Chemistry Glossary

During your chemistry studies you are going to meet lots of strange new words, phrases and formulae. Studying chemistry can be a bit like learning a new language.

It is essential that you learn these new words, phrases and formulae as you will use them over and over again throughout your A-level work.

Design a glossary or series of glossaries to record all the new language and formulae from your chemistry studies. For each term you add to your glossary, include a definition or explanation of what it means or when it is used.

Consider the following points:

- How will you set out your glossary? Will you use a table, or will you use record cards for each term? Perhaps you can think of a different method that suits your own learning style.
- Do you want to have one glossary or do you want to have a separate glossary for words and their definitions and another for mathematical formulae and so on?
- If you need to learn word-for-word definitions, do you also want to include space for your own definitions?
- How much space will you need for each term?
- How can you ensure there is room to add new terms as you move through your studies?
- How can you make sure your glossary is effective and easy to use when it comes to revision?

Compare your glossaries with the examples in the Answers.

The ability to work with numbers is essential for chemistry, from working out how many moles of a substance you have produced to calculating an energy change for a reaction. Numbers you will encounter in chemistry will range from the incredibly small, for example the radius of an individual atom, to the incredibly large, for example the number of atoms in a mole of an element. The following number-handling skills will be needed throughout your chemistry studies.

Decimal places

Answers to calculations aren't always whole numbers. The calculator will show a 'decimal point' after the whole number and then one or more numbers, for example 12.5 – this is read as '12 point five' and means 12 and a half, or exactly halfway between 12 and 13.

More usually calculators display lots of numbers after the decimal point, and you will need to decide how many of these numbers to use in each stage of your calculations and how many to write down when you give an answer. Each number after the decimal point is referred to as a 'decimal place'.

Decimal place is abbreviated to 'dp' and exam papers will often ask you to give answers to a certain number of decimal places, usually two. This is written as '2dp'. If this isn't the case, it's best to write down any answer with all the decimal places shown and then round up or down to two decimal places.

In exams, make sure you give answers to the number of decimal places the exam paper has asked for – too many students lose marks because they don't do this.

If a calculation gave an answer of 4.87509545, there are eight decimal places shown. This would be written as:

- 4.9 to 1dp
- 4.88 to 2dp
- 4.875 to 3dp
- 4.8751 to 4dp, and so on

You may have noticed that the last decimal place often differs from the original number – if you aren't sure why, read the section below on rounding up or rounding down.

Rounding up and rounding down

Once you know how many numbers after the decimal point you need to include, you may need to 'round up' or 'round down'. This is because if the first number you are *not* including is closer to the next highest whole number, it's too big to ignore.

If you were asked to quote 7.083754 to 1dp, it would become 7.1 – the eight that comes after the zero is too large to ignore, so you have to **round up** the preceding number (in this case the zero). If you had been asked to quote the same number to 2dp, however, it would be 7.08 – the eight wouldn't change because the three that comes after it is small enough to ignore, so you **round down** and keep the preceding number the same.

The general rule is: find the number that represents the last decimal place you need to quote. If the next number is smaller than five, round down (you won't change the last decimal place you quote). If it is five or more, round up (the last decimal place you quote will increase by one).

You can only round up or down once. If you rounded 55.445 up to 55.45, you cannot then round this up to 55.5, as 55.445 to 1dp is only 55.4.

When carrying out calculations, it is best to leave rounding up and down until you have your final answer. If you round up or down too early you may end up with the wrong figure at the end.

Significant figures

Significant figures are useful when quoting numbers to a certain number of decimal places isn't appropriate.

If you quoted 0.0002 to 2dp, it would appear that you had a value of zero (0.00) but the two, which has been ignored, may be highly important (for example, the required concentration of a poison): it is **significant**.

Significant figures (sig. fig. or SF for short) are numbers that tell you something about the magnitude (rough size) of a figure. You start counting significant figures as soon as you come across a non-zero number reading from left to right. Zeros between other numbers and at the end of numbers are classed as significant also. Where the decimal place is has no bearing on whether a number is significant or not – all numbers are significant as soon as you encounter a number that isn't zero.

