Chapter 7

Separating Mixtures

CONTEXT AREA

- Most of the materials on Earth are mixtures, and they only have limited uses. How can we separate mixtures to obtain the best materials for our society to use?
- To be able to separate mixtures, we need to know about solubility, sieves, flotation, magnetism, inks and dyes, charcoal and static electricity.
- This knowledge can be applied to our everyday lives, and it is used by industry to make the common materials we use every day.

PRESCRIBED FOCUS AREAS

4.2 uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena

4.3 identifies areas of everyday life that have been affected by scientific developments

DOMAINS

KNOWLEDGE AND UNDERSTANDING

4.7 describes the observed properties of substances using scientific models and theories

4.7.5 **a** identify some common mixtures

b identify, using examples, the importance of water as a solvent

d identify situations where the processes of filtration, sedimentation, sieving, distillation, chromatography, evaporation, condensation, crystallisation and magnetic attraction are appropriate to separate components of a mixture

SKILLS

4.13 clarifies the purpose of an investigation and produces a plan to investigate a problem

4.17 evaluates the relevance of data and information

4.19 draws conclusions based on information available

4.21 uses creativity and imagination to suggest plausible solutions to familiar problems

4.22 completes a variety of individual and team tasks with guidance

VALUES AND ATTITUDES

4.23 demonstrates confidence and willingness to make decisions and to take responsible actions

4.24 respects different viewpoints and is honest, fair and ethical

4.25 recognises the relevance and importance in lifelong learning and acknowledges the continued impact of science in many aspects of everyday life

4.26 recognises the role of science in providing information about issues being considered and in increasing an understanding of the world around them

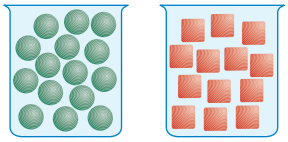
CONCEPTS

Why separate?	Importance of separating and pure substances
	Use of symbols to show parts of a mixture
Filtering and sieving	Sieves, strainers, filters
	Particle size
Sedimentation	Sedimentation, decanting, centrifuge
Magnetism	Use of magnets in separating
Flotation	Sinking and floating
Chromatography	Separation of inks and dyes
Adsorption	Adsorption onto powders
Electrostatics	Use of static electricity
Large-scale separations	Fractional distillation of crude oil
	Froth flotation
	Mineral sands
Know the properties	Importance of properties
Chemical properties	Chemical properties are different to physical

7.1 Why separate?

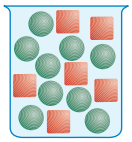
Most substances we find on the Earth are mixtures. People have worked out how to separate the useful materials in a mixture. Separating mixtures is important because there are many uses for the new substances that are produced.

If we draw the parts of a pure substance as ● and ■, the whole substance would look like this:



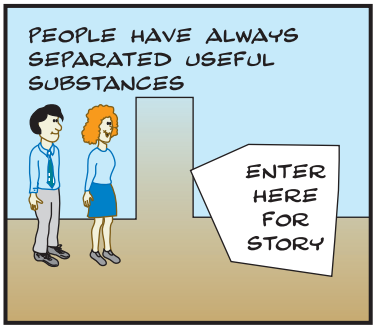
Pure substance

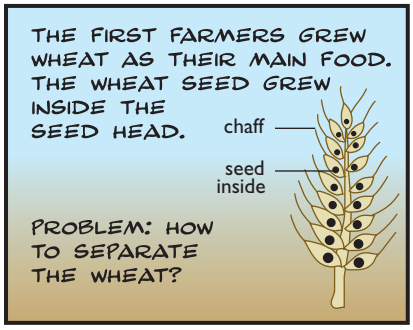
The mixture of these substances would look like this:

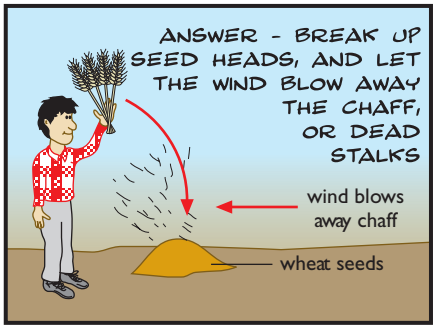


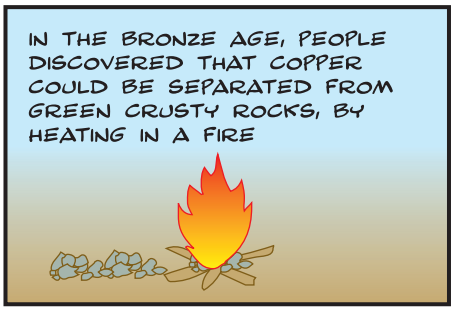
A mixture

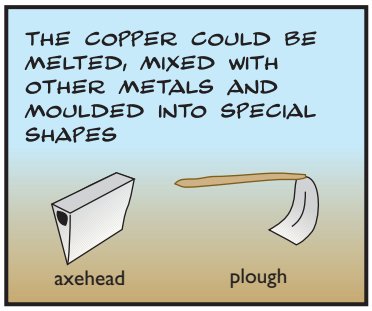
A substance is impure when there is another substance mixed with it. The substance which is

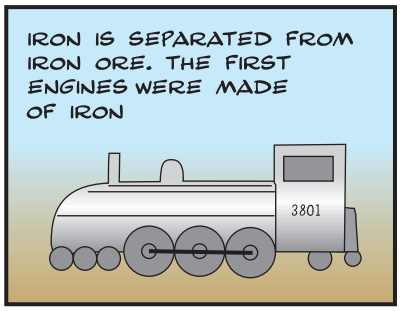


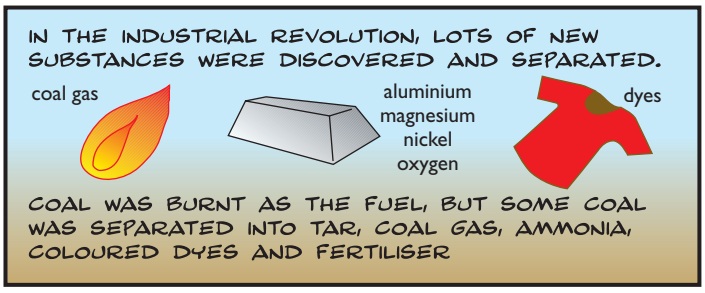


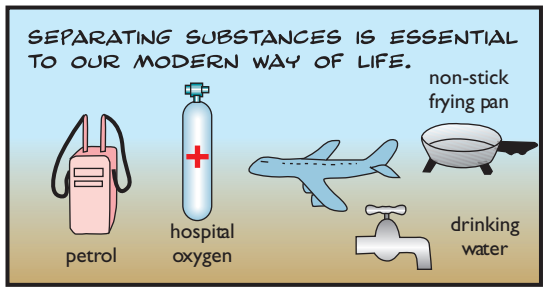


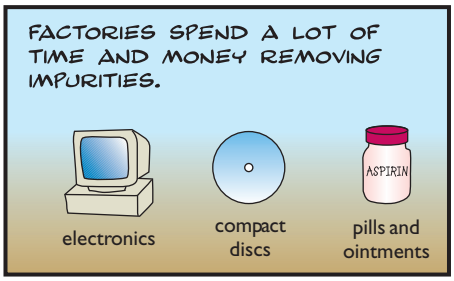


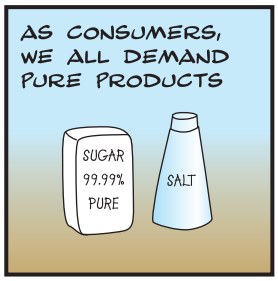


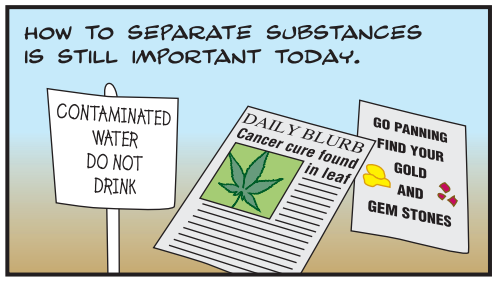




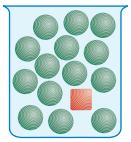








mixed with it is called the impurity. In this diagram, the impurity is shown with the ■ symbol.



