National 4 chemistry

combining atoms

Chemical reactions

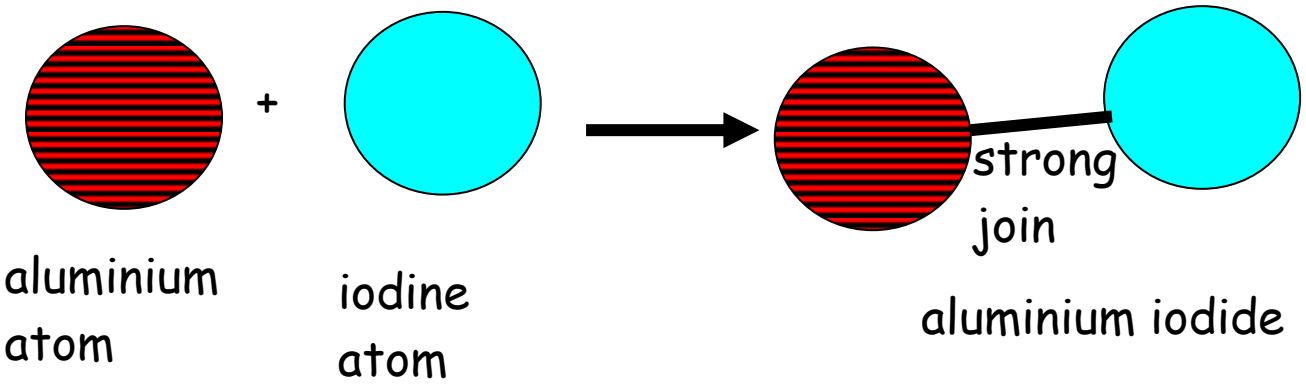
Read

You already know that in every **chemical reaction** a **new substance is always made**.

Some elements can be reacted together to make a new substance. When different elements join together the new substance is called a **compound**.

Your teacher may demonstrate some reactions where two different elements are joined together

- Aluminium joining to iodine
- Copper joining to chlorine
- Magnesium joining to oxygen
- Hydrogen joining to oxygen



When two elements join together we use a set of rules to name the new compound. The name of the compound will end with ide if two elements have been joined.

- Aluminium joining to iodine makes a new compound called aluminium iodide.

- Copper joining to chlorine makes a new compound called copper chloride.

- Magnesium joining to oxygen makes a new compound called magnesium oxide.

The second part of the name changes like this

- nitrogen joins to make **nitride** compounds
- fluorine joins to make **fluoride** compounds
- sulphur joins to make **sulphide** compounds
- bromine joins to make **bromide** compounds

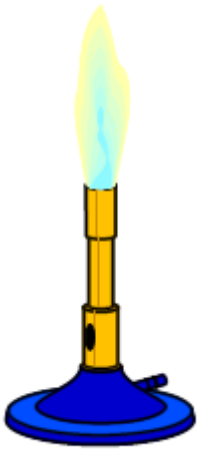
Write a heading and try the following work

1. Describe what happened in one of the demonstrations.
2. What does the word compound mean?
3. What is the name of the new compound made when
   a) magnesium joins to oxygen
   b) sodium joins to oxygen
   c) iron joins to sulphur
   d) potassium joins to bromine
   e) copper joins to fluorine
4. What elements have been joined together to make
   a) sodium chloride
   b) lithium sulphide

Making a compound

Read

In this experiment you will join iron to oxygen by burning the iron.



Collect

A tub of iron powder
A spatula
Metal tongs
A heat proof mat and bunsen burner

1. Light the Bunsen.
2. Use the spatula to scoop out a very small amount of the iron powder.
3. Flick the powder very gently into the flame and observe what happens.

Your teacher may also ask you to do an experiment to make a compound from iron and sulphur.

Continue your work by answering the questions below.

1. Think back to what you know already about the speed of chemical reactions. Most people would say that iron does not burn. Why were you able to burn iron in this experiment?
2. What is the name of the new compound that you made?

Other naming rules

The names of some compounds are shown on the bottles below.

Some compounds have names that end in **–ite** or **–ate**. Ite or ate is a code meaning that the compound has been made from **three elements** and one of them is **always oxygen**. For example the compounds called **copper carbonate** contains copper, carbon and oxygen.

When you are working out the names of the elements in a compound you can use a data book.

Write a heading and try the work below.

1. If the name of a compound ends in **ide**, how many elements was it made from?

2. If the name of a compound ends in **ite**, how many elements was it made from?
3. If the name of a compound ends in **ate**, how many elements was it made from?
4. What element is always present in a compound that has a name that ends with **ite** or **ate**?
5. Copy the table below and complete it by looking at the display (you should also use a data book for help with the names of the elements).

The name of the compound	what elements are in it?

Your teacher may ask you to use the naming compound cards to match up the name of a compound to the elements it contains.

Word equations

Read

A word equation is a short way to write down what happens in a chemical reaction. There is set of rules for writing equations.

1. Draw an **arrow** in the middle of a line.
2. The names of the chemicals we **start with (the reactants) go before the arrow.**
3. The names of the new chemicals that are **made (the products) go after the arrow.**

Look at the example below.

When methane reacts with oxygen the new substances that are made are water and carbon dioxide.

The word equation for this reaction will be:

Methane + oxygen ⟶ water + carbon dioxide

It is often better to write the names of chemicals like carbon dioxide on two lines as you can see in the example above.

In this word equation, the reactants are methane and oxygen. The products are water and carbon dioxide.

Write a heading and try the work below.

