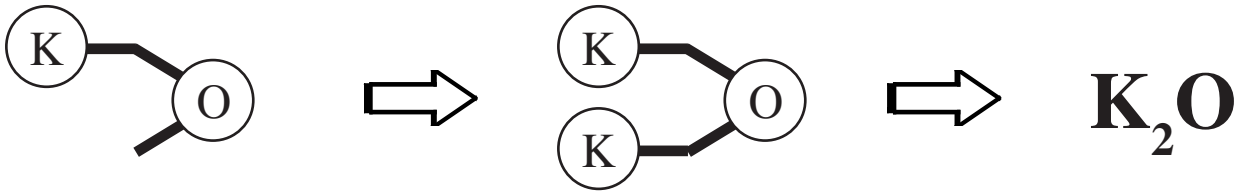
Formula Writing & Chemical Equations



- Balanced Equations
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SiO_2 H_2O

$KMnO_4$

These sheets belong to _____

What is a Formula ?

The ***formula*** of a ***compound*** tells you two things about the ***compound*** :-

SiO_2 H_2O

$KMnO_4$

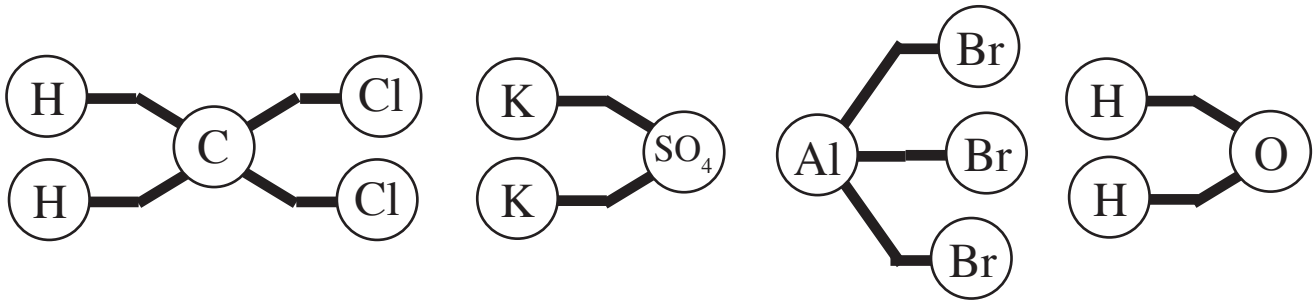
i) ***which elements*** are in the compound using ***symbols***,

and

ii) ***how many*** atoms of each ***element*** are in the compound using ***numbers***.

Test Yourself

What would be the formula for each of the following?



Using the Name Only

Some ***compounds*** have extra information in their ***names*** that allow people to work out and write the correct ***formula***.

The ***names*** of the elements appear as usual but this time the ***number*** of each type of atom is included using

carbon ***mon***oxide CO

carbon ***di***oxide CO_2

dinitrogen ***tetr***oxide N_2O_4

mono- = 1 ***di-*** = 2 ***tri-*** = 3 ***tetra-*** = 4

Test Yourself

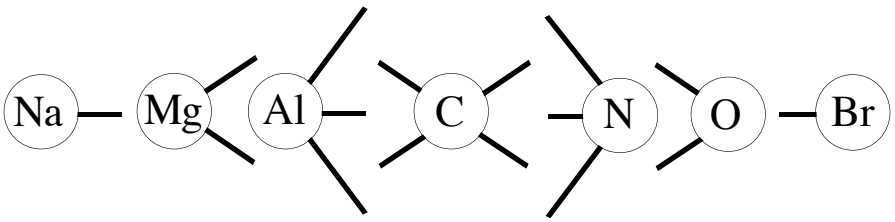
What would be the formula for each of the following?