An impurity

The hardest thing to understand about real mixtures is that they might not look like mixtures. Many mixtures are made of more than two substances mixed together. We might not be able to see all the parts in the mixture. In most of our experiments you can see the parts, but they are very small. We have to use special chemical techniques, such as filtering and crystallising, to separate them.

Sometimes people need to *make* mixtures instead of *separating* them. Glass, paint, concrete and lots of foods are all examples of useful mixtures.

CHECKPOINT:

COPY AND COMPLETE

Most substances we find on the Earth are _____. Separating mixtures is _____ because there are many ____ for the ___ substances produced.

A substance is _____ when there is another substance _____ with it. The substance which is mixed with it is called the _____.

The hardest thing to understand about ____ mixtures is that they might not look like _____. We might not be able to see all the _____ in the _____. We have to use special techniques, such as _____ and _____, to separate them.

Sometimes people need to ____ mixtures instead of _____ them. _____, _____, _____ and ____ are all examples of _____ mixtures.

QUESTIONS

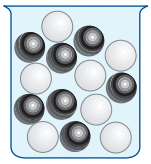
1 What is the meaning of pure, impure, and impurity?

2 Write a sentence with these pairs of words used in their correct context: pure / mixture, impurity / impure

3 Show the meaning of the words pure, impure, impurity, using diagrams with □, ○ and ◗ symbols.

4 Draw what these mixtures would look like when each is separated into its components.

a



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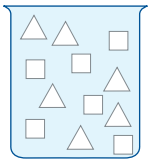
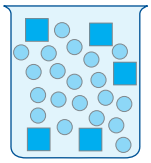


5 A mixture contains particles of ■ in a substance made of ●. What is the percentage of ■ in ●?



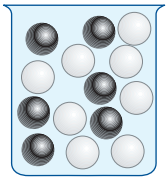
6 Why is separating substances useful to our society?

7 Name some useful mixtures.

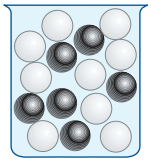
Questions 8 to 10 relate also to Chapter 2. They are about filtration, crystallisation, and distillation.

8 Explain how you would separate these mixtures:
a chalk from water
b salt from sea water
c fresh water from sea water.

9 The diagram represents a mixture. If the black balls represent an insoluble substance, and the white balls represent a soluble substance, explain how you would quickly separate them.



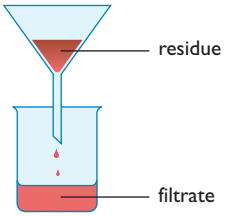
10 The diagram represents a mixture of two liquids. How would you separate them if the black balls boil at 50°C and the white balls boil at 150°C?



7.2 Filtering and sieving

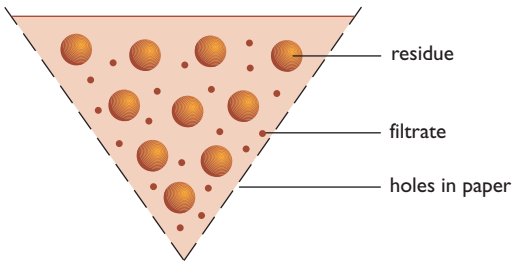
Filtering is like sieving and straining. In a sieve the largest lumps are caught and the small lumps go through the holes. Filter paper is like a sieve with tiny holes. Lumps of chalk cannot fit through the holes, but the parts of a solution can.

The substance caught in the filter paper is called the residue. The substance which passes through is called the filtrate. The filtrate has been filtered out.



Filtrate and residue

The diagram below shows what the filter paper, filtrate and residue would look like.



How filter paper separates the residue and filtrate

There are lots of filters all around us. They might be called strainers or sieves, but they all filter. Here are some examples:

- vegetable or rice strainer
- lemon squeezer
- filter bag in a vacuum cleaner
- tea strainer
- dust mask
- air cleaner and oil filter in a car engine
- lint filter in a clothes drier
- grate in a gutter at the side of the road
- gauze screen on a window

You might have some filter paper at home. Percolated coffee is filtered through paper. Tea bags let the dissolved tea go through the paper, but hold back the tea leaves.

A colander is used to drain vegetables. It consists of a sieve held in a round plastic frame. Spoons can also be used as sieves in the kitchen.

Some common filters, strainers and sieves

EXPERIMENT

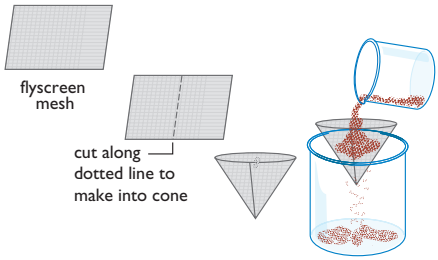
AIM: To use a sieve to separate a mixture

Your teacher will give you a mixture of sand and bean bag beads in a beaker. Your task is to separate them with a sieve. You can make a sieve with some flyscreen mesh.

Sieve the mixture, and separate the bean bag beads and sand into two beakers. Show your teacher, and write a report in your notebook.

1 What difference between the beads and sand did we use to separate them?

2 What is the best way to make the sand pass through the sieve as quickly as possible?



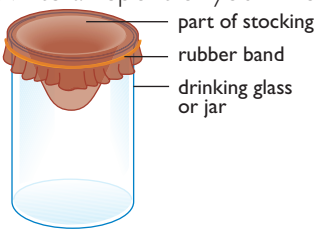
Using flyscreen mesh to make a sieve

EXPERIMENT

AIM: To filter a suspension of vegetable juice

Vegetable juice and tomato juice are suspensions. There are crushed bits of vegetables (called pulp) floating in juice. Like all suspensions, juice can be filtered. (The filtration is not perfect because some of the pulp is small enough to go through filter paper.) Filter the juice suspension using filter paper and a filter tunnel. Remember, you should never eat or drink any food you have used in the laboratory.

Try this experiment at home using a stocking as a filter. Which part of the juice has the taste: is it the liquid or the pulp? Is this true of orange juice too? Write a report of your findings in your notebook.



A stocking filter

CHECKPOINT:

COPY AND COMPLETE

Filtering is like _____ and _____. The _____ lumps are caught in the sieve, and the _____ lumps go through. _____ paper is like a sieve with ____ holes.

The substance caught in the _____ paper is called the _____. The substance which passes through is called the _____. The filtrate has been _____.

There are lots of _____ all around us. They might be called _____ or _____, but they all filter.

