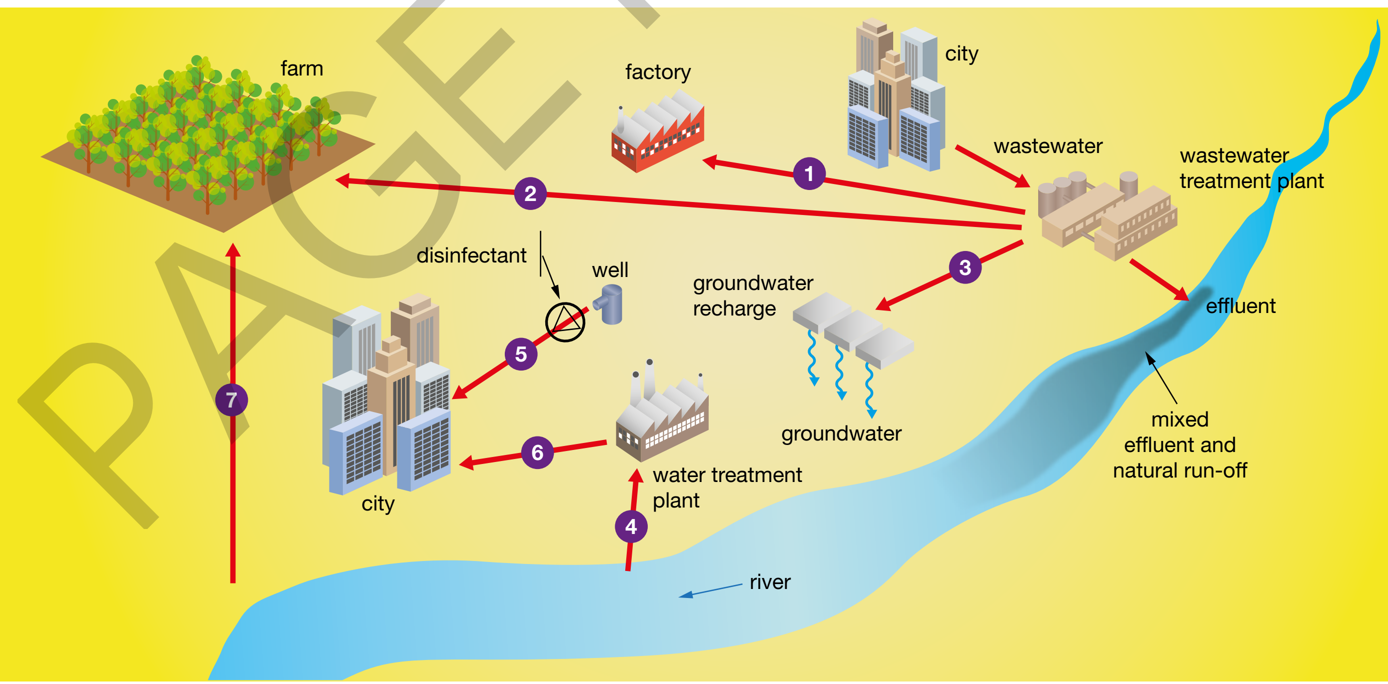
Reverse osmosis is one of the processes that can be used for recycling sewage. In Toowoomba, for example, the wastewater would have been treated using filtration, reverse osmosis, ultraviolet disinfection and oxidation processes to destroy micro-organisms. Reverse osmosis is already used around the world to provide water for industry, as well as drinking water on ships.

REVIEW

1 Explain why some authorities are looking at sewage as a potential source of drinking water.
2 Name the process most likely to be used in Australia to recycle sewage.
3 Create a flow chart that shows the process of turning wastewater into potable water
4 List the advantages and disadvantages of using recycled sewage as a major water supply.
5 Should Australia plan to use recycled sewage in the future? Use evidence from your summary in question 4 to support your answer.

