Year 11 to 12 Chemistry Transition Work

Welcome to A-Level Chemistry, we hope you're looking forward to getting started on your studies in Chemistry again! Chemistry is an interesting and challenging A-Level in which you will need a wide range of skills that you will have already started to acquire during your GCSE studies. In order to get you even more prepared, you can start to have a look at the following tasks:

Task 1

Read and summarise the Chemistry Fact Sheet titled 'Basic Atomic Structure'. In September you will begin with a recap on atomic structure where you will need to know a bit more detail than GCSE on how the model of the atom was proposed. Ensure you summarise the key points when you read this article, have a look at the following website which give you an idea how to summarise an article.

https://www.scribbr.com/working-with-sources/how-to-summarize/

Task 2

Good mathematical skills are vital for A-level chemistry course. Below is a list of the skills which you should be confident with based on your GCSE science studies. Please check through the list and revise any areas you find difficult. We will recap some of these skills in September and have a short test to assess these. To help you with this you could look back over your GCSE notes or use websites such as BBC Bitesize to help you.

- Calculate the relative formula mass (Mr) of a compound from its formula
- Calculate the percentage of an element in a compound, given its formula
- Calculate the masses of individual products from a given mass of a reactant and the balanced symbol equation.
- Calculate percentage yields of reactions
- Find the gradient of a straight line
- Draw a tangent to a curve
- Calculate the chemical quantities in titrations involving concentrations (in moles per dm^3) and masses (in grams per dm^3).
- Calculate the energy transferred in reactions using supplied bond energies.
- Calculations involving moles of a gas.
- Rearranging mathematical equations.

If you are confident on these skills, read through and practice the calculations in the Chemistry Fact Sheet titled 'Moles and Equations'. This goes through some example calculations, then has some practice questions and answers at the end.

Task 3- Study Skills

Read the document from Hodder Magazines on 'Study Skills'. You do not need to make notes or summarise this. Just ensure you have an idea of the breadth of skills that are needed for you to succeed in your A-Levels. Pages 4-8 on developing study skills and pages 16-19 on applying these in homework and exams will be really useful.

Task 4- Going Further (Optional)

If you want to go further you could begin to have a look through some articles on Chemistry World Magazine for some insights in recent research in chemistry (you will need to make an account):

https://www.chemistryworld.com/

Or similarly you could have a look at New Scientist Magazine:

https://www.newscientist.com/

Begin to have a look through the A-Level Specification on the AQA website. In your first term you will be looking at topics on Atomic Structure, Periodicity, Amount of Substance, Bonding, Introduction to Organic Chemistry and Alkanes.

https://www.aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/specification-at-a-glance

See you in September!

Mr Clements (Subject Leader Chemistry)

j.clements@chg.kevibham.org

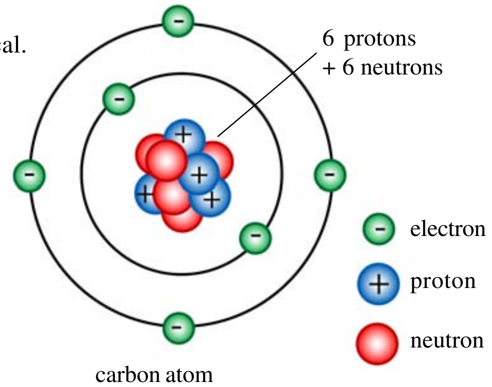
Chem Factsheet

www.curriculum-press.co.uk Number 203

Basic atomic structure

Chemists have long believed that all matter is composed of "atoms". At GCSE you will have learned that these atoms are considered to be:

1. Spherical.



carbon atom

2. Very small.
3. Composed of sub-atomic particles called protons, electrons and neutrons with relative masses 1, 0 and 1 respectively and relative charges 1+, 1- and 0 respectively.
4. Characterised by the number of protons present.
5. Structured so that the protons and neutrons are positioned in a very small central nucleus.
6. Structured so that the electrons are orbiting in 3D shells about the nucleus.
7. Structured so that 2 electrons can occupy the first shell, 8 in the second and 8 in the third.
8. More stable if the outer electron shell is "full" – 2 electrons for the first shell but 8 for others.

These points constitute a "model" of atomic structure – in other words a physical picture of the constitution of an atom that has been derived and modified using experimental evidence. It superseded previous models as new evidence was produced and will be further modified and advanced as further new evidence emerges – any model must be formulated to be consistent with experimental observations!

This FactSheet aims to describe how the "scientific method" led to this basic model of atomic structure.

What is the Scientific Method?

In simple terms this can be represented as the sequence of *"ask a question" (e.g. how are atoms structured?) experiment, observation, analysis and finally, conclusion*. The "conclusion(s)" is/are, in this case, some aspect of how atoms are structured. They must consistent with the experimental observations and, better still, allow new predictions to be made which can then be tested by *further* experimental work. For example, the basic model presented above, can be used to explain how atoms bond together to make larger structures or explain the patterns in the Periodic Table.

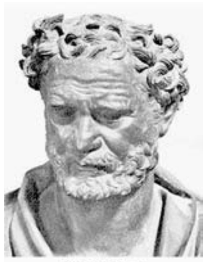
But this is not the end! Science is forever advancing and the "GCSE model of atomic structure" has now been replaced and, as science advances further, it is almost inevitable that new models will emerge!

How Big are Atoms?

From about the 1920's, X-ray crystallography and related techniques allowed atomic radii to be measured. They fall in the approximate range 30 – 300pm (1 pm (picometre) = 10^{-12}m). Hydrogen is the smallest and atoms like caesium are amongst the largest. On average, about 500,000,000 atoms could be laid end-to-end inside one centimetre!

Very Early Ideas about Atomic Structure

The ancient Greek philosopher, Democritus, claimed that all matter is made up of particles that he called "atomos" – Greek for *indivisible*. This is the origin of the idea of an atom.


Democritus
ca. 460 – 370BC

However, he went on to make what now appear to be outrageous claims about the natures and interactions of these particles. For instance:

1. Atoms are indestructible
2. Atoms are always in motion
3. Atoms exist in an infinite number of kinds, differing in shape and size
4. The "solidness" of matter depends on the shape of the atoms involved – e.g. water "atoms" are smooth and slippery while salt "atoms", because of their taste, are sharp and pointed
5. Atoms can combine to larger, more solid substances using tiny hooks and eyes or balls and sockets.

Clearly, this does not correspond to current ideas. For instance, he made no distinction between atoms and molecules. However, even though he did not get involved in experimental work, he did establish the idea that matter is particulate rather than continuous and that the particles show various degrees of motion.

Antoine Lavoisier


Antoine
Lavoisier
1743 - 1794

Further progress in developing atomic theory did not occur until the *science of chemistry* began to develop in the late 18th century. In 1789, Lavoisier adopted an experimental approach and, from his experimental data, formulated the *law of conservation of mass* (total mass of reactants = total mass of products). More importantly, he also defined an *element* as a substance that could not be further broken down by chemical methods.

John Dalton


John Dalton
1766 - 1844

In 1805, John Dalton (an English teacher and philosopher – not a scientist!) applied the *concept of atoms* to explain why elements always react in small whole number ratios. He is widely considered to be the founder of modern atomic theory wherein he proposed that:

1. Each element consists of tiny particles called atoms.
2. Atoms cannot be divided.
3. Atoms in one element are unique to that element.

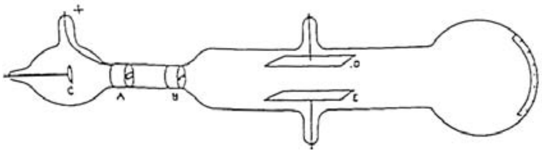
4. Atoms can join together to form chemical compounds.
5. Each different atom/element could be represented by a symbol.
6. Each different atom/element had a characteristic atomic mass.

Interestingly, he listed "lime" (CaO) and "soda" (Na_2CO_3) as elements because he did not have the means to break them down to simpler substances. Nevertheless, a lot of his ideas have stood the test of time!

J. J. Thomson


J.J. Thomson
1856 - 1940

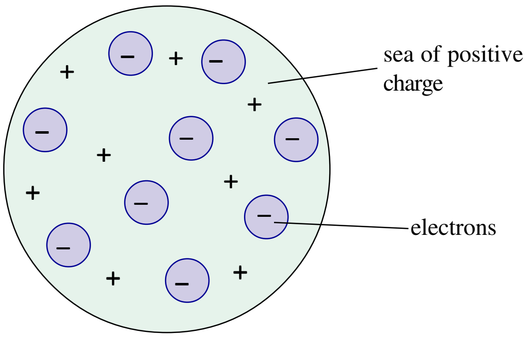
From 1897 to 1906, Joseph John Thomson investigated the properties of *cathode rays*. These are emitted from the negative electrode of a cathode ray tube (CRT) which allows a high voltage to be applied across a near- vacuum. By measuring deflections of the rays in either an electrical field or a magnetic field he was able to show that cathode rays are made up of very small *negatively* charged particles and that the same particles were produced no matter what trace gas was present in the tube.


Thomson's CRT

Hence, since different elements in the CRT produced the same rays, he had shown that atoms are ***not*** indivisible, contrary to the ideas of the early Greeks and Dalton! He concluded that **all atoms** must contain these sub-atomic particles which he called *corpuscles* but which later became known as electrons.

He was also able to measure the mass of these particles as about 1/2000th of the mass of the lightest atom, H.

Plum pudding atom

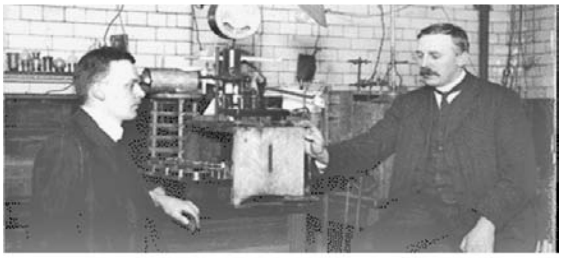


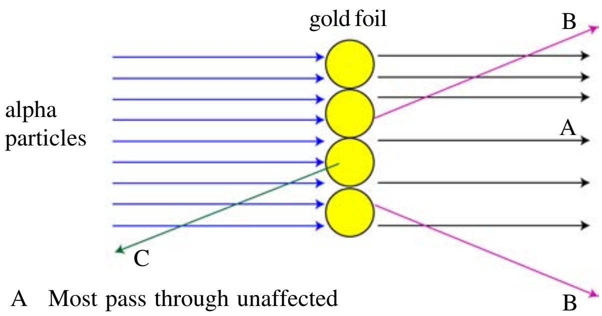
Following these findings, in 1904, Thomson proposed a "new" model of atoms where they are made up negative electrons moving around in a "sea of positive" charge which is equal, but opposite, to the total charge of the electrons in order to give the overall neutrality of the atom. This became known as his "*plum pudding atom*" – not very satisfactory considering the amount of detailed and precise experimental work done, because it implies that the very smallest of atoms (H) contains about 2000 electrons!

Ernest Rutherford


Ernest Rutherford
1871 - 1937

Surprisingly, Thomson's model remained unchallenged for quite some time until, in 1909, Rutherford (one of Thomson's own students!) examined experimental results produced by his own research students Geiger and Marden. He directed them to examine what happened when positively charged alpha-particles, with a relative mass of 4, (obtained from a radioactive source but not shown to be helium nuclei until much later) were directed towards a sheet of very thin gold foil. His idea was to test Thomson's model because Rutherford expected (by calculation) the α-particles to pass through the foil mostly unaffected.


