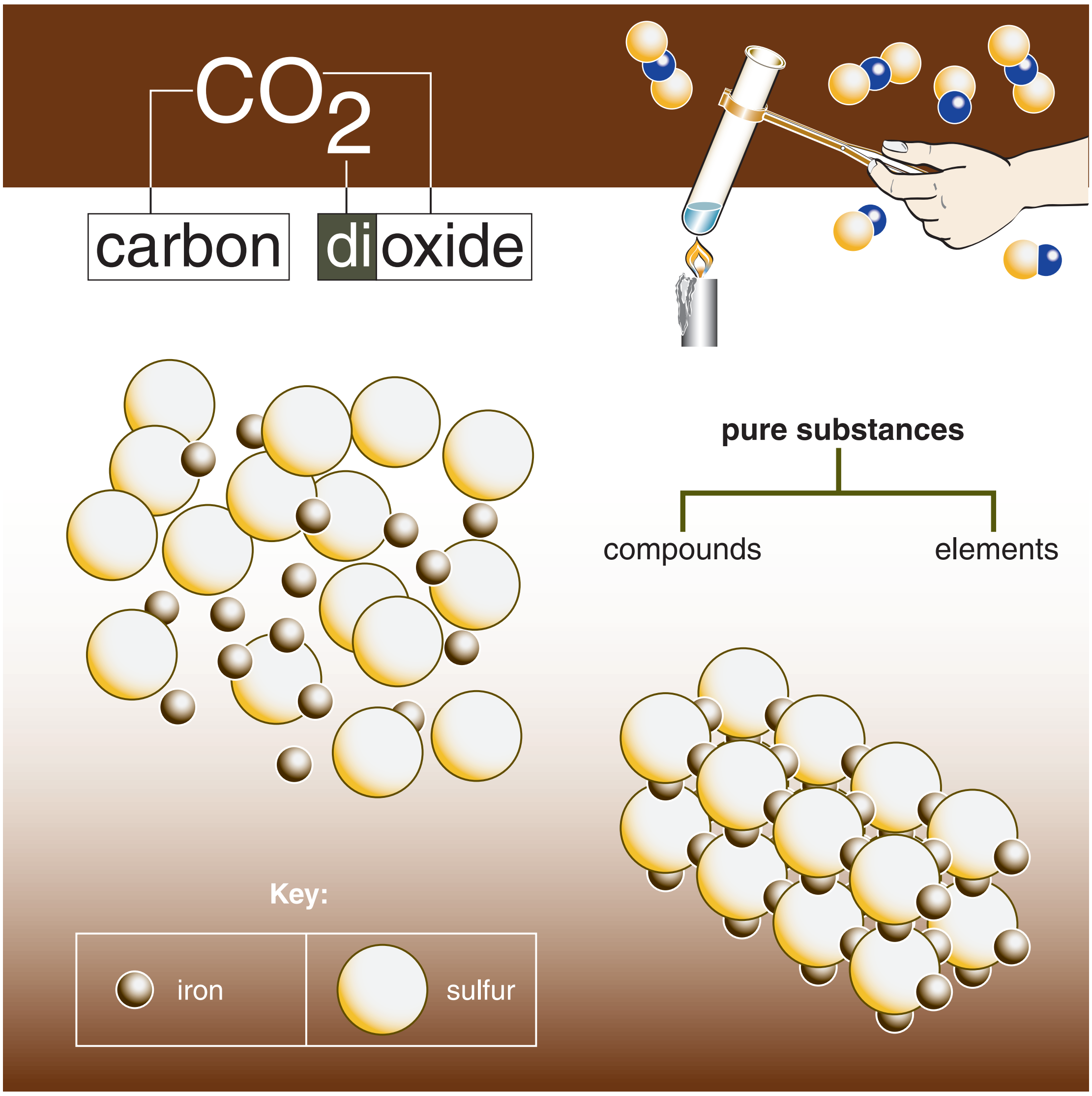
Science

Stage 4

Elements, compounds and graphs



S 43928

Number: **43928** Title: **Elements Compounds and Graphs**

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CLI Project Team acknowledgement:

Writer: Dick Alliband
Editor: Julie Haeusler
Illustrator: Quan Pham

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Contents

Unit overview

This unit introduces key concepts of chemistry: element, compound and reaction. There will also be practice in extracting information from a variety of graphs.

- Part 1 is about elements, atoms, symbols and the classification of elements as metals or non-metals.
- Part 2 distinguishes compounds from elements and mixtures.
- Part 3 provides experience in extracting information from column graphs, histograms, divided-bar and sector graphs, lines graphs and composite graphs.

Outcomes and essential content

By completing the activities and exercises in this unit, you are working towards achieving the following outcomes.

4.2	A student uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena
4/5.2	Students learn about the nature and practice of science. Students learn to:
4.2a	evaluate the role of creativity, curiosity, objectivity and logical reasoning in describing phenomena, carrying out investigations and in the devising and testing of hypotheses
4.2e	use examples which show that scientists isolate a set of observations, identify trends and patterns and construct hypotheses or models to explain these
4.2f	give examples that demonstrate the benefits and limitations of using models
4.2g	identify that the nature of observations made depends upon the understanding that the observer brings to the situation.
4.7	A student describes observed properties of substances using scientific models and theories.
4.7.4	Students learn about elements. Students learn to:

4.7.4a	classify elements as metals or non-metals according to their common characteristics
4.7.4b	identify internationally recognised symbols for common elements.
4.7.5	Students learn about mixtures. Students learn to:
4.7.5d	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.
4.7.6	Students learn about compounds and reactions. Students learn to:
4.7.6a	distinguish between elements and compounds
4.7.6b	identify when a chemical reaction is taking place by observing changes in temperature, the appearance of a new substance or the disappearance of an original substance
4.7.6c	distinguish between compounds and mixtures.
4.11	A student identifies where resources are found, and describes ways in which they are used by humans.
4.11	Students learn about natural resources. Students learn to:
4.11a	distinguish between natural and made resources
4.11b	give examples of resources from living things and resources extracted from the air, Earth and oceans
4.11c	identify fossil fuels and describe some of their uses
4.11d	identify renewable and non-renewable sources of energy.
4.16	A student accesses information from identified secondary sources.
4/5.16	Students learn about gathering information from secondary sources. Students learn to:
4.16c	extract information from column graphs, histograms, divided bar and sector graphs, line graphs, composite graphs, flow diagrams, other texts and audio/visual resources
4.17	A student evaluates the relevance of data and information.
4/5.17	Students learn about processing information. Students learn to:
4.17a	collate information from a number of sources
4.17b	distinguish between relevant and irrelevant information
4.17f	identify trends, patterns, relationships and contradictions in data and information.

Indicative time

This unit has been written to take approximately 15 hours. Each part should take approximately 5 hours.

Your teacher may suggest a different way to organise your time as you move through the unit.

Resources

Internet access is important for further information about elements and compounds.

Go to the website: http://www.cli.nsw.edu.au/Kto12. Select **Science**, then Stage 4 Junior Science, and follow the links to **Elements, compounds and graphs.**

Part 1: Elements

- copper, magnesium and zinc
- a 'lead' pencil (properly called a graphite pencil)
- some aluminium foil from the kitchen
- an iron nail (not galvanised, that is, coated with zinc or cadmium)
- three wires with alligator clips, battery holder, lamp, lamp socket and battery clip
- two 'AA' batteries
- steel wool or wet and dry paper or fine sand paper.

Part 2: Compounds

- bicarbonate of soda (baking soda or sodium hydrogen carbonate)
- vinegar (approximately 5% solution of acetic acid)
- a clean teaspoon
- a beaker
- matches
- 1 test tube
- a spirit burner (or Bunsen burner)
- a test tube holder
- copper carbonate
- safety goggles

- a mat or dish to go under your spirit burner and in case your test tube breaks
- a plastic teaspoon
- washing soda (sodium carbonate)
- 2 teaspoons
- lemon juice
- 4 test tubes
- a beaker to rest the test tubes in
- a screw-top jar containing limewater (made by adding half a teaspoon of calcium hydroxide, almost completely filling the jar with water, shaking and leaving for at least one day). Be careful not to shake the bottle. Leave the white solid at the bottom of the jar.

Part 3: Graphs

- ruler
- pencil
- protractor.

Icons

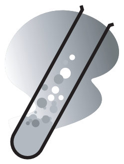
Here is an explanation of the icons used in this unit.

Write a response or responses as part of an activity. An answer is provided so that you can check your progress.

Compare your response for an activity with the one in the suggested answers section

Complete an exercise in the exercises section that will be returned to your teacher.

Think about information or ideas, a question or problem. You need to pause and reflect. You may need to make notes.



Perform a practical task or investigation.

Stop and consider the risks to safety for yourself and others.

Access the Internet to complete a task or to look at suggested websites.

Glossary

The following words, listed here with their meanings, are found in the learning material in this unit.

alkane	compound with the formula C_nH_{2n+2}; main part of the mixture, petroleum; a hydrocarbon that contains carbon and hydrogen
atmosphere	layer of a mixture of gases around the Earth
atom	smallest particle in a chemical that can take part in a chemical reaction
biosphere	part of the Earth's atmosphere where life exists
brittle	something that breaks into pieces when you try to bend it
chemical property	property of matter; behaviour with other chemicals such as oxygen, water or acid.
column graph	graph using separate columns to compare quantities
composite graph	graph that displays complex data or makes comparisons of large quantities of data; often a combination of two types of graph
compound	pure substance that contains at least two different types of atoms joined together; heat is usually lost or gained when a compound is formed
conductor	material that allows the passage of electricity or heat
dependent variable	responding variable that changes as the independent variable is changed; usually plotted on the (vertical) y-axis of a graph
divided bar graph	graph that shows proportions of a whole; looks like rectangle divided into parts
ductile	property of matter; easily drawn into a wire shape
element	pure substance that contains only one type of atom
extrapolation	prediction beyond the plotted points of a graph
histogram	graph consisting of touching columns representing a frequency distribution
hydrocarbon	compound of hydrogen and carbon only
hydrosphere	part of the Earth's crust where water is found
independent variable	manipulated variable that is changed in an investigation; usually plotted on the (horizontal) x-axis of a graph
interpolation	prediction of a missing point between plotted points on a graph
line of best fit	straight line or smooth curved line drawn to minimise the distance between plotted graph points and the line
lithosphere	outer layer of the Earth; solid rocks of the Earth’s crust and the solid upper mantle
malleable	property of matter; easily hammered into shape
Material Safety Data Sheet (MSDS)	document providing risk and safety information for a chemical (normally an element or compound)

metal	element which has most of these properties: can be made to shine, is malleable and ductile and is a good conductor of electricity
mixture	mix of elements and/or compounds; has a range of properties depending on its components and their proportions; usually no heat is lost or gained when mixtures form (except solutions)
molecule	two or more atoms joined together into a particle
non-conductor	substance that does not allow passage of electricity or heat
non-metal	element which has most of these properties: is dull, brittle and does not conduct electricity
non-renewable	a resource that once used is lost forever, e.g. coal
petrochemical	chemical compound obtained from petroleum
physical property	property of a substance that can be observed without permanently changing the substance
pie graph	a graph that shows proportions of a whole; circle showing parts like slices of a round pie
pure substance	chemical with fixed properties; element or compound
renewable	resource that can be used over and over again, many times, e.g. wind
scattergram	plot of data on a graph that shows each data point, usually as a cross (X)
sector graph	circle showing parts as sectors of the circle; pie graph
symbol	sign which represents something
timeline	line that shows order in time for events

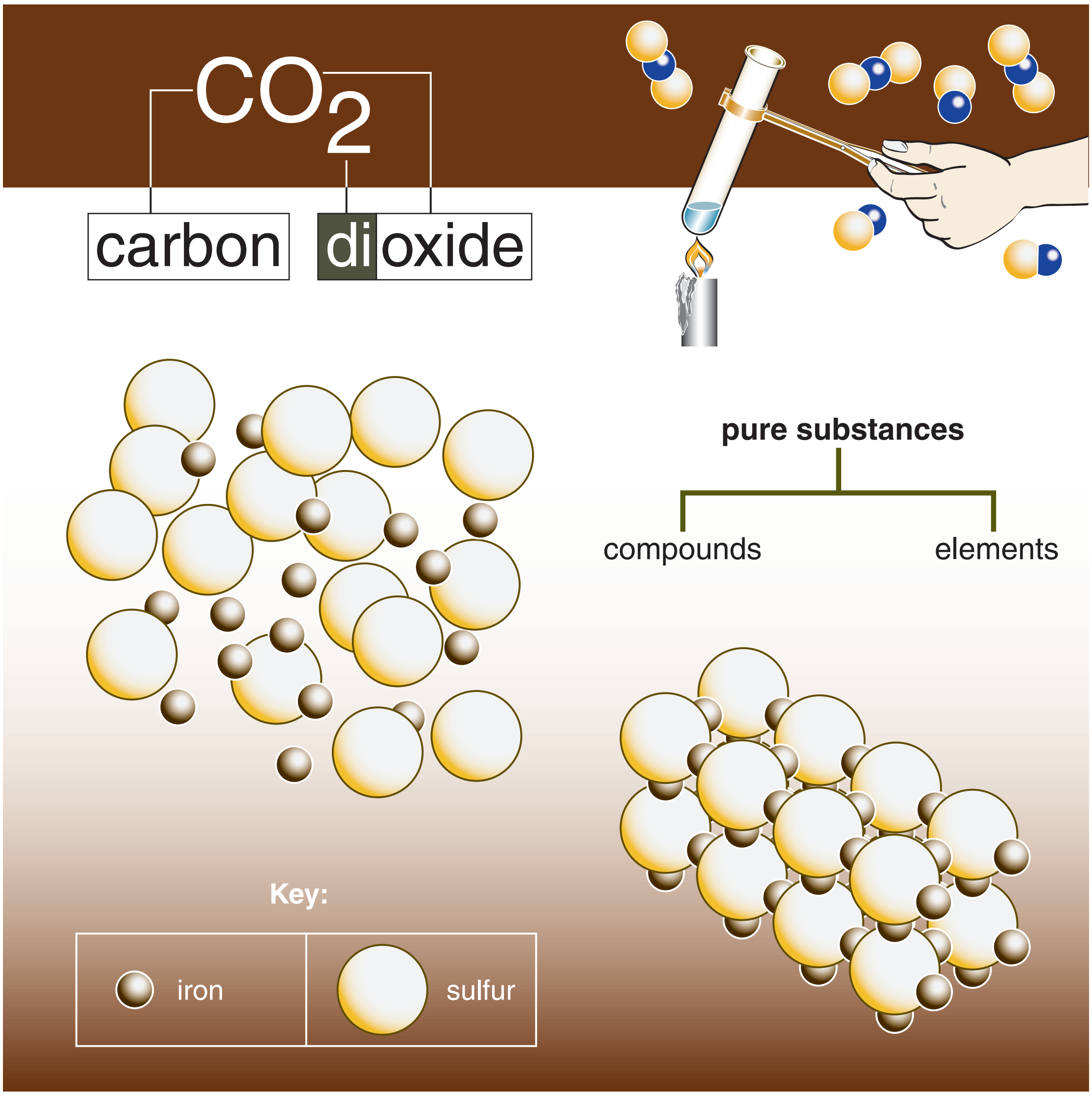
Science

Stage 4

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

Elements, compounds and graphs

Part 1: Elements



Contents – Part 1

Lesson 1 – Classifying substances

Science is divided into many different branches. Each branch investigates part of the natural world. Biologists investigate living things and geologists investigate the Earth. What do chemists investigate?

Write a sentence describing what chemists investigate.

Rearrange these words to make a sentence about chemists:
matter properties chemists and investigate its.

Chemists investigate matter and its properties.

What is meant by the term, *matter*? Write a sentence using the keywords, space, matter, mass.

Matter is anything which has mass and takes up space.

What is meant by properties? Write your own sentence using these keywords: features, properties, substances, characteristics.

Properties are the characteristics or features of substances.

You can observe the properties of substances by using your senses or by using instruments.

Properties of matter

The properties of substances can be divided, or classified, into two groups.

1. Physical properties are properties of the substance measured by itself, not with other chemicals. Physical properties can be observed without permanently changing the substance.
2. Chemical properties are descriptions of a substance's behaviour with other chemicals, such as oxygen, water or acid. The other chemical may react with the substance and change it.

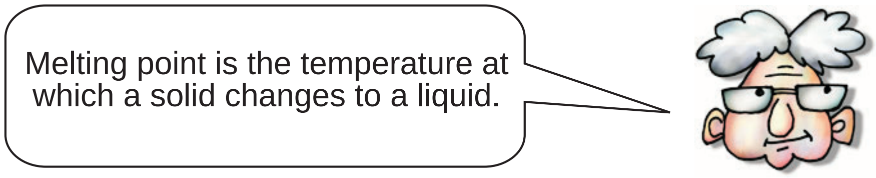
Activity: Physical or chemical?

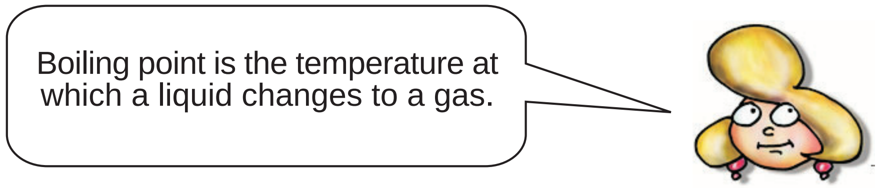
Read through the list of properties below. Then check the definitions of physical and chemical properties again.

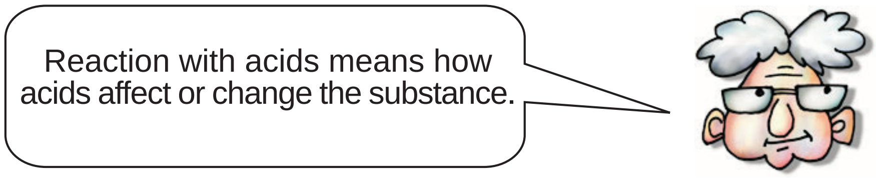
Write P in the box if you think the property is a physical property, or C in the box if you think the property is a chemical property.

If you are not familiar with some of the terms in the question, look at the cartoons following.

- ❑ colour
- ❑ melting point
- ❑ boiling point
- ❑ reaction with acids
- ❑ hardness
- ❑ whether it burns in air





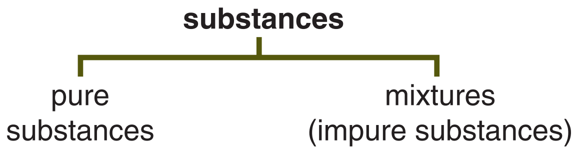


Check your answers.

Often, the properties of substances determine how they are used. You will find out more about uses of substances later in the unit.

Pure substances and mixtures

There are many ways to classify, or group, substances. One way is to divide them into pure substances and mixtures (impure substances).



A pure substance has fixed properties. Information about the properties of pure substances can be looked up in books or on the Internet because the properties are fixed. Information is available for about twenty million pure substances!

It is much more difficult to find information on the properties of mixtures.

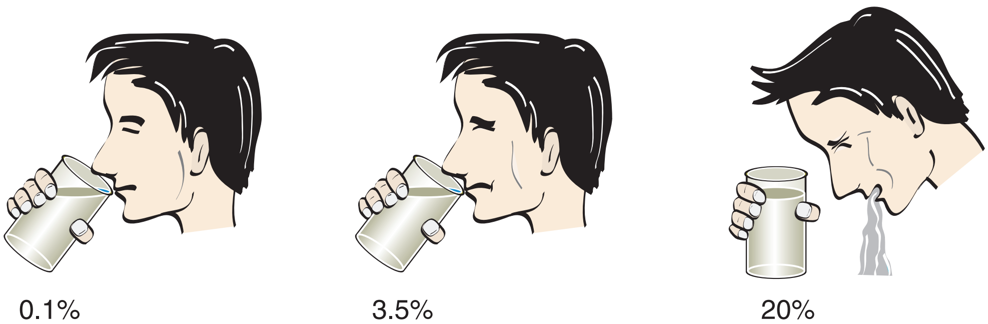
Think about the different properties of mixtures of salt and water.

A mixture of 0.1% salt and 99.9% water tastes slightly salty.

A mixture of 3.5% salt and 96.5% water tastes like sea water.

A mixture of 20% salt and 80% water can make you vomit.

The properties of a mixture vary as the proportions of the parts vary.



There is a slight reaction to tasting 0.1% salt water; a marked reaction to tasting 3.5% salt water (sea water); and a vomiting reaction to tasting 20% salt water.

States of matter

What is another way to classify substances? Think about glass, air and water.

We can put each of these substances into a different group. What are these three groups called?

We can group substances as solids, liquids or gases. Glass is a solid, air is a gas and water is a liquid.

State when used in science means whether a substance is a solid, a liquid or a gas. Here are some of the properties of solids, liquids and gases.

Solids:

- cannot flow
- keep their shape
- stay the same volume.

Liquids:

- flow
- take the shape of the bottom of their container
- stay the same volume.

Gases:

- flow and spread as much as they can
- take the shape and volume of the whole of their container.

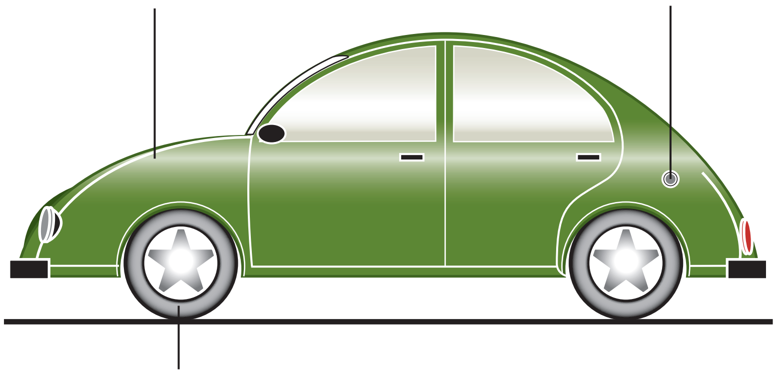
Activity: Using state

We often make use of the property of state to decide which substance to use for a particular job. Think of the substances used in the parts of a car. What substances are they? And why are they used?

Answer these questions by completing the sentences below

The body of a car is made from a solid material because
____
____

The fuel used in the tanks of most cars is in the form of a __________ because the fuel must flow easily from the tank to the engine.

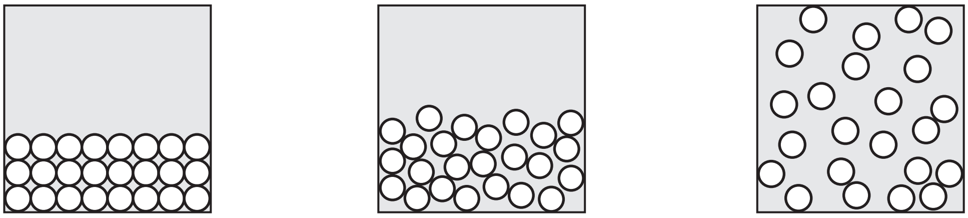


The tyres of the car are filled with a gas because gases change _______ easily.

Check your answers.

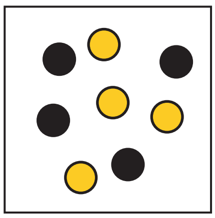
The particle model

The particle model is used to describe and explain the solid, liquid and gas states. Particles are shown as circles.



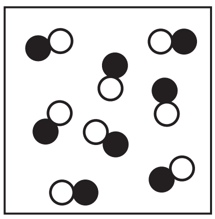
In solids, particles are packed closely together. | In liquids, particles are neither very close nor wide apart. | In gases, particles are spaced widely apart.

Scientists also classify matter by looking at the types of particles that it contains. The particles can be single *atoms*. Or the particles can be groups of atoms joined together, called *molecules*.



This box contains two different kinds of particles. They are different kinds and shown shaded as different colours.

Each particle is called a single atom.



This box contains only one kind of particle.

Each particle is made up of atoms joined together.

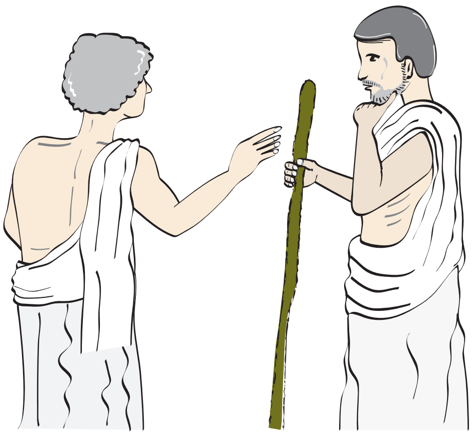
Each particle in this box is a molecule.

Complete Exercise 1.1: Ways of classifying.

Lesson 2 – Atoms

What are atoms?

In Ancient Greece, about 2500 years ago, scientific facts were mostly established by talk and debate instead of by carrying out experiments. People tried to decide exactly what matter is by talking about it. Setting up experiments to investigate and understand what was happening was rare.



