Key Stage 3 Science (Chemistry)

Elements, Compounds and Mixtures

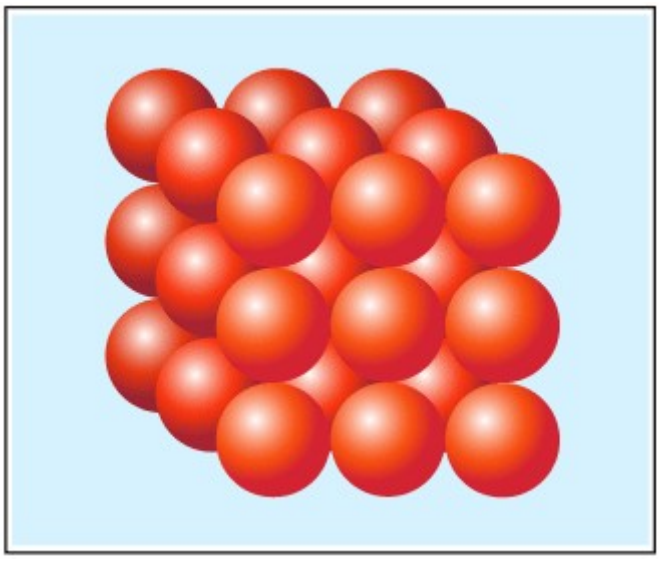
This Section is about elements, compounds and mixtures. It has these parts in it:

- **Atoms and elements**
- **Chemical symbols / the periodic table**
- **Compounds**
- **Atoms and molecules**
- **Chemical Formulae**
- **Mixtures**
- **Checkpoint**
- **Separating Mixtures**

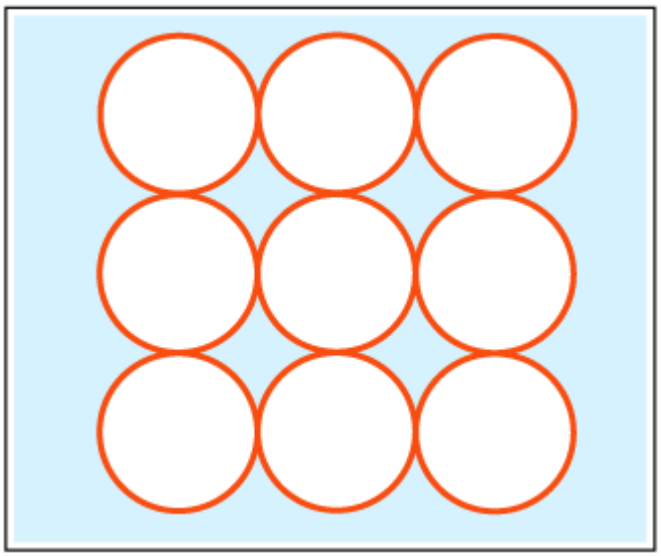
Atoms and Elements

Atoms

Everything is made from atoms, including you. Atoms are tiny particles that are far too small to see, even with a microscope. If people were the same size as atoms, the entire population of the world would fit into a box about a thousandth of a millimeter across!



We usually imagine atoms as being like tiny balls



We often draw atoms as circles

Elements

There are over a hundred different types of atom. A substance that contains just one type of atom is called an element. Because there are over a hundred different types of atoms, there are over a hundred different elements.

Lead and gold are elements. They only contain lead or gold atoms. You cannot change one element into another element, or anything simpler, using chemical reactions. This is why any attempts to turn lead into gold are doomed to fail.

Elements v atoms

- An element is a substance made from one type of atom. It cannot be changed into another element or anything simpler using chemical reactions.
- An atom is the smallest particle of an element you can get.

Chemical Symbols / The Periodic Table

Chemical symbols

Each element is given its own chemical symbol. This is usually one or two letters long, but sometimes three letters are used. Every chemical symbol starts with a capital letter, with the second or third letters written in lower case. For example, Mg is the correct symbol for magnesium, but mg, mG and MG are wrong.