All of the following are quoted to three significant figures:

- 3.67
- 0.000000899
- 4.01
- 7.00

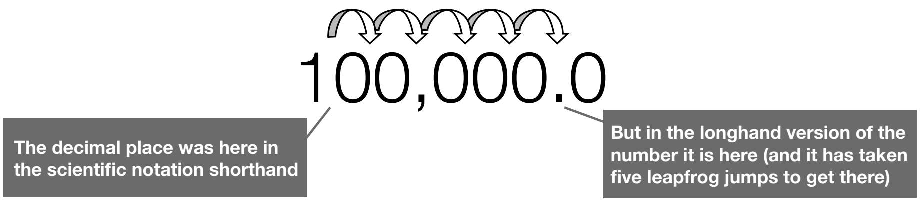
Scientific notation (standard form)

Some numbers in science are just so large that they would take too long to write out in their full form, so we use shorthand called 'scientific notation' or 'standard form'.

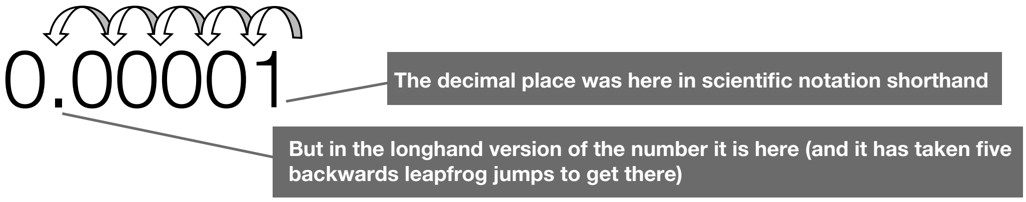
This shorthand always takes the form of a number between 1.0 and 9.9 multiplied by 10 raised to a given power, for example 3.6×10^3 (this would be read as 'three point six times 10 to the power of three').

Consider the number 100,000. If we write this in scientific notation it becomes 1.0×10^5, because if we multiply 1.0 by 10^5, we get 100,000. A simple way to remember how to convert numbers into scientific notation is to imagine that the power the number 10 is raised to tells you how many numbers the decimal place needs to 'leapfrog' over to get back to its place in the longhand answer.

It is often helpful to draw this out:



It works for very small numbers too, except the decimal place has to leapfrog backwards, so the scientific notation shows a number between 1.0 and 9.9 multiplied by 10 raised to a negative power, for example 1.0×10^{-5} is 0.00001.



Questions

1. What is 0.867666 to 2dp?
2. What is 67.02887 to 3dp?
3. What is 489.0448 to 2dp?
4. What is 20.49 to the nearest whole number?
5. What is 0.0034577 to three significant figures?
6. What is 1.000642 to three significant figures?
7. What is 1.00546 to three significant figures?
8. How many significant figures are shown in 4000?
9. How many significant figures are shown in 9.000034?
10. What is 2000 in scientific notation?
11. What is 0.00067 in scientific notation?
12. What is 4570 in scientific notation?
13. What is 0.00000000044 in scientific notation?
14. Is 0.9×10^3 expressed in scientific notation?
15. What is 5.5×10^4 in longhand notation?
16. What is 2.7×10^7 in longhand notation?
17. What is 3.0×10^{-2} in longhand notation?
18. What is 2.5×10^{-5} in longhand notation?
19. What is 602000000000000000000000 in scientific notation?
20. What is 326700 in scientific notation, quoted to three significant figures?

SI Units

Chemists across the world need to be able to communicate with one another. For this reason it is important that all chemists know the units of measurement to follow. It would be very difficult if a chemist in one country set out to check and confirm another chemist's experimental results by measuring something out in pounds and ounces if the original work was done in another country, working in grams!