AB 4.8

FIGURE 4.4.11 Some possible uses of recycled wastewater



1 Direct industrial re-use
2 Direct agricultural re-use
3 Groundwater recharge
4 Indirect potable re-use from river
5 Indirect potable re-use from well
6 Potable water supply system
7 Indirect agricultural reusable re-use from river

MODULE 4.4

Review questions

Remembering

1 Define the terms:
  a potable
  b flocculant
  c blackwater
  d sewage.

2 What term best describes each of the following?
  a water not fit to drink
  b water from showers and sinks but not toilets
  c the system that takes sewage away to treatment plants
  d the process of removing salts from seawater.

3 What is the chemical formula for pure water?

4 List three systems of water treatment.

5 List the steps in sewage treatment before the water is ready to use for irrigation.

6 Name the desalination process that uses high pressure to filter salt water.

Understanding

7 Explain why most of the water around you is a mixture and not pure.

8 Describe two separation methods used in a septic tank.

9 In the past, some detergents contained phosphates. However, they are not used now due to the environmental problems they caused. Explain the decision to ban phosphates from detergents.

10 a Explain why blackwater has more bacteria (germs) in it than greywater.
  b Predict the problems if blackwater was filtered and then re-used on the garden.

Applying

11 Identify four separation methods used in the sewage treatment plant in Figure 4.4.6 on page 169.

12 a Explain how the arrangement of different sized particles like sand and pebbles in the Science4fun on page 166 can clean muddy water.
  b Identify the separation technique being used in the science4fun.

Analysing

13 Classify the wastewater from the following as either greywater or blackwater:
  a Kate is having a shower.
  b Jill is washing her hair over the bath.
  c Rod is using the urinal in the mensroom.
  d David is using the washing machine.

14 Compare water treatment by the sewerage system with that by septic tanks.

Evaluating

15 Propose a reason why camping and fishing are often prohibited near dams.

16 Your basins at home have an 'S' bend in the water pipes below the drain hole, as shown in Figure 4.4.12. The bend keeps some water trapped in it. When you turn on the taps the trapped water is pushed out and replaced by new water. You have a similar water trap in your toilet. Propose some reasons why a water trap is needed in basins.

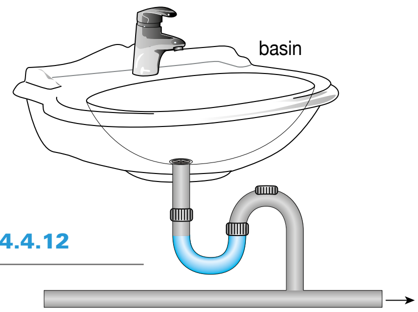


FIGURE 4.4.12

17 Much of the sewage of Sydney is still released untreated through long pipes into the ocean near Bondi, North Head and Malabar. What problems do you think this might cause?

Creating

18 Septic tanks require bacteria living in them to break down the wastes. The soil filters out solids and dissolved materials and keeps the groundwater clean.
  a You should never tip disinfectants, bleaches or paint down the sink if you have a septic tank. Propose a reason why.
  b Construct a pamphlet that plumbers can give to clients with blocked septic tanks explaining what not to do and why.

MODULE 4.4

Practical investigations

1 • Flocculation

Processing & Analysing

Evaluating

Purpose

To compare different chemicals as possible flocculating agents.

Timing 30 minutes

Materials

- muddy water
- test flocculants (1 M solutions in dropper bottles)
  - potassium aluminium sulfate (alum)
  - aluminium sulfate
  - sodium carbonate
  - sodium hydrogen carbonate
  - sodium chloride
  - iron(II) sulfate
  - calcium chloride

- 2 × 100 mL beakers
- filter funnel
- filter paper
- filter stand
- test-tube rack
- 7 small test-tubes

SAFETY

A Risk Assessment is required for this investigation.

All the chemicals should be considered to be toxic, so do not touch, sniff or taste them.

Procedure

1 Filter the muddy water to remove large particles.

2 Use the filtrate (the leftover water from Step 1) to half fill the seven test-tubes. Label each tube with a code so you know which flocculant you will add to it.

3 Add five drops of your first test flocculant to the first test-tube, add five drops of the second to the second test-tube, and so on , as shown in Figure 4.4.13. Record your observation on each test-tube in a table.

