

FACTFILE: GCSE CHEMISTRY: UNIT 1.5



Symbols, formulae and equations

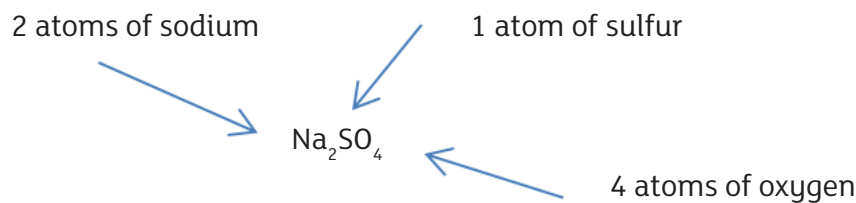
- 1.5.1 recognise symbols and names for common elements and recall the diatomic elements;
- 1.5.2 interpret chemical formulae by naming the elements and stating the number of each type of atom present;
- 1.5.3 write chemical formulae of compounds;
- 1.5.4 demonstrate understanding that chemical reactions use up reactants and produce new substances called products;
- 1.5.5 construct word equations to describe the range of reactions covered in this specification;
- 1.5.6 recognise that in a chemical reaction no atoms are lost or made but they are rearranged, and as a result we can write balanced symbol equations showing the atoms involved;
- 1.5.7 write balanced symbol equations for all reactions covered in this specification and for unfamiliar chemical reactions when the names of the reactants and products are specified;
- 1.5.8 **write balanced ionic equations for reactions covered in this specification;**
- 1.5.9 **write half equations for reactions covered in this specification;**
- 1.5.10 demonstrate knowledge and understanding that in chemical equations the three states of matter are shown as (s), (l) and (g) with (aq) for aqueous solutions, and include appropriate state symbols in equations for the reactions in this specification.

The Data leaflet given to you in your examinations will contain a Periodic Table, which includes the names and symbols of all elements. Some elements are **diatomic elements** and have **two** atoms covalently bonded in the molecule – these are shown in the table below.

Diatomic element	Hydrogen	Nitrogen	Oxygen	Fluorine	Chlorine	Bromine	Iodine	Astatine
Formula of the molecule	H ₂	N ₂	O ₂	F ₂	Cl ₂	Br ₂	I ₂	At ₂

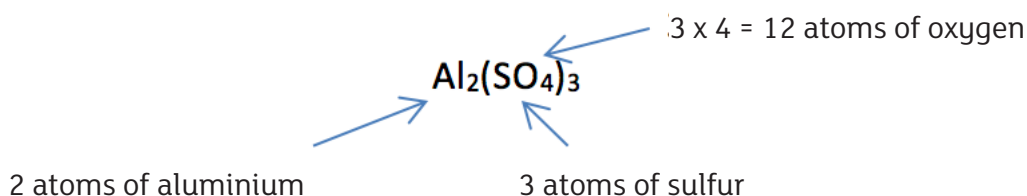
Interpreting Formulae

A formula gives information about the type and the number of each atom present in the compound.



If there are brackets in a formula, to determine the number of each type of atom present, the atoms inside the brackets are multiplied by the number outside the brackets.

For example, for aluminium sulfate:



Ion charges

Each group in the Periodic table forms an ion with a different charge as shown below:

Group	Charge on ion
1	1+
2	2+
3	3+

Group	Charge on ion
5	3-
6	2-
7	1-

Some elements for example copper and iron, are transition metals. Your Data Leaflet gives the symbol and charges of some transition metal ions. Some metals can have several different charges – roman numerals indicate this in the name, for example iron(III) chloride or iron(II) chloride.

A molecular ion is a charged particle containing more than one atom. For example sulfate is a molecular SO_4^{2-} . It has charge of 2- and contains sulfur and oxygen atoms. Again, your Data leaflet shows the charges of molecular ions.

Writing chemical formulae of ionic compounds

1. In an ionic compound there is a positive and negative ion. Use the Data Leaflet to write down the symbol and charge of each ion in the compound.
2. Ignore the sign, and if the number of the charges are the same then write the formula in a 1:1 ratio.
3. If the number of the charges is different swap the charges by crossing sides, drop the signs and write the formula.
4. If **more than one molecular ion** is present, then you need **brackets**.

Worked examples:

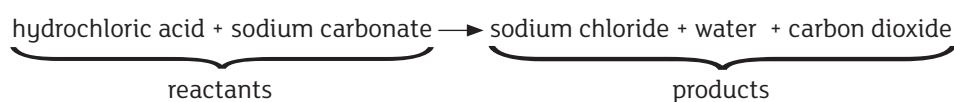
Copper(II) sulfide	Calcium carbonate	Potassium sulfate	Calcium hydroxide
Symbol Cu S	Symbol Ca CO ₃	Symbol K SO ₄	Symbol Ca OH
Charge 2+ 2-	Charge 2+ 2-	Charge 1+ 2-	Charge 2+ 1-
SAME	SAME	SWAP DROP 2 1	SWAP DROP 1 2
CuS	CaCO₃	K₂SO₄	Ca(OH)₂

Equations**Word equations**

All reactions can be represented using word equations which must have an arrow (→)



For example:



It is useful to remember the general word equations shown.