A universal set of **base units** has been established that tells scientists the correct units of measurement to work with. They are known as **SI units**, which stands for Système International d'Unités. The SI units you are likely to encounter in A-level chemistry are outlined in the table below:

What is being measured	Unit name (symbol)	Useful conversion factors
Length	Metre (m)	1 m = 100 cm 1 m = 1000 mm 1 m = 1,000,000 μm (micrometres)
Time	Seconds (s)	1 minute = 60 s 1 hour = 3600 s 1 day = 24 hours
Temperature	Kelvin (K)	Temperature in K = temperature in °C + 273.15
Mass	Kilogram (kg)	1 kg = 1000 g 1 g = 1000 mg 1 g = 1,000,000 μg (micrograms) 1 tonne = 1000 kg
Amount of substance	Mole (mol)	1 mole = 6.02×10^{23} atoms or molecules Mass of 1 mole of an atom = that atom's atomic mass in g

You will not always be required to work in SI units in your studies; for example, you will usually work in Celsius when measuring temperature and in grams rather than kilograms when recording mass. However, you must be aware of how to convert measurements into SI units.

Questions

Convert the following into SI units:

1 67 cm

2 30 minutes

3 100°C

4 –27°C

5 0.1 g

6 2.7 tonnes

7 5 g

8 1.806×10^{24} atoms of a given element

9 6.02×10^{20} atoms

10 12 g carbon into moles (carbon's atomic mass is 12)

10 *Calculator Skills*

You are going to be building a strong friendship over the course of your A-level Chemistry studies… with your scientific calculator!

A scientific calculator is an invaluable tool for any chemist, so you need to be confident about using it, and you will need to practise using some of the functions to make sure you don't get calculations wrong.

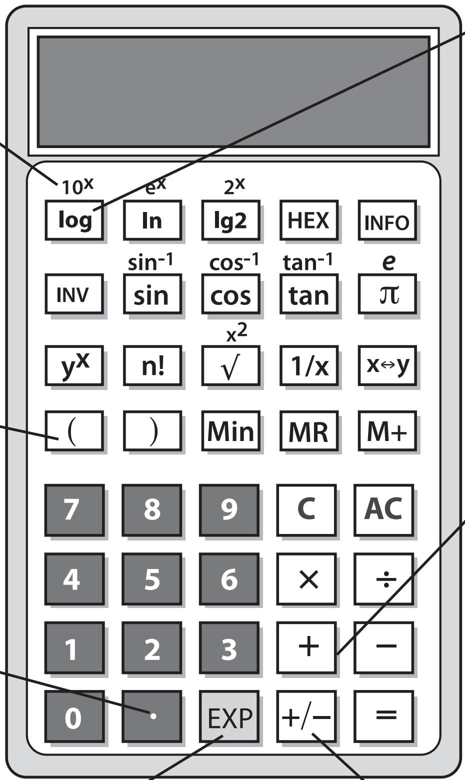
Obviously the calculator described here may not be exactly the same as yours, in which case check the instruction booklet that came with your calculator so you can find the equivalent functions – and do this long before any exams.

The functions you are most likely to need are as follows:

The **10**^{x} function is the inverse function to the **log** button. You will need to use this when you are dealing with pH values and pOH values. You will need to press 'Shift' or 'Second Function' then input the value '10' is raised to, for example '3' for '10^3'.

These buttons allow you to input **brackets** into a calculation; this tells the calculator to work these parts out first, for example when you calculate relative atomic masses.

This '.' button lets you input **decimal places**, for example when you carry out calculations about concentrations, such as 0.1 (mol dm^{-3}).



The **log** function allows you to input numbers that are 'logarithms to base 10', '$\log_{10}$' or 'logs' for short. These allow you to deal with very large numbers that are part of a 'logarithmic scale', such as pH values. For example, to calculate the log of 1000, press 'log' then input 1000, and then '=' to get the answer '3'.

Here are your standard buttons: '+' for addition, '−' for subtraction, '×' for multiplication, '÷' for division and '=' for equals (that is, the answer!).