4 Filter one of the clearest test-tubes and observe the filtrate and residue.

5 Dispose of all residues from experiments as directed by your teacher.

Review

1 Identify the test materials that appeared to be flocculants.

2 Is there any way of telling which substance was the best flocculant? Explain.

3 Explain how this experiment is relevant to our lives.

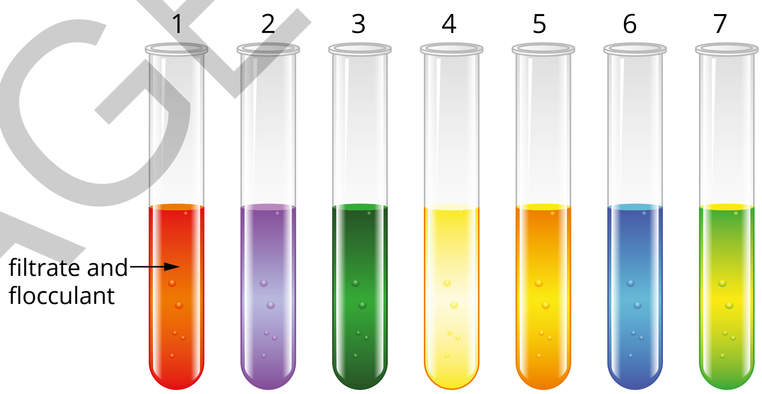


FIGURE 4.4.13

CHAPTER 4

Practical investigations

• STUDENT DESIGN •

2 • Sewage treatment

Planning & Conducting

Evaluating

Purpose

To design and construct a model of a sewage treatment plant.

Timing 90–120 minutes

Materials

- 500 mL of a mixture of water, vegetable oil, mud, sand, gravel and paper
- potassium aluminium sulfate
- equipment chosen by students

SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 In your group, decide what are the essential features of a sewage treatment plant.

2 Design a model of a sewage treatment plant. The method of separation should model the processes used in a real sewage treatment plant. You are only modelling the sewage treatment processes. Some processes are too difficult, time consuming or dangerous to actually do in a laboratory. Do not actually aerate the mixture, use real ultraviolet light or add chlorine. You can pretend you are doing these processes by using materials to simulate the processes (see Hints).

3 Draw your design in your workbook and write how you intend to separate the mixture.

4 Before you start any practical work, assess your model and how it will work. List any risks that it might involve and what you might do to minimise those risks. Show your teacher your design and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

- Fly wire is a good sieve
- You can simulate aerating the mixture by blowing into a plastic tube
- A lamp can simulate a UV steriliser.
- You could 'pretend' that a salt solution is chlorine.