Take care to write chemical symbols correctly

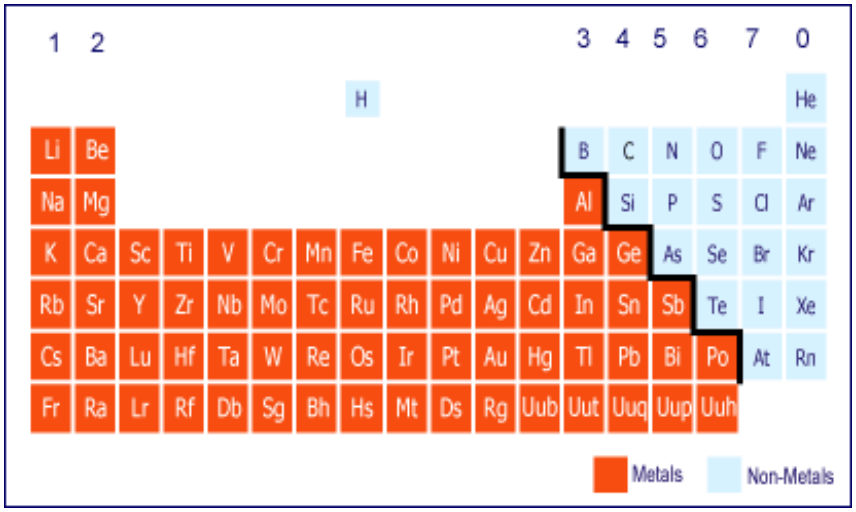
Sometimes it is easy to tell which element a symbol stands for. For example, O stands for oxygen and Li stands for lithium.

Sometimes it is not easy to tell which element a symbol stands for. This is because the symbol comes from a name for the element that is not an English word. For example, W stands for tungsten (from the word wolfram) and Na stands for sodium (from the word natrium). However, the same chemical symbols are used all over the world, no matter which language is spoken.

The periodic table

All the different elements are arranged in a chart called the **periodic table**.

- They are arranged so that similar elements are found in vertical columns, called **groups**.
- The horizontal rows are called **periods**.
- The **metals** are on the left and the **non-metals** are on the right.
- One non-metal, **hydrogen**, is often put in the middle.



Only elements are found in the periodic table

Compounds

The atoms of the different elements can join together in chemical reactions to form **compounds**. For example, hydrogen and oxygen are elements. They react together to form water, a compound. There are countless different ways for the elements to join together, and millions of compounds are known.

Properties of compounds

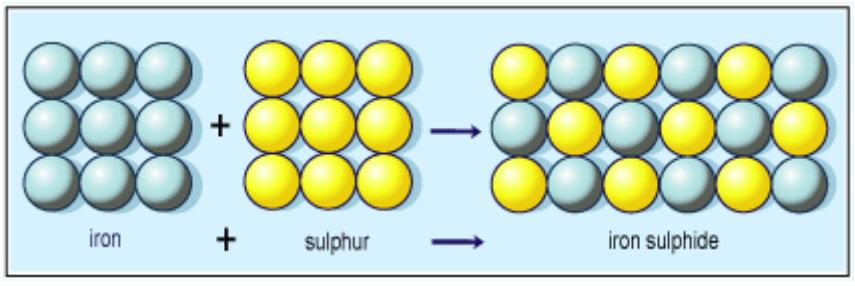
The **properties** of compounds are usually very different from the properties of the elements they contain. For example, hydrogen and oxygen are both **gases** at room temperature, but water is a **liquid**.

The reaction between iron and sulphur to make iron sulphide is often used in school to study elements and compounds. Look at the animation to remind you what happens in this reaction

The table compares the properties of iron and sulphur (the two elements), and iron sulphide (the compound).

