MIXTURES 3

3.1 Mixtures are a combination of two or more substances

3.2 A solution is a solute dissolved in a solvent

3.3 Mixtures can be separated according to their physical properties

3.4 Mixtures can be separated according to their size and mass

3.5 The different boiling points of liquids can be used to separate mixtures

3.6 Solubility can be used to separate mixtures

3.7 Waste water is a mixture that can be separated

3.8 Materials recovery facilities separate mixtures

What if?

Case mix

What you need:

a variety of different pencil cases (size, shape, colour)

What to do:

1. Place all the pencil cases in one pile.
2. List your pencil case's properties that will allow it to be identified easily (e.g. colour, shape, size and weight).
3. Give the list to another student. Can they identify your case by using the list?

What if?

- » What if you were blindfolded? Could you still find your pencil case?
- » What if the pencil cases were too small to feel? How could you identify yours?
- » What if all the pencil cases were exactly the same? Would it still be a mixture?

3.1 Mixtures are a combination of two or more substances

Consider the things around you. Perhaps they are made of wood, glass or plastic. Wood, glass and plastic are all mixtures – each of these materials is made up of two or more **substances**. Some materials are pure substances. A **pure substance** is one where all the particles are identical. Pure water, oxygen and diamonds are examples of pure substances.

Properties of mixtures

There are many different types of **mixtures**, each with different characteristics. For this reason, scientists have grouped mixtures according to their **properties**: what they are made of and how they behave. Knowing the type of mixture helps us work out ways to separate it into pure substances.

Solutions

When you mix salt into water, it seems to disappear. But we know the salt is still there because we can taste it. The particles of salt become so small, they spread evenly throughout the water. This clear mixture of salt and water will not separate by itself. It is a solution. A **solution** is a mixture of one substance dissolved evenly throughout another. Solutions are usually transparent (see-through).

Figure 3.1 Most of the things we use every day are mixtures. What mixtures can you see in this photograph? Can you see any pure substances?

Suspensions

Dirty water is an example of a suspension. A **suspension** is a mixture of two substances, in which a solid is dispersed, undissolved, in a liquid. The result is a cloudy liquid. Sand in water is also a suspension. If you shake a container of sand and water, the sand spreads through the water, forming a cloudy liquid. The sand will then settle to the bottom of the container as **sediment**. Suspensions often need to be shaken or stirred before use to spread the sediment through the liquid.

Colloids

When two types of particles are mixed, they don't always separate out with time. Suspensions that don't separate easily are referred to as **colloids**. These can be formed by a solid being suspended in a liquid, such as hot chocolate in milk. Occasionally different particles can get suspended in a gas. Fog is an example of this: small drops of water suspended in the air. The word 'colloid' comes from the Greek word *kolla*, which means 'glue'. You can think of a colloid as a substance being 'stuck' – suspended – in another substance. The benefit of colloids is that there is no need to mix them before using them. Hair gel and hand cream are examples of colloids.

Emulsions

An **emulsion** is a colloid of two or more liquids. Usually, one liquid is the 'base' and the other is broken into tiny droplets spread throughout the 'base'. Milk is an emulsion, with tiny droplets of fats and oils spread throughout the base, which is water.

In some cases, when mixtures like this are left to settle, the tiny droplets float above the base liquid. (This is different from what happens in a suspension, where the solid particles tend to fall to the bottom.) A substance called an **emulsifier** can be added to these mixtures to allow the liquids to remain completely mixed.

The most common emulsions we use are mixtures of different types of oil mixed with water and an emulsifier. Examples include food and drinks, and 'emulsion' paints.

CHALLENGE 3.1: COMPARING DIFFERENT TYPES OF MIXTURES
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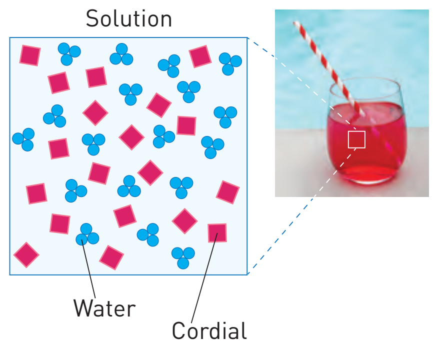

Figure 3.2 This glass of cordial is an example of a solution. The small cordial particles are dissolved evenly throughout the water. The swimming pool water in the background is also a solution, with chlorine and other chemicals dissolved evenly in the water.

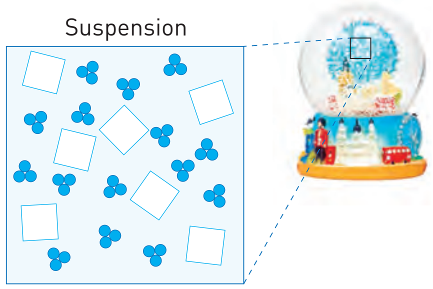

Figure 3.3 A snow dome can be described as a suspension, with the larger 'snow' particles being suspended in the water for a short time before they fall to the bottom of the dome to form a sediment.

Figure 3.4 Fog is a colloid because it is made up of suspended liquid particles in air.

Figure 3.5 Milk is a colloid because it contains many substances suspended in what is mainly water.

Check your learning 3.1

Remember and understand

1 What is a pure substance?

Apply and analyse

2 Identify the following as pure or a mixture:
   a cup of tea
   b soft drink
   c table salt
   d soap
   e olive oil

3 For any that you think are not pure, write down what substances you think they might contain.

Evaluate and create

4 In which mixture(s) would you find sediment?

5 Complete the table below for mixtures.

TYPE OF MIXTURE	SUBSTANCES INVOLVED	APPEARANCE WHEN LIGHT SHINES THROUGH	SEPARATES ON STANDING?	EXAMPLE
Suspension	Solid + liquid	Cloudy	Yes, slowly	Milo in milk
Emulsion				
Colloid				
Solution				

3.2 A solution is a solute dissolved in a solvent

In Unit 3.1 you learnt that a solution contains one substance mixed evenly through another. An example of this is lemonade, in which the sugar and flavour are dissolved evenly through the water. The more solute (sugar) that is dissolved in the solvent (water), the more **concentrated** the solution. A solution becomes **saturated** when no more solute will dissolve.

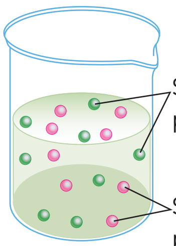

Figure 3.6 A solute dissolves in a solvent to create a solution.

Solubility and insolubility

In some places in Australia, the water from the local water supply has an unpleasant taste. Or washing with soap is difficult because the water forms a scum instead of a foamy lather. In these cases, the water contains metal salts that affect its taste and behaviour. Because they are so small, these metal salts do not fall to the bottom, or float on the top, but remain evenly spread through the liquid. The resulting mixture (a solution) is clear – light will shine through it. We say that the metal salts have **dissolved** in the water.

A substance that is able to dissolve in a liquid is considered to be **soluble**, whereas one that cannot is **insoluble**. The substance dissolving is called the **solute**, whereas the liquid into which it dissolves is called the **solvent**. An example of this is salty water. The salt is the solute, and the water is the solvent. Sometimes it is necessary to help a solute such as salt to dissolve. Warming the solvent (water) is the most common way of making a solute dissolve faster.

Working with solutions

You have seen that a solution is a solute dissolved in a solvent. Solutions can be compared in terms of their **concentration**: how much solute is in the solvent. If just a little solute is dissolved, the solution is described as **dilute** (low concentration). If a lot of a solute is dissolved, then the solution is described as concentrated (high concentration).