The **EXP** button lets you input numbers that are multiplied by a power of 10. After pressing it, '00' usually appears and you input the power you need, for example Avogadro's number 6.02×10^{23} would be inputted as 6.02 'EXP' 23. Powers of 10 can be negative.

This '+/–' button lets you input a negative number, for example when you perform calculations about exothermic enthalpy changes.

Finally, before inputting calculations into your calculator, there is an important rule to learn about the order in which functions have to happen. Remember it as BEDMAS: Brackets first; then Exponents (powers/roots), then Division *or* Multiplication, then Addition *or* Subtraction.

It doesn't matter which order division or multiplication and addition or subtraction happen in, except if they are the only functions needed for a calculation, in which case you should work from left to right.

Questions

Complete these questions, using your scientific calculator where required. Questions one to five test your knowledge of BEDMAS; complete these without a calculator first to check how well you have understood this rule.

Check against the answers to ensure you are using your calculator correctly.

1 $3 + 5 \div 4 =$

2 $10^2 - 10 \div 2 =$

3 $77 - (3 \times 2) + 2^2 =$

4 $77 - (3 \times 2) \times 2^2 =$

5 $10 - 7 + 2 + 11 - 3 + 1 - 4 \times 2 =$

6 $-10 + 25 =$

7 $-99 - -98 =$

8 $6.02 \times 10^{23} \times 5 =$

9 $0.025 \times 1.5 \times 10^3 =$

10 $10 \times 2.0 \times 10^{-3} =$

11 $1.0 \times 10^{-3} \div 3 =$

12 $10^{4.5} =$

13 $10^3 =$

14 $\log_{10} 1000 =$

15 $\log_{10} 0.1 =$

11 *Line Graphs*

Chemical investigations can produce a great deal of numerical results. One of the most effective ways to display sets of data is by using graphs. Graphs allow data to be interpreted easily.

During your A-level Chemistry studies you are most likely to use line graphs as they are used to show relationships between two **variables**. A variable is a factor that changes, such as temperature, time or concentration.

Most often in chemistry, a graph is needed to monitor a reaction over time. This is why line graphs are most frequently used, as they show **continuous** data (where values are related and flow from one value to another, for example 1 second becomes 2 seconds and so on). Bar graphs, histograms and pie charts are used to show **discrete** data (where values are not necessarily related to one another, for example acid A, acid B).

How do I draw a line graph?

You must use a sharp pencil and a ruler when plotting a line graph.

First you must draw your **axes** (the horizontal x axis runs across the page, the vertical y axis runs up the page).

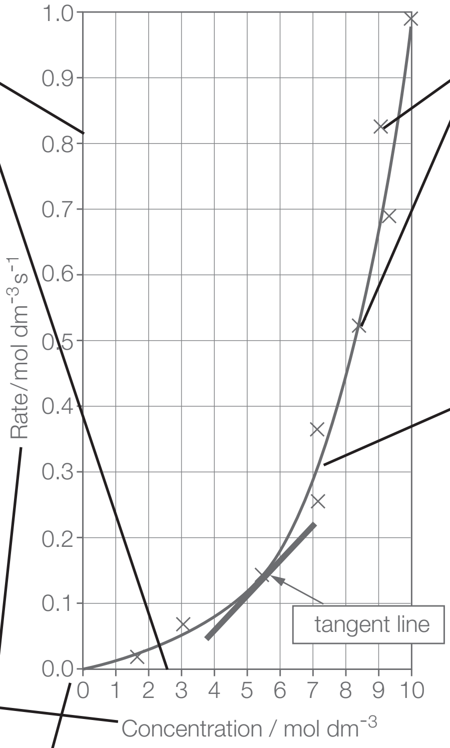
Look at the range of your results, for example 0 → 100, and decide how you can fit this into the number of squares available on your graph paper.

Don't draw your axes on the very edge of the page as you need room for writing labels and units.

Write labels for each axis with the unit next to it, shown using a forward slash, for example 'time / s'.

The **independent** variable goes on the x axis; this is the variable that the chemist is in control of.

The **dependent** variable goes on the y axis. Its value generally 'depends' on how the independent variable changes.