1. What is a word equation?
2. What is the difference between a reactant and a product?

3. What side of the arrow do the reactants get written?
4. What side of the arrow do the products get written?
5. The sentences below tell you about some chemical reactions. **Copy** each sentence **and** underneath it write a word equation for the reaction.

a) When calcium reacts with oxygen a new substance called calcium oxide is made.

b) When copper reacts with chlorine a new substance called copper chloride is formed.

c) When iron reacts with fluorine a new substance called iron fluoride is made.

d) Magnesium chloride is made when magnesium reacts with chlorine.

e) Sodium bromide is made when sodium reacts with bromine.

f) When aluminium is added to hydrochloric acid two new substances are made. The new substances are called aluminium chloride and hydrogen.

g) Sodium hydroxide and hydrogen are made if sodium is added to water.

h) Petrol burns in oxygen to make carbon dioxide and water.

i) Sugar burns in oxygen to give carbon dioxide and water.

j) If mercury oxide is heated it can be turned into mercury and oxygen.

6. Choose a colour for the reactants and a colour for the products and shade/highlight the reactants and products in the word equations you have written in your jotter.

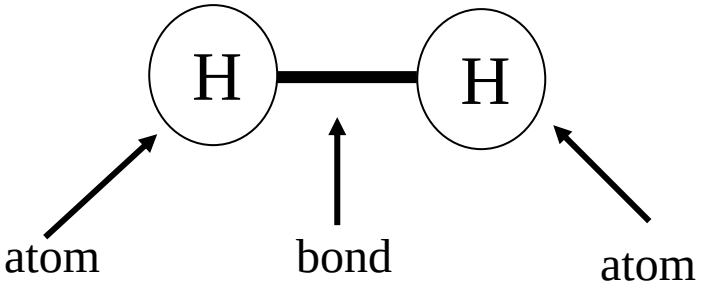
What do the atoms in compounds look like?

Read

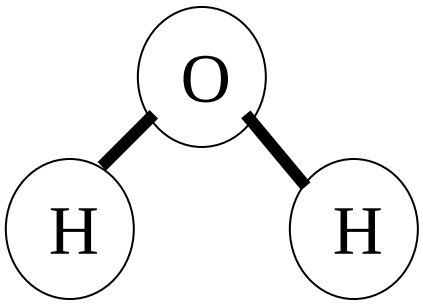
When atoms in different elements react, they join together to make new substances. We can make simple drawings of the atoms in these new substances. The number of atoms of each element joined together is called the chemical formula. There are two rules that we need to remember about writing formula:

- Numbers always go at the **bottom after the symbol**
- We **do not** write the **number one**.

A small number of atoms joined together makes a **molecule**. The molecule below is hydrogen.

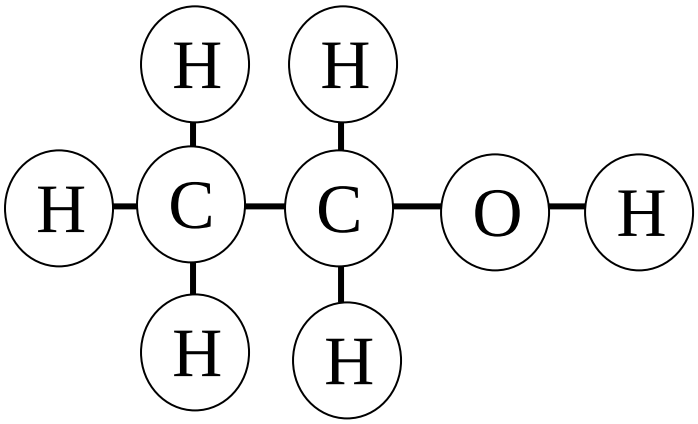


Each circle is an atom. The whole thing is a molecule.
A molecule of hydrogen has 2 hydrogen atoms and the formula is H_2.



There are 3 atoms in total in this water molecule. A molecule of water has 2 hydrogen atoms and 1 oxygen atom so the formula for water is H_2O.

The molecule below is called ethanol. It is the alcohol molecule in alcoholic drinks.



There are 9 atoms in total in this molecule.
If we apply these rules we can see that the formula for ethanol is

C_2H_6O

Be careful not to confuse formula in chemistry with maths powers; C^2H^6O is **not correct** for a chemical formula.

Write a heading and try the work below

1. Explain what a molecule is – a picture might show your understanding better.
2. Collect the sheet called molecules. Complete it and stick it into your jotter.
3. How did you decide which ones were elements and which were compounds?
4. What are the two rules for writing formula?
5. Copy the ethanol molecule that is shown and explain why it has the formula C_2H_6O.
6. Use a data book to copy and complete the table below.

Colour of atom	element name	element symbol
Black	Carbon	C
White	Hydrogen	
Red	Oxygen	
Green	Chlorine	
Yellow	Sulphur	
Blue	nitrogen	

7. Collect the sheet called formula. Complete it by writing the formula for each molecule into the boxes and stick it into your jotter.

Read

The molecules on the sheets you have stuck have certain uses. The molecule with the formula H_2 is used to make margarine. A molecule used in welding has the formula C_2H_2
CO_2 is used in fire extinguishers. $Cl_2$is used in bleach. C_2H_5OH is used in alcoholic drinks. Vinegar contains mainly $C_2H_4O_2$.

Present this information in a table with 2 headings.

8. Now look at the molecules that your teacher has put around the classroom and for each one:
    - Draw it
    - Colour it in
    - Work out its formula.