Hans Geiger 1882 - 1945 Ernest Marsden 1889 - 1970



A Most pass through unaffected
B A few pass through but are deflected
C A very small number are reflected back towards the source

However, it was observed that, despite the fact that most particles did pass through the foil without deviation, a few were deflected through large angles and an even smaller number were deflected back towards the α-particle source.

Rutherford was very surprised by these observations, famously saying "it was almost as incredible as if you fired a 15 inch shell at a sheet of tissue paper and it came back and hit you".

Subsequently, Rutherford used these observations and associated measurements to show by calculation that the positive charge of the atom must be concentrated in a very small volume, much smaller than the total volume of the atom. This region was the birth of the idea of the nucleus!

Hence, in 1911, Rutherford proposed the "*nuclear atom"* as a model to supersede Thomson's plum pudding model. His model said:
1. the entire positive charge and most of the mass of an atom are *concentrated in a nucleus*, located at the centre of an atom.
2. negatively charged electrons *orbit the nucleus* – he imagined this by analogy with the orbits of the planets about the sun.
3. the total positive charge in the nucleus and the total negative charge in the orbits must *balance* to give a neutral atom.
4. most of an atom's volume is *empty space* between the minute nucleus and the electron orbits.

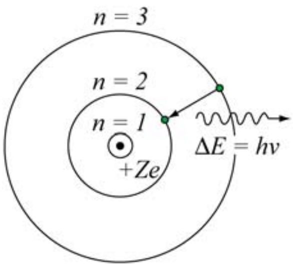
Note: It varies from one element to another, but the ratio of atomic diameter to nucleus diameter has been shown (by experiments similar to Rutherford's but using electron beams instead of α-particles) to be about 100,000:1. A reasonable picture of this ratio is provided by imagining an H atom to be represented as the size of Wembley Stadium. On the same scale, the nucleus would be represented by a pea at the centre spot!

In 1911 Antonius van den Broek, after analysing X-rays emitted by various elements, suggested that the total nuclear charge of different elements was equal to the element's position in the Periodic Table – in other words equal to its atomic number. This was confirmed by Henry Moseley in 1913. Finally, following Rutherford's discovery and characterisation of the proton in 1917, it was realised that the atomic number of an element is equal to the number of protons in its nucleus.

Niels Bohr

Niels Bohr
1885 - 1962

In 1885 Johann Balmer had observed that hydrogen could be caused to emit *specific frequencies (f)* in the visible part of the spectrum by a suitable input of energy. In 1913, Bohr suggested that, in order to account for these observations, the electrons of an atom must be in *specific shell-like orbits* around the nucleus, each associated with a *fixed energy level*. The electrons levels are said to be quantised and are numbered 1, 2, 3 etc away from the nucleus.



This allows Balmer's emission spectrum to be explained. The "Balmer frequencies" in the visible region are caused by electrons from level 2 being excited by an energy input and so jumping up to levels 3, 4, or 5 etc. This would be unstable and the electron can revert to level 2 by emitting energy in the form of visible light.

If E_n represents the energy of the n^{th} electron shell, then
Lower frequency emitted (f_1) = $E_3 – E_2/h$
(where h = Planck's constant)

Next frequency emitted (f_2) = $E_4 – E_2/h$

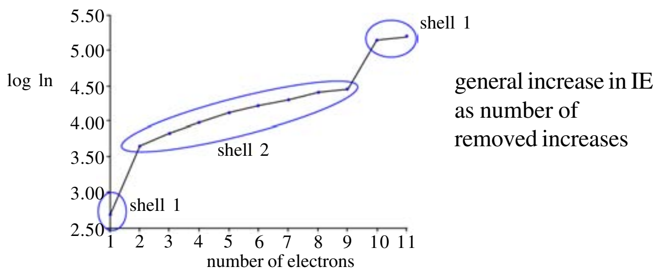
Next frequency emitted (f_3) = $E_5 – E_2/h$ etc.

Furthermore, Bohr said that, since the emission frequencies get closer and closer together, then the energy levels must also get closer and closer together as distance from the nucleus increases.

Successive Ionisation Energy Patterns

The n^{th} ionisation energy (I_n) of an atom is the energy needed to remove the n^{th} electron from one mole of gaseous atoms/ions.

e.g. $Na(g) \rightarrow Na^+(g) + e^-$; $I_1[Na]$
$Ca^{3+}(g) \rightarrow Ca^{4+}(g) + e^-$; $I_4[Na]$ etc.



A sodium atom has 11 electrons and, according to Rutherford's model, it should get steadily more difficult to remove successive electrons from an increasingly positive particle. However, as seen in the graph of $I_1 – I_{11}$ for sodium, even there is an overall increasing trend the significant steps between I_1 and I_2, and then between I_9 and I_{10}, in the graph contradict Rutherford's model. However, it is consistent with Bohr's model because electrons being removed from an energy level nearer to the nucleus will be much more difficult to remove because they are nearer to the positive nucleus and less shielded from the nuclear attraction by inner energy levels.

Furthermore, when these results are compared with similar graphs for other elements, it can be shown that the inner energy level never has more than 2 electrons and the next, never more than 8. These are the numbers familiar from the "GCSE" model of the atom!

James Chadwick

James Chadwick
1891 - 1974

Rutherford was worried as to why protons in the nucleus do not "fly apart" as a result of mutual repulsions and why they could not account for overall atomic masses. In 1921 he postulated that another particle – the *neutron* – with no electrical charge and similar mass to the proton, must be present in the nucleus which could somehow compensate for the repelling effects and also account for the "missing" mass. In 1932, Rutherford's theory about the existence of neutrons in the nucleus was proved by James Chadwick using experiments involving the bombardment of beryllium with alpha particles. Chadwick's discovery was a remarkable feat since neutral particles are very difficult to detect and monitor. However, it was vitally important in reinforcing Rutherford's ideas and accounting for atoms of the same element being able to have different masses – isotopes!

This is not the entire story! Many contributors have not been mentioned and much more sophisticated models of atomic structure have since emerged in response to further experimental work – sub-shells, orbitals, the electron as a wave, mathematical models etc. These are for future study but, in the meantime, the model discussed so far allows most aspects of A-level chemistry (e.g. periodicity and bonding) to be accounted for.

Acknowledgements: *This Factsheet was researched and written by Mike Hughes.* ***Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU. ChemistryFactsheets*** *may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.* ***ISSN 1351-5136***

Chem Factsheet

September 2000 Number 03

Moles and Equations

To succeed with this topic, you need to:
- ensure you understand the work on 'moles' from Factsheet No. 2 - Moles and Formulae
- **learn thoroughly** the valencies of the commonest cations and anions
- **learn thoroughly** those common formulae you are expected to know
- practice writing formulae and balancing equations because unless these are correct your calculations will always give the wrong answers!

After working through this Factsheet, you will understand:
- how to write chemical formulae
- putting formulae together in an equation to describe a chemical reaction
- balancing chemical equations
- calculating quantities from balanced equations
- using molar volumes of gas in equations
- writing ionic equations

> ***Exam Hint:** Writing formulae and balanced chemical equations is central to all questions at AS level. The time spent working on these will repay you in terms of marks and grades.*

Writing chemical formulae

Chemical formulae fall into three main categories:

a) Formulae which must be **learnt**:

Water	H_2O	Sulphuric acid	H_2SO_4
Oxygen	O_2	Hydrochloric acid	HCl
Nitrogen	N_2	Nitric acid	HNO_3
Ammonia	NH_3	Phosphoric acid	H_3PO_4
Ozone	O_3	Chlorine	Cl_2
Argon	Ar	Bromine	Br_2
Neon	Ne	Iodine	I_2
Hydrogen	H_2		

N.B. Use the Periodic Table whenever you can for elements eg. Mg, Fe, Na, etc., but notice those elements in the list above are **diatomic** (two atoms in a molecule) - O_2, H_2, and the Halogens (Cl_2, Br_2, I_2).
Noble gases (Ne, Ar, etc.) are **monatomic**.

b) Formulae that can be worked out from their **names** alone:

The list of terms used is shown below

mono=1	penta=5	octa=8
di=2	hexa=6	nona=9
tri=3	septa=7	deca=10
tetra=4		

Carbon dioxide	CO_2	Carbon monoxide	CO
Sulphur trioxide	SO_3	Phosphorus pentachloride	PCl_5
Dinitrogen trichloride	N_2Cl_3	Sulphur dioxide	SO_2

NB: Hydrocarbons have a different system of naming
eg methane, CH_4 ethane, C_2H_6
This is covered in the Factsheet No. 13.

c) Formulae that can be worked out from the charge on their **ions**:

These compounds usually contain metals (the cations) and non-metals (the anions). You are expected to know these cations and anions; some have to be learnt, but you can use the Periodic Table to help you for the ions of elemental atoms - the box below reminds you how to do this.

> **Using the Periodic Table to help you find the charges on ions**
> - Group 1 form ions with charge +1
> - Group 2 form ions with charge + 2 (but beryllium compounds may not be ionic)
> - Group 6 form ions with charge -2
> - Group 7 form ions with charge -1

The table below contains the commonest ions at AS level, but more are used as you progress through the course. You must learn these - and you will find later work much easier if you do it now, rather than waiting until the exam.

Table 1. Cations and Anions for AS-level

CATIONS		ANIONS	
Ions that can be worked out from Periodic Table rules above		**Ions that can be worked out from Periodic Table rules above**	
Name	Formula	Name	Formula
lithium	Li^+	chloride	Cl^-
sodium	Na^+	bromide	Br^-
potassium	K^+	iodide	I^-
magnesium	Mg^{2+}	oxide	O^{2-}
calcium	Ca^{2+}	sulphide	S^{2-}
strontium	Sr^{2+}		
barium	Ba^{2+}	**Other Anions**	
		Name	Formula
Other Cations		hydroxide	OH^-
Name	Formula	nitrate (V)	NO_3^-
hydrogen	H^+	nitrate (III)	NO_2^-
zinc	Zn^{2+}	cyanide	CN^-
aluminium	Al^{3+}	hydrogencarbonate	HCO_3^-
silver	Ag^+	hydrogensulphate	HSO_4^-
cobalt	Co^{2+}	carbonate	CO_3^{2-}
* copper	Cu^+/Cu^{2+}	sulphate (IV)	SO_3^{2-}
* iron	Fe^{2+}/Fe^{3+}	sulphate (VI)	SO_4^{2-}
* lead	Pb^{2+}/Pb^{4+}	phosphate	PO_4^{3-}
* manganese	Mn^{2+}/Mn^{4+}	manganate (VII)	MnO_4^-
ammonium	NH_4^+		

* = elements with more than one valency
For these, **Roman Numerals** are used to show which valency is being used - eg copper (II) hydroxide contains Cu^{2+}, whilst copper (I) oxide contains Cu^+
For non-metals, this refers to the **oxidation state** (see Factsheet 11) of the non-metal involved - eg sulphate (VI) contains sulphur in the +6 oxidation state

> ***Exam Hint:** If a question uses compound names with roman numerals - eg sodium sulphate (IV) - make sure you take note of them! Many students lose marks through assuming sodium sulphate (IV) is Na_2SO_4, rather than Na_2SO_3*

Using Ions to Find Formulae
The method used is the "cross-over rule" as shown below:

eg 1: Magnesium chloride
Mg^{2+} Cl^{-}
1 2 $\Rightarrow MgCl_2$

eg 2: Sodium oxide
Na^{+} O^{2-}
2 1 $\Rightarrow Na_2O$

eg 3: Magnesium nitrate (V)

Mg^{2+} NO_3^{-}
1 2 $\Rightarrow Mg\ (NO_3)_2$

> ***Tip:*** *If the formula involves a poly-atomic ion (i.e. an ion containing more than one atom), you will need to put* ***brackets*** *round it in any formula that involves more than one of that ion.*
>
> *In the above example, you could not write $MgNO_{32}$ - since this would not show that we had two lots of nitrogen.*
>
> *It is also incorrect to "multiply out the brackets" and write MgN_2O_6, since we need to show that we have two lots of the nitrate (V) ion NO_3^-, not just that we have 2 nitrogen atoms and 6 oxygen atoms.*

In some cases, you can "cancel down":

eg 4: Zinc Sulphate

Zn^{2+} O^{2-}
2 2 $\Rightarrow ZnO$

i.e. 2:2 'cancels down' to 1:1,

Some compounds do have formulae that do not cancel down - for example hydrogen peroxide (H_2O_2) and ethane (C_2H_6), but these are either covalent (like ethane) or contain special ions (like the peroxide ion O_2^{2-})

You need to be happy with working out formulae before going onto the rest of this Factsheet. Questions 1 and 2 at the end will give you practice at this.