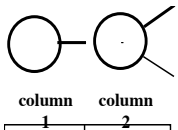
1. sulphur trioxide
2. silicon tetrafluoride
3. dinitrogen oxide
4. phosphorus trichloride
5. dinitrogen tetroxide
6. nitrogen monoxide
7. nitrogen dioxide
8. tin dibromide
9. sulphur dioxide

Valency Numbers

Apart from the *Noble Gases* (column 8), all ***atoms*** can form ***bonds*** and join to other atoms in ***compounds***.

The ***number of bonds*** an atom can form is called its ***Valency***.

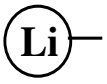




Li 1	Be 2	
Na 1	Mg 2	
K 1	Ca 2	

lithium ⇐ ***Name***

Li ⇐ ***Symbol***



⇐ ***Valency Picture***

To begin with, you will be given a special ***Periodic Table*** which you can use to find the ***Valency Number*** of an ***Element***.

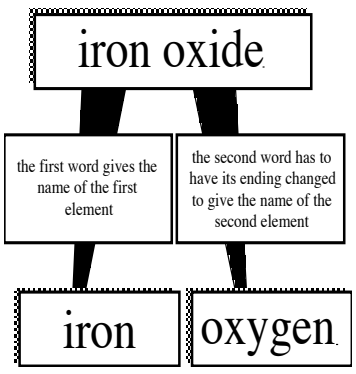
Use the ***Name*** of the ***Element*** to find its ***Symbol*** and then draw the correct ***Valency Picture***

Test Yourself Draw the Valency Picture for each of these Elements.

1. beryllium	2. boron	3. nitrogen	4. fluorine
5. sodium	6. silicon	7. sulphur	8. calcium
9. chromium	10. cobalt	11. arsenic	12. selenium

2 Elements Only

The name of a 2-element ***compound*** usually lists ***both*** the ***elements*** in the compound.

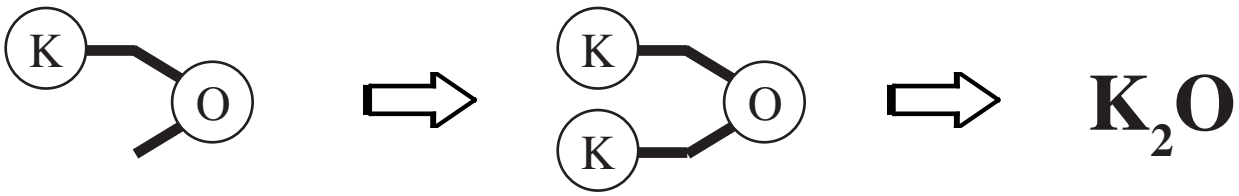


-ide *endings* are used to emphasise that there are ***only two elements*** in the compound.

exceptions: compounds ending ***hydroxide*** or ***cyanide*** have ***more*** than 2 elements in them

Writing a ***correct formula*** is all about looking up the ***correct symbol***, identifying the ***correct valency number*** and then ***balancing*** the two halves of the ***compound***. This is easier if you use ***Valency Pictures***.

For example, to work out the formula for ***potassium oxide.***



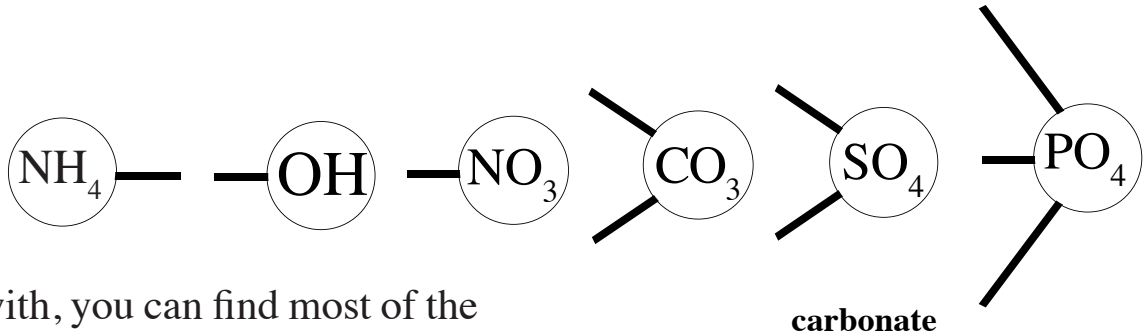
1. *Draw the Valency Pictures for atoms of **potassium** and **oxygen**.*
2. *Draw them as shown. This valency picture is not complete.*
3. *Draw another **potassium** atom to complete the picture.*
4. *Now write the correct formula for **potassium oxide**.*

Test Yourself Work out the formula for each of these compounds.