Democritus said that you could go on dividing a piece of matter until sooner or later you got to a piece of matter that cannot be divided again. He said that matter was made of tiny indivisible pieces. He called the tiny pieces, 'atoms'.

But Aristotle, one of the most important thinkers of the time, said that you can go on dividing your piece of matter forever. Aristotle believed that matter was continuous. Because he was very important, his ideas were thought to be better than anyone else's and so almost everyone agreed with him.

Use the information above to fill in the following table.

Year	**Person**	**Ideas about matter**
	Democritus	
	Aristotle	

The Greek idea of atoms was forgotten for nearly 2000 years.

Activity: Ancient Greek ideas about matter

Some ancient Greeks may have made simple observations like:

- watching a wet cloth dry out without seeing anything come out of the cloth
- notice a dry cloth can become wetter and heavier if it hanging somewhere moist, once again, without seeing anything go into the cloth.

Explain how this supports the idea of Democritus that matter is made up of very small particles.

Check your thoughts against the ideas in the answer pages.

Dalton's ideas about matter

In England, in the early 1800s, a teacher called John Dalton put forward the following ideas:

> 'I think that matter is made of atoms. I picture these atoms as little balls. These balls are very hard and can't be broken up. In one type of matter, the balls are all alike. I call this type of matter an 'element'. I think there are a few (maybe 50 or 60) different elements. These elements can join together in many different ways. The hundreds of different combinations of atoms make all the different types of matter.'

Dalton's ideas came from thinking about his experiments with gases and experiments carried out by other scientists that he had read about.

Use this information to complete the table below. List all the points that Dalton makes about matter.

Year	Person	Ideas about matter
	Dalton	

People who test their ideas with experiments, as Dalton did, are called scientists. Today scientists rarely work alone. Most scientists are part of a team that includes support staff such as technicians.

Modern ideas about matter

In 1985 a team of scientists and technicians at the American computer company IBM developed a new kind of electron microscope.

The scanning tunnelling microscope could magnify the surface of objects by 10 000 000 000 times.

With this microscope, the surface of a piece of metal looks like a neat pattern of fuzzy balls—a bit like oranges stacked in a box, except out of focus.

Use this information to complete the following table.

Year	**People**	**Ideas about matter**
	team at IBM	

Chemical elements

All substances are made of atoms.

How many different types of atoms do you think there are?

Did you guess that there are millions of different atoms? Or did you guess 50 to 60 like Dalton did?

All the millions of chemical substances are made of about 115 different types of atoms. The 26 letters of the English alphabet can be joined to make about 750 000 words. Similarly, 115 different types of atoms can be joined to make many millions of pure chemical substances.

There are two types of pure substances: elements and compounds.

A pure substances containing only one type of atom is called an element.

Pure substances consisting of atoms of different types joined together are called *compounds*.

Most types of atoms occur naturally. This means that they can be found somewhere on Earth, on the land, in the sea or as part of the air.

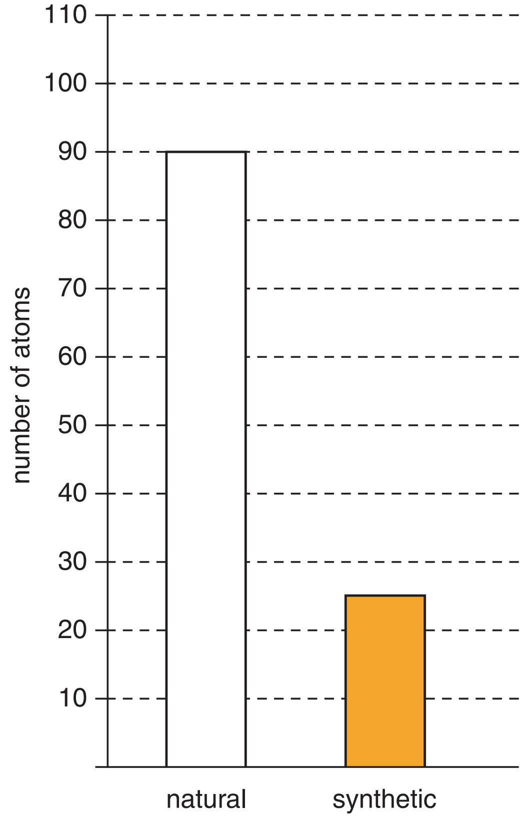
Atoms can also be *synthetic*. This means that they have been made from other atoms in a laboratory. There may be more than 115 types of atoms by the time you read this unit.

Activity: Natural or synthetic?

Approximately how many types of atoms are found naturally? ________

Approximately how many types of atoms are synthetic? _____________

Estimate the values from the column graph below.



Numbers of natural and synthetic atoms

Check your answers.

Activity: How many elements? How many types of atoms?

A chemical element is a pure substance that is made up of only one type of atom.

Use information from this lesson to answer the questions below.

1 How many different types of atom are there?

____

2 What is a chemical element?

____

3 How many different types of elements are there?

____

4 Now complete the sentences below using words from the list: atom, elements compounds.

The sentences will make a summary of what you have found out about elements and compounds so far.

Pure substances can be either elements or ______________.
Compounds are made of different types of atoms joined together whereas ______________ are made of one type of ______________ only.

Check your answers.

There are 92 elements that occur naturally on Earth. Between 1937 and 2005 a further 22 elements were made artificially (synthesised).

There are names of 103 elements in the list below.

actinium	erbium	mercury	samarium
aluminium	europium	molybdenum	scandium
americium	fermium	neodymium	selenium
antimony	fluorine	neon	silicon
argon	francium	neptunium	silver
arsenic	gadolinium	nickel	sodium
astatine	gallium	niobium	strontium
barium	germanium	nitrogen	sulfur
berkelium	gold	nobelium	tantalum
beryllium	hafnium	osmium	technetium
bismuth	helium	oxygen	tellurium
boron	holmium	palladium	terbium
bromine	hydrogen	phosphorus	thallium
cadmium	indium	platinum	thorium
calcium	iodine	plutonium	thulium
californium	iridium	polonium	tin
carbon	iron	potassium	titanium
cerium	krypton	praseodymium	tungsten
caesium	lanthanum	promethium	uranium
chlorine	lawrencium	protactinium	vanadium
chromium	lead	radium	xenon
cobalt	lithium	radon	ytterbium
copper	lutetium	rhenium	yttrium
curium	magnesium	rhodium	zinc
dysprosium	manganese	rubidium	zirconium
einsteinium	mendelevium	ruthenium	

An element is a pure substance that contains one kind of atom only. There are about 115 different elements, each with its own kind of atom.

Elements have been named in many different ways.

Activity: How do elements get their names?

Elements have been named after people, places and characteristics, such as colour and smell.

Refer to the list of elements on page 13 to name the elements in the questions below.

1 Find the names of two elements named after famous people.

____

2 Find the name of an element named after:

a) a continent ______________________________

b) a country ______________________________

c) a state in the USA __________________________

Check your answers.

Complete Exercise 1.2: Extracting information from a graph.

Lesson 3 – Symbols for elements

Activity: Symbols

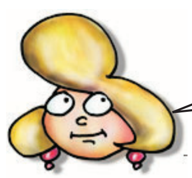
Symbols are signs that stand for something. Do you know what these symbols stand for? Write the meaning next to each symbol.

Sign	**Meaning**
$	
%	
&	
#	
©	
®	

If you'd like to check your answers, turn to the answer pages.

Each element has its own symbol. Every scientist in the world uses the same symbols for the names of the elements.

Each element has its own symbol. This symbol can be used to represent the element or a single atom of the element.



Chemists in all countries of the world use element symbols to communicate clearly.

Elements and their symbols

Symbol	Element	Symbol	Element	Symbol	Element
Ac	actinium	Hf	hafnium	Pr	praseodymium
Al	aluminium	He	helium	Pm	promethium
Am	americium	Ho	holmium	Pa	protactinium
Sb	antimony	H	hydrogen	Ra	radium
Ar	argon	In	indium	Rn	radon
As	arsenic	I	iodine	Re	rhenium
At	astatine	Ir	iridium	Rh	rhodium
Au	gold	Fe	iron	Rb	rubidium
Ba	barium	Kr	krypton	Ru	ruthenium
Bk	berkelium	La	lanthanum	Sm	samarium
Be	beryllium	Lw	lawrencium	Sc	scandium
Bi	bismuth	Pb	lead	Se	selenium
B	boron	Li	lithium	Si	silicon
Br	bromine	Lu	lutetium	Ag	silver
Cd	cadmium	Mg	magnesium	Na	sodium
Ca	calcium	Mn	manganese	Sr	strontium
Cf	californium	Md	mendelevium	S	sulfur
C	carbon	Hg	mercury	Ta	tantalum
Ce	cerium	Mo	molybdenum	Tc	technetium
Cs	caesium	Nd	neodymium	Te	tellurium
Cl	chlorine	Ne	neon	Tb	terbium
Cr	chromium	Np	neptunium	Tl	thallium
Co	cobalt	Ni	nickel	Th	thorium
Cu	copper	Nb	niobium	Tm	thulium
Cm	curium	N	nitrogen	Sn	tin
Dy	dysprosium	No	nobelium	Ti	titanium
Es	einsteinium	Os	osmium	W	tungsten
Er	erbium	O	oxygen	U	uranium
Eu	europium	Pd	palladium	V	vanadium
Fm	fermium	P	phosphorus	Xe	xenon
F	fluorine	Pt	platinum	Yb	ytterbium
Fr	francium	Pu	plutonium	Y	yttrium
Gd	gadolinium	Po	polonium	Zn	zinc
Ga	gallium	K	potassium	Zr	zirconium
Ge	germanium				

How do elements get their symbols?

What do you observe about the first letter of all the symbols in the table?
The first letter of all the symbols is an upper case (capital) letter.

What do you notice about the second letter in all the two letter symbols?
The second letter of two letter symbols is always a lower case (small) letter.

Activity: One letter symbols

Here is a list of elements whose symbol contains one letter only.

Use the table to write the symbols for these elements.

Element	Symbol	Element	Symbol
carbon		phosphorus	
oxygen		fluorine	
nitrogen		iodine	
hydrogen		potassium	
sulfur		uranium	

Check your answers.

Activity: Two letter symbols

How many letters are there in the alphabet? How many elements are there?

Obviously every element cannot have a single letter symbol. You would run out of letters. If you look at the number of elements whose names start with 'C' you will soon see why two letter symbols are needed.

Here are some elements whose symbols have two letters. Write the symbols of these elements in the table.

Element	Symbol	Element	Symbol
nickel		calcium	
neon		cobalt	
aluminium		helium	
silicon			

What do you notice about all these symbols (apart from the upper and lower case letters)?

The symbol is the first two letters in the name of the element.

Other elements use the first letter of the name together with a letter from later in the name. What are the symbols for these elements?

Element	**Symbol**
magnesium	
chromium	
zinc	
chlorine	
cadmium	

Check your answers.

Activity: Other symbols

For some elements, the origin of the symbol is very obscure (hidden) unless you happen to know Latin. Many of the names of the elements were given to them when scientists from different countries communicated using Latin.

Write the symbols for some of these elements in the table.

Element	**Name in Latin**	**Symbol**
sodium	natrium	
mercury	hydragyrum	
silver	argentum	
gold	aurum	
copper	cuprum	
iron	ferrum	
potassium	kalium	
lead	plumbum	
antimony	stibium	
tin	stannum	

Check your answers.

Using symbols

Many students notice that the symbols of the elements can be 'strung' together to make words. In this section you will making words using element's symbols so you can become more familiar with the symbols.

To make the words make sense, ignore the upper case letters. For example, the symbols for: oxygen **O**, thorium **Th**, erbium **Er**, sulfur, **S** make the word **others**.

Use the list of symbols to decide what word you can make from the symbols of these elements.

nitrogen, silver

carbon, argon

actinium, titanium, oxygen, nitrogen

The words are: nag, car, action.

Activity: An elemental message

Try deciphering this message. Each new word starts on a new line.

Read the words downwards to find the message.

tungsten, hydrogen, iodine, carbon, hydrogen ________________

tin, actinium, potassium ________________

iodine, sulfur ________________

helium, aluminium, thorium, yttrium ________________

aluminium, iodine, sulfur, oxygen, nitrogen ________________

lithium, potassium, einsteinium ________________

calcium, potassium, einsteinium ________________

yttrium, vanadium, oxygen, nitrogen, neon, sulfur ________________

phosphorus, rhenium, iron, rhenium, nitrogen, cerium ________________

iodine, sulfur ________________

barium, sodium, sodium, sulfur ________________

Check your answer.

Activity: Another hidden message

The wonderword following contains the names of 28 elements. Here are the symbols for the elements in the puzzle. Write the name of each element next to its symbol. (Which ones can you write from memory?)

H		Zn	
C		Si	
N		He	
O		P	
S		Cl	
Al		Ca	
Cu		Na	
Mg		K	
Fe		U	
Pb		Ra	
Au		Ag	
F		Ar	
Ne		Sn	
Os		I	

Now find the names of the elements in the grid on the next page. (The element with the symbol Sn is included twice!) Put a cross through each letter in the element names that you find. The remaining letters spell out a message if placed in order after the letter E.

You should have 38 letters left over that are not part of the names of any elements. Write these letters in the spaces below.

Start at the top left of the grid and write the letters in order as you would read them. Your letters should make a sentence about elements.

E _

_ _.

Check your answers.

Wonderword grid

L	A	L	U	M	I	N	I	U	M	E	M	E	N
M	T	C	A	R	B	O	N	S	A	R	E	S	T
U	H	M	N	O	D	A	R	U	F	L	U	S	S
I	E	M	U	R	A	N	I	U	M	R	B	I	U
C	H	M	U	I	S	S	A	T	O	P	L	L	I
L	E	Y	L	I	S	D	O	H	N	V	I	I	N
A	L	G	D	B	M	E	P	D	E	O	R	C	R
C	I	O	L	R	D	S	N	R	I	O	E	O	E
I	U	X	O	L	O	T	O	G	N	U	C	N	P
O	M	Y	O	H	I	G	K	S	A	O	M	F	P
D	A	G	P	N	L	L	E	A	D	M	L	M	O
I	N	E	G	O	R	T	I	N	A	Z	I	N	C
N	T	N	C	H	L	O	R	I	N	E	T	E	R
E	A	R	G	O	N	E	N	I	R	O	U	L	F

Complete Exercise 1.3: Using element symbols.

Lesson 4 – Testing element properties

In this lesson you will carry out some tests on elements. You will use the results of these tests to find another way of classifying the elements. You will be sharing results with a student named Alide.

Alide has tested the elements sulfur, phosphorus and iodine.

Her results are already recorded in the tables for this lesson. You can add the results of your testing to hers. Scientists often come up with worthwhile ideas by considering their own results and the results of other scientists.

You will use all the results to complete the exercise for this lesson.

Tests on elements

What you will need:

- copper, magnesium and zinc
- a 'lead' pencil (properly called a graphite pencil)
- some aluminium foil from the kitchen
- an iron nail (not galvanised, that is, coated with zinc or cadmium)
- three wires with alligator clips, battery holder, lamp, lamp socket and battery clip
- two 'AA' batteries
- steel wool or wet and dry paper or fine sand paper.

Make sure you follow the instructions carefully. If you get the elements mixed up, use the photograph at the website: <http://www.cli.nsw.edu.au/kto12>

Go to **Science**, then go to **Junior Science Stage 4**, **Elements, compounds and graphs** to identify the elements.

Test 1: Appearance

1 Select one sample of an element.

2 Use steel wool or sand paper to rub a small section of the sample. Look at this small, cleaned section and in the table below describe its colour. Then write down whether it is shiny or dull.

3 Repeat this test for each sample, one at a time.

4 Do the same test for the aluminium foil from your kitchen. Then repeat the test for the iron nail.

5 The last substance for you to test is carbon. The material inside a 'lead', pencil is a form of carbon called graphite. There is no need to rub the carbon with the sandpaper. Make your observations and record your results in the table.

Alide has already written her results in the table.

6 Complete the table by writing in the symbols of the elements.

Element	**Symbol**	**Colour**	**Shiny or dull?**
magnesium			
copper			
iron			
zinc			
carbon			
aluminium			
sulfur		yellow	dull
phosphorus		brown	dull
iodine		violet	shiny

Test 2: Does the element bend easily?

If a solid element bends readily then it is easy to shape into wires or sheets.

People used hammers to shape certain elements into sheets or decorative shapes. This is often done by machines now, but some decorations are still made by hammering an element. Elements which can be hammered into shapes are said to be **malleable**.

Some elements are made into wires. Elements which bend easily can also be drawn out to form wires. Elements which can be drawn into wires are said to be **ductile**.

Elements which do not bend easily may break into pieces when you try to bend them. These elements are said to be **brittle**.

To summarise, some elements can bend easily and so are said to be malleable and ductile. Elements which do not bend easily are said to be brittle.

1 Take one of the elements. Try to bend the element. If it does not bend easily, do not force it. Record the result of your test in the table below.

2 Test your next sample. Continue (one sample at a time) until you have completed the table.

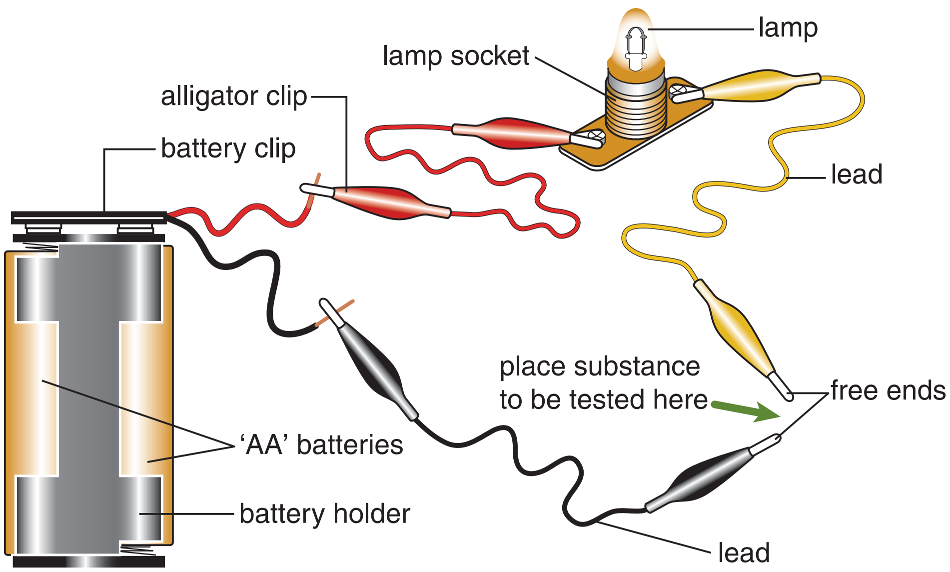
3 Alide has filled in the results for her elements.

Element	**Malleable and ductile, or brittle?**
magnesium	
copper	
iron	
zinc	
carbon	
aluminium	
sulfur	brittle
phosphorus	brittle
iodine	brittle

Test 3: Does the element conduct electricity?

For electricity to flow from one battery terminal to another it needs to follow a complete path called a circuit.

Here is a diagram showing how to put your equipment together to make a circuit. You will use this circuit to test the elements.



Circuit for testing electrical conductivity of solids

Build this circuit. Test your circuit by quickly touching the two free ends together. Does the lamp light? If it doesn't, here are some things you can check.

- Check that the batteries are the right way round. Make sure you have matched the ⊕ signs on the battery with those on the battery holder.
- Check the wires on the battery holder. Have the wires frayed? They may not be making contact if they have. You might need to strip off some of the plastic to expose fresh wire.
- Check all the connections in the circuit. The metal alligator clip should be attached to the metal wire and not to the plastic.
- Check that the lamp is screwed into the socket firmly.
- Check the bulb is all right. If not sure try a different bulb.
- Check that your batteries are still good. Try them in a torch or radio.

Select one of your element samples. Put it in the circuit by touching the alligator clips to each end of the element. Does the lamp light?

If is does, the element carries an electric current and is called a **conductor**. Write *conductor* in the second column.

If the lamp does not light, the element does not conduct electricity. Write *non-conductor* in the second column.

Element	**Conductor or non-conductor?**
magnesium	
copper	
iron	
zinc	
carbon	
aluminium	
sulfur	non-conductor
phosphorus	non-conductor
iodine	non-conductor

Complete Exercise 1.4: Results of testing elements.

Lesson 5 – Metals and non-metals

Here are the results obtained by two students who tested physical properties of nine solid elements.

Use the information provided to fill in the element column.

Element	Symbol	Colour	Shiny or dull?	Malleable or brittle?	Electrical conductor or non-conductor?
	Mg	grey	shiny	malleable	conductor
	Cu	red-brown	shiny	malleable	conductor
	Fe	grey	shiny	malleable	conductor
	Zn	grey	shiny	malleable	conductor
	C	black	shiny	brittle	conductor
	Al	aluminium	shiny	malleable	conductor
	S	yellow	dull	brittle	non-conductor
	P	brown	dull	brittle	non-conductor
	I	violet	shiny	brittle	non-conductor

Check your answers.

Grouping elements

The six ovals below contain descriptions of these elements. Write the symbols of the elements that fit each description on the line in the oval.

Elements which are shiny
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Elements which are dull
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Elements which are malleable
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Elements which are brittle
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Elements which are conductors

Elements which are non-conductors

Now collect all that information together. Fill in these ovals.

Elements which are shiny malleable, ductile and conductors

Elements which are dull brittle and non-conductors

Others

Check your answers.

Activity: Metals and non-metals

Elements which are shiny, malleable (easily bent), ductile (able to be drawn into wires) and conductors of electricity are metals. Write the symbols of the elements you are sure are metals in the first oval below.

Elements which are dull, brittle and do not conduct electricity are non-metals. Write the symbols of these elements in the other oval.

Elements which are metals

Elements which are non-metals

Check your answers.

Activity: Other elements

What about the elements in the 'Others' oval? There are always some things that do not fit perfectly into a classification system. These elements are put into the group that they are most similar to.

How would you classify these elements? Give a reason for your answer.

carbon ____

iodine ____

Check your answers.

Elements can be classified into two groups – metals and non-metals.

- **Metals** can be made to shine; they are malleable and ductile; they conduct electricity.
- **Non-metals** are dull; they are brittle; they do not conduct electricity.

Activity: Metal or non-metal?

Here is a table of information about some elements.

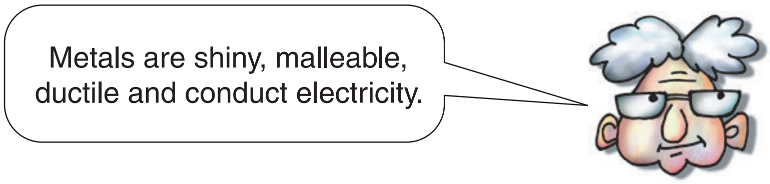
Element	Shiny or dull?	Conducts electricity?	Result when bent
selenium	dull	no	breaks
zirconium	shiny	yes	bends
nickel	shiny	yes	bends
palladium	shiny	yes	bends
tellurium	dull	no	breaks
argon	(neither)	no	(gas, so cannot test)
lead	dull	yes	bends

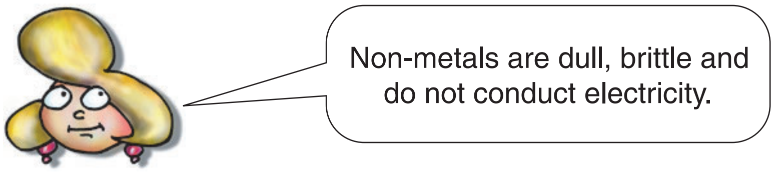
1 Which elements are you sure are non-metals? Give a reason for your answer.

2 Which elements are you sure are metals? Give a reason for your answer.

3 Were any elements hard to classify? Why?

Check your answers.





Complete Exercise 1.5: Metals and non-metals.

Suggested answers – Part 1

Activity: Physical or chemical?

P colour

P melting point

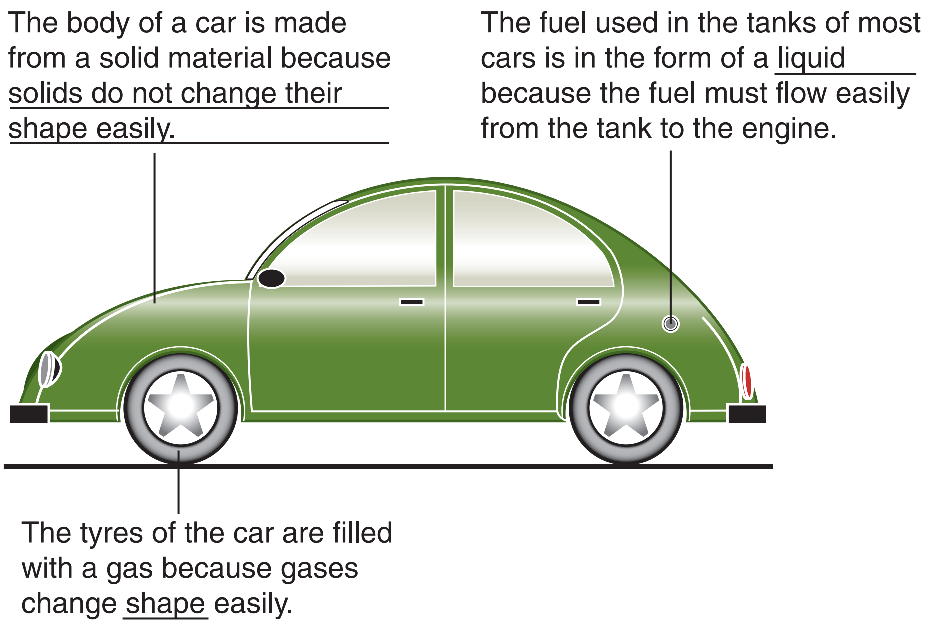
P boiling point

C reaction with acids

P hardness.

