4 Building blocks of matter

Planning page

- Getting started
- 4.1 Atoms and molecules page 69
- 4.2 Elements and compounds page 71
  - Activity page 72
  - Investigate 8 Flame tests
  - Activity page 77
  - Assessment task 4 Minor elements
- 4.3 Chemical reactions page 80
  - Investigate 9 Making a compound
  - Investigate 10 Breaking a compound
  - Animation Water reaction
- Main ideas
  - Chapter 4 crossword
- Review
  - Chapter 4 test

Essential Learnings for Chapter 4

Essential Learnings	*References*		
	Student book (page number)	*Workbook (page number)*	*Teacher Edition CD (Assessment task)*
Knowledge and understanding ***Natural and processed materials*** Matter can be classified according to its structure	pp. 69, 74, 83	pp. 27–30, 32	Assessment task 4 Minor elements
Chemical reactions can be described using word and balanced equations		Exercise 8 p. 31	
Science as a human endeavour People from different cultures contribute to and shape the development of science	p. 70 p. 73		
Ways of working Conduct and apply safety audits and identify and manage risks	Investigate 9–10 pp. 80–82		
Evaluate data, information and evidence to identify connections, construct arguments and link results to theory	Investigate 9–10 pp. 80–82		
Communicate scientific ideas, explanations, conclusions, decisions and data, using scientific argument and terminology, in appropriate formats	pp. 71–72		Assessment task 4 Minor elements

QSA Science Essential Learnings by the end of Year 9

Vocabulary

aluminium
calcium
chlorine
compound
elements
formula
hydrogen
molecule
nitrogen
oxygen
phosphorus
sodium chloride
sulfide
sulfur
symbol
zinc

Focus for learning

Prepare a news item about an imaginary journey by Super-Sci through the particles of solids, liquids and gases (page 68).

Equipment and chemicals (per group)

Investigate 8 page 74	Bunsen burner, small atomiser bottles containing 0.5M solutions of soluble metal salts (eg barium chloride, calcium chloride, copper sulfate, potassium chloride, sodium chloride, strontium chloride), unknown metal solution
Activity page 77	molecular models kit (ball-and-stick or space-filling type)
Investigate 9 pages 80–81	powdered sulfur, iron powder, dilute hydrochloric acid (1M), spatula, bar magnet, small test tube, Bunsen burner, tripod and heatproof mat, aluminium foil, crucible, pipeclay triangle
Investigate 10 page 82	dilute sulfuric acid (1M), voltameter, 2 pyrex test tubes, wooden splint (eg paddle-pop stick), distilled water, power pack, taper

Starting point

1 Allow the students some brainstorming time to plan the Getting Started activity. The activity works well as a group-work task and can be presented orally, particularly if students choose to be TV news reporters. Encourage them to be creative but scientifically factual. Computers may help. It is a good idea to set time limits for different parts of the activity. One lesson should be sufficient.

2 It is important for students to get some idea of the size of atoms. Present some fascinating points to the class about atoms, such as the following:

- Explain to students that there are about as many atoms in the air in one person's lungs at any moment as there are breaths of air in the atmosphere of our world. It takes around six years for one exhaled breath of air to be evenly mixed in our atmosphere. On average, each breath you breathe in will contain one of the atoms from one person's exhaled breath.
- In one gram of water (just over a teaspoonful) there are about 10^{23} atoms—that is 1 with 23 zeros after it, which is a huge number. It may be helpful to write the number on the board and ask the class to check you have written the correct number of zeros. Fill a beaker with water and ask them to estimate how many atoms they think it contains.
- To further illustrate how small atoms are, hand out to the students some flat-headed steel nails and ask them to estimate how many atoms they think the nail head contains. (They can base their estimate on the fact that eight million atoms placed side by side would fit across the head of a pin.)

4 Building blocks of matter

Getting Started

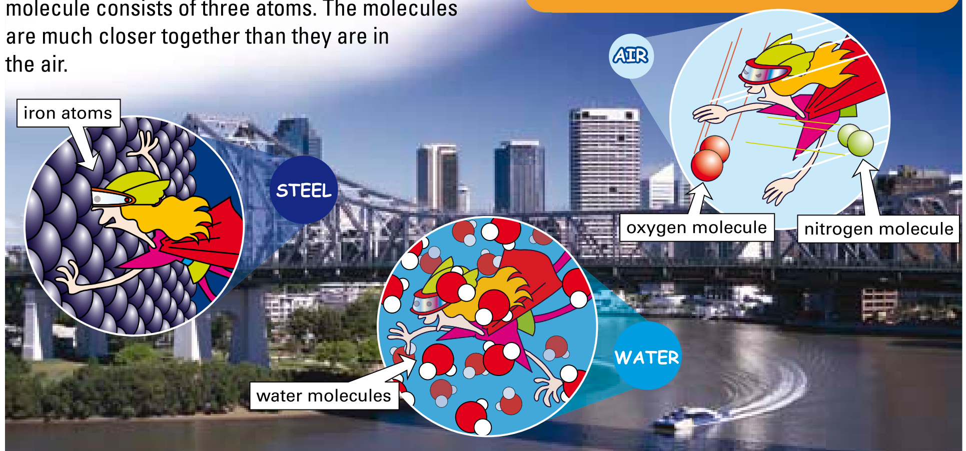
Meet Super-Sci. She can make herself smaller and smaller until she is not much bigger than the tiny invisible particles in all matter. These are called atoms and molecules.

Super-Sci travels through the air where she sees nitrogen and oxygen molecules. These are 'double atoms', made of two atoms stuck together. They are whizzing past at about 1800 km/h, all moving in different directions. Occasionally they collide with each other.

When Super-Sci dives into the river, she finds herself surrounded by water molecules. Each molecule consists of three atoms. The molecules are much closer together than they are in the air. They often touch each other and are constantly moving past one another, continually changing their positions.

Finally Super-Sci tries to push her way into the steel in the bridge, but the ball-like iron atoms are so close together she can't crawl through. The iron atoms stay in their places, but they are constantly vibrating. Super-Sci counts the atoms and calculates that about eight million of them placed side by side would fit across the head of a pin!

Imagine you are a TV news or current affairs presenter. Prepare a news item on Super-Sci's fantastic voyage.



4.1 Atoms and molecules

In *ScienceWorld 1* you learnt about the tiny particles that make up all matter. For example, if you could break a piece of gold into smaller and smaller bits you would eventually end up with a single atom of gold.

Atoms are the basic building blocks of all matter—both living and non-living. They are incredibly small. To give you some idea of their size, there would be 10 000 000 000 000 000 atoms in the dot at the end of this sentence. This means that there are about 2500 times more atoms in the dot than there are people in the world!

Atoms are not usually found on their own. Two or more atoms joined together is called a **molecule**. For example, an oxygen molecule consists of two oxygen atoms held together by a chemical bond.

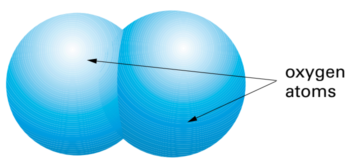


Fig 2 An oxygen molecule is made up of two oxygen atoms bonded together.

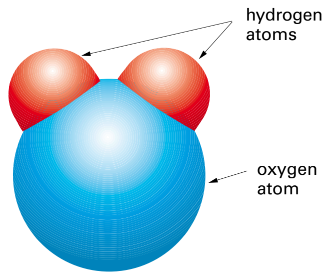
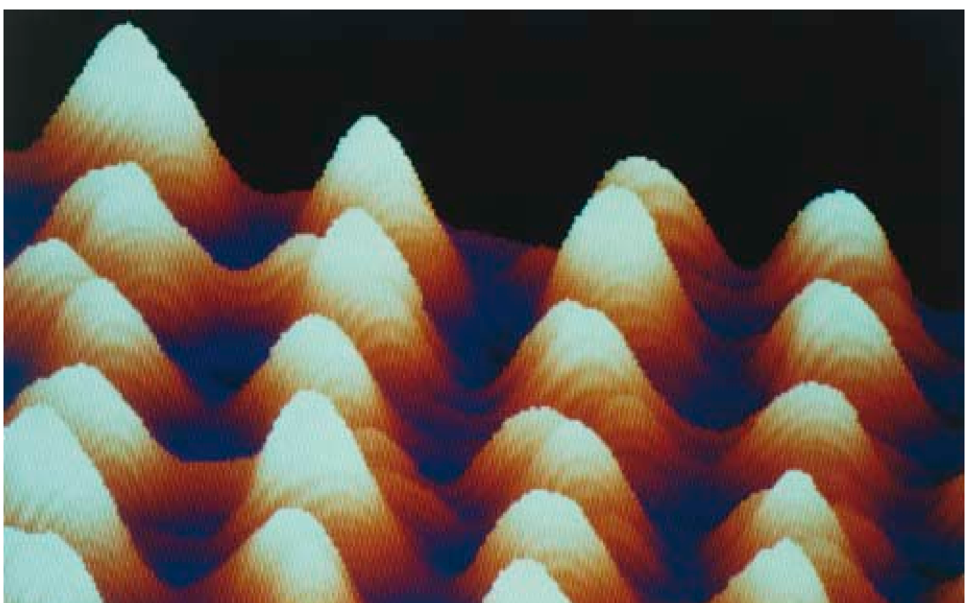


Fig 3 A water molecule is made up of an oxygen atom combined with two hydrogen atoms, one on each side, a bit like Mickey Mouse's ears.