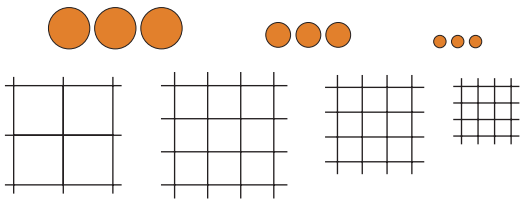
QUESTIONS

1 What are the meanings of the following words: filter, solution, suspension, filtrate, residue?

2 When separating sand and salt, a student dissolved the salt in water and then filtered the mixture. Copy the diagram, and write the labels salt, sand, filtrate and residue on it.

3 Explain why these are filters:
- **a** a gauze flyscreen on a door or window
- **b** a strainer at the bottom of a tub or bath or sink
- **c** a tea bag.

4 The following diagram shows some stones. You need to sort them into three sizes. Which sieves, and in which order, would you use to separate the stones?

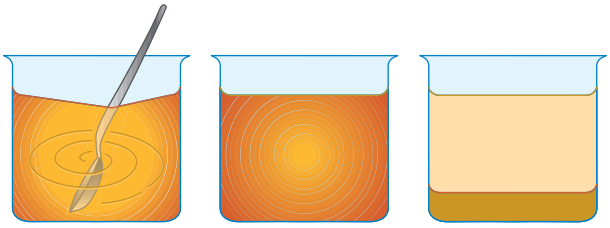


5 In a bank, piles of coins are separated by sieving. Which coins would they sieve out first? Which coins would pass through the sieve? How many sieves would the bank need to separate all the coins we use?

6 Propose the equipment that you would need to sieve or filter the following mixtures. Use only equipment that you see in a supermarket or a kitchen.
- **a** popcorn from dry rice grains
- **b** fertiliser pellets (2 mm balls) from grass cuttings
- **c** frozen peas from rice grains

7.3 Sedimentation

If you mix an insoluble substance such as chalk with water, it will not dissolve. The chalk will quickly settle to the bottom.



The sedimentation process

The process of letting an insoluble substance settle to the bottom of a container is called sedimentation. Large, heavy particles will settle more quickly than small, light particles.

Decanting

You can use a special case of sedimentation in your science experiments. If you let the chalk settle to the bottom, then tip out the clear liquid at the top, you have decanted the liquid. This is an easy separation. Decanting means pouring off a liquid to leave a sediment of insoluble substance behind in the container.

Centrifuging

You can speed up the process of sedimentation by using a centrifuge. A laboratory centrifuge contains test tubes which spin at high speed. The heavier substances move to the bottom of the test tubes.

The spin-dryer in a washing machine is an example of a centrifuge. It spins quickly and the water flies out through the holes in the sides. The side of the spin-dryer is like a sieve, and the clothes stay in the bowl.

Centrifuges are used at the blood bank to separate blood cells from the liquid part of the blood, and in dairy processing plants for separating cream from milk. Centrifuges spin fast and have a cover around them to prevent injury to people.

DEMONSTRATION

AIM: To see if a centrifuge speeds the sedimentation process

How good are centrifuges? Are they worth the trouble? Your teacher will prepare some muddy water with a lot of sediment in it. They will centrifuge half of the muddy water, and let the rest settle naturally. Does the centrifuge speed the process of sedimentation?

CHECKPOINT:

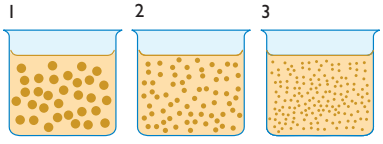
COPY AND COMPLETE

The process of letting an _____ substance _____ to the bottom of a _____ is called _____.
Large, _____ particles will settle more _____ than _____, _____ particles.
Decanting means _____ ___ a liquid and leaving the sediment of _____ substance behind in the _____.
A laboratory centrifuge contains test tubes which ____ at ____ _____. The _____ substances move to the _____ of the test tubes.

QUESTIONS

1 What is the meaning of these words: suspension, sedimentation, decanting, centrifuge?

2 Which of these mixtures will settle quickest?



3 Imagine that the suspensions in Question 2 were mixed together and allowed to settle. Draw a diagram showing what the sediments at the bottom of the beaker would look like.

4 Where are centrifuges used? Give two examples.

5 Explain why the spin-dryer in a washing machine is a type of centrifuge?

6 Fast-flowing rivers are an example of a suspension.
a Describe how the gravel, sand and silt would settle as sediments.
b Does this change, depending on the speed of the river? Explain your answer clearly.

7.4 Magnetism

Some objects are magnetic. Magnetic substances are attracted to a magnet. They are made of iron or a mixture containing iron.

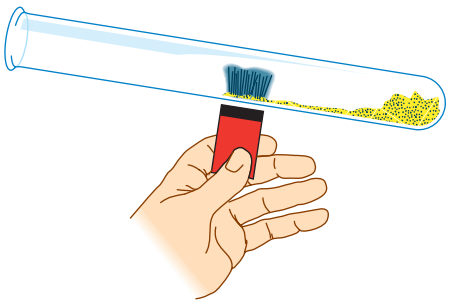
Magnetism can be used to separate some objects. Some examples are separating iron nails from glass clippings, and separating iron paper clips from brass ones. Some plastic paper clips are magnetic because they are made of iron with a plastic coating.

Magnetic separators are used in factories. Some kinds of beach sands have magnetic grains, which are separated from the other grains with a magnetic roller.

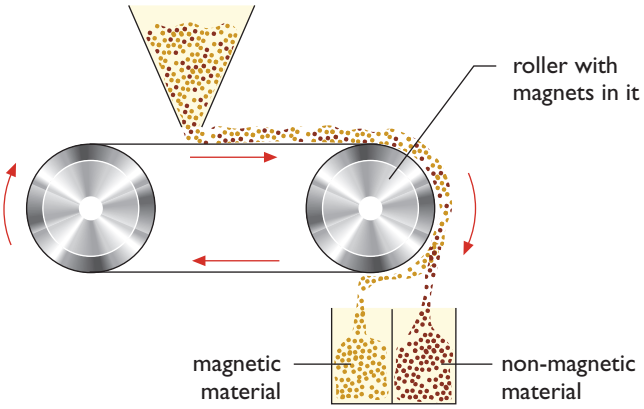
EXPERIMENT

AIM: To separate iron filings from chalk

Your teacher will give you a mixture of iron filings and a powdery chalk or sulfur. Use a magnet to separate the iron filings. Cover the magnet with cling wrap, and be careful not to get any iron on it.



A magnet can be used to separate iron filings from a non-magnetic powder



A magnetic roller separates useful minerals in beach sands

CHECKPOINT:

COPY AND COMPLETE

Magnetic substances are attracted to a _____. They are made of ____ or a mixture containing ____. _____ is used to separate objects. _____ separators are used in factories. Some kinds of _____ sands have _____ grains, which are separated from the other grains with a _____ roller.

QUESTIONS

1 Which of these substances would be attracted to a magnet: brass drawing pins, a plastic sieve, filter paper, nails used in building, filter funnel, retort stand, tripod stand, beaker?

2 After you had done this, how could you separate the large nails from the small nails?

3 If you owned a large factory and had to separate thousands of tonnes of iron nails from match sticks, explain how you could do it. (There is more than one method.)