	Element		Compound
	iron	sulphur	iron sulphide
colour	silvery grey	yellow	black
is it attracted to a magnet?	yes	no	no
reaction with hydrochloric acid	hydrogen formed	no reaction	smelly hydrogen sulphide formed

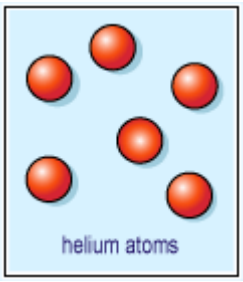
The atoms in a compound are chemically joined together by strong forces called **bonds**. You can only separate the elements in a compound using another chemical reaction. Separation methods like filtration and distillation will not do this.



Compounds form when atoms join together in new ways in chemical reactions

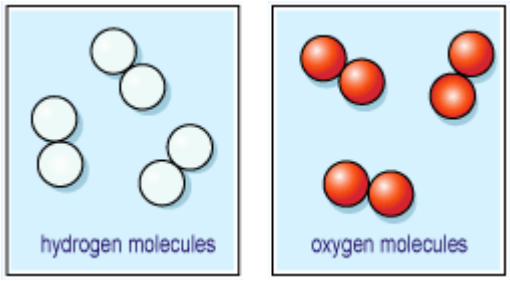
Atoms and Molecules

Remember that an element is a substance made from only one type of atom. The atoms of some elements do not join up with each other. The element Helium, an unreactive gas used in party balloons, is like this.



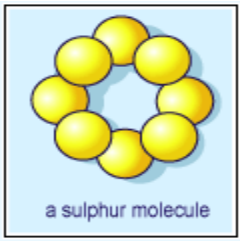
Helium atoms do not join up with each other.

The atoms of most other elements do join up with each other. They form **molecules**. Molecules consist of **two or more atoms joined together**. Some molecules consist of pairs of atoms. Hydrogen and oxygen are like this.



Hydrogen and oxygen atoms pair up to form molecules.

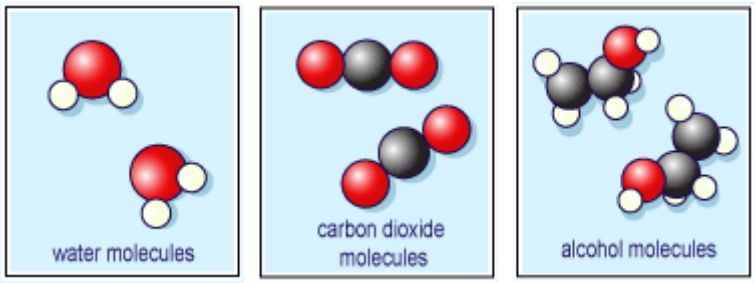
Some molecules consist of lots of atoms joined together. Sulphur is like this.



A sulphur molecule contains eight atoms joined together.

Compounds

Remember that a compound is a substance made up from two or more elements, chemically joined together. This means that compounds will **always** exist as molecules, not separate atoms. The diagrams show some molecules of common compounds.



Molecules of three common compounds.

Chemical Formulae

Formula v formulae

If we have more than one formula, we don't say formulas, we say formulae ("form-u-lee").

Formulae for molecules

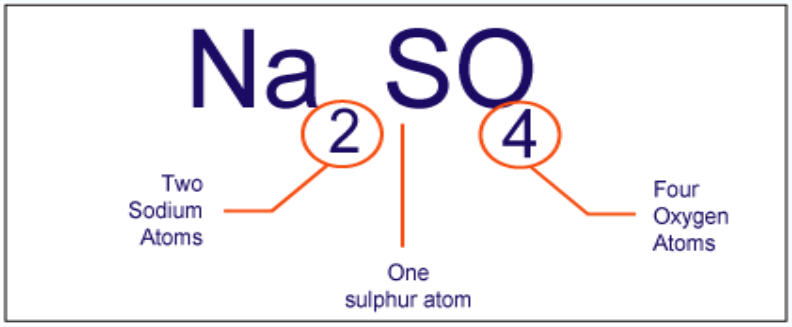
Remember that we use chemical symbols to stand for the elements. For example, C stands for carbon, O stands for oxygen, S stands for sulphur and Na stands for sodium. If we want to do the same for a molecule, we use a chemical formula.