Figure 3.7 The concentration of salt in the Dead Sea in Israel is so high that when people try to swim in it, they float instead!

EXPERIMENT 3.2A: WHAT IF SALT WERE DISSOLVED IN WATER?
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EXPERIMENT 3.2B: WHAT IF THE SOLVENT WERE HEATED WHEN MAKING A MIXTURE?
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It is only possible to dissolve a certain amount of a particular solute in a solvent. If no more solute can dissolve into a solution, the solution is described as saturated. What sort of cordial drink do you prefer: dilute, concentrated or saturated?

We often work with solutions in our everyday lives. By adding solutes to pure liquids, the properties of the pure liquids may change. An example is adding bath crystals to a bath to give the water a pleasant smell.

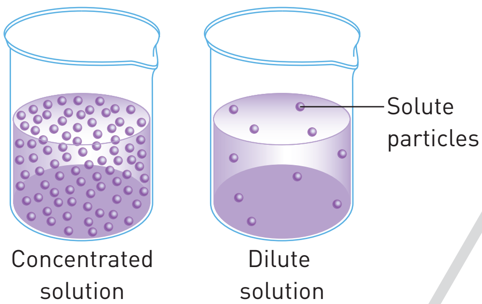

Figure 3.8 A concentrated solution contains more solute particles in a given volume than a dilute solution.

Figure 3.9 Oxygen dissolved in water is essential for aquatic organisms.

Water as a solvent

Water is a good solvent. This is one of its most important properties. Our digestive system uses water to dissolve our solid and liquid food, and to break up the food into nutrients that our body needs to build new cells, grow and repair.

Our bodies are more than 60% water. Our blood, which is mainly water, transports oxygen to every cell and carries away dissolved carbon dioxide gas (a waste product).

Humans are not the only living things that depend on water as a solvent. Without water's ability to dissolve gases, there would be no underwater life in our oceans and lakes and no fish in the rivers. These creatures all live by extracting dissolved oxygen gas from the water.

Imagine you found a colourless and see-through liquid and were really thirsty. Is it water? There many other colourless and clear liquids, and you don't know what substances might be dissolved in them. Tasting may be dangerous. There are more scientific ways of working out whether a liquid is pure. This is explored further in Unit 3.3.

Check your learning 3.2

Remember and understand

1 If someone asked for a dilute glass of cordial, would you add a lot of cordial or only a little?
2 How could you increase the amount of a solute that will dissolve in a solvent?
3 Scientifically, how do you describe a solution that will not allow any more solute to dissolve?
4 True or false: you can see the particles of a solute in a solution.

Apply and analyse

5 Do all solutes dissolve in water? Explain your answer.
6 What happens to the sugar particles when they dissolve in water?

Evaluate and create

7 Are the particles in a suspension, colloid or emulsion soluble? Explain.

SKILLS LAB 3.3A: SEPARATION USING MAGNETIC PROPERTIES
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3.3 Mixtures can be separated according to their properties

A mixture contains components that can be separated because of their different properties. Properties are how a substance looks (size, mass, texture, shape, volume) and how it behaves around other substances (magnetic, soluble). Before you can separate a mixture, you need to find out what properties its components have that are different. For example, one substance may be soluble in water, whereas another may not. One substance may be magnetic and another not magnetic.

Figure 3.10 Different separations need different techniques.

Simple separation

Some mixtures are quite simple to separate. Sometimes we can simply pick out the bits we need to separate. A bag of mixed lollies may contain a few of your favourites. You could easily use your fingers to pick these lollies out so that you could eat them first. This works well if it is a small bag and you can see the individual lollies. What if the bag contained hundreds of lollies that were too small to see? You may need another way of separating out your favourites.

Magnetic separation

Do you separate recyclables from your rubbish? Have you ever wondered how the different recyclable materials are separated once they're out of your house?

Magnetic separation uses magnets to attract and separate particular objects. Some metals are magnetic. Magnetic substances are attracted to a magnet. They are made of iron, or a mixture containing iron.

Because **magnetism** will only separate substances containing iron, magnetic materials, such as iron nails, can be separated from other non-magnetic materials, such as glass, aluminium and paper.

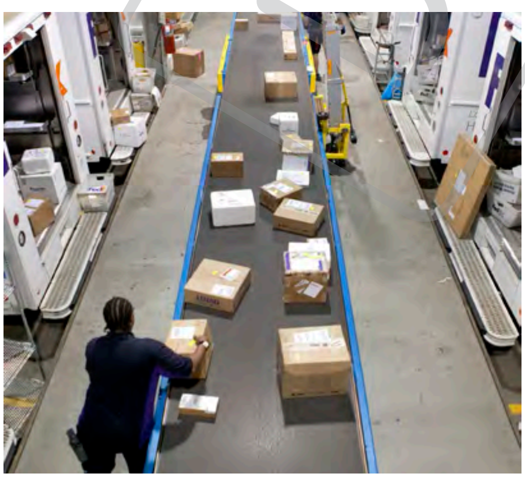

Figure 3.11 Separating a mixture of packages is simple.

Figure 3.12 Magnets are used to separate metals in recycling plants.

SKILLS LAB 3.3B: SEPARATING MIXTURES USING SEDIMENTATION AND FLOTATION
GO TO PAGE 177

EXPERIMENT 3.3: WHAT IF A FLOCCULENT WERE ADDED TO MUDDY WATER?
GO TO PAGE 178

Figure 3.13 Magnets can be used to separate tin cans (left), which are magnetic, from aluminium cans (right), which are not.

Figure 3.14 Decanting wine separates the undrinkable sediment.

Tin cans are magnetic, whereas aluminium cans are not. Sometimes large magnets are used to separate aluminium cans in the rubbish from tin cans. This means both types of cans can be recycled in different ways.

Decanting, sedimentation and flotation

Have you ever had a piece of food in the bottom of your drink? Did you use a spoon to remove it? Or maybe you carefully poured your drink into another glass, leaving the food behind? The careful pouring of liquid, or **decanting**, is often done to remove sediment from wine.

The objects or liquids that sink are denser than the liquid on the top. The particles in **dense** objects are packed together more tightly than in less dense objects. Oil floats on top of water because the particles in the oil are packed very loosely. The water particles pack together more tightly, so they sink to the bottom, below the oil.

The particles in a grain of sand are packed together very tightly. The sand is more dense than water. Therefore, the sand settles to the bottom of a glass of water. The sand forms a **sediment** in the glass.

Sedimentation and **flotation** are used in sewage treatment to separate the mixture of substances. Sewage is left in settling ponds to allow the sediment to settle to the bottom. Fats and oils that float to the top of the ponds can be scooped off for digestion by bacteria.

Oil spills can be cleaned up using the fact that oil floats on the surface of water. Cork and other substances can be sprinkled on top of the oil to soak it up, and these substances are then scooped off and squeezed out.

In certain situations, sedimentation is more difficult. Chemicals called **flocculants** can be added to a mixture to make suspended particles clump together. This makes them heavy enough to settle to the bottom. Flocculation is regularly used to separate substances from water.

Figure 3.15 Sewage treatment involves sedimentation and flotation.

Figure 3.16 Oil floats on the surface of water.

Check your learning 3.3

Remember and understand

1. What do the following words mean?
   a. sediment
   b. flocculation
   c. decant
   d. density
2. What property differs between tin cans and aluminium cans?

Apply and analyse

3. Why does flotation allow oil spills to be cleaned up more easily?
4. If a suspension doesn't separate, what can be done to cause sedimentation?
5. In what situation might you rely on people to separate a mixture by hand?

Evaluate and create

6. What are the limitations for using magnetism to separate a mixture?

3.4 Mixtures can be separated according to their size and mass

Other properties can be used to separate particles. Large particles can be separated from smaller particles by filtering. Heavy particles can be separated from light particles by using a centrifuge.

Filtering

Anyone who has cooked pasta will probably have used a colander or sieve to separate the boiling water from the cooked pasta. The holes in the colander or sieve are designed to let the water through, but not the pasta.

A filter has a series of holes in it that lets through small things, but traps the larger particles. A grate on a storm water drain is an example of a filter. The grate lets the water through while filtering out the leaf matter and rubbish. Fly screens on windows and doors filter bugs and some dust from the air, and tea bags filter the leaves from the liquid.

Figure 3.17 Tea bags are a common household filter.

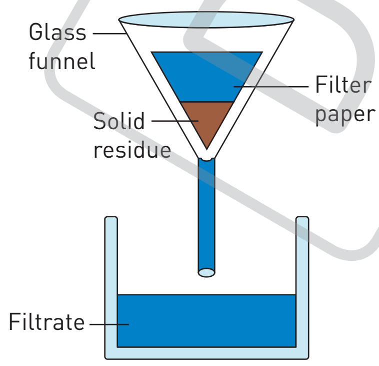

Figure 3.18 Filters are used in science to separate substances. Particles that pass through the filter are called the filtrate. The filter paper traps the residue.

Figure 3.19 A HEPA filter is used to filter fine particles from the air.

Filtering separates substances according to the size of their particles. In science, using a sieve is called **filtering**. Filtering is the same process as sieving: it separates particles in a mixture according to their size and the size of the holes in the sieve. The **filtrate** passes through the filter and the **residue** is left behind in the filter.

Filter paper is a paper sieve with holes that are too small to see. Solutions can flow through the filter paper because the particles in the solution are small enough to fit through the holes; however, most solid particles in suspensions are not. Different filter papers come with different-sized holes. Coffee filters and the filters found in vacuum cleaner bags are both made of paper filters. HEPA (high-efficiency particle arrestance) filters are used in vacuum cleaners, air conditioners and face masks to remove even tiny dust particles.

Sometimes filters remove substances using chemicals rather than by physically stopping them. Gas masks often contain a special type of charcoal that attracts and holds onto some poisonous gases.

SKILLS LAB 3.4: FILTERING A MIXTURE OF SAND AND WATER
GO TO PAGE 179

EXPERIMENT 3.4: WHAT IF YOU CENTRIFUGE MILK?
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Figure 3.20 A gas mask uses activated charcoal to filter poisonous gases.

Centrifuging

Sometimes mixtures do not separate well using sedimentation because the particles are not dense enough. Sometimes things need to be separated using their weight.

Some playgrounds have equipment that spins around very fast. When you spin very fast on this equipment, you can feel a force pulling you towards the outside of the spin. Heavy objects feel the pull more than light objects.

Centrifuging separates light and heavy particles by spinning a mixture. A centrifuge is a machine that spins very quickly. In a laboratory, small test tubes of mixtures are fixed to the inside of the bowl of the centrifuge. The spinning motion causes the heavier particles to move to the bottom of the tubes.

Centrifuges are used in medical research and at blood banks. When blood is spun in a centrifuge, the red blood cells, which are heavier, sink to the bottom of the test tube, leaving the yellowish liquid part of blood (plasma and platelets) at the top. Medical professionals use different parts of blood depending on the particular medical need.

Centrifuges are used in dairy processing factories to separate cream from milk. Salad spinners and washing machines also use this principle.

Figure 3.21 When blood (right) is separated by a centrifuge, the red blood cells collect at the bottom of the tube and the less dense liquid, the plasma and platelets, collects at the top (left).

Check your learning 3.4

Remember and understand

1 What filters are used around your home and school? What substances do these filters allow to pass through them and what substances do they collect?

2 For each of the following pairs, write a sentence explaining the difference between them:

a mixture – pure substance

b sedimentation – flotation

c residue – filtrate

3 Complete the sentences below by filling in the missing words.

Filtering is like using a _____________. The _____________ lumps are caught in the sieve, and the _____________ goes through the _____________ paper.

The substance caught in the _____________ paper is called the __________. The substance that passes through is called the __________.

Apply and analyse

4 Why would a forensic scientist who was investigating a crime want to compare a mixture of different types of sand found in a suspect's car to a similar mixture found at the crime scene?

Evaluate and create

5 Is a butterfly net an example of a filter? Explain.

6 List two places where centrifuges are used.

Figure 3.22 A spinning washing machine is a centrifuge, separating water from the clothes.

3.5 The boiling points of liquids can be used to separate mixtures

The various parts of a mixture will often have different **boiling points**. This means they become a gas at different temperatures. Alcohol boils at 78°C. Water boils at 100°C. In a mixture of alcohol and water, the alcohol will always evaporate first. Any solids left behind will crystallise. Filtering, sedimentation, flotation, centrifuging and magnetic separation are useful for some types of separation. But what do you do when they don't work?

Evaporation and crystallisation

When water in a saucepan is heated, it will quickly start to boil. This means the liquid **evaporates**: it becomes a gas. Every substance evaporates at a different temperature. Table 3.1 shows the boiling point of some common liquids.

The different boiling points of liquids can be used to separate them in a mixture. A mixture of water and turpentine can be easily separated because the water will evaporate first. This means the water will become a gas (steam) and move away from the turpentine. Eventually only turpentine will be left behind.

This method can also be used to separate the parts of a solution. Salt evaporates at 1414°C. When a mixture of salt and water is heated, the water evaporates first, leaving behind the salt crystals. This process of evaporating the solvent (the water) and leaving behind the solute (salt) is called **crystallisation**.

Figure 3.23 Water will evaporate from a mixture of salt and water, leaving behind salt crystals.

Table 3.1 Boiling points of common liquids

LIQUID	BOILING POINT
Water	100°C
Alcohol	78°C
Petrol	95°C
Olive oil	300°C
Tar	300°C
Turpentine	160°C

EXPERIMENT 3.5: CRYSTALLISATION OF SALT WATER
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CHALLENGE 3.5: DESIGN A WAY TO PURIFY WATER FROM SEA WATER
GO TO PAGE 181

Distillation

What if we want to keep the substance that has the lowest boiling point? Collecting drinkable water from sea water is difficult if all the water evaporates into the air. **Distillation** is a way of collecting the gas that evaporates from a mixture and cooling it down so that it becomes a liquid again. This cooling down of a gas into a liquid is called **condensation**.

The crude oil that is removed from the earth is a mixture of different liquids that all have different boiling points. When the crude oil is heated, petrol is one of the first substances to evaporate. The petrol gas rises up the column until it cools and condenses. The liquid petrol is then collected on one of the trays in the column. The oil used in heating has a higher boiling point. It evaporates more slowly and condenses quicker. It is collected on a tray lower in the column.

Figure 3.24 Whisky production uses distillation.

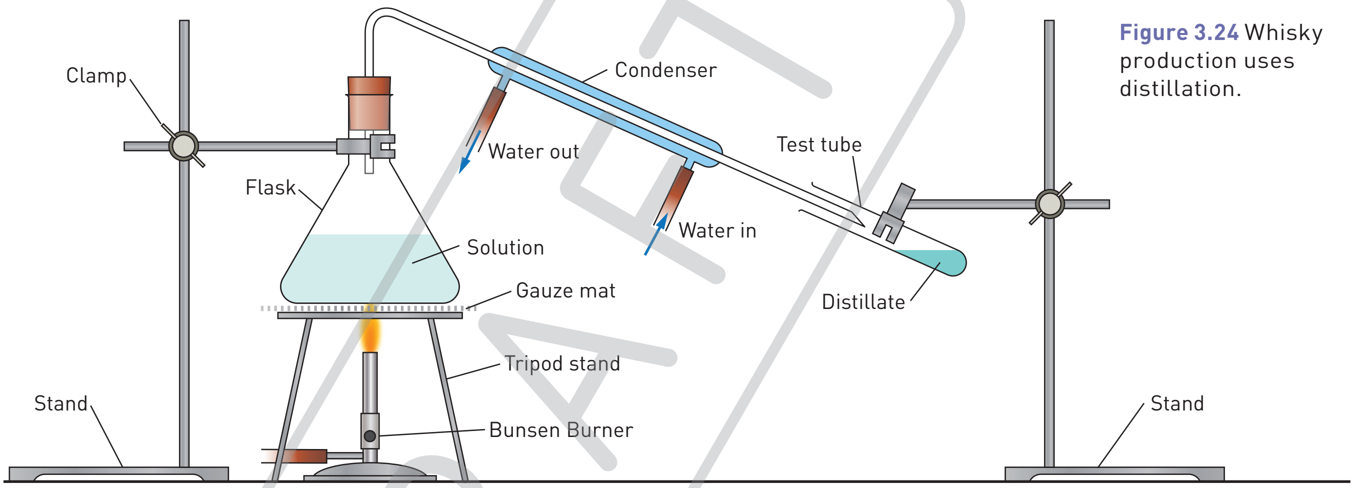

Figure 3.26 Equipment set-up for distillation.

Figure 3.25 Crude oil can be separated into different fuels because each boils at a different temperature.

Check your learning 3.5

Remember and understand

1. Explain the difference between evaporation and crystallisation.

Apply and analyse

2. Give an example of a mixture you would separate using evaporation and crystallisation. Explain why distillation may not be appropriate.
3. What separation technique is being conducted in Figure 3.27?

Figure 3.27

Evaluate and create

4. Draw the equipment set-up that could be used to produce pure water from sea water by distillation.

3.6 Solubility can be used to separate mixtures

Some substances are able to dissolve more easily than others. **Chromatography** can be used to separate mixtures of substances that have different solubilities.

Solubility

Another property that can differ between substances is solubility. **Solubility** describes how easily a substance dissolves in a solvent. Some dyes have a higher solubility than others. This can be used to separate them from each other. Many dyes are small particles that are suspended in a solvent. They are usually made from plants or minerals. Early Greeks made a mixture of soot and vegetable gum that could be used for writing. One thousand years later, the Chinese made red ink from mercury sulfate and black ink from iron sulfur mixed with sumac tree sap. Today, many of the inks in textas are made of a mixture of these dyes. We can separate these dye mixtures because the dyes have different solubilities.

Chromatography

Paper chromatography is a common way to separate a mixture. **Chromatography** works when the end of the absorbent paper is dipped in water, allowing the water to slowly move up the paper. As the water moves past the dye mixture, the most soluble dye dissolves and starts to move with the water. The other dyes in the mixture take longer to dissolve. Eventually the next dye forms a solution and starts moving towards the top of the paper. Finally, the paper has a series of smudged dyes running up to the top. The coloured dye that is the most soluble is at the top, whereas the dye that is least soluble is at the bottom.

Figure 3.28 Chromatography is used to separate samples, such as inks and dyes.

EXPERIMENT 3.6: WHO WROTE THE NASTY NOTE?
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CHALLENGE 3.6: SEPARATION CHALLENGE
GO TO PAGE 183

Figure 3.29 Performing gas chromatography.

More complex and sensitive chromatography instruments are used to separate mixtures such as drinks and polluted air. Science laboratories often contain instruments that can be used to detect even one gram of a substance present in thousands of litres of solution. Scientists use chromatography to find out what substances are in a mixture. Different substances will move through at different times. The height of each peak tells the scientist how much of a particular substance there is.

One of the uses of chromatography today is to identify athletes who use banned substances when they compete by testing their urine. A chromatography machine separates all the substances in the urine, including any illegal drugs that leave the body in this way.

Airport security also tests for illegal drugs in this way. A piece of chromatography paper is wiped over a person or their bag, and then inserted into a machine. A gas is pushed through the paper. If the drug is soluble in the gas, then it will dissolve and be detected by the sensors. An alarm sounds and the security guard will take the person for questioning.

Figure 3.30 Airport security also uses chromatography to test for illegal drugs.

Check your learning 3.6

Remember and understand

1. What was used to make the first inks?
2. How does chromatography separate inks and dyes?
3. When is chromatography used to separate substances?
4. What is the solvent used in the chromatography for drugs at the airport?
5. What does solubility mean?

Apply and analyse

6. Some people think they can disguise drugs at airports by putting them in a strong smelling substance such as coffee beans. Explain why this will not work with airport security.

//SCIENCE AS A HUMAN ENDEAVOUR//

3.7 Waste water is a mixture that can be separated

Washing dishes or using the bathroom produces waste water containing a mixture of vegetable matter, paper, cloth and plastics. This cannot be released directly into waterways without harming the environment. Scientists use their knowledge of separating mixtures to make the water safe. Many unusual things have been found at waste water treatment plants, including BMX bikes, toys, false teeth and even money. One of the biggest problems currently is caused by the small stickers found on fruit. If eaten accidentally, the small plastic stickers pass through the digestive system and end up at the water treatment plants.

Primary treatment

Initially, the waste water is filtered to remove any large products.

Aluminium sulfate is added to the waste water to encourage any suspended particles still remaining to coagulate or clump together. This process is called flocculation.

The small clumps are then left to sit in sediment ponds to allow the clumps to form a sediment on the bottom of the pond. This sediment is called sludge and can be removed and disinfected. Many industries use the sludge as fertiliser or to manufacture biofuels.

Secondary treatment

The remaining waste water often contains levels of nutrients (e.g. nitrogen and phosphorus) that would be harmful to rivers or the ocean. When these nutrients enter waterways in large amounts, algae feed off them and grow into large blooms. The large numbers of algae use all the oxygen and nutrients in the water, leaving other aquatic life to starve. Secondary waste treatment pumps the waste water through a series of tanks where bacteria remove the excess nutrients from the water.

Figure 3.31 A water treatment plant.

Figure 3.32 Flocculation results in the clumping together of suspended particles in waste water.

Figure 3.33 An algal bloom.

Figure 3.34 Chlorine and waste water tanks in a tertiary water treatment plant.

Tertiary treatment

Sometimes the water will be treated at a tertiary treatment plant. Once again the water is filtered to remove any particles that may be left in the water. Chlorine can be added (just as in a swimming pool) to kill any bacteria that may still be in the water.