A water molecule is made up of two hydrogen atoms bonded to one oxygen atom. This means water contains two different types of atoms.

Molecules vary in size from tiny hydrogen molecules up to the huge protein molecules in your body. Each of these protein molecules contains about half a million atoms. Only in recent years have scientists been able to use special microscopes to 'see' atoms and molecules.

Fig 4 Each little 'mountain' is a molecule in this photo taken using a scanning tunnelling microscope.



Hints and tips

- Atoms cannot be seen with visible light. This is because light travels in waves and atoms are smaller than the wavelengths of visible light. To be visible under the highest magnification, a particle needs to be greater than the wavelength of light. Electron microscopes, however, can be used to photograph atoms. The high-energy electron beam used in a scanning tunnelling microscope has a wavelength many times smaller than visible light, and atoms can be seen.
- Give the class a pre-test to establish known facts and to identify areas which need to be covered in greater detail. A good pre-test should be carefully planned. Test the *key* points you think the students should already know and what you would like them to understand by the end of this chapter. You may like to give the same test again at the end of the chapter so that the students can evaluate their own learning progress.

Learning experience

It is worth doing a demonstration to try to show how small atoms are.

1. Stack some sugar cubes on a board.
2. Remove one cube from the stack and break the cube so you have individual grains.
3. Take one grain of sugar and crush it so you have a powder.
4. Ask the class at each stage of the process if you have isolated a single atom. (Obviously you haven't!) Even when the sugar is a powder, you still don't have single atoms.
5. Tell students to imagine the classroom is like one particle of sugar powder. The atoms in the particle are then like students packed into the classroom.

Hints and tips

In 1805, John Dalton published his atomic theory which can be simplified as follows.

- All matter is composed of tiny particles called atoms.
- They are held together by attractive forces.
- Atoms are indivisible.*
- Atoms cannot be created or destroyed.
- All atoms of the same element are identical (in every way).
- Atoms of different elements are totally different and have different masses.
- Atoms of different elements can combine to form compounds.

*Later scientific research showed that atoms *are* in fact divisible.

The modern particle theory (*ScienceWorld 1* page 215) is as follows:

- All matter is made up of small particles.
- There are spaces between the particles and each particle is attracted to another particle. The further the particles are from each other, the weaker the attractive force.
- Each particle is moving.
- At high temperatures the particles move faster than at low temperatures.

The particle theory may have been revisited in Chapter 3 (see page 48). If so, do not spend a lot of time discussing it.

Science in action

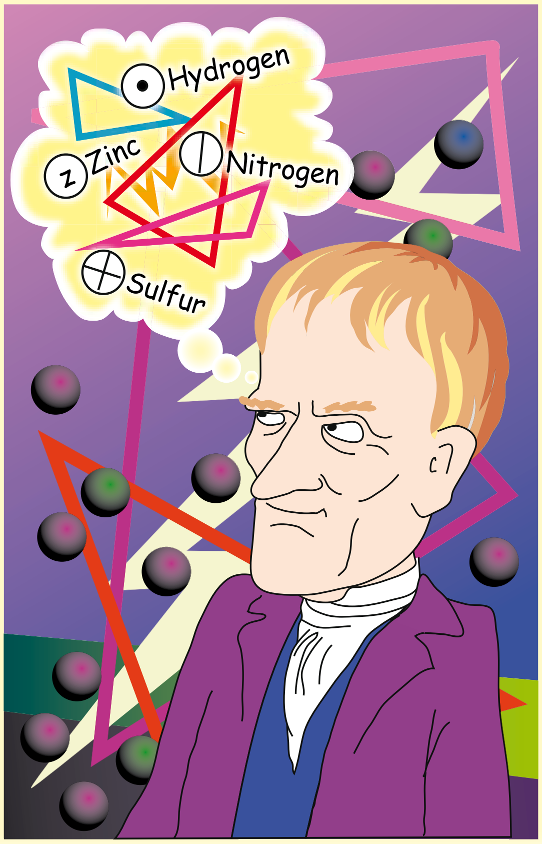
John Dalton (1766–1844)

John Dalton was born in 1766 and spent his childhood in a small English town. He soon became interested in mathematics and science, and when he was 12 he started a school of his own. This school seems to have been quite a success, despite the difficulty he had keeping the other children in order, especially those who were older than he was. Dalton continued teaching and lecturing throughout his life. He never married, and he said this was because his head was 'too full of triangles, chemical processes, and electrical experiments to think much of marriage'.

Dalton was a Quaker, and Quaker men and women had to dress in dark clothes. He was also colour-blind. The story is told that he once bought his mother a pair of bright scarlet stockings. He thought they were 'bluish-drab and Quakerish', and was very upset when his mother said she could not wear them because they were too bright. She had to call in a neighbour to convince her son that the stockings were bright scarlet and not bluish-drab.

Dalton made over 200 000 recorded weather observations during his life. However, his greatest achievement was his atomic theory. He did a series of experiments and hypothesised that the atoms of any one element are identical to each other but different from those of all other elements. He also suggested that chemical reactions take place through rearrangements of atoms.

Dalton imagined his atoms to be like pool balls, and he devised symbols for the different atoms. Some of his ideas later proved to be incorrect. For example, he inferred that a water molecule is made up of one oxygen atom and one hydrogen atom, instead of *two* hydrogen atoms. However, the atomic theory used today is basically the same as the theory Dalton proposed 200 years ago.



Questions

1 Which nationality was John Dalton?
2 What did he do for a living?
3 In your own words, explain why Dalton never married.
4 What was Dalton's atomic theory?
5 How did he explain chemical reactions?
6 Suggest why Quakers wore drab clothing.
7 How does a hypothesis like Dalton's become a theory?
8 Is Dalton's atomic theory the same as the particle theory (*ScienceWorld 1*, Chapter 10)? Explain.

Learning experience

The students could complete a time line of events in the development of ideas/models about the atom. Since the ideas and models can be complex, it is a good idea to summarise each idea/model in simple terms that students will understand. Ask them to make comparisons between the models. Suggested scientists to investigate are Aristotle, Sir Isaac Newton, Marie and Antoine Lavoisier, John Dalton, JJ Thomson, Ernest Rutherford and Niels Bohr.

4.2 Elements and compounds

Elements

If you could look inside a piece of iron like Super-Sci did on page 68, you would find that it is made of millions and millions of tiny iron atoms—all the same. Similarly, a piece of copper is made of copper atoms only. But the piece of copper is different from the iron, because the copper atoms are different from iron atoms. Pure substances like iron and copper, whose atoms are all the same, are called **elements**.

The photo below shows children building with Lego blocks. Thousands of different models can be built from a small number of different types of blocks. In a similar way, everything in the world around us is made from just over one hundred different elements.

The first elements discovered were the metals gold, tin, copper and iron. Over the years more and more elements were discovered. In total, 90 elements have been found in the Earth's rocks, soil, air and water. Another 20 or so elements, which do not occur naturally, have been made by nuclear scientists, and more will almost certainly be made in the future. The radioactive substance plutonium is one of these synthetic elements. Some elements, like gold and silver, are very rare. Other elements are very common. For example, oxygen makes up about half of the mass of the Earth's crust.

Some common elements are listed in the table opposite. They can be classified into two main groups—metals and non-metals. (Metals conduct electricity, and most non-metals do not.) The elements can also be classified according to whether they are solids, liquids or gases at room temperature (20°C).

Each element is represented by a **symbol**. This is a shorthand way of writing the name of the element. Sometimes the symbol is the first letter of the English name of the element: for example, carbon **C**. However, some elements have the same first letter: for example, carbon and calcium. In these cases a second letter is used: calcium **Ca**. Note that the first letter is a capital, but the second letter is not. In some cases the symbol comes from a Greek or Latin name. For example, the symbol for gold is **Au**. This comes from the Latin word *aurum*, which means 'shining dawn'. Some elements are named after famous people or places: for example, einsteinium and francium.

Fig 6 From just a few different Lego blocks you can build many different models.

Hints and tips

This chapter contains a lot of definitions needed for later studies in chemistry. It is therefore important that students find a way to remember and understand each definition. ESL students and students with language difficulties may find remembering the terms tricky. Spend extra time with them and monitor their progress through the topic to ensure they have grasped the main concepts. It may be appropriate to encourage ESL students to write the definitions in their native language.

Note: check the fifth line from the bottom in the second column of text on this page: *For example, the symbol for gold is **Au**.* In earlier printings the symbol was missing.

Homework

Ask students to do some research and add 5–10 more elements to the table on page 72. They should include all the relevant information that is contained within the table for each element, and check that the units are the same as the ones given in the table.

Learning experience

The students could compile their own glossary of terms for this chapter. They need to write the definition in their own words and give an example. (For help with writing definitions, see *ScienceWorld 1 Workbook* pages 42–43.) Suggested words are: *atom, molecule, element, compound, radioactive, DNA, mixture, pure substance, chemical equation*. After each new term has been added to their glossary, students could then check the glossary at the end of the textbook. However, make sure they avoid copying it.