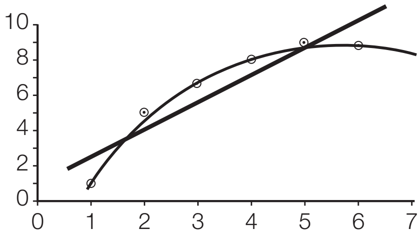
Not all scales have to start from zero here, as it is not always appropriate; for example, if your graph needed to show the number of atoms in 1g of different metals, it wouldn't be sensible as the numbers would be huge.

When choosing scales use increments that will be easy to work with, such as making each square worth 2, 5, 10, 20, 50, 100 etc. If you had a scale where squares are worth 2.75 each it won't be very easy to read off values.

You will need to plot individual **data points** onto the graph using a small, neat crosses or dots. Your data points will be the values that you have recorded during your experiments.

Individual data points must be linked up using an unbroken **line of best fit**. Lines of best fit must be smooth; they are not drawn by merely linking each individual data point.

Lines of best fit should be positioned so there are approximately the same number of data points above it as below it, or so they touch as many as they can if most are in a line. Some lines of best fit may not even touch a single data point.



Look at your data points and decide whether a curved line or a straight line will include the most data points.

Carefully consider where the **origin** of your line of best fit should be (where it crosses the y axis); it doesn't always have to go through zero; for example, a reaction may have a starting temperature of 23°C.

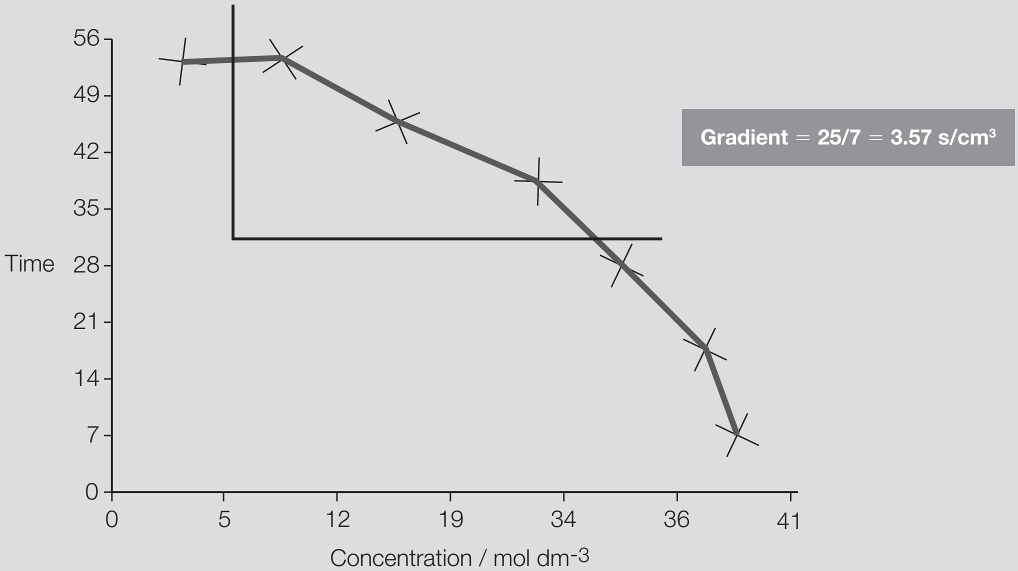
The steepness (**gradient**) of the line of best fit for concentration–time graphs can be used to tell you the rate of reaction.

Gradient = vertical change / horizontal change. For curved lines you will need to draw a **tangent** (a straight line that lays flat against just one point on a curved graph) and calculate the gradient of this. Gradients can be positive (the line goes up from left to right) or negative (the line goes down from left to right).

Questions

A cosmetics company realised that a new lemon-scented body wash they had produced was 'going off' too quickly and the concentration of the lemon-fragranced compound was dropping very rapidly. A junior chemist was asked to conduct an investigation into this and report any findings.