A chemical formula is made up of the symbols for the elements it contains. For example, the formula for carbon monoxide is CO. It tells you that each molecule of carbon monoxide consists of one carbon atom joined to one oxygen atom. Take care when writing your symbols and formulae - CO means a molecule of carbon monoxide but Co means an atom of cobalt.

Numbers

Many formulae also contain numbers. These tell you if the molecule contains more than one atom of an element. For example, the formula for carbon dioxide is CO_2. It tells you that each molecule of carbon dioxide consists of one carbon atom with two oxygen atoms joined to it. Take care when writing these formulae - CO_2 is correct but CO^2 is wrong.

Some formulae are more complicated. For example, the formula for sodium sulphate is Na_2SO_4. It tells you that sodium sulphate contains two sodium atoms, one sulphur atom and four oxygen atoms.



The formula for sodium sulphate and what it means.

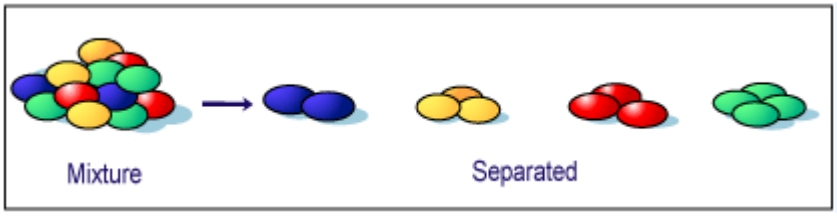
All compounds have a definite composition. Let's look at water as an example. A water molecule always has two hydrogen atoms and one oxygen atom - it cannot be a water molecule if it has different

numbers of these atoms.

Mixtures

A mixture is made from different substances that are not chemically joined together - imagine coloured sweets which can be mixed together in a packet, but which are not chemically joined to each other.

The different substances in a mixture can be separated from each other without needing a chemical reaction, in the way that different coloured sweets can be picked out and put into separate piles.



A packet of sweets contains a mixture of different colours

Mixture and compounds

Mixtures have different properties from compounds. The table summarises these differences.

	Mixture	Compound
Composition	Variable composition – you can vary the amount of each substance in a mixture.	Definite composition – you cannot vary the amount of each element in a compound.
Joined or not	The different substances are not chemically joined together.	The different elements are chemically joined together.
Properties	Each substance in the mixture keeps its own properties.	The compound has properties different from the elements it contains.
Separation	Each substance is easily separated from the mixture.	It can only be separated into its elements using chemical reactions.
Examples	Air, sea water, most rocks.	Water, carbon dioxide, magnesium oxide, sodium chloride.

An example

Remember that iron and sulphur react together when they are heated to make a compound called iron sulphide. What are the differences between a mixture of iron and sulphur, and iron sulphide? Here are some of them:

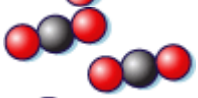
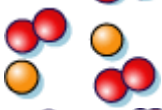
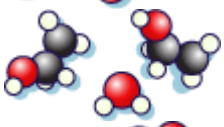
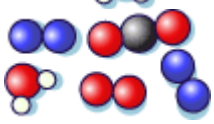
- The mixture can contain more or less iron, but iron sulphide always contains equal amounts of iron and sulphur.
- The iron and sulphur atoms are not joined together in the mixture, but they are joined together in iron sulphide.
- The iron and sulphur still behave like iron and sulphur in the mixture, but iron sulphide has different properties from the iron and sulphur it contains.
- You can separate the iron from the mixture using a magnet but this does not work for iron sulphide.

Checkpoint

Can you recognise elements, compounds and mixtures?

- An element contains just one type of atom.
- A compound contains two or more types of atom joined together.
- A mixture contains two or more different substances that are not joined together.
- The different substances in a mixture can be elements or compounds.

The table shows some examples.

Diagram	Description	Example
	Pure element	oxygen
	Pure compound	carbon dioxide
	Mixture of elements	oxygen and helium
	Mixture of compounds	alcohol and water
	Mixture of elements and compounds	air

Seperating Mixtures

The different substances in mixtures are usually easily separated from one another. The method you use depends upon the type of mixture you have.

Chromatography

This is good for separating dissolved substances that have different colours, such as inks and plant dyes. It works because some of the coloured substances dissolve in the liquid better than others, so they travel further up the paper.

Filtration

This is good for separating an insoluble solid from a liquid (an insoluble substance does not dissolve in water). For example, sand can be separated from a mixture of sand and water using filtration.

Evaporation

This is good for separating a soluble solid from a liquid (a soluble substance dissolves in water to form a solution). For example, copper sulphate crystals can be separated from copper sulphate solution using evaporation. Remember that it is the water that evaporates away, not the solution.

Simple distillation

This is good for separating a liquid from a solution. For example, water can be separated from salty water by simple distillation. This method works because the liquid evaporates from the solution, but is then cooled and condensed into a separate container. The salt does not evaporate and so it stays behind.

Fractional distillation

This is good for separating two or more liquids from each other. For example, ethanol (alcohol) can be separated from a mixture of ethanol and water by fractional distillation. This method works because the two liquids have different boiling points

Elements, Compounds, Mixtures Test

1. Which is the smallest particle ?
   a) an atom
   b) a molecule
   c) a speck of dust

2. How many different atoms are there in an element ?
   a) one
   b) two
   c) more than two

3. Which of these is the correct symbol for magnesium ?
   a) MG
   b) mg.
   c) Mg

4. How may different atoms are there in a compound ?
   a) one
   b) always
   c) two or more

5. Which statement about atoms and molecules is correct ?
   a) elements always exist as separate atoms
   b) elements always exist as pairs of atoms called molecules
   c) elements and compounds can exist as molecules.

6. Is water an element, compound or mixture ?
   a) element
   b) compound
   c) mixture

7. Which is the best way to get salt from salty water ?
   a) evaporation
   b) filtration
   c) distillation

8. Pure water can be separated from inky water by simple distillation because :
   a) water and ink have different boiling points
   b) water evaporates leaving the ink particles behind
   c) ink evaporates leaving the water behind.

9. The correct order for obtaining salt from a mixture of sand, salt and water is :
   a) dissolving – filtration – evaporation
   b) evaporation – filtration – dissolving
   c) filtration – dissolving – evaporation

10. Which method is usually used to seperate coloured substances from each other ?
    a) simple distillation
    b) evaporation
    c) chromatography

Answers

1. **Answer - a**
   An atom is the smallest particle

2. **Answer- a**
   An element by definition is a substance made of a single atom

3. **Answer - c**
   Magnesium is represented by the symbol Mg

4. **Answer - c**
   A compound is a substance made up of 2 or more atoms

5. **Answer - c**
   It does not matter of how many atoms a substance is made up of and hence both elements and compounds can exist as molecules

6. **Answer - b**
   Water is a compound because its molecule consists of the atoms of both hydrogen and oxygen

7. **Answer - a**
   Through evaporation the water will evaporate leaving the salt particles behind.

8. **Answer – b**
   Water has a lower boiling point and will therefore evaporate before ink on heating, thus separating both substances

9. **Answer - a**
   A mixture of sand, salt and water can be separated by first dissolving all the three substances. Through filtration we will be able to separate sand. We will be left with a mixture of salt and water which we can further isolate using the method of evaporation

10. Answer - c

Chromatography is a method which uses the properties of colours in easing the procedure for separating coloured substances.