Learning experience

Using the table of elements on page 72, the students could construct their own find-a-word or crossword puzzle. Constructing a crossword extends the students, as it means they need to think up clues to describe each element so that it differs from the description of any other element. For the find-a-word, students should be able to use all 22 elements in the list, but if doing a crossword, ask them to include at least 10 elements. (Alternatively, set this activity as homework.)

Hints and tips

It is important for the students to recognise some commonly known elements—their names and symbols (as in the list on this page). Devise a game to help them remember. Alternatively, ask them to remember the elements in the list and test the students at the beginning of each lesson by randomly choosing about ten elements to test at a time. Award the students certificates if they are able to remember all 22 elements in a single test (name and symbol).

Activity notes

- Review the properties of metals and non-metals.
- It is a good idea to explain what is meant by 'ancient' (prehistoric, or before written history) in the table.
- Revise the concept of density and make sure the students do not confuse it with mass. Very simply, density is how much matter is packed into a set volume.

Activity

Use the table below to answer the questions.

1 Write down the symbols for the following elements:

calcium	iron	nitrogen
carbon	lead	oxygen
hydrogen	magnesium	sodium

2 Which elements have the following symbols?

Al	Au	Br	Cl	Cu
Hg	K	P	S	Zn

3 Which one of the elements in the table has the highest melting point?

4 Which is the most recently discovered element in the table? When was it discovered?

5 Which of the elements are solids, which are liquids, and which are gases?

solids: melting point and boiling point above 20°C (room temperature)

liquids: melting point below 20°C, but boiling point above 20°C

gases: melting point and boiling point below 20°C

Put your answers in a table.

6 Are metals usually solids, liquids or gases at room temperature?

7 Which is the lightest gas?

Element	Symbol	Metal or non-metal	Melting point (°C)	Boiling point (°C)	Density (g/cm³)	Date of discovery
aluminium	Al	metal	660	2060	2.7	1825
argon	Ar	non-metal	–189	–188	0.0017	1894
bromine	Br	non-metal	–7	58	3.1	1826
calcium	Ca	metal	850	1440	1.6	1808
carbon	C	non-metal	3500	4200	2.2	ancient
chlorine	Cl	non-metal	–101	–35	0.003	1774
copper	Cu	metal	1080	2500	9.0	ancient
gold	Au	metal	1060	2700	19.3	ancient
hydrogen	H	non-metal	–259	–253	0.00008	1766
iodine	I	non-metal	114	183	4.9	1811
iron	Fe	metal	1540	3000	7.9	ancient
lead	Pb	metal	327	1744	11.3	ancient
magnesium	Mg	metal	650	1110	1.7	1808
mercury	Hg	metal	–39	357	13.6	ancient
nitrogen	N	non-metal	–210	–196	0.00117	1772
oxygen	O	non-metal	–219	–183	0.00132	1774
phosphorus	P	non-metal	44	280	1.8	1669
plutonium	Pu	metal	640	3230	19.8	1940
silver	Ag	metal	961	2200	10.5	ancient
sodium	Na	metal	98	890	0.97	1807
sulfur	S	non-metal	119	444	2.1	ancient
zinc	Zn	metal	419	910	7.1	1700

Learning experiences

Element Memory

Make two sets of cards—one set with the element names on them and the other set with their symbols. In pairs, the students can play a game of memory. Lay the shuffled cards out on the table, face down, and students take turns in flipping two cards up at a time. If they flip up the name and matching symbol, they win that pair, and so on. If 22 elements (44 cards) is too many, limit the number of cards to half a pack and play the game in two sessions.

Element Snap

As with Element Memory, make two sets of cards—one set with the element names on them and the other set with their symbols (the same cards can be used from Element Memory). In pairs, the students can play a game of Snap. One student should have the set of cards with the symbols, while the other student has the set of names. Each student shuffles their pack of cards. The first person to say 'Snap!' or 'Element!' wins the pair if the cards match. A full set of cards (22 elements/44 cards) can be used.

Science in action

Marie Curie (1867–1934)

Marie Curie was born in Poland in 1867. At school she was always top of her class, and she went to university in Paris. Marie and her husband Pierre, who was also a scientist, became interested in pitchblende, an ore of uranium that was radioactive. It gave off a strange new radiation, including the newly discovered X-rays. They found that it was even more radioactive than pure uranium. So what else could be in the ore that gave out radiation? Marie thought she was on the track of a new element.

Marie bought a tonne of pitchblende and had it dumped outside the shed where she worked in Paris. She and her husband ground the heap of ore to a powder, 20 kilograms at a time. They dissolved each lot of powder in acid, and evaporated the solution to form crystals. After four years of backbreaking work, Marie and Pierre had a tiny pile of white crystals a little bigger than the head of a pin. These crystals contained a new element called *radium*. In the dark it glowed with a bluish light.

Whenever Marie worked with radioactive radium, her hands became covered with sores, burns and blisters. This led to the discovery that radium can be used to kill diseased cells in cancer tumours. Even though the gram of radium she had extracted was worth millions of dollars, she gave it to her university. During World War I, Marie organised mobile X-ray vans so that pieces of shells in wounded soldiers could be found and removed.

In 1934 Marie Curie died of leukaemia, a disease probably caused by the radioactive materials she had worked with. She was the first woman to receive a Nobel Prize—one in physics and one in chemistry. During her life she had discovered two new elements—radium and polonium. In 1946 American scientists discovered another radioactive element. It was called *curium* in honour of Marie and Pierre Curie.

Questions

1 When and where was Marie Curie born?
2 What was radium used for?

Fig 8 Marie Curie in her laboratory

3 What was the name of the ore from which she obtained radium?
4 Suggest why Marie named one of the elements she discovered *polonium*.
5 Which new element was named in honour of Marie and Pierre Curie after their deaths?
6 Suggest how Marie could have protected herself from radiation.

WEBwatch

Research Marie Curie on the internet. Here are two sites to get you started:

Marie Curie and the science of radioactivity
Her life in detail, well-illustrated

Marie Sklodowska Curie
Her life presented as a series of simulated news articles that might have been written during her life

Hints and tips

Using very simple language, explain what a radioactive element is and what radioactivity is. Make sure the students are aware of the dangers associated with radioactive materials.

Homework

Do the Webwatch if you have access to computers in class, or give it as a homework exercise.

Research

As an extension activity, construct a chart on the board to compare the advantages and disadvantages of radioactivity in everyday life. You will need to give the students research time. You may like to assign one half of the class to investigate the positive aspects and the other half the negative aspects. A task like this encourages critical thinking about an issue. This activity could be extended to nuclear energy (*ScienceWorld 3* pages 130–133).

Investigate 8 FLAME TESTS

Aim

Different metals produce different colours in a flame. The aim of this investigation is to identify various metallic elements using flame tests.

Materials

- Bunsen burner
- small atomiser bottles containing 0.5 M solutions of the following or other soluble metal salts:
  barium chloride, potassium chloride, calcium chloride, sodium chloride, copper sulfate, strontium chloride
- unknown metal solution (Step 4)

Planning and Safety Check

- Draw up a suitable data table to record your results.
- What safety precautions will be necessary?

Method

1 Light the burner and adjust it to the blue flame.

2 Hold the first atomiser bottle just below the top of the burner, about 20 cm away from the flame. Spray the mist so that it goes up into the flame and observe the flash of colour as the solution vaporises. (You may need to repeat this if you did not see the colour clearly.)

3 Repeat the procedure with the atomisers of the other solutions.

Record the flame colours for the different metals in your data table.

4 Now that you know the colour each metal produces in a flame, your teacher will give you an unknown metal salt. Test it and infer which metal it contains.

Particles in elements

Metals, such as gold, are composed of collections of single atoms. In non-metals the atoms are bonded together. For example, diamond consists of carbon atoms, each linked to four other carbon atoms, as shown in Fig 10.

Some gaseous elements contain separate molecules. For example, the molecules hydrogen (H_2), nitrogen (N_2), oxygen (O_2) and chlorine (Cl_2) each contain a pair of atoms. The gas ozone (O_3), which protects us from UV radiation from the sun, has a molecule containing *three* atoms of oxygen.

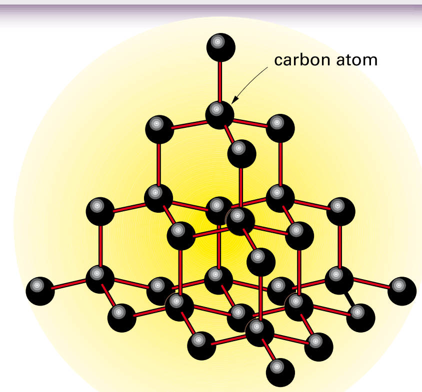


Fig 10 Part of a crystal of diamond

Hints and tips

Give the class a quick quiz based on the material they have already learnt. In doing this, you can get an indication if any concepts need to be revised. Ask the students to write the answers only (no need for the questions).

Lab notes

- Atomiser bottles, together with a good tray to store them in, are available from Haines Scientific.
- Limit the number of students who are spraying the solutions at one time. If you have one, make use of the fume cabinet or do the activity near an open window to reduce fumes in the classroom. Make sure to have the room's extractor fan on.
- Watch for students spraying each other. Any spray should be washed off with plenty of water.
- Alternatively, students could use pure powdered samples of the metallic salts. Use wooden pegs to hold a toothpick or piece of looped nichrome wire dipped in a powder and carefully bring it close to the flame (not close enough to burn). To make the powder adhere to the toothpick or looped wire, dip the end into some hydrochloric acid (2M) before dipping it into the powder. Repeat the process with new (clean) toothpicks or looped wire for each metallic salt. Make sure to remind the students not to contaminate the hydrochloric acid. (Set up a different metallic salt on each workstation with wire already looped to help minimise contamination.)
- Copper sulfate and barium chloride are toxic and need to be handled with care.
- Safety glasses are essential and it is advisable for students to wear protective gloves.
- The flame colours are more easily observed if the room is darkened.

Metallic salt	Colour
Barium	Apple green
Calcium	Lemon
Copper	Emerald green
Lithium	Red
Potassium	Lilac
Sodium	Yellow/orange
Strontium	Crimson

science bits

Fireworks

The Chinese were probably the first to use fireworks when they discovered how to make the black powder we call gunpowder about AD 850. They wrapped the black powder in bamboo or paper tubes to make crude missiles and flares that could be used to frighten away potential invaders. This was the beginning of pyrotechnics, which means 'the art of making fireworks'.

The Italians were probably the first to experiment with coloured fireworks in the early 1700s. The white colours of fireworks are due to the metals aluminium and magnesium burning at about 3000°C. The gold colours are due to iron and charcoal at a lower temperature. The other colours are produced by adding small amounts of other metals. For example, barium gives you a green colour, copper gives you blue and strontium gives you red.

A fireworks shell is a cardboard sphere filled with hundreds of little black balls called stars, which contain the colour-producing elements. The stars are surrounded by the bursting charge. Multiple-burst shells are designed with several separate compartments. At the bottom of the shell is a compartment that contains the black powder lift charge.

To set off the firework, pyrotechnicians place the shell in a plastic cylinder and light the main fuse. This in turn lights the main fuse that ignites the lift charge at the bottom. This propels the shell high into the sky, where the time-delay fuse ignites the bursting charges to propel the stars out of the shell.

Andrew and Christian Howard are brothers. They are directors of Howard and Sons Pyrotechnics, who light up our skies with spectacular fireworks displays. Andrew's interest in fireworks was sparked at the age of seven, when his father took over the business from his grandfather. When asked how he got started, Andrew said 'There are TAFE courses that specialise in high explosives, but not in fireworks. There are no textbooks covering our trade, so basically we learn from the dos and don'ts. We abide by some fairly strict safety regulations, particularly to ensure no spectators or staff are injured.' Christian has arranged the special effects in movies such as *The Matrix* and live shows such as *Metallica* and *Pink Floyd*.

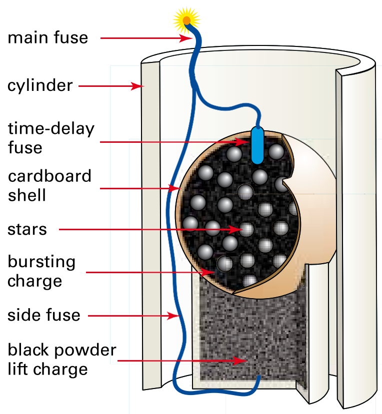


Fig 11 The design of a fireworks shell

WEBwatch

For great fireworks photos, go to www.scienceworld.net.au and follow the links to **Howard and Sons Pyrotechnics**.

Hints and tips

- When heated, certain elements produce characteristic coloured light (Investigate 8 page 74). The spectacular colours of fireworks come from the light emitted by excited electrons in metallic elements descending back to their normal state. Excited atoms are unstable and give out the energy they absorbed as they return to their stable state. They release this energy as light (photons), not as heat. Each colour spectrum is unique for each element and therefore can be used in element identification. Although this can be complex for students at this level to understand, it is worth explaining in simplified terms, something like this:

  If atoms are given extra energy (in the form of heat), they become excited and when they get rid of the extra energy, they do it in the form of light. Visible light is made up of a rainbow of colours. As we know, each element is different because of its properties, and one of these properties is the colour of the light emitted when it releases energy after being excited.
- Another simple example you could describe is static electricity. When static electricity causes a spark from clothing made from synthetics, the blue-coloured light is emitted by excited nitrogen atoms in the air.
- It may be appropriate to explain to the class about subatomic particles of atoms. Explaining electron shell configuration is best left for later (*ScienceWorld 3*).

Learning experience

Have a discussion about safety issues to do with fireworks. What makes them dangerous? Why should they never be taken on board an aircraft?

Hints and tips

Before starting any new material, have the students document and prepare the key points from the last few lessons. How much they can recall will determine how much time you need to spend on review before moving on to more advanced concepts.

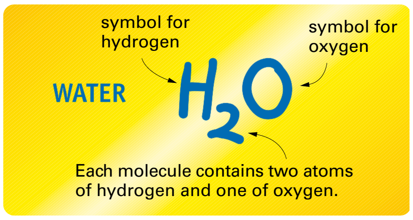
Compounds

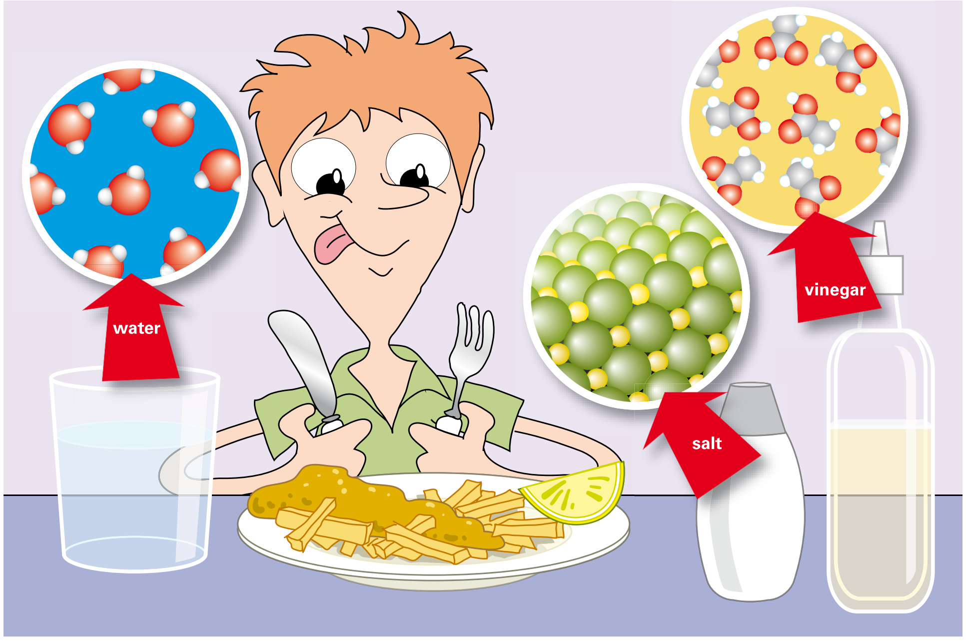
If you look at Fig 3 on page 69 you will see that water molecules contain two different kinds of atoms—hydrogen and oxygen. Similarly, molecules of the poisonous gas carbon monoxide contain one carbon atom combined with one oxygen atom. And molecules of carbon dioxide (which plants use in photosynthesis) contain one carbon atom combined with *two* oxygen atoms. Such substances that are made of two or more different kinds of atoms are called **compounds**.

A **chemical formula** is a shorthand way of showing which elements are in a compound. It also tells you how many atoms of each element are present in one molecule of the compound. For example, water has the formula H_2O. This tells you that each molecule of water contains two atoms of hydrogen (symbol H) and one atom of oxygen (symbol O). In other words, the hydrogen and oxygen are in the *ratio* 2:1. To read the formula aloud you say 'H two O'.

Sodium chloride (common salt) has the formula NaCl. To read such a formula you say the letters in order: N-a-C-l. Sodium chloride is a solid compound and has the structure shown below, with sodium and chloride particles packed together tightly. There are no separate molecules, but the formula tells you that there are equal numbers of sodium and chlorine atoms.

Iron oxide (rust) has the formula Fe_2O_3 (F-e-two-O-three). It has a similar structure to sodium chloride, but there are two particles of iron for every three particles of oxygen. (The iron and oxygen are in the ratio 2:3.)





Homework

Ask students to find the chemical formulas for at least 10 different gemstones or minerals. You could make the search harder, and say they need to be found in Australia. Start the class off with sapphire (Al_2O_3), amethyst (SiO_2) or ruby (Al_2O_3).

Learning experience

Prepare some half-page worksheets for the students so they have to count how many atoms there are of each element in molecules of different compounds.

- Make some of the problems tricky to challenge the students who quickly master the technique (eg $3H_2O$, $5NaCl$, $7C_{12}H_{22}O_{11}$).
- Construct the sheets as a table so the students fill in the names of each element present as well as the number of atoms of each element, and the total number of atoms. Preparing at least two different sheets means you can rotate them among the students.
- Give a time limit for completion and then ask the students to swap the sheets to be checked. If any of their answers differ, they should confer with each other.

Activity

Molecular models

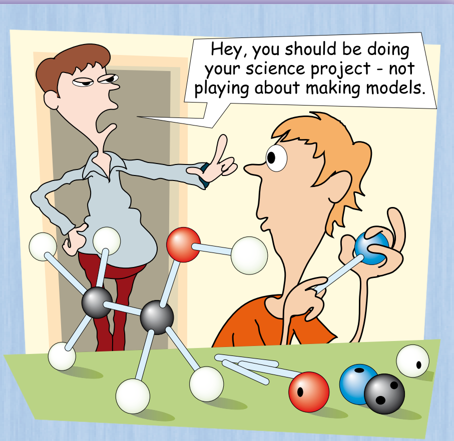
Because atoms and molecules are too small, we use models to represent them. There are two main types of molecular models. In both types the atoms are represented by coloured balls of different sizes. Different colours represent different atoms.

In ball-and-stick models (see Fig 10 on page 74) the balls are joined by sticks to form molecules. There are no such sticks connecting atoms—they merely represent the bonds between the atoms. When you use these models you will notice that the bonds between atoms are at definite angles.

The other type of model is the space-filling type (Fig 3 on page 69), where the atoms fit together at the correct angles.

Make models to represent these molecules:

hydrogen (H_2)	ammonia (NH_3)
oxygen (O_2)	methane (CH_4)
water (H_2O)	carbon dioxide (CO_2)



Draw a diagram of each molecule, labelling the different atoms.

Examine the models to see how many bonds each type of atom can form. Record your results in a table.

Living and non-living

All things, whether living or non-living, are made up of elements and compounds of these elements. Common non-living things like salt and sugar are usually compounds. For example salt (sodium chloride) is a compound of sodium and chlorine. Cane sugar is a compound of carbon, hydrogen and oxygen. Many substances, such as petrol, are a mixture of a number of different compounds.

Living things contain a large number of different compounds, some very simple (eg water), and others very complex (eg proteins, fats and carbohydrates). These compounds are made up of about twenty essential elements, as shown in the diagram on the right.

About 65% of your body mass is water (hydrogen and oxygen). The proteins, fats and carbohydrates all contain carbon. Hence the high proportion of oxygen, carbon and hydrogen in your body.

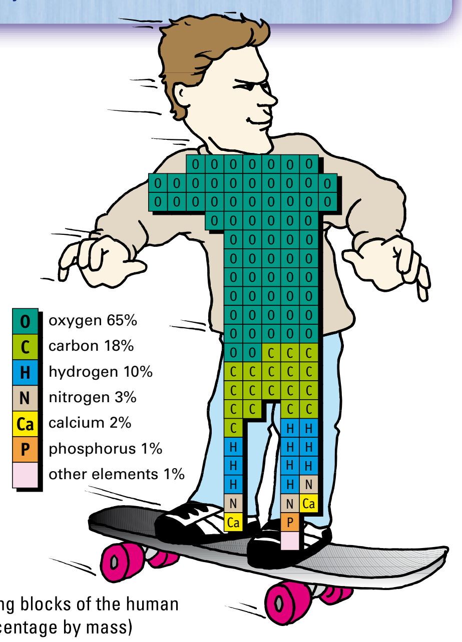


Fig 16 The building blocks of the human body (percentage by mass)

Activity notes

- It is a good idea to draw up a big table on the board and get students to draw the molecules as they make them. Give quicker students some larger molecules to tackle.
- Polystyrene balls and wooden skewers can be used. The balls can easily be written on with markers to identify the elements.

Research

Students could research the vitamins and minerals our bodies are considered to require each day. Ask them to find out what our daily intake of some essential elements should be (iron, calcium, magnesium, zinc, phosphorus, selenium, potassium, sodium, etc). Which foods are these elements found in?

Homework

Food packaging is required to list the item's nutritional value and often has the recommended daily intake for some elements as a percentage (RDI %). Students could make a list of foods they have at home and write down the relevant nutritional data.

Hints and tips

Deoxyribonucleic acid (DNA) consists of long, thread-like molecules, and is found in chromosomes. You can link this to Chapter 6.

Assessment task

This would be a good place to set *Assessment task 4: Minor elements*, found on the CD.

The basis of life is a compound called DNA, which determines what you are like. It contains only the elements carbon, hydrogen, oxygen, nitrogen and phosphorus. However, DNA is very complex, and the various atoms can be combined in millions of different ways. The result is that there are millions of different types of DNA. What makes you different from everybody else is the way in which the atoms in the DNA in your body are put together.

All matter can be divided into living and non-living things. Cells are the building blocks for living things. But cells and all non-living things are made of elements and compounds, which in turn are made of atoms and molecules. The salt in your body is the same as the salt on the kitchen table. And the calcium carbonate in an eggshell and in your bones is the same as the calcium carbonate in limestone.

Just what gives a living thing life is not well understood. In the nineteenth century scientists said that living things contained a mysterious 'vital force'. However, it is now known that living things contain very complex compounds. Somehow life is associated with these complex compounds.

Scientists have been able to work out the structures of living substances. In fact, they have even been able to make quite complex substances in the laboratory. One such substance is insulin, one of the smallest proteins. Some day scientists may be able to create life itself!

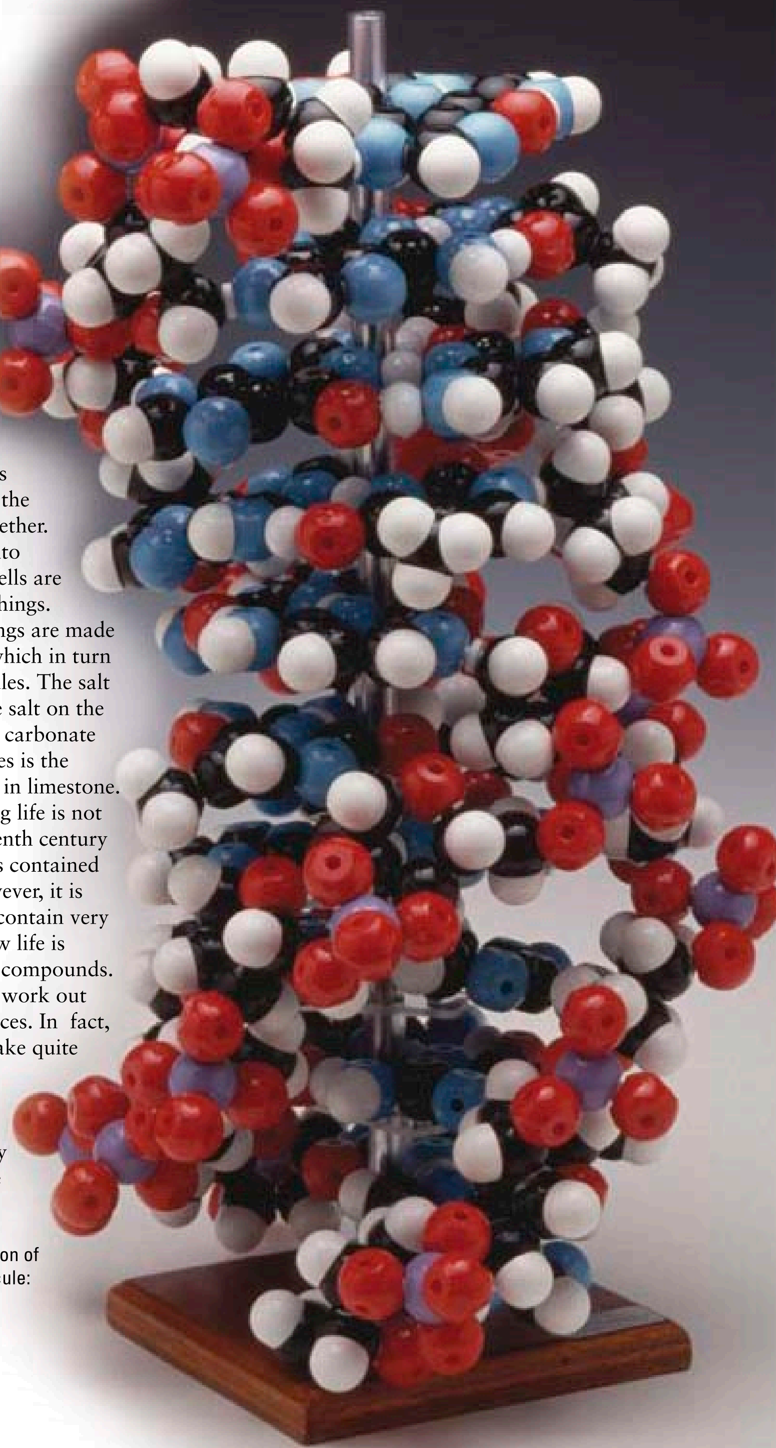


Fig 17 A model of a small section of the complex DNA molecule:
oxygen—red
carbon—black
hydrogen—white
nitrogen—blue
phosphorus—purple

Learning experience

1. What makes us living? What is DNA? What is a cell? Ask the students to read the text on this page and write down as many questions as they can about it. They should include what they *know* about each question posed and *how* they can investigate the answers.
2. Get them to select about five of their posed questions to research further. A way to order their work may be as a chart with the headings: *Question*, *What I know*, *How to find out more*.

Check!

1 Ask someone to check your spelling of these words:

carbon dioxide	hydrogen
compound	molecule
element	sodium chloride
formula	symbol

2 What is the difference between—
  a an atom and a molecule?
  b an atom and an element?

3 Which of the following are elements: aluminium, carbon monoxide, copper, iron oxide, kerosene, mercury, phosphorus, sand, sugar, water?

4 Which element is present in all of the following compounds?

SO_2 H_2S H_2SO_4 $CuSO_4$

5 Suppose you represent the atoms in three different elements by ●, ■ and ▲. How many different molecules could you form by linking these atoms together:
  a two at a time?
  b three at a time?

challenge

1 Use Fig 16 on page 77 to draw a bar graph and a pie chart of the elements in the human body.

2 Why are there so many more compounds than elements?

3 Draw up a table with two columns headed 'Elements' and 'Compounds'. Put each of the following into the correct column:

Al	SiO_2
CO_2	Cu
N_2	NH_3
H_2SO_4	O_3

4 Write the formula for each of the following molecules:
  a nitrogen dioxide contains one nitrogen atom and two oxygen atoms
  b propane contains three carbon atoms and eight hydrogen atoms
  c glucose contains six carbon atoms, twelve hydrogen atoms and six oxygen atoms.

5 A tiny crystal of magnesium chloride contains 2 billion magnesium atoms and 4 billion chlorine atoms. What is the formula for the compound?

WEBwatch

Select an element and use library resources to find out what you can about it. Here are some things you might look up:

1 Name of discoverer, date of discovery, how the element was named.

2 Properties and uses of the element.

Go to www.scienceworld.net.au and follow the links to these websites:

Web Elements
Select an element for a range of information including photos, cartoons and audio descriptions.

CHEM4KIDS
Simple information on the first 36 elements, with puzzles and help with pronouncing their names.

The Visual Elements Periodic Table
Very colourful and interactive

It's elemental
Below the table you can click on a number of online games based on the elements.

The Periodic Table of Comic Books
Click on an element to see a list of comic book pages involving that element.

Check! solutions

1 Check the spelling of these terms from this chapter or the glossary at the back of the book.

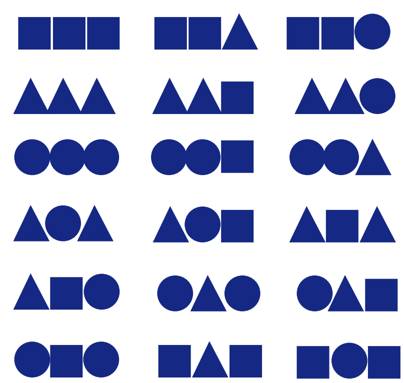
2 a A molecule consists of atoms joined together by chemical bonds.
  b An atom is the smallest part of an element.

3 The elements in this list are aluminium, copper, mercury and phosphorus.

4 The element that is common to all these compounds is sulfur.

5 a The possible combinations two at a time are:

  b The possible combinations three at a time are:

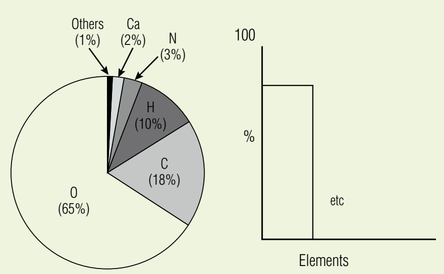


Remember that they will be the same backwards, eg:

 is the same as 

Challenge solutions

1



2 There are about 100 elements and there are thousands of compounds. This is because different elements combine in different ways to form compounds. This is like different letters combining to form many different words.

3

Elements	Compounds
Al	NaCl
N_2	NH_3
Cu	CO_2
O_3	H_2SO_4

4 The formulae are:
  a NO_2
  b C_3H_8
  c $C_6H_{12}O_6$

5 The ratio is 1:2 and therefore the formula is $MgCl_2$.

Hints and tips

A compound is two or more different elements that are chemically joined together, always in the same proportion for that substance. For a mixture, the proportions of the elements (or compounds) can vary considerably. Consider breathing in lungfuls of air from the slopes of Mount Kosciuszko compared with peak-hour air in the centre of Sydney. Although the composition of the air will be different, it is still air, which is a mixture. The proportions of elements and compounds in the air differ.

Lab notes

Part A

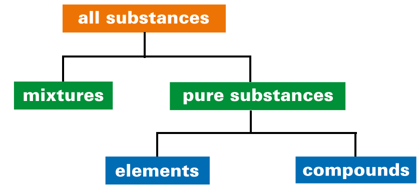
As usual, count the magnets before they are distributed and again when they are returned to avoid theft or misplacement.

4.3 Chemical reactions

Over the years scientists have experimented with substances—mixing them, heating them and passing electricity through them. For example, a chemical reaction occurs when sugar is heated. It splits into two simpler substances—water and carbon (which is black). Scientists discovered that carbon and other elements cannot be split into anything simpler by chemical reactions. They cannot be split because they contain only one sort of atom.

Using chemical reactions, scientists are also able to make many new compounds. For example, when carbon is heated it reacts with the oxygen in the air to form the compound carbon dioxide.

As you learnt in previous studies, most substances are not pure, but are mixtures of two or more different substances (elements or compounds) which are not chemically combined. Air is a good example of a mixture. It contains many different elements and compounds, whose proportions are not always the same.



In Investigate 9 you can use a chemical reaction to make a compound. Then in Investigate 10 you can break a compound down into its elements.

Investigate 9 MAKING A COMPOUND

Aim

To make a compound from the elements iron and sulfur.

Planning and Safety Check

- Read through the experiment and note the places where safety precautions will be necessary.
- Discuss the experiment with your teacher. Only one group at a time can use the fume cupboard, and your teacher may prefer to demonstrate all or part of the experiment.

Materials

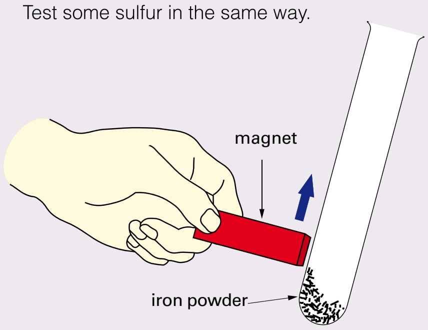
- powdered sulfur
- iron powder
- dilute **hydrochloric acid** (1 M) **Corrosive**
- spatula
- bar magnet
- small test tube
- Bunsen burner
- tripod and heatproof mat
- aluminium foil
- crucible
- pipeclay triangle

PART A Testing iron & sulfur

Method

1 Place a small amount of iron powder in a test tube. Use a magnet as shown to test whether you can pull the iron powder up the side of the test tube. If you can, then the iron powder is magnetic.

Test some sulfur in the same way.



Learning experience

Ask the students to devise a table listing as many compounds and mixtures as they can. It would be a good idea to form a class list to make sure the students have accurately identified each substance listed.

2 Add a few drops of dilute hydrochloric acid to some iron powder in a test tube.

Observe what happens.

Do the same with the sulfur.

3 Put two spatulas of sulfur in another test tube, then two spatulas of iron powder. Mix them well by shaking the test tube.

Test the mixture with the magnet. What do you notice?

Discussion

1 Did the properties of the iron and sulfur change when you mixed them?

2 Was there a chemical reaction when you mixed them?

3 Have the iron and sulfur formed a mixture or a compound? Explain your answer.

PART B
Making iron sulfide

Method

1 Line the crucible with some aluminium foil and pour in the mixture of iron and sulfur. (The aluminium foil doesn't react—it simply stops the hot mixture sticking to the crucible.)

Caution: The fumes from burning sulfur are poisonous. It is essential to use a fume cupboard so that you don't breathe in any of the fumes.

2 Put the crucible in a pipeclay triangle on a tripod, as shown. Heat it with a Bunsen burner. As soon as the mixture begins to glow, turn off the burner.

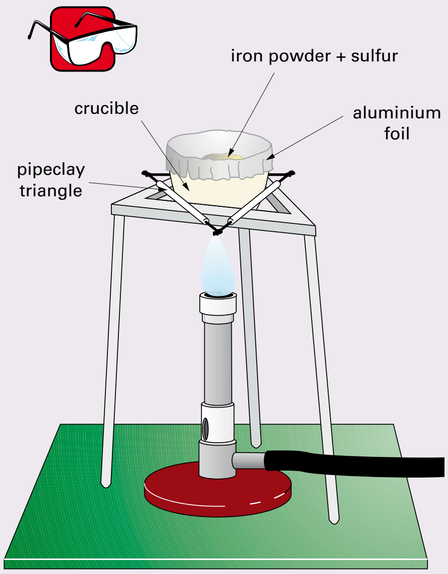
3 When the crucible has cooled examine the new substance that has formed.

Describe the properties of the new substance.

Is the substance magnetic?

Can you separate the iron and sulfur?

Wear safety glasses.