The junior chemist set up an investigation to monitor the concentration of the lemon compound over time and used a line graph to display the results. Unfortunately the graph contained many errors. Identify and explain as many errors as you can.



12 *Rearranging Equations*

An equation is a mathematical way of showing a relationship between two or more **variables**. For example, ‘a = b + c’ tells us that ‘a’ is the same as ‘b’ and ‘c’ added together; a, b and c could stand for anything, for example ‘a’ (total revision time) = ‘b’ (maths revision time) + ‘c’ (chemistry revision time).

Symbolic equations (equations that contain symbols) are used extensively in chemistry and you must be confident at rearranging them and recognising the symbols they contain.

How do I rearrange an equation?

Equations show individual variables and how these are connected; they will be connected by **operations** such as ‘+’, ‘−’, ‘÷’, ‘×’and ‘√’.

Operations can be thought of as coming in pairs, where the two operations forming the pair perform opposite functions.

Opposite operations	
+ (addition)	− (subtraction)
× (multiplication)	÷ (division) division is sometimes written as /
x^2 (square)	√ (square root)

‘Rearranging an equation’ means re-writing it in a new order, so a different variable is on its own and equal to some combination of all the others. This variable becomes the **subject** of the equation.

The key thing to remember when rearranging equations is that you must do the same things to *both* sides of the equation (the left *and* right side of the ‘=’ sign).

Returning to ‘a = b + c’, if we had values for just ‘a’ and ‘c’, we would need to rearrange this to make ‘b’ the subject to be able to find its value.

As the equation is written, ‘b’ is being added to ‘c’, so to ‘undo’ this we need to perform the opposite operation. In this case we need to subtract ‘c’ from both sides of the equation, giving:

Because ‘c’ is being added and then subtracted again, these cancel out, so we don’t need to write them

$$a - c = b + c - c$$

or, $b = a - c$

It’s usual practice to put the main subject on the left

What if the equation is more complicated?

Let’s imagine we want to find a value for ‘c’ in the following equation:

When symbols are written together like this, they are being multiplied

$$ab = c^2 / d$$

At the moment, ‘c’ is being squared *then* divided by ‘d’ (if you are unsure why this is the case, take a look at Task 10)

So, step 1 is to multiply both sides by 'd', giving:

$$abd = c^2 / d \times d$$
$$\text{or, } abd = c^2$$

'/ d' and '× d' cancel each other out, so we don't need to write them anymore

Step 2 is to take the square root of both sides, giving:

$$\sqrt{abd} = \sqrt{c^2}$$
$$\text{or, } c = \sqrt{abd}$$

The square root and the square cancel each other out. Don't forget, the square root applies to all the variables that were there when you applied it.

Students often get confused when symbols within equations are unusual or unfamiliar. Take your time – the process is always the same, no matter what the equation. Identify the symbol you need as the subject, then just unpick the equation one step at a time by using opposite operations. But remember – you must always do the same to both sides.

Questions

Rearrange the following equations:

1 Find a if ab = cd

2 Find x if $x^2 = y$

3 Find a if abc = d

4 Find mass if number of moles = mass / molar mass

5 Find molar mass if number of moles = mass / molar mass

6 Find volume if number of moles = concentration × volume

7 Find m if $q = mc\Delta T$

8 Find h if $E = h\nu$

9 Find ΔH if $\Delta G = \Delta H - T\Delta S$

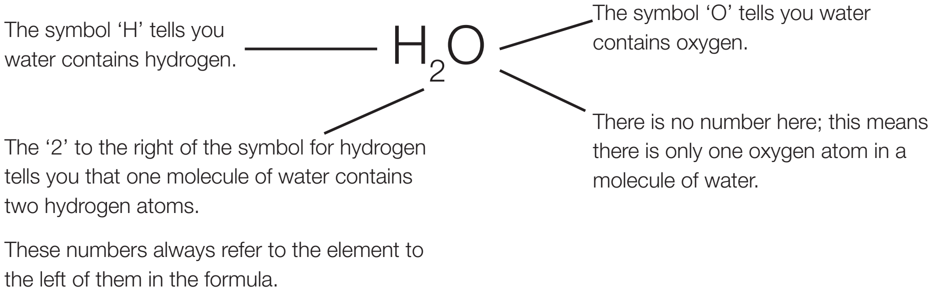
10 Find R if pV = nRT

13 *Chemical Formulae*

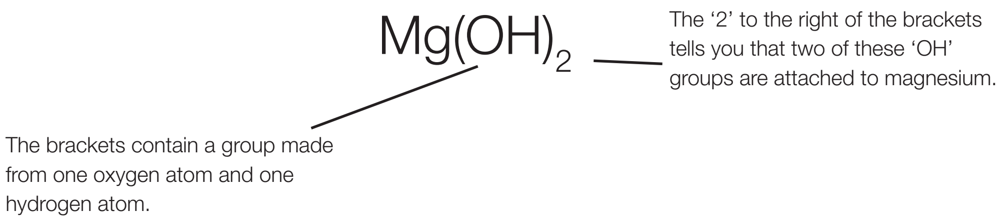
If you buy a piece of furniture that needs to be assembled, you are provided with a set of instructions to tell you the parts you need and how it fits together. A chemical formula is exactly that too – it tells you what elements are needed for a given compound or molecule and the ratios you need them in.

Chemical formulae are written in shorthand, using the element symbols found on the periodic table.

Most people know the formula for water is H_2O, but what does that actually mean?



Sometimes formulae contain brackets. These show groups of elements within compounds. Any number immediately outside the bracket tells you how many of these groups are present. For example, when magnesium reacts with water, one of the products is magnesium hydroxide, $Mg(OH)_2$.



Simple chemical names can usually be worked out from looking at the formula. If a metal is present, it will come first in the compound name. Subsequent chemicals will come next, and their name endings will change depending on the type of compound they form.

- The ending '-ide' tells you a compound has been formed from only two elements (it won't necessarily be just two atoms though), for example sodium chlor**ide**, NaCl
- The ending '-ate' tells you the compound has been formed from more than two elements, one of them being oxygen, for example calcium carbon**ate**, $CaCO_3$

> **Helpful tip**
>
> **You may be asked to predict the formulae for some simple compounds. Remember, an element's group number shows how many electrons it has in its outer shell. When elements bond, they usually bond with elements that can either accept all their outer electrons or that can help them gain/share enough electrons to make a full outer shell with eight electrons in it. For example, chlorine (group 7) happily accepts sodium's electron (group 1), and magnesium (group 2) gives its two outer electrons to two chlorine atoms.**

If a prefix is added to an element's name, this tells you how many of its atoms are involved in the compound. (Some prefixes are different when naming hydrocarbon chains however.)

- 'Mono' (sometimes abbreviated to 'mon') means one; for example carbon **mon**oxide, CO, contains one oxygen atom

- 'Di' means two; for example carbon **di**oxide, CO_2, contains two oxygen atoms
- 'Tri' means three; for example boron **tri**fluoride, BF_3, contains three fluorine atoms
- 'Tetra' means four; for example carbon **tetra**fluoride, CF_4, contains four fluorine atoms
- 'Hexa' means six; for example sulphur **hexa**fluoride, SF_6, contains six fluorine atoms

Questions

1 How many atoms of oxygen are represented in the formula for sulphuric acid, H_2SO_4?

2 How many atoms of silver are represented in the formula for silver nitrate, $AgNO_3$?

3 How many atoms of hydrogen are represented in the formula for calcium hydroxide, $Ca(OH)_2$?

4 How many atoms in total are represented in the formula for iron oxide, Fe_2O_3?

5 How many atoms in total are represented in the formula for manganese hydroxide, $Mn(OH)_2$?

6 What is the name of HF?

7 What is the name of MgO?

8 What is the name of $BaCO_3$?

9 What is the name of SO_2?

10 What is the name of CCl_4?

11 Predict the formula for calcium oxide.

12 Predict the formula for nitrogen monoxide.

13 Ammonia's formula is NH_3. What elements does it contain?

14 One beryllium atom can bond with two chlorine atoms. What would the name and formula of the product of this reaction be?