Review

1 Compare your model with a real sewage treatment plant.

2 Evaluate the performance of your design.

3 Discuss the relevance of this practical activity to everyday life.

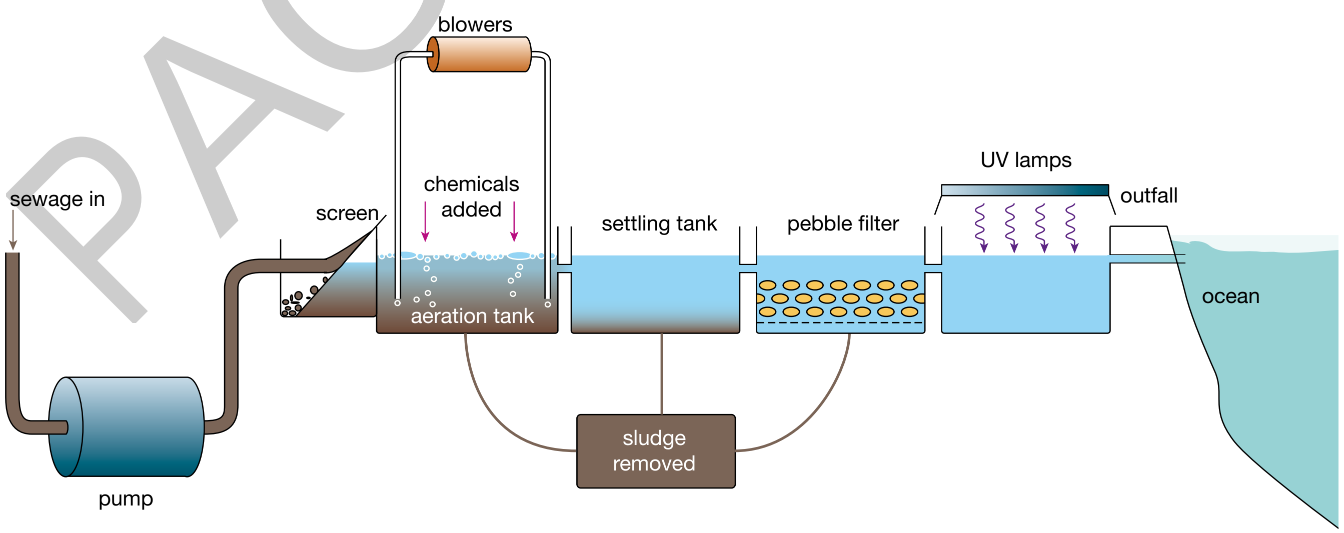


FIGURE 4.4.14 The typical stages for sewage treatment.

CHAPTER 4

Chapter review

Remembering

1 Where are each of the following devices used?
   a centrifuge
   b reverse osmosis plant
   c paper chromatography
   d Liebig condenser
   e septic tank.

2 What are the benefits of a greywater recycling system in the home?

Understanding

3 Outline how you could separate oil and water.

4 Outline the process of distillation.

5 Outline the desalination process known as reverse osmosis.

Applying

6 Identify a method you could use to separate:
   a sand and water
   b iron filings and sand
   c salt and water
   d alcohol and water
   e pebbles and water.

7 You have a solution containing blue dye.
   - You filter some of the solution through filter paper. There is no residue in the filter paper and the filtrate is blue.
   - When you filter some of the solution through an even finer carbon filter, the filtrate is colourless.
   - When you take this carbon filter and shake it in methylated spirits, the liquid turns blue.

   Apply your knowledge of solvents and separation techniques to outline what is happening at each step.

8 A student adds 10 grams of solid X to 100 mL of pure water, but only 1 gram dissolves.
   a Describe this solution.
   b Calculate how much of solid X would settle on the bottom of the container.

Analysing

9 Use words or a Venn diagram to compare:
   a solutions with suspensions
   b evaporation with distillation
   c evaporation with crystallisation.
   d pure water and seawater
   e sewage with the sewerage system
   f greywater and blackwater.

Evaluating

10 The physical properties of a mixture influence the type of separation method used. Use examples to justify this statement.

11 Which of the following would be the best way to dispose of 500 mL of cooking oil? Justify your answer.
   A Pour it down the sink.
   B Flush it down the toilet.
   C Mix it with detergent and put it in the sink.
   D Soak it into paper and put it in the bin.

12 Assess the following statement made by a scientist:
   It is essential in Australia that we increase the amount of water we are recycling. Greywater and blackwater can become a vital part of this.

13 When you add 20 g of substance Z to 50 mL of water, only 5 g dissolves.
   a Calculate how much more of substance Z would dissolve if you added another 50 mL of water to the container.
   b Predict what would happen to the amount of substance Z if you added 200 mL of water to the original solution.

14 a Assess whether you can or cannot answer the questions on page 139 at the start of this chapter.
   b Use this assessment to evaluate how well you understand the material presented in this chapter.

Creating

15 Design an experiment to separate a mixture containing salt, sand and iron filings.

16 Use the following ten key terms to construct a visual summary of the information presented in this chapter.

mixture	solution	water treatment
filtration	gravity	distillation
evaporation	sewage	
purifying water	insoluble	

AB 4.11

CHAPTER 4 Inquiry skills

Research

1 Communicating Evaluating

Research three methods of cleaning up pollution from oil spills in the ocean. Choose methods that use separation techniques you have studied such as filtering, gravity separation or centrifuging. In your answer:

- **a** Outline each method.
- **b** Identify the separation technique each method uses and explain how each method works.

Present your findings in digital form.

2 Communicating

Research two separation methods used in either the food industry or the wine industry.

- **a** Name the methods used.
- **b** Explain the purpose of each separation method.

Present your research as diagrams, photos or videos illustrating the equipment used in the separation method.

3 Communicating Evaluating

Water shortages are becoming a reality in many places in Australia. There are many possible solutions to this. Consider the following list of possible strategies a government may use and discuss by providing points for and against each strategy.

- increase the price of water
- impose severe water restrictions
- increase fines for using water without permission
- build more water treatment plants
- improve water recycling methods in the home and industry
- public awareness campaigns.

4 Communicating Evaluating

One way of trying to save water is by using alternative toilet designs. One alternative design is the composting or dry toilet, which can be used instead of the flushing toilet usually found in homes. Research the different types of toilets used around Australia.

- **a** Include a diagram of each type of toilet.
- **b** Explain how each toilet works.
- **c** Propose reasons why composting toilets are not more widely used in homes.

Present your research as a pamphlet to homeowners or a display for a home show.

5 Communicating Processing & Analysing

Research the water purification process called reverse osmosis.

- **a** Describe the basic process of reverse osmosis using a diagram.
- **b** Compare the process of reverse osmosis with filtration.
- **c** Include a diagram showing:
  - a typical reverse osmosis unit that can be used in a home to purify tap water
  - how of a desalination plant uses reverse osmosis.
- **d** Include a map showing a desalination plant that uses reverse osmosis nearest to your home.

Present your research in digital form.

Inquiry skills

Thinking scientifically LS

1 Refer to the following data to answer the questions below:

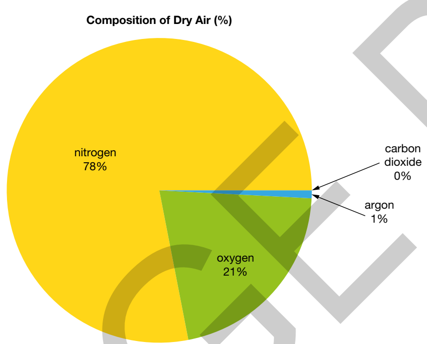
Air is a mixture of gases. This table shows the composition and proportion of gases in air where water vapour has been removed.

TABLE 4.5.1 Composition and proportion of gases in air where water vapour has been removed

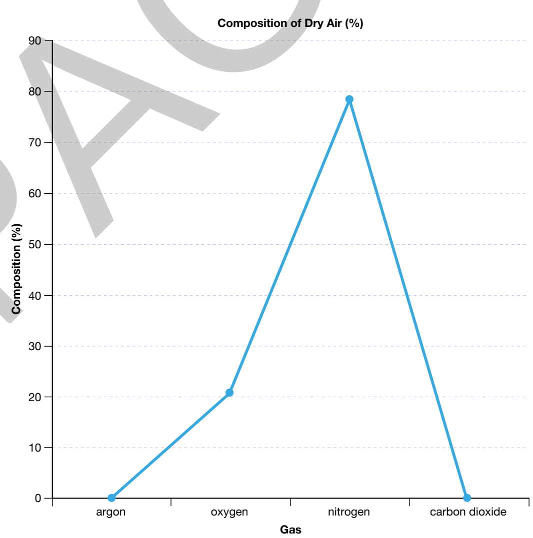
Substance	Proportion of dry air (%)	Boiling point
argon	0.96	–186
oxygen	21	–183
nitrogen	78	–196
carbon dioxide	0.04	–79

a Which two graphs could be used to represent the composition of dry air? Select one or more correct answers.

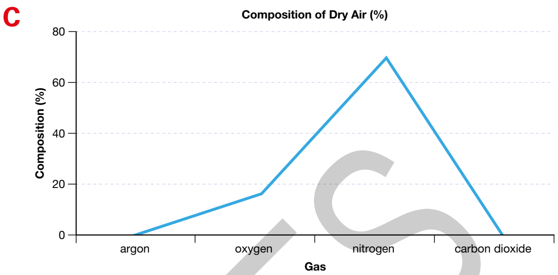
A



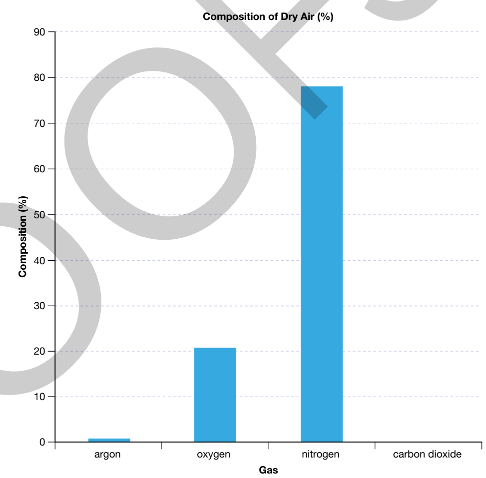
B



C



D



b Which substance in air has the lowest boiling point?

A argon
B oxygen
C nitrogen
D carbon dioxide.

c Which process could be used to separate the substances that make up air?

A filtration
B decanting
C distillation
D chromatography.

2 Refer to the following data to answer the questions below.

Soda is a mixture.

The bubbles in soda water come from carbon dioxide gas dissolved in water (Figure 4.6.1).

FIGURE 4.5.1

The amount of carbon dioxide in water depends on the temperature of the water (Figure 4.6.2).

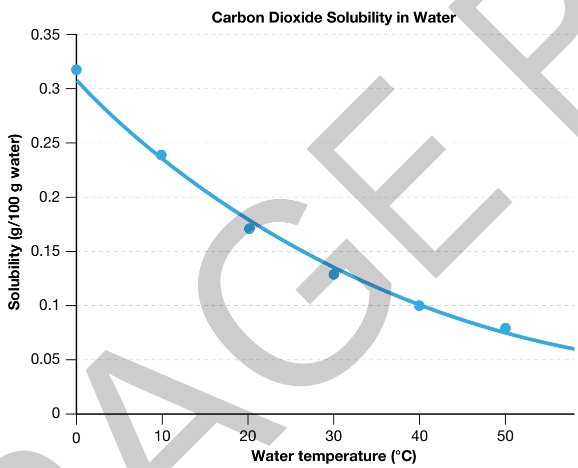


FIGURE 4.5.2

a What is the trend in the above graph?
- **A** erratic
- **B** increasing
- **C** decreasing
- **D** unchanging.

b What is the solubility of $CO2$ at 25°C?
- **A** 0.05 g/ 100 mL
- **B** 0.15 g/ 100L
- **C** 0.16 g/ 100 mL
- **D** 0.70 g/ 100 mL.

c What would the solubility of $CO2$ at 70°C be?
- **A** 0.03 g/ 100 mL
- **B** 0.05 g/ 100L
- **C** 0.06 g/ 100 mL
- **D** 0.10 g/ 100 mL.

d What is the independent variable in the graph?
- **A** water
- **B** solubility
- **C** temperature
- **D** carbon dioxide.

e What is $CO2$ in this mixture?
- **A** solute
- **B** aquifer
- **C** solvent
- **D** solution.

f Carbon dioxide can trap heat in the atmosphere. Carbon dioxide is naturally dissolved in the ocean waters.
What will be the effect of climate change warming the ocean waters?
- **A** The oceans will begin to fizz.
- **B** More carbon dioxide will be dissolved in the oceans.
- **C.** The rate of change to hotter climates will be increased.
- **D.** The rate of change to hotter climates will be decreased.

3 Fifi and Gina filtered some muddy water through conical filter paper and fluted filter paper. Their results are shown in Table 4.6.1.

TABLE 4.6.1 Time taken to filter muddy water using fluted and unfluted filter paper

Type of fold	Trial 1 (sec)	Trial 2 (sec)	Trial 3 (sec)	Average 2 (sec)
Conical paper	55.4	62.2	56.6	
Fluted paper	37.6	42.1	38.4	

a Calculate the average time taken to filter.

b List five variables that would have to be controlled for this experiment to be a fair test.

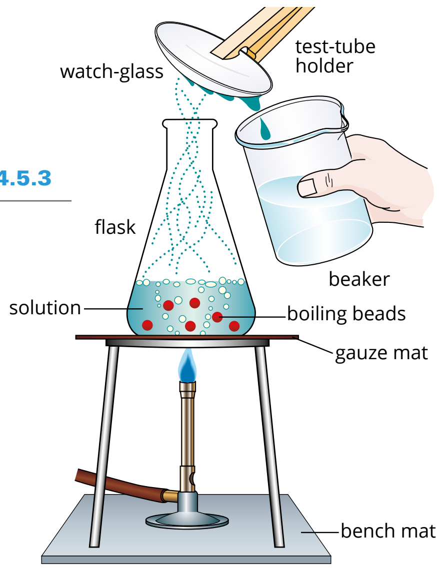
c Which paper was superior?

d Explain Fifi and Gina's results.

Inquiry skills

4 Michael and Andrew used the procedure shown in Figure 4.5.3 to separate copper sulfate from water from an aqueous copper sulfate solution.

FIGURE 4.5.3



a Identify the main separation method that resulted in the liquid in the beaker.

b If they continue to heat the conical flask, predict what it will contain at the end.

c Identify three possible safety issues with the experiment.

d How successful do you think this method of separation is? Predict some problems with the process.

e Identify equipment that would do a better job of separating the copper sulfate solution.

5 Scientist Jane noticed that where muddy water from a river met the ocean, it became clear fairly quickly. Scientist Jim suggested that the sediment settled because the river slowed down when it met the sea and the particles were too heavy to stay suspended in the water. When experiments with the muddy river water were conducted it was found that the mud particles stayed suspended in the test-tube when the water was left to settle. Jane disagreed with Jim, and proposed a different hypothesis.

a What hypothesis do you think Jane proposed? State a likely hypothesis.

b Use results from an experiment you have already performed to support your answer.

CHAPTER 4

Glossary

Aqueous solution: solution that has water as its solvent

Blackwater: wastewater from toilets and kitchens

Centrifuge: device that spins very fast to separate solids from liquids, or liquids from other liquids

Chromatography: a method of separating a mixture by making it move over or through another substance that stays still

Concentrated: there is a lot of solute in the solvent

Crystallisation: formation of crystals as a dissolved substance solidifies

Crystallisation

Decantation: separation by pouring liquid off the top of a mixture of solid in liquid, or liquid in liquid

Desalination: removing dissolved salts such as sodium chloride from water

Dilute: when there is little solute in the solution

Disperse: when particles spread without dissolving

Dissolve: break up into tiny particles that are smaller than the eye can see

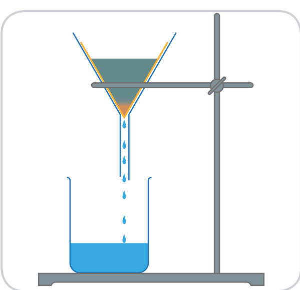
Distillation: a process that uses evaporation and condensation to separate solids from liquids or liquids from liquids, enabling the recovery of both

Evaporation: a process that uses heat to make a liquid solvent change state to a gas, and leave behind the solute it had dissolved

Filter: screen or membrane used in filtration

Filtrate: liquid that passes through the filter paper

Filtration: separation of solids or liquids from a liquid or gas by using a barrier with holes smaller than the particles being separated



Filtration

Gravity separation: a method of separating two components from a suspension by using the force of gravity to separate heavier particles to the bottom

Greywater: wastewater from shower/bath and laundry

Impurities: unwanted substances

Insoluble: substance that does not dissolve in a particular solvent

Mixture: a substance made from two or more pure substances that have been stirred together and that can be separated to recover the original substances

Potable water: drinkable water

Pure substance: a substance made of only one type of material

Residue: solid left in the filter paper after filtration

Saturated: as much substance as possible is dissolved in a solvent

Septic tank: concrete or plastic tanks placed underground that process sewage from homes and businesses outside the sewerage system

Sewage: wastewater from toilets, bathrooms, kitchens and laundries that may contain human waste and other organic chemicals or harmful chemicals

Sewerage system: system of pipes underground that collects wastewater from homes and businesses and takes it to treatment plants

Soluble: able to be dissolved

Solute: a substance that dissolves to make a solution when it is mixed into another substance

Solution: when a substance dissolves in another, forming a clear mixture

Solvent: a substance that dissolves another substance

Suspension: mixture in which a substance will not dissolve in another and quickly separates out if left to stand

Wastewater: water that has been used and disposed of because it is no longer clean

AB 4.10

Suspension