Writing and Balancing Chemical Equations

(a) Balancing chemical equations

A 'balanced' chemical equation is one which has the same number of atoms of each element on both sides of the arrow, $\rightarrow$.

The rule for balancing is very simple:

> *You can change the numbers in* ***front*** *of formulae but you* ***never*** *change the formulae themselves*

When you are balancing, you should not expect to get it all balanced in one step! You may need to change numbers as you go along. The examples below show how to go from one side to the other to balance the equation.

eg 1. $Mg + O_2 \rightarrow MgO$
$1\times Mg \quad 2\times O \rightarrow 1\times Mg\ 1\times O$

We have different numbers of oxygens on each side. We balance them by having 2 lots of MgO:

$Mg + O_2 \rightarrow 2\ MgO$
$1\times Mg \quad 2\times O \rightarrow 2\times Mg\ 2\times O$

Now the magnesiums are unbalanced! So we balance them by having two lots of Mg

$2Mg + O_2 \rightarrow 2MgO$
$2\times Mg \quad 2\times O \rightarrow 2\times Mg\ 2\times O$

Now the equation is balanced, because we have the same number of each type of atom on each side

eg 2. $Fe + O_2 \rightarrow Fe_2O_3$
$1\times Fe \quad 2\times O \rightarrow 2\times Fe\ 3\times O$

We notice with the oxygens that we have 2 on one side and 3 on the other. We won't manage to balance them by multiplying just one side by something - there's no whole number we can multiply 2 by to get 3. So we have 3 lots of O_2 and 2 lots of Fe_2O_3 - so we end with 6 oxygens on each side (this is a bit like the cross-over rule)

$Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$
$1\times Fe \quad 6\times O \rightarrow 4\times Fe\ 6\times O$

The irons still are not balanced:
$4Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$
$4\times Fe \quad 6\times O \rightarrow 4\times Fe\ 6\times O$

Question 3 at the end provides further practise with balancing equations.

(b) Writing balanced chemical equations from word equations

The method is to replace the names with their formulae and then balance them.

eg 1. Calcium carbonate + hydrochloric acid $\rightarrow$ calcium chloride + water + carbon dioxide

Formulae:
$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

Balance:
$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

eg 2. methane + oxygen $\rightarrow$ carbon dioxide + water

Formulae:
$CH_4 + O_2 \rightarrow CO_2 + H_2O$

Balance:
$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

(c) Using the description to find the word equation

The process is:

description of reaction → word equation → balanced chemical equation

Sometimes the description gives you all the reactants and products, and in other cases you have to apply your knowledge of chemical reactions to find the products. Both types are shown in the following examples:

eg 1. Calcium hydroxide is the only product when calcium oxide dissolves in water.

Calcium oxide	+	water	→	calcium hydroxide
CaO	+	H_2O	→	$Ca(OH)_2$

eg 2. Sulphuric acid reacts with potassium hydroxide

Acid	+	Alkali	→	salt	+	water
Sulphuric acid	+	potassium hydroxide	→	potassium sulphate	+	water
H_2SO_4	+	KOH	→	K_2SO_4	+	H_2O
H_2SO_4	+	$2KOH$	→	K_2SO_4	+	$2H_2O$

Question 4 at the end provides further practise with writing equations.

Calculation work based on equations

All calculation work must be based on **balanced chemical equations** - ones that have the same number of atoms of each type on each side of the arrow. Any calculation based on an unbalanced equation will automatically be wrong!

Calculation work also requires you to use **moles**. You need to ensure you are happy converting between masses and moles (see Factsheet 2 - Moles and Formulae) before you go any further.

e.g. $2Mg + O_2 \rightarrow 2\,MgO$

The numbers in front of the formulae tell us the **mole ratio** in the reaction - for every 2 moles of magnesium, we need 1 mole of oxygen, and we will produce 2 moles of magnesium oxide.

So if you wanted to react 4 moles of magnesium, you'd need 2 moles of oxygen and you would get 4 moles of magnesium oxide. Similarly, if you reacted 1 mole of magnesium, you'd need 0.5 moles of oxygen and you'd get 1 mole of magnesium oxide.

> ***Tip:*** *The equation can never tell you how much of a substance is actually reacting - that depends on how much of the chemicals you decide to use! It only tells you the **ratios***

We can use these mole ratios to find out **mass ratios** - which are what we need to work with to find masses. To find these, we need to use the equation **mass = moles × M_r**. So for the equation above, we have:

	$2Mg$	+	O_2	→	$2\,MgO$
Mole ratio	2		1		2
Multiply by M_r:	2×24		1×32		2×40
Mass ratio	48		32		80

Note that the masses balance - the total is 80 on both sides of the equation.

In all mass calculations based on equations, you must always follow these steps:

1. Write a balanced equation
2. Work out the mass ratio
3. Use the mass ratio, together with the information given in the question, to find the unknown masses.

The following examples illustrate how to do this:

eg 1. How much magnesium oxide will be made by burning 12g of magnesium?

	$2Mg$	+ O_2	→	$2MgO$
Mass ratio	48	32		80
Actual mass	12			?

To work out the required mass of magnesium oxide, we use the fact that 48:80 and 12:? are in the same ratio. One easy way of dealing with ratios is using the "cross method", shown in the box below

> **Working with ratios using the "cross method"**
> This method involves 3 easy steps:
> 1. Write down the two ratios underneath each other, putting in a ? for the number you don't know.
> 2. Draw a cross
> 3. Multiply the two joined numbers and divide by the other one.
>
> Using the example above, our two ratios are:
>
> 48 : 80
> 12 : ?
>
> So we do $12 \times 80 \div 48 =$ **20**
> If you are not happy working with ratios, see Factsheet 14: Maths for Chemists 1

So mass of MgO = 20g

eg 2. What mass of calcium carbonate is needed to make 0.12g of calcium oxide? (M_r values: Ca = 40, C = 12, O = 16)

	$CaCO_3$	→	CaO	+	CO_2
	1 mole	→	1 mole	+	1 mole
Mass ratios	100	→	56	+	44
Actual mass	?		0.12		

So our ratios are 100 : 56 and ? : 0.12
So ? = $100 \times 0.12 \div 48$ = **0.25g**

Gas Molar Volumes

Up to this point **state symbols** have not been used in any of the equations:

(s)	=	solid
(l)	=	liquid
(g)	=	gas
(aq)	=	solution (i.e. dissolved in water ≡ 'aqueous')

They are important and in effect complete any balanced chemical equation. They are used in examination questions, and are useful because you may need to specify that something is precipitated (so it will have an (s) not an (aq)), and, most importantly in this section, because some formulae - and hence some methods - only work for gases! The key fact is:

> *1 mole of any gas has a volume of 24 dm^3 (24000cm^3) at room temperature and pressure (rtp) - which is 1 atmosphere and 25°C*
>
> *At standard temperature and pressure (stp) - which is 1 atmosphere and 0°C - the volume of 1 mole of any gas is 22.4dm^3 (22400cm^3)*

There are two types of questions that use this fact:

1. Equations involving **only gas volumes**

The method here relies on the fact that **mole ratio = gas volume ratio**
So the steps are:

1 Write a balanced equation
2 Write down the mole ratio
3 Use the mole ratio, together with the gas volume information given in the question, to find the unknown volume.

eg 1. What volume of SO_3 would be made from $200cm^3$ O_2 reacting with SO_2?

	$2SO_2$ (g) +	O_2 (g)	➔	$2SO_3$ (g)
mole ratio	2	1		2
volumes		200		?

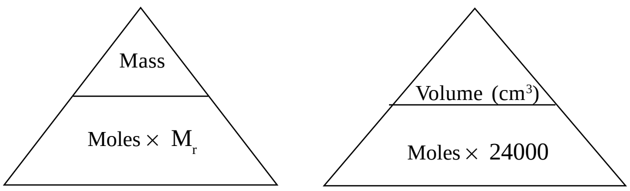
So 1: 2 and 200 : ? are in the same ratio.
So ? = 200 × 2 ÷ 1 = **$400cm^3$**

2. Equations involving **gas volumes** and **masses**.
Here, we cannot rely on simple ratio methods. We need to convert between masses/volumes and moles, then work with moles and the mole ratio.
NB: This approach will also work with all the previous types of calculation, so if you'd rather remember just one method, use this one!
The procedure is:

1 Write a balanced equation
2 Write down the mole ratio
3 For the substance you have information about, work out how many moles of it there are
4 Use the mole ratio to find out how many moles there are of the substance you're asked about
5 Find out the mass or volume you're asked for using the correct moles equation

You may find the "triangles" below helpful:

Triangles for moles formulae



Cover up the thing in the triangle you want to find. Then, what you can see tells you the calculation to do. For example, if you want to find moles, cover it up and you are left with mass/M_r

NB: Convert litres (= dm^3) to cm^3 by multiplying by 1000.
Convert cm^3 to litres by dividing by 1000

	$CaCO_3$(s)	➔	CaO(s)	+	CO_2(g)
Mole ratio	1	➔	1	+	1

We know we have 20g of $CaCO_3$. So we work out how many moles this is:
$M_r(CaCO_3)$ = 40 + 12 + 48 = 100
moles of $CaCO_3$ = mass÷M_r
= 20÷ 100 = 0.2 moles
We're asked about CO_2. The mole ratio $CaCO_3$: CO_2 is 1:1.

So we have 0.2 moles of CO_2.

Now we must find the volume of CO_2.

Volume CO_2 = moles × $24000cm^3$ = **$4800cm^3$**

eg 2. Iron reacts with oxygen to make iron (III) oxide. Calculate the mass of iron and the volume of oxygen required to produce 3 grammes of iron (III) oxide. (A_r values are Fe: 56 O:16)

	4Fe +	$3O_2$	➔ $2Fe_2O_3$
Mole ratio	4	3	2

We're told about iron (III) oxide, so find moles of it:
$M_r(Fe_2O_3)$ = 112 + 48 = 160
moles of Fe_2O_3 = 3 ÷ 160 = 0.01875
NB: We do **not** round at this stage - it leads to loss of accuracy.

We need to find the moles of iron and the moles of oxygen:
Moles of iron = 0.01875 × 4 ÷ 2 = 0.0375
Moles of oxygen = 0.01875 × 3 ÷ 2 = 0.028125
Now we need to find the mass of iron and volume of oxygen:
Mass Fe = moles × 56 = **2.1g**
Volume O_2 = moles × $24000cm^3$ = **$675cm^3$**

Tip: If you are at all unsure what to multiply by and what to divide by when you are using ratios:
- *Use the "cross method"*
- *Double check that the substances with the larger number in the mole ratio has the higher the number of moles.*

Writing ionic equations for precipitation reactions

In precipitation reactions, the reactants are solutions, but one of the products is a solid. So state symbols are very important when writing equations for these reactions.

The key idea used here is that when an ionic substance is in solution, the ions seperate - so we can consider sodium chloride solution, for example, to consist of Na^+ (aq) and Cl^- (aq).

The worked example below shows how it works:

eg. Write the following equation in its ionic form.

$FeSO_4$ (aq) + 2NaOH(aq) ➔ Fe $(OH)_2$ (s) + Na_2SO_4 (aq)

Three of the substances are in solution (we know this from the (aq)), so we split them into ions:

Fe^{2+}(aq) + SO_4^{2-}(aq) + $2Na^+$(aq) +$2OH^-$(aq)➔ $Fe(OH)_2$(s) + $2Na^+$ (aq) + SO_4^{2-} (aq)

Note that some ions appear on both sides of the equation - they started off in solution and they stay in solution. These are called **spectator ions**. We must "cancel them out" to give the final **ionic equation:**

Fe^{2+}(aq) + ~~SO_4^{2-}~~(aq) + 2~~Na^+~~(aq) +$2OH^-$(aq)➔ $Fe(OH)_2$(s) + 2~~Na^+~~ (aq) + ~~SO_4^{2-}~~ (aq)

Fe^2 (aq) + 2 OH^- (aq) ➔ Fe $(OH)_2$ (s)

Practice Questions

1. Write the formulae for the following compounds:

a) Sodium iodide	b) Iron (III) nitrate (V)	c) Lithium sulphide
d) Copper (II) nitrate(V)	e) Magnesium carbonate	f)Dihydrogen monoxide
g) Silver (I) oxide	h) Calcium chloride	i) Barium sulphide
j)Potassium sulphate(VI)	k) Carbon disulphide	l) Zinc carbonate
m) Magnesium oxide	n) Sulphur dioxide	o) Sulphur dichloride
p) Aluminium hydroxide	q) Hydrochloric acid	r) Lead (IV) oxide
s) Hydrogen chloride	t) Hydrofluoric acid	u)Trioxygen (Ozone)
v) Hydrogen gas	w)Ammonium chloride	x) Argon gas
y) Dinitrogen monoxide	z)Aluminium fluoride	aa) Magnesium iodide
ab)Disulphur dichloride	ac) Copper (I) carbonate	ad)Carbon tetrafluoride

2. Write the names of the following compounds, as fully as possible:

a) SO_3	b) $Ca(OH)_2$	c) $FeCl_2$	d) ZnS	e) FeS
f) $ZnCO_3$	g) I_2	h) $Sr(HSO_4)_2$	i) Li_2S	j) H_2O_2
k) NO	l) $Fe(OH)_3$	m) $(NH_4)_2SO_4$	n) CuF	o) $NaHSO_4$
p) NaOH	q) P_2O_3	r) BeO	s) $Mg(CO_3)_2$	t) $CuSO_4$

3. Balance each of the following equations:

a)	___Na + O_2	➔	___Na_2O
b)	K_2CO_3 + ___HCl	➔	___KCl + CO_2 + H_2O
c)	Ba + ___H_2O	➔	$Ba(OH)_2$ + H_2
d)	C_4H_8 + ___O_2	➔	___CO_2 + ___H_2O
e)	$Al_2(SO_4)_3$ + ___NaOH	➔	___$Al(OH)_3$ + ___ Na_2SO_4
f)	$SrCO_3$ + ___ HNO_3	➔	$Sr(NO_3)_2$ + H_2O + CO_2
g)	___ Fe + ___ O_2	➔	Fe_3O_4
h)	___HNO_3 + ___Cu	➔	___$Cu(NO_3)_2$ + ___NO + ___H_2O
i)	___NaOH + H_3PO_4	➔	Na_3PO_4 + ___H_2O
j)	Na_2CO_3 + $CuCl_2$	➔	$CuCO_3$ + ___NaCl
k)	___$NaNO_3$	➔	___$NaNO_2$ + O_2
l)	___Fe + ___H_2O	➔	Fe_3O_4 + ___H_2
m)	___SO_2 + O_2	➔	___SO_3
n)	N_2 + ___H_2	➔	___NH_3

4. Write the balanced chemical equation for each of the following:

a) Ethane (C_2H_6) burns in oxygen to produce carbon dioxide and water vapour.
b) Silicon tetrachloride reacts in water to make silicon dioxide and hydrogen chloride.
c) Heating strontium carbonate to produce the metal oxide and carbon dioxide.
d) Hydrogen reacting with oxygen to produce water.
e) Magnesium burning in are to make the oxide.

5. Write the balanced chemical equation for each of the following reactions:

a) Nitric acid with copper carbonate.
b) Burning potassium in air
c) Adding sodium hydroxide solution to zinc chloride solution
d) Potassium oxide with sulphuric acid
e) Burning octane (C_8H_{18}) in air

6. a) What mass of iron (III) oxide would be made by reacting 50g of iron with oxygen?
b) What mass of sulphur needs to be burnt in oxygen to produce 5g of sulphur dioxide?
c) What mass of calcium oxide and carbon dioxide would be made by heating 2g of calcium carbonate?
d) What mass of hydrogen would be produced by adding 10g of calcium to water?
e) What mass of oxygen would need to be added to 0.5g of carbon to turn it all into carbon dioxide?

7. a) In the reaction N_2 (g) + 3 H_2 (g) ➔ 2 NH_3 (g)
i) What volume of hydrogen would react with 50cm^3 of nitrogen
ii) What volume of ammonia would be made?
b) 2 SO_2 (g) + O_2 (g) ➔ 2 SO_3 (g)
What volumes of SO_2 and O_2 would be needed to produce 25 cm_3 of SO_3?
c) CO_2 (g) + C(s) ➔ 2 CO (g)
What volume of carbon monoxide would be made from 100cm^3 of carbon dioxide?

8. a) The equation below shows the fermentation process:
$C_6H_{12}O_6$ (aq) ➔ 2 C_2H_5OH(l) + 2 CO_2 (g)
What volume of CO_2 would be made from 5g of $C_6H_{12}O_6$?
b) 2 $NaNO_3$ (s) ➔ 2 $NaNO_2$ (s) + O_2 (g)
What volume of hydrogen would be made by adding 5.8g magnesium to excess hydrochloric acid?

9.Write the ionic equation for each of the following:

a) NaOH (aq) + HCl (aq)	➔	NaCl (aq) + H_2O (l)
b) Mg (s) + H_2SO_4 (aq)	➔	$MgSO_4$ (aq) + H_2 (g)
c) $Al_2(SO_4)$ (aq) + 6 NaOH (aq)	➔	2Al $(OH)_3$ (s) + 3 Na_2SO_4 (aq)
d) Na_2CO3 (aq) + 2 HNO_3 (aq)	➔	2 $NaNO_3$ (aq) + H_2O (l) + CO_2 (g)
e) 2 $AgNO_3$ (aq) + $CuCl_2$ (aq)	➔	$Cu(NO_3)_2$ (aq) + 2 AgCl (s)

Answers

1.a) NaI	b) $Fe(NO_3)_2$	c)Li_2S	d) $Cu(NO_3)_2$	e) $MgCO_3$	f) H_2O
g) Ag_2O	h) $CaCl_2$	i) BaS	j)K_2SO_4	k) CS_2	l) $ZnCO_3$
m)MgO	n) SO_2	o) SCl_2	p) $Al(OH)_3$	q) HCl	r) PbO_2
s) HCl	t) HF	u) O_3	v) H_2	w) NH_4 Cl	x) Ar
y) N_2O	z)AlF_3	aa)MgI_2	ab) S_2Cl_2	ac) Cu_2CO_3	ad)CF_4

2.a)sulphur trioxide b) calcium hydroxide c) iron (II) chloride
d) zinc sulphide e) iron (II) sulphide f) zinc carbonate
g)iodine h) strontium hydrogen sulphate (VI)
i) lithium sulphide j) dihydrogen dioxide k) nitrogen monoxide
l) iron(III) hydroxide m)ammonium sulphate (VI)
n) copper (I) fluoride o) sodium hydrogen sulphate (VI)
p) sodium hydroxide q) diphosphorus trioxide
r) beryllium oxide s) magnesium carbonate t)copper (II) sulphate

3. a).4, 2	b) 2, 2	c) 2	d) 6, 4, 4	e) 6, 2, 3
f) 2	g) 3, 2	h) 8, 3, 3, 2, 4	i) 3, 3	j) 2
k) 2, 2	l) 3, 4, 4	m) 2, 2	n) 3, 2	

4.a)	2 C_2H_6 + 7 O_2	➔	4 CO_2 + 6 H_2O
b)	$SiCl_4$ + 2 H_2O	➔	SiO_2 + 4 HCl
c)	$SrCO_3$	➔	SrO + CO_2
d)	2 H_2 + O_2	➔	2 H_2O
e)	2 Mg + O_2	➔	2 MgO

5.a)	2 HNO_3 + $CuCO_3$	➔	$Cu(NO_3)_2$ + H_2O + CO_2
b)	4 K + O_2	➔	2 K_2O
c)	2 NaOH + $ZnCl_2$	➔	$Zn(OH)_2$ + 2 NaCl
d)	K_2O + H_2SO_4	➔	K_2SO_4 + H_2O
e)	2 C_8H_{18} + 25 O_2	➔	16 CO_2 + 18 H_2O

6. a) 71.52g b)2.496g c)1.12g, 0.88g d) 0.5g e) 0.73g

7. a) i) 150cm^3 ii)100cm^3 b)25cm^3 , 12.5cm^3 c) 200cm^3

8. a) 1344cm^3 b) 5760cm^3

9. a)	H^+ + OH^-	➔	H_2O
b)	Mg + $2H^+$	➔	Mg^{2+} + H_2
c)	Al^{3+} + 3 OH^-	➔	$Al(OH)_3$
d)	CO_3^{2-} + 2 H^+	➔	H_2O + CO_2
e)	Ag^+ + Cl^-	➔	AgCl

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CONTENTS

Introduction

1. Study skills: A-level success and the 'step up' for university
2. How to be a good 'independent learner'

The study skills

3. An atmosphere for study and success: organising for learning
4. Reading and responding: active reading
5. Using wider reading and using reading in essay writing
6. Take notes / Making notes
7. Critical analysis / Comparison
8. Research skills
9. Using the library (and the librarian)
10. Writing skills: planning and writing extended essays

Applying your study skills

11. Effective homework
12. Effective revision skills
13. Exam preparation
14. Exam technique / Approaching questions / Scoring marks

Personal skills

15. Being numerate / Number skills
16. Time management
17. Public speaking / Presentation skills and debating
18. Team-working / Collaborations / Group discussion
19. Critical thinking and problem solving
20. Emotional study skills

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Introduction

1. Study skills: for A-level success and the 'step up' needed for university

In 2013, speakers at a conference organised by the University of Cambridge Admissions Office gave several suggestions for the characteristics they were looking for in an **ideal A-level candidate**.

The list included the following:

- Commitment to their chosen degree subject;
- Interest and aptitude;
- Ability to think independently, critically and analytically;
- Logical, problem-solving approach;
- Enthusiasm for complex, challenging ideas;
- Motivation and organisation;
- Intellectual flexibility and curiosity;
- Perseverance and willingness to collaborate;
- Vocational/professional aspirations (where appropriate).

Although these points were identified as especially important to the Cambridge team, they can be regarded as a wish list for *all* universities and colleges. These are the skills and qualities that universities will be looking for when you apply to them.

When I showed this list to my Year-12 students in a recent assembly, there was an audible gasp in the hall; students were looking at the list and seeing a mismatch between what was being asked for and what they could offer. This Learning Skills booklet is an attempt to address these concerns and show that the learning journey from GCSE through to the completion of your A-levels offers many opportunities to set the habits and practise the skills that will give you the 'step up' needed for success at A-level, and university.

Therefore, this booklet contains advice, guidance, support and examples to enable you to transform your approaches to learning *from*:

- Dependent to **independent**;
- 'Spoon-fed' to **self-sufficient**;
- Accepting to **questioning**;
- Avoiding difficulty to **embracing challenges**;
- Indifferent to **curious**;
- Passive to **active**;
- Attentive to **engaged**;
- Coasting to **driven**.

These transformations provide the basis of a **'scholarly' approach** to learning that fits in with the objectives, atmosphere and expectations of university education. Independence and original thinking lie at the heart of scholarship and so it makes sense to think about how these qualities can be developed and strengthened at the outset.

2. How to be a good 'independent learner'

Independent learners stand out in classrooms for many reasons.

- They take the initiative to read and research in advance and do not wait for lessons to introduce topics.
- They read more widely and consequently often have better notes.
- They organise their own learning.
- They develop their own ideas and test them by entering into class discussion, engaging in questioning with their teachers, and by participating in challenges and competitions.
- They are efficient learners; they are equipped to get on at their own pace.
- They actively find out about opportunities within the subject, both within school and outside.

If you look at this list, there is nothing there that you could not start to do yourself. Why wait for a teacher to tell you what to read if you have (a) a reading list, and (b) subject specifications? Why stick to just one textbook when there are alternative books and magazines available, as they may have better coverage/examples and may be more relevant/up-to-date? Since you know your timetable and the term dates, why not organise your own learning around your lessons, scheduled tests and revision periods? Why not apply to join useful organisations, participate in summer schools and taster days, take your own trips and enter competitions to enhance your learning?

A good 'independent learner' seizes the initiative; takes control of the learning process; and is able to form an original and individual perspective on the subject being studied.

The study skills

3. An atmosphere for study and success: organising for learning

A scholarly, independent learner sets an atmosphere for study and success at school/college and at home.

Planning your time

When you are studying during a typical week, you will be guided by a **timetable of lessons**.

Go one step further and ask for a copy of the **academic calendar** for your institution so that you can **plan** the number of teaching weeks per term and see when training days, half-terms, examination periods and other special events interrupt the usual timetable. With this information, you can plan to manage your time effectively during each term and have targets for the weekly **'study periods'** on your timetable. You can organise **'study groups'** so that some sessions are collaborative: most of my classes also have social media groups to share ideas and resources. There is a great deal of value in discussing your studies with class-mates and talking about topics informally; the group is a support base and sounding board, and everybody benefits from a **shared sense of purpose**. Make use of areas within your school/college that are most conducive to learning (such as a quiet library) and avoid social distractions when you have planned to study. That said, even the most thorough planning should include some balance, with time for friends and also some space to pursue extracurricular/voluntary interests and perhaps some work experience.

You will be expected to **attend** all lessons and arrive **punctually** and ready to learn. Teaching at A-level is mainly sequential within topic areas and subject teachers are usually specialists who will have their own take on the various topics. You cannot afford to miss anything. It may seem like an obvious point but excellent records of attendance and punctuality are vital for success at A-level and beyond.

A place to study

Many students see 'home' as a sort of academic headquarters; I often hear the phrase 'I work better at home than at school.' However, the home is only a better place to work if an atmosphere for study and success has been set. It is difficult to offer general advice for study environments at home because the contexts differ greatly. When I was a Sixth Form student, I had two study options, for example: one next to a warm coal fire, but also close to the family TV; the other, lying on the floor in a very cold bedroom. Neither option was ideal! If you have better options than I had then it might be worth modelling your 'home' space on the standard student accommodation at university: desk, lamp, bookshelves and a noticeboard for planning, revision sheets and reminders. To make sure that 'home' has the study atmosphere you need to achieve success you also need to be honest about the barriers to learning that you encounter at home. It is worth carrying out a **distraction audit** to identify the things that interfere with your learning the most.

Main distractions that get in the way of learning at home	Ways in which they interfere with your learning	Ways in which they could enhance your learning (if any)?	Proposed solutions
1			
2			
3			
4			
5			

One of the most common things I hear at parents' evenings in relation to under-performing students is 'But my son/daughter is in the bedroom until the early hours on the computer', to which my reply is always,
'Doing what?'

It is very rarely effective studying! You need to be honest about the distractions that you face at home and how to manage these. It will be good practice for managing the same sort of distractions in university halls of residence. I recognise, however, that there are some double-edged swords here: social media, for example, can seriously hinder effective learning but it can also enhance it if used for an academic purpose. If you **plan for balance** in your home life, you can develop the right atmosphere for effective study periods, whilst rewarding yourself with some time for doing the things you enjoy. Just don't mix study and leisure and expect great results!

Course notes

You must also develop and maintain tidy and comprehensive **files of notes** for each of your subjects/subject teachers and ensure that you add to these in your own time. You should *at the very least* have an A4 ring binder for each subject, with dividers for each of the topics and a clear system for ensuring that subject specifications, handouts, assessed work and past papers are incorporated into your folders in appropriate places. Please date your notes and handouts for ease of reference when filing. I would also recommend – if the opportunity is available to you – to get a **locker** so that you can store files and books during the day rather than having to carry these from lesson to lesson.

4. Reading and responding: active reading

As anybody who has watched BBC's *University Challenge* will know, when you go to university you will be 'reading' for your degree. So it's essential that you pick up the reading habit at A-level to prepare you for the higher-level reading expectations that you will face in Higher Education.

Reading is a hugely rewarding and engaging pursuit and lies at the heart of all academic studies.

One of the first things that you will notice about reading for your A-level studies is the range of texts that you may encounter. This is a non-exhaustive list:

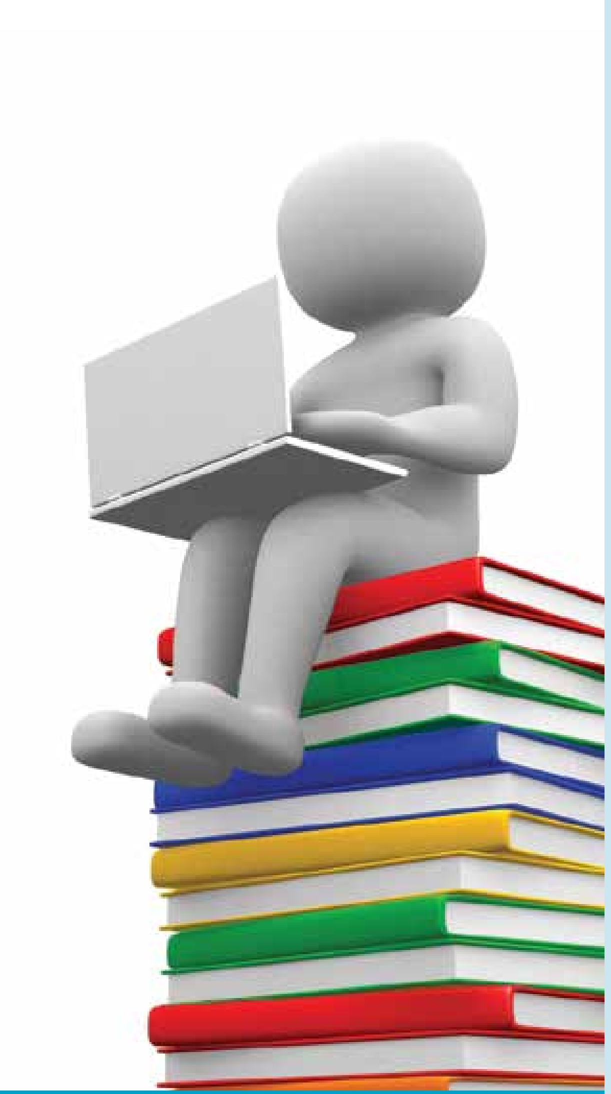
- Textbooks
- Books (fiction, non-fiction, biographies, diaries/letters)
- Plays, scripts and screenplays
- Magazines and Journals
- Newspapers (online or paper-based)
- Dictionaries, atlases and encyclopaedia
- Websites and blogs
- Official reports
- Historical sources
- Legislation
- Tables of data

The independent reader will always **go beyond the recommended textbook**; most textbooks contain lots of recommendations for further reading or links elsewhere. **Magazines and journals** are especially useful to the A-level reader as they may **focus** on and **update** topics that might have received more limited coverage in a textbook. It is a feature of higher-level studies that you consult a **range of sources** on topics to find the most compelling perspectives and evidence. These will assist you not only in learning and understanding the topic but also in developing your ideas and arguments for assessment purposes.

You should spend some time in a library familiarising yourself with academic books so that you can make the most of these resources within the time constraints that you have and taking account of the commitments you are balancing. This is, in addition, excellent practice for university study. Take particular note of the **contents page** for general chapter headings; any **tables, appendices** or **glossary**; and the layout of the index. All of these tools will allow you to **scan** the book quickly for relevant material and locate the **key parts** of the text. Such advice is given with a caution, however: you always need to give thought to the **context** in which such material appears and you should be prepared to read introductory or preceding text to ensure that you have a thorough understanding of the relevant passage that you have identified.

Active reading

When you read academic books, you should also aim to read **actively** rather than passively, to get the most out of them for your studies. At the most basic level, this might be reading with a **notepad** and **dictionary** at hand. The dictionary is a vital tool for decoding academic texts and avoids any discouragement or frustration that may set in when faced with difficult language, concepts or references. Some academic texts are notoriously difficult – and it can be very satisfying to rise to the challenge of understanding such a text. At a more sophisticated level, **active reading** should involve **'read and precis' note-taking methods** – I recommend the **Cornell method**, see below – that involve engaging with the text, recording key points and ideas, raising questions and comparing with other texts, theories and ideas. This is a *lively* form of reading that promotes scholarly enquiry. You are having a mental dialogue with the author in your note-taking and questioning – Who? What? How? Why? When? – yet also reaching for other texts to clarify, confirm, compare and assess. This process also promotes **original thinking** as you are no longer reliant on one view but alert to other perspectives. You are forming your **own view**.



Active reading: the top-five

- Familiarise yourself with the text and **scan** its contents (What are you looking for? Where can it be found? In what context does it appear?)
- Read with a **dictionary** and **notepad** to hand
- **Engage with the text**: ask questions, compare with other sources and think critically
- **Take notes** to record, selectively, the key terms, concepts, arguments or ideas in the text
- **Review** the text and your notes to summarise what you have read and **form your own view**

5. Using wider reading / Using reading in essay writing

Active readers are able to use their wider reading, both to enhance their notes in the subject and their essay-writing, because they are taking account of a wider range of sources and weighing the merits of competing perspectives. This is a scholarly approach that underpins effective academic performance.

In arts/humanities subjects, essay questions usually offer one view of a topic that you are expected to discuss. It is so much easier to unpick that view and to weigh up the arguments for and against it if you have read widely and know where writers/theorists agree and where they disagree. This shows an examiner that you have engaged with the topic and can explain and analyse competing views. Such wider reading should enable you, in addition, to arrive at a reasoned conclusion, which you can justify.

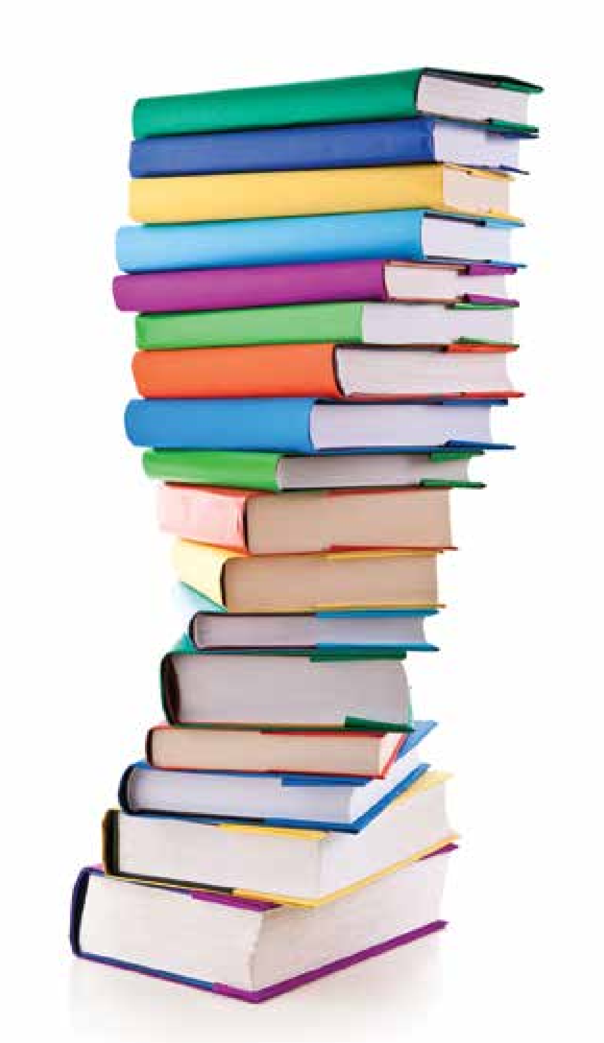
Under examination conditions, it is enough that you can recall the name of the theorist who offered a certain view and provide an explanation of the view, perhaps supported by a relevant short quote, and compare and contrast that view as far as is necessary given the requirements of the question. It is often useful if you can include a tiny bit of biographical information about the theorist to provide some context: e.g. the time in which he/she was writing; and, say, the school of thought with which the theorist was associated.

In prepared essays, coursework and extended essays, however, your teacher/examiner will be alert to the potential for **plagiarism**: copying from another source directly without attributing any credit to it. Plagiarism is perceived as the gravest academic offence you can commit: it shows the extent of your reliance on the ideas of others and undermines your intellectual credibility. Scholars have no need to plagiarise; they are reading the views of others to form their own opinions and are happy, as English mathematician, physicist and philosopher Isaac Newton (1643-1727) famously wrote, to 'stand on the shoulders of giants' to see a little bit further in their subjects. This is the nature of a 'literature review', which forms the basis for most extended essays. Use ideas, but add something of your own thinking.

Citing references

When preparing your own essays, and reviewing the relevant literature/views, make sure that you credit your sources by making use of a system of referencing. Use your own words to explain views or ideas, and make it clear if you are quoting directly from another source with your own introductory comments (e.g. 'As Marx argued …'; 'As Keynes pointed out …'). There are several ways of referencing your sources:

- At the foot of each page
- At the end of each section/chapter
- At the end of the essay



Most word-processing office packages include referencing tools so that you do not have to create your own systems. For some Arts/ Humanities subjects, academic referencing tends to take the form of **footnotes** or **end-notes**, though there are no hard and fast rules on this. You would add a numeral whenever you are including information that has been gained from a source and you would record, in full, the name of your source at the foot of the page or at the end of the section or essay. Take this example from a Government and Politics essay:The Fixed Term Parliaments Act 2011 provides some evidence for the view that the Liberal Democrats, in coalition government, were responsible for diluting the power of the Prime Minister.[1]'

[1] See McNaughton, N and Magee, E, 'The 2010-15 fixed-term parliament', Politics Review, April 2015 (vol 24, no 4) at pp30-33.

In the Sciences, however, the **Harvard system** is more often, but not exclusively used. This style of referencing provides an easy code (author's surname and date of publication of the relevant work) so that the reader can identify, at the end of the essay, the full details of this specific source that the author has credited in the text. An example is provided by the February 2013 issue of Philip Allan's **'Physics Review'** where writer Roussel de Carvalho, discussing ultraviolet radiation in Antarctica, draws on a specific source in the course of his article: 'Vitamin D production peaks at 297 nm, which is in the UVB band (MacLaughlin et al. 1982).' The reader can then find the full details for this source at the end of the article: MacLaughlin, J. A. et al. (1982) 'Spectral character of sunlight modulates photosynthesis of previtamin D3 and its photoisomers in human skin', Science Vol. 216, No. 4549, pp.1001-1003.

6. Taking notes / Making notes

During your A-level studies, and indeed your degree, you will be expected to make sense of the many hours of teaching/lecturing you receive, and any further reading/research that you have completed. The best and most efficient way of coping with so much information is to take notes at the time, from which further (and better) notes can be made when they are needed (such as for revision).

There are many methods of taking notes and you must choose the style that best suits you. In the lesson/lecture there are many styles of note-taking available to students and these will largely be determined by the format of the presentations you receive. Many A-level teachers provide handout material to assist your note-taking (**'guided notes method'**): such resources encourage **active learning** by providing a framework of headings for you to understand the main elements of the topic, whilst requiring you to fill in some of the details and examples as they are being explained.

In the absence of supporting materials, you need to develop a style that will best enable you to filter the most important points, explanations and examples from the session, whether that be in a **linear written form** (using **shorthand**, where necessary: see the following guide developed by the University of Portsmouth (http://tinyurl.com/psu4cyt) or through a **non-linear method**, perhaps including visual cues, such as **mapping ideas** as they develop. Whatever you choose, the method needs to capture the essential points of the lesson/lecture and filter out the digressions, anecdotes and asides that are not directly relevant to learning the topic.

Cornell method of note-taking

This refers to a method popularised by Professor Walter Pauk at this American Ivy League university in the 1950s, may be used for lessons/lectures but strikes me as especially useful for making sense of further reading and research, and building on earlier notes, to achieve a greater degree of understanding and **synthesis** of a topic. It involves dividing the page into two columns, with the one on the right much larger than the one on the left. The left is used for key words/ terms/headings; the right is used for explanations and examples, in shorthand written form. The last few lines of the page are meant to be left blank for questions or for a short summary of the session – but I would reserve this for the end of your topic notes rather than for every page.

Notes should be frequently reviewed, added to and re-made in the important transformation process that has to take place during the **revision** process (see below).

Note-taking: the top five

- Remain **active** in lessons/lectures by **taking detailed notes of key points** edit as you listen
- Adopt a **style** that best suits you: linear notes or non-linear mapping?
- Use **shorthand** where possible to increase the efficiency of your note-taking: and ensure that you capture everything you need
- **Review**, add to and re-make your notes
- **Transform your notes** for **revision**

7. Critical analysis / Comparison

Note-taking in lessons/lectures and for further reading assists you in identifying:

- Patterns and trends
- Problems and suggested solutions
- Contradictions, paradoxes and anomalies
- Points of comparison (similarities and differences)
- Views for which there is a degree of consensus (agreement)
- Views for which there is a degree of dispute (disagreement)

In addition, most A-level examinations will ask you to interpret relevant data, with the expectation that you will select relevant figures and detect significant points of comparison.

With such evidence at hand, you have the basis for **critical analysis**; for breaking down a question, or problem, into its components and examining each part for inconsistencies in the evidence or contrasting views on its interpretation. If you are examining contrasting viewpoints, the analysis is **qualitative** and you should be looking for the main **'points of clash'** in the debate to make effective comparisons between the two positions. If, however, you are focusing on numerical data the analysis will often be **quantitative** in nature, comparing and contrasting the figures and, where necessary, manipulating the data mathematically to illustrate implications and consequences. Effective analysis will ensure a balanced assessment of the evidence – rather than a one-sided assessment, which may exclude relevant information – and informs the evaluative judgements you will have to make in concluding an answer.

8. Research skills (including online)

The independent, scholarly student does not wait to be told; they are keen to find out for themselves. This is the essence of academic enquiry – a wonder about the world that leads, through research, to exploration and discovery.

At A-level you will encounter two main types of research – referred to as **primary** and **secondary** – that can then be subdivided into a series of methods that may be used to produce **qualitative** (written) or **quantitative** (numerical) results.

Primary research

This includes methods such as questionnaire surveys, observations and focus groups, and involves the process of gathering data *first-hand* from an identified group of respondents. The implementation of the method will determine the interpretation of results: a questionnaire comprising of closed questions lends itself to quantitative analysis; a focus group, on the other hand, will be formed for the purpose of obtaining qualitative results. The value of such research will depend on factors such as lack of bias in the selection of the sample of respondents and, for surveys, the size of the sample to gauge to which it represents the wider population. The effectiveness of the research will depend very much on the quality of the questions asked and the extent to which these are tailored to the objectives of the research.

Primary research also includes experiments and researchers devise and conduct these to test **hypotheses**. One of my favourite pieces of research involved the testing of the hypothesis that valuable Stradivarius violins played no better than modern instruments. It involved a blind test of instruments by experienced musicians and recorded their responses. The research results suggested that even though the instruments were separated by millions of pounds in market value, there was no discernible difference in sound or playing quality between authentic Stradivari and modern instruments.[2] A carefully devised experiment of this nature can form the basis of an excellent EPQ.

Secondary research

In contrast, this involves surveying the field of works that have already been published or disseminated. The researcher is conducting a 'literature review'. I offer further comments on this form of research in the 'library skills' section below.

Whilst it is considerably easier to conduct secondary research than to devise valid primary research, the effectiveness of the research relies on the quality of the search for resources and selectivity in filtering the results. This is as true for online research as it is for a visit to a physical library (see below). British universities produce guides for students to refine their online searches for information: see the University of Reading's useful support material, for example, at http://tinyurl.com/pyssxwf

In research projects at A-level, I have found the Google Scholar search engine (https://scholar.google.co.uk/) useful for generating academic articles and providing starting points for further research, though your teachers and librarians may be able to direct you to subject-specific portals and archives that are more focused and relevant for your studies and projects. I also encourage students – see below – to apply for access, where possible, to academic libraries and research institutes, as these may be able to search through online archives of journals that are usually only available on a subscription-only basis.

[2] Sample, I, 'How many notes would a virtuoso pay for a Stradivarius?', The Guardian, 3/1/2012, pp1-2. See online version at: http://www.theguardian.com/music/2012/jan/02/how-many-notes-violinist-stradivarius

9. Using the library (and the librarian)

Since your studies at A-level and beyond will involve a great deal of reading and researching, and these are habits that you have been encouraged to develop, it is vital that you become familiar with using **libraries** and drawing on the skills and expertise of **librarians**. You would be right in thinking that you have access to libraries at your fingertips – search engines can bring a world of wonder to your screen – but without a librarian's expertise, you might be missing out on a wealth of resources.

The physical library contains many items that you will not be able to find freely available online. It will contain shelves of books and magazines (some of which, like the Philip Allan series, are targeted specifically at A-level students) that are carefully managed, reviewed and updated by librarians. You may also find **signage** and **guidance notes** to help you navigate the shelves and a librarian will be able to suggest starting points for finding the information you need. If the physical library does not contain what you are looking for, ask about it: you have several options at your disposal, including a visit to a larger library that includes the item in its catalogue; or requesting an inter-library loan (usually for a small fee) to have the item delivered to your library; or of course looking online for a valid alternative source.

If you are researching for an extended project (EPQ), research institutes and university libraries are usually welcoming to A-level students provided that your school/college can provide you with a **'letter of introduction'** on headed paper that confirms your position and sets out your research needs. The independent, scholarly student will benefit enormously from a visit to a research library: here you will be able to access academic journals, university textbooks, government reports and official publications, whether physically or online, that might not be freely available elsewhere.

As for online research, a librarian can help you **refine your internet searches** and direct you to **portals** that will open up subject-specific libraries of material. They will also be able to steer you in the direction of **valid sources** and help you find freely available resources, rather than those hidden behind paywalls. A librarian really is a "gatekeeper of knowledge" and offers vital support to A-level students. Please make the most of your library, draw on the expertise of librarians and give yourself the best possible access to quality academic resources to enrich your learning experience.

Online searching: the top-five

- Use **unique and specific terms** that are strong in your subject area
- Use the minus operator to **narrow your search**
- Use **quotation marks** for matching exact phrases
- **Customise** your searches with '+', '~' and '*'
- Change tactics when things don't work out: **try another search engine or talk to someone!**

Adapted from TechRepublic: http://tinyurl.com/ncdmmuk

10. Writing skills / Planning and writing (extended) essays

Effective writing

The writing that you do at A-level is largely guided by question formats and assessment objectives. It is clear, however, that there are some features of effective writing that apply across the board:

- Write in fully developed sentences that are appropriately punctuated. And no text language: begin with a capital letter and end in a full stop!
- Write clear sentences that convey your intended messages to the reader; if you are unsure, proof-read/read-back to yourself.
- Vary the length of your sentences and take pride in crafting your written work; think to yourself as you write: every sentence matters and should have impact.
- Be mindful of structuring your work carefully so that the written piece guides the reader to its conclusion with a logical sequence of paragraphs, working from introductory comments and explanations, through to the discussion of views and evidence (depending on the nature of the question) and leading to a reasoned, justified conclusion.
- Develop your points and arguments by providing supporting explanation and examples and evidence.
- And one of the biggest issues in A-level writing, *answer the question set* (and if it has sub-parts, tackle each one to a sub-conclusion and on to the next until you reach your overall judgement)!

Essay planning

Over and above these general comments, there are few prescriptive rules for essay-writing. Essays come in all shapes and sizes, though you do have to accept that specific subjects will have preferences as to the style and format that these pieces of writing will take, and extended essays have to be very carefully planned and structured. One feature that you should bear in mind is that an essay should have some **balance**; it cannot be so one-sided that valuable considerations on the other side of the argument are simply ignored. This does not stop you writing a superb essay that seeks to persuade the reader that one side of the argument is stronger than the other from the outset, provided of course that you acknowledge that there are arguments and evidence on the other side and take care to show why you think your side outweighs the other. The alternative, safer approach is to introduce a matter of dispute, set it in context and then explore each side of the argument before arriving at your own conclusion, which will be justified because you have fully assessed the merits of each position and examined the main points of dispute.

Essay writing: the top-five

- **Clarify** the task/question before you start
- **Map** your ideas
- Identify **knowledge gaps** for further research
- First draft: check for a **logical flow** from one idea to the next, one paragraph to the next
  - Have an **introduction**: set the scene
  - Have a **key idea** in every paragraph
  - Make sure that **sentences** provide explanation, examples and reasoning
  - Consider **both sides** of the argument
  - Make a **conclusion**
- Final draft and edit; always **review and edit**!

Applying your study skills

11. Effective homework

Your homework needs to reflect the study skills that we discussed in the first section of this booklet. It should be **laid out neatly** and clearly – title, date, name and headings as appropriate – and be submitted by the **deadline** set. If it is a science or mathematics piece of homework you should ensure that workings are clearly set out, in a logical order. The value of homework lies in the fact that you can look back over your answers, and the feedback provided, when preparing for your examinations.

Homework should be welcomed. It forces you to keep up-to-date notes and to keep topics under review. It offers you an opportunity not only to test your understanding of an area but also to *apply* your knowledge to certain questions. Homework also provides a space for you to experiment and make mistakes on the first occasion you meet a certain type of question; you will learn from any errors. It encourages you to be **bold** – such as drawing on a wide range of further reading - and to 'have a go' at the task. Teachers will always acknowledge thought and effort in the work you submit, even if there are problems with some elements of your answer. When teachers assess the work, they will be looking

to offer you feedback on **'what went well' (www)** and give you pointers for **'even better if …' (ebi)**, whether they use these precise words or not. In the early stages of your A-level, the feedback you receive should outweigh the significance of any form of indicative grade. The grade only becomes meaningful when you can see it as representative of the assessment framework for that subject and when you know, precisely, which assessment objectives have been met fully and which only in part.

There has been a recent trend in schools and colleges for assessed homework to be hand-written (in preparation for examinations) in subject exercise books that are kept separately from the folder of notes. One of the reasons for this approach is to place an emphasis on the value of assessment as part of the learning process and for your assessed work to reflect an **on-going dialogue** between you and your teacher. If the same ebi comments are recurring across several pieces of work, it is easier for you, and your teacher, to pick up on this pattern and focus on rectifying the situation.

12. Effective revision skills

Everybody revises differently. We all have a different learning style, which means that certain approaches work better for some types of people than for others. I particularly liked transforming my notes by creating **revision posters** and listening to my **own voice reading through my notes**. I have seen other students with topics carefully – and colourfully – recorded on index cards; playing **revision card games** (definitions on one side, theorist or key term on the other); or creating elegant, spidery **mind maps** of particular topics.

My emphasis here is therefore not on what method you should employ but rather on ensuring that, whatever is chosen, the revision is effective. In other words, the revision succeeds in enabling you to recall key terms, concepts and examples and understand them well enough to apply and discuss in the exam situation.

Effective revision is **long-term** and **cumulative**; you develop a body of knowledge with which you become familiar and comfortable. So comfortable that there will be areas that you 'know' without having to review completely.

Good revision begins in *September* of the first year and is a continual process; it becomes a habit that reinforces learning at every stage. One way that you can build effective revision into your academic planning is to add to class notes with further reading for each topic and then **transform your notes** into a memorable format at the end of the topic. You can also draw on any feedback you have received on your academic performance in this topic.

Such an approach fits in with the scholarly, independent learning that has been advocated elsewhere. You are managing your own learning, maintaining a sensible pace and keeping one step ahead for homework tasks and internal tests. In certain subjects, such as mathematics, revision is achieved through the tackling of **past-paper questions**, as you are gaining familiarity with types of questions and the application of techniques that recur within the subject.

Cramming doesn't work

Short-term 'cramming', by contrast, is very rarely effective. It may have kept some students afloat at GCSE but it is unlikely to have a similar effect at A-level, where questions are more taxing and often quite discursive; they require you to think in the examination. The student who says "I haven't started revising yet" at Easter is a potential problem for every teacher: we know that the student will barely have time to transform their notes and learn the material, let alone practise past papers, in the time remaining before the examinations. Thus, that student's success is often more a question of luck than judgement. If you start your revision early enough you gain increasing confidence in the material – and you avoid the burden of pressure associated with leaving the task so late.

13. Exam preparation

There are many strands to examination preparation. We have already considered the benefits of **long-term revision**, which clearly provides strong foundations in preparing for any examination. There is the issue of **revision planning**, which takes into account your particular examination timetable and enables you to identify the best times to focus on each of your subjects; it should build on all your earlier work, rather than offer a stand-alone short term revision "solution". There is also the **health and welfare** strand, where the old advice cannot be repeated often enough: drink lots of **water** (and avoid energy drinks), take regular **exercise**, eat healthily and get plenty of **sleep** (see, for example, the following *New Scientist* article: http://tinyurl.com/nmr5mxu

The examination boards provide you with a further – and vital - branch of exam planning: the information they include on their websites for exam candidates in their subjects. These include:

- **Unit specifications**: scholarly, independent learner will have been consulting these since day one to inform further reading and note-taking but as the exams loom, it really is important to know the topics, key terms and themes that are likely to be assessed for each unit
- **Past papers**: you need to be familiar with the format, layout and question-styles adopted by the papers that you will sit; look for patterns of questioning and identify common themes
- **Mark schemes**: these are important in giving you a flavour of what the examiners were looking for, based on the assessment objectives in your subject, for specific questions; you can use mark schemes to understand the expected parameters of answers (i.e. what to put in and what to leave out) and gain advice on the sort of analytical and evaluative points that would score highly
- **Examiner reports**: these reveal some of the 'tricks of the trade' by noting what candidates do well, identifying common mistakes and shortcomings, and suggesting 'best practice' approaches to certain types of questions.

You must make use of these free and incredibly helpful resources when preparing for your examinations.

Revision and exam prep: the top-five

- Effective revision starts in September of your first year: think **long-term** and **cumulative**!
- **Transform your notes** into **revision resources** that work for you
- **Plan revision** carefully to give equal weight to your subjects
- Use **past papers** and other **exam-board guidance** wisely
- Stay **fit, healthy and active**: and avoid the pressure of cramming!

14. Exam technique / Approaching questions / Scoring marks

The examination board resources mentioned above will give you a head start in understanding effective exam techniques. These techniques range from the very practical, such as writing at sufficient speed, to important matters of content, such as how many arguments to discuss or the appropriate length of an evaluative paragraph.

Your approach to each question must take account of the relevant **assessment objectives**, as outlined in the specifications (these are the specific skills that will be assessed when your exam is marked), for the **number of marks** allocated and bearing in mind the **time available**. Do not spend too long on a question for which few marks are available; know in advance how long you will spend on each type of question and stick to this rule. If you are unsure as to the format of a strong answer, ask your teachers for an **exemplar script**; this should be read as a guide rather than as a template to be followed but I'm sure you will find it useful to see a piece of work that meets the various assessment objectives – and all the better, if these are identified in feedback on the exemplar.

The **assessment objectives** indicate how you can score top marks in your answer but watch out for 'confidence-boosters' wherever they appear; for example, many arts/humanities students pick up marks for clear communication without even thinking about it, and maths and science students are rewarded for their workings.

Know the command words

When answering any question, make sure that you know what the examiner wants by understanding the command words. One example – from AQA – is here: http://tinyurl.com/pdql8hj

Personal skills

15. Being numerate / Number skills

Although not all A-levels will assess numeracy skills directly, it will be presumed that students have number skills and can interpret and manipulate data. The areas of numeracy that tend to cross over A-level subjects are ones that will be familiar to you from GCSEs and include:

- Basic arithmetic application and formula/ratio calculations
- Percentages, and especially percentage change (increase and decrease)
- Averages
- Statistical/graphical analysis

You do not have to be a confident mathematician to be able to work with numbers; you just need to be able to think critically about the data presented. When presented with a set of figures in any subject, ask yourself: Are there any patterns or trends? Are there significant points of comparison? Can the data be used for calculations that will provide the basis for interpretive judgements? If you are presented with statistics in a graph form, always think about the scale that has been used and whether the figures have been accurately represented. And if you have to calculate or interpret any set of figures, always filter the information with the question "Does this look right?" and a willingness to **estimate**, where necessary.

The new A-level specifications detail the maths that will be assessed in each subject; make sure that you are familiar with what's required.

One tip for developing a numerical mind-set would be to make a habit of listening to Radio 4's excellent *More or Less* programme (http://tinyurl.com/oxrq6a4), which analyses some of the statistical claims that appear in the media to assess their validity. It illustrates week after week that we should not accept every statistic presented to us, but to think through the processes that led to these conclusions. Have the numbers been misinterpreted at some point? How much truth is there in these figures?

In an article for *New Scientist*,[3] the writer Mike Holderness provided an example of a BBC news item from 2002 that included the line 'for every alcoholic drink a woman consumes, her risk of breast cancer rises by 6%'.

If you start to ask some of the questions suggested above, you might soon start to think that this might not look right and that there might be some doubt as to the truth of the matter. Having dismissed the statistic as 'arrant nonsense', Holderness pointed out that 'You don't need to reach for the calculator to see that if such a statistic were true, very few women who enjoyed a cocktail from time-to-time would escape cancer.'[4] His article goes on to examine how the statistic came to be misreported, identifying a journalist's misinterpretation of a study by Cancer Research UK as the root of the error. The message he delivers is a simple one: be careful about accepting statistics at face value and think critically when presented with them.

[3] Holderness, M, 'Penetrating the Numbo-Jumbo' (Review of 'The Tiger that Isn't' by Blastland, M, and Dilnot, A), New Scientist, 15/9/2007, at p57
[4] Ibid. (Ibid is useful Latin shorthand for "in the same place".)

16. Time management

The importance of effective **time management** is a recurring theme within this booklet and supports student success in so many ways:

- Macro-planning: using the academic calendar to plan for the year ahead
- Micro-planning: using your timetable to plan for review/revision study sessions during the school/college day and at home
- Maintaining excellent records of attendance and punctuality
- Meeting homework/coursework deadlines
- Planning and management of revision periods
- Balancing academic work with extracurricular and voluntary commitments
- Applying for opportunities related to academic studies (e.g. summer schools)
- Examination technique: making sure that you give the right amount of time required for each question on an exam paper and that you complete the whole paper in the time allowed

This skill is a priority during your A-level studies as you will need to be highly **organised** to juggle your commitments and keep on top of deadlines and revision. The correlation between effective time management and excellent academic performance is consistent and compelling; you must master this vital skill at A-level and set the strong foundations for self-organisation that will subsequently be required at university and in the workplace.

17. Public speaking / Presentation skills and debating

Although it can feel a bit daunting at first, the skill of **public speaking** is one that will stand you in good stead for A-level, through your degree (where presentations might be assessed) and almost certainly into the world of work. It is therefore worth practising as much as you can now to develop your confidence for the future.

You will take the stress out of public speaking by **preparing thoroughly** – and doing a bit of rehearsal, whether to friends or in front of a mirror! – so that you are comfortable with what you have to say. Start with something written in full and reduce it, through practising, to a set of headings or key words, or a set of index cards. This will allow you to look up from your notes and will strengthen your communication and engagement with an audience. Think about your **audience** when preparing your presentation and also take into account the **timing** that you have been allocated and the guidance you have been given on **content**.

If you are using **visual aids**, make sure that you do not include too many words on each slide and try to include some images for your audience. Test the equipment before you begin. It is always useful to have a **'just in case' resource** at the ready (e.g. a handout based on the presentation slideshow). At the end of the presentation, be prepared to accept feedback; any constructive criticism you gather now will be useful for the next time you deliver a presentation.

There are many extracurricular opportunities that involve public speaking but **debating** is one of the most useful because it helps to enhance skills that you will be using elsewhere in your A-level studies: research, critical analysis and argument. In British Parliamentary Debating, you will form part of a team either proposing a certain motion or opposing it. A famous example of a debating motion is '*This House would fight for Queen and country*'. Your precise role will depend on the side and part of the team that you have been allocated – are you setting the 'policy' of your team, are you developing the arguments, are you offering a fresh extension to your arguments (such as exploring the debate from a new angle or context) or are you summarising your team's position? In preparing for a debate you will work within your team to prepare, researching the topic for the strongest arguments and thinking critically about flaws in reasoning and evidence, potential counter-arguments and ways of responding to challenges. The skills you will learn in debating can influence your marshalling of evidence and development of arguments in **essay-writing**. You are also learning how to apply two aspects of scholarship that have been valued for centuries: **logic** and **rhetoric**. The former refers to the quality of your argument, whilst the latter concerns the power to persuade; used effectively, these are formidable academic skills.

18. Team-working / Collaboration / Group discussion

This booklet has had much to say about developing intellectual curiosity and academic independence but it also acknowledges the great rewards to be gained from working with peers in a spirit of **shared purpose**, which reflects mutual interests in completing A-level courses successfully and rehearsing for university and work tasks, and interview assessments, in the future. Everybody gains. Team-working is fun, brings a range of skills, qualities and talents together and provides a space for individual strengths to be expressed; as a human activity, it is also challenging, occasionally frustrating and requires genuine collaboration to succeed. A positive team dynamic can take a while to develop – so do not expect instant success – but it is worth working towards. **Team-working** can be individually empowering and collectively satisfying. Effective teams play to the strengths of every participant. If you wish to test your team-working skills outside the classroom, I strongly encourage participation in extracurricular activities such as **Young Enterprise**, **Model United Nations** and the **Duke of Edinburgh Award Scheme**; and urge you to join dedicated **study groups** in each of your subjects.

Teachers like to see A-level students engage in **group discussion** because it reveals confidence, interest and a willingness to test ideas and respond to challenges. We also find that the interplay between students, and the healthy competition that can ensue, creates a memorable learning experience. You should look forward to group discussions not in a gladiatorial spirit of needing to vanquish your opponents but rather in a spirit of shared intellectual enquiry. If you are unsure initially, let others speak first; but listen attentively and then have your say. This is a space within a lesson – or study group – where you can introduce aspects of your further reading, try out arguments that you have been thinking about and safely make mistakes. A strong discussion will bring your learning alive!

19. Critical Thinking and Problem Solving

We have already referred to the importance of critical thinking in developing academic **independence**, in improving **analysis** and in examining, rather than accepting at face value, some of the numerical data with which we are presented. The discipline of critical thinking reaches into all areas of A-level learning and will be an expected part of your approach to learning at university. Two further strands of critical thinking are worth considering in your A-level studies:

- Assessing the validity and **credibility of evidence**
- Assessing the logic, structure and strength of **arguments**

These strands encourage you, once again, to adopt a sceptical, rather than accepting, approach to the information with which you have been presented. The critical thinker is concerned with getting, as far as is possible, to the 'truth' of the matter. When you are presented with a bold claim, think seriously about the reputation and expertise of the source and whether there is any suggestion of bias or a hidden agenda. You can test this on any day of the week by taking a current political dispute and analysing the approaches to it from newspapers across the political spectrum. You will soon see that the issue looks very different when viewed through the differing political lenses of each newspaper, with some offering very sophisticated analysis on one side or the other and others with a much more biased "black and white" appeal to the reader. Where might the 'truth' lie in these accounts? You should also be prepared to subject arguments to critical scrutiny, picking up on flaws in their logic and comparing strong arguments, supported by a wealth of evidence, with weaker arguments that rely more, say, on personal attack, or red herrings, or the slippery slope of conjecture. You can find out more about critical thinking from British university websites: see, for example, these resources from the University of Leeds (http://tinyurl.com/pf6fvra), including a link to a University of Plymouth critical-thinking guide.

A critical approach that adheres to logic will give you an advantage in **problem solving**. You will approach problems in an open-minded way and with the willingness to take account of alternatives. You will proceed cautiously, but reflectively, testing ideas where possible but also drawing conclusions only when justified by the information available. Your application of knowledge will be based on an appreciation of the context, an informed understanding of the task and a logical chain of reasoning in working towards a solution. By developing these skills you will learn to embrace challenges and relish the opportunity to tackle difficult problems.

20. Emotional study skills

There is an increasing recognition by pastoral/tutorial managers in schools and colleges that 'study skills' include emotional management. Some centres acknowledge this by providing lessons on 'Happiness', 'Emotional Maturity' or 'Mindfulness', or by placing an emphasis in the tutorial programme on the health and well-being of students. We appreciate that the teenage years can be a period of considerable turbulence and maintaining a steady course in these circumstances, as academic and social pressures mount, is not an easy task. There is also such an emphasis on continuous success that students will rarely have encountered failure before in any sphere, yet we know instinctively that to master any discipline mistakes will be made along the way and failure should be viewed in this context – as a natural part of the educative process. (A very high achieving independent girls' school, Wimbledon High School, decided to devise a 'failure week' in 2012 to help the students understand how to cope with and move on from setbacks.) This booklet is about building the skills for academic success but it is also realistic about the educational journey, which is rarely smooth for any student.

You can safeguard your own health and well-being by confronting 'worst case scenarios' honestly and directly, by talking them through with your teachers, to develop the resilience to **'bounce-back'** in the event of any setbacks. One way of approaching this issue is to consider your 'mindset' as psychologists such as Professor Carol Dweck (Stanford University, US) have identified that individuals with a **'growth mindset'** – who see effort and challenge as part of the learning journey – are better able to adapt to circumstances, respond to feedback and persevere with determination and hard work, than those who have **'fixed mindsets'** – the belief that natural ability takes away the need for effort and challenge – and seek to explain away any negative feedback rather than work on the areas needing improvement. The growth mindset idea has much to commend it, not least because the learning process allows for personal growth, developing through experiences and learning from mistakes.

I hope that this booklet has given you an insight to the study skills that universities are hoping to see reflected in your applications and that you should aim to be developing during your A-level studies. This is a period in your life when you can shape your academic identity and have the freedom to show your independence, engage in scholarly activity and express your intellectual curiosity. Allow for personal growth and respond positively to feedback and circumstances wherever possible.
As you gain confidence, through practising the skills outlined within this guide, you will be at an advantage in your A-level studies and increasingly ready for the exciting challenges that lie ahead at university.

Andrew Mitchell

Andrew is Assistant Head of Sