SURFING

NSW CHEMISTRY 1&2

Module 1 Properties and Structure Of Matter

Module 2 Introduction To Quantitative Chemistry

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Introduction

This book covers the Chemistry content specified in the NSW Chemistry Stage 6 Syllabus. Sample data has been included for suggested experiments to give you practice to reinforce practical work in class.

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory parts of the syllabus, along with questions and answers.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions. These cover every aspect of the topic, and are useful for revision and exam practice.

Words To Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

Surfing

NSW CHEMISTRY 1&2

Module 1

Properties and Structure of Matter

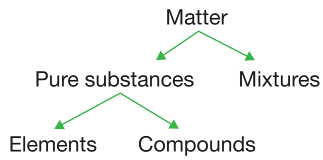
Content Focus

In this module you will:

- Analyse trends and patterns in relation to the properties of pure substances and use these to predict the properties of other pure substances.
- Use this knowledge to determine the ways in which substances can be separated from each other and those that allow them to remain together.
- Understand that matter can be either pure substances with distinct measurable properties (e.g. melting and boiling points, reactivity, strength, density) or mixtures with properties that are dependent on the identity and relative amounts of the substances that make up the mixture.
- Use the periodic table to examine trends and patterns that exist between chemical elements and atoms, and discover that fundamental particles give all chemicals their properties.
- Engage with all the Working Scientifically skills for practical investigations involving the focus content to design and conduct investigations to interpret trends in data and to solve problems related to properties and structure of matter.

1 Pure Substances and Mixtures

Everything that exists is either a pure substance or a mixture.



A **mixture** contains more than one type of particle and they are not joined together. Its composition (what it is made of) can vary, so its properties also vary depending on the types and amounts of the substances present.

A **pure substance** has distinct, measurable properties that do not vary and can be measured – for example, melting point, boiling point, reactivity, strength and density. A pure substance has a definite composition, contains only one type of particle and can be an element or a compound.

An **element** is a pure substance; and each element contains only one type of atom. There are 92 elements that occur naturally.

A **compound** is a pure substance; it contains two or more elements whose atoms are chemically combined in a definite ratio. It doesn't matter how a compound is made, or where you find it, or how much or how little you have, a compound will always contain the same elements combined in the same ratio. The elements in a compound cannot be separated by a physical change, they can only be separated by a chemical reaction.

Table 1.1 Examples of elements, compounds and mixtures.

Pure substances		Mixtures
Elements	Compounds	
Calcium Ca	Hydrochloric acid HCl	Fried rice
Sodium Na	Calcium hydroxide $Ca(OH)_2$	Air
Magnesium Mg	Sodium chloride NaCl	Ocean water
Aluminium Al	Calcium oxide CaO	Blood
Oxygen O		Nail polish

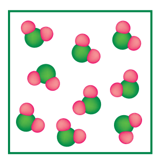
QUESTIONS

1. Use a table to summarise the differences between mixtures and compounds.
2. Explain why there is never a symbol or formula for a mixture whereas compounds have a formula and each element has a symbol and sometimes a formula as well.
3. Copy and complete the following table to show the composition of each of the following compounds. The first one is done for you.

Compound	Formula	Composition	Ratio
Sulfuric acid	H_2SO_4	Hydrogen : sulfur : oxygen	2 : 1 : 4
Carbonic acid	H_2CO_3		
Sodium hydroxide	NaOH		
Calcium hydroxide	$Ca(OH)_2$		
Sodium chloride	NaCl		
Magnesium chloride	$MgCl_2$		
Methane	CH_4		
Carbon dioxide	CO_2		

4. (a) Salt water is a mixture of two main compounds. Identify these compounds.
   (b) Is there a formula for salt water? Explain.
   (c) Is there a formula for water or salt? Explain.
5. Classify each of the following diagrams as representing a mixture, an element or a compound. Justify your answers.

(a)



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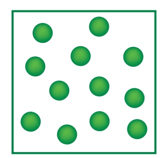

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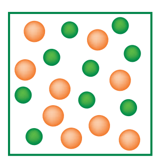

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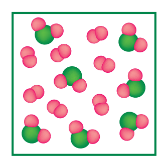

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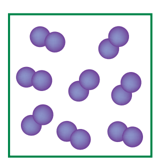


6. Check your knowledge with this quick quiz.
   (a) A substance that has its components chemically combined is called a ....
   (b) If a substance can be separated into components by physical methods it is a ....
   (c) Identify five compounds.
   (d) Name five common mixtures.
   (e) Name five elements.
   (f) State the name and composition of the compound with the formula HNO_3.
   (g) State the name and composition of the compound with formula $Ca(OH)_2$.

2 Physical and Chemical Properties

We use the properties of substances to help classify and separate them, so this is a good time to revise the differences between physical and chemical properties of substances.

Physical properties

Physical properties of a substance are those that can be found by studying the substance itself rather than its reactions. For example, hardness, melting and boiling points, conductivity, malleability and density.

Chemical properties

Chemical properties of a substance describe how it reacts. For example, whether it is reactive or inert, if it is stable or decomposes when heated, whether it reacts with water, acids and bases.

Properties of elements and compounds

Each **element** has its own distinctive properties, both physical and chemical. For example, physical properties of metals include having a shiny lustre and being malleable (can bend). A chemical property of all the elements in group 1 is that they are very reactive, whereas elements in group 8 are unreactive.

When two or more elements combine chemically, the elements lose their properties. The new **compound** formed has its own distinctive physical and chemical properties that are very different from the properties of the elements in the compound. For example, the compound **water** is made of the elements hydrogen and oxygen, chemically combined together. Table 2.1 looks at some of the properties of these three substances.

Table 2.1 Properties.

Substance	Chemical properties	Physical properties at 25°C
Water	Puts out fires	Colourless liquid Boiling point: 100°C
Hydrogen	Burns explosively in air or oxygen	Colourless gas Boiling point: –253°C
Oxygen	Promotes burning	Colourless gas Boiling point: –183°C

Obviously, water is nothing like either of the elements from which it is made. Another common compound is sodium chloride, common table salt. This is made from the metal sodium and the non-metal chlorine combining together. The properties of sodium chloride are different from the properties of sodium and from those of chlorine gas. It is safe to eat sodium chloride, but it is certainly not safe to eat either of the elements it is made of. Table 2.2 compares the properties of salt, sodium and chlorine.

Table 2.2 Properties of salt, sodium and chlorine.

Substance	Chemical properties	Physical properties at 25°C
Sodium chloride	Will not burn. Does not react with water. Does not react with hydrogen.	White crystals. Dissolves in water. Does not conduct electricity when solid. Conducts electricity when molten and when dissolved in water.
Sodium	Burns in air or oxygen. Reacts explosively with water. Reacts explosively with hydrogen.	Soft, silver solid. Conducts electricity when solid and molten.
Chlorine	Burns in air or oxygen. Reacts with water. Reacts explosively with hydrogen.	Green-yellow poisonous gas. Does not conduct electricity.

Properties of mixtures

A mixture does not have its own properties, its properties depend on what the components are. The components of a mixture keep their own properties. For example, a mixture of hydrogen and oxygen would keep the properties of hydrogen and oxygen.

QUESTIONS

1. (a) Identify three physical properties.
   (b) Identify three chemical properties.
2. The physical and chemical properties of compounds are different from the properties of the elements that make up these compounds.
   Support this statement using rust as an example.
3. Mercury oxide is a reddish powder that decomposes at about 500°C. Compare the properties of mercury oxide with properties of the elements it contains. Tabulate your answer.
4. You performed a first-hand investigation to compare the properties of some common elements in their elemental state with the properties of the compound(s) of these elements.
   (a) Identify the compound you studied.
   (b) Identify the elements that make up this compound.
   (c) Use a table to compare the properties of this compound and its component elements.
5. Check your knowledge with this quick quiz.
   State whether each of the following is a physical or chemical property.
   (a) Malleability.
   (b) Boiling point.
   (c) Reactivity with acid.
   (d) Stability to heat.
   (e) Hardness.

3 Homogeneous and Heterogeneous Mixtures

We are surrounded by mixtures. Examples of mixtures are fried rice, blood, fruit cake, air, salt water, soil, rocks, and alloys such as steel and brass. How do we tell if something is a mixture?

It is easy to see that **fried rice** is a mixture – it obviously contains a variety of things (components) which can be physically separated out. Also, it can be made from different recipes and still be called fried rice. Its composition can vary and its properties, e.g. taste, will change as the composition changes. This is because the components of a mixture keep their own properties.