4 Add some dilute hydrochloric acid to a small piece of the substance in the crucible. (This should also be done in a fume cupboard as the 'rotten egg' gas given off is poisonous.)

Record your observations.

Is this the same gas that was formed when you added hydrochloric acid to iron powder? How could you tell?

Discussion

1 Did the properties of the iron and sulfur change when you heated the mixture? Explain.

2 Was there a chemical reaction? How do you know?

3 What was needed to make the reaction occur?

4 Have the iron and sulfur formed a mixture or a compound? Explain your answer.

5 The compound you have made is called *iron sulfide*. What are the elements in it?

Lab notes

Part B

- There are significant health and safety issues with heating sulfur, so make sure you do it in a fume cabinet. Don't forget to fill in a risk assessment form for this activity. You may choose to do the activity as a demonstration. Allow the students to examine the product and answer the questions.
- Good room ventilation is important. Avoid doing the investigation on a hot, stuffy day. It is a good idea to open windows to reduce the 'rotten egg' smell of the gas in the room.

Lab notes

- This is best done as a demonstration, even if it has to be done several times by the teacher.
- Dry balsa wood is ideal for the wooden splint for the oxygen test. Paddle-pop sticks can be moist and slow to re-ignite.

Alternative demonstration: the 'big bang'

A variation of this activity, which provides an excellent demonstration, is given below. However there are significant safety issues involved with this demonstration. A Perspex safety screen should be used, and the opening of the delivery tube should be kept well away from any flame. If you have not done this before, it is essential to try it before you do so with a class.

1 Put the dilute acid and two lead electrodes in a large (2 L) wide-mouthed, sealed plastic jar, and produce a mixture of hydrogen and oxygen through a plastic delivery tube.
2 Use the gas mixture from the delivery tube to make bubbles in a plastic container (a 2 L ice-cream container is ideal) of soapy water. Ignite the bubbles with a burning splint.
3 When the mixture is exactly right, the explosion can be deafening. Warn your class and nearby classes.

Investigate

10 BREAKING A COMPOUND

Aim

To find out what substances are produced when water is decomposed (split up) by passing electricity through it.

Materials

Corrosive

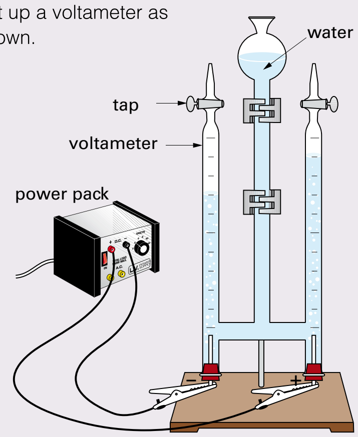
- dilute **sulfuric acid** (1 M)
- voltameter (vol-TAM-e-ter)
- 2 *pyrex* test tubes
- wooden splint, eg paddle-pop stick
- distilled water
- power pack
- taper

Planning and Safety Check

Read through the investigation. A voltameter is an expensive piece of equipment and the school probably has only one. So your teacher will probably set up the equipment for you.

Method

1 Set up a voltameter as shown.



2 Open the taps at the top and add water containing a few millilitres of dilute sulfuric acid to the middle tube. (The acid makes the water conduct electricity more easily.) When the side tubes are full, close the taps.

3 Connect the voltameter to a power pack set on 6 volts DC. Turn it on.

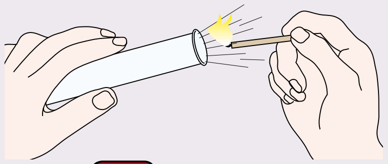
4 Allow the current to flow for about 15 minutes, and observe the gases that collect in the tubes.

Compare the volumes of the gases in the two tubes.

5 Invert a dry test tube over the tube with the most gas in it. Then open the tap and collect the gas.

Light a taper, tilt the test tube upwards, and put the burning taper near its mouth.

A 'pop' indicates the gas is hydrogen.



Wear safety glasses.

After the 'pop', look for water droplets inside the tube. Infer where they came from.

6 Collect a test tube full of gas from the other voltameter tube. Light the wooden splint, then blow it out so that it has a glowing tip. Put the glowing splint into the test tube. If it bursts into flame this indicates the gas is oxygen.

Discussion

1 What were the two gases produced when electricity was passed through water?
2 Copy and complete this sentence. Water is a compound of the elements ______ and ______.
3 When hydrogen burns it combines with the oxygen in the air. Infer what substance is formed. (See Step 5 above.)
4 The volume of hydrogen produced was twice the volume of oxygen. Suggest a reason for this.

Chemical equations

When you mixed iron and sulfur and heated the mixture, a chemical reaction occurred. The iron and sulfur were the reactants—the substances you started with. The iron sulfide was the product of the reaction. The equation for the reaction is:

iron (Fe) + sulfur (S) → iron sulfide (FeS)

The reactants and products in a reaction can be solids, liquids or gases. For example, in Investigate 10 liquid water decomposed to produce hydrogen gas and oxygen gas.

water (H_2O) → hydrogen (H_2) + oxygen (O_2)

During this reaction, molecules of water break apart and form molecules of hydrogen and oxygen.

Water molecules always contain two atoms of hydrogen bonded to every atom of oxygen. So when water decomposes, two molecules of hydrogen are formed for every molecule of oxygen, as Fig 22 shows. This is why the volume of hydrogen gas produced in Investigate 10 was exactly twice the volume of oxygen gas produced. Similarly, when a compound is made, exact quantities of the different elements react.

The atoms in some molecules are more tightly bonded together than in other molecules. As a result, when molecules are rearranged during a chemical reaction, energy may be needed or energy may be released. The reaction between iron and sulfur needed heat to make it go, and the decomposition of water needed electricity. On the other hand, burning produces heat, and the reactions that occur inside batteries produce electricity.

To see how this works, open the **Water reaction** animation on the CD.

Working with technology

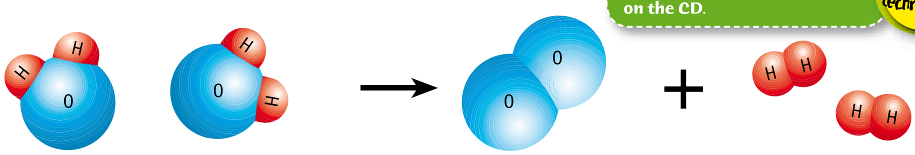


Fig 22 The compound water decomposes to form the elements hydrogen and oxygen.

Check!

1 State whether each of the following statements is true or false. Rewrite those that are false.
- **a** New substances are produced in a chemical reaction.
- **b** The rusting of iron is a chemical reaction.
- **c** Hydrogen is another name for water.
- **d** Hydrogen sulfide contains two elements—hydrogen and sulfur.
- **e** In a mixture, the parts can be separated only by a chemical reaction.
- **f** Compounds cannot be broken down into simpler substances.
- **g** The same elements can combine to form many different compounds.

2 Classify the following substances as elements, compounds or mixtures.

air	protein
copper	pure water
hydrogen	rust
iron oxide	soft drink
mercury	sulfur dioxide

3 Sodium is a soft silvery metal that reacts violently with water, and chlorine is a poisonous green gas. Sodium chloride (common salt) contains these two elements, but is safe to eat. How can you explain this?

4 Pure substance X is a green powder. When heated, it gives off a gas and changes to a black powder. Is substance X an element or a compound? Give reasons.

Hints and tips

Check that students understand the importance of the direction of the arrows in the equations.

Animation

Students should view the animation *Water reaction* on the CD.

Check! solutions

1
- a True.
- b True.
- c False. Hydrogen oxide is another name for water.
- d True.
- e False. In a compound, the parts can only be separated by a chemical reaction.
- f False. Compounds can be broken down into simpler substances.
- g False.

2

Elements	*Compounds*	*Mixtures*
copper	protein	air
hydrogen	pure water	soft drink
mercury	iron oxide	
	sulfur dioxide	
	rust	

3 Sodium chloride is a compound that has very different properties from its two elements. This is the case with most compounds.

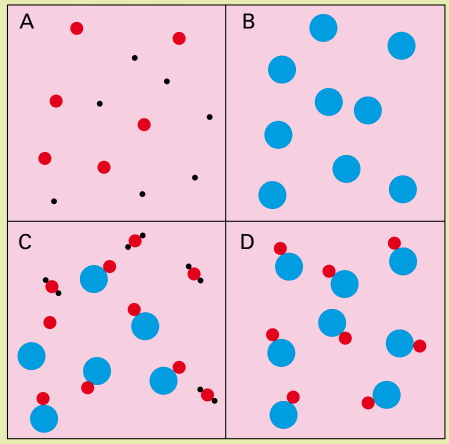
4 Substance X is a compound because when heated, a chemical change occurs to form new substances. These new substances may be elements or compounds.

Learning experience

For more able students, prepare some worksheets on balancing simple equations. Combine both the chemical symbols and chemical names. The science department may already have some blackline masters or other resources available ready for photocopying, which may save time.

challenge

1 Diagrams A to D below represent the particles in different substances. Which represents:
  a an element?
  b a compound?
  c a mixture of elements?
  d a mixture of compounds?

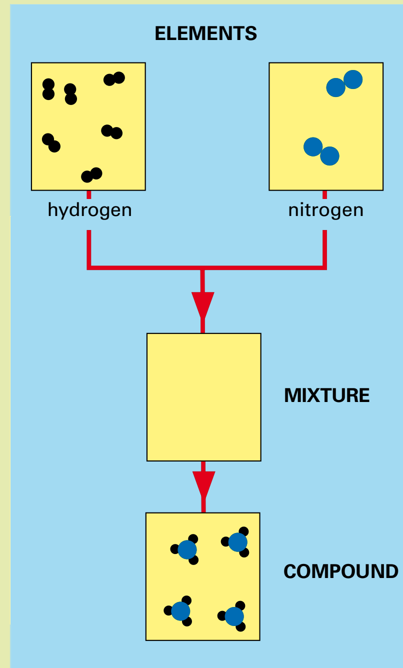


2 a What substance do you predict will be formed when hydrogen and oxygen react together? Explain your prediction.
  b Write a word equation for the reaction.

3 Tamara heated a white powder, and two different gases were given off. One was a poisonous brown gas called nitrogen dioxide, and the other was oxygen. A red substance was left behind in the test tube.
  a Is the white powder an element or a compound?
  b Which elements can Tamara be sure are in the white powder?
  c When Tamara continued to heat the red substance, she was left with a silvery liquid called mercury. More oxygen was also produced. What are all the elements in the white powder?

4 Hydrogen peroxide is a compound of hydrogen and oxygen. However, it is quite different from water, and is used in bleaches and antiseptics, and in rocket fuel. If water and hydrogen peroxide are both made up of hydrogen and oxygen, why are they so different? Write an explanation.

5 The diagram below illustrates how ammonia gas is made from nitrogen and hydrogen gases.



  a What is the ratio of nitrogen atoms to hydrogen atoms in the ammonia molecule?
  b In what ratio do the nitrogen and hydrogen react? Is this the same ratio as in the ammonia product?
  c What is the total number of atoms in the product? Is this the same as the total number of atoms in the reactants?
  d Copy the diagram and draw the molecules in the box labelled MIXTURE.
  e Write a word equation for the reaction.

Challenge solutions

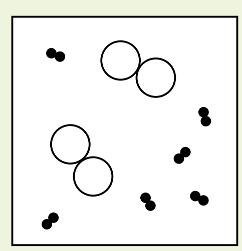
1 a B represents an element.
  b D represents a compound.
  c A represents a mixture of elements.
  d C represents a mixture of compounds.

2 a You could predict that hydrogen oxide would be formed. This substance is commonly known as water. This is a good prediction because most elements will react with oxygen to form an oxide.
  b A simple equation is:
  hydrogen + oxygen ⟶ water

3 a The white powder is a compound because it reacts to form new substances.
  b Tamara can be sure that the elements nitrogen and oxygen are in the white powder.
  c The elements present in the white powder are nitrogen, oxygen and mercury.

4 Each molecule of hydrogen peroxide consists of 2 hydrogen atoms and 2 oxygen atoms (H_2O_2), while a molecule of water contains 2 hydrogen atoms and only 1 oxygen atom. This means that different compounds have different properties.

5 a The ratio is 3H:1N in each molecule.
  b The molecules must react in the same ratio, which is 3:1.
  c The total number of atoms in the product is 16, which is the same as the number of atoms in the reactants. This is always the case.
  d The mixture box is:



  e A word equation is:
  hydrogen + nitrogen ⟶ ammonia

MAIN IDEAS

Copy and complete these statements to make a summary of this chapter. The missing words are on the right.

1 ______ are the basic building blocks of all ______, both living and non-living.

2 Pure substances can be either ______ or compounds. Most substances are ______ of two or more pure substances.

3 A ______ is two or more atoms joined together by chemical ______.

4 An element is a ______ made of atoms of only one type. It cannot be decomposed into simpler substances by chemical reactions.

5 There are over 100 different elements, each with its own ______.

6 A ______ is a pure substance made up of two or more different elements combined together.

7 The chemical ______ for a compound tells you what elements it contains. It also tells you the ratio of the atoms of these elements.

8 ______ can be used to make compounds from elements, and to break down compounds into elements.

atoms
bonds
chemical reactions
compound
elements
formula
matter
mixtures
molecule
pure substance
symbol

Try doing the Chapter 4 crossword on the CD. Working with technology

Main ideas solutions

1 atoms, matter
2 elements, mixtures
3 molecule, bonds
4 pure substance
5 symbol
6 compound
7 formula
8 chemical reactions

REVIEW

1 Which one of the following can you normally see without a microscope?
A cells
B elements
C molecules
D atoms

2 Copper, iron and chlorine are all:
A compounds
B mixtures
C elements
D metals

3 How many naturally occurring substances are there that cannot be broken down into simpler substances by chemical reactions?
A ninety
B hundreds
C many thousands
D not known

4 Which one of the following is a compound?
A sodium
B chlorine
C sugar
D hydrogen

Review solutions

1 **B**—Only elements, eg the substances copper, mercury and chlorine, can be seen without a microscope.

2 **C**

3 **A**—There are only 90 elements found naturally, but they can combine to form many thousands of different compounds.

4 **C**—Sugar is a compound of carbon, hydrogen and oxygen.

5 **C**—Only NO_2 has nitrogen and oxygen in the ratio 1:2. The ratios of nitrogen to oxygen are:

NO	1:1
N_2O	2:1
NO_2	1:2
N_2O_2	2:2 or 1:1

6 **B** represents an element—atoms of one type only. (**A** represents a mixture of elements and compounds, **C** represents a mixture of elements and **D** represents a compound.)

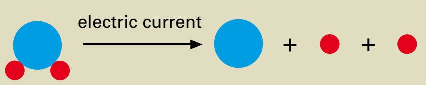
7 **Four** (three hydrogen and one nitrogen)—although there are only two different *types* of atoms.

8 **a** 1 and 4
b 2 and 4
c 4—because it gives a yellow flame *and* produces a purple gas

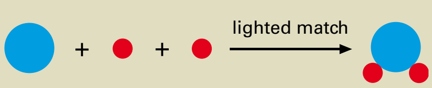
9 **B**—The tests show that the elements hydrogen, chlorine and zinc are present. The zinc reacted with the acid, so the acid contains only hydrogen and chlorine.

10 Your answer should be something like this: Elements and compounds are substances but atoms and molecules are invisible particles. A compound is a substance containing two or more elements combined together. A molecule is two or more atoms joined together.

11 The electric current causes the water to decompose into the elements hydrogen and oxygen (see page 82).



When hydrogen and oxygen are mixed, a lighted match causes them to combine again. In both cases a chemical reaction occurs.



12 The scientist needs to use chemical reactions to break the compounds into their elements, as in Question 11. If she does this, the first compound ●■ will give her equal amounts of ● and ■. The second compound ●■● will give twice as much ● as ■.

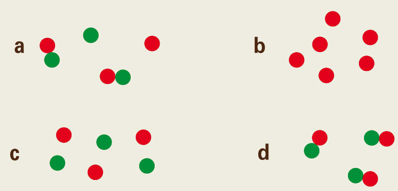
REVIEW

5 Nitrogen dioxide is a compound which contains nitrogen and oxygen in the ratio of one atom of nitrogen to two atoms of oxygen. Its formula would be:

A NO **C** NO_2
B N_2O **D** N_2O_2

6 If ● and ● represent two different atoms, which one of the following would best represent:

a an element?
b a compound
c a mixture



7 The formula for ammonia is NH_3. How many atoms are there in a molecule of ammonia?

8 Nicholas knows that compounds containing sodium (a metal) produce a golden-yellow colour in a flame. He also knows that compounds containing iodine produce a purple gas when heated with concentrated sulfuric acid. He tests four chemicals and records his results.

Substance	Yellow flame	Purple gas
1	✓	✗
2	✗	✓
3	✗	✗
4	✓	✓

a Which of these chemicals contain the element sodium?
b Which contain the element iodine?
c Which is likely to be the compound sodium iodide?

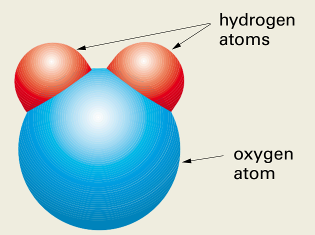
9 Jake pours some acid onto the element zinc. Hydrogen gas is formed and a colourless solution is left. He tests the colourless solution and finds that it contains only two different elements—zinc and chlorine. On the basis of these tests Jake can conclude that the acid contains:

A hydrogen only
B hydrogen and chlorine only
C chlorine only
D zinc and chlorine only

10 Write several complete sentences to explain the differences between an atom, a compound, an element and a molecule.

11 Stephanie passes an electric current through water in a voltameter, as in Investigate 10. She finds that the water slowly disappears and she is left with two gases—hydrogen and oxygen. She then mixes the two gases and puts a match to them. An explosion occurs and water is formed again.

Knowing the structure of a water molecule, how can you explain Stephanie's results?



12 A scientist has two different compounds. She knows that the molecules in one can be represented by ●■ and the molecules in the other can be represented by ●■●. However she does not know which is which. How could she use chemical reactions to find out?

Check your answers on page 319.