4 Sand and salt are separated by filtration. What steps, and in what order, would you use to separate a mixture of iron filings, sand and salt?

5 A cleaner in a stationery shop accidentally knocked over a bulk delivery of glue sticks, steel paper clips and brass drawing pins. You are given a mixture of these in a large cardboard carton. Propose ways to separate this mixture.

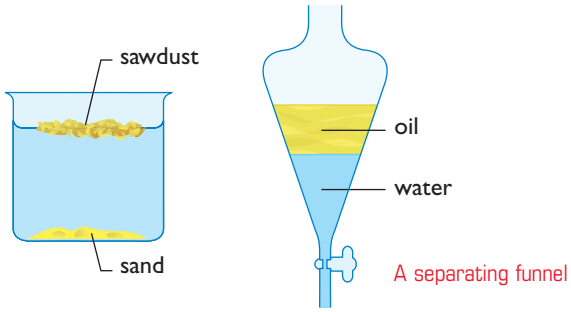
7.5 Flotation

Sawdust and sand are simple to separate. Sawdust floats in water, and sand sinks. This is called flotation.

Oil and water do not mix. Oil is lighter than water, and floats on top of the water.

Two liquids that do not mix can be separated by decanting or by using a separating funnel. The tap at the bottom is opened to allow the heavier liquid to flow out. The operator closes the tap before the lighter liquid comes out.

Full cream milk is a mixture of milk and cream. If the milk is not homogenised in the processing plant, then the cream separates and floats on top of the milk. Salad dressing is a mixture of oil and water, with flavouring agents.



A separating funnel

EXPERIMENT

AIM: To separate four substances

In this section your task is to separate a mixture of sand, iron filings, sawdust and salt. How would you do it? You already know something about each substance. Use the table below to help you decide the best method.

Substance	Soluble in water?	Magnetic?	Floats in water?
sand	*no*	*no*	*no*
salt	*yes*	*no*	*no*
sawdust	*no*	*no*	*yes*
iron filings	*no*	*yes*	*no*

Tips:

- Sawdust soaks up water, then sinks. Do not leave the sawdust in the water for too long.
- Iron filings will rust if they get wet. Keep them dry.

Before you start the experiment, answer these questions.

1 Which property would you use to separate each substance?

2 What is the best order in which to separate them? Write the steps neatly in your note book.

3 When your teacher has approved your method of separation, separate the mixture. Collect each substance on a piece of paper towel, except the salt which will be dissolved. Show the separated substances to your teacher.

CHECKPOINT:

COPY AND COMPLETE

Sawdust _____ in water, and sand _____. This is called _____.
Oil and water do not ___. Oil is _____ than water, and _____ on top of the water.
Two liquids which do not mix can be separated using a _____ _____.

QUESTIONS

1 What is a separating funnel?

2 Which pairs of substances could be separated using flotation?
- **a** nails and lawn mower cuttings
- **b** sand and iron filings
- **c** sand from stones
- **d** bean-bag beads from stones.

3 Which pairs of liquids below could be separated using a separating funnel?
- **a** lemonade and water
- **b** kerosene and water
- **c** methylated spirits and water
- **d** cooking oil and water
- **e** cooking oil and kerosene

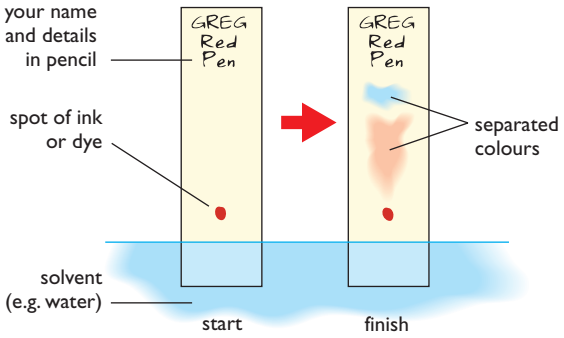
4 Some types of salad dressing consist of vinegar (a water solution), cooking oil and small pieces of vegetables. Propose how to separate this mixture.

7.6 Chromatography

Dyes and inks are used to colour things we use. They are mixed to make the colours for food, clothes and pens. It is easy to find out if the colour in a felt pen is a pure dye or a mixture of dyes. The process is called chromatography.

Chromatography is the separation of coloured chemicals. It works because some are more soluble than others. It only works for soluble dyes, like in food and pens, not the dyes in clothes. Paper chromatography uses paper to separate the parts in a mixture. The most soluble dyes end up higher on the paper than the less soluble dyes.

The way to do a paper chromatography is shown in the diagram. A special paper is used for chromatography, but filter paper can also be used. Paper towel is not suitable because it soaks up water too quickly. You can cut a strip from a filter paper circle, and fold it so that the strip touches the water in a beaker or jar.



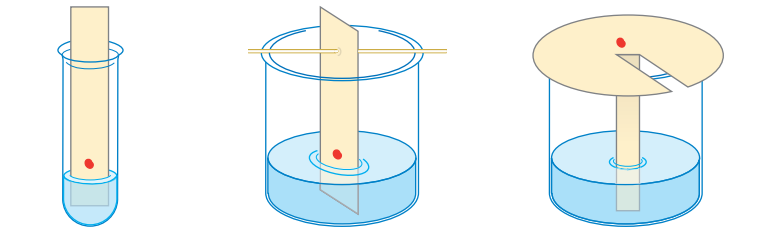
Paper chromatography

Water proof pens have dyes and inks that are not soluble in other solvents such as methylated spirits and turpentine. These solvents can be used in chromatography. Note that they are flammable and volatile (evaporate easily). They should only be used in a fume cupboard and not poured down the drain.

EXPERIMENT

AIM: To separate dyes

Set up a chromatography experiment, either in a test tube or a beaker. The drawings show you three methods. Use the method which best suits you and the equipment you have. These separations can be done at home as well as at school. Separate the ink in water-soluble felt tip pens or in food dye.



Three ways to set up a paper chromatography experiment

CHECKPOINT:

COPY AND COMPLETE

Chromatography is the separation of _____ chemicals. It works because some are more _____ than others. The most _____ dyes end up _____ on the paper than the _____ soluble _____. Paper chromatography uses _____ to separate the parts in a _____. A special paper is used for _____.

QUESTIONS

1 What is the meaning of chromatography?

2 Why are soluble dyes used in this method?

3 When you write your name on the paper strips you use for chromatography, you should not use biro or felt tip pen. Pencil is best. Why is this?

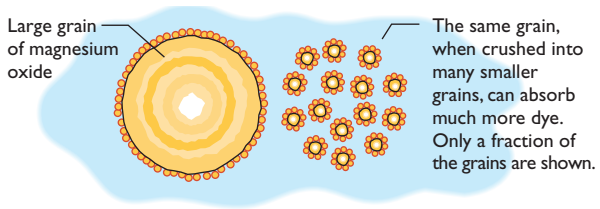
4 Name some other dyes and solvents that could be used in chromatography.

7.7 Adsorption

Have you ever touched wet paint? Do you remember how your fingers stuck to it? We say that the paint is sticky. Many substances have this property of stickiness. Two examples are honey and glue.

Some substances are not sticky to us, but are sticky to dyes and many other chemicals. The chemicals stick to the outside of the tiny grains of the substances. The tinier the grains, the more chemicals that can stick to them.