9. Which molecules have the same formula but a different shape?

10. Collect a model kit and build the molecule $C_2H_4O_2$. The rules are that you must use the **grey** bonds and make sure all of the holes on the atoms are full. Show the molecule to your teacher. This is the main acid molecule in vinegar – draw it into your jotter. It is called ethanoic acid.

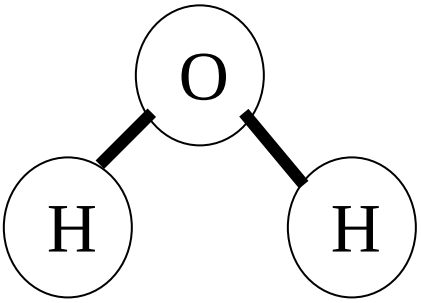
11. Now build three of your own molecules. For each one draw it, colour it in and write the formula.

Atoms and valency

Read

Different atoms can make different numbers of links with other atoms.

The **valency** of an atom is the number of links it can make to join up with other atoms. These links are the bonds inside the molecule.

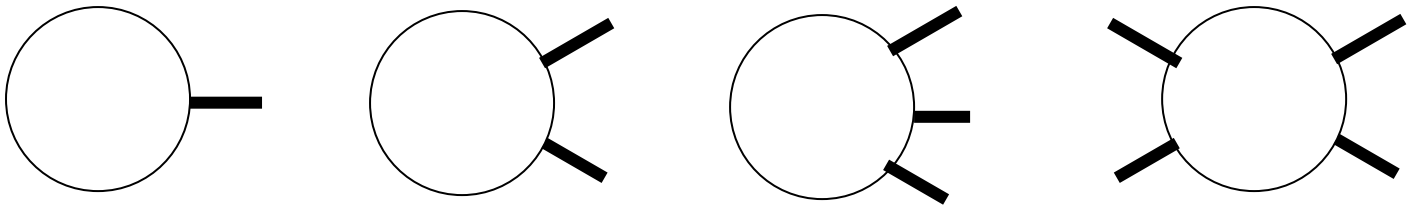


The oxygen atom in this water molecule can make 2 links (one link goes to each hydrogen atom). Each hydrogen atom only makes 1 link.

An atom which can make one link has a valency of **1**.
An atom which can make 2 links has a valency of **2**.
An atom which can make 3 links has a valency of **3**.
An atom which can make 4 links has a valency of **4**.

Atoms that cannot make any links have zero valency.

We can draw valency pictures for atoms by drawing the atoms as circles and showing their valency by drawing lines.

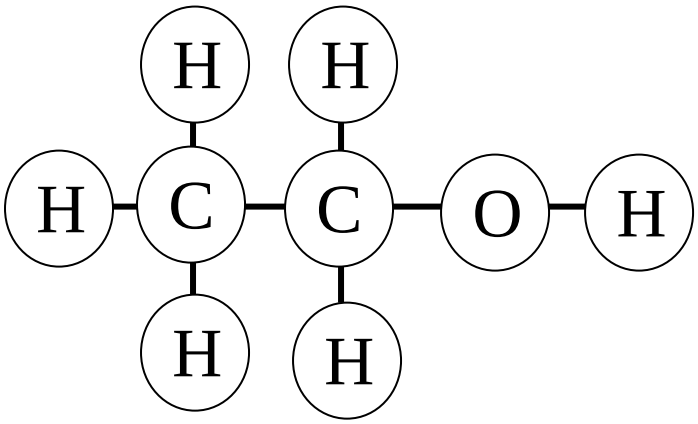


Write a heading and try the work below.

1. What is the meaning of the word valency.
2. Copy the four pictures on the previous page to show how we draw atoms with 1 to 4 valency.
3. Draw a water molecule.
4. What is the valency of the oxygen – how do you know?
5. What is the valency of the hydrogen – how do you know?
6. Some atoms have a valency of 0. Will these atoms be able to join up with other atoms? Explain your answer.

Read

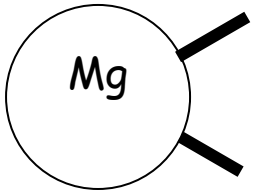
Different elements in the periodic table have different valencies.



In this alcohol molecule every hydrogen atom has a valency of 1. The oxygen atom has a valency of 2 and each carbon atom has a valency of 4. Check this by counting the lines for each atom on the molecule.

Collect a set of **yellow** valency cards and look through them to see the valency of the different elements.

You can see that each valency picture shows the element symbol and the number of links shows its valency.



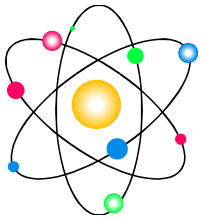
- The circle stands for the atom.
- The Mg stands for the symbol for magnesium.
- The lines stand for the valency (2).

7. Copy the magnesium example above and list what the parts of the drawing stand for.
8. Find cards for hydrogen, copper and nitrogen and copy the pictures for these atoms.
9. Choose at least 4 more atoms and draw them to show their valency.