C whether it burns in air

Activity: Using state



Activity: Ancient Greek ideas about matter

The particles of water that leave and enter a cloth as it dries out or becomes moist are so small that they cannot be seen. So, matter is made up of very small particles, too small to be seen.

Activity: How many types of atoms occur naturally?

About 90 types of atoms are natural; about 25 are synthetic.

Activity: How many elements? How many types of atoms?

1 There are 115 different types of atoms.

2 A chemical element is a pure substance that contains one type of atom only.

3 There are 115 different types of elements (because there are 115 different types of atom).

4 Pure substances can be either elements or compounds. *Compounds* are made of different types of atoms joined together whereas *elements* are made of one type of *atom* only.

Activity: How do elements get their names?

1 Curium was named after chemists, Marie and Pierre Curie who isolated new elements from radioactive material.

Einsteinium was named after Albert Einstein, the famous physicist.

Mendelevium was named after Dmitri Mendeleev, a Russian chemist who developed a way of classifying elements into a periodic table.

Fermium was named after Enrico Fermi, a famous Italian physicist.

Nobelium was named after Alfred Nobel, the Swedish inventor of dynamite and the founder of the Nobel prizes.

Did you think caesium was named after Julius Caesar? It's a good guess but the element is named after a Latin word which means blue.

2 a) a continent: europium (Europe), americium (America)

b) a country: germanium (Germany), francium (France), polonium (Poland), gallium (Gaul, an old name for France)

Did you think indium was named after India? That's a good idea but indium is named after a word that means the colour indigo in Greek.

c) a state in the USA: californium (California)

Activity: Symbols

Sign	**Meaning**
$	dollar
%	per cent
&	and
#	number
©	copyright
®	registered (name or trademark)

Activity: One letter symbols

Element	Symbol	Element	Symbol
carbon	C	phosphorus	P
oxygen	O	fluorine	F
nitrogen	N	iodine	I
hydrogen	H	potassium	K
sulfur	S	uranium	U

Activity: Two letter symbols

Element	Symbol	Element	Symbol
nickel	Ni	calcium	Ca
neon	Ne	cobalt	Co
aluminium	Al	helium	He
silicon	Si		

magnesium	Mg
chromium	Cr
zinc	Zn
chlorine	Cl
cadmium	Cd

Activity: Other symbols

Element	Name in Latin	Symbol
sodium	natrium	Na
mercury	hydragyrum	Hg
silver	argentum	Ag
gold	aurum	Au
copper	cuprum	Cu
iron	ferrum	Fe
potassium	kalium	K
lead	plumbum	Pb
antimony	stibium	Sb
tin	stannum	Sn

Activity: An elemental message

tungsten, hydrogen, iodine, carbon, hydrogen: *which*

tin, actinium, potassium: *snack*

iodine, sulfur: *is*

helium, aluminium, thorium, yttrium: *healthy*

aluminium, iodine, sulfur, oxygen, nitrogen: *Alison*

lithium, potassium, einsteinium: *likes*

calcium, potassium, einsteinium: *cakes*

yttrium, vanadium, oxygen, nitrogen, neon, sulfur: *yvonnes*

phosphorus, rhenium, iron, rhenium, nitrogen, cerium: *preference*

iodine, sulfur: *is*

barium, sodium, sodium, sulfur: *bananas*

So the message is: *Which snack is healthy? Alison likes cakes. Yvonne's preference is bananas*.

Activity: Another hidden message

On the grid below, letters not used in names of elements are shaded.

L	A	L	U	M	I	N	I	U	M	**E**	**M**	**E**	**N**
M	**T**	C	A	R	B	O	N	**S**	**A**	**R**	**E**	S	**T**
U	**H**	M	N	O	D	A	R	U	F	L	U	S	S
I	**E**	M	U	R	A	N	I	U	M	R	**B**	I	**U**
C	H	M	U	I	S	S	A	T	O	P	L	L	**I**
L	E	Y	**L**	I	S	**D**	O	H	N	V	**I**	I	**N**
A	L	**G**	D	**B**	M	E	P	D	E	O	R	C	R
C	I	O	**L**	R	D	S	N	R	I	O	E	O	E
I	U	X	**O**	L	O	T	O	G	N	U	**C**	N	P
O	M	Y	O	H	I	G	**K**	**S**	A	**O**	M	**F**	P
D	**A**	G	P	N	**L**	L	E	A	D	M	**L**	**M**	O
I	N	E	G	O	R	T	I	N	**A**	Z	I	N	C
N	**T**	N	C	H	L	O	R	I	N	E	**T**	**E**	**R**
E	A	R	G	O	N	E	N	I	R	O	U	L	F

The hidden message is: *Elements are the building blocks of all matter*.

Activity: Metals and non-metals

Element	Symbol	Colour	Shiny or dull?	Malleable or brittle?	Electrical conductor or non-conductor?
magnesium	Mg	grey	shiny	malleable	conductor
copper	Cu	red-brown	shiny	malleable	conductor
iron	Fe	grey	shiny	malleable	conductor
zinc	Zn	grey	shiny	malleable	conductor
carbon	C	black	shiny	brittle	conductor
aluminium	Al	aluminium	shiny	malleable	conductor
sulfur	S	yellow	dull	brittle	non-conductor
phosphorus	P	brown	dull	brittle	non-conductor
iodine	I	violet	shiny	brittle	non-conductor

Activity: Grouping elements

Elements which are shiny
Fe, Zn, Mg, Al, Cu

Elements which are dull
C,S,P

Elements which are malleable
Fe, Zn, Mg, Al, Cu

Elements which are brittle
C,S,P,I

Elements which are conductors
Fe, Zn, Mg, Al, Cu, C

Elements which are non-conductors
S,P,I

Did you make these decisions to combine the information?

Elements which are shiny malleable, ductile and conductors
Fe, Zn, Mg, Al, Cu

Elements which are dull brittle and non-conductors
S,P

Others
C,I

Activity: Metals and non-metals

Elements which are metals	Elements which are non-metals
Fe, Zn, Mg, Al, Cu	S,P

Activity: Other elements

Carbon is a non-metal because it has most of the properties of non-metals.

Iodine is a non-metal because it has most of the properties of non-metals.

Activity: Metal or non-metal?

1. Selenium and tellurium are non-metals because they are dull, poor conductors of electricity and are brittle.
2. Zirconium, nickel and palladium are metals because they are shiny, are good conductors of electricity and are malleable.
3. It was difficult to classify argon because the only result in the table that can be used is that it is a non-conductor. (Scientists usually use a group of characteristics to classify a substance.)

   It was difficult to classify lead because it is dull, although the other properties of lead are those of metals.

Exercises – Part 1

Name: ______________________________

Teacher: ______________________________

Exercise 1.1: Ways of classifying

1 Distinguish between physical and chemical properties of a substance.

____

____

____

2 Use the particle model to explain the solid, liquid and gas states.

____

____

____

3 Distinguish between an atom and a molecule.

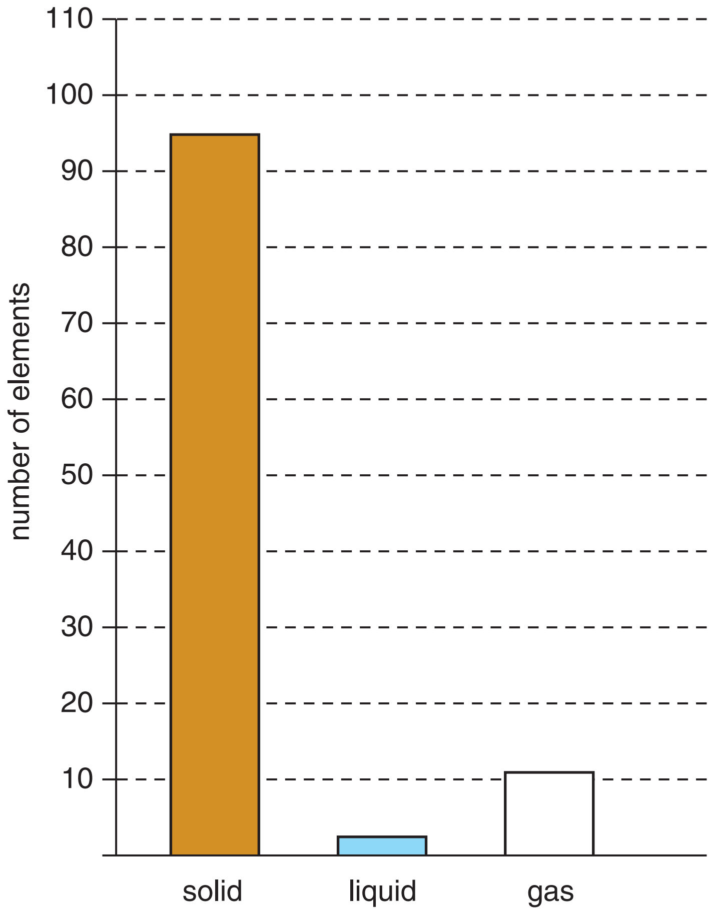
____

____

____

Exercise 1.2: Extracting information from a graph

Here is a column graph showing the states of many elements under normal conditions (at 25°C and atmospheric pressure). (Remember, state means whether a substance is a solid, liquid or gas.)



States of the elements under normal conditions

Use information from the graph to fill in the spaces in the sentences below.

1 Approximately 94 of the elements are ________.

2 Approximately ________ of the elements are liquid.

3 Approximately ________ of the elements are gaseous.

4 Most elements are ________.

5 Elements are rarely found in the ________ state.

Exercise 1.3: Using element symbols

Element uses

Here are some important uses of elements. Complete the table by writing in the symbols of the elements.

Element	Symbol	Use
aluminium		saucepans, wrapping foil
zinc		coating iron to stop the iron rusting
magnesium		flares, fireworks
sulfur		insecticide
lead		roofs of buildings
iron		bridges and buildings
mercury		fillings in teeth
phosphorus		matches
tin		coat steel used for food containers
chlorine		used to sterilise water

Element states

Here are some of the elements grouped according to their state at room temperature and pressure. Write the symbol for each element.

Solids		Liquids		Gases	
Element	**Symbol**	**Element**	**Symbol**	**Element**	**Symbol**
copper		mercury		hydrogen	
sulfur		bromine		oxygen	
calcium				nitrogen	
iron				fluorine	
zinc				chlorine	
magnesium				helium	

Natural or made elements

Most elements are found in nature while others are made artificially. Write the symbols of these elements.

Natural elements		**Made elements**	
Element	**Symbol**	**Element**	**Symbol**
calcium		fermium	
aluminium		mendelevium	
uranium		curium	
silicon		einsteinium	
sodium		nobelium	
barium		lawrencium	

Found as free elements

The naturally occurring elements may be found alone or combined with other elements. Write the symbols for these elements.

Found alone (free)		**Found combined with other elements**	
Element	**Symbol**	**Element**	**Symbol**
gold		sodium	
silver		potassium	
mercury		calcium	
sulfur		fluorine	
oxygen		bromine	
nitrogen		iron	

Exercise 1.4: Results of testing elements

1 Use the table of results for each test to fill in this summary table.

You should copy Alide's results as well as your own.

Element	**Symbol**	**Colour**	**Shiny or dull?**	**Malleable and ductile, or brittle?**	**Conductor or non-conductor?**
	Mg				
	Cu				
	Fe				
	Zn				
	C				
	Al				
	S				
	P				
	I				

2 In this lesson, you carefully and logically tested each element to find its properties. Why was it important to test each element in several different ways?

____

____

____

____

Exercise 1.5: Metals and non-metals

1 Here is some information about tungsten.

colour: grey

electrical conductivity (ability to conduct electricity): good

appearance: shiny

Is tungsten a metal or a non-metal? Give reasons for your answer.

____

____

2 Here is a description of the element, silicon.

Silicon is a grey solid. It is a poor conductor of electricity. Silicon is brittle and cannot be bent into shapes.

Is silicon a metal or a non-metal? Give reasons for your answer.

____

____

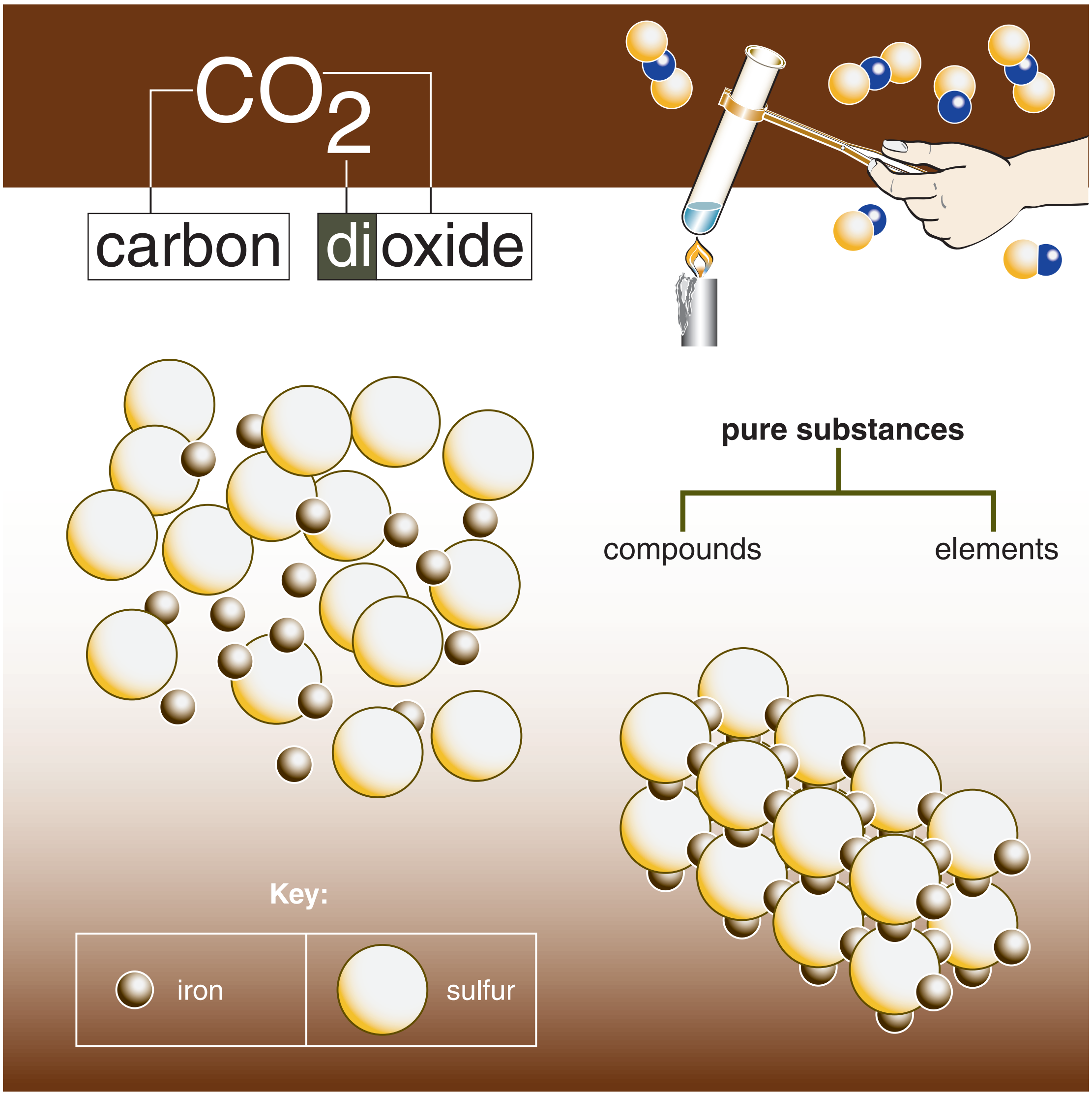
Science

Stage 4

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

Elements, compounds and graphs

Part 2: Compounds



Contents – Part 2

Lesson 6 – Pure substances

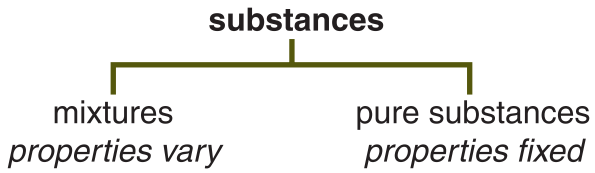
Pure substances come from mixtures

Practically all of the natural resources extracted from the air, Earth and oceans are mixtures. Air, rocks, sea water and soil are examples of mixtures.

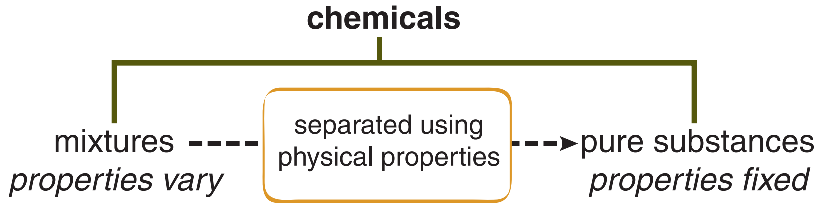
Mixtures are impure substances. As the proportions of the parts of a mixture vary so do its properties. For example, sea water from the Dead Sea has a different density to sea water in an ocean or sea water near the mouth of a river. (The Dead Sea has a high proportion of salt.)

It is difficult to predict what will happen when mixtures are combined. Concrete suppliers have to be careful with the type of sand they use in producing concrete. Beach sand will produce a different type of concrete from river sand. Chefs learn by experience which mixtures are best for their cooking. If the proportions of ingredients in a sauce vary the taste of a meal varies. If there is more salt in a sauce the taste is quite different.

Chemists prefer to work with pure substances rather than mixtures. Pure substances have fixed properties. This makes it easier (and safer) to predict what will happen if pure substances are used.



Chemists spend a lot of time and energy extracting pure substances out of the mixtures obtained from nature. Mixtures can be separated into pure substances by using the different physical properties of the parts of the mixture.



Water can be evaporated from sea water leaving salt behind. This is because the water has a much lower boiling point than the salts. Differences in the physical property of boiling point are used to separate the parts of this mixture.

Activity: Methods of separation

Name a separation method which could be used to separate each of the mixtures listed: crystallisation, decanting, distillation, evaporation, filtration, magnetic attraction, sedimentation, sieving.

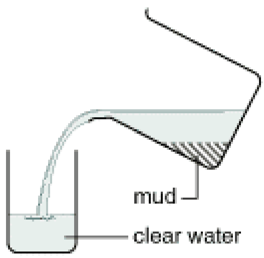
Separation method	Kinds of mixtures
	solid substances in lumps of different sizes, e.g. mixture of sand and gravel
	liquid containing dissolved solid that crystallises out when the solution is cooled, e.g. saturated salt solution
	mixture of magnetic and non-magnetic materials, e.g. magnetic ilmenite and non-magnetic rutile in beach sand
	liquid separated from an insoluble solid in the bottom of the container, e.g. water from settled out clay
	dissolved solid in a liquid solution, e.g. salt dissolved in sea water
	suspensions or sediments mixed with water, e.g. mud from water
	liquids with different boiling points, e.g. petrol, kerosene and oil in petroleum
	insoluble solid from a mixture of solid and water, e.g. clay from a mixture of clay and water

Check your answers.

Activity: Naming separation methods

Here is a list of separation methods: crystallisation, decanting, distillation, evaporation, filtration, magnetic attraction, sedimentation, sieving.

Name each separation method shown in the diagrams.

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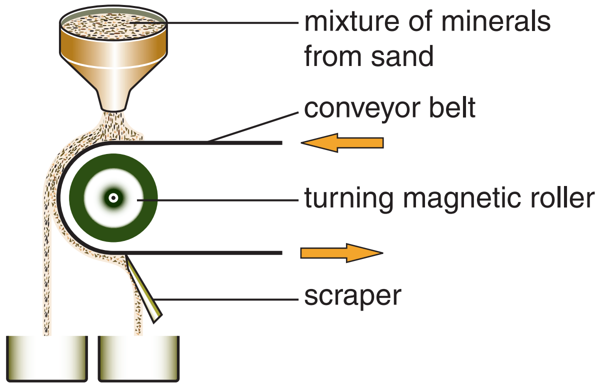
<tr><td></td><td>
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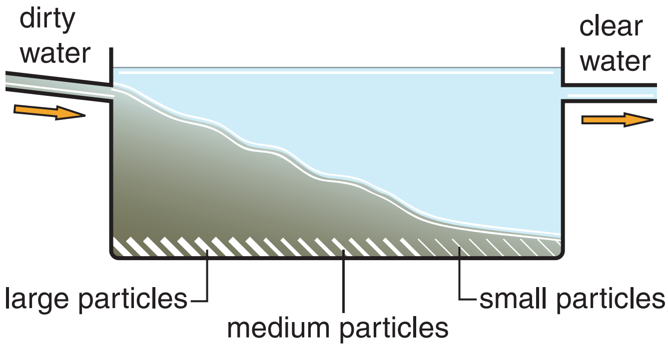
<tr><td></td><td>
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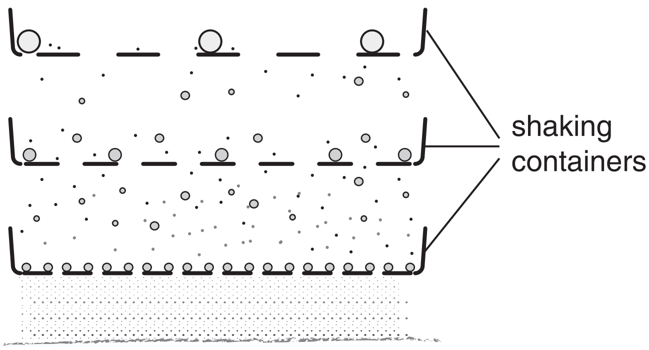
<tr><td></td><td>
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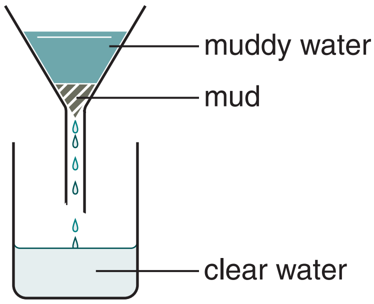
<tr><td></td><td>
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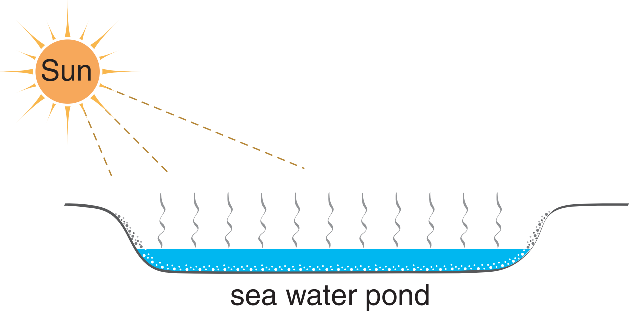
<tr><td></td><td>
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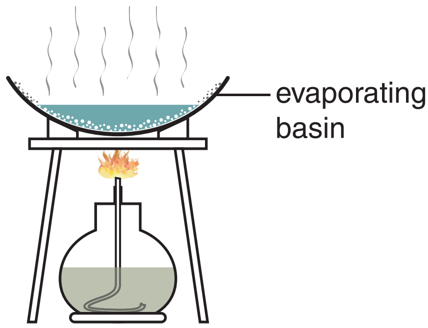
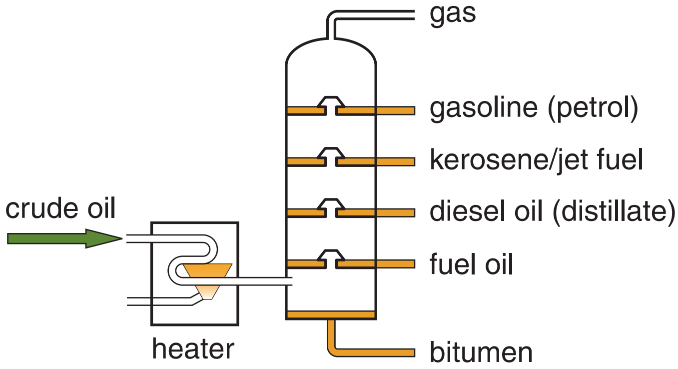
	
	

Check your answers.

Activity: Physical properties used in separation

Here is a list of physical properties: boiling point, density, magnetism, particle size.