Two of these substances are magnesium oxide and charcoal. Magnesium oxide is a white powder that is sticky to some types of food dye. Charcoal is the common name for burnt wood. It is mostly carbon. You can make charcoal, or buy it as a powder. It is light and dusty just like baby powder, only black. Charcoal which has been steamed or heated in a special way is called activated charcoal. Sometimes it is called activated carbon.



The surface area of grains depends on their size

Activated carbon is used in many factories to remove impurities. The impurities stick onto the outside of the tiny grains. Carbon removes the brown colour from brown sugar when it is being converted into white sugar. Many water purifiers contain canisters of carbon, which the water passes through. These purifiers both filter and adsorb.

EXPERIMENT

AIM: To remove colour from water

1 Prepare a solution of red food dye by dissolving five drops in 200 mL of water. Add a level teaspoon of white magnesium oxide powder. Warm and stir for a few minutes, then filter. Observe the colour of the magnesium oxide and the filtrate. Where is the food dye?

2 Your teacher will give you a solution of litmus dye dissolved in water. Litmus dye comes from red cabbages, and can be pink or blue in colour. The dye is adsorbed onto carbon. Take 50 mL of the solution, and add one level teaspoon of activated carbon. Stir the solution, and warm it gently. Filter through filter paper.

Write a report of the experiment. How effective is the adsorption process? (Is the water colourless, or tainted with colour?)

CHECKPOINT:

COPY AND COMPLETE

Some substances are not _____ to us, but are sticky to ____ and many other _____.
Magnesium oxide is a _____ _____ that is sticky to some _____ of food ___. Activated _____ is used in many _____ to remove _____.

QUESTIONS

1 What are the meanings of adsorb and absorb? What do paper towels do? What does charcoal do?

2 What is activated charcoal? How is it different to normal charcoal?

3 One cure for an upset stomach or similar pains is to stir some activated carbon in water and then drink it. What would this do in your stomach?

4 The photograph shows a person wearing a gas mask. It works by filtration and adsorption. Explain how.

A gas mask filters out harmful particles; some can even filter out gases

7.8 Electrostatics

When some types of objects are rubbed together, they produce electricity. This sort of electricity is called static electricity. You see and feel it when you rub your feet on nylon carpet, rub woollen slacks on a plastic chair, or run a comb through dry hair.

Objects that have lots of static electricity can attract bits of paper, hair and grains of chemicals. This is another method of separation. It is called electrostatic separation.

Electrostatic separators

In chimney smoke, some of the particles are charged, and are attracted to a charged grate or grill. The charged grate is often connected to a battery, so it does not lose its charge. When the particles touch the charged grate they fall downwards. This reduces the amount of smoke and ash going up the chimney. A device that uses this idea is called an electrostatic separator. Another common method of removing particles from chimney smoke is by filtration.

Many cleaning cloths have a small electrostatic charge.

Dust is attracted to these cloths when you wipe them over smooth surfaces such as window sills.

An electrostatic separator

EXPERIMENT

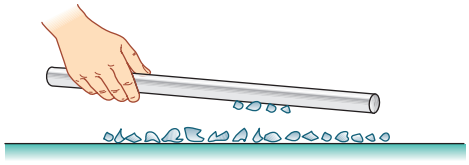
AIM: To perform an electrostatic separation

Rub a piece of perspex rod or an ebonite rod, which your teacher can give you. Use the part of the rod you have rubbed to separate:

- tiny pieces of paper and cardboard
- salt and pepper (make sure they are both dry).

1 How effective is electrostatics as a method of separation?

2 Pieces of paper and cardboard can be separated using a fan or a hair dryer. Which method is better: electrostatics, or wind from a fan?



Using a charged rod

CHECKPOINT:

COPY AND COMPLETE

Objects that have lots of _____ _____ can attract bits of _____, hair and _____ of chemicals. This is another method of _____. It is called _____ separation.

In _____ smoke some of the dust particles are charged, and are attracted to a _____ or _____. When the _____ touch the _____ grate they fall _____. This is called an _____ separator.

QUESTIONS

1 What are two ways to remove smoke from factory chimneys?

2 Tiny pieces of paper and cardboard can be separated in many ways. What are two methods mentioned in this section?

3 The charged rods or grates in an electrostatic separator are connected to a battery. Why is this?

4 How do household cleaning cloths work?

5 A big problem with electrostatic separators is making the dust safe for transport. It is hot, dry, and very dusty. How could you make the dust safe?

7.9 Large-scale separations

Separating mixtures is essential to our society and our way of life. Some separations are done on a large scale, involving thousands of tonnes of chemicals.

Fractional distillation

Crude oil is oil that comes out of the ground. It is a mixture of chemicals such as petrol, tar, oil, dissolved gases and kerosene. Crude oil is also called petroleum.

Each liquid in the crude oil mixture has a different boiling point. This difference enables the chemicals to be separated. The method of separation is called a fractional distillation. The separation occurs in a column called a fractionating column. In an oil refinery, the fractionating column can be 40 metres high.

In the diagram, the gases in crude oil are shown as blue circles. The different liquids rise to different heights, depending on their boiling points. The lower the boiling point, the higher in the column the vapours travel. The red circles represent tar and waxes, which melt but do not boil. In a real fractionating column, liquids are taken from the column at more than three places.

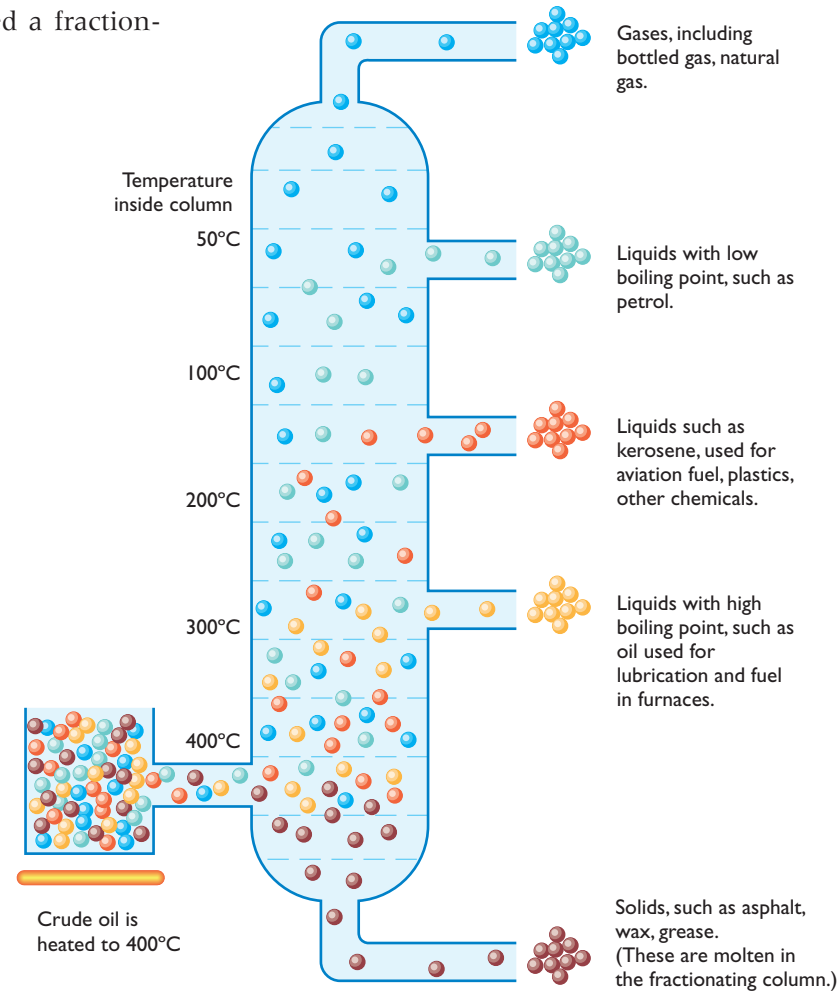
Crude oil from different parts of the world has different compositions. Once separated, the components can be changed into different products, depending on the demand for them.