15 What is the name of I_2?

Balancing Chemical Equations

It is essential to be able to balance chemical equations, and as long as you follow some general rules and think logically about how to do this, it needn't cause you too much of a headache.

Chemical formulae tell you which elements are in compounds or molecules and the ratios they are in; these facts can't change, if they did, you would no longer have the same chemical. A simple analogy for this is a kitchen table and its component parts: a table top and four legs. Lets give the table top the symbol 'T' and the legs the symbol 'L'. If we wrote an equation for constructing the table it would be:

$$T + 4L \rightarrow TL_4$$

> **The table's formula is TL_4 as it's made from one table top and four individual legs**

All the individual formulae are fixed; all you are able to change is how many of each component you can use up. You can't just change the table's formula to TL_2 because the table would fall over!

It's the same for chemicals: water is always H_2O, oxygen is always O_2, chlorine is always Cl_2, sulphuric acid is always H_2SO_4, and so on. You *cannot* and *must not* change the numbers within formulae when you balance equations, as that would change the chemical. And, equally as important, the parts you had at the beginning must all still be there at the end (that is, on either side of the arrow), just in different combinations.

Balancing equations can sometimes seem confusing when you have to consider how all the chemicals are typically found. Let's return to our table analogy. If table tops are always bought as packs of two, you can't just make a single table so you'd need more legs. The equation would now be:

$$T_2 + 8L \rightarrow 2TL_4$$

> **Because 'T' is found as a pair, we need twice the amount of 'L'. All the starting materials have to be used up, so we end up with two tables, $2TL_4$. Both sides of the equation have two T and eight L, so it's balanced.**

It's exactly the same with chemicals, we cannot change how the chemicals are found, so all we can do is change the amount of them we use, by changing the numbers *in front* of the formulae.

Consider sodium and chlorine reacting to form sodium chloride. First, **write out the element symbols**, showing how they are found naturally, with reactants on the left and products on the right, then count how many of each atom is present at the start:

$$Na + Cl_2 \rightarrow NaCl$$

> **The numbers of sodium remains constant, but there is one chlorine missing at the end.**

Now **adjust the numbers in front of the formulae until the numbers of each atom match** at the beginning and end of the reaction. If we make another NaCl (that is, 2NaCl) and add another sodium at the start, it will balance:

$$2Na + Cl_2 \rightarrow 2NaCl$$

> **Chlorine is always found in pairs of atoms, so we will need two individual sodium atoms.**

> **One sodium atom can only react with one of the chlorine atoms, hence the formula NaCl. So, we have to make two NaCl to use up all the starting atoms. So, on both sides of the equation we still have two Na and two Cl; it's balanced.**

Finally, remember that in a balanced equation each element symbol actually represents one **mole** of that element (see Task 26 if you are unsure on moles), so it is possible to have half a mole of an element as that's actually 3.01×10^{23} atoms; this can sometimes help balance the equation.

For example, when carbon monoxide is formed as follows you could write the equations in either of these ways:

$C + \frac{1}{2}O_2 \rightarrow CO$ OR $2C + O_2 \rightarrow 2CO$

For the purposes of balancing equations, half a mole of oxygen molecules can be considered equivalent to a mole of oxygen atoms, as the same number of oxygen atoms are present.

Questions

Balance the following equations.

1. $H_2 + Cl_2 \rightarrow HCl$
2. $Mg + HCl \rightarrow MgCl_2 + H_2$
3. $Cu + O_2 \rightarrow CuO$
4. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
5. $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
6. $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
7. $N_2 + H_2 \rightarrow NH_3$
8. $Ca + HNO_3 \rightarrow Ca(NO_3)_2 + H_2$
9. $PbS + O_2 \rightarrow PbO + SO_2$
10. $Fe + Cl_2 \rightarrow FeCl_3$