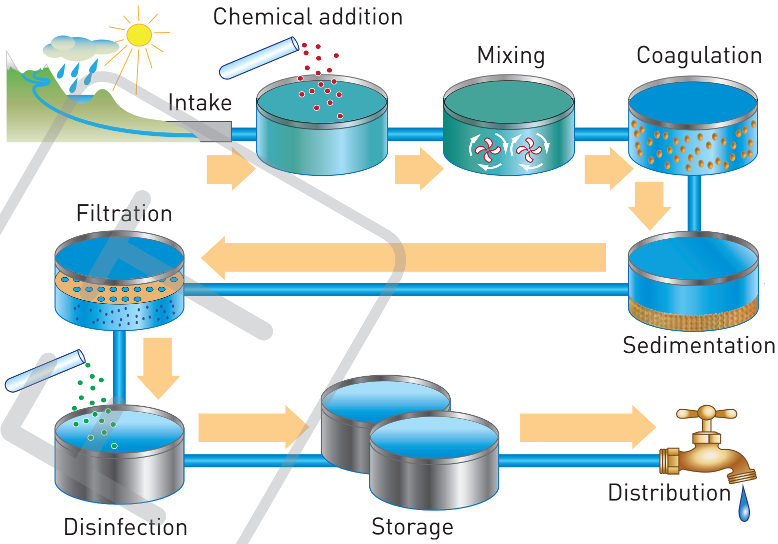


Figure 3.35 Summary of the water treatment process.

Extend your understanding 3.7

1 Water use is often an indication of the amount of waste water produced per person every year. A graph of the annual water consumption per person is shown in Figure 3.36.
   a Which city uses the highest amount of water per person each year?
   b Which city uses the lowest amount of water per person each year?
   c How much water does the average person in Canberra use?
   d Can you suggest why a person living in Brisbane uses more water than a person living in Melbourne?

2 Describe what type of objects might be removed during the primary treatment of waste water.

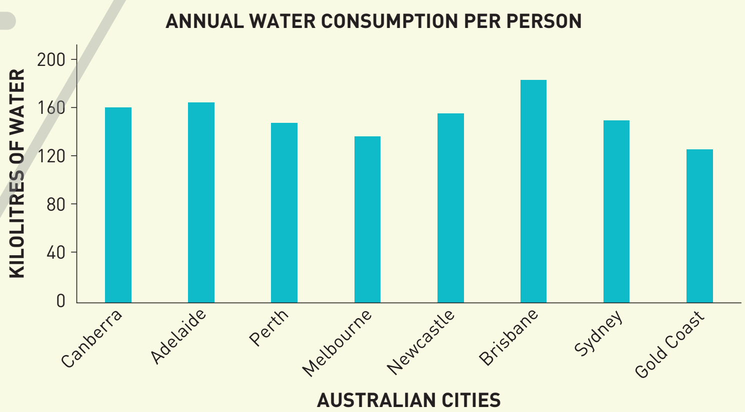


Figure 3.36

3 How can an algal bloom damage a river?

4 What is the purpose of the tertiary treatment of waste water?

5 Draw a cartoon that shows one stage of the treatment process.

Join your cartoon with those from others in your class who drew the other two stages, so that combined you show all levels of the water treatment process.

//SCIENCE AS A HUMAN ENDEAVOUR//

3.8 Materials recovery facilities separate mixtures

A Materials Recovery Facility uses the properties of the items in a recycling bin to separate them to be reused. The items are separated on the basis of mass, colour and magnetic properties. Recycling of rubbish saves electricity and water, and reduces the amount of greenhouse gases that would be released by landfill.

Figure 3.37 xxx

Household recyclables

Have you ever wondered what happens to the rubbish in the recycle bins collected by your local council? Most households put their paper, cardboard, glass bottles, cans and recyclable plastics into a separate rubbish bin. These items are collected by a different truck to the general rubbish trucks. Instead of going to landfill, the trucks take the recyclable rubbish to a Materials Recovery Facility. As the name suggests, this facility separates the mixture of rubbish before sending it off to be recycled.

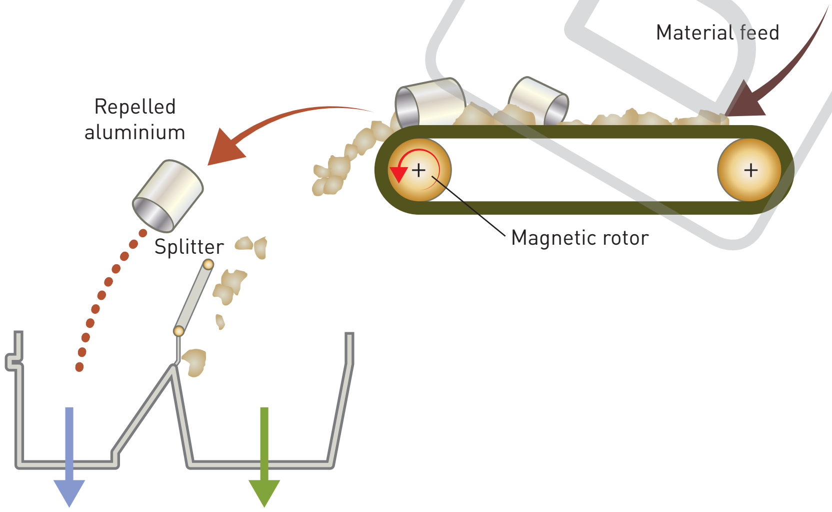


Figure 3.38 xxx

The Materials Recovery Facility

At the Materials Recovery Facility, the truck unloads the recycled rubbish onto a conveyer belt. The conveyer belt carries the rubbish into the facility before allowing the rubbish to drop onto a slight incline belt. Paper, cardboard and other light rubbish stay on the incline belt and are carried up and along to where they are sorted by hand. People separate the paper from the plastic bags, placing each into their special bins for recycling.

Heavier objects such as larger plastic containers, aluminium and tin cans, fall backwards off the incline conveyer belt onto another moving belt. This conveyer belt uses a large magnet to separate the steel and tin cans into a large bin. Aluminium cans are not attracted to the magnet and remain mixed with the larger glass and plastic containers.

The aluminium cans, glass and plastics are exposed to a special eddy current separator. This separator pushes the aluminium cans away so that the cans fall further than the glass and plastic bottles.

The conveyer belt carries the remaining glass and plastic bottles forward over a pit. The heavier glass containers fall faster and are

collected in a bin. The lighter plastic containers are caught by the last conveyer belt and are separated on the basis of colour. A light scans each plastic container for the type of plastic. Each type of recycled plastic is a different colour. Each colour plastic receives a different blast of air that projects it into the correct bin.

Why recycle?

The recycled glass is crushed into a 'cullet' and heated to 1500 °C until it is liquid/molten. The molten glass is then poured into a mould to form new bottles. The energy saved from recycling 1 glass bottle will run a 100 watt light globe for 4 hours. Aluminium cans are recycled in a similar manner. Each aluminium can that is recycled will create enough electricity to run a television for 3 hours. Recycling one tonne of paper and cardboard will save 13 trees.

Extend your understanding 3.8

1 What property allows the separation of;
   a different types of plastics
   b glass and plastic
   c aluminium cans from glass and plastic
   d steel and tin cans from the recycling rubbish
   e paper and cardboard from the recycling rubbish
2 What is molten glass?
3 Why are people needed to separate the paper from the plastic bags?
4 What type of recyclable materials are collected in your area? Where is your nearest recycle facility?