Petroleums from different parts of the world have varying compositions of low and high boiling point fractions.

Froth flotation

Froth flotation separates valuable metal ores from sand and rock. The diagrams show how it works.

By themselves, ore and sand will not separate, no matter how much they are shaken or stirred. But if a small amount of kerosene is added, the ore is easily separated. This is because the ore is adsorbed onto kerosene. When the kerosene is shaken or bubbles are blown through it, air bubbles with the kerosene and ore float to the top. The froth can be skimmed off and recycled. This method is used to separate lead, zinc and copper ores from sand and clay.



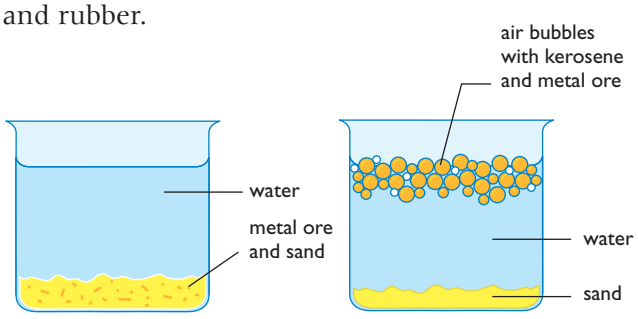
Fractional distillation of crude oil

Mineral sands

Some of the sand on NSW beaches contains grains of rutile, zircon, and ilmenite. These substances are valuable, but they must be separated out before they can be used. The first step is to separate the sand. Sand is not as heavy, so it washes away quickly. The waste sand and water is pumped back onto the land.

The remaining valuable grains are separated using electrostatic and magnetic methods. Zircon does not become electrically charged and it is removed first. Then a magnetic separator is used. Ilmenite is magnetic and rutile is not.

Mineral sands have many uses. Rutile and ilmenite contain the metal titanium. Titanium is stronger than steel but only half as heavy. Rutile is used as a white pigment in paint and paper. Zircons are used for making abrasives, paints, glass and rubber.



How froth flotation works

Froth flotation in a factory

CHECKPOINT:

COPY AND COMPLETE

Crude oil is oil which comes out of the _____. It is a mixture of chemicals such as _____, ___, ___, dissolved _____ and _____.

Each liquid in the crude oil _____ has a different _____ _____. The method of separation is called a _____ _____. The separation occurs in a column called a _____ column.

Froth _____ works because the ore is adsorbed onto _____. When the kerosene is shaken or _____ are blown through it, air bubbles with the _____ and ___ float to the top. The _____ can be _____ off and _____.

Minerals in sands are _____, but they must be _____ out before they can be _____. Sand is not as _____ as the _____. The remaining _____ grains are separated using _____ and _____ methods.

QUESTIONS

1 Explain in words what is meant by fractional distillation and froth flotation.

2 Froth flotation is a mixture of two methods of separation described earlier. What are they?

3 What are some products which you have seen or used recently which were separated from crude oil by fractional distillation?

4 Name the three processes used to separate mineral sands?

5 What are some uses of mineral sands?

6 In separating crude oil into its components:
   a Why is a flotation method not used?
   b Why can fractional distillation be used?

7 Draw a flowchart showing the separation of grains of sand, rutile, zircon and ilmenite.

7.10 Know the properties

The experiment in this section is to separate a mixture of six substances. How would you do it? The key to any separation is to know the properties of each substance in the mixture.

Properties are the features of each substance. Some properties of water are its colour, the temperature at which it boils (its boiling point), how runny it is (its viscosity), and its density. Every substance has different properties to every other substance.

Properties which do not change how the substance reacts are called physical properties. Physical properties can be used to work out how to separate different substances.

There are many chemical substances, and they have different physical properties. No one can remember them all. Chemists look up the properties in data books, or on computers. There are lists of useful data on thousands of chemicals.

The separations we have studied in this section have relied on physical properties such as solubility, magnetism, flotation, adsorption onto carbon, and electrostatics. Properties such as colour are not useful in separating mixtures, but they are important to many people, such as an artist who wishes to use them in pottery or painting.

EXPERIMENT

AIM: To separate six substances

Your teacher will give you a small container with a mixture of the substances listed. It is your task, with your experiment group, to separate these substances using the properties shown.

1 Copy the table into your note book, and complete it. Confirm with your group that you are correct, or check with your teacher.

2 Plan the method of separation, and write it out in point form or as a diagram. Check your order of separations with your teacher before you start.

3 After you have separated the substances, show your teacher small pieces of paper towel with sand, lead pellets, iron filings and sawdust on them, and a solution of copper sulfate in a beaker. You won't be able to show the litmus dye.

Substance	Soluble?	Magnetic?	Floats or sinks?	Adsorbed onto charcoal?
sand				
lead pellets				
sawdust				
iron filings				
litmus dye				
copper sulfate				

CHECKPOINT:

COPY AND COMPLETE

Properties are the _____ of each substance. Every substance has different _____ to every other substance. These properties can be used in _____ and they do not _____ the substance that we are separating. Properties which do not change the type of substance are called _____ properties. The separations we have studied in this chapter have relied on _____ properties such as _____, magnetism, _____, _____ onto carbon and electrostatics.

QUESTIONS

1 What do these words mean: property, physical property, data book?

2 What properties would you use to separate:
a sawdust and sand
b iron filings and sand
c lead pellets and iron filings
d lead pellets and sand
e salt crystals and sand grains

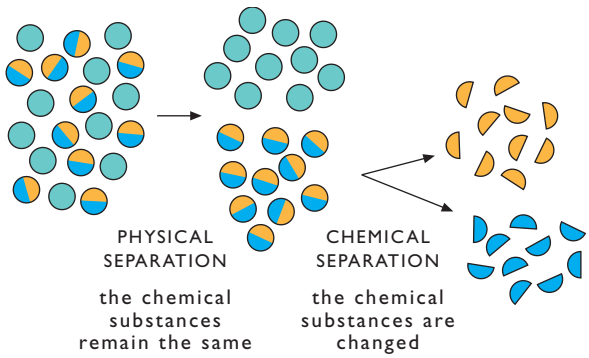
3 What are the physical properties we use to separate these substances from others: iron filings, felt pen ink, litmus dye, salt, sawdust, sand.

7.11 Chemical properties

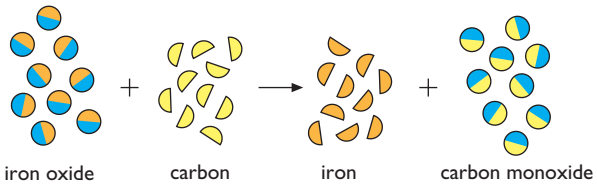
In the experiments in this chapter we have separated mixtures of substances. We did not change the substances, only separated them or purified them. These are physical separations, because the substance is still the same.