1. hydrogen oxide	2. sodium bromide	3. phosphorus fluoride
4. magnesium oxide	5. sulphur chloride	6. aluminium sulphide
7. silicon oxide	8. calcium sulphide	9. nitrogen iodide

Group Valencies

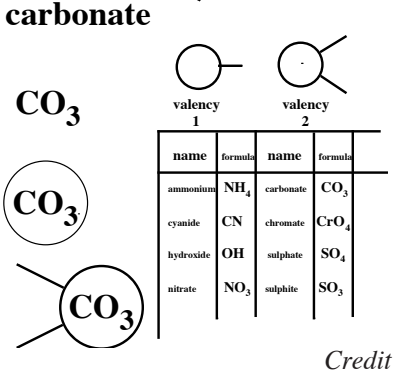
Atoms often join together to form "***Groups***" - *fixed numbers* of ***atoms*** with a certain number of ***spare bonds*** still available - a ***group valency***.



To begin with, you can find most of the ***Groups*** on the other side of the special "***Periodic Table***".

This will show you the ***Symbol*** and the ***Valency Number*** for most of the ***Groups*** you will need.

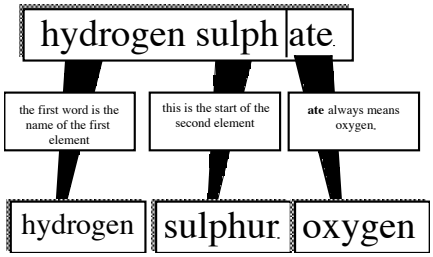
Valency ⟹



Test Yourself Draw the valency picture for each of these Groups.

1. hydroxide	2. sulphate	3. ammonium	4. permanganate
5. silicate	6. phosphate	7. sulphite	8. hydrogencarbonate
9. carbonate	10. chromate	11. nitrate	12. thiosulphate

More than 2 Elements



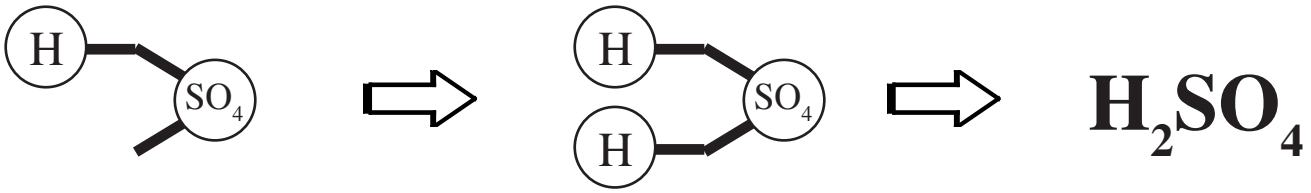
-ite
-ate

endings are used to warn that there are ***more than two elements*** in the compound.

exceptions: none

Compounds may have ***more than 2 elements***, but they will still only involve ***two parts*** :- one of which is a ***Group***.

For example, to work out the formula for ***hydrogen sulphate.***



1. *Draw the Valency Pictures for an atom of* ***hydrogen*** *and the* ***sulphate group****.*

2. *Draw them as shown. This valency picture is not complete.*

3. *Draw another* ***hydrogen*** *atom to complete the picture.*

4. *Now write the correct formula for* ***hydrogen sulphate****.*

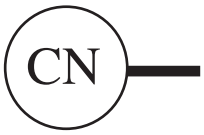
Test Yourself Work out the formula for each of these compounds.