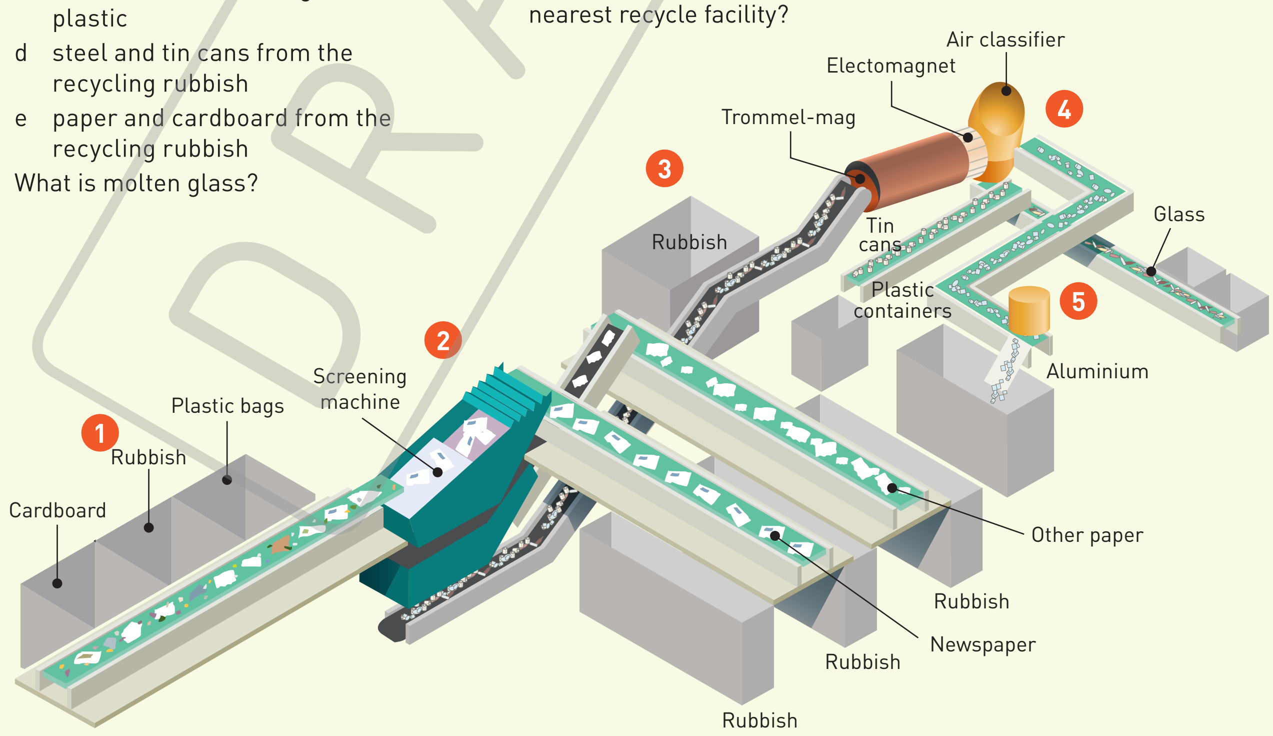


Figure 3.39 xxx

Remember and understand

1 Examine Figure 3.40 and identify the suspension, the solution and the colloid.

Figure 3.40

2 What is the major difference between evaporation and distillation?

3 a Which separation technique is used to separate the parts of blood?

b Which physical property is being used to separate this mixture?

4 Give an example of a mixture that could be separated into its parts by filtration.

5 What safety recommendations would you give to someone using evaporation and crystallisation?

6 Imagine dropping salt in sawdust. How would you separate the parts of this mixture?

7 A criminal buries an aluminium drink can containing DNA evidence in the sand. Could the aluminium can be separated from the sand using a magnet? Explain your answer.

Apply and analyse

8 Nail polish remover and paint stripper are both useful solvents.

a What is a solvent?

b Identify the solute for each solvent.

9 Daniel was measuring the solubility of two chemicals (A and B) in water. He placed a spatula full of each substance in a separate test tube of water. Figure 3.41 shows what he saw.

Use the words ***dissolve***, ***solvent***, ***solute*** and ***suspension*** to explain what has happened in each test tube.

Figure 3.41 Test tube A (left) and test tube B (right).

10 Imagine you have just bought a large factory. Due to flood damage it is filled with tonnes of matchsticks mixed with tonnes of iron scraps.

a How would you separate this mixture?

b What equipment would you need to make this happen on such a large scale?

Evaluate and create

11 Look at the chromatograms in Figure 3.42, taken from blue pens belonging to suspects (A–D). Compare these with the one taken from the original forged cheque (X). Decide whether any of the suspects is likely to be the culprit.

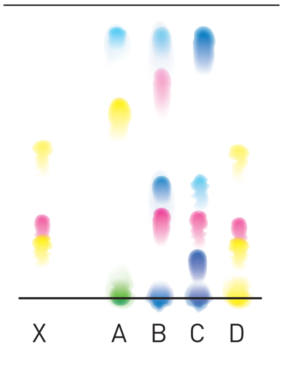


Figure 3.42

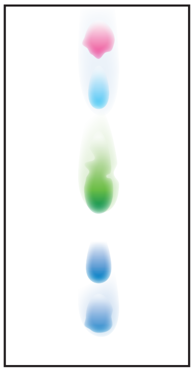


Figure 3.43

12 A particular coloured dye is being created for Fashion Week.

a Look at the chromatogram of the dye mixture in Figure 3.43. How many pure dyes were mixed to create the colour?

b Explain how chromatography could help create an exact copy of the dye for a rival manufacturer.

13 Do you think that performance-enhancing drugs are spoiling the image of sports? Pair up with a partner and make a list of all the implications of athletes using these drugs to compete.

14 Which techniques, and in what order, would you use to separate a mixture of iron filings, sand, marbles and salt? Present your answer as a flow chart.

15 People sometimes need to enter environments containing poisonous gases. In these situations, they will wear a gas mask. Use the Internet or other research tool to find out how gas masks interact with poisonous gases and how they change the air before it is inhaled by the person wearing the mask.

Research

Choose one of the following topics to research about working with mixtures. Some questions have been included to get you started.

How do we work with mixtures?

Research a separation technique that is used in a different industry or in nature. Prepare a 'SWOT' analysis as part of your report, listing the **s**trengths, **w**eaknesses, **o**pportunities and **t**hreats of the separation technique that you choose to research. You may choose to present your report with a series of photographs of the technique.

Filters of the sea

Certain types of whales, known as baleen whales, have a filter in their mouth made of a bone-like substance called baleen. Research what these plates do and what they filter. In addition, investigate how whales are different from other filter-feeders, such as barnacles, sponges and flamingos.

Distillation for survival

Imagine you were hiking in central Australia, became separated from your group and had run out of drinking water. Research some techniques of distilling water from gum leaves. As part of your report, you may like to demonstrate one technique to the class.

Human filtration

The human body needs to control what goes into it and what comes out. In particular, the filtering system of the kidneys prevents us from being poisoned by our own wastes, and tiny hairs in our noses filter dust and germs as we breathe. Find out more about these human filtration systems and see if you can identify others.

Self-cleaning suburbs

As our population grows, new suburbs are being built on the outskirts of cities. In some of these new suburbs, several features have been included to keep the water and air clean. Find out about strategies that are used to purify water and the air in housing estates.

*KEY WORDS

3

boiling point (BP)
the temperature at which a liquid boils and turns to a gas

centrifuging
technique used to separate light from heavy particles by rapidly spinning the mixture

chromatography
technique used to separate substances according to differing solubilities

colloid
type of mixture that always looks cloudy because clumps of insoluble particles remain suspended throughout it – they don't settle as sediment

concentrated
contains a large number of solute particles in the volume of solution

concentration
how much solute is dissolved in a solvent

condensation
the cooling down of gas into a liquid

crystallisation
separation technique used in conjunction with evaporation to remove a dissolved solid from a liquid; after the liquid has been evaporated the solid remains, often in the form of small crystals

decanting
technique used to separate a sediment from the liquid it is in by carefully pouring the liquid away

dilute
contains a small number of solute particles in the volume of solution

dissolved
a solute forms a solution

distillation
technique that uses evaporation and condensation to separate a solid contaminant and the solvent in which it has dissolved

emulsifier
a substance that enables oil and water to form an emulsion

emulsion
a colloid of two or more liquids

evaporation
change in state from liquid to gas; also a technique used to separate dissolved solids from water

filter paper
paper sieve with tiny holes that are too small to see; solutions can flow through but most solid particles will not

filtering
technique used to separate different-sized particles in a mixture depending on the holes in the filter used

filtrate
the substance that passes through a filter

flocculants
chemicals added to a mixture to make suspended particles clump together

insoluble
does not dissolve

magnetic
able to be magnetised or attracted by a magnet

mixtures
something made up of two or more pure substances mixed together

properties
(*chemistry*) characteristics or things that make something unique

pure substance
something that only contains one type of substance

residue
the substance left behind in a sieve or filter

saturated
a solution in which no more solute can be dissolved

sediment
something that settles to the bottom in a mixture

solubility
how easily a substance dissolves in a solvent

soluble
can be dissolved in a liquid

solute
a substance that dissolves in a liquid (solvent)

solution
a liquid made up of a solvent with a solute dissolved in it

solvent
any liquid that dissolves other substances

substances
a solid or liquid that can be mixed

suspension
a cloudy liquid containing insoluble particles

3.3A SKILLS LAB

Separation using magnetic properties

What you need:

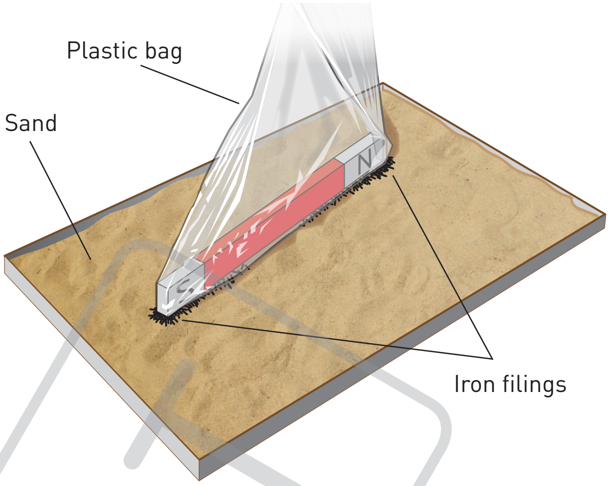
mixture of iron filings and sand, magnet, plastic bag

What to do:

1. Place the magnet inside the plastic bag.
2. Pass the bagged magnet over the mixture so that the iron filings are attracted.
3. Turn the plastic bag inside out so that all the iron filings are trapped.

Questions

1. How effective do you think this method was at separating the iron filings from the sand?
2. Could you use this method for all metals? Explain.



3.3B SKILLS LAB

Separating mixtures using sedimentation and flotation

What you need:

two mixtures ('A' contains sand and sawdust; 'B' contains sand and salt), water, spatula, stirring rod, two beakers

What to do:

1. Place at least three heaped spatulas of mixture A into a beaker.
2. Add water and stir the mixture.
3. Wait until sedimentation has occurred.
4. Scoop off any floating material from the top of the water. Decant the water to retrieve the sand.
5. Repeat the procedure for mixture B.
6. Draw a labelled diagram of your results.

Questions

1. How successful was the method for separating and collecting the sand from mixture A?
2. How successful was this method for collecting sand from mixture B?
3. What are some of the difficulties with decanting?
4. List the advantages of the combined sedimentation–flotation separation system.
5. After separating the two substances from mixture B, what would need to be done to collect the salt as a solid?

Clean up

After separating a mixture, make sure that all insoluble solids go into a specially provided container. Only throw substances in the bin if your teacher says it is okay to do so. Never wash solids down the sink.

6. Think of three reasons why disposing of solids down the sink is not a good idea.

3.3
EXPERIMENT

What if a flocculent were added to muddy water?

Aim

To investigate the effect of a flocculent.

Materials

- Muddy water (3 g dirt in 50 mL water)
- 2 jars
- 0.5 M sodium carbonate solution
- 0.5 M aluminium sulfate solution
- Test tubes

Method

SAFETY: HANDLE THE ALUMINIUM SULFATE SOLUTION WITH CARE, WEAR EYE PROTECTION AND AVOID CONTACT WITH SKIN.

1. Half-fill each jar with muddy water and label one A and the other B.
2. Add half a test tube of aluminium sulfate solution to jar A.
3. Slowly add half a test tube of sodium carbonate solution to jar B.
4. Leave both jars undisturbed for approximately 15 minutes.
5. Record your observations, comparing the water in jar A with that in jar B.

Inquiry: How much flocculent is needed to effectively separate a mixture of mud and water?

- What amounts of the flocculent will you add to the muddy water mixture?
- How will you measure if the muddy water is separated enough? (HINT: how much light should shine through the mixture?)
- Name three variables you will keep the same as in the first method.
- Write down the method you will use to complete your investigation.
- What sort of table will you need to draw up to show your results?

(Show your teacher your planning for approval.)

Results

Complete your investigation, filling in your table of results.

Discussion

1. What effect did the aluminium sulfate solution have on the muddy water?
2. What effect did the sodium carbonate solution have on the muddy water?
3. Which of the two substances (aluminium sulfate or sodium carbonate) acted as a flocculent? Give evidence to support your answer.
4. Why might it be important for water treatment plants to minimise the amount of flocculent added to waste water?

Conclusion

What affect does a flocculent have on mixtures?

3.4
SKILLS LAB

Filtering a mixture of sand and water

What you need:

mixture of sand and water, beaker, 100 mL conical flask, spatula, small funnel, filter paper, stirring rod

What to do:

1. Fold a round filter paper in half, then in half again to get quarters and then in half again to get eighths, as shown in Figure 10.26.
2. Unfold the filter paper and lay it flat (Figure 10.27).
3. Re-fold back and forth over the creases in the filter paper to obtain a fluted shape, as shown in Figure 10.28.
4. Set up the funnel and flask as shown in Figure 10.29.
5. Place the filter paper into the funnel as shown in Figure 10.30.
6. Dampen the filter paper with some extra water to help it stick to the sides of the funnel (see Figure 10.31).
7. Swirl the sand mixture and slowly pour it from the beaker into the funnel (Figure 10.32). Do not overfill the funnel.
8. Keep adding the mixture slowly until it is all used up.
9. Extra water can be added to the beaker mixture to pour out the last solid particles.
10. Wait for the filtering to finish. Remove the filter paper carefully and allow it to dry. In most experiments the residue (the solid on the paper) is kept and the filtrate (the liquid in the flask) is discarded.

Questions

1. Draw a scientific diagram of your equipment. Label the filtrate and residue.
2. What physical properties are being used to filter substances?
3. Describe at least three things you need to be careful about when filtering.

Figure 10.26

Figure 10.27

Figure 10.28

Figure 10.29

Figure 10.30

Figure 10.31

Figure 10.32

3.4 EXPERIMENT

What if you centrifuge milk?

Aim

To separate the components of milk.

Materials

- Centrifuge
- Different types of milk (full cream, low fat, soy milk)
- Test tubes

Method

1 Label your test tube with your name and part fill it with milk.

2 Pass your test tube to the teacher and observe how he or she sets up the centrifuge.

3 Examine the test tubes when the centrifuge completes the separation.

4 Use a ruler to measure the amount of each separated component of milk.

5 Draw one of the test tubes after centrifuging. Identify and label the parts of the milk.

Inquiry: What if different types of milk were centrifuged?