- metal + acid → salt + hydrogen
- metal oxide + acid → salt + water
- metal hydroxide + acid → salt + water
- metal carbonate + acid → salt + water + carbon dioxide
- ammonia + acid → ammonium salt
- element + oxygen → oxide of element
- metal + water → metal hydroxide + hydrogen (for metals that react with cold water)
- metal + steam → metal oxide + hydrogen

Balancing symbol equations

In a chemical reaction no atoms are lost or made but they are rearranged. This means that chemical equations have equal numbers of each atom on each side of the equation and we say they are balanced.

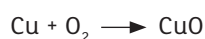
Atom	CuCO ₃	→	CuO	+	CO ₂
Cu	1		1		
C	1				1
O	3		1		2

To balance an equation

- Count the number of atoms of each element on each side of the equation.
- If the equation is not already balanced then **put numbers in front** of the formulae to balance it – the numbers multiply the formula.

Example

Balance the equation:



Answer

Step 1: Under the arrow list the symbols of all elements present and write the total number of atoms of each element on each side of the equation.

Atom	Cu	+	O ₂	→	CuO
Cu	1				1
O			2		1

Step 2: To balance put numbers in front and readjust the totals.

Atom	Cu	+	O ₂	→	2CuO
Cu	1				2
O			2		2

Step 3: Continue to balance by putting numbers in front and readjust the totals again.

Atom	2Cu	+	O ₂	→	2CuO
Cu	2				2
O			2		2

There is the same number of each type of atom on each side of the equation and it is balanced.

Writing balanced symbol equations

To write balanced symbol equations the method is:

Step 1: Write the formula for any compound which you know underneath the word equation, for example the formula for hydrogen, carbon dioxide, water. (It is useful to learn the formula of the acids – hydrochloric acid (HCl), sulfuric acid (H₂SO₄), nitric acid (HNO₃).

Step 2: Work out any other formula by the swap and drop method and write under the equation.

Step 3: Balance the equation.

For example

Example: potassium hydroxide + sulfuric acid → potassium sulfate + water

Step 1: + H₂SO₄ → + H₂O (now work out formula of the other two compounds)

Step 2: KOH + H₂SO₄ → K₂SO₄ + H₂O

Step 3: 2KOH + H₂SO₄ → K₂SO₄ + 2H₂O

In general if a balanced symbol equation is allocated 2 marks, it does not need balancing – there is one mark for the left hand side formula, and one for the right. A 3 mark equation has one extra mark which is for the balancing.

State symbols

Chemical equations may include the following state symbols

- (s) = solid
- (l) = liquid
- (g) = gas
- (aq) = aqueous solution

The equation shown below includes state symbols:



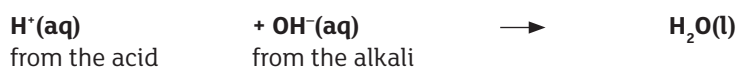
When asked to include state symbols your Data Leaflet may be useful to help determine if a substance is soluble or not, and whether it is (s) or (aq).

Ionic equations

When dissolved ionic compounds react, some of the ions react, however others do not react and remain unchanged. These ions are called spectator ions and are not shown in the ionic equation for the reaction. Ionic equations only show what happens to the ions which react.

When acids react with alkalis, it is the hydrogen ions from the acid which react with the hydroxide ions from the alkali, to form water. The other ions are left unchanged.

The ionic equation for neutralisation is:



When two solutions of ionic compounds are mixed a solid precipitate may form. For example when silver nitrate solution is added to sodium chloride solution the silver ions and the chloride ions react and a precipitate of insoluble silver chloride forms.

Revision Questions

- Write the formula of:
 - oxygen gas
 - nitric acid
 - copper(II) sulfate
 - hydrogen gas
 - magnesium oxide
 - aluminium hydroxide
 - calcium chloride
 - iron(III) sulfate
 - magnesium iodide
 - calcium nitride
 - magnesium hydroxide
 - sodium sulfate
 - calcium nitrate
 - potassium carbonate
- Balance the following equations:
 - $\text{Na} + \text{Cl}_2 \longrightarrow \text{NaCl}$
 - $\text{CH}_4 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$
 - $\text{Li} + \text{HNO}_3 \longrightarrow \text{LiNO}_3 + \text{H}_2$
 - $\text{Al} + \text{O}_2 \longrightarrow \text{Al}_2\text{O}_3$
 - $\text{Pb} + \text{O}_2 \longrightarrow \text{Pb}_3\text{O}_4$
 - $\text{Na} + \text{H}_2\text{O} \longrightarrow \text{NaOH} + \text{H}_2$
 - $\text{N}_2 + \text{H}_2 \longrightarrow \text{NH}_3$
 - $\text{C}_2\text{H}_4 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$
- Write word and balanced symbol equations for:
 - magnesium + oxygen
 - sulfur + oxygen
 - calcium + nitric acid
 - sodium hydroxide + sulfuric acid
 - calcium carbonate + hydrochloric acid
 - copper(II) oxide + hydrochloric acid
- Write an ionic equation for :
 - sodium hydroxide + hydrochloric acid
 - barium chloride + magnesium sulfate
 - silver nitrate + sodium bromide
- Write half equations for:
 - chlorine molecules changing to chloride ions
 - sodium ions changing to sodium atoms
 - oxygen atoms changing to oxide ions