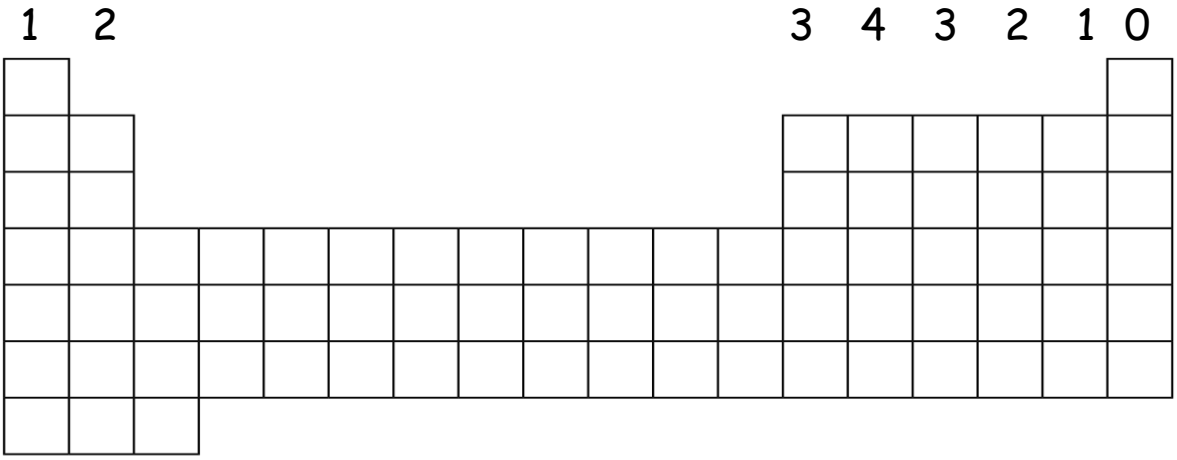
Valency pictures from the periodic table

Read

You are not always allowed to use cards to work out valency pictures but you can use a periodic table to work out valency because the **valency depends on which column the element is in**. The picture below shows which columns have which valencies.



valency



Group/column 1 elements have a valency of 1.
Group/column 2 elements have a valency of 2 and so on.
The valencies for the elements in between column 2 and 3 are not shown in a periodic table. You may learn more about these special elements later.

Write a heading and try the work below.

1. Collect a copy of a periodic table. Choose 4 colours of pencil to represent the four valencies and colour in columns 1 to 7. Make sure you add a key to the table. Stick this periodic table sheet into one of the inside covers of your jotter.

2. Draw the valency picture for
   a) a potassium atom
   b) a calcium atom
   c) a bromine atom
   d) a germanium atom
3. What is the valency number for
   a) lithium
   b) sodium
   c) potassium
   d) beryllium
   e) magnesium
   f) calcium
   g) boron
   h) aluminium
   i) carbon
   j) silicon
   k) nitrogen
   l) phosphorus
   m) oxygen
   n) sulphur
   o) chlorine
   p) iodine
   q) helium
   r) argon
4. Name some elements that we cannot use the columns of a periodic table to work out their valency.

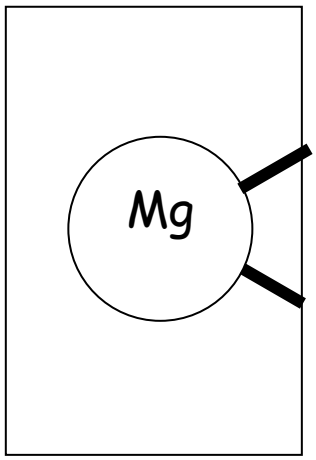
Joining atoms together

Read

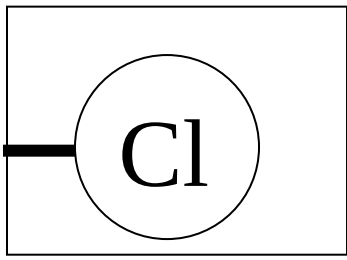
Earlier in this booklet you saw some demonstrations about joining elements together and you did an experiment to burn iron powder and join it to oxygen. We can use valency cards to show how the atoms actually bond together to make a new compound.

The main rule is that **we are not allowed to leave any loose links**.

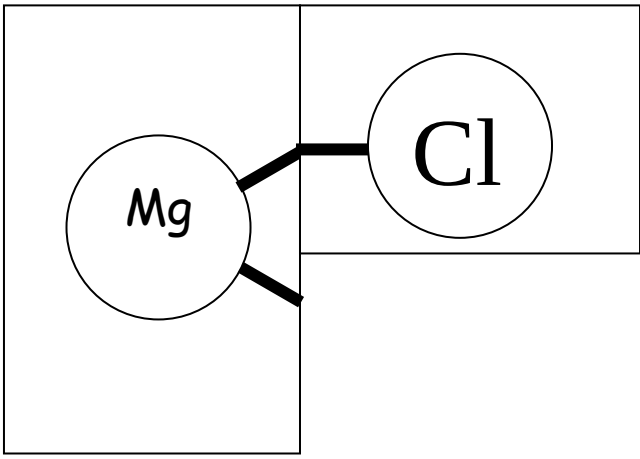
If magnesium atoms are reacted with chlorine atoms, the new compound made is magnesium chloride. We can show what happens to the atoms using cards:



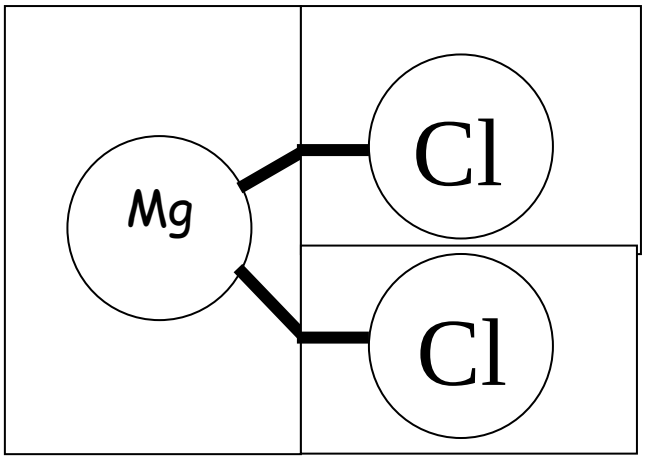
1. To build the valency picture for magnesium chloride we need to use the magnesium and chlorine cards.



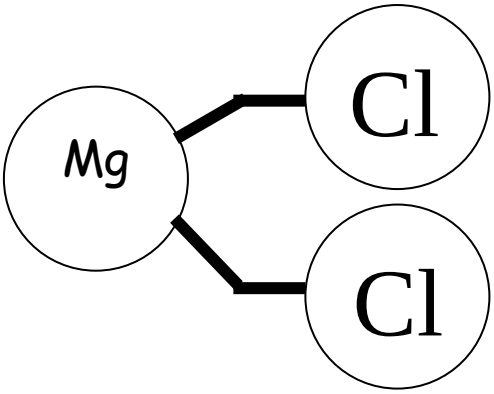
2. We start to join the atoms together by linking the "arms" but can see that one of the links from magnesium is loose.



3. We need to add another chlorine atom to complete the picture and get rid of the loose end.



4. We draw the atoms but **not** the lines for the cards.



The valency picture also gives us the formula.

By **counting** the atoms in the valency picture the formula for magnesium chloride is

$MgCl_2$

The formula tells us the ratio of the atoms, so in a tub of magnesium chloride there is 1 magnesium for every 2 chlorine i.e. the ratio for

Mg to Cl is 1 to 2

So a tub of magnesium chloride contains twice as much chlorine compared to magnesium or we could also say there is half as much magnesium compared to chlorine.

Write a heading then use the cards to work out the valency picture for the following 9 examples. For <u>each</u> example:

- Write the name of the compound
- Draw the picture
- Work out the formula and write it beside the picture
- Write out the ratio of the atoms

1. Magnesium chloride
2. Hydrogen chloride – this is the acid in your stomach.
3. Phosphorus hydride
4. Sodium oxide
5. Calcium sulphide
6. Aluminium nitride
7. Carbon hydride – this is the gas that is used in homes for central heating and cooking.
8. Silicon oxide – this is the chemical name for sand.
9. Aluminium oxide (this one is a bit harder) – this is the chemical name for the gem stone called ruby.

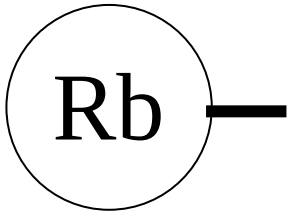
Making compounds without cards

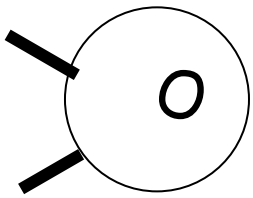
Read

You can use your valency periodic table instead of cards to work out how atoms join together.

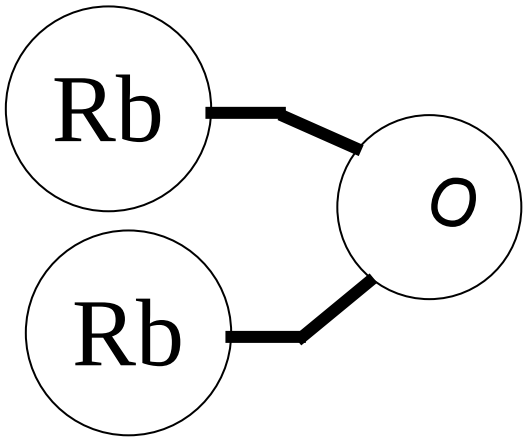
The example shown below is for rubidium oxide.

Draw the valency pictures for the separate atoms – you need to look up your valency coded periodic table and remember the 1234321 pattern. Rubidium is in column 1 so it has a valency of 1. Oxygen is in column 6 so it has a valency of 2.





Work out how to join the atoms together and write the formula:



Rb_2O

Write a heading and use your valency coded periodic table to work out the valency picture for the 6 examples below. For each example:

- Write the name of the compound
- Draw the picture

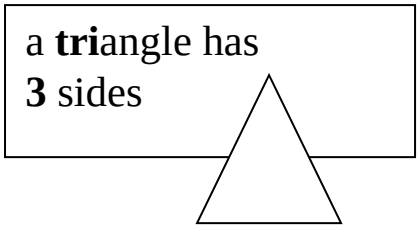
- Work out the formula and write it beside the picture

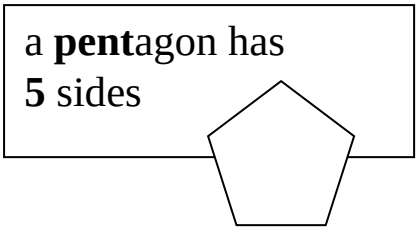
1. lithium iodide
2. potassium sulphide
3. boron fluoride
4. magnesium sulphide
5. germanium oxide
6. calcium phosphide

Compound names and prefixes

Read

The name of an object sometimes tells us about the object. A **tri**cycle has **three** wheels; an **oct**opus has **eight** legs.





The little bit at the beginning of the word is called a **prefix**. Prefixes have certain meanings in chemistry.

prefix	mono	di	tri	tetra	penta	hex	hept	oct
meaning	1	2	3	4	5	6	7	8

The prefix tells us the number of atoms.

- carbon **tetra**chloride contains carbon and 4 chlorine
- carbon **di**oxide contains carbon and 2 oxygen.

Write a heading and try the work below.

1. How do you know that a tricycle has three wheels?
2. Copy the table that shows the meanings of prefixes 1 to 8.
3. Copy and complete the following sentences

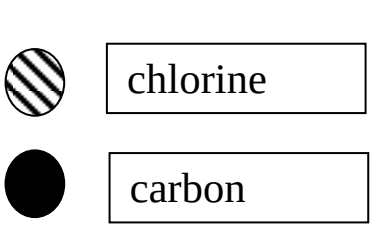
Sulphur **di**oxide contains _____ and _____ _____.
Sulphur **tri**oxide contains _____ and _____ _____.
Carbon **mon**oxide contains _____ and _____ _____.
Nitrogen **di**oxide contains _____ and _____ _____.
Phosphorus **penta**chloride contains _____ and _____ _____.
Silicon **tetra**flouride contains _____ and _____ _____.

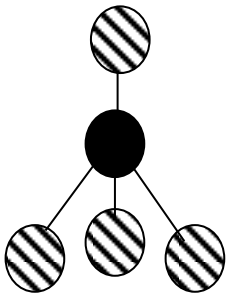
Formula and prefixes

Read

Sometimes we can work out the formula of a molecule even if we cannot see the molecule or the valency picture. We can do this if the name has a prefix in it.

Carbon **tetra**chloride contains carbon and chlorine but tetra means **four** so this tells us that there are **four chlorine** atoms. There is **not** a prefix in front of the carbon part of the name so this means that there is only **one** carbon atom.

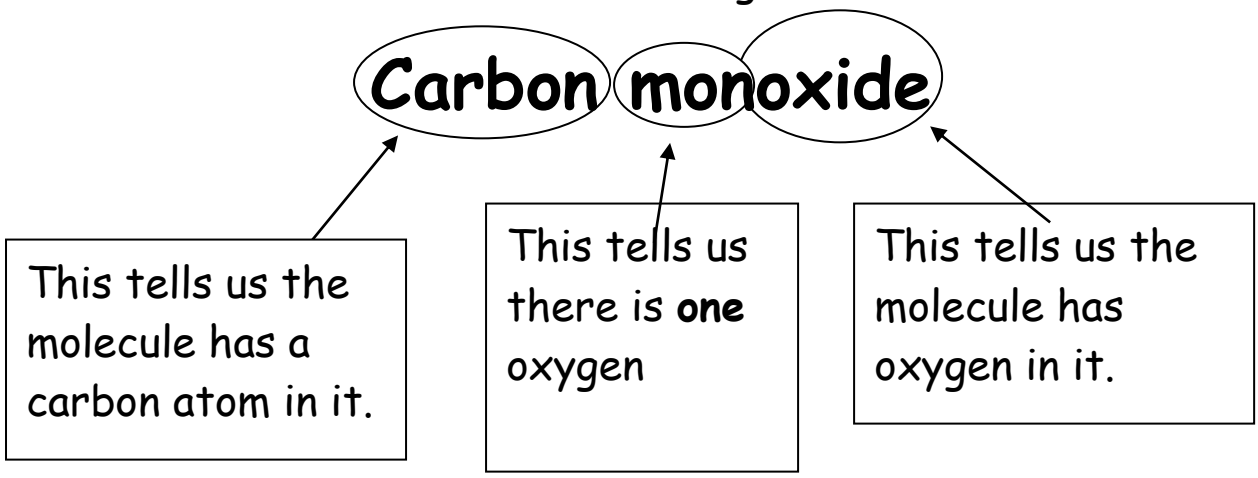




The symbol for carbon is *C* and the symbol for chlorine is *Cl*. The

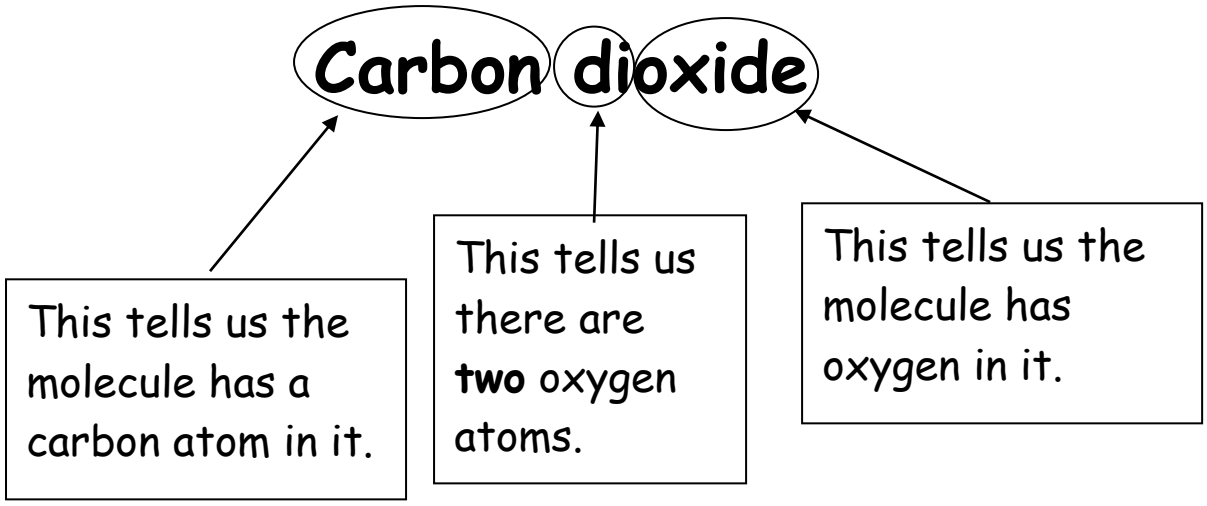
The formula for this molecule will be **CCl_4**

You might have heard of a poisonous gas called **carbon monoxide**. The diagram below shows you how you can use the name to work out the formula of this gas.



So the formula will be **CO** (remember we don't write one's in chemistry).

Another example follows



So the formula will be CO_2

Write a heading and try the work below.

1. Copy the diagram showing how to work out the formula for the poisonous gas called carbon monoxide.

2. Copy and complete the following table.

name	elements present	formula
carbon dioxide	carbon and oxygen	CO_2
carbon monoxide		
sulphur dioxide		
sulphur monochloride		
carbon tetrafluoride		
phosphorus trihydride		
uranium hexafluoride		
diphosphorus trioxide		
dinitrogen oxide		
diphosphorus pentoxide		
	carbon and chlorine	CCl_4
	nitrogen and oxygen	NO_2

Your teacher may ask you to try the make a molecule game at http://www.kscience.co.uk/animations/make_a_molecule.htm

Formula for elements to memorise

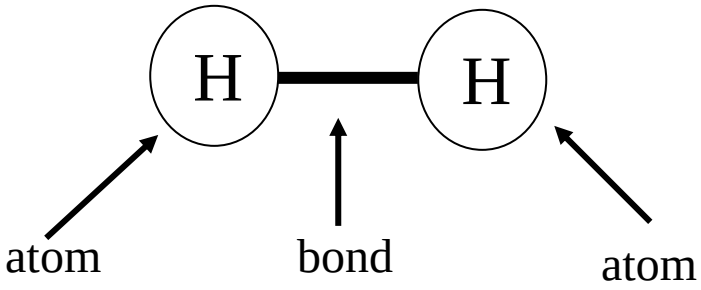
Read

Up until now the formula you have been working out are for compounds but elements have a formula too.

There are 7 elements that have a special formula

Bromine
Oxygen
Nitrogen
Chlorine
Hydrogen
Iodine
Fluorine

You have to memorise the names of these 7 elements. They are called diatomic elements and they always have 2 atoms in each molecule



The formula for hydrogen is H_2

Bromine	**Br_2**
Oxygen	**O_2**
Nitrogen	**N_2**
Chlorine	**Cl_2**
Hydrogen	**H_2**
Iodine	**I_2**
Fluorine	**F_2**

Copy these 7 elements somewhere so you can find them easily again.

The formula for the other elements is easy. The formula is the same as the symbol.

The formula for magnesium is Mg.
The formula for sodium is Na.
The formula for carbon is C.

Write a heading and try the following work

1. Write the formula for

a) calcium
b) oxygen
c) magnesium
d) barium
e) iron
f) hydrogen
g) fluorine
h) potassium
i) sulphur
j) chlorine
k) boron
l) helium
m) iodine

Formula equations

Read

You learned how to do word equations earlier in this course.

carbon + oxygen ⟶ water + carbon dioxide

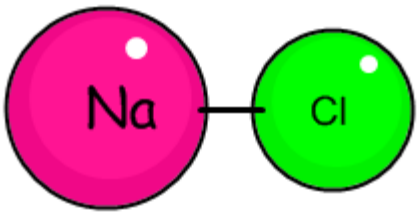
Formula equations have formulae instead of words.

When sodium reacts with chlorine, a new solid called sodium chloride is produced.
The word equation will be:

sodium + chlorine ⟶ sodium chloride

To turn this into a formula equation all we do is write formula instead of words but we will need to think about each chemical.

Sodium is an element and it's formula is Na.
Chlorine is one of the 7 diatomic elements so it's formula is Cl_2.
Sodium chloride is a compound so we need to draw the valency picture to work out it's formula.



NaCl

So for

sodium + chlorine ⟶ sodium chloride

The formula equation is

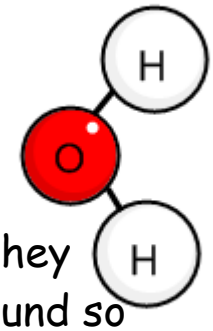
$$Na + Cl_2 \longrightarrow NaCl$$

The reaction that happens when a burning splint pops in the hydrogen gas test is

Hydrogen + oxygen ⟶ hydrogen oxide

We can turn this into a formula equation by applying what we learned in this book about how to change names into formulae for elements and compounds

$$H_2 + O_2 \longrightarrow H_2O$$



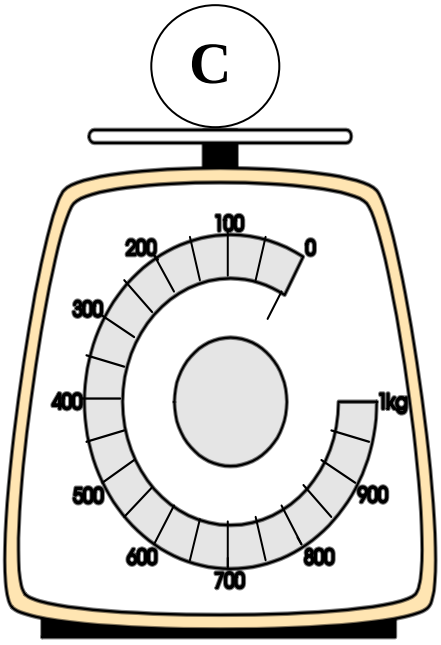
Hydrogen and oxygen are special diatomic elements so they have the formula H_2 and O_2. Hydrogen oxide is a compound so we need to draw a valency picture for it i.e. H_2O.

Your teacher will ask you to try some formula equations from textbooks. Remember you may have to draw valency pictures for the compounds and use your memory for the diatomic elements.

Relative mass

Read

Even though atoms and molecules are very tiny, chemists have been able to work out how much they weigh.



A single carbon atom has a mass of 12 amu. The mass of atoms are in units called amu because grams are too big for weighing atoms.

Chemists do not work out masses using balances like the picture, they need to use very special equipment because atoms are so small.

You can find out about the mass of atoms in a data book. The mass in a data book is called the relative atomic mass. Different elements have different relative masses.

Write a heading and try the work below

1. **Collect** a copy of a data book and look at the contents page.

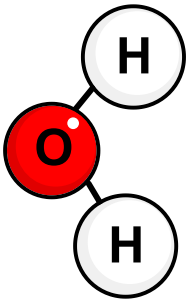
   a) What page would you look up to find out the relative mass of atoms?
   b) What is the mass of a carbon atom?
   c) What is the mass of a gold atom?
   d) What is the mass of a hydrogen atom?

e) What is the mass of an oxygen atom?

f) Choose four other elements and write down the mass of their atoms.

Relative masses for molecules

Read



Chemists work out the mass of a molecule by **adding the masses of the atoms together**. A water molecule has 2 hydrogen atoms and one oxygen atom so it has a mass of

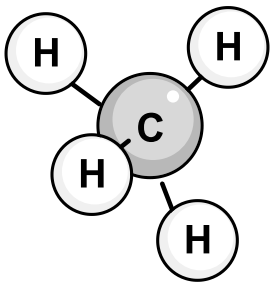
2 + 16 = 18amu

Write a new heading and try the following questions.

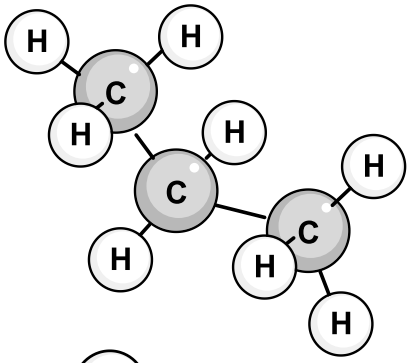
1. Draw a water molecule and explain why it has a mass of 18.

2. Work out the mass of the molecules shown.

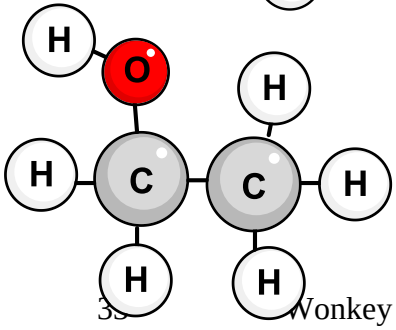
a) methane



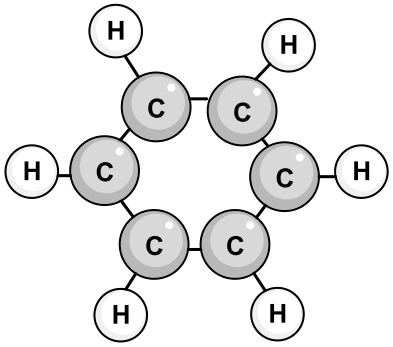
b) propane



c) alcohol



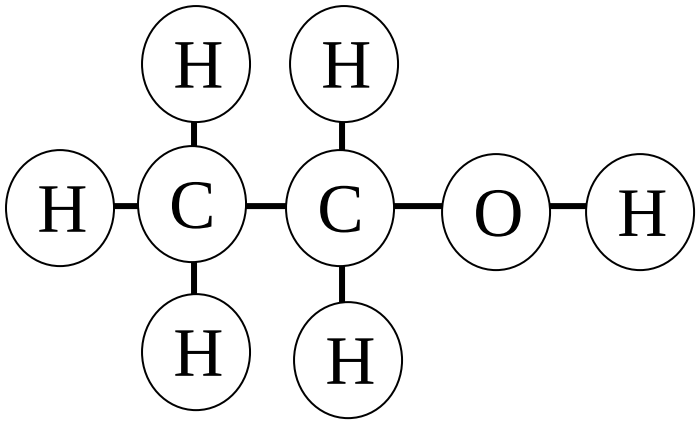
d) benzene (used in unleaded petrol).



Relative formula mass

Read

You have learned how to work out the total mass of a molecule but we can also work out the mass from a formula. This is called the **relative formula mass**.



By looking at data book we can see that each carbon weighs 12, each hydrogen weighs 1 and each oxygen weighs 16.

So the weight of this molecule will be

2x12	=	24
+ 6x1	=	6
+ 1x16	=	16
the total weight	=	46

We can also do this from the formula

C_2H_6O

1x 16 = 16
6x 1 = 6
2x 12 = 24
46

1. Work out how the relative formula mass for each of the following formula – remember to draw arrows down from each element.

a) Na_2O

b) Ca_3P_2
c) CO_2
d) $H_2\ SO_4$
e) $CuCl_2$
f) C_5H_{12}
g) H_2O
h) C_6H_{12}
i) HNO_3
j) SO_2
k) NO_2
l) Fe_2O_3
m) CH_4
n) K_2O
o) $MgSO_4$
p) PbO_2

2. Which formula is the heaviest and which is the lightest?
3. Which formula contains the most atoms?
4. Is the formula with the most atoms the heaviest – give a reason for your answer?