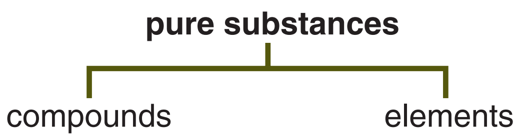
Match each physical property with a separation method in the table below.

Separation method	**Physical property used**
magnetic attraction	
sedimentation	
distillation	
filtration	

Check your answers.

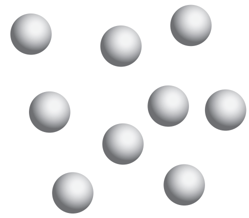
Chemical formulas for pure substances

Pure substances can be divided into elements and compounds.



Element formulas

An element contains only one sort of atom. So an element cannot be changed to anything simpler. But the element formula can tell you something about the particles making up the element.

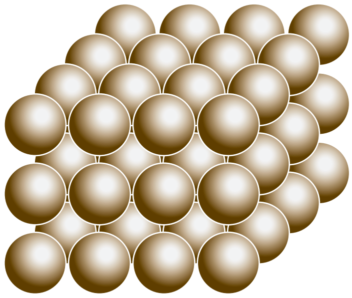


Inert gas particles are single atoms

Most elements are made up of single atoms, e.g. metals, noble gases (helium He, neon Ne, argon Ar, Krypton Kr, Xenon Xe and Radon Rn).

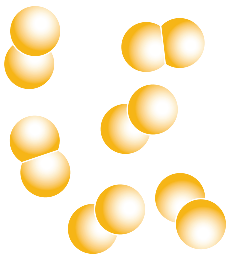
Solid non-metals are usually written as single atoms, e.g. sulfur S, carbon C, phosphorus P, silicon Si.

The symbol for an element can be used to represent the element or a single atom of the element.



Particles in a solid metal

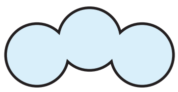
The particles in other elements are molecules made up of two or more identical elements joined together.



Diatomic molecules of elements

Most of the gaseous elements are made up of diatomic molecules containing two identical atoms, e.g. hydrogen H_2, oxygen O_2, nitrogen N_2, fluorine F_2, chlorine Cl_2.

H is the symbol for the element hydrogen or a single atom of hydrogen. H_2 should be used to represent the particles making up hydrogen.



Triatomic molecule of ozone

A rare form of oxygen called ozone is made up of triatomic molecules containing three atoms. The formula for ozone is O_3.

O is the symbol for oxygen, O_2 represents the particles in the oxygen gas that we breathe while O_3 represents the particles in the ozone form of oxygen gas.

Elements and their symbols

Symbol	Name	Symbol	Name	Symbol	Name
Ac	actinium	Hf	hafnium	Pr	praseodymium
Al	aluminium	He	helium	Pm	promethium
Am	americium	Ho	holmium	Pa	protactinium
Sb	antimony	H	hydrogen	Ra	radium
Ar	argon	In	indium	Rn	radon
As	arsenic	I	iodine	Re	rhenium
At	astatine	Ir	iridium	Rh	rhodium
Au	gold	Fe	iron	Rb	rubidium
Ba	barium	Kr	krypton	Ru	ruthenium
Bk	berkelium	La	lanthanum	Sm	samarium
Be	beryllium	Lw	lawrencium	Sc	scandium
Bi	bismuth	Pb	lead	Se	selenium
B	boron	Li	lithium	Si	silicon
Br	bromine	Lu	lutetium	Ag	silver
Cd	cadmium	Mg	magnesium	Na	sodium
Ca	calcium	Mn	manganese	Sr	strontium
Cf	californium	Md	mendelevium	S	sulfur
C	carbon	Hg	mercury	Ta	tantalum
Ce	cerium	Mo	molybdenum	Tc	technetium
Cs	caesium	Nd	neodymium	Te	tellurium
Cl	chlorine	Ne	neon	Tb	terbium
Cr	chromium	Np	neptunium	Tl	thallium
Co	cobalt	Ni	nickel	Th	thorium
Cu	copper	Nb	niobium	Tm	thulium
Cm	curium	N	nitrogen	Sn	tin
Dy	dysprosium	No	nobelium	Ti	titanium
Es	einsteinium	Os	osmium	W	tungsten
Er	erbium	O	oxygen	U	uranium
Eu	europium	Pd	palladium	V	vanadium
Fm	fermium	P	phosphorus	Xe	xenon
F	fluorine	Pt	platinum	Yb	ytterbium
Fr	francium	Pu	plutonium	Y	yttrium
Gd	gadolinium	Po	polonium	Zn	zinc
Ga	gallium	K	potassium	Zr	zirconium
Ge	germanium				

Compound formulas

A compound formula contains more than one type of element symbol.

Given the formula for water, H_2O, you can see that it contains two elements: hydrogen and oxygen. The $_2$ shows that there are two hydrogen atoms joined to one oxygen atom. If there is no number after an element's symbol then there is only one atom of that element.

The formulas below are for common compounds—they contain symbols of more than one element.

Formula	Common compound	Elements in the compound
H_2O	water	hydrogen, oxygen
HCl	hydrochloric acid	hydrogen, chlorine
H_2SO_4	sulfuric acid	hydrogen, sulfur, oxygen
$CuCO_3$	copper carbonate	copper, carbon, oxygen
CuO	copper oxide	copper, oxygen
$Ca(OH)_2$	calcium hydroxide	calcium, oxygen, hydrogen

Complete Exercise 2.1: Particle diagrams.

Lesson 7 – Compound formulas

Compounds are made up of different sorts of atoms combined. A compound is made up of different elements. Therefore, the formula for a compound must contain at least two different symbols.

The elements and the ratio of the atoms in a compound are shown by its formula.

The formula for water H_2O shows that there are two hydrogen atoms H combined with one oxygen atom O. The formula for sodium chloride NaCl shows that there is one sodium atom (Na) for each chlorine atom Cl. Calcium carbonate $CaCO_3$ contains one calcium atom Ca for each carbon C and every three oxygen atoms O.

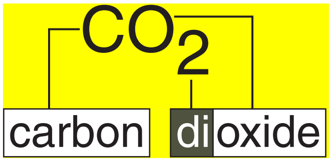
How many hydrogen H, sulfur S and oxygen atoms O are in sulfuric acid, H_2SO_4?

There are two H, one S and four O atoms in each molecule of sulfuric acid.

The names of many compounds can be used to work out the formula:

- When a compound only contains two elements its name usually ends in *-ide*.
- In compounds made from non-metals only prefixes like *mono*- for one, *di*- for two and *tri*- for three, show the number of atoms.

The diagram below shows how different parts of the name refer to different parts of the formula.



The compound carbon dioxide is made up of one carbon atom and two oxygen atoms in each molecule.

Activity: Matching formulas and names

Match this list of formulas with the names of the compounds in the table.

CO, CO_2, SO_2, SO_3, NO, NO_2

Compounds like these containing only non-metals use prefixes like *mono*- for one, *di*- for two and *tri*- for three to show the number of atoms.

Compound name	**Compound formula**
carbon monoxide	
sulfur dioxide	
sulfur trioxide	
nitrogen monoxide	
nitrogen dioxide	
carbon dioxide	

Check your answers.

All of the compounds in the table above contain oxygen combined with another element. They are oxides, compounds of oxygen and one other element.

Activity: Compounds of metals and non-metals

The name and formula of compounds made up of a metal and non-metal(s) start with the name of the metal. So, sodium chloride (table salt) has sodium before chlorine in the name sodium chloride and in the formula NaCl.

Note that because the compound contains only two elements *chlor*- ends in -*ide* not -*ine*. Note also that prefixes like *mono*-, *di*- and *tri*- are not used in naming compounds that contain metals.

What would you call the compounds of a metal and a non-metal in the table below?

Compound formula	**Compound name**
CuO	
MgO	
CaO	
ZnO	
KCl	
LiF	

Check your answers.

Activity: Compounds containing three elements

Compounds containing three elements often contain oxygen as one of the elements. If the oxygen is combined with another non-metal such as carbon, sulfur or nitrogen the name ends in -*ate*.

$CuCO_3$ is called copper carbonate.

$CaCO_3$ is called calcium carbonate.

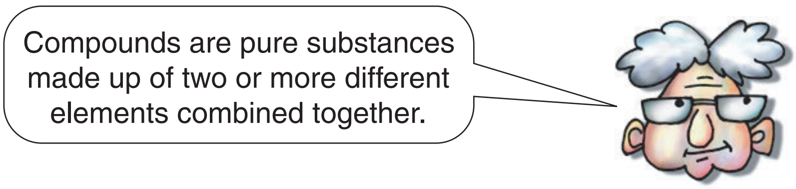
$CuSO_4$ is called copper sulfate.

$NaNO_3$ is called sodium nitrate.

Name the compounds listed in the table below.

Compound formula	Compound name
$MgCO_3$	
$MgSO_4$	
$ZnSO_4$	
KNO_3	
$ZnCO_3$	
$CaSO_4$	
$LiNO_3$	

Check your answers.



Activity: Metal hydroxides, an exception

Metal hydroxides contain three elements but their names end in -*ide* not -*ate*. The hydroxide group OH often has brackets () around it and a number after the last bracket to show how many hydroxides are in the formula.

Sodium hydroxide, $NaOH$, only contains one hydroxide so there are no brackets.

Calcium hydroxide, $Ca(OH)_2$ contains two hydroxides for each calcium so there is a $_2$ after the brackets.

Aluminium hydroxide, $Al(OH)_3$ contains three hydroxides for each aluminium so there is a number $_3$ after the brackets.

Name the metal hydroxides in the second column of this table.

Hydroxide formula	**Metal hydroxide name**
$Mg(OH)_2$	
$Zn(OH)_2$	
KOH	
$Ca(OH)_2$	
$Cu(OH)_2$	
NaOH	

Check your answers.

Activity: Numbers in compound formulas

A number is placed after an atom if there is more than one atom in the formula.

A number is placed after the last bracket if there is more than one group of atoms (such as hydroxide OH, carbonate CO_3, sulfate SO_4 and nitrate NO_3).

Name the compounds in the second column of this table. The first three have been done for you.

Compound formula	**Compound name**
$MgCl_2$	magnesium chloride
Na_2SO_4	sodium sulfate
$Cu(NO_3)_2$	copper nitrate
$Pb(NO_3)_2$	
$Al_2(SO_4)_3$	
Li_2CO_3	
K_2SO_4	
Na_2CO_3	

Check your answers.

Complete Exercise 2.2: Naming compounds.

Lesson 8 – Elements and compounds

Elements and compounds are pure substances. They have fixed properties. This lesson compares the properties of a compound with the properties of the elements needed to make the compound.

You will compare physical properties (properties of a the substance by itself) and chemical properties (properties of the substance with other chemicals).

Comparing properties

Sodium chloride, sodium and chlorine

You probably already know some of the properties of sodium chloride, it is the salt used in cooking, at the table, and the main salt in seawater.

To see pictures, uses and reactions of sodium with air and water go to http://www.cli.nsw.edu.au/kto12, **Science**, **Junior Science Stage 4**, **Elements, compounds and graphs**.

To see pictures, uses and reactions of chlorine with water go to http://www.cli.nsw.edu.au/kto12, **Science**, **Junior Science Stage 4**, **Elements, compounds and graphs**.

Properties of the compound sodium chloride, NaCl are compared with the properties of the metal sodium and the non-metal chlorine below:

Substance	Properties
sodium chloride	solid at room temperature, reacts with some elements, colourless, melting point = 801°C
sodium	solid metal at room temperature, reacts readily with most non-metal elements and with water, shiny silvery surface, melting point = 98°C
chlorine	gas at room temperature, reacts readily with most metals and non-metals, yellow, melting point = –101°C

Activity: Sodium chloride, sodium and chlorine

Compare the properties of the compound, sodium chloride, with the properties of the elements that it consists of.

1. What is the state of sodium chloride, sodium and chlorine at room temperature?

2. What colours are sodium chloride, sodium and chlorine?

3. Compare the melting point of sodium chloride with the melting points of sodium and chlorine.

4. Compare the readiness of sodium chloride, sodium and chlorine to react.

5. Are the properties of sodium chloride the same as those of sodium and chlorine?

Check your answers.

Calcium carbonate, calcium, carbon and oxygen

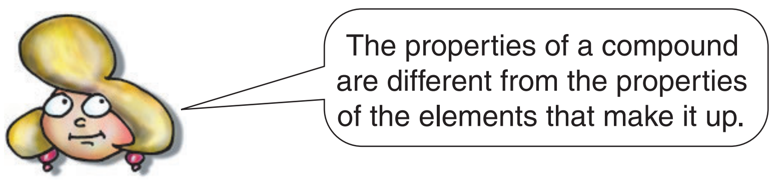
The table following shows the properties of a compound called calcium carbonate $CaCO_3$. Sea shells and limestone rock consist of calcium carbonate. The table also shows the properties of the elements in calcium carbonate: calcium, carbon and oxygen.

Substance	**Properties**
calcium carbonate	white solid, doesn't react with water but reacts with acid, melting point = 1339°C
calcium	grey solid, reacts with water and acid, melting point = 842°C
carbon	black solid, doesn't react with water or acid, melting point = 3974°C
oxygen	colourless gas, doesn't react with water or acid, melting point = –219°C

Complete the sentences comparing the properties of calcium carbonate, calcium, carbon and oxygen.

- Calcium carbonate is white. Calcium is grey. Carbon is black and oxygen has no colour. That is, the substances are all different __________.
- Calcium carbonate, calcium and carbon are all solids whereas oxygen is a __________ at room temperature.
- Both __________ and __________ don't react with water or acid. Calcium carbonate reacts with acid whilst calcium reacts with water and acid.
- There is a wide range of __________ points from –219°C to 3974°C.
- The properties of the compound, calcium carbonate, are very different from the __________ of the elements it is composed of.

Check your answers.



Complete Exercise 2.3: Water and its elements.

Lesson 9 – Compounds and mixtures

Compounds, unlike mixtures, have only one set of properties.

In this lesson, you will be investigating other differences between compounds and mixtures. This will help the picture you are building up of what a compound is.

Robert's experiment

A Year 8 student, Robert, was investigating the question: What is the difference between a mixture and a compound?

He carried out an experiment using the elements, iron and sulfur. He tested the properties of a mixture of iron and sulfur. Heating the mixture produced a compound. He then tested the properties of the compound, iron sulfide.

Aim:

What is the aim of Robert's experiment?

____

____

Robert's aim was: To investigate the differences between a mixture and a compound.

In this lesson, you will be writing the steps in an experimental method.

Method:

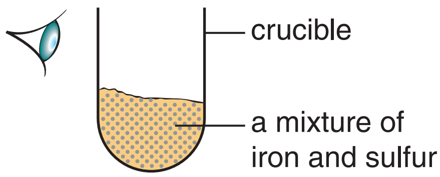
A method is a description of how an experiment was carried out. One way to set out a method is to list the steps of the experiment, in order.

Methods are written in past tense. This means that the experiment has already been done. They are also written impersonally. This means that there is no reference to the person who did the experiment.

Use Robert's experiment description below to practise writing out a method.

Robert drew diagrams and wrote sentences to describe the steps in his experiment. You can see from the first diagram that Robert is observing a mixture of iron and sulfur in a crucible. The crucible is made of clay and is coated in a white glaze. It is used for heating substances strongly.

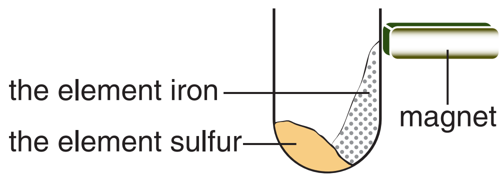
Step 1: The general appearance of a mixture of iron and sulfur was observed.



Notice that Robert's sentence for Step 1 describes something that has already happened. Also notice that he doesn't mention that *he* did the experiment. He has described the method impersonally.

Now write the next step in Robert's method.

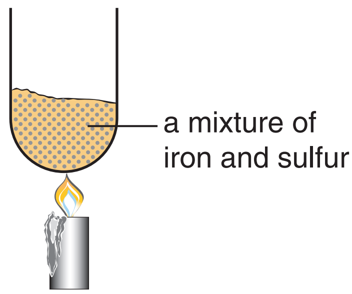
Step 2: ____



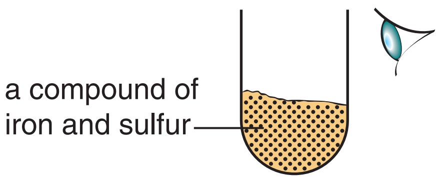
Did you write something similar to this? The mixture was tested to see if it was attracted to a magnet.

Now complete the other steps for Robert's method.

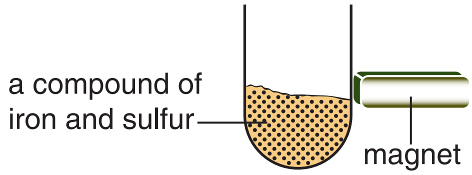
Step 3: ____



Step 4: ____



Step 5: ____



Check your sentences.

How did you go? It takes a little practice to get it right. This may not normally be how you would describe something. Scientists write this way to make it easier for other scientists to repeat the experiment. If the experiment can be repeated with similar results it becomes part of the body of knowledge and understanding called science.

Results:

The observations that Robert made during the experiment are shown in the table below.

Substance	**Appearance**	**Effect of a magnet**
iron and sulfur mixture	mixture of solid yellow sulfur and shiny black iron	iron is attracted to the magnet; sulfur is not affected
compound of iron and sulfur	black hard solid	no effect

Conclusion:

Write a conclusion for this experiment.

____

____

____

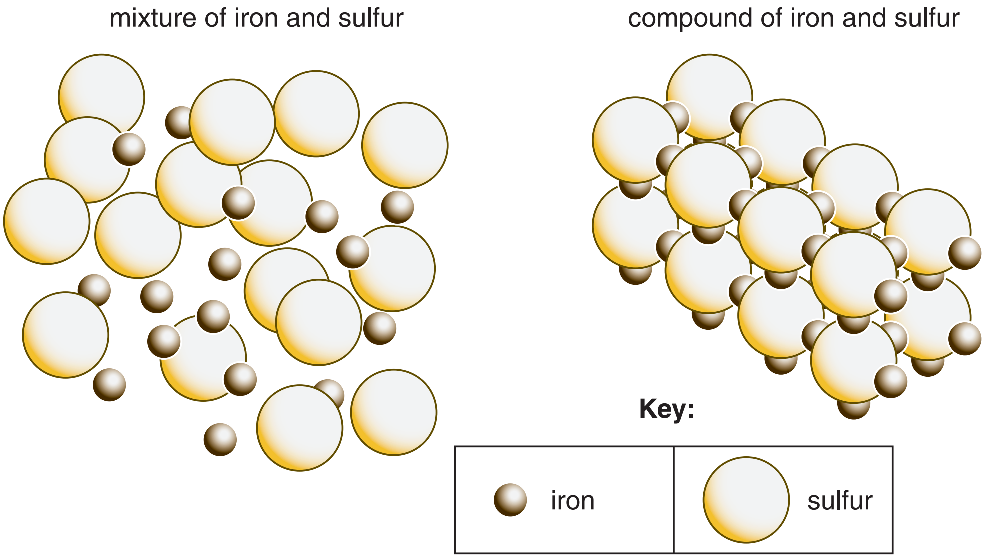
Compare your conclusion with the one in the answer pages.

Discussion:

Often there is a section in a scientific report called 'Discussion'. This is the part of the report where you can explain the results of your experiment.

Robert decided that the easiest way to explain the results was by drawing diagrams. These diagrams describe what Robert thought was happening, not things that he actually observed. Robert has developed a model to explain and predict observations.

The diagrams that Robert drew for his model are shown below.



Take a closer look at the diagrams that Robert drew and try to work out how they explain what he observed.

Compare the diagrams of the mixture and the compound.

How is the arrangement of the iron and sulfur atoms in the compound different from their arrangement in the mixture?

____

____

The iron and sulfur atoms are arranged and joined in a regular way in the compound. In the mixture, the atoms of iron and sulfur are all over the place. Their arrangement is irregular.

Iron and sulfur lost their element properties when they formed a compound. The compound made from iron and sulfur has its own set of properties.

Why do you think Robert drew the iron and sulfur atoms in the compound so that each one was joined to at least one other?

____

____

Robert may have wanted to show that the elements join together to form something new in a compound. The new structure would have a new set of fixed properties.

When two or more elements combine to form a compound, they lose their properties. The compound has its own set of properties which are different from the properties of the elements it contains.

Because the compound has its own set of fixed properties, it must be a pure substance. The compound is something quite different from its elements.

Activity: So what is a compound?

Can you remember all the features of compounds? What makes a compound different from all other substances? Write your list below.

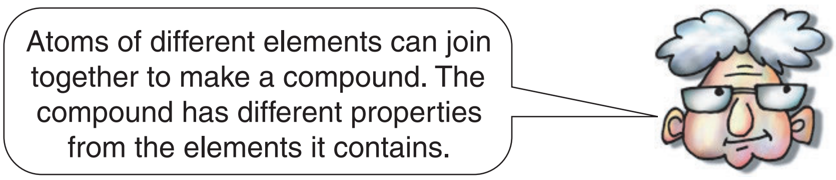
____

____

____

Compare your list with the one in the answer pages.

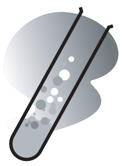
Complete Exercise 2.4: Distinguishing between a mixture and a compound.



Lesson 10 – Chemical reactions

During a chemical reaction, existing substances react to form new substances. But how do you know that a chemical reaction has occurred?

- a substance that was present could 'disappear'
- a new substance may appear
- bubbles of gas or a solid may form
- there may be a change in colour
- heat energy may be absorbed or released.



Activity: What is a chemical reaction?

Here is a quick experiment to help you observe some of these things.

You will need:

- bicarbonate of soda (baking soda or sodium hydrogen carbonate)
- vinegar (approximately 5% solution of acetic acid)
- a clean teaspoon
- a beaker
- matches.

What to do:

1 Look at a match. Then observe it as it burns. You are watching a chemical reaction occur. Tick the things below that you observe.

Existing substances …

❑ something 'disappears'

are changed into new substances containing ...

❑ a new gas forms

❑ a new solid forms

❑ colour changes

different amounts of heat energy.

❑ it gets colder or hotter

2 Look at the vinegar. Then look at the bicarbonate of soda.

- Pour about 0.5 cm depth of vinegar into the glass.
- Add about half a teaspoon of bicarbonate of soda.
- Watch the two chemicals as they react.

Tick the things below that you see.

Existing substances …

❑ something 'disappears’

are changed into new substances containing …

❑ a new gas forms

❑ a new solid forms

❑ colour changes

different amounts of heat energy.

❑ it gets colder or hotter

Which indicators of a chemical change did you observe? Check your answers.

A chemical reaction can also be called a chemical change. In a chemical change a new chemical is formed.

Chemical and physical change

A chemical change produces new substances; a physical change doesn’t.

For example, when candle wax melts, solid wax changes to liquid wax. The wax you start with is the wax you end up with. Melting is an example of a physical change. Other examples include boiling, evaporation, condensation and freezing.

However, if you burn paper, you don’t end up with paper. Carbon dioxide, carbon and water are produced. All are new substances produced as the paper burns. This is an example of a chemical change.

Activity: Heating copper carbonate

In the next activity, you are going to heat copper carbonate. You will also prepare a scientific report for this activity.

You need to be supervised while you do this activity.

Read all the directions for this activity first then tell your supervisor what you are going to do. Your supervisor also needs to watch while you do it.

Aim

In this activity, you will investigate the effect of heating copper carbonate.

Part of doing an activity in science is writing a scientific report. You start a scientific report with a statement that tells the reader why you are doing the experiment. This is the aim or purpose of the experiment.

The aim of an experiment can start with 'To' followed by a word that indicates what you are going to do. The word after 'To' might be: test, find, investigate, measure, observe, determine.

Write the aim or purpose of this experiment.

____

____

Here are some examples of correct aims.

- To find out what happens when copper carbonate is heated
- To investigate the effect of heating copper carbonate
- To observe the effect of heating copper carbonate
- To determine the effect of heating copper carbonate
- To test the effect of heating copper carbonate

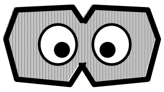
Method

Now you need to collect the materials and equipment listed below.

You will need:

- 1 test tube
- a spirit burner (or Bunsen burner)
- a test tube holder
- copper carbonate
- safety goggles
- matches
- a mat or dish to go under your spirit burner and in case your test tube breaks
- a plastic teaspoon.

Once you have collected all these things and read all the instructions, you are ready to begin. Make sure that you have looked at the diagram below to remind yourself about how to safely heat a test tube.



Are you wearing your safety goggles?

You need your safety goggles to protect your eyes.