1. ammonium nitrate	2. potassium hydroxide	3. calcium sulphate
4. sodium carbonate	5. ammonium chloride	6. lithium phosphate
7. copper chromate	8. sodium sulphate	9. caesium nitrate

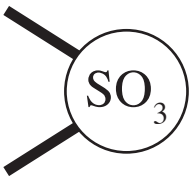
Awkward Customers

Some ***Groups*** are particularly ***awkward*** and you need to watch out for them.

The ***Hydroxide Groups*** is particularly ***awkward*** because it ***contains two elements*** but ends in **-IDE**.



The ***Cyanide Groups*** is particularly ***awkward*** because it ***contains two elements*** but ends in **-IDE**.

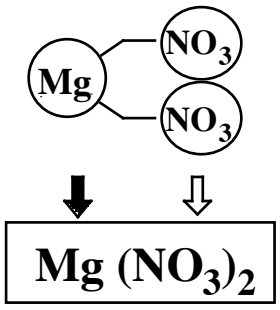


The ***Sulphite Groups*** is particularly ***awkward*** because it is very similar to the ***Sulphate Group***, SO_4.

The ***Ammonium Groups*** is particularly ***awkward*** because it ***comes at the beginning*** of the compounds name.

Using Brackets

Whenever ***two or more*** of a ***group*** appears in a ***formula***, ***brackets*** must be used to avoid confusion.



✗ $MgNO_{32}$

Wrong because it means 1Mg, 1N and 32 O atoms.

✗ MgN_2O_6

Better, but we lose the fact that we have NO_3 groups.

✔ $Mg(NO_3)_2$

Ideal. We can see the nitrate group present, and tell how many

Test Yourself

Work out the formula for each of these compounds.

1. aluminium nitrate
2. calcium hydrogencarbonate
3. ammonium sulphate
4. magnesium hydroxide
5. sodium chloride
6. carbon monoxide
7. magnesium sulphate
8. cobalt nitrate
9. potassium oxide
10. lithium carbonate
11. magnesium cyanide
12. copper carbonate

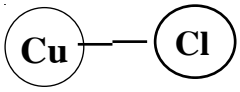
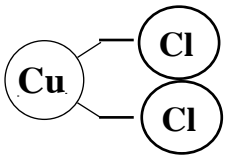
Transition Metals

The ***Transition Metals*** are awkward because they can ***change the number of bonds they use*** from ***compound*** to ***compound***.

This problem is solved by including the ***valency number*** *in the name* of the compound.

Roman numerals are used

(***I*** = one, ***II*** = two, ***III*** = three and ***IV*** = four).

name	copper **(I)** chloride	copper **(II)** chloride
picture		
formula	**Cu Cl**	**$Cu Cl_2$**

Remember that the ***Roman numeral*** tells you the ***number of bonds***, it does not tell you how many atoms should be in the formula.

Test Yourself Work out the formula for each of these compounds.

1. copper (II) chromate	2. lead (II) nitrate	3. barium permanganate
4. silver (I) hydroxide	5. iron (III) phosphate	6. lead (IV) oxide
7. chromium (III) nitrate	8. nickel (II) sulphate	9. sodium bromide

Word Equations

We write a ***"Word Equation"*** to describe the ***changes*** that take place during a ***chemical reaction***.

magnesium + *hydrogen chloride* → *magnesium chloride* + *hydrogen*

1. The + sign means ***and***.

2. The → sign means ***change into***.

3. The chemicals which react are called the ***Reactants*** and are written on the ***left***.

4. The chemicals which are produced are called the ***Products*** and are written on the ***right***.

Test Yourself

Write a ***Word Equation*** for each of the reactions described below.

1. When magnesium metal burns, it reacts with oxygen in the air to form magnesium oxide, a white powder.

2. In the Blast Furnace, iron is made by reacting iron (III) oxide with carbon monoxide gas. Carbon dioxide gas is also produced.

