Lesson Two

Chemistry: Elements and Compounds

Aims

By the end of this lesson you should be able to:

- understand ideas of elements and compounds
- relate these to the ideas of atoms and molecules
- remember the names and symbols of some of the common elements

Context

This lesson introduces you to Chemistry, the second of the three main sciences.

Introduction

Chemists are fascinated by the **materials** the world is made from, which they call **substances** or "chemicals".

In this lesson we learn about the search for the most basic sorts of substance – the **elements** – and how chemists believe they are combined to give other materials called **compounds**.

Get it right! An "object" is a single article or thing. A "substance" or "material" is the stuff the object is made from. So chairs and tables are objects, but wood and metal are the materials most chairs and tables are made from.

Elements

The earliest chemists looked at the thousands of different materials in the world, and felt dissatisfied. They knew in their bones that there *must* be something simpler hiding underneath all this complication. They guessed that all these materials are in fact made up of only a few basic, simple materials. They called these basic materials the **elements**.
But what are they?

The Search for the Elements

"Aha!" said the chemists. "I'll know when I find an element, because it will be impossible to split it up into two or more simpler substances!"

So they set out in search of the elements. They got hold of all the materials they could and tried splitting them up. When they found a substance that they couldn't split they assumed it must be an element.

Well, they often got it wrong. The Ancient Greek scientists, for example, decided that there are only four elements: earth, air, fire and water. This was a good try, but we now know you can split each of these up. For example:

- if you make air extremely cold, it turns into liquid air. If you then warm it up slowly, different gases boil off

separately, including oxygen and nitrogen. If you can split air into oxygen and nitrogen it cannot be an element!
- if you pass electricity through water (don't try this at home!), it splits up into two gases, hydrogen and oxygen. If you can split water into hydrogen and oxygen it cannot be an element!

Eventually, however, hundreds of years later, the chemists got it right. Between the years 1669 and 1945 they gradually discovered all the elements that everything is made of.

Bizarrely enough, there are 92 of them!

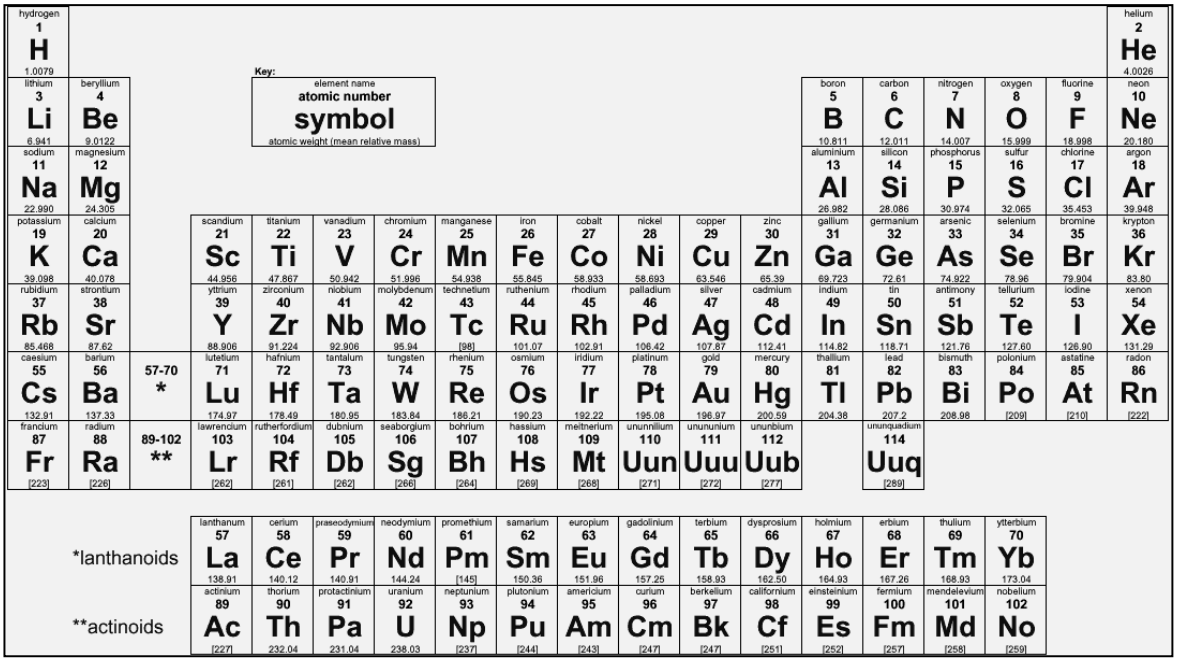
Activity 1

Go to the clip section of the BBC's Learning Zone at www.bbc.co.uk/learningzone/clips/ Enter "Lavoisier" into the search box, and watch a video about the man who discovered that air is not an element but contains the elements oxygen and nitrogen.