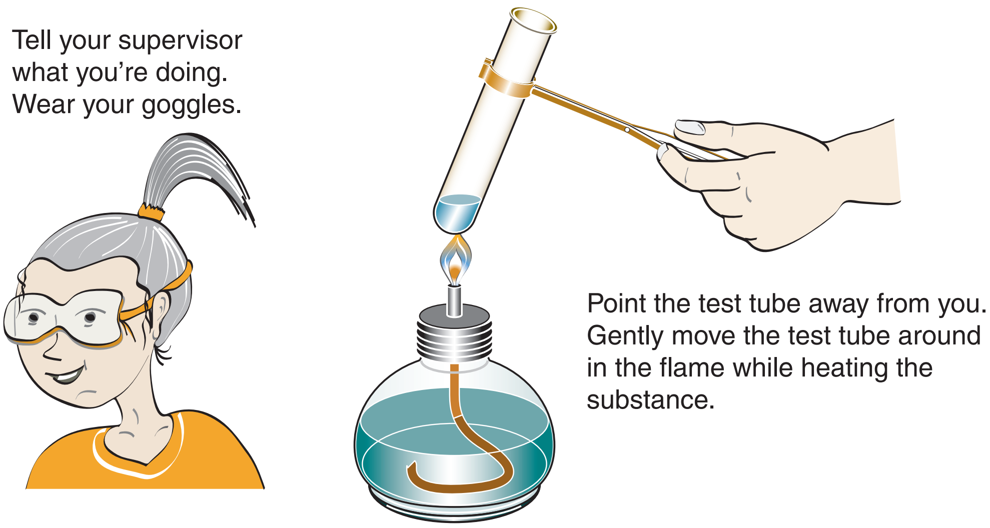
What to do:

1 Look at the copper carbonate and describe it. Write your description in the 'Observations' section of the report below.

2 Light the burner.

3 Place half a teaspoon of copper carbonate into the test tube and use the test tube holder to hold the test tube.

4 Carefully heat the copper carbonate in the test tube.



5 Describe the effect of heating copper carbonate.

Observations

6 Describe copper carbonate.

____

7 Describe what happens when copper carbonate is heated.

____

8 What are some properties of the substance that is now in the test tube?

____

9 Is the substance that you started with the same as the substance you ended up with? Explain your answer.

____

____

Check your answers.

Conclusion

This is the part of the scientific report where you summarise what you have learned from doing the experiment. A conclusion should answer the aim of the experiment. So you need to look back at the aim when you write a conclusion.

10 The aim of this experiment was to investigate the effect of heating copper carbonate. Write the conclusion.

The conclusion could be: Heating copper carbonate produced a new substance with different properties.

When cool the black solid (and any unreacted green copper carbonate) can be emptied on to some waste paper, wrapped up and placed in a garbage bin. Make sure you clean and put away all your equipment.

What have you learned?

When copper carbonate is heated, it breaks down into new substances. What evidence from your experiment suggests that a new substance formed?

There was a colour change. The solid, green copper carbonate decomposed into solid, black copper oxide and a colourless gas, carbon dioxide that escaped from the test tube.

The changes that you observed can be represented in a word equation:

copper carbonate → copper oxide + carbon dioxide

What could you have observed if copper carbonate had been physically changed by heating instead of being chemically changed? Briefly describe what you think could have happened instead.

The solid, green copper carbonate could have melted to become liquid, green copper carbonate. No new substancec could have formed.

A physical change is different from a chemical change.

A chemical change produces new substances; a physical change does not.

Some properties of carbon dioxide

Can you describe the distinguishing features of carbon dioxide?

1 What colour is carbon dioxide?
2 What state is carbon dioxide at room temperature?
3 Soda water is a mixture of carbon dioxide and water. If you shake a bottle of soda water or any fizzy drink, bubbles are released. What do these bubbles contain?
4 Is carbon dioxide soluble in water?

Carbon dioxide has no colour; it is colourless. It is a gas at room temperature. Bubbles in soda water contain the gas, carbon dioxide. Carbon dioxide dissolves in water (because that's how soda water is made!).

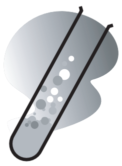
A test for carbon dioxide

Carbon dioxide is a colourless gas. But colourless also describes many other gases, such as oxygen, hydrogen and helium. How could you easily identify a sample of carbon dioxide gas?

The test that is often used shows a chemical change. Limewater turns cloudy in the presence of carbon dioxide.

Are the properties of carbon dioxide the same no matter how the gas is produced? In other words, does carbon dioxide made in different ways turn limewater cloudy?

Before you can test this, you need to make at least two samples of carbon dioxide in different ways.



Making carbon dioxide

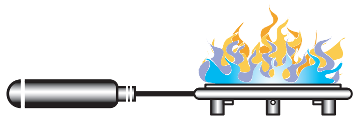
The drawings on the next page show you some of the ways that carbon dioxide is produced.

Fruit salts, such as Eno®, produce carbon dioxide when they are dissolved in water. Carbon dioxide is produced when materials that contain carbon, e.g. paper are burnt. Bicarbonate of soda produces carbon dioxide when it is added to an acid, such as vinegar.

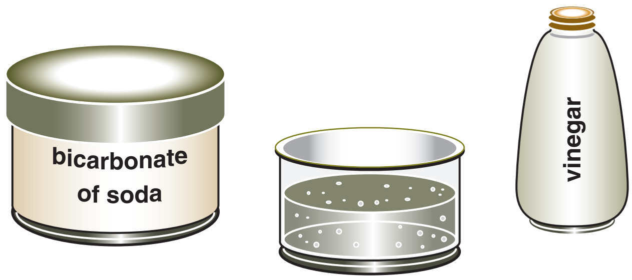
The following activity gets you to produce carbon dioxide in two different ways, both involving chemical changes.

Once you have produced the new substance, carbon dioxide, you can compare the properties of the gas from the two samples.

1. stirring fruit salts into water



2. burning



3. mixing bicarbonate of soda and vinegar

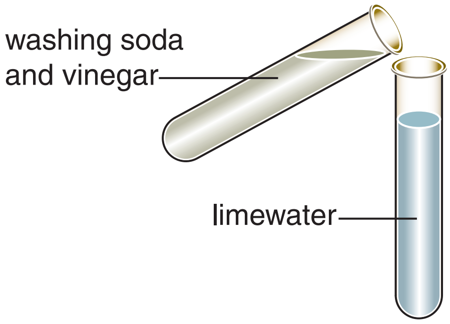
You will need:

- washing soda (sodium carbonate)
- bicarbonate of soda
- 2 teaspoons
- vinegar
- lemon juice
- 4 test tubes
- a beaker to rest the test tubes in
- a screw-top jar containing limewater (made by adding half a teaspoon of calcium hydroxide, almost completely filling the jar with water, shaking and leaving for at least one day). Be careful not to shake the bottle. Leave the white solid at the bottom of the jar.

What to do:

1. Fill two test tubes with clear limewater. (Do not shake the jar! The limewater must be clear to begin the experiment.)
2. Place half a teaspoon of washing soda into a third test tube. Three quarters fill this test tube with vinegar.

   While the mixture is bubbling, bring the test tubes containing limewater close together as shown in the diagram. Observe what happens as carbon dioxide gas flows into the limewater test tube.



3 Place half a teaspoon of bicarbonate of soda into the fourth test tube. Half fill this test tube with lemon juice. Bring the other test tube containing limewater close to this fourth test tube so that the top of the test tubes is close like in the diagram above. Observe what happens.

4 Compare the effect of the two gases on the limewater.

a) Was the carbon dioxide in both tests a colourless gas? ___________

b) What happened to the limewater with each carbon dioxide sample?

____

____

Both samples of carbon dioxide were colourless gases poured from the top test tube into the bottom test tube. Both the gases made the limewater cloudy.

Do you have any leftover chemicals?

Mix leftover calcium hydroxide in some water and pour it onto the soil of a garden, or wash it down the sink. You can wrap leftover green copper carbonate, and the black copper oxide you made, in paper and put them in the garbage.

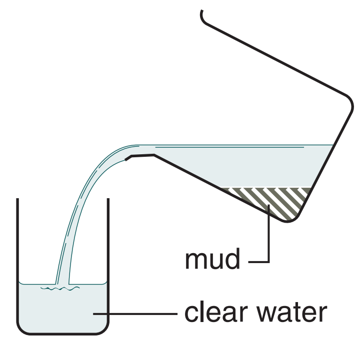
Complete Exercise 2.5: Comparing compounds.

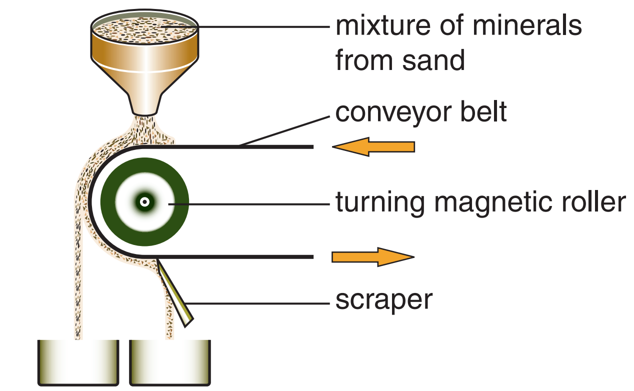
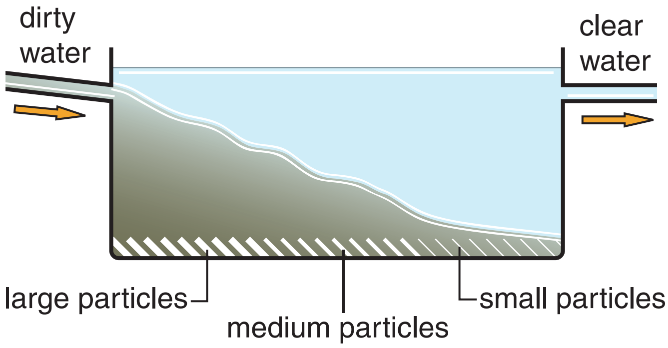
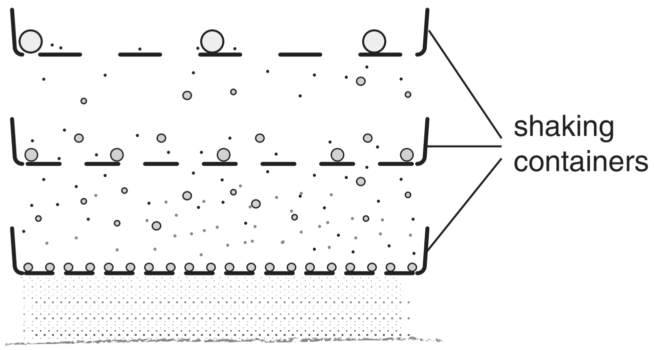
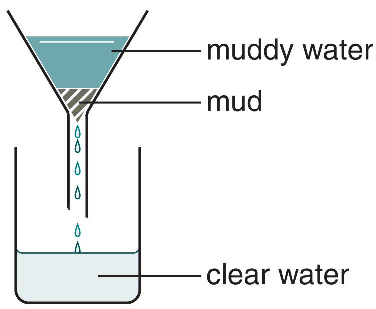
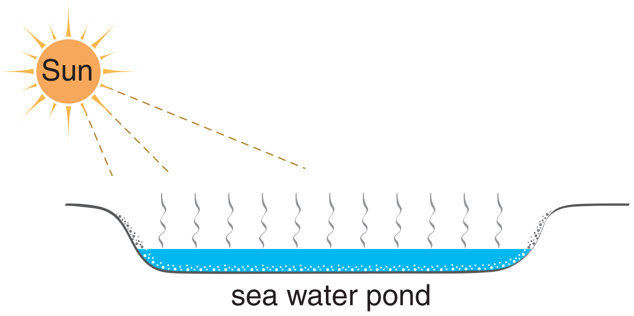
Suggested answers – Part 2

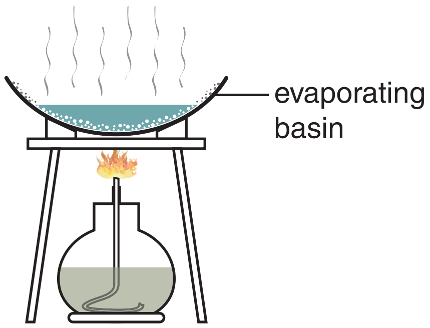
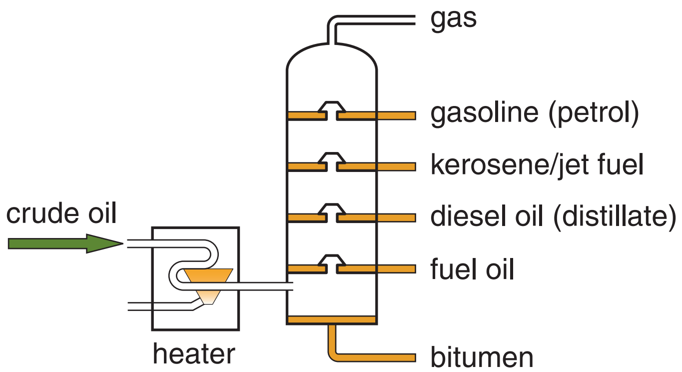
Activity: Methods of separating mixtures

Separation method	**Kinds of mixtures**
sieving	solid substances in lumps of different sizes, e.g. mixture of sand and gravel
crystallisation	liquid containing dissolved solid that crystallises out when the solution is cooled, e.g. saturated salt solution
magnetic attraction	mixture of magnetic and non-magnetic materials, e.g. magnetic ilmenite and non-magnetic rutile in beach sand
decanting	liquid separated from an insoluble solid in the bottom of the container, e.g. water from settled out clay
evaporation	dissolved solid in a liquid solution, e.g. salt dissolved in sea water
sedimentation	suspensions or sediments mixed with water, e.g. mud from water
distillation	liquids with different boiling points, e.g. petrol, kerosene and oil in petroleum
filtration	insoluble solid from a mixture of solid and water, e.g. clay from a mixture of clay and water

Activity: Naming separation methods

Separation method	**Diagram showing the separation method**
decanting	

magnetic attraction	
sedimentation	
sieving	
filtration	
evaporation	

crystallisation	
distillation	

Activity: Physical properties used in separation

Separation method	**Physical property used**
magnetic attraction	magnetism
sedimentation	density
distillation	boiling point
filtration	particle size

Activity: Matching formulas and names

Compound name	**Compound formula**
carbon monoxide	CO
sulfur dioxide	SO_2
sulfur trioxide	SO_3
nitrogen monoxide	NO
nitrogen dioxide	NO_2
carbon dioxide	CO_2

Activity: Compounds of metals and non-metals

Compound formula	Compound name
CuO	copper oxide
MgO	magnesium oxide
CaO	calcium oxide
ZnO	zinc oxide
KCl	potassium chloride
LiF	lithium fluoride

Activity: Compounds containing three elements

Compound formula	Compound name
$MgCO_3$	magnesium carbonate
$MgSO_4$	magnesium sulfate
$ZnSO_4$	zinc sulfate
KNO_3	potassium nitrate
$ZnCO_3$	zinc carbonate
$CaSO_4$	calcium sulfate
$LiNO_3$	lithium nitrate

Activity: Metal hydroxides, an exception

Hydroxide formula	Metal hydroxide name
$Mg(OH)_2$	magnesium hydroxide
$Zn(OH)_2$	zinc hydroxide
KOH	potassium hydroxide
$Ca(OH)_2$	calcium hydroxide
$Cu(OH)_2$	copper hydroxide
$NaOH$	sodium hydroxide

Activity: Numbers in compound formulas

Compound formula	Compound name
$MgCl_2$	magnesium chloride
Na_2SO_4	sodium sulfate
$Cu(NO_3)_2$	copper nitrate
$Pb(NO_3)_2$	lead nitrate
$Al_2(SO_4)_3$	aluminium sulfate
Li_2CO_3	lithium carbonate
K_2SO_4	potassium sulfate
Na_2CO_3	sodium carbonate

Activity: Sodium chloride, sodium and chlorine

1 Sodium chloride and sodium are both solids while chlorine is a gas at room temperature.

2 Sodium chloride is colourless, sodium is shiny and silvery while chlorine is a yellow gas.

3 Sodium chloride has a high melting point (MP) of 801°C, while sodium has a low MP of 98°C and chlorine a very low MP of –101°C

4 Sodium chloride reacts with some elements; sodium reacts with most non-metal elements and water. Chlorine also reacts with most elements.

5 No. Sodium chloride has very different properties from those of both sodium and chlorine.

Activity: Calcium carbonate, calcium, carbon and oxygen

- Calcium carbonate is white. Calcium is grey. Carbon is black and oxygen has no colour. That is the substances are all different *colours*.
- Calcium carbonate, calcium and carbon are all solids whereas oxygen is a *gas* at room temperature.
- Both *carbon* and *oxygen* don't react with water or acid. Calcium carbonate reacts with acid whilst calcium reacts with water and acid.
- There is a wide range of *melting* points from –219°C to 3974°C.
- The properties of the compound, calcium carbonate, are very different from the *properties* of the elements it is composed of.

Activity: Robert's experiment

Step 3: The mixture of iron and sulfur was heated.

Step 4: The general appearance of the compound, iron sulfide, was observed.

Step 5: The compound was tested to see if it was attracted to a magnet.

Activity: Conclusion

Compounds are different from mixtures. Compounds have one set of properties only. But the parts of a mixture retain their properties. Therefore, a mixture has more than one set of properties.

(Remember, a conclusion for an experiment answers the aim. The aim of this experiment was to investigate the differences between a mixture and a compound.)

Activity: So what is a compound?

- Compounds are pure substances.
- Each compound has a fixed set of features or properties (such as colour, state at room temperature, solubility in water, melting point, boiling point, behaviour when heated).
- Compounds contain two or more different elements joined together.

Activity: What is a chemical reaction?

1 When a match burns:

Existing substances …

√ something 'disappears' (the match)

are changed into new substances containing …

√ a new gas forms ('smoke')

√ a new solid forms (charcoal)

√ colour changes (black)

different amounts of heat energy.

√ it gets colder or hotter (gives out heat)

2 When a vinegar and bicarbonate of soda react:

Existing substances …

√ something 'disappears' (the soda)

are changed into new substances containing …

√ something 'disappears' (bubbles)

❑ a new solid forms

❑ colour changes

different amounts of heat energy.

❑ it gets colder or hotter

Activity: Heating copper carbonate

6 Copper carbonate is a green powder.

7 When copper carbonate is heated, the solid goes from green to black.

8 The substance produced is a black powder.

9 The substance produced is quite different from the substance that was heated. The properties of the copper carbonate differ from the properties of the substances produced.

Exercises – Part 2

Name: ____

Teacher: ____

Exercise 2.1: Particle diagrams

Label each of the following diagrams with the appropriate number.

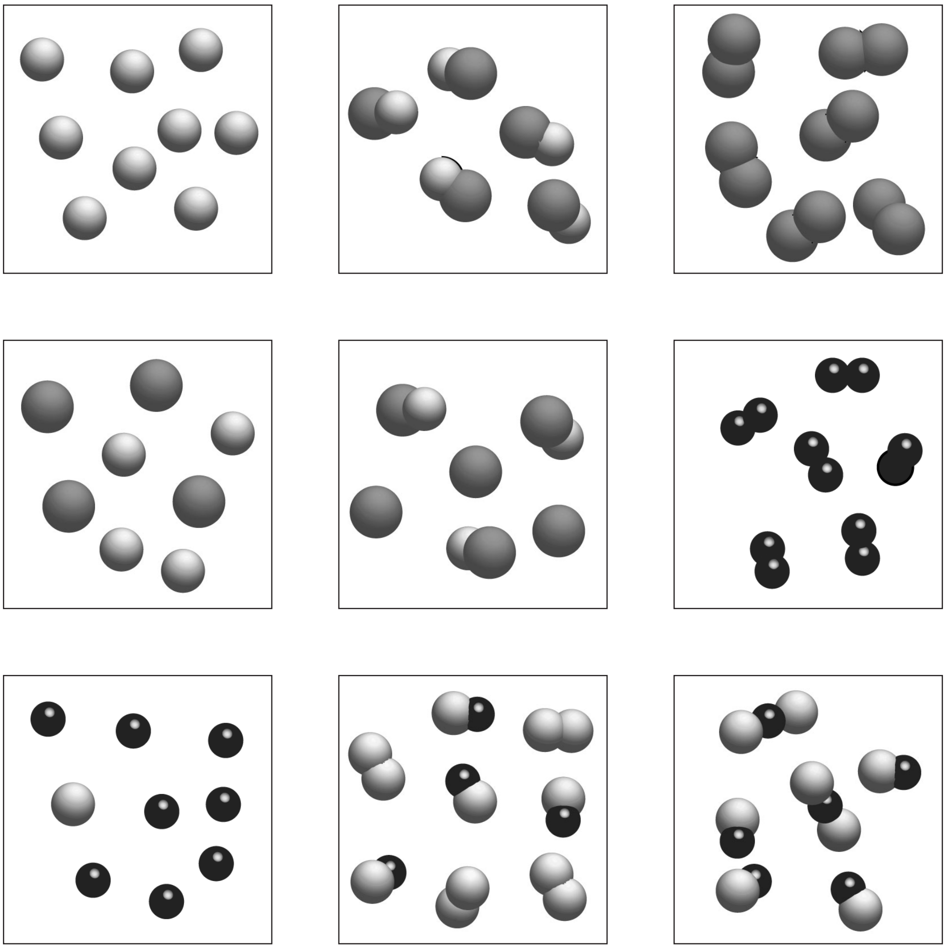
1 element

2 compound

3 mixture of two elements

4 mixture of two compounds

5 mixture of an element and a compound.



Exercise 2.2: Naming Compounds

Complete the table below by writing the names of the compounds using the formulas.

Compound formula	**Compound name**
CuS	copper sulfide
FeS	
$CaCl_2$	calcium chloride
NaCl	
PbO	lead oxide
Na_2O	
KF	potassium fluoride
CaF_2	
$Al(OH)_3$	aluminium hydroxide
LiOH	
K_2CO_3	potassium carbonate
$CuCO_3$	
$CuSO_4$	copper sulfate
$CaSO_4$	
KNO_3	potassium nitrate
$NaNO_3$	
CuO	
$CuCl_2$	
$Cu(OH)_2$	
$Cu(NO_3)_2$	

Exercise 2.3: Water and its elements

You probably already know some of the properties of pure water: colourless, odourless, boiling point of 100°C, density of 1.00 gcm^{-3} and reacts with some elements such as sodium and chlorine.

Properties of the compound water, H_2O are compared with the properties of the elements hydrogen and oxygen in the table below:

Substance	Properties
water	liquid at room temperature, reacts with some elements, colourless, boiling point = 100°C
hydrogen	gas at room temperature, explosive, reacts with most elements, colourless, boiling point = –259°C
oxygen	gas at room temperature, reacts with most elements, colourless, boiling point = –183°C

Compare the properties of the compound, water, with the properties of the elements that it consists of.

1 What is the state of water, hydrogen and oxygen at room temperature?

___

___

2 What colour is water, hydrogen and oxygen?

___

___

3 Compare the boiling point of water with the boiling points of hydrogen and oxygen.

___

___

4 Does water react with most elements? Does hydrogen or oxygen?

___

___

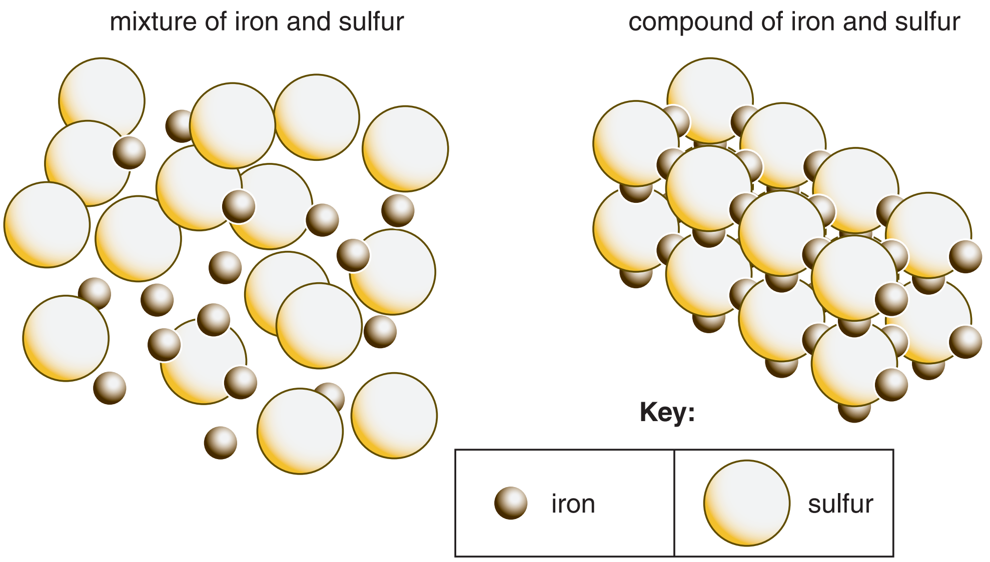
5 Are the properties of water the same as those of hydrogen and oxygen?

___

___

Exercise 2.4: Distinguishing between a mixture and a compound

Here are Robert's diagrams of a mixture and a compound.