Figure 3.1 Fried rice.

It is harder to see that **air** is a mixture or that sea water is a mixture. They each look as if they are made of just one thing. They are called **homogeneous** mixtures whereas fried rice is described as a **heterogeneous** mixture.

Air is mostly nitrogen, but it also contains oxygen, argon, carbon dioxide, water vapour and various pollutants. Its composition can vary, but it is still called air. The main components of air can be separated out by a physical technique called fractional distillation.

Blood is another mixture. It contains water, cells, dissolved gases, food, wastes and hormones. The proportions of all these components (parts) can vary (its composition varies) but it is still blood. We can physically separate out some components by using a centrifuge. The properties of blood will change with changes in its composition. For example, its ability to carry oxygen depends on the number of red blood cells.

A **mixture** contains two or more substances, mixed together in any ratio. A substance is a mixture if:

- It has a **composition that can vary**, i.e. the ratio of its components can vary.
- Its **properties can vary** as the composition varies.
- The substances in it (components) **are not chemically combined** together and they **keep their own properties**.
- Its **components can be separated out** relatively easily by physical changes (e.g. evaporating, centrifuging, sieving, filtering, chromatography).

QUESTIONS

1. Describe the meaning of the following terms.
   (a) Composition. (b) Components.
   (c) Property. (d) Proportion.
   (e) Homogeneous. (f) Heterogeneous.
2. Identify four examples of physical changes.
3. Copy and complete the following table to justify the classification of soil as a mixture.

Characteristics of mixtures	Properties of soil
Its properties can vary	
Its components are not chemically combined and keep their own properties	
Its composition can vary	
Its components can be separated by physical methods	

4. Describe how you could show experimentally that salt water is a mixture.
5. Distinguish between a homogeneous and a heterogeneous mixture and give three examples of each.
6. You have carried out a first-hand investigation to separate the components of a naturally occurring mixture.
   (a) Identify the mixture you separated.
   (b) Outline the techniques you used to do this.
   (c) Identify the components you separated out.
   (d) Identify the property of the components that enabled separation.
   (e) Identify any necessary safety precautions.
7. Research the composition of the following common mixtures.
   (a) Air.
   (b) Steel.
   (c) Granite.
   (d) Ocean water.
8. Explain why mixtures are not classified as pure substances.
9. Check your knowledge with this quick quiz.
   (a) The composition of a mixture (is fixed/can vary), so its properties (are fixed/can vary).
   (b) The components of a mixture can be separated by a (physical/chemical) change.
   (c) The components of a mixture are (chemically combined/mixed together).
   (d) The components of a mixture are present in (a fixed ratio/any ratio).

4 Physical and Chemical Changes

This chapter revises physical and chemical changes. To break down a compound into its elements you need to use a chemical change. To separate the components of a mixture, or to change the state of a substance you need a physical change.

Physical changes

Physical changes include processes such as filtering, distillation and evaporation. These do not involve any chemical change as no new substance is produced. They can be used to separate the components of a mixture.

Another physical change is change of state. When a substance changes state, the chemical itself is not changed, only the speed and arrangement of its particles changes.

For example, when we heat ice and boil water, it changes state from a solid to a liquid to a gas. However, the water particles themselves do not change during these changes of state. Whether it is a solid, liquid or a gas, each particle is still an H_2O unit composed of hydrogen and oxygen in the ratio 2 : 1.

When these particles are in the solid state (ice), they just vibrate in a fixed position. Heating allows the particles to move more freely and the water becomes liquid. Absorbing more heat lets particles move around even faster and still more freely. Eventually the particles have enough energy to break free from the surface of the water and then we describe them as water vapour – a gas.

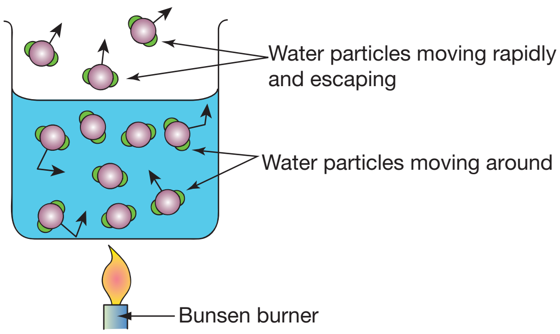


Figure 4.1 Boiling and evaporation of water.

If we cool these water vapour particles, they slow down and move closer – the water becomes a liquid once more, and with more cooling it will freeze solid. In each state, the particles are still water particles, they are just moving differently. No new substance has been produced, so a **change of state is a physical change**.

Physical changes cannot break up a compound into its component elements. Only a chemical change can do that.

Chemical changes

All chemical reactions, e.g. combustion, decomposition, synthesis and electrolysis, involve chemical changes as a new substance is produced in each case.

For example, electrolysis of water can be carried out using a **voltameter**. This is a piece of equipment that allows us to pass electric current through a liquid such as water and collect any gases produced as the liquid decomposes.

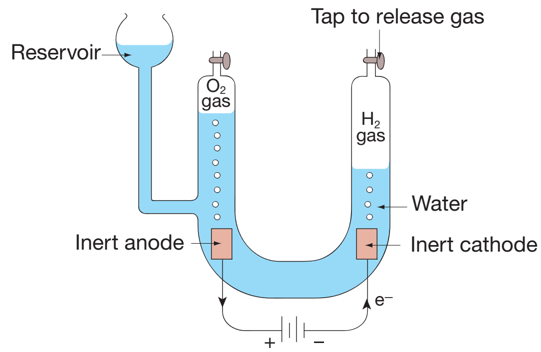


Figure 4.2 Voltameter.

When we pass an electric current through water, the water is split up into two gases, hydrogen and oxygen – the two elements that form the compound water. If we look at the formula for water – H_2O – we can see why we produce twice as much hydrogen as oxygen when water decomposes.

The passage of an electric current through water causes a **chemical change**; it decomposes the water and new substances are produced – hydrogen and oxygen.

The decomposition of a compound such as water by the passage of an electric current through it is called **electrolysis**.

We can show this as an equation:

Water $\rightarrow$ hydrogen + oxygen

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

You will recall that we can carry out tests to check that the gases produced are indeed hydrogen and oxygen.

A **test for hydrogen** is that it pops when lit. The 'pop' is really a mini explosion formed by the fast combustion (burning) of the hydrogen.

Hydrogen + oxygen $\rightarrow$ water

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

A **test for oxygen** is that it 'relights a glowing splint'. To make a 'glowing splint' we can take a splinter of wood (a broken 'paddle pop' stick works well) and set it alight, then let the flame die down until the stick is just glowing. If we place this glowing stick in oxygen, it will suddenly burst into flames again.

Our two new substances, hydrogen and oxygen, produced by the electrolysis of water, *cannot* be turned back to liquid water by physical changes such as cooling, so a chemical change must have taken place. A chemical change is more difficult to reverse than a physical change.

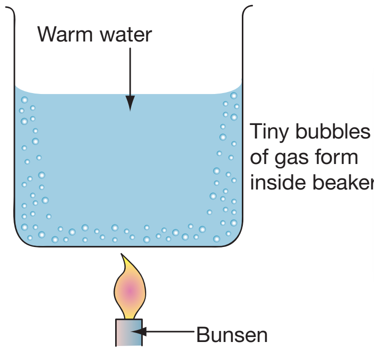
The **differences between physical and chemical changes** are summarised in Table 4.1.

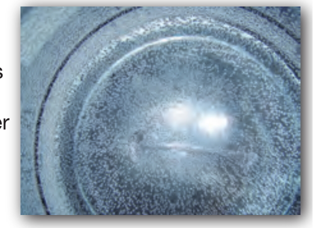
Table 4.1 Physical and chemical changes.

Factor	Physical change	Chemical change
New substances	No new substance is formed.	A new substance is formed.
Particles	Particles stay the same (they just move differently).	New particles are formed (atoms have been rearranged).
Reversal	Usually easy to reverse by physical changes.	Usually difficult to reverse.
Energy involved	Small energy changes usually involved.	Energy changes are usually large.
Examples	Filtration, centrifuging. Change of state, e.g. melting, boiling, evaporation, condensation.	Combustion (burning). Acids on metals. Decomposition by heat or by electrolysis.

QUESTIONS

1. Classify each of the following changes as a physical or a chemical change. In each case justify your decision.
   (a) Filtering sand and water.
   (b) Burning wood.
   (c) Centrifuging blood.
   (d) Decomposition of copper carbonate.
   (e) Evaporation of alcohol.
   (f) An acid reacting with a metal.
   (g) Melting butter.
   (h) Fractional distillation of petroleum.
   (i) Crystallising salt from salt water.
2. Use a table to compare what happens when water boils and when it undergoes electrolysis.
3. Electrolysis involves the 'passing of electric current' through a substance. It is not considered accurate to refer to 'passing electricity' through the substance when defining electrolysis. Explain.
4. (a) Distinguish between a voltameter and a voltmeter.
   (b) When carrying out electrolysis of water, a small amount of salt or dilute acid is usually added to the water. Explain why this is necessary.
5. When water is first heated, tiny bubbles of gas form in the water on the inside of the beaker.





   Many people think these bubbles are hydrogen and oxygen formed by heat making the water decompose.
   (a) If hydrogen was formed whenever water was heated, it would not be safe to light any matches around hot or boiling water. Explain.
   (b) What are the bubbles and why do they form?
6. The main indication that a chemical change has occurred is the formation of a new substance. From the chemical reactions you have carried out in class, list four observations that would indicate to you that a new substance had been formed.
7. Outline a test you could use to distinguish whether or not an unknown gas is:
   (a) Oxygen.
   (b) Hydrogen.
8. Boiling of water involves a physical change whereas electrolysis of water involves a chemical change. Justify this statement.
9. (a) Model the boiling of water to show:
      (i) Movement of the molecules.
      (ii) Any changes in the molecules.
   (b) Model the electrolysis of water to show any change in the water molecules.
10. Test your knowledge with the following quiz.
   (a) Identify the gas which 'pops' when ignited.
   (b) Identify the gas which can relight a glowing splint.
   (c) Which process forms a new substance, a physical or a chemical change?
   Classify each of the following processes as either a physical or chemical change.
   (d) Boiling.
   (e) Electrolysis.
   (f) Evaporation.
   (g) Filtration.
   (h) Burning.
   (i) Decomposition of a compound.

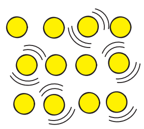
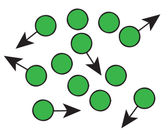
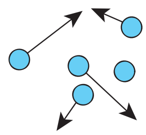
5 Kinetic Particle Theory

You will recall the **kinetic particle theory** which provides a model for the structure and properties provides a model for the structure and properties of matter.

This theory states that all matter is made of many, very small particles that are continuously in random motion and interacting with each other. The energy of the particles controls their movement and the state (solid, liquid or gas) of the substance. Heating a substance gives it more energy, making its particles move faster and possibly changing its state.

The kinetic energy of particles increases with temperature. Experiments predict that zero kinetic energy of the particles in matter will occur at a temperature of –273ºC, which no one has yet been able to achieve. This is known as **absolute zero** and is the basis for the Kelvin temperature scale.

Table 5.1 States of matter and particle theory.

Solid	Liquid	Gas
Particles are close together and vibrating in fixed positions	Particles are close together and moving more freely	Particles are far apart and moving very freely
		
Definite shape	Shape depends on container	Shape depends on container
Definite volume	Definite volume	Fills all available space
Cannot be compressed	Cannot be compressed	Can be compressed
Cannot diffuse (spread through other substances)	Can diffuse	Can diffuse

The particles referred to in this theory can be **atoms**, **molecules or ions**. The types and arrangement of particles in a substance tell us if it is an element, compound or mixture.

Particles in elements

The particles in an element are all the same. They may be single atoms, or molecules made of identical atoms. We can show this as in Figure 5.1.

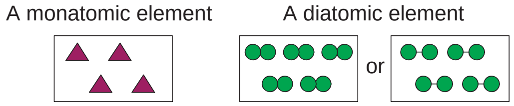


Figure 5.1 Particles in elements.

Particles in compounds

The particles in any compound are all the same. Each particle is made of two or more different smaller particles chemically combined together, always in the same ratio. We can show compounds as in Figure 5.2.

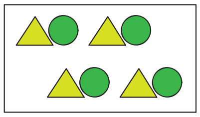


Figure 5.2 Particles in compounds.

Particles in mixtures

The particles in mixtures are *not* all the same. Mixtures may contain particles of different elements, different compounds, or elements and compounds.

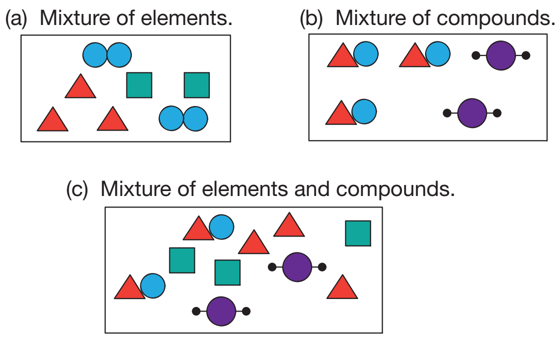


Figure 5.3 Particles in mixtures.

Physical change

In a physical change, the particles are rearranged. For example, during change of state, the particles stay the same, but they move differently and change their distance apart.

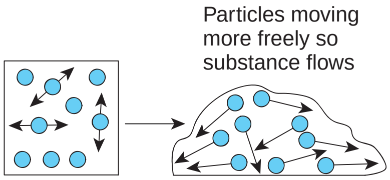


Figure 5.4 Particles during a change of state.

Chemical change

In a chemical change, the atoms are rearranged. For example, during electrolysis the water particles split and rearrange.

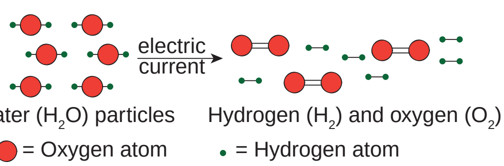


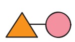
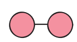
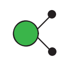
Figure 5.5 Particles in a chemical reaction.

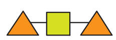
Particles and the states of matter

In different states (solid, liquid and gas), the particles of a substance move differently. The energy of the particles controls their movement and thus the state of the substance. When particles of a substance change speed, this may cause a change in state of the substance. **The particles themselves do not change their state.** Heating a solid may make its particles move faster and more freely, and break apart from each other, so that the substance becomes a liquid. Cooling a substance causes its particles to slow down.

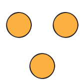
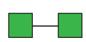
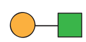
QUESTIONS

1. The following diagrams illustrate a number of particles. Deduce whether each of these diagrams represents an element or a compound. Justify your answers.

(a)  (b)  (c) 

(d)  (e) 

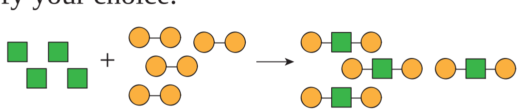
2. The following diagrams show three different molecules.

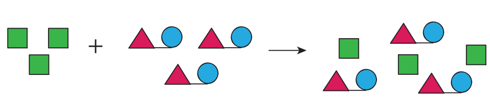
(i)  (ii)  (iii) 

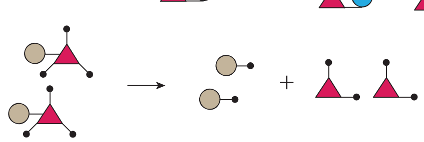
Identify which diagram represents:
(a) An element that has diatomic molecules.
(b) A compound.
(c) An element that has monatomic molecules.
Justify your answers.

3. Draw diagrams of:
(a) A molecule of a compound which has three different types of atoms.
(b) A molecule of a compound which has four atoms of three different types.
(c) A molecule of an element that is diatomic.
(d) A molecule of an element that is monatomic.
(e) A mixture of an element which has diatomic molecules and a compound with two different types of atoms.

4. Identify which of the following diagrams show a physical change and which show a chemical change. Justify your choice.

(a) 

(b) 

(c) 

5. (a) How is the theory that all matter is made of particles helpful in chemistry?
(b) In terms of particles, what is the difference between a physical and a chemical change?

6. Explain the meaning of:
(a) Particle. (b) Kinetic. (c) Compressed.
(d) Vibrating. (e) Matter.

7. Explain, in terms of particles, why:
(a) Solids have a definite volume but gases do not.
(b) Gases can be compressed but solids and liquids cannot be compressed.
(c) Liquids and gases can diffuse (spread) through each other, but solids cannot diffuse.

8. (a) Identify three types of particles.
(b) Name the theory that states – all matter is made of moving particles.
(c) If the particles in a substance are identical then it must be a(n) .... or ....
(d) Which state(s) of matter can be compressed?
(e) Name and state the symbol of five elements.
(f) Name five common mixtures.
(g) Name five compounds and state a formula for each.

6 Separating Components Of a Mixture

The method used to separate out the parts of a mixture depends on what is in the mixture (its components) and the properties of these components. To separate the components of a mixture, you need to find differences between the components – find a property that one has and the other components do not have.

Properties of substances present in mixtures that can be used to separate the components include particle size, solubility, magnetism, density, electrostatic attraction, melting point and boiling point. The property that is different will determine the procedure used.

Table 6.1 Use of properties to separate components of mixtures.

Property used	Example of mixture	Process used
Solubility	Salt and sand (Salt is soluble, sand insoluble.)	Add water, decant/ filter, evaporate filtrate
Boiling points	Petroleum, air (Different boiling points.)	Fractional distillation
Magnetism	Sand and iron	Magnetic attraction
Size of solid particles	Flour and wheat germ, sand and gravel	Sieving

Notice that all the processes used to separate out the components of a mixture involve **physical changes**. There are no chemical reactions involved – no new substances are produced. Many physical separation processes are used in recycling, to separate metals, plastics and paper from waste. The following diagrams show these physical processes.

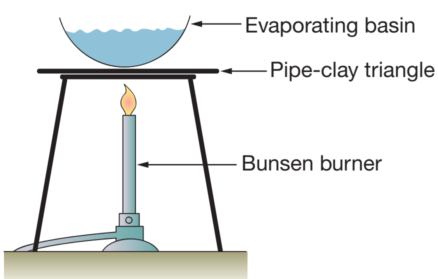


Figure 6.1 Evaporation.

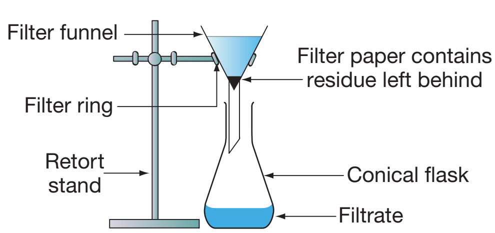


Figure 6.2 Filtration.

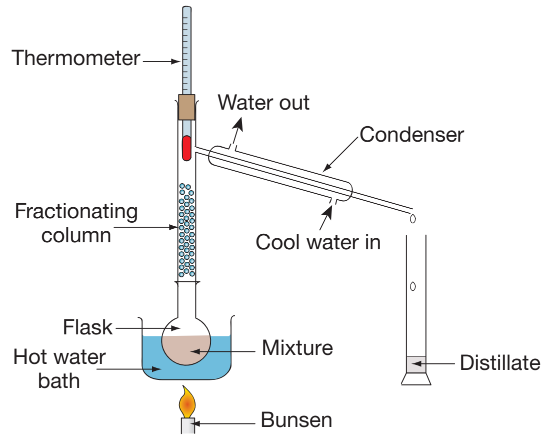


Figure 6.3 Fractional distillation.

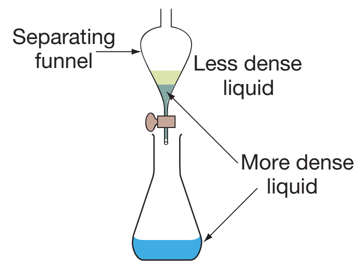


Figure 6.4 Using a separating funnel.

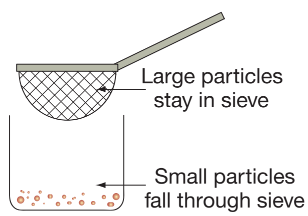


Figure 6.5 Sieving.

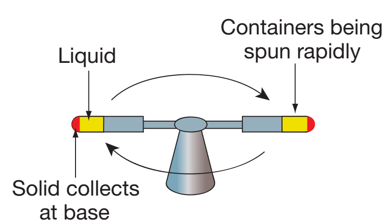


Figure 6.6 Centrifuging.

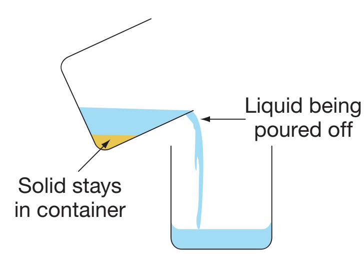


Figure 6.7 Decanting.

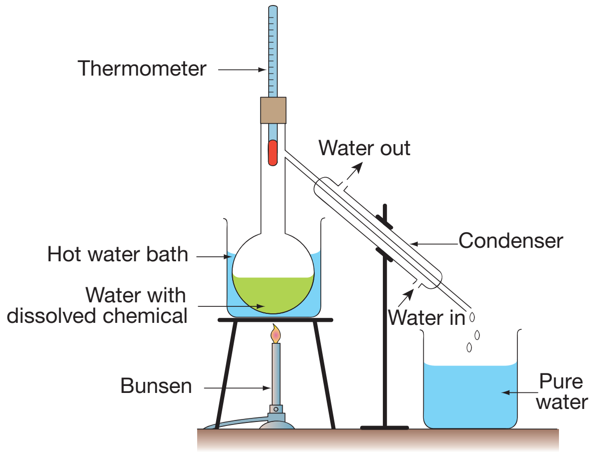


Figure 6.8 Distillation.

QUESTIONS

1. Could you use the property of magnetism to separate the mixtures listed? In each case, justify your answer.
   (a) Sand and iron.
   (b) Iron and steel.
   (c) Sand and aluminium.
2. Copy and complete the following table to summarise some separation techniques.

Components of mixture	Process used	Property
Sand from gravel	Sieving	Solids with different-sized particles.
Petrol and water		
Solid sewage from liquid sewage		
Blood cells from liquid blood		
Sugar crystals from the liquid released from crushed sugar cane		
Sand and salt		
Nitrogen and oxygen in air		

3. Draw fully labelled diagrams to show apparatus you could use to separate the following mixtures in the laboratory.
   (a) Ethanol and water.
   (b) Sand and a solution of copper sulfate (to recover the sand, copper sulfate and the water).
   (c) Oil and water.
4. Outline the meaning of the following terms.
   (a) Filter. (b) Liquefaction.
   (c) Fractional distillation. (d) Decant.
   (e) Centrifuge. (f) Sieve.
5. Sugar is extracted from the stems of the sugar cane plant. This extraction process can be simplified and summarised as follows.

> The sugar cane stems are cut and taken to the processing plant where they are crushed. During crushing, a liquid is forced out of the stems. The liquid is separated from the remains of the crushed stems by a machine which **spins the mixture**. During the spinning, the solid stems stay in the machine and liquid is spun out through holes, rather like the spin cycle on a washing machine. The liquid spun out of this machine is removed and heated. During this process, **water disappears and crystals of sugar form**.
>
> The waste plant material left after the extraction of sugar used to be disposed of by burning, which produced a great deal of polluting smoke, solid particles and carbon dioxide. Now much of this waste material (called biomass) is used to produce ethanol and polymers.

   (a) Draw a flow chart to show the steps in the processing of sugar cane as described above.
   (b) Identify the physical separation processes in bold print.
   (c) For each of the processes in (b), identify the property of the mixture used in its separation.
   (d) Identify a useful product (other than sugar) obtained from sugar cane.
   (e) Discuss issues associated with wastes produced during the extraction of sugar from sugar cane.
6. Sometimes when we analyse a mixture we use a chemical reaction to separate out one or more components. For example, to find the mass of chloride ions in a weighed sample of salt water we could either evaporate the water (physical method) or precipitate the chloride out by reacting it with silver nitrate (a chemical method). This produces a white precipitate of silver chloride. Write equations in words and symbols for this reaction.
7. Check your knowledge with this quick quiz.
   (a) Name two substances you could separate by:
      (i) Filtering.
      (ii) Crystallisation.
      (iii) Sieving.
      (iv) Using a separating funnel.
   (b) Mixtures are separated into their components by (physical/chemical) changes.

7 Separation By Froth Flotation

Rocks are mixtures of minerals. Every rock contains a mixture of two or more minerals.

A **mineral** is a compound found naturally in rocks, for example calcite, mica, hematite, quartz. Because these minerals are compounds they have definite properties which can be used to identify them – their colour, lustre, hardness, their cleavage and fracture (how they break), their transparency when cut in thin slices.

An **ore** is a rock that contains useful minerals in a high enough concentration that it is economic to mine the rock and extract the minerals. Waste material present in an ore with these useful minerals is called gangue.

Read the passage below then answer the questions that follow.

There are many separation processes used in industry; one of these is **froth flotation**. This is a technique, developed in Australia, to separate minerals, mainly lead, zinc and copper sulfides, from the waste material they are mixed with in the rocks of the Earth's crust.

Lead-zinc ores are rocks containing lead and zinc, mainly in the form of the mineral galena (lead sulfide) and sphalerite (zinc sulfide), together with other waste minerals called gangue. Froth flotation is a method of separating useful minerals from gangue by using the different surface tension properties of the minerals and gangue.

Australia has more than 20 per cent of the known lead-zinc resources in the world and is the largest exporter of these metals. Before the development of froth flotation, the extraction of lead and zinc sulfides from the rocks was a slow and expensive process.

The mined ore is first crushed and ground into small particles. The crushed ore is mixed with water in a large tank, the mixture is stirred and air is blown through the tank. Chemicals are added to cause frothing and to help the metal minerals cling to the froth.

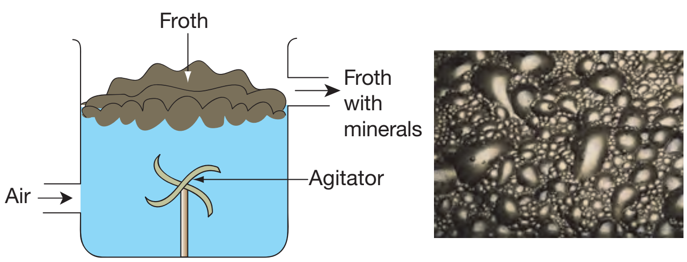


Figure 7.1 Froth flotation.

Metal sulfide minerals cling to the bubbles and float to the top of the tank. Gangue minerals do not cling to the bubbles because they have different surface tension properties. Instead, they fall to the bottom of the tank.

After the compounds lead sulfide and zinc sulfide are separated from the ore, they are treated chemically to extract the metals lead and zinc. To do this they are heated in a smelter.

The wet gangue from the froth flotation vessel is stored in a dam, usually lined with cement, called a tailings dam. The liquid is allowed to evaporate.

QUESTIONS

1. Define the following terms.
   (a) Froth flotation.
   (b) Gangue.
   (c) Ore.
   (d) Mineral.
2. (a) Define the term 'mixture'.
   (b) Use this definition to justify the classification of a rock as a mixture.
3. (a) Name a mineral that contains:
   (i) Lead.
   (ii) Zinc.
   (b) Research uses of lead and zinc.
   (c) Research the use of a tailings dam and problems associated with its use.
4. Draw a flow chart to show the steps in froth flotation.
5. Froth flotation can be carried out on a small scale in the laboratory as follows.
   - Use a mortar and pestle to crush a spatula of a sulfide ore (or make your own with a small amount of a sulfide mixed with some crushed waste rock).
   - Put your crushed mixture into a beaker.
   - Add 100 mL water.
   - Add a few drops of detergent and eucalyptus oil.
   - Stir vigorously while your partner blows air through a straw into the beaker.

   (a) Draw a mortar and pestle.
   (b) Justify the use of:
   (i) Detergent.
   (ii) Eucalyptus oil.
6. Check your knowledge with this quick quiz.
   (a) Mineral ores are separated from waste ores by the process called ....
   (b) Waste from ores is called ....
   (c) Identify the property used in froth flotation.

8 Separation By Fractional Distillation

Fractional distillation is a method of separating the components of a mixture containing two or more liquids or gases. Its use depends on the components having different **boiling points**. Figure 8.1 shows typical equipment used in a school laboratory to carry out fractional distillation to separate the components of a mixture of liquids.

To separate a mixture of ethanol (boiling point 78°C) and water (boiling point 100°C), the mixture is gently heated. At 78.3°C, the ethanol vaporises, rises to the top and passes out through the condenser.

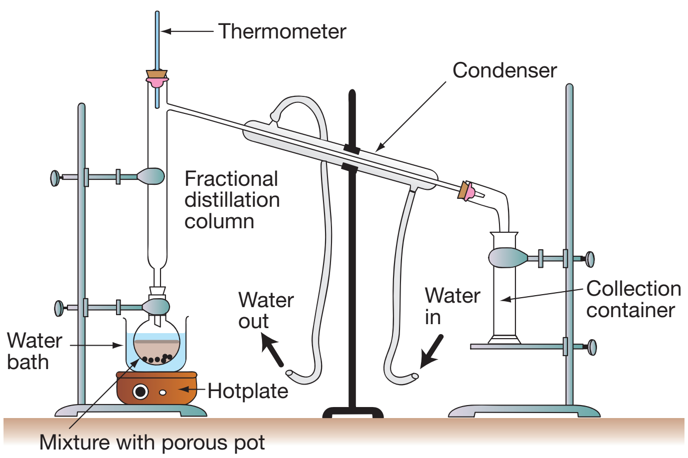


Figure 8.1 Fractional distillation.

As the ethanol vapour passes through the condenser, the cool water in the outside jacket cools the vapour and condenses it back to liquid ethanol, which is collected in a container.

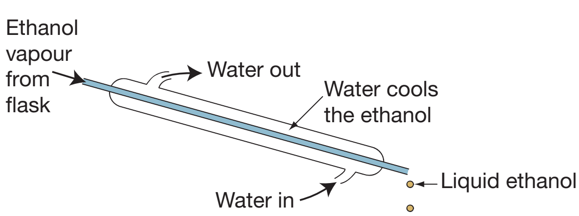


Figure 8.2 Condenser.

Heating continues while the ethanol is evaporating, but its temperature stays at 78.3°C, the extra heat being used to change the state of the ethanol from liquid to gas. When all of the ethanol has vaporised and been condensed by the condenser, the two liquids have been separated. Ethanol is the distillate in the collection container, water is left in the original flask.

Fractional distillation is used in industry to separate mixtures such as air and to fractionate crude oil.

QUESTIONS

1. You performed a first-hand investigation using the process of fractional distillation to separate the components of a mixture.
   (a) Identify the components of the mixture you separated.
   (b) Use a labelled diagram to show the equipment you used.
   (c) Outline the steps in your method.
   (d) Name the property of the components that allowed fractional distillation to be used as a separation technique.
   (e) Explain any safety precautions necessary when carrying out this experiment.
2. A condenser is always set up so that the cooling water goes into the bottom of the condenser and comes out of the top, as shown in Figure 8.1.
   (a) Explain why this is necessary.
   (b) Does the cooling water in the condenser have any contact with the mixture or the ethanol distilled off? Explain.
3. Explain why the mixture being distilled in Figure 8.1 is being heated with a hot water bath rather than with a direct Bunsen flame.
4. Fractional distillation is used in industry to separate the components of crude oil. It is also used to separate the components of air after it has been liquefied.
   (a) Describe how you could liquefy air.
   (b) Check the boiling points of oxygen and nitrogen in a data book. Use this information to decide which element would evaporate first if a mixture of liquid oxygen and liquid nitrogen underwent fractional distillation.
   (c) Outline ways in which the distillation of petroleum and air are similar to each other and to the laboratory distillation process.
5. Identify some areas in which the development of the technique of fractional distillation has had an impact on science and society and discuss this impact.
6. Check your knowledge with this quick quiz.
   (a) When carrying out fractional distillation of ethanol and water, which is produced first?
   (b) What process is carried out by the condenser?
   (c) Fractional distillation can be used to separate a mixture of liquids with different ....
   (d) The function of the condenser is to .... and .... the vapour.

Answers

1 Pure Substances and Mixtures

1.

Mixtures	Compounds
Composition varies – can contain elements and/or compounds in any ratio.	Definite composition – always contains the same elements combined in the same ratio.
Components are not chemically combined together.	Components are chemically combined together.
Components can be separated by physical methods.	Components can be separated by chemical methods.
Properties can vary.	Properties are always the same.

2. A mixture does not have a definite composition, so it cannot have a symbol or formula. It contains more than one type of atom.
A compound always has a formula because it has a definite composition – it is always made of the same elements combined together in the same ratio. The formula of a compound shows the symbols of any elements present and the ratio in which they are combined. For example, the formula for water is H_2O meaning it consists of hydrogen and oxygen in the ratio 2 : 1.
An element is usually represented by a symbol, e.g. Na, Mg, O, but some elements exist as identical atoms combined together, in which case they have a formula, e.g. O_2, O_3, N_2.

3.

Compound	Formula	Composition	Ratio
Sulfuric acid	H_2SO_4	Hydrogen : sulfur : oxygen	2 : 1 : 4
Carbonic acid	H_2CO_3	Hydrogen : carbon : oxygen	2 : 1 : 3
Sodium hydroxide	NaOH	Sodium : oxygen : hydrogen	1 : 1 : 1
Calcium hydroxide	$Ca(OH)_2$	Calcium : oxygen : hydrogen	1 : 2 : 2
Sodium chloride	NaCl	Sodium : chlorine	1 : 1
Magnesium chloride	$MgCl_2$	Magnesium : chlorine	1 : 2
Methane	CH_4	Carbon : hydrogen	1 : 4
Carbon dioxide	CO_2	Carbon : oxygen	1 : 2

4. (a) Salt water consists of the compound water (H_2O) with salts dissolved in it. The main salt is the compound sodium chloride (NaCl).
(b) No, salt water is a mixture. The ratio of salt to water can vary so it cannot have a formula.
(c) Yes. Water has the formula H_2O, it is a compound and it is always made of hydrogen and oxygen in the ratio 2 : 1. Salt usually refers to sodium chloride which has the formula NaCl. It is a compound and it is always made of the elements sodium and chlorine combined in the ratio 1 : 1.

5. (a) A compound – one substance only and each particle contains two elements (two types of atoms) joined together in the same ratio.
(b) An element – one substance, one type of atom.
(c) A mixture – two elements mixed together – two different types of atoms and they are not joined.
(d) A mixture – an element and a compound mixed together.
(e) An element – a diatomic element, each molecule contains two identical atoms.

6. (a) Compound.
(b) Mixture.
(c) Various, e.g. water, carbon dioxide, sodium hydroxide, hydrochloric acid, calcium oxide, sodium chloride, ammonia.
(d) Various, e.g. air, sea water, orange juice, ink in a pen, blood, nail polish and other cosmetics, soil, paint, watermelon, fried rice, soup, cake, bread.
(e) Various, e.g. sodium, carbon, hydrogen, magnesium, gold, oxygen, aluminium, (any name on the periodic table).
(f) Nitric acid – composition is hydrogen : nitrogen : oxygen in the ratio of 1 : 1 : 3.
(g) Calcium hydroxide – composition is calcium : oxygen : hydrogen in the ratio 1 : 2 : 2.

2 Physical and Chemical Properties

1. (a) Various, e.g. hardness, melting and boiling points, density, conductivity, malleability.
(b) Various, e.g. stability to heat, reaction with water, reaction with acids, reaction with oxygen.

2. The physical and chemical properties of rust differ from those of the elements oxygen and iron that make up rust. For example:

Substance	Chemical properties	Physical properties at 25°C
Rust	Insoluble in water. Reacts with dilute acids.	Brown, flaky solid.
Iron	Insoluble metal. Reacts slowly with oxygen to form rust,	Strong, hard, shiny, solid metal.
Oxygen	Promotes burning.	Colourless gas. Boiling point: –183°C

3.

Substance	Chemical properties	Physical properties at 25°C
Mercury oxide	Decomposes at about 500°C.	Red powder. No melting point as it decomposes.
Mercury	Burns in air or oxygen.	Silver liquid. Melting point is minus 39°C.
Oxygen	Supports burning.	Colourless gas. Melting point is minus 219°C.

4. Various, e.g.
(a) The compound magnesium oxide.
(b) Magnesium oxide is made of the elements magnesium and oxygen.
(c)

Substance	Chemical properties	Physical properties at 25°C
Magnesium oxide	Puts out fires.	White powder. Melting point 2800°C.
Magnesium	Burns in air or oxygen with a brilliant white light. Tarnishes in air.	Silver solid. Melting point 650°C.
Oxygen	Promotes burning.	Colourless gas. Melting point minus 219°C.

5. (a) Physical. (b) Physical.
(c) Chemical. (d) Chemical.
(e) Physical.

3 Homogeneous and Heterogeneous Mixtures

1. (a) Composition means what something is made of – the components present and the ratio (proportion) in which they are present.
   (b) Components are the parts that something is made of.
   (c) A property is a characteristic.
   (d) Proportion means the ratio.
   (e) Homogeneous means all the same or uniform throughout – looking as if it is made of only one thing.
   (f) Heterogeneous means having different parts.
2. Various, e.g. evaporation, condensation (or any other change of state), sieving, using a magnet, centrifuging, distillation, crystallisation, fractional distillation, decanting.
3. Various, e.g.

Characteristics of mixtures	Properties of soil
Its properties can vary.	Soil with lots of sand will let water flow through quickly. Soil with lots of clay will not let water flow through quickly.
Its components are not chemically combined and keep their own properties.	Different-sized particles, e.g. twigs and leaves, can be separated out physically and they remain twigs and leaves when in the soil.
Its composition can vary.	It can have different ratios of components such as sand, clay, and humus.
Its components can be separated by physical methods.	A sieve can be used to separate out different-sized particles.

4. Heat the salt water to boiling point. The water will evaporate, leaving the salt behind as crystals. This means you will have separated the components (water and salt) by a physical method (evaporating). The use of this method is possible because water and salt have different properties – water can change to a gas at this temperature whereas salt cannot. This method can be used for different ratios of salt and water – the composition can vary and still be salt water. It fits the characteristics of a mixture.
5. In a homogeneous mixture you cannot see the component parts, e.g. mayonnaise, sunscreen lotion, air, petrol, any solution, alloys such as brass and steel. In a heterogeneous mixture the component parts are visible, e.g. fruit cake, granite rock, garden soil, concrete.
6. (a) Various, e.g. salt water.
   (b) Various, e.g. evaporation of the water and crystallisation of the salt (*Note*: If asked to 'describe' you would include labelled diagrams of the methods you used and give more details of your method.)
   (c) Water and salt.
   (d) Temperature at which they vaporise.
   (e) Various, e.g. wear protective glasses, tie back long hair, heat gently to avoid spitting.
7. (a) Air – nitrogen 78.1%, oxygen 20.9%, argon 0.93%, carbon dioxide 0.03%, neon 0.002%, other gases 0.038%.
   (b) Steel – composition depends on the required properties of the steel being manufactured. Steel contains iron and carbon together with small amounts of a number of other elements such as chromium, nickel, titanium, molybdenum and manganese.
   (c) Granite – is a rock made of minerals such as quartz, mica and feldspar.
   (d) Ocean water – water with dissolved salts such as sodium chloride, magnesium sulfate, calcium hydrogen carbonate, sodium bromide.
8. In a pure substance the components are chemically combined in a fixed ratio, its composition is always the same and its properties are always the same. Also the components can only be separated by chemical reactions. These things do not apply for mixtures, so they are not pure substances. In contrast, a mixture has varying components, which can be present in any ratio, they are not chemically combined and can be separated by physical methods.
9. (a) The composition of a mixture can vary, so its properties can vary.
   (b) The components of a mixture can be separated by a physical change.
   (c) The components of a mixture are mixed together.
   (d) The components of a mixture are present in any ratio.

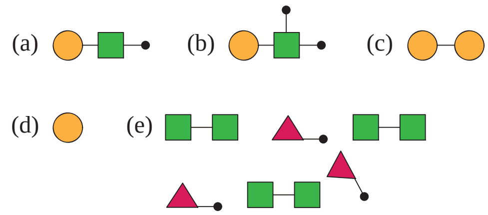
4 Physical and Chemical Changes

1. (a) Filtering sand and water: physical change because no new substance is produced, you still have sand which collects in the filter paper and water which passes through. Particles stay the same and the process is easy to reverse.
   (b) Burning wood: chemical change – new substances are produced, e.g. black carbon and carbon dioxide. Process is impossible to reverse and large energy changes take place (lots of heat and light is produced).
   (c) Centrifuging blood: physical change – no new substance is produced. The blood cells are packed in the bottom of the centrifuge container and a yellowish liquid collects on top. Particles stay the same and the change is easy to reverse.
   (d) Decomposition of copper carbonate: chemical change – copper oxide and carbon dioxide are the new substances produced. The change is difficult to reverse and large energy changes occur.
   (e) Evaporation: physical change – no new substance is produced, the particles of alcohol stay the same, the change is easy to reverse as long as the gas phase is collected, and the vapour produced can be cooled so that it changes back to the liquid.
   (f) An acid reacting with a metal: chemical change, hydrogen gas is the new substance produced. The change is difficult to reverse, and large energy changes occur with heat being released to the environment.
   (g) Melting butter: physical change – no new substance is produced, butter particles stay the same, they just move more freely. The process is easy to reverse just by cooling.
   (h) Fractional distillation: physical change – no new substance is produced, particles stay the same, and the process is easy to reverse.
   (i) Crystallising salt: physical change – no new substance is produced, the water evaporates leaving crystals of the salt behind. Particles stay the same and the process is easy to reverse.
2.

Factor	Boiling/evaporation	Electrolysis
Changes in water	Water changes state from liquid to gas – both are still water molecules.	Water decomposes to form new substances – hydrogen and oxygen gases.
Changes in particles	H_2O particles stay the same. They move faster and more freely.	Particles have changed. Water particles (H_2O) have disappeared, new particles (H_2 and O_2) have formed.
Reversal of the process	Easy to reverse – cooling water vapour changes it back to a liquid.	Reversal is not as easy. To convert hydrogen and oxygen gases back to water a chemical reaction is needed (burn the mixture of hydrogen and oxygen).
Type of change	Physical change.	Chemical change.

3. 'Electricity' could be referring to a current of electricity or to static electricity. Static electricity will not cause electrolysis, although an electric current will.
4. (a) A voltameter is equipment used to pass electricity through a liquid such as water. It allows for the decomposition of a compound by electric current. A voltmeter is an instrument used to measure the voltage of an electric circuit.
   (b) Water is a poor conductor of electricity, adding salt or dilute acid makes it a better electrical conductor.
5. (a) If hydrogen was formed whenever water was heated, lighting any matches in the area would make the hydrogen produced burn explosively.
   (b) They are air bubbles. Air (a mixture of gases) dissolves in water, especially when it is cool because gases dissolve better in cold water than in hot water. When water is heated, the dissolved air becomes less soluble and comes out of solution, in the form of tiny bubbles on the inside of the walls of the container. A physical change cannot decompose a compound – only a chemical change can do that.
6. Indicators that a new substance has formed and thus a chemical change has occurred are: a change in colour, a gas is produced (there may be bubbles or a smell), a precipitate (a solid) is formed, and heat is released or taken in.
7. (a) To test for oxygen: Take a sample of the gas. Place a glowing splint into the gas. If it bursts into flames, then the gas is oxygen.
   (b) To test for hydrogen: Take a sample of the gas and ignite it in air or oxygen. If it 'pops' then the gas is hydrogen. Hydrogen + oxygen $\rightarrow$ water.
8. When water boils, no new substance is produced, particles are unchanged, it is easy to reverse. These are the signs of a physical change.
   During electrolysis of water new substances are produced (oxygen and hydrogen), the particles are changed (from H_2O to H_2 and O_2), and the change can only be reversed with a chemical reaction. These are the signs of a chemical change.
9. Various – your model could be a concrete model, e.g. ball bearings in a container, or you could use molecular model kits; a computer simulation; or a well-labelled diagram.
   (a) (i) Show the molecules moving faster as the water is heated until they eventually break free of the surface of the water.
   (ii) Show that the molecules do not change their structure.
   (b) Show that the molecules change. H_2O molecules are split by the electrical energy, forming hydrogen (H^+) and oxygen (O^{2-}) ions. The hydrogen ions move to the negative electrode, the oxygen ions move to the positive electrode. Here the ions combine to form diatomic molecules of oxygen (O_2) and hydrogen (H_2) which bubble up out of the water above each electrode.
10. (a) Hydrogen.
   (b) Oxygen.
   (c) Chemical change.
   (d) Physical.
   (e) Chemical.
   (f) Physical.
   (g) Physical.
   (h) Chemical.
   (i) Chemical.

5 Kinetic Particle Theory

1. (a), (c) and (d) are compounds – each consists of two or more different particles joined together. (b) is an element – two identical particles are joined to make a diatomic molecule of an element. (e) is an element – two identical particles are present but they are not joined – they represent two monatomic molecules of an element.
2. (a) A diatomic element is represented by diagram (ii). Two identical particles are joined.
   (b) A compound is represented by diagram (iii). Two different types of particles are joined together.
   (c) A monatonic element is represented in diagram (i). There are three identical particles, but they are not joined – so this represents monatomic molecules of an element.
3. 

4. (a) Chemical – new particles are formed.
   (b) Physical – particles simply mix, no new particles are formed.
   (c) Chemical – new particles are formed.
5. (a) The particle theory provides a model which helps us to visualise what is happening within matter. It helps us to explain many things about solids, liquids and gases, e.g. their shape, what happens when you try to compress them, and why liquids and gases can diffuse but solids cannot.
   (b) In a *physical* change the particles remain the same, they just move differently, e.g. faster or slower. In a *chemical* change, new particles are formed – we see this when atoms are rearranged during a chemical reaction.
6. (a) Particle – a tiny bit of matter.
   (b) Kinetic – moving.
   (c) Compressed – squashed into a smaller space.
   (d) Vibrating – moving backwards and forwards while staying in the same position.
   (e) Matter – what everything is made of.
7. (a) Particles of a solid are held in a fixed position so the shape and space occupied stay the same. Particles in a gas are free to move and spread through all the available space, so their volume changes with the container.
   (b) The particles of a gas are far apart, so there is room to squash them closer, i.e. to compress them into a smaller space. Solids and liquids have particles that are already very close together, so they cannot be pushed closer, i.e. they cannot be compressed.
   (c) The particles in liquids and gases are able to move around, so they can spread through each other. Particles in a solid are held in a fixed position, only vibrating in that position, so they cannot spread through another substance.
8. (a) Atoms, molecules, ions.
   (b) Kinetic particle theory.
   (c) Element or compound.
   (d) Gas.
   (e) Various, e.g. sodium Na, oxygen O, hydrogen H, aluminium Al, mercury Hg. (Any name on the periodic table is correct for this question.)
   (f) Various, e.g. air, sea water, ink in a pen, nail polish, paint, bread, cosmetics, soil, rocks, soup.
   (g) Various, e.g. water H_2O, sodium chloride NaCl, sodium hydroxide NaOH, hydrochloric acid HCl, ammonia NH_3.

6 Separating Components Of a Mixture

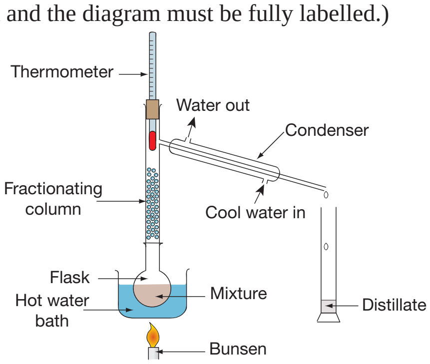
1. (a) Yes – iron is attracted to the magnet, sand is not.
   (b) No – steel contains iron; so both are attracted to a magnet. (Except some types of stainless steel - you might like to research why this is so.)
   (c) No, neither sand nor aluminium is attracted to a magnet. (Not all metals are magnetic. The magnetic metals are iron, nickel and cobalt only.)

2. Various, e.g.

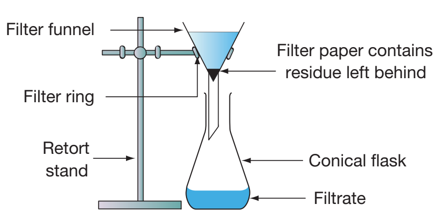
Components of mixture	Process used	Property
Sand from gravel	Sieving.	Solids with different-sized particles.
Petrol and water	Use a separating funnel.	Two liquids that have different densities and do not mix.
Solid sewage from liquid sewage	Filtration. Sedimentation.	Liquid and a solid – different states.
Blood cells from liquid blood	Centrifuge, then decant off the liquid.	Liquid and a solid – different states.
Sugar crystals from the liquid released from crushed sugar cane	Evaporation of water and crystallisation of sugar crystals.	Sugar is dissolved in the water. Sugar will not evaporate; water will.
Sand and salt	Add water to dissolve the salt, then filter.	Salt is soluble in water; sand is not. Dissolved salt will pass through the filter paper with the water; sand will not.
Nitrogen and oxygen in air	Cool gas mixture until it turns to a liquid (liquefaction) then carry out fractional distillation.	Liquid nitrogen and oxygen have different boiling points.

3. (*Note:* Any diagrams you draw should be in pencil, large enough to clearly see how the apparatus is connected and used, straight lines ruled and the diagram must be fully labelled.)

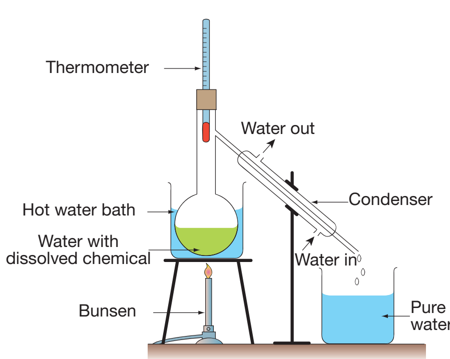
(a)



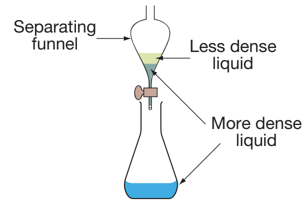
(b) (i)



(ii)

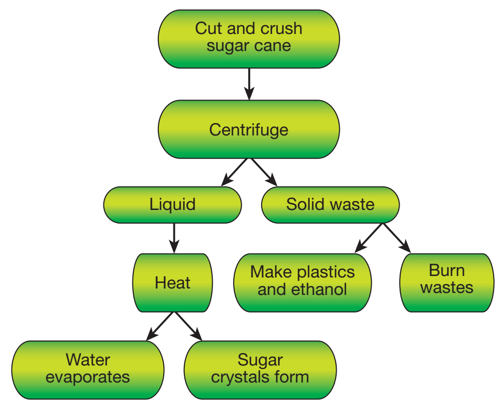


(c)



4. (a) Filter – method used to separate a mixture of a liquid and an insoluble solid. The liquid passes through filter paper, the solid stays in the filter paper.
(b) Liquefaction – change of state involving converting a gas to a liquid by cooling.
(c) Fractional distillation – separating two liquids with different boiling points by heating the mixture to the boiling point of each component in turn, starting with the one with the lowest boiling point.
(d) Decant – separate a mixture of a liquid and an insoluble substance by allowing the solid to settle and then pouring off the liquid.
(e) Centrifuge – device used to spin a mixture of a solid suspended in a liquid. Any solid components fall to the bottom and the liquid floats on top. This can also be used with two liquids which do not mix and have different densities – the most dense liquid goes to the bottom when centrifuged.
(f) Sieve – device used to separate solids with different-sized particles. Particles that are smaller than the holes in the sieve will pass through. Large particles will stay in the sieve.

5 (a)



(b) 'Spins the mixture' – centrifuging. 'Water disappears and crystals of sugar form' – evaporation and crystallisation.
(c) Centrifuging – components are different states – liquid sugar solution and solid wastes.
Evaporation and crystallisation – only the solvent (water) evaporates, the solute (sugar crystals) stays behind and crystallises.
(d) Ethanol – is used as a fuel, mixed with petrol, in motor vehicles.
(e) The waste plant material left after the extraction of sugar used to be disposed of by burning, a process that produced a great deal of polluting smoke, solid particles and carbon dioxide. Today, much of this waste material is being used to produce useful ethanol and polymers (plastics), thus reducing pollution.

6. Silver nitrate + sodium chloride → silver chloride + sodium nitrate

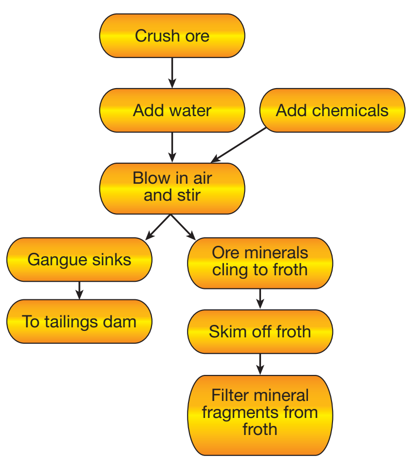
$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

7. (a) Various, e.g.
(i) Sand and water.
(ii) Salt and water.
(iii) Flour and husks of wheat.
(iv) Oil and water.
(b) Physical changes.

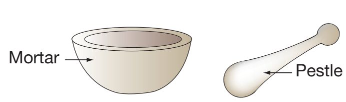
7 Separation By Froth Flotation

1. (a) Froth flotation – a method of separating useful minerals from gangue (unwanted minerals) by using the different surface tension properties of the mineral and the gangue.
   (b) Gangue – waste minerals present in rocks mixed with other more useful minerals.
   (c) Ore – a rock that contains enough of a useful mineral to be economic to mine.
   (d) Mineral – a chemical present in a rock.
2. (a) A mixture contains two or more substances, together in any proportion and not chemically combined. A mixture has:
   - A composition that can vary.
   - Components that are not chemically combined together.
   - Components that can be separated out relatively easily by physical changes (e.g. evaporating, sieving, decanting, using a magnet, centrifuging).
   - Properties that can vary.

   (b) A rock consists of a mixture of chemicals called minerals.
   - These minerals can be different in different rocks and can be in any proportion, so the composition of rocks can vary.
   - The minerals are not chemically combined with each other so they can be separated by physical methods.
   - Its properties are the properties of its components. If the components are different, e.g. more quartz or iron compounds, the properties will be different.
   - The definition of a rock fits the definition of a mixture.
3. (a) (i) Lead – galena.
   (ii) Zinc – sphalerite.
   (b) Various, e.g. Lead and zinc have many uses. For example, lead is used in lead-acid batteries and as a protective barrier against radiation, whereas zinc is used to galvanise steel, to make alloys such as brass and to make the cases of dry cell batteries.
   (c) In a tailings dam, the water is allowed to evaporate and then the solid waste (called tailings) is disposed of. It must be disposed of safely as it may contain small amounts of toxic lead and zinc and other metals. Polluted water from the dam must be kept out of local waterways and prevented from entering the food chain. (In the future, if more efficient methods of extraction are discovered, it may one day be possible to economically extract the small amounts of lead and zinc ores left in these tailings.)
4. Flow chart showing the steps in froth flotation.



5 (a)



   (b) (i) Detergent – causes frothing and bubbles carry mineral particles to the surface of the water.
   (ii) Eucalyptus oil – affects the surface tension properties of some minerals so they cling to bubbles and float better.
6. (a) Froth flotation.
   (b) Gangue.
   (c) Surface tension of particles of minerals.

8 Separation By Fractional Distillation

1. Various, e.g.
   (a) Ethanol (alcohol) and water.
   (b) Various.
   Note: When you are asked to draw equipment you used for an experiment you should:
   - Use a pencil and ruler.
   - Draw it assembled ready for use.
   - Label everything using ruled lines that just touch the item being labelled.

   (c) Steps in the method should include:
   - Place the mixture in the distillation flask.
   - Connect up the distillation apparatus as shown in the diagram.
   - Turn on water and let it flow through the condenser jacket.
   - Insert the distillation flask into a water bath and heat gently.
   - The temperature on the thermometer should be maintained at 78.3°C.
   - Allow the ethanol to boil and vaporise. The vapour will pass into the condenser where it will cool, change back to a liquid (condense) and be collected in a clean container.

   (d) Different boiling points of ethanol and water.
   (e) In this question you are asked to *explain* safety precautions – so you must not only state the safety precautions taken, but also give an account of why each safety precaution is necessary. For example:
   - Glasses must be worn to prevent chemicals such as ethanol getting into the eyes and causing damage.
   - Ethanol must be kept away from flames as it is volatile and could easily catch alight and cause a fire.
   - Use a water bath instead of a naked flame to heat the distillation flask as the ethanol is volatile – this reduces the risk of fires.
   - Use sand or pieces of porcelain in the flask to prevent the mixture from 'bumping' as it is heated.
   - Ensure all joints are completely sealed and the equipment is adequately supported so that accidents do not happen.
2. (a) Water always enters through the lower end of the condenser so that the condenser jacket fills with water before any can run out. This keeps a jacket of water around the tube through which the vapour is leaving the flask so it is able to cool the vapour more efficiently.
   (b) No, the cooling water does not come into contact with the original mixture or the ethanol produced. The cooling water is in an outside jacket around the tube containing the vapour being condensed.
3. A hot water bath is safer – no flames come close to the distillation flask.
4. (a) Cool it (or put it under pressure) until it condenses from a gas to a liquid.
   (b) Boiling point liquid oxygen is –183°C.
   Boiling point liquid nitrogen is –196°C.
   Nitrogen will be evaporated and distilled off first as it has the lower boiling point.
   (c) They all involve separating a mixture of liquids. The components of these mixtures have different boiling points. In each case the mixture is heated until the boiling point of one component is reached. This component evaporates first, leaves the flask and is collected and cooled so it condenses back to a liquid to be used or stored.
5. Various, for example:
   Fractional distillation made possible the separation of the components of air and crude oil.
   Air – Oxygen is used in medicine to treat patients after surgery, trauma and during illness such as lung disorders. In industry it is used in oxyacetylene welding. Liquid nitrogen is used to snap-freeze vegetables such as peas immediately after harvesting and for cryogenics. Liquid argon can also be separated out from air.
   Crude oil – See next chapter for many uses of the fractions obtained from crude oil. They are used extensively for transport.