Some separations change the substances. A new chemical is made. These changes are called chemical changes. Chemical changes are useful because they allow us to obtain chemical substances which are not found naturally on Earth.

Iron ore contains the metal iron. Iron ore is made of iron oxide mixed with sand. To separate the sand, a physical change is needed. To separate the iron, a chemical change is needed.



Physical and chemical changes



Making iron

EXPERIMENT

AIM: To separate aluminium from a mixture of metals

Your teacher will give you a mixture of small pieces of magnesium and aluminium. These metals have similar physical properties and cannot be separated using the methods discussed in this chapter.

One major chemical property in which these two chemicals are different is their reactivity in acid. Magnesium reacts with acid and dissolves, while aluminium does not.

Add 50 mL of dilute sulfuric acid to the mixture of metals. When the magnesium metal has dissolved, filter to remove the pieces of aluminium. The magnesium is present in solution as magnesium sulfate. It can be recovered by crystallisation. Note that the atoms of magnesium are now in a new chemical substance. This is a chemical change.

CHECKPOINT:

COPY AND COMPLETE

Some separations _____ the substances. A new _____ is made. These changes are called _____ changes. Chemical _____ are useful because they allow us to obtain chemical _____ which are not found _____ on Earth.

Iron ore contains the metal ____. Iron ore is made of ____ _____ mixed with ____. To separate the sand, a _____ change is needed. To separate the iron, a _____ change is needed.

QUESTIONS

1 What is a physical change? What is a chemical change? What is the difference between a physical change and chemical change?

2 In the diagram that represents the removal of sand from iron ore, what colour circles represent the sand? Which represent the iron ore?

3 In the second diagram showing the making of iron, what colours are iron, oxygen and carbon monoxide?

Review and Research

Review questions

1 Use the diagrams at the bottom of the page to help answer these questions. Review Activities 1.7 and 2.4 before commencing these questions.

Use the letters A, B, C or D to answer these questions:

a used to obtain salt from sea water
b used to obtain fresh water from sea water
c used to separate sand from water
d used to separate ground chalk from water
e used to crystallise copper sulfate from water
f uses a condenser
g is called decanting
h is called crystallisation
i is called distillation
j is called filtration

2 How would you separate the following? The methods of separation are listed below, and each answer is only used once.

- chromatography
- use a magnet
- use a sieve
- centrifuging
- distillation
- flotation
- crystallisation
- adsorption

a iron filings from dry sand
b obtain salt from sea water
c remove coloured dye from water
d separate sawdust from sand
e separate the colours in biro ink
f separate cream from milk
g removes stones from sand
h obtain pure water from sea water

3 The lawn mower won't start. Someone left it in the rain, and water has got into the petrol tank. Draw what a water and petrol mixture would look like, and explain how you could separate them using an empty coffee jar.

4 In hospitals, blood cells are separated from blood serum using a centrifuge. How does a centrifuge work? Where in the centrifuge tubes would you find the heavy parts of the blood?

5 Your little sister has thrown some nails onto the grass. How can you quickly remove the nails from the grass before mowing it?

6 Rescue workers often wear gas masks when working in dangerous areas. The air they breathe is passed through a carbon-filled cartridge. The cartridges are replaced often. What is the purpose of the carbon cartridges? Why are they replaced?

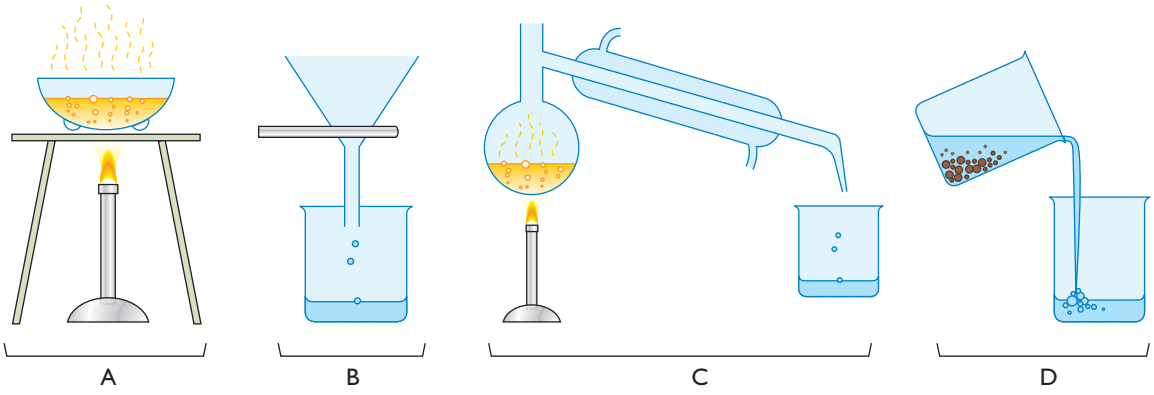
7 You have purchased some lawn fertiliser, and you think that there may be some sand in it. How could you quickly check for sand in the fertiliser? (Hint: lawn fertiliser is very soluble.)

8 List two ways you could separate 50 mm long steel nails from bamboo rods of the same size.

9 A spin-dryer in a washing machine is a sieve and a centrifuge at the same time. Explain why it is a centrifuge, and why it is a sieve.

10 Draw a diagram and label the filtrate and residue. Which is soluble and which is insoluble?

Remember back to Chapters 1 and 2. You will need to know about crystallisation and distillation, and the methods of separation in this chapter, before starting on the next question.



11 In the following questions, use the answers below. Write the number corresponding to the answer in your note book. The answers to select from are:

1 *filtration or sieve*
2 *decanting*
3 *distillation*
4 *flotation*
5 *crystallisation*
6 *magnetism*
7 *centrifuging*
8 *adsorption*
9 *chromatography*
10 *electrostatics*

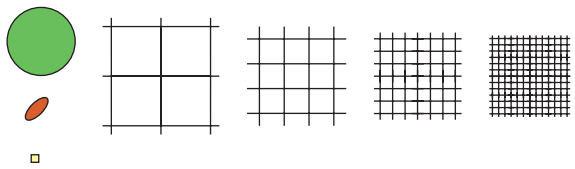
a How would you separate the following?
- **i** kerosene and water
- **ii** salt and sand
- **iii** sawdust and sand
- **iv** iron filings and sand
- **v** copper sulfate and sand
- **vi** water and sand
- **vii** colours in dye
- **viii** sand and clay
- **ix** colours in triple dye
- **x** pieces of paper from cardboard

b How would you remove the following impurities?
- **i** pepper from salt and pepper
- **ii** coloured dye mixed with water
- **iii** copper sulfate from a copper sulfate solution
- **iv** water from a copper sulfate solution
- **v** iron nails from match sticks
- **vi** lead pellets from sand
- **vii** poisonous gas from the air you breathe
- **viii** dust from air
- **ix** dust from chimney smoke
- **x** sand from sugar

12 What is the difference in meaning between the words in each pair?
- **a** soluble and insoluble
- **b** solution and suspension
- **c** physical and chemical changes
- **d** sedimentation and centrifuging
- **e** solute and solvent
- **f** magnetic and non-magnetic
- **g** adsorption and absorption

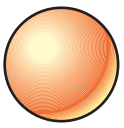
13 What is the meaning of these words: desalination, distillate, activated charcoal, physical properties, chemical properties?