- What type of milk will you centrifuge?
- What differences might you expect from the original milk you tried?
- What variables will you keep the same as in the first method?

Results

1 Centrifuge your milk. Draw and label the various components of the milk.

2 Draw a column graph showing the type of milk and the amount of each component.

Discussion

1 What differences did you notice between the different types of milk after they had been centrifuged?

2 Can you explain why the different types of milk might vary in their components?

3.5 EXPERIMENT

Crystallisation of salt water

Aim

To separate a salt from a solution by evaporation and crystallisation.

Materials

- Evaporating dish
- Tripod
- Clay triangle
- Bunsen burner and mat
- Salt solution
- 250 mL beaker
- Magnifying glass
- Matches

Method

1 Collect a sample of the salt solution.

2 Half-fill an evaporating dish with the solution.

3 Place the evaporating dish on the clay triangle over the tripod.

4 Heat the evaporating dish, with a blue flame.

5 When the solution starts boiling, half-close the Bunsen burner collar. (Don't change to a yellow flame – this is not the same.)

6 Add more solution to the dish as the level drops due to evaporation. Be careful as the evaporation nears completion because the hot salt may spit and splatter.

7 Turn off the Bunsen burner when just a little liquid remains with the salt. Leave the dish to cool.

8 Examine the salt crystals with a magnifying glass.

Results

Draw a diagram of the crystals in your notebook.

Discussion

After the water has evaporated from the solution, salt remains in the evaporating dish.

1 If the solution contained a mixture of more than one solute, would the separation technique used in this experiment be suitable? Explain.

2 What is wasted in this experiment? Can you think of any way this could be avoided?

Conclusion

Explain how evaporation and crystallisation can be used to separate a mixture of salt and water.

3.5

CHALLENGE

Design a way to purify water from sea water

Design brief

You are preparing for a natural disaster that will affect the water supply. Design some equipment that will enable you to provide drinking water for a single person from sea water indefinitely.

Criteria restrictions

- Your materials must be available in a supermarket or your home.
- You must provide the cost of building your equipment.
- Your only available heat source is the Sun.

Questioning and predicting

> How will you heat the water so that it evaporates?
> How will you collect the water vapour?
> How will you cool the steam so that it condenses?
> Draw a labelled diagram of your design.
> Build a prototype of your design.

Processing, analysing and evaluating

1 What changes did you have make to improve your design?
2 What was the most successful feature of your design? What was the least successful?
3 What was the final cost of your design?
4 Is there any practical use for your design?
5 If you were doing this experiment again, how would you modify your design? Explain.

Communicating

Present the various stages of your investigation in a formal experimental report.

3.6
EXPERIMENT

Aim

To separate the inks from three different water-soluble black felt-tip pens.

Materials

- 3 black water-soluble felt-tip pens (they must all be different brands and labelled A, C and U) (Note: Permanent markers are not suitable for this experiment because they are not water-soluble.)
- 250 mL beaker
- Glass rod
- Salt solution (1%)
- Filter paper or chromatography paper
- Scissors
- Pencil
- Ruler

Who wrote the nasty note?

Figure 10.33 The suspects.

Your forensic laboratory is investigating a crime of extortion: one person is forcing or frightening another into handing over money.

The police have identified that the extortion note was written with a black felt-tip pen. They have collected a black felt-tip pen from the three suspects: Aunt Aggie (A), Cousin Cranky (C) and Uncle Buncle (U).

Other forensic scientists in your laboratory have already run a chromatography test on the note written by the extortionist. After you have tested the three pens from the suspects, collect the chromatogram from the original note from your teacher for comparison.

Method

1 Cut the filter or chromatography paper into three strips measuring approximately 2 cm × 10 cm.

2 Draw a faint pencil line across the width of each paper strip, 3 cm from the bottom.

3 Label one strip A, another C and the remaining one U. Make sure the label is at the very top of the paper strip.

4 Carefully trace over the pencil line at the bottom of strip A with the first felt-tip pen. (Do not make the line too thick.)

5 Do the same for the other two pens on their separate strips.

6 Add the salt solution to the bottom of the beaker, no deeper than approximately 2 cm.

7 Hang the paper strips over the glass rod so that they just dip into the salt solution. Make sure the salt solution does not touch the pen lines on the paper.

8 Leave the papers to soak up the salt solution for approximately 10–15 minutes, or until the solvent level is up to the top of the paper.

9 In the meantime, draw a diagram of the chromatography equipment in your notebook, labelling all the parts.

10 When the chromatogram is finished, take the papers out of the solution to dry.

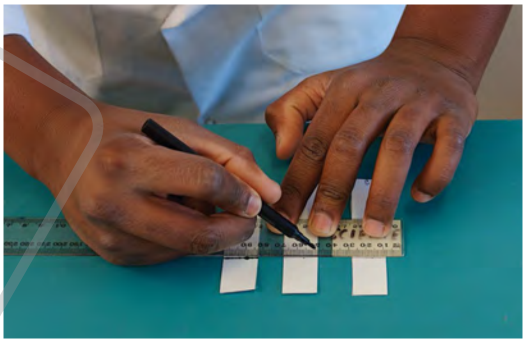


Figure 10.34 Trace over the pencil lines at the bottom of the chromatography paper.

Figure 10.35 Hang the paper strips over a glass rod so they just dip into the salt solution.

Figure 10.36 Take the papers out to dry.

Results

Tape the dry chromatograms for suspects A, C and U in your notebook or workbook. Collect and copy the chromatogram from the original note. Label this as the extortionist's chromatogram.

Discussion

1 Compare the chromatogram for the extortionist with the chromatograms from the three suspects. Do any of the suspects' chromatograms match the one from the original note? If so, who is most likely to be guilty?

2 Which felt-tip pen (A, C or U) had the most colours in its black ink?

Conclusion

How can the inks from three different black felt-tip pens be separated?

Separation challenge

Challenge

Now that you are a scientist who has trained in separating techniques, it is time to separate a mixture of sand, salt, sawdust and iron filings.

Criteria restrictions

You may only use equipment available in the laboratory.

Questioning and predicting

Think about the properties of each pure substance. This may help you decide on a way to separate the substances. Write what you know about the properties of sand, iron filings, sawdust and salt in the table below.

SUBSTANCE	SOLUBLE IN WATER?	ATTRACTED TO A MAGNET?	FLOATS/ SINKS IN WATER?
Sand			
Iron filings			
Sawdust			
Salt			

Discuss with a partner some possible ways to separate the four substances.

Planning and conducting

- Draw up a flow chart showing the steps you will take to separate the four substances.
- Devise an aim and an equipment list for your experiment.
- Write a detailed method for separating the substances. Include at least two diagrams.
- What safety issues might there be when doing this experiment?
- Have your plan checked by your teacher.
- Perform your separation experiments and make relevant observations.

Processing, analysing and evaluating

1 How well did your plan work? Grade the success of the plan on a scale of 1–5, where 1 means the experiment did not work well and 5 means the experiment was a great success. If you completed this challenge as a group, discuss your grading with others in your team.

Figure 10.37 Some of the equipment you may need for the separation challenge.

2 If your success was lower than 5 on the scale, how would you change 'plan B' to improve the results on another occasion?

3 Did you manage to separate the four substances successfully? Write your answer to this question as the conclusion in your laboratory report.

Communicating

Present your investigation in a formal experimental report.