3. In our bodies, starch, which we get from our food, reacts with water and breaks down to form glucose.

4. When calcium metal is added to water, a gas is given off and calcium hydroxide solution is formed. When tested with a burning splint, the gas burns with a "pop".

Formula Equation

The next stage is to replace all the ***names*** of chemicals with their ***formulae***, ie write a ***Formula Equation***. e.g.

word equation

magnesium + hydrogen chloride → magnesium chloride + hydrogen

element | H—Cl | Mg Cl Cl | diatomic element

formula equation

$Mg + HCl \rightarrow MgCl_2 + H_2$

Elements in Equations

Most ***elements*** are easy. They are simply represented by their ***symbol***.

There are, however, ***7 elements*** which are made up of ***molecules***, each with ***2 atoms***. This needs to be shown in their ***formulae***, such as H_2 for ***hydrogen***.

"The Diatomic 7"

hydrogen
nitrogen
oxygen
fluorine
chlorine
bromine
iodine

H_2										He
						B	C	N_2	O_2	F_2	Ne
						Al	Si	P	S	Cl_2	Ar
	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br_2	Kr
	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I_2	Xe
	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Test Yourself

Write a ***Formula Equation*** for each of the reactions describe by the ***Word Equations*** shown below.

1. When magnesium metal burns, it reacts with oxygen in the air to form magnesium oxide, a white powder.

2. In the Blast Furnace, iron is made by reacting iron (III) oxide with carbon monoxide gas. Carbon dioxide gas is also produced.

3. In our bodies, starch, which we get from our food, reacts with water and breaks down to form glucose.

4. When calcium metal is added to water, a gas is given off and calcium hydroxide solution is formed. When tested with a burning splint, the gas burns with a "pop".

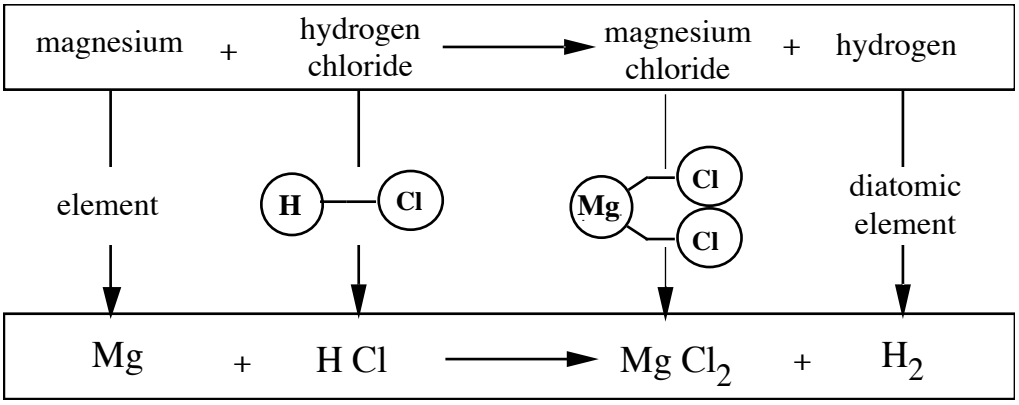
5. Black copper oxide powder and carbon dioxide are made when green copper carbonate powder is heated.

Balancing Equations

A ***balanced equation*** has the ***same number*** of each ***type of atom*** in the ***Reactants*** & ***Products***.

In other words, *all the atoms that are there at the beginning of a reaction* (***Reactants***) *must still be there at the end* (***Products***).

If we look at our earlier example,



This is an ***unbalanced*** reaction, *there is **1 H** on the left but **2** on the right*

*there is **1 Cl** on the left but **2** on the right*

Equations are ***balanced*** by ***increasing the amount*** of some of the chemicals.

$$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$$

Test Yourself Balance each of the equations shown below.

1. $Mg + Cl_2 \rightarrow MgCl_2$

2. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

3. $N_2 + H_2 \rightarrow NH_3$

4. $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$

5. $NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$