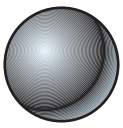
14 The child you have been baby-sitting has mixed the dried peas, rice and sugar. You have four sieves to separate them.



Which sieves, in which order, would you use?

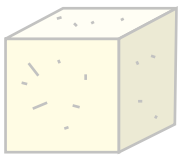
15 Complete a table of properties of the following objects. Design a method you could use to separate them if they were all mixed together.


glass marble (15 mm)


steel ball bearing (15 mm)


bean bag filling (5 mm)

sugar grain (1 mm)

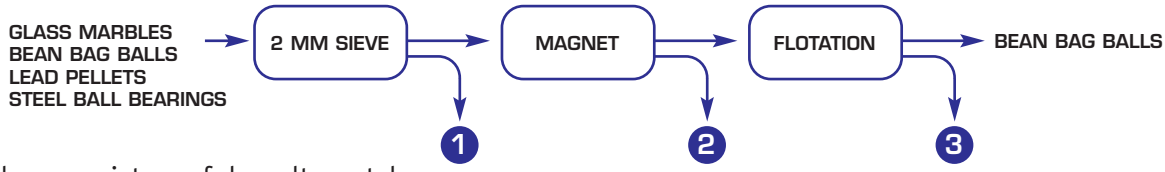

sugar cube (15 mm)


lead pellet (3 mm)

Object	*Size*	*Soluble?*	*Magnetic?*	*Floats in water?*
Glass marble	.....	.....	.....	.....
Steel ball bearings	.....	.....	.....	.....
Bean bag filling	.....	.....	.....	.....
Sugar grains	.....	.....	.....	.....
Sugar cubes	.....	.....	.....	.....
Lead pellets	.....	.....	.....	.....

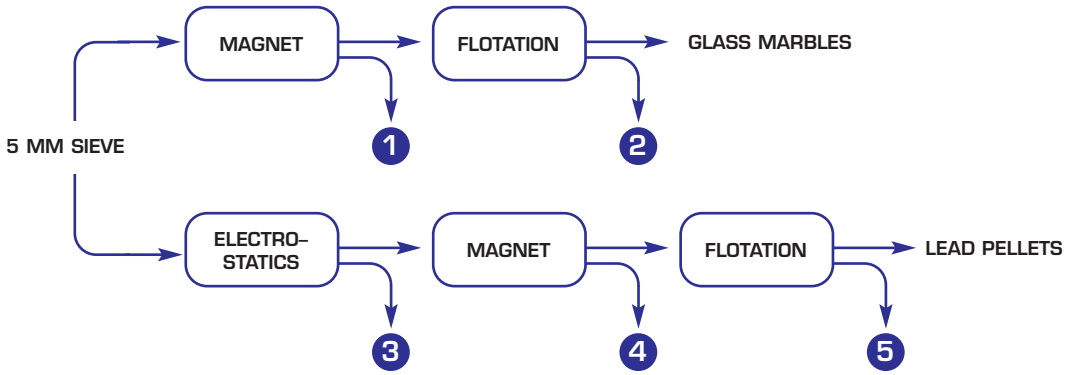
16 You have been given a mixture of glass marbles, bean bag balls, lead pellets and steel ball bearings. A separation is shown in the flow chart below.

Identify the components of the mixture labelled 1, 2 and 3.



17 You have a mixture of dry salt crystals, sawdust, steel ball bearings, bean bag balls, iron filings, lead pellets and glass marbles. A method of separation is shown below.

Identify the components of the mixture labelled 1, 2, 3, 4, and 5.



Extension experiments

Aim: To perform chromatography with food dyes

The colours of many foods are made of synthetic dyes. The dyes are water-soluble and can be separated by chromatography. The best to use are Smarties, M&Ms, Beanies, and similar chocolate lollies that are coated in bright colours.

Chromatography of coloured chocolate lollies

This is an experiment you can do at home or school. Carefully lick the dye, and wipe the dye from the lolly onto the paper. You can eat the lollies when you have finished! Water is the solvent to use, or water with a small amount of salt added to it.

Find and record which food colours are used to make the outside colour of these lollies. Record your results in a table in your notebook.

Aim: To find out which colours magnesium oxide adsorbs

In Activity 7.7 you adsorbed red food dye onto grains of magnesium oxide. Magnesium oxide adsorbs only some of the colours in food dyes; it does not adsorb the other colours. We say that the colours are selectively adsorbed. Which colours does magnesium oxide adsorb?

Put five drops of red, green and blue food dye in 200 mL of water into six beakers as shown.

Selective adsorption

Add a teaspoon of magnesium oxide to one beaker of red dye, one beaker of green dye and one beaker of blue dye. Leave the other three beakers for comparison. Warm and stir the solutions, and then filter them separately. At the end of the experiment, what colour is the magnesium oxide? What colour is the filtrate?

Find and record which dyes are adsorbed by the magnesium oxide? Try other food colourings if you have time. Record your results in a table.

Thinking questions

1 Some information is given below about three substances. Suggest a way to separate a mixture of these three substances.

sand	*insoluble in water*	*insoluble in methylated spirits*
iodine	*insoluble in water*	*soluble in methylated spirits*
salt	*soluble in water*	*insoluble in methylated spirits*

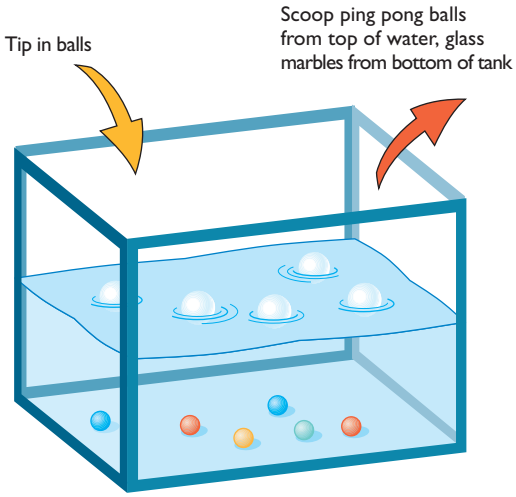
2 Some information is given below about three substances. Suggest one way to obtain three pure samples of each of these substances from a mixture of all three.

salt	*no change when heated*	*soluble in water*
sand	*no change when heated*	*insoluble in water*
ammonium chloride	*sublimes when heated*	*soluble in water*

3 Propose how to separate these substances, based on their solubility.

Substance	*Soluble in water*	*Soluble in methylated spirits*
Iodine	no	yes
Salt	yes	no
Sand	no	no

4 Separating glass marbles and ping pong balls is fairly simple. But imagine that, in a factory, you have to separate 2000 glass marbles from 2000 ping pong balls every hour. You have to invent a machine or device that will do the separation for you. Using your knowledge of separations, describe four methods of separation.



Separating glass marbles and ping pong balls

Research question

You and your friends are going on a holiday to an old gold-mining area. The locals say that there is still lots of gold to be found in the creeks. How would you look for the gold? What equipment would you need? What methods would you need to practise? (You cannot use a metal detector!)

Word check

absorption
activated
adsorption
centrifuge
chromatography
decant
dye
electrostatic
filtrate
filtration
flotation
fractional distillation
froth flotation
impurity
magnetism
sedimentation
sieve
solubility
solution
suspension

Concept map

Draw a concept map which shows methods of separations and reasons for them.