The Elements

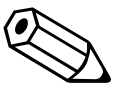
You will find a complete list of the elements below in a table called **The Periodic Table** (more about this later). You will know quite a few of these already. There is a bigger version of this table at Appendix A at the back of your file.

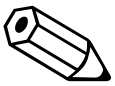
You will notice there are over 100 elements on the list, not 92.



The Periodic Table

That is because scientists have recently made a few extra elements artificially in nuclear reactors. So chemists usually say there are “about 100 elements”, or “92 naturally occurring elements”.

Activity 2	Using The Periodic Table, write down the names of (a) ten elements you have heard of (b) five elements you have not heard of.
	

Activity 3	Here is a list of different materials. Using The Periodic Table to help you, divide the list into two parts: those which are elements and those which are not: Soap, iron, wood, zinc, nitrogen, water, air, gold, uranium, flour, salt, silicon, glass, krypton, petrol, mercury.
	**Elements** **Non-elements**

Symbols

Chemists have developed a shorthand way of writing the elements, called chemical **symbols**. These are written under the names of the elements in the boxes of The Periodic Table.

As you can see, each symbol has one or two letters. The first is always a Capital letter. If there is a second it is always a small letter.

Sometimes the letters don't seem to have anything to do with the name of the element, e.g. Fe for "iron". In this case the symbol is taken from the Latin name for the element, e.g. *ferrum* is Latin for "iron".

Activity 4

1. Write down the symbols for these elements. Make sure you write the capital and small letters correctly:

   Oxygen, hydrogen, nitrogen, silver, gold, iron, magnesium, silicon, carbon, iodine.

2. Now write down the names of the elements of which these are the symbols. Be careful – often there are two or more elements whose symbols start with the same letter:

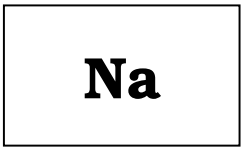
   N, He, Pt, P, Mn, S, Cl, Na.

Some of these symbols are used a lot in Chemistry, and it will be helpful to remember them if you can. Here is a list of the most important ones:

H – Hydrogen	C – Carbon	N – Nitrogen
O – Oxygen	Na – Sodium	S – Sulphur
Cl – Chlorine	K – Potassium	Mg – Magnesium
Ca – Calcium	Fe – Iron	Cu – Copper
Zn – Zinc	Ag – Silver	Sn – Tin
I – Iodine	Pt – Platinum	Au – Gold
Hg – Mercury	Pb – Lead	U – Uranium

Activity 5

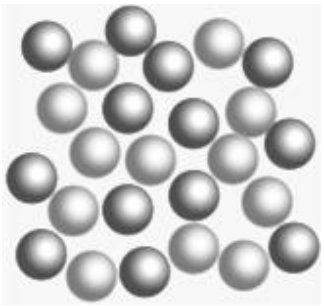
Buy some index cards, and on one side write the chemical symbol of an element. On the other side write out the name of the element and anything you learn about it. The first 21 should be the elements listed above. Add more element cards as you meet them during the course.



Atoms

OK, there are about 100 different elements, and none of them can be split up into anything simpler. But why?

The answer was suggested by an English chemist called John Dalton in the early 1800s. He proposed that all materials are made up of incredibly small, unsplittable balls called atoms.

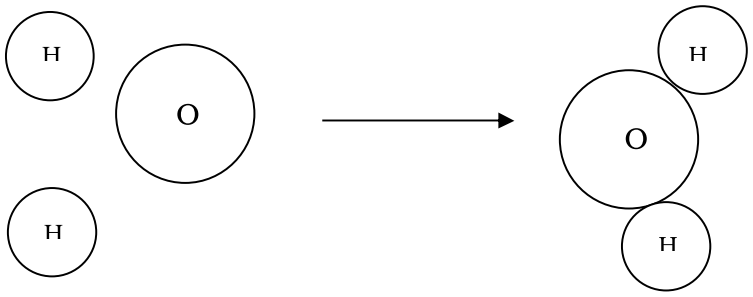


Dalton suggested that there are many different sorts of atom — with different sizes and weights — but that an element contains only one sort of atom. So iron is made up of identical iron atoms, oxygen is made up of identical oxygen atoms, and so on. It follows that there are about 100 different sorts of atom, one for each element.

Compounds and Molecules

Dalton also suggested that atoms can join together into small groups called **molecules**. When they do this a **chemical reaction** occurs and a completely new substance is formed.

For example, oxygen and hydrogen atoms join together to form water molecules like this:



one oxygen atom and two hydrogen atoms

a water molecule

Log on to Twig and look at the film titled: **Molecule**

www.ool.co.uk/469tp

Two or more atoms held strongly together by covalent bonds.

Substances like water, made up of molecules with two or more sorts of atom in them, are called **compounds**.