1 In what way are this mixture and compound similar?

____

2 How is the model of the mixture and compound different?

____

3 Complete the following summary about mixtures and compounds.

In a compound, ____________ are chemically joined together forming a pure substance with its own fixed set of properties.

Mixtures contain substances close together but not chemically joined.

Substances in the ____________ have their own ____________ so the properties of the mixture ____________ as the proportions of the parts in the mixture vary.

A mixture can be separated using differences in ____________ properties of the parts.

4 Robert was being scientific when he did his experiment.

Robert made observations. He identified a trend or pattern about properties and then constructed a model to explain the trend or pattern.

a) What was the model that Robert constructed?

____

____

b) Do you think this model helps you understand the difference between a mixture and a compound? Why or why not?

____

____

5 Robert carried out further experiments to investigate his model. He found that in the compound each atom of iron was combined with one atom of sulfur.

a) Why should Robert change his model diagram for the compound?

____

b) Suggest a name and formula for the compound of iron and sulfur.

____

Exercise 2.5: Comparing compounds

The table below has a list of some of the properties of Compound X, Compound Y and Compound Z.

Compare the three compounds and then answer the questions that follow.

Compound	Colour	State	Melting point (°C)	Boiling point (°C)	Solubility in water
X	white	solid	801	1465	yes
Y	blue	solid	727	1050	yes
Z	white	solid	1282	decomposes	no

1 In what way(s) are compounds X, Y and Z similar?

____

2 In what way(s) are compound X and compound Y similar?

____

3 In what way(s) are compound X and compound Z similar?

____

4 In what way(s) are Compound X and Compound Y different?

____

5 In what way(s) are Compound X and Compound Z different?

____

6 Imagine that you had samples of each of the three substances, Compound X, Compound Y and Compound Z. You went to the storage cupboard and discovered that their labels had fallen off!

Briefly describe what you would do to work out which sample was Compound X, which was Compound Y and which was Compound Z.

____

____

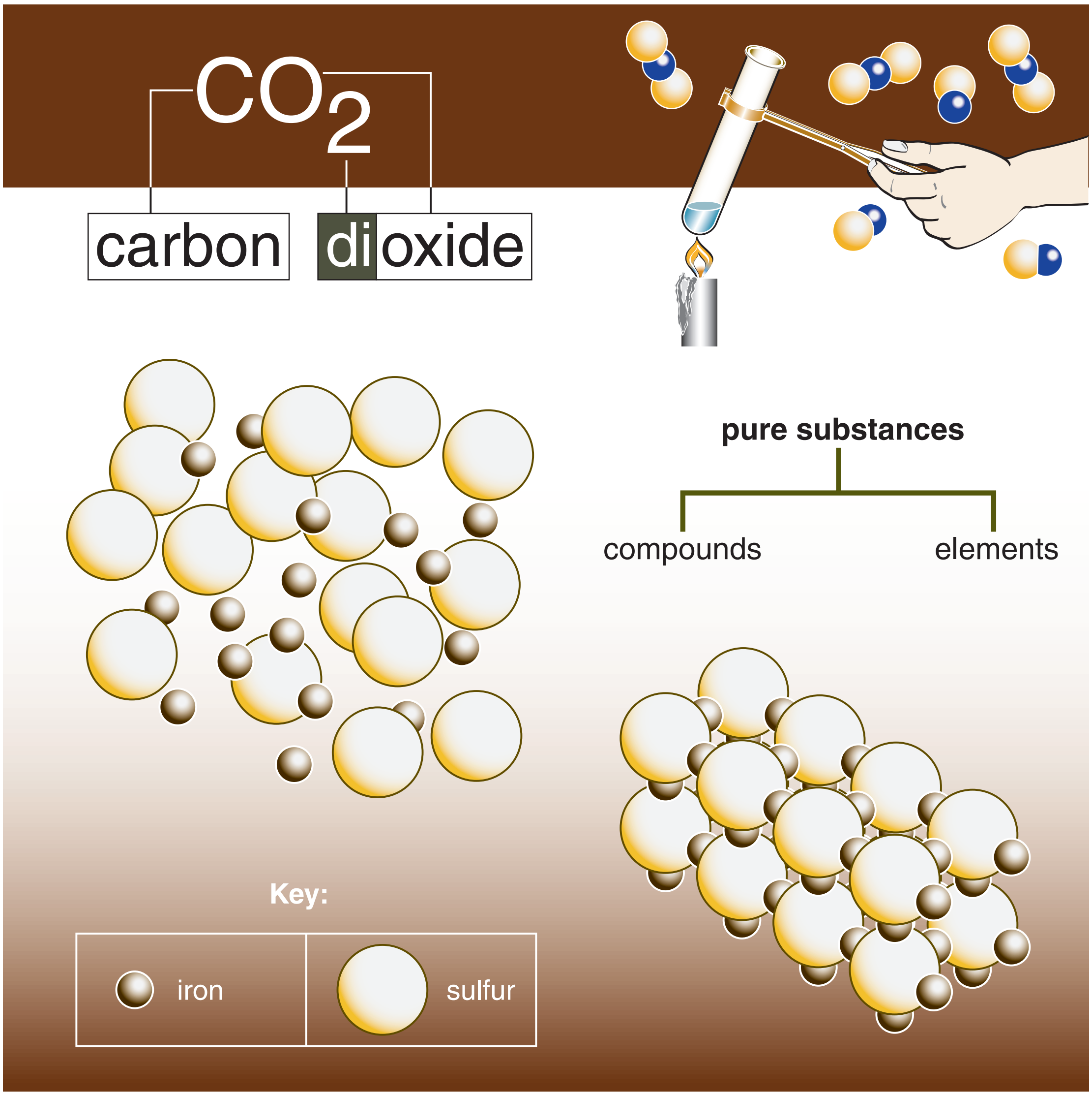
____

Science
Stage 4

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

Elements, compounds and graphs

Part 3: Graphs



Contents – Part 3

Lesson 11 – Resource graphs

Natural resources are materials obtained from nature. Natural resources include plants, animals, fossil fuels (coal, petroleum, natural gas) and minerals. Most natural resources are mixtures. Large amounts of energy and time are spent in separating natural resources into pure substances.

Mineral resources in Australia

Two examples of natural resources, important in Australia, are the minerals haematite and bauxite. They are physically separated to give the compounds iron oxide and aluminium oxide. These compounds are then chemically changed to give the elements iron and aluminium.

Mixtures	**Pure substances**	
Natural resources	**Compounds**	**Elements**
haematite	iron oxide	iron
bauxite	aluminium oxide	aluminium

The element iron makes up about 30% of the mass of haematite and about 70% of the mass of iron oxide.

The element aluminium is about 25% of the mass of bauxite and about 50% of the mass of aluminium oxide.

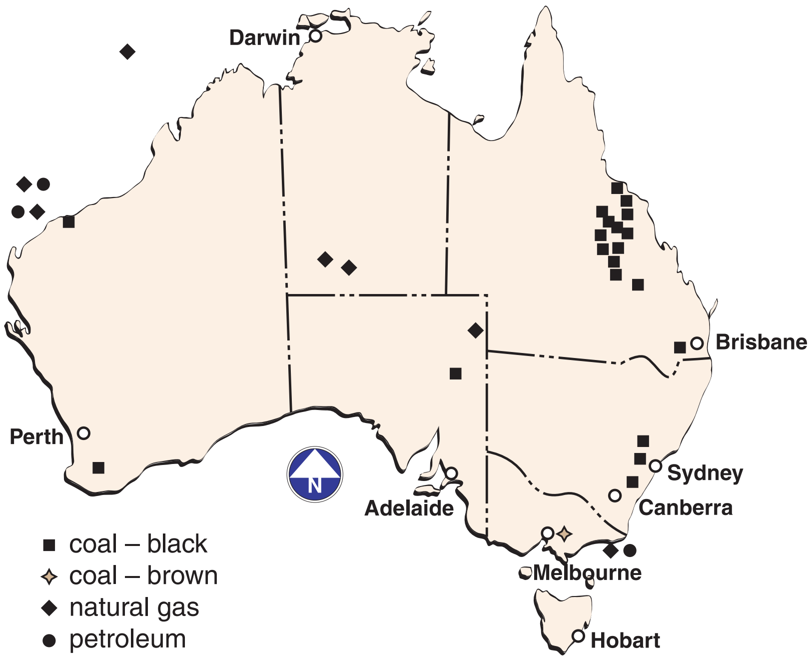
Pure substances (elements and compounds) have fixed properties that can be accessed using data sources, e.g. SI data book, Material Safety Data Sheets (MSDS) and Internet. Pure substances are simpler and safer to use because they have known properties, reactions and safety information.

Technology is used to make resources using materials found in nature. These manufactured or made resources are used in your home, school and workplace.

Products made from pure substances have more predictable and consistent properties and should be of higher quality than mixtures. The purity of iron used in bridge construction and the purity of aluminium used in aircraft wings affect the strength of these structures.

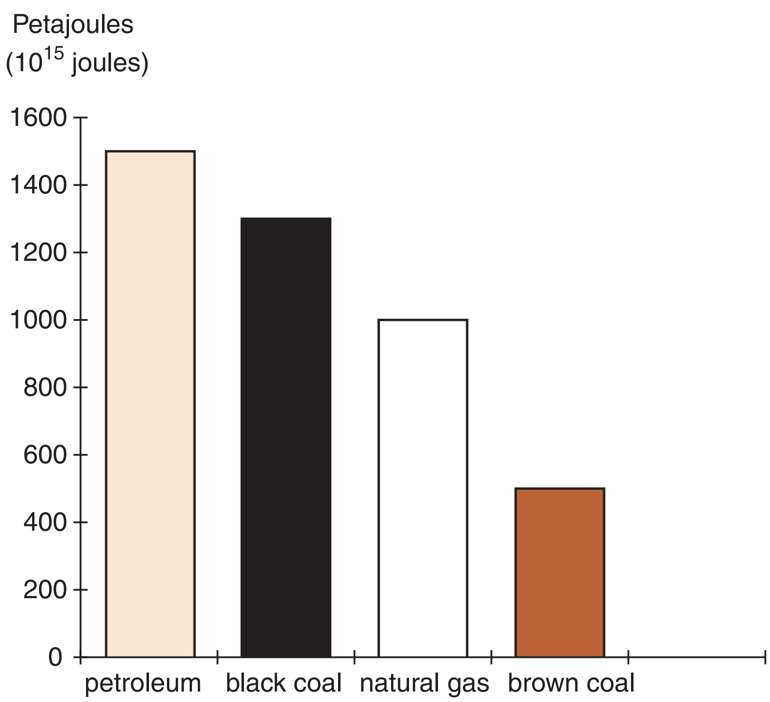
Energy resources in Australia

Most of Australia's energy resources are fossil fuels that come out of the ground, e.g. petroleum, black coal, natural gas and brown coal.



Australian sources of fossil fuels

Column graphs



Approximate Australian consumption of mined energy resources in 2000

A useful way of comparing quantities is by using a column graph. A column graph works well, especially when the quantities are arranged in order of increasing or decreasing size. You can easily see the order of importance of the quantities labelled on the horizontal or x-axis. You can estimate or measure the quantities using the scale on the vertical or y-axis.

In the column graph on the previous page, the amount of energy used in Australia in the year 2000 is shown in petajoules. *Peta* means one thousand million million or 1 000 000 000 000 000. The 1 followed by fifteen zeros can be more simply written as 10^{15}.

One petajoule, 1pJ, is 10^{15} joules of energy.

The joule, represented by J, is the international unit of energy. It takes about 1 J of energy to lift a cup or glass from a table surface to your mouth. If you are an active person you need about 10^7 J (10 000 000 J) per day from food to maintain your body weight.

Activity: Australia's consumption of energy from the ground

1 Which of the mined energy sources provided the most energy?

____

2 a) There are 50 petajoules of food energy eaten by Australians each year. Where should the column go on the graph?

____

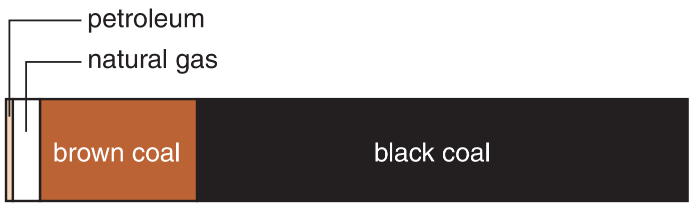
b) Do you think of food as a source of energy from the ground? Why or why not?

____

Check your answers.

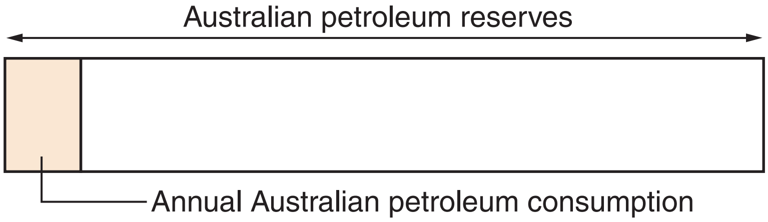
Divided bar graphs

A divided bar graph shows the parts of a total. The bar is a rectangle divided into the parts. The divided bar graph following shows estimated energy resources in Australia.



Estimated energy resources in Australia

The length of a part of the graph can be used to estimate a percentage (%), meaning parts out of 100.



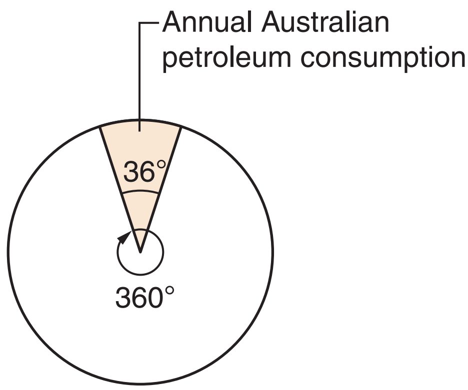
Australian petroleum reserves and annual petroleum consumption

Use a ruler to estimate to measure what fraction of Australia's petroleum reserves are consumed each year. Change the fraction to a percentage.

$$\text{\% of Australia's petroleum comsumed each year} = \frac{10 \text{ mm}}{100 \text{ mm}} = 10\%$$

Sector or pie graph

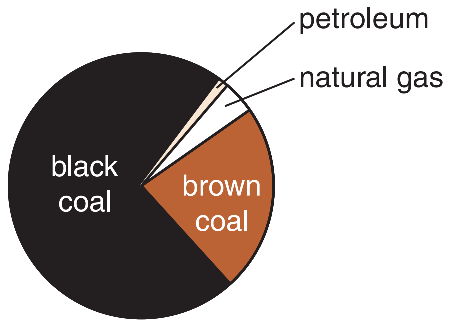
The information displayed in a divided bar graph can also be displayed as sectors of a circle. Then it is called a sector graph (parts shown as sectors of a circle) or a pie graph (parts shown like slices of a round pie).



Sector/pie graph showing Australian annual consumption and petroleum reserves

You need a protractor to measure the angle of a sector (pie slice). If a sector angle is 36° of the 360° in a circle then the sector represents:

$$\frac{36}{360} \times \frac{100}{1} = 10\% \text{ of the total.}$$



Sector/pie graph of estimated energy reserves in Australia

Complete Exercise 3.1: How long will Australia's fossil fuels last?

Australia may not have much in the way of petroleum reserves but it has a greater variety of energy resources than most countries. Australia does not use nuclear reactors to produce energy but it has over 30% of the world's main fuel for nuclear reactors, uranium.

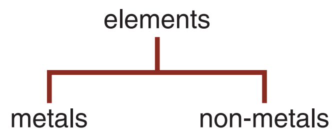
Australia also has plentiful solar energy, geothermal sources of heat energy from underground rocks and many places where wind energy can be used to generate electrical energy. These are renewable resources that can be used over and over again, many times.

Fossil fuels and uranium are non-renewable. Once used, they are lost forever. They are non-renewable resources.

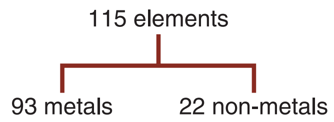
Lesson 12 – Metals and non-metals

Most of the information known about elements is presented using numbers in tables. However, information is often easier to remember, quicker to understand and more meaningful if you can visualise it in a graph.

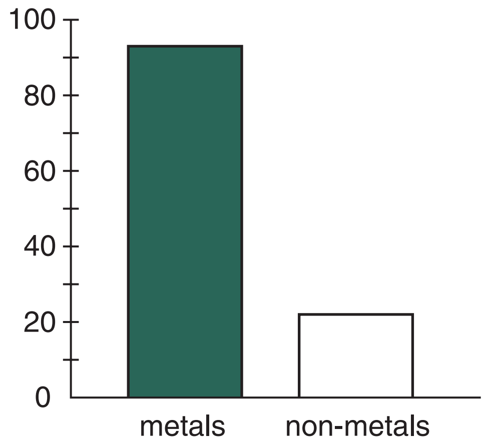
Take, for example, the division of elements into metals and non-metals.



There are more metals than non-metals.

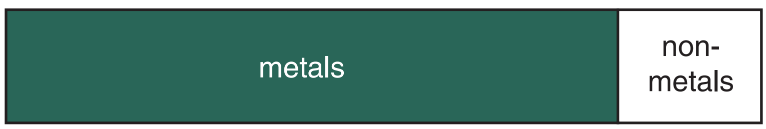


A column graph quickly shows you how many more metals there are compared with non-metals. Column graphs are very good for comparing.



Number of elements that are metals and non-metals

A divided bar graph is also good at showing proportions of elements that are metals or non-metals.



Metals and non-metals

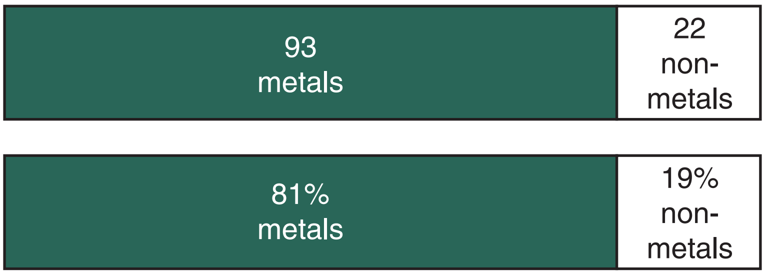
Activity: Measuring the percentage of elements that are metals

The bar in the divided bar graph of elements should be 100 mm long. Measure the length of the bar that is for metals. Use this measurement to work out the percentage of elements that are metals.

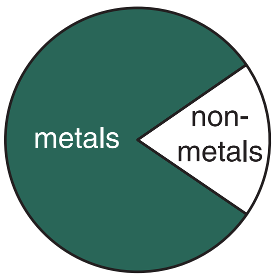
___

Check your answer.

Sometimes you do not need to estimate the number of or percentage of metals because the figure is provided in the divided bar graph.



A sector or pie graph is also good at showing the proportions of elements that are metals or non-metals.

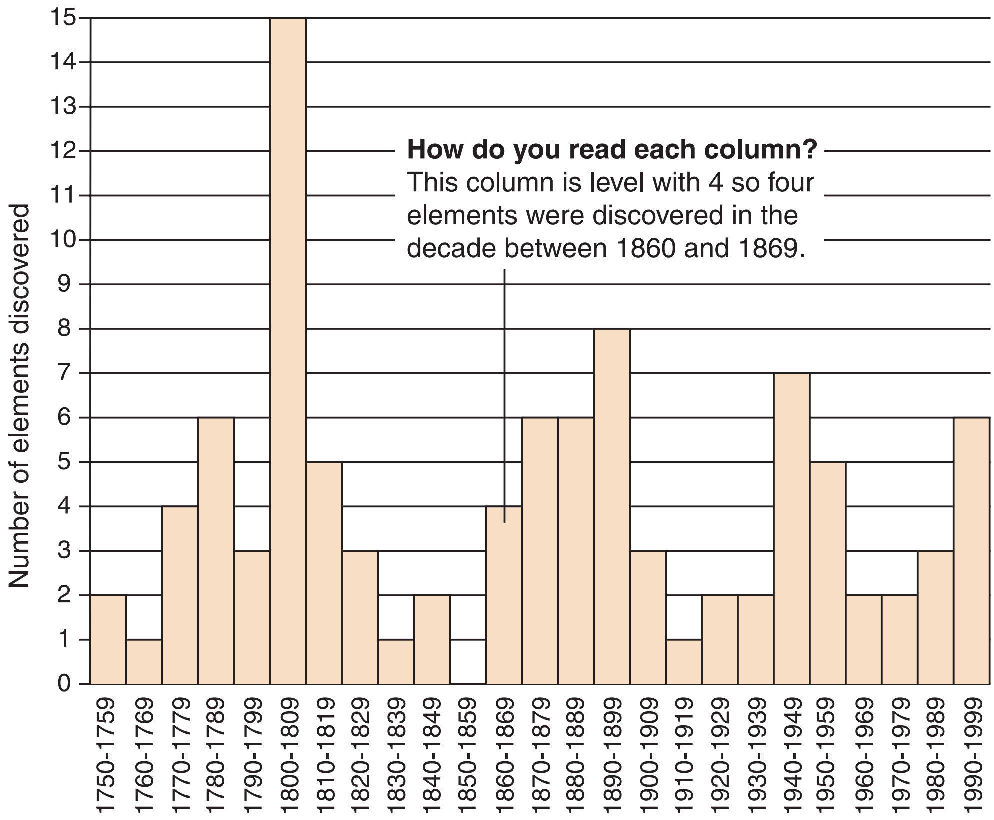


Metals and non-metals

Complete Exercise 3.2: Percentage of metals and non-metals

Histograms

The histogram following shows the number of new elements discovered each decade (every ten years) from 1750 to 1999. Only 16 elements had been discovered before this period; 115 elements were known by the year 2000.



Number of chemical elements discovered in each decade from 1750 to 1999

Histograms look a bit like column graphs but have important differences.

Column graph	**Histogram**
columns do not touch	columns touch
columns compare different things	same type of data in each column
each column has a different thing label	each column has a frequency range
not a frequency distribution	a frequency distribution – each column shows how often something happened
columns often arranged in increasing or decreasing size	columns rarely arranged in increasing or decreasing size

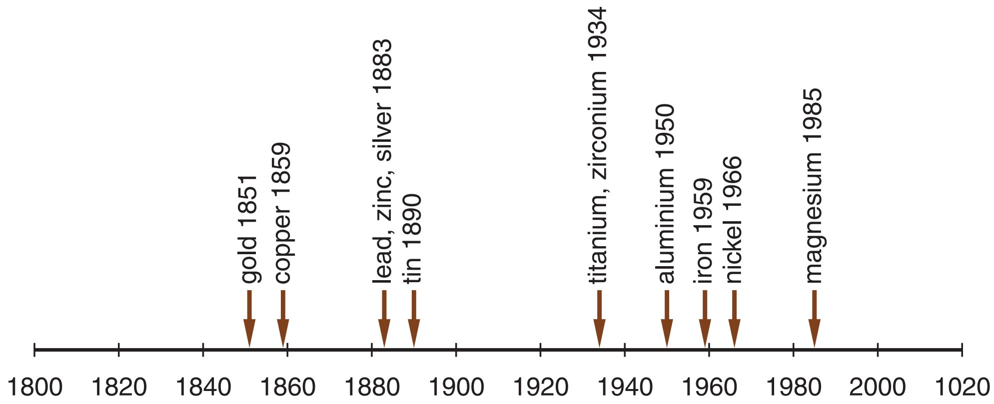
Check the features of a histogram that you can see:

- ❑ columns touch
- ❑ same type of data in each column
- ❑ each column has a frequency range below it
- ❑ each column shows how often something happened
- ❑ columns not arranged in decreasing or increasing size.

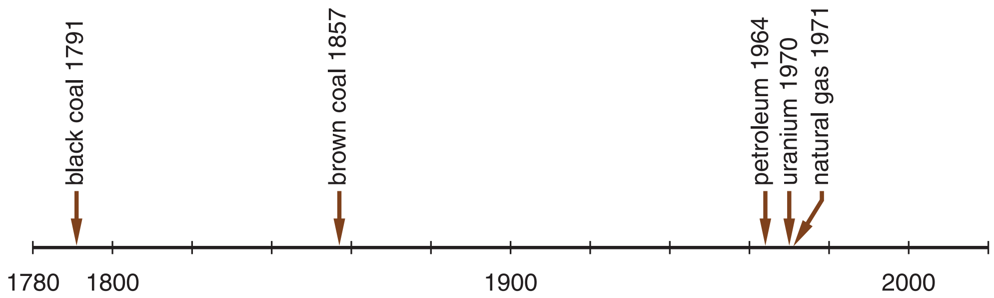
Timelines

A **timeline** is a straight line that shows order in time. The straight line is usually labelled with years or dates in years.

Here are timelines for the discovery of important resources in Australia



Timeline for discovery of major metal deposits in Australia



Timeline for discovery of important fuel deposits in Australia

Lesson 13 – Element abundance

What elements are found where?

How many of the different elements (as the element or as part of a compound) are present in the:

- Universe
- **lithosphere**, **hydrosphere** and **atmosphere**
- **biosphere**?

