FACTFILE:
GCSE DAS CHEMISTRY: UNIT 1.5

Rewarding Learning

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, where appropriate**; and

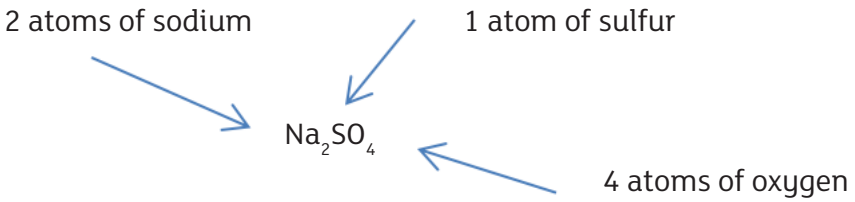
1.5.10 demonstrate knowledge and understanding that in chemical equations the three states of matter are shown as (s), (l) and (g) with (aq) for aqueous solutions, and include appropriate state symbols in balanced symbol equations for the reactions in this specification.

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

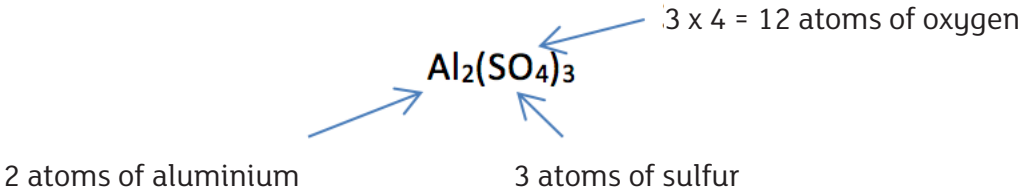
Interpreting Formulae

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) sulphide			**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			**$CaCO_3$**			**K_2SO_4**			**$Ca(OH)_2$**		

Equations

Word equations

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

reactants ⟶ products

For example

hydrochloric acid + sodium carbonate ⟶ sodium chloride + water + carbon dioxide

reactants — products

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:

$$Cu + O_2 \longrightarrow CuO$$

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 (H_2SO_4), nitric acid (HNO_3).

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:		+ H_2SO_4	⟶		+ H_2O (now work out formula of the other two compounds)
Step 2:	KOH	+ H_2SO_4	⟶	K_2SO_4	+ H_2O
Step 3:	2KOH	+ H_2SO_4	⟶	K_2SO_4	+ $2H_2O$

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:

$MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$

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:

$H^+(aq)$	**+ $OH^-(aq)$**	⟶	**$H_2O(l)$**
from the acid	from the alkali		

Half equations

Half equations are equations which include electrons.

To write half equations the method is :

- step 1: write the reactant and product
- step 2: balance the atoms
- step 3: write the total charge underneath each species in the equation
- step 4: balance the charge by adding electrons.

The total charge on the left hand side of the equation must equal the total charge on the right hand side of the equation. This can be used to check that a half equation is balanced.

Example

Write a half equation for the conversion of a bromine molecule into bromide ions.

Answer

Step 1: $Br_2 \longrightarrow Br^-$

Step 2: $Br_2 \longrightarrow 2Br^-$

Step 3: $Br_2 \longrightarrow 2Br^-$

Charge 0 -2

Step 4: to balance the charge, add two electrons to the left hand side

$$Br_2 + 2e^- \longrightarrow 2Br^-$$

Charge $\underbrace{0 \quad -2}_{-2}$ -2 (the charge on both sides is equal)

Revision Questions

1. Write the formula of:

   (a) oxygen gas
   (b) nitric acid
   (c) copper(II) sulfate
   (d) hydrogen gas
   (e) magnesium oxide
   (f) aluminium hydroxide
   (g) calcium chloride
   (h) iron(III) sulfate
   (i) magnesium iodide
   (j) calcium nitride
   (k) magnesium hydroxide
   (l) sodium sulfate
   (m) calcium nitrate
   (n) potassium carbonate

2. Balance the following equations:

   (a) $Na + Cl_2 \longrightarrow NaCl$
   (b) $CH_4 + O_2 \longrightarrow CO_2 + H_2O$
   (c) $Li + HNO_3 \longrightarrow LiNO_3 + H_2$
   (d) $Al + O_2 \longrightarrow Al_2O_3$
   (e) $Pb + O_2 \longrightarrow Pb_3O_4$
   (f) $Na + H_2O \longrightarrow NaOH + H_2$
   (g) $N_2 + H_2 \longrightarrow NH_3$
   (h) $C_2H_4 + O_2 \longrightarrow CO_2 + H_2O$

3 Write word and balanced symbol equations for:

   (a) magnesium + oxygen
   (b) sulfur + oxygen
   (c) calcium + nitric acid
   (d) sodium hydroxide + sulfuric acid
   (e) calcium carbonate + hydrochloric acid
   (f) copper(II) oxide + hydrochloric acid

4. Write an ionic equation for the reaction between sodium hydroxide and hydrochloric acid.

5. Write half equations for:

   (a) chloride ions changing to chlorine molecules.
   (b) sodium ions changing to sodium atoms.
   (c) oxide ions changing to oxygen atoms.