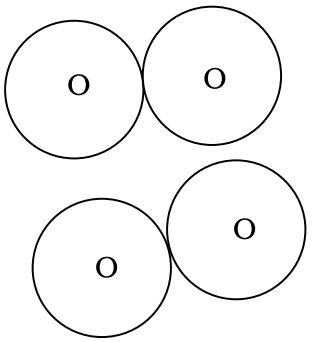
The properties of a compound are often completely different to the properties of the elements it is made up of. For example, oxygen and hydrogen are both colourless gases, quite different to water which is a liquid. (We will be looking at states of matter, i.e. solids, liquids and gases, in Lesson Six.)

A compound can be split up into its elements, by breaking up its molecules, but only by another chemical reaction. This is what happens when electricity is passed through water, as mentioned above.

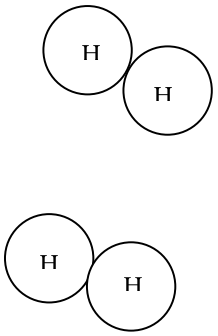
Two sorts of Molecule

There is one confusing complication to tell you about.

In many elements, the atoms also join together to form molecules. For example, oxygen and hydrogen look like this:



two oxygen molecules



two hydrogen molecules

So both elements and compounds can be made up of molecules. But *in elements the molecules contain only one sort of atom.*

Grouping the Elements

The elements are a very mixed bunch. Some are gases, most are solids and two are liquids. Most are metals, but some are not. Some are harmless and some are deadly poisonous. They have various colours.

The most important division is between **metal** and **non-metal elements**:

- **Metals** are elements like iron, aluminium, copper, silver, gold and lead. They are shiny, can bend without breaking, and conduct heat and electricity well. Most of the elements are metals.
- **Non-metals** are solid elements like carbon, sulphur and silicon, and gases like oxygen, nitrogen and helium. They have opposite properties to metals.

Activity 6	How many of the elements mentioned above can you find around your house? Carbon is found in "lead pencils", copper in electric wires, and aluminium in drinks cans. You can find pictures of the other elements by entering their names in the search box in Google Images.

Later on we will discover the reasons for the similarities and differences between the elements. As you can probably guess, it is caused by similarities and differences between their atoms.

Activity 7

Using The Periodic Table, write down the names and symbols of:

(a) Two elements which are solids, but non-metals
(b) Three elements which are solids, and also metals

See if you can find out:

(c) One element which is a liquid
(d) One element which is poisonous
(e) One element which is radioactive

Log on to Twig and look at the film titled: **Introduction to the Periodic Table**

www.ool.co.uk/1395fr

In 1869, Russian scientist Dmitri Mendeleev created the Periodic Table, ordering the naturally occurring elements by their structure and properties. His Periodic Table changed the course of Chemistry forever, and even predicted the future.

Activity 8

Go to the Website BBC Bitesize: KS3 Science:

http://www.bbc.co.uk/schools/ks3bitesize/science/

Click on "Chemical and Material Behaviour", and then "Revise" for "Atoms and Elements" and view pages 2 and 3, followed by "Activity" at the bottom.

Activity 9

The Royal Society of Chemistry has a great list of useful resources on its education page at

http://www.rsc.org/Education/Teachers/Resources/OnlineResourcesHome.asp

Click on "visual elements", or go straight to the page at

http://www.rsc.org/chemsoc/visualelements/index.htm

to download a stunning tour through the elements of the periodic table. Not to be missed!

Keywords

Substance	**The Periodic Table**
Element	**Symbol**
Compound	**Non-metal**
Atom	**Chemical reaction**
Metal	**Molecule**

Self-Assessment Activities

1. Give the name for:

   (a) A material which cannot be broken down into anything simpler.
   (b) A particle made of two or more atoms joined together.
   (c) A substance made of three elements joined together.

2. Give the names the elements of which these are the symbols:

   (a) C (f) Cl
   (b) Si (g) Fe
   (c) Mg (h) Cu
   (d) H (i) Ag
   (e) U

3. Give the chemical symbol for each of these elements:

   (a) Nitrogen (b) Sodium (c) Zinc (d) Sulphur (e) Potassium (f) Lead.

4. Imagine you are talking to an ancient Greek scientist. Explain to him why you do not believe that water is an element.

Suggested Answers to Activities

Activity 3

Elements: iron, zinc, nitrogen, gold, uranium, silicon, krypton, mercury.
Non-elements: Soap, wood, water, air, flour, salt, glass, petrol.

Activity 4

1. O, H, N, Ag, Au, Fe, Mg, Si, C, I.
2. Nitrogen, Helium, Platinum, Phosphorus, Manganese, Sulphur, Chlorine, Sodium.

Activity 7

(a) Carbon, Sulphur and Silicon are good examples.
(b) That's most of them! E.g. Iron, Copper, Tin …
(c) Mercury and Bromine are the only liquids.
(d) Arsenic is a famous example.
(e) Uranium is a good example, but there are others.