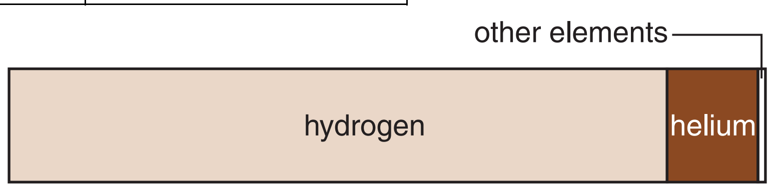
This information could be presented to you as tables or as graphs.

Elements in the Universe

Suppose you wanted to know which elements are most common in the Universe. This information could be provided in a table or as a divided bar graph.

Table of the most common elements in the Universe

Element	% mass of Universe
hydrogen	87
helium	12
oxygen	0.06
carbon	0.03
neon	0.02
nitrogen	0.01



Divided bar graph of the most common elements in the Universe

Activity: Comparing table and graph data

1 What is an advantage of presenting data as a divided bar graph?

____

____

2 What is a disadvantage of presenting data as a divided bar graph rather than in a table?

____

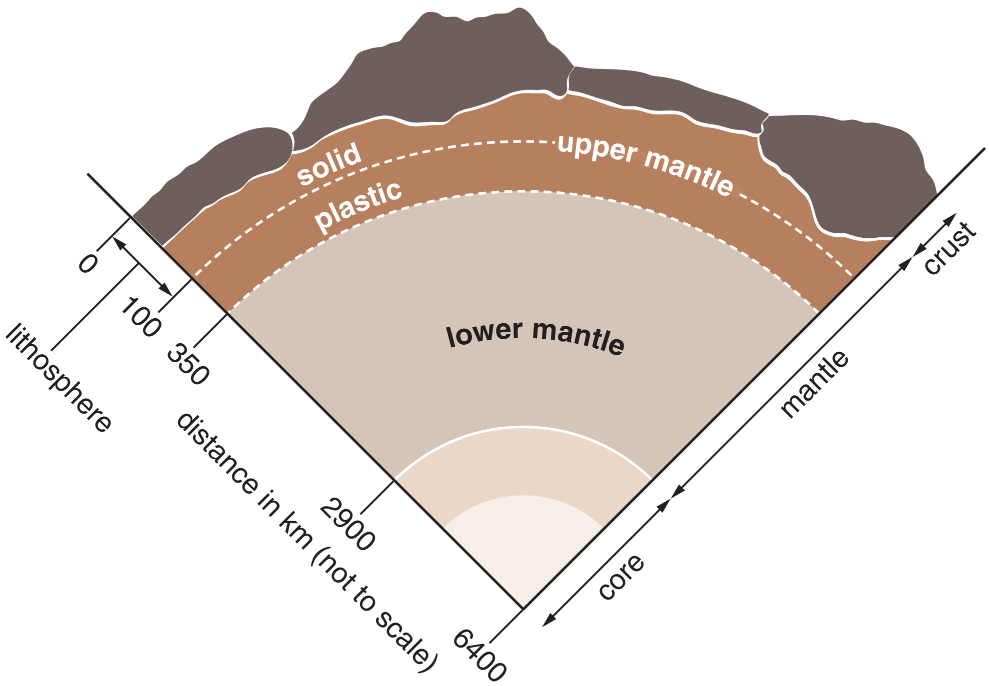
____

Check your answers.

Elements in the lithosphere

The outer layer of the Earth is called the crust. Below the crust is the mantle and towards the centre is the core. Most of the core consists of magnetic elements, iron and nickel. These elements are believed to be the source of the Earth's magnetism.

The lithosphere consists of the solid rocks of the crust and the solid upper mantle.



Layers of the Earth

Table of the most common elements in Earth's crust and lithosphere

Element	**Crust (% by mass)**	**Lithosphere (% by mass)**
oxygen	49	45
silicon	27	25
aluminium	8	8
iron	4	6
calcium	3	5
magnesium	2	3

Activity: Comparing elements in the lithosphere

Compare the most common elements in the crust and the lithosphere. Which elements would you expect to find in higher percentages in the mantle than in the crust? Choose the best answer.

A oxygen and silicon

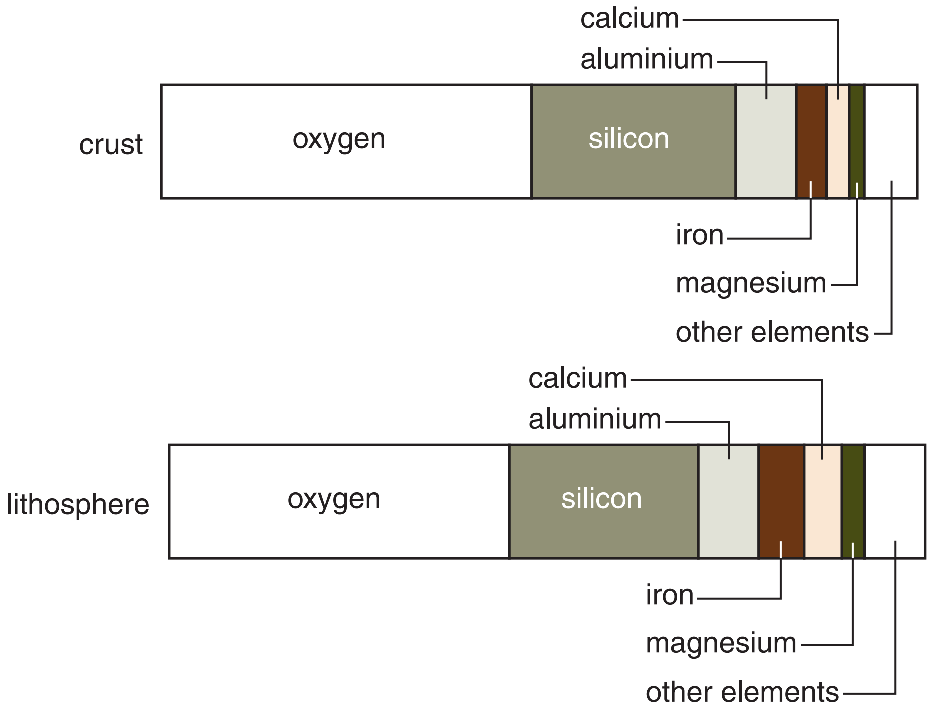
B aluminium, iron, calcium and magnesium

C iron, calcium and magnesium

D oxygen, silicon and aluminium.

Check your answer.

Instead of a table, two divided bar graphs could be used:



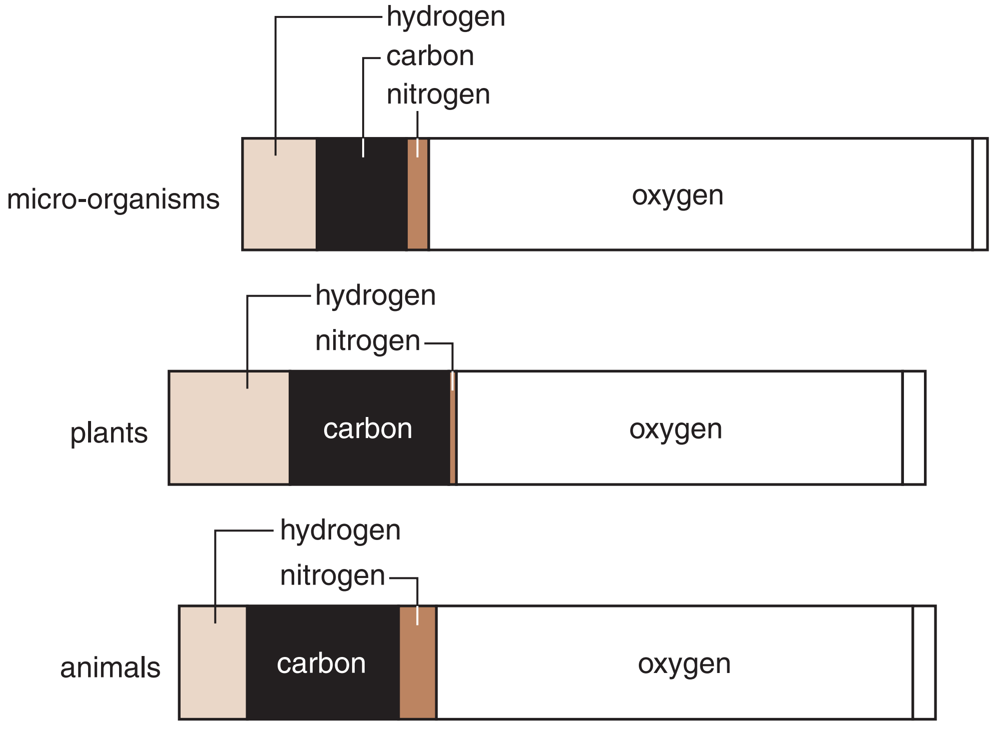
Divided bar graphs of the most common elements in Earth's crust and lithosphere

Elements in biosphere

Compare the most common elements in living things. These figures are average values because there is great variation within micro-organisms (bacteria, yeasts, moulds), plants (flowering, cone-bearing, ferns) and animals (vertebrates and invertebrates). The figures show percentage by mass.

Table of the most common elements in different living things

Element	**Micro-organisms**	**Plants**	**Animals**
hydrogen	10	16	9
carbon	12	21	20
nitrogen	3	1	5
oxygen	73	59	63
phosphorus	1	1	2
sulfur	0.3	0.1	0.6



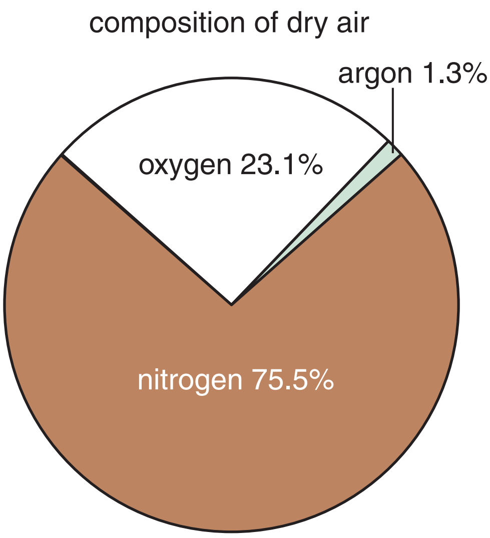
Divided bar graphs showing most common elements in different living things

What is the most effective way to communicate this data—a table of figures or a divided bar graph?

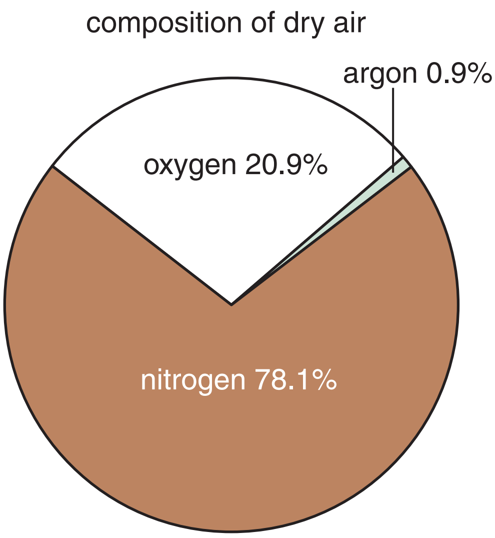
You could design an experiment to see if people can extract the information most quickly or most accurately from a table of figures or a divided bar graph.

Elements in the atmosphere

Compare these two sector graphs. They are both correct. But why are they different?



Composition of dry air by mass



Composition of dry air by volume

One graph shows percentage by mass while the other shows percentage by volume.

Can you use the two graphs to work out which of the gas molecules is heaviest? Which is lightest? Explain your answers.

Argon is heaviest as 0.9% by volume becomes 1.3% by mass. The percentage by mass is nearly one and a half times the percentage by volume.

Nitrogen is lightest as the percentage by volume is the only one that is larger than the percentage by mass.

You may have heard the phrase ‘comparing apples and oranges’. This phrase points out that it is difficult to compare unlike things.

What is wrong with saying ‘dry air is 75.5% nitrogen and 20.9% oxygen’?

The figure for nitrogen is percentage by mass while the figure for oxygen is percentage by volume.

A way of reducing the chances of ‘comparing apples and oranges’ is to check that what you are comparing have the same units. It is very important that any graph displaying complex data has all units shown clearly.

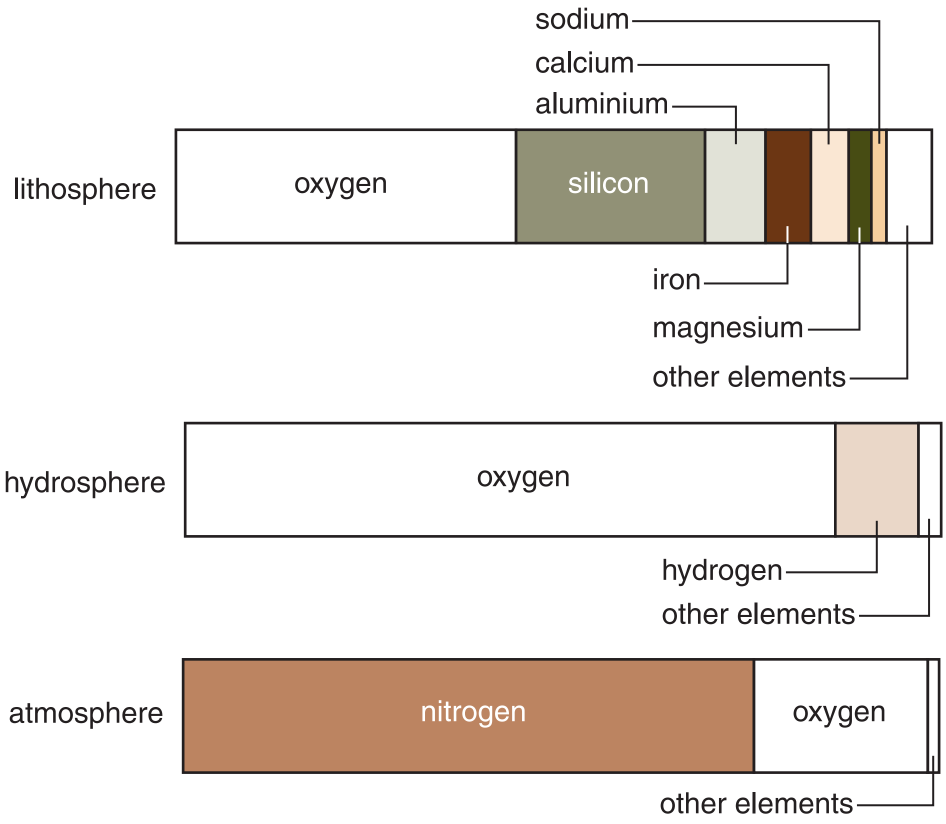
Elements in the spheres

The table below shows percentage by mass of the most common elements in the lithosphere, hydrosphere and atmosphere of the Earth.

Percentage by mass of elements in the lithosphere, hydrosphere and atmosphere

Element	**Lithosphere**	**Hydrosphere**	**Atmosphere**
hydrogen	0.15	11	-
carbon	0.02	-	-
nitrogen	-	-	75.5
oxygen	45	86	23
sodium	2	1	-
magnesium	3	-	-
aluminium	8	-	-
silicon	25	-	-
chlorine	-	2	-
argon	-	-	1.3
calcium	5	-	-
iron	6	-	-

Compare the table with divided bar graphs following.



Suggest a reason why this data is best shown in a table rather than a graph.

Many of the elements are found in only one of the spheres, e.g. nitrogen is only found in significant quantities in the atmosphere. Graphs are better for comparing things that have common components.

Complete Exercise 3.3: Composite graphs.

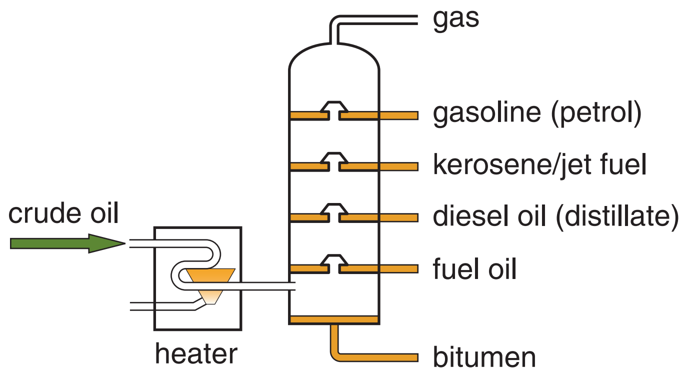
Lesson 14 – Petrochemicals

Petroleum ('rock oil'), commonly called crude oil, is the world's most important non-renewable source of energy. The world's petroleum production is expected to peak in 2006 and then decline. In 2003 $8 billion was spent worldwide on exploration that discovered $4 billion worth of oil. In the same year no oil field containing more than 500 million barrels was discovered anywhere in the world. That year Australia consumed over 300 million barrels of oil.

At present over 95% of petroleum is burnt as fuel, mostly for transport, e.g. cars, trucks, ships and planes. Less than 5% is separated into pure substances and used to make plastics, synthetic rubbers and synthetic fibres for textiles, paints, detergents and pesticides.

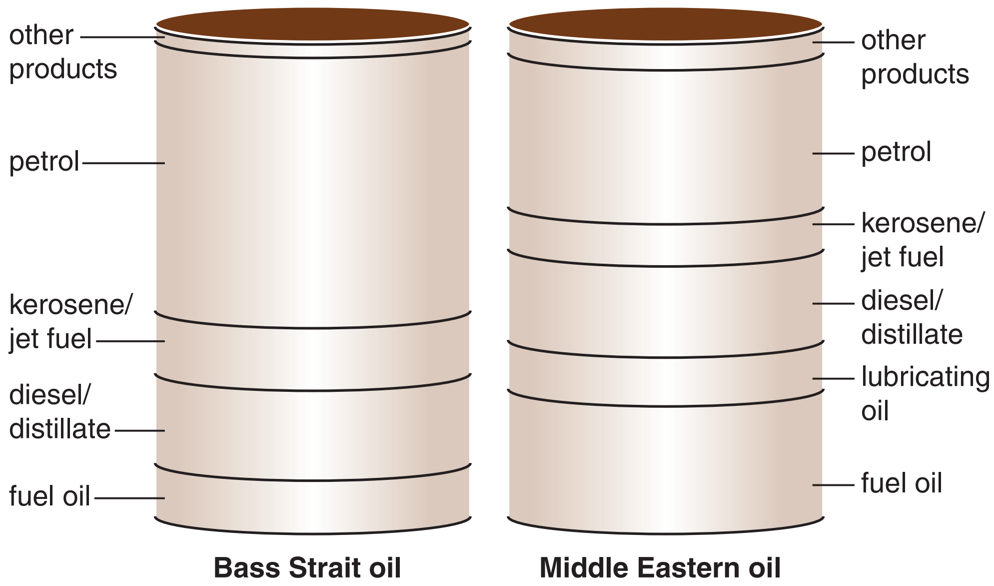
Petroleum is heated out of contact with air to separate it into fractions with different boiling points. Separation occurs in the tall fractional distillation columns that can be seen at a petroleum refinery.

The liquid with the lowest boiling point evaporates and reaches the top of the fractionating column first. The liquid with the highest boiling point will evaporate last and collect at the bottom of the fractionating column.



Fractional distillation of petroleum

Petroleums from different parts of the world have different compositions.



Comparison of Australian Bass Strait oil and a Middle Eastern oil

Activity: Discussion about Australia's oil needs

Discuss, with at least one other person, why 'Australia, a country that can produce about as much oil as it needs, exports some of its Bass Strait oil and imports some Middle Eastern oil'.

List the main points that came out of your discussion:

____

____

____

____

____

____

Compare your main points with those in the answer pages.

Petrochemicals from oil

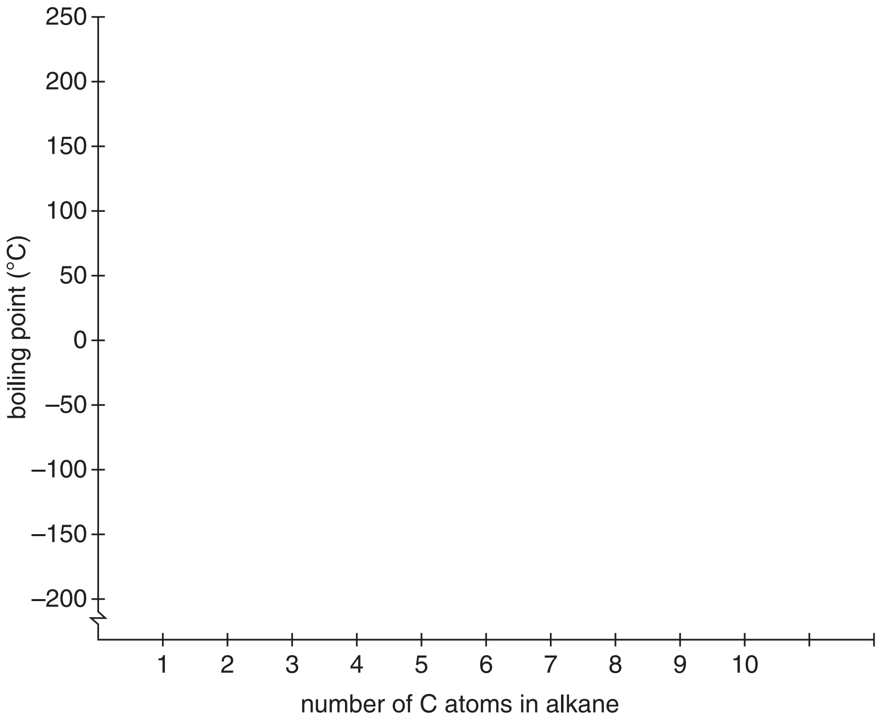
A petrochemical is any chemical compound obtained from petroleum.

A compound is usually isolated from a petroleum fraction by fractional distillation. Most of the compounds are hydrocarbons—compounds of hydrogen and carbon only.

The most common petrochemical compounds are alkanes – compounds which have the formula C_nH_{2n+2} where n = 1,2,3,4, etc.

Formula, name and boiling point of some alkanes

Formula	**Name**	**Boiling point (°C)**
CH_4	methane	–162
C_2H_6	ethane	–89
C_3H_8	propane	–42
C_4H_{10}	butane	–1
C_5H_{12}	pentane	36
C_6H_{14}	hexane	
C_7H_{16}	heptane	98
C_8H_{18}	octane	126
C_9H_{20}	nonane	151
$C_{10}H_{22}$	decane	174



Activity: Drawing and using a scattergram

1 Use the information in the table to mark the boiling point for each alkane with an X on the graph following.

The graph you have drawn is called a scattergram. A scattergram displays the distribution of two variables. In this graph the two variables are the boiling point and the number of carbon atoms in the molecule. Each point of the graph represents a pair of the two variables.

The points can be connected to produce a line of best fit.

2 Place the straight edge of a transparent plastic ruler along the points so that:

- the line shows the trend in the data
- there are about as many points above the line as below the line.

Now draw a straight line of best fit so that the line has about as many points above it as below it. It's OK for the line to go through some of the points. If you marked each data point with an X you can still see the scattergram data on which the line is based.

A line of best fit can be used to predict a missing point between other points (this is called interpolation) or predict a point beyond the plotted points (this is called extrapolation).

3 Use your line of best fit to predict the boiling point of hexane, the alkane with six carbon atoms in its molecule. Doing this uses interpolation.

4 Extend your straight line of best fit beyond the point for decane $C_{10}H_{22}$. Use this extrapolation to predict the boiling points of undecane $C_{11}H_{24}$ and dodecane $C_{12}H_{26}$.

Check your answers.

Complete Exercise 3.4: Scattergram and line of best fit.

Lesson 15 – Review of graph types

This lesson reviews different types of graphs. You will extract information from graphs that give data about elements and compounds.

Activity: Data for graphs

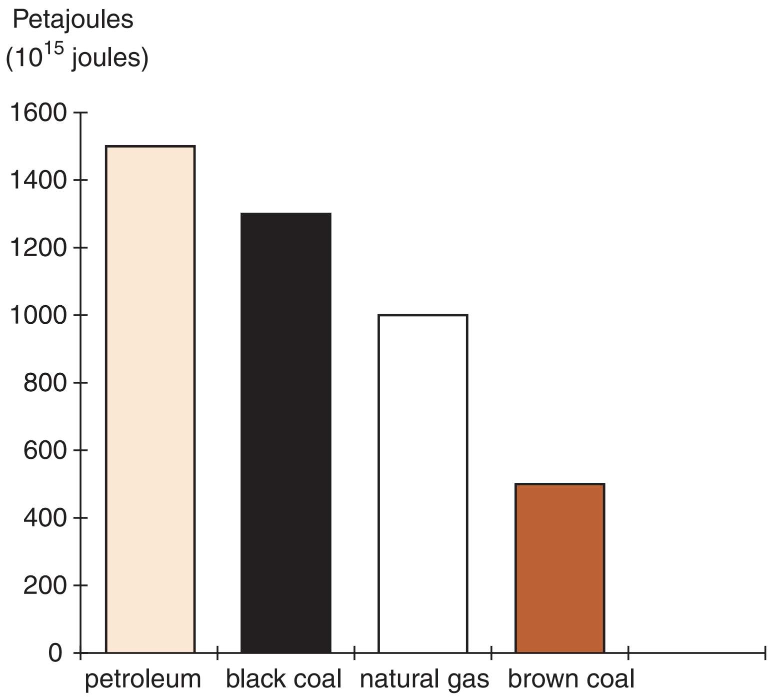
Why is so much data available for elements and compounds but not mixtures?

____

____

Check your answer.

Column graphs are used to compare quantities.

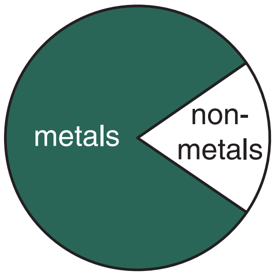


Column graph of Australian consumption of petroleum in 2000

Divided bar graphs display the parts of a total as divided parts of a rectangular bar.

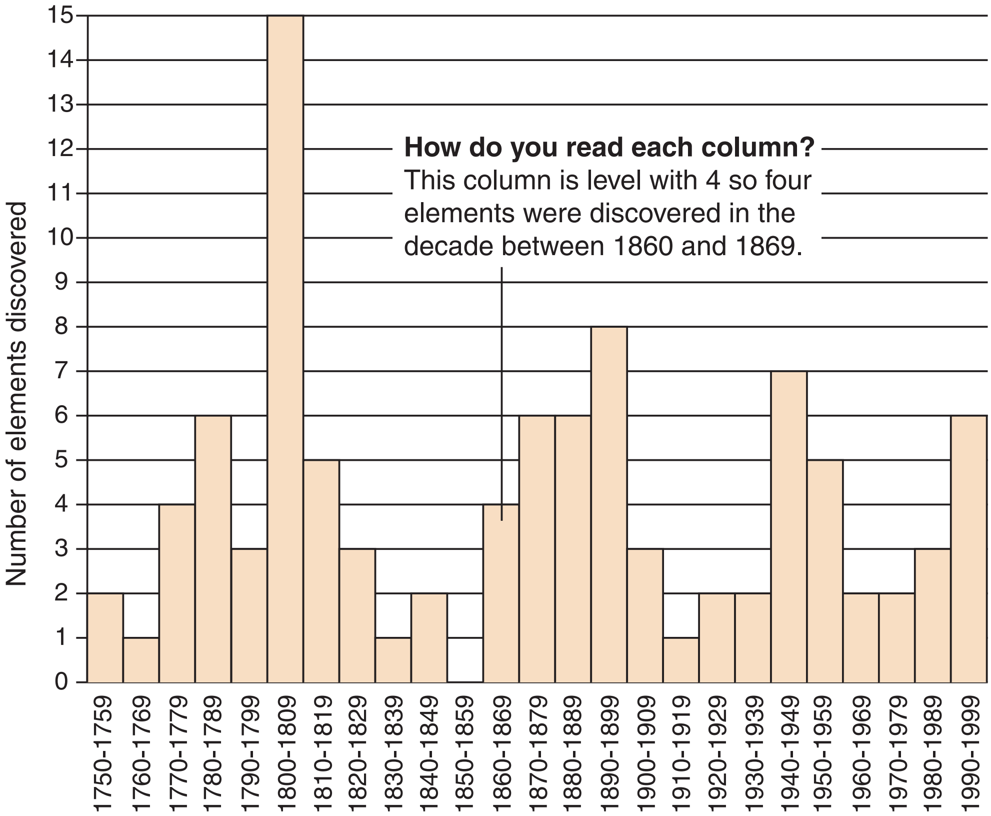
Divided bar graph of metals and non-metals

Sector or pie graphs display the parts of a total as sector parts of a circle.



Sector graph of metals and non-metals

A **histogram** is used to display frequency distributions.



Number of chemical elements discovered in each decade from 1750 to 1999

Activity: Histogram

1 In which decade was the greatest number of elements discovered?

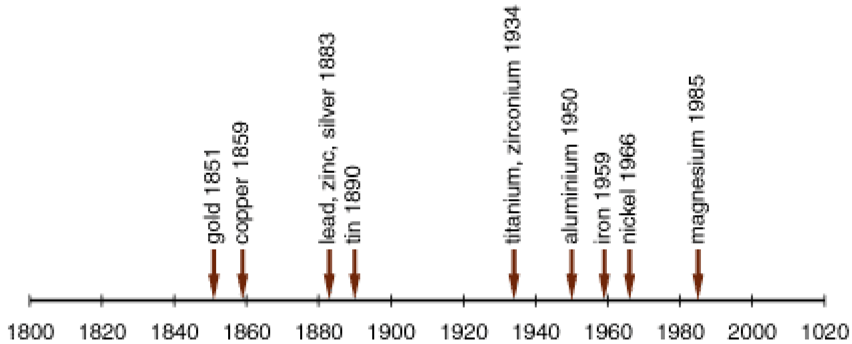
____

2 In which decade were no elements discovered?

____

Check your answers.

A **timeline** displays the order in time for events.



Timeline for major metal discoveries in Australia

Activity: Timeline

In which decades were the most major mineral discoveries made in Australia?

____

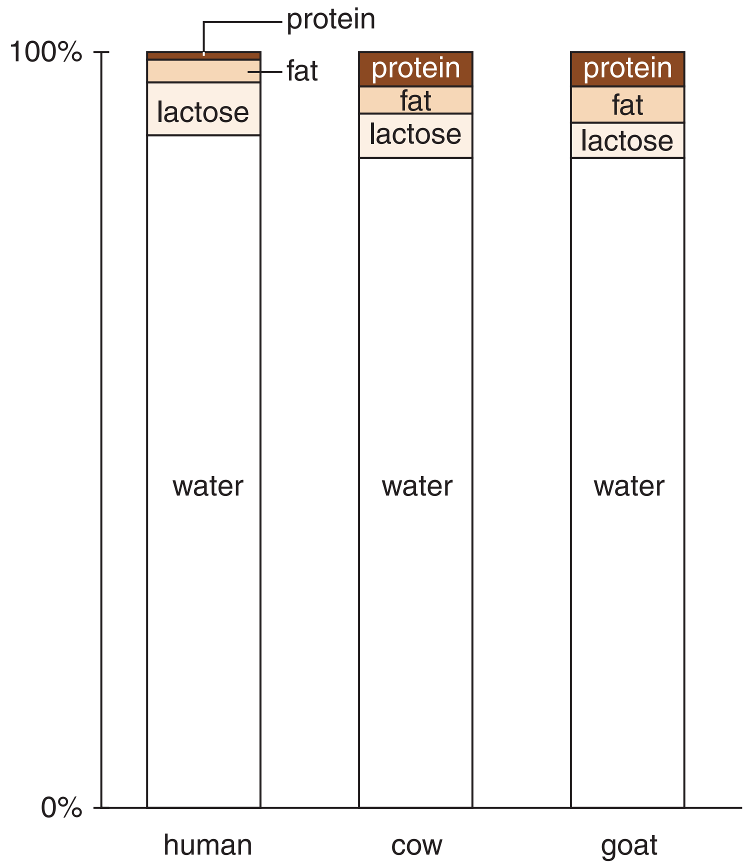
Check your answer.

Composite graphs display complex data. They can be used to comparison of large quantities of data. Composite graphs are often a combination of two types of graph.

Activity: Composite graph

What are the two types of graph combined in the composite graph that follows?

____



Compounds in different types of milk

Check your answer.

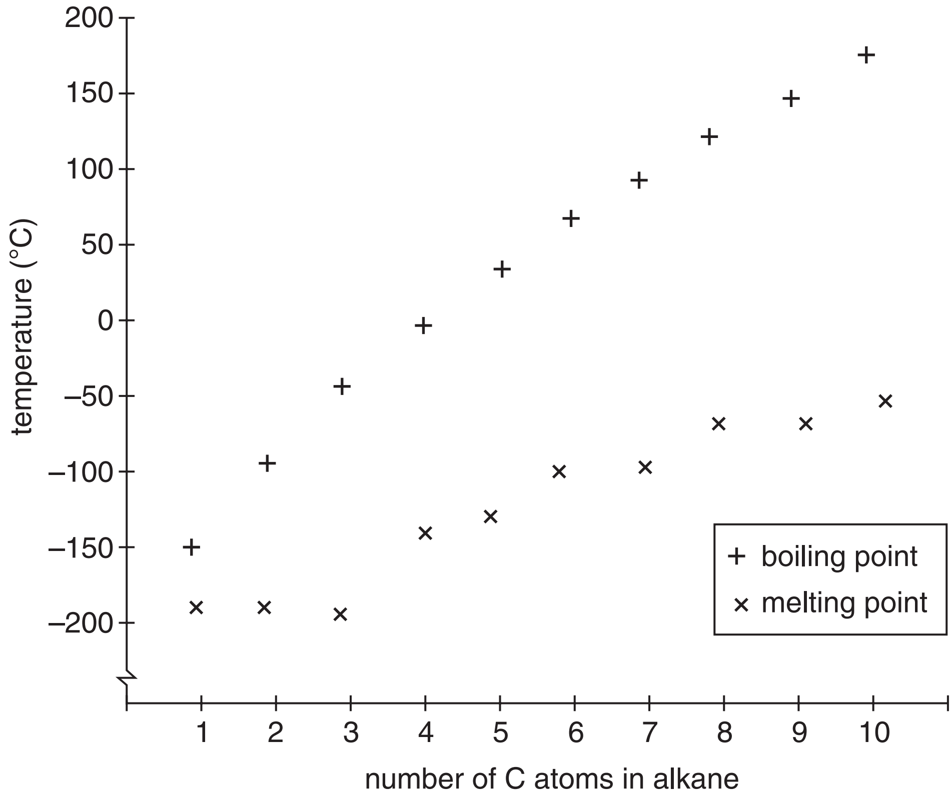
Scattergrams display the distribution of two variables.

The variable you start with in the investigation is placed along the horizontal (x) axis. This is the manipulated variable that you change. It is called the independent variable.

The variable that changes according to the independent variable is placed along the vertical (y) axis. This is the responding variable that changes as the independent variable is changed. The responding variable is called the dependent variable.

A scattergram shows each measurement. The scatter of the points shows any trend. A line or curve of best fit can be drawn to make the trend more obvious.

If a point does not fit the trend it could be due to an error in making that measurement. Or it could be due to something unexpected or as yet unexplained happening. Investigating unexpected features of a graph can lead to greater understanding.



Scattergram of melting points and boiling points of alkanes

Boiling points of alkanes increase as the molecules get bigger.

The melting points do not change as smoothly as the boiling points. The melting points generally increase as the molecules get bigger. But how closely the molecules are packed together can also affect the melting point. Chemists study the shapes of molecules and how they fit together.

Suggested answers – Part 3

Activity: Australia's consumption of energy from the ground

1 Petroleum (1500 pJ) provided the most energy in Australia in 2000. If brown and black coal figures are combined, then coal (1800 pJ) provided the most energy.

2 a Yes. Most food energy comes from plants grown in soil or animals that eat plants grown in soil.

b You would add a column to the right of brown coal to keep arrangement of decreasing size.

Activity: Measuring the percentage of elements that are metals

Metals are shown as 81 mm of the 100 mm in the graph. Therefore:

$\frac{81}{100} \times 100 = 81\%$ of elements are metals.

Activity: Comparing table and graph data

1 A divided bar graph helps you to see the parts of a whole and how large the parts are compared with one another.

2 Numbers in the table may not be included in a divided bar graph. So, it may be difficult to calculate the proportions of each part of the whole.

Activity: Comparing elements in the lithosphere

A *incorrect*: oxygen and silicon are more common in the crust than the lithosphere

B *incorrect*: aluminium has the same percentage in both crust and lithosphere

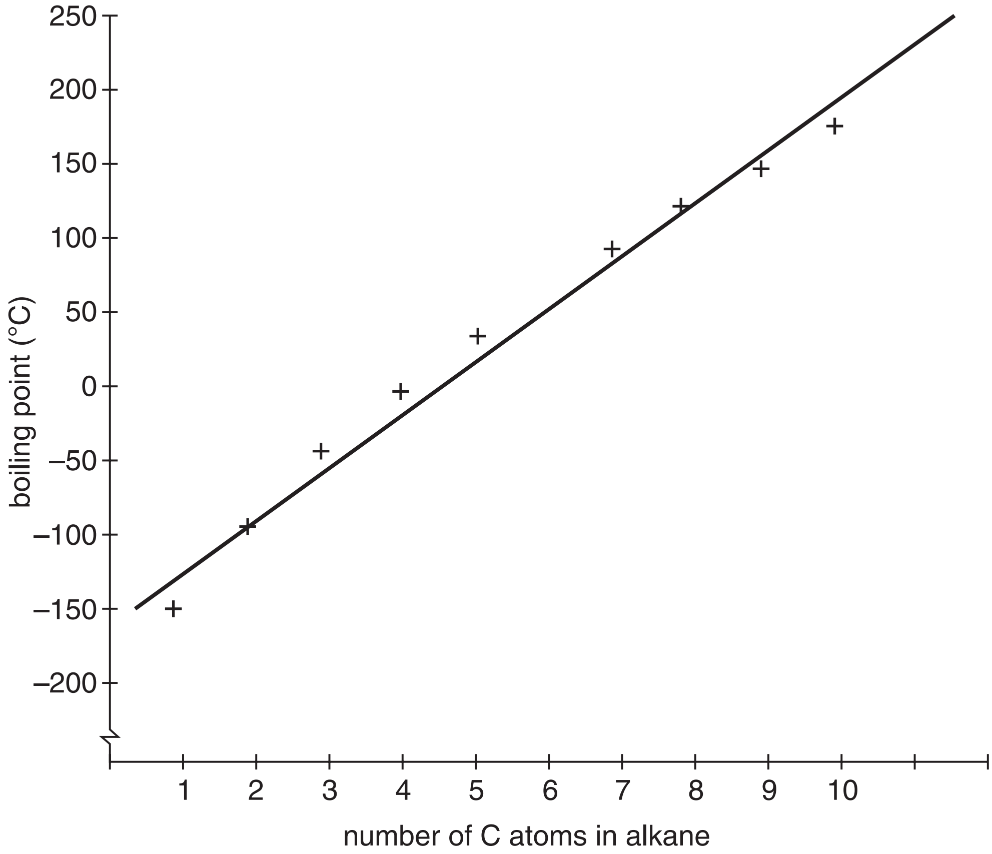
C *correct*: iron, calcium and magnesium all have higher percentages in the lithosphere (upper mantle + crust) than in the crust

D *incorrect*: oxygen and silicon are more common in the crust than the lithosphere.

Activity: Discussion about Australia's oil needs

- Bass Strait oil is a different mixture of compounds compared with Middle Eastern oil
- Middle Eastern oil contains lubricants missing from Bass Strait oil; more petrol and jet fuel can be obtained from Bass Strait oil.
- Oil is mostly sold by private companies. Most of their decisions are designed to maximise profits for owners and shareholders.
- Middle Eastern oil supplies (oil reserves) are much greater than Australian oil supplies.

Activity: Drawing and using a scattergram



3 Your prediction should be in the range 65-70°C. 69°C is the actual boiling point of hexane.

4 196°C and 216°C are the actual boiling points.

Activity: Data for graphs

Elements and compounds are pure substances and so have fixed properties that can be measured. Properties of a mixture vary according to the proportions of the different parts of the mixture—there are too many possible pieces of data to record.

(Data is available on 115 elements and over 20 000 000 compounds).

Activity: Histogram

15 elements were discovered in the decade 1800-1809.

No elements were discovered in the decade 1850-1859.

Activity: Timeline

1850–59 decade (this was the decade in which Australia’s population had the greatest percentage increase from immigration, largely due to the gold rush and 1950–59 decade.

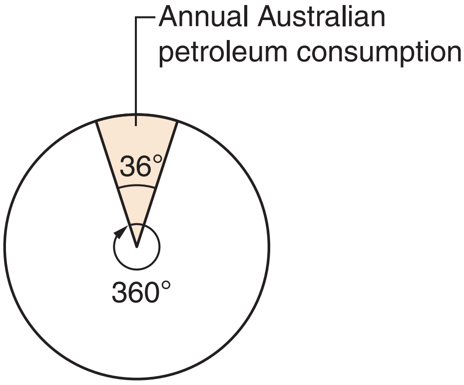
Activity: Composite graphs

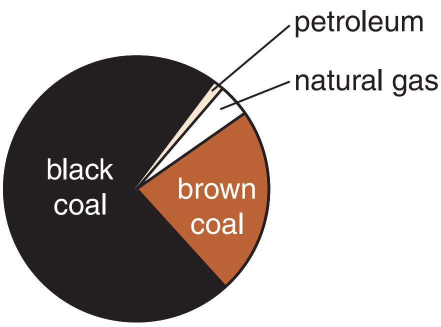
Column graph and divided bar graphs.

Exercises – Part 3

Exercise 3.1: How long will Australia's fossil fuels last?

Use the graphs below to answer the questions that follow.





1 Estimate how long petroleum reserves will last at the present rate of consumption? (Assume no petroleum is imported.)

____

2 Australia exports about as much petroleum as it imports. How will this affect how long Australia's petroleum reserves last?

____

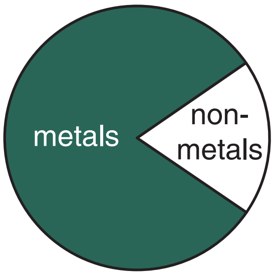
3 Australia is the biggest exporter of coal in the world. If this continues, how will it affect Australian coal reserves?

____

____

Exercise 3.2: Percentage of metals and non-metals

Use a protractor to measure the angle of the sector representing non-metals.



1 Why is it easier to measure the angle for non-metals than for metals?

___

___

2 If the whole circle is 360° what fraction of the circle represents non-metals?

___

___

3 Convert the fraction for non-metals to a percentage for non-metals.

___

___

4 Explain an easy way to calculate the percentage of elements that are metals (without measuring the angle).

___

___

Exercise 3.3: Composite graphs

Composite graphs are useful for displaying complex data or comparing large quantities of data. A table full of numbers may contain much more detail but a composite graph can make things clearer.

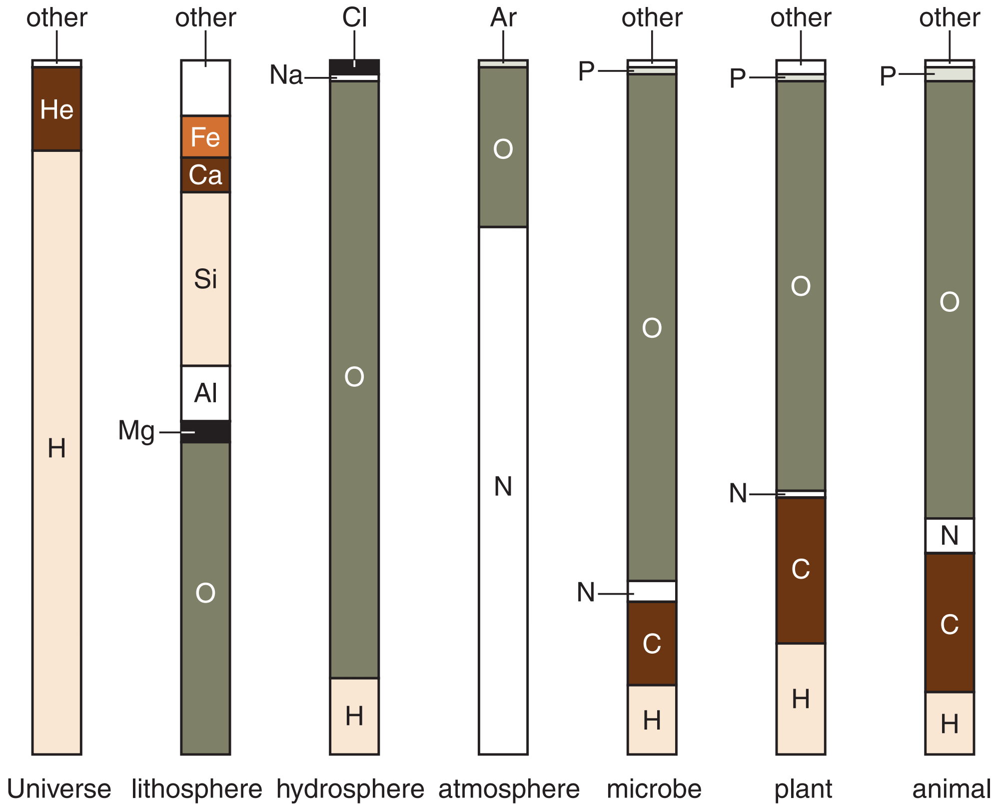
When you present information consider:

- the audience
- the purpose of the information
- the best way to organise the information.

Compare the table and the composite graph below that summarises data from this lesson.

Percentage by mass of elements

Element	Universe	Lithosphere	Hydrosphere	Atmosphere	Microbe	Plant	Animal
H	87		11		10	16	9
He	12						
C					12	21	20
N				76	3	1	5
O		45	86	23	73	59	63
Na			1				
Mg		3					
Al		8					
Si		25					
P					1	1	2
Cl			2				
Ar				1			
Ca		5					
Fe		6					
others	1	8			1	2	1



1 What must the audience know about elements to make sense of the table and the graph?

2 Discuss whether the table and the composite graph have the same purpose.

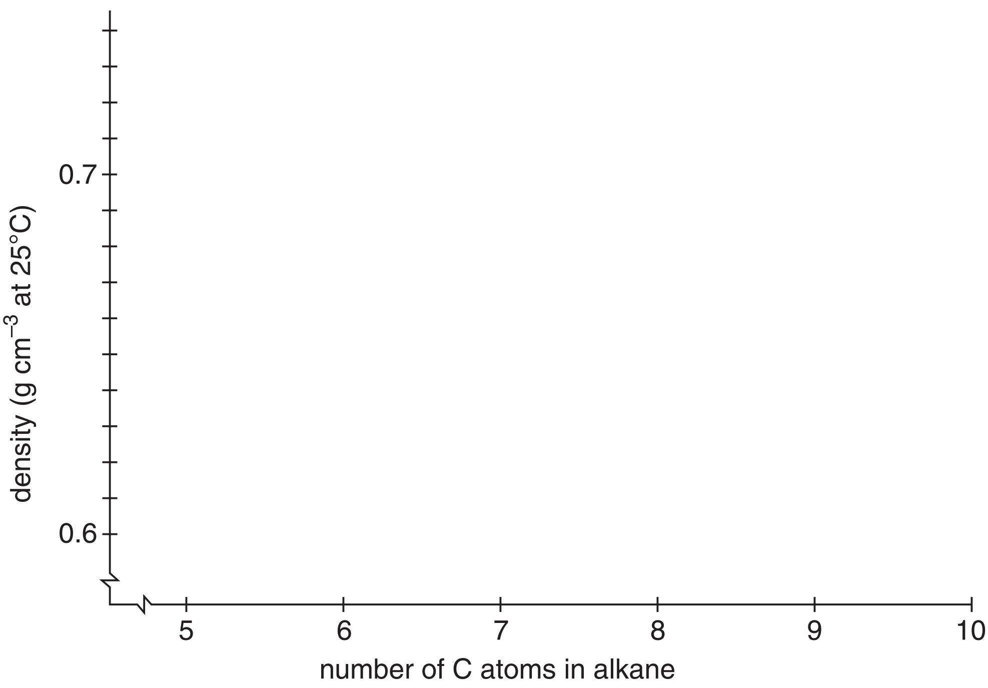
3 Discuss the advantages and disadvantages of using a composite graph rather than a table.

Exercise 3.4: Scattergrams and line of best fit

Use the density data in the table following to draw a scattergram and line of best fit for liquid alkanes pentane to decane.

Density of some liquid alkanes

Formula	**Name**	**Density (gcm^{-3} at 25°C)**
C_5H_{12}	pentane	0.621
C_6H_{14}	hexane	0.655
C_7H_{16}	heptane	0.680
C_8H_{18}	octane	0.698
C_9H_{20}	nonane	0.714
$C_{10}H_{22}$	decane	0.726



Unit evaluation

Name ______________________________

Teacher ______________________________

We need your input! Can you please complete this short evaluation to provide us with information about this unit. This information will help us to improve the design of these materials for future publications.

1 Did you find the information in the unit clear and easy to understand?

____

____

____

2 What sort of learning activity did you enjoy the most? Why?

____

____

3 Name any sections you feel need better explanation (if any).

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4 Were you able to complete each part in around 5 hours? If not which parts took you a longer or shorter time?

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5 Do you have access to the appropriate resources? This could include a computer, the Internet, equipment and people to provide information and assist with the learning.

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Centre for Learning Innovation
NSW Department of Education and Training
51 Wentworth Road
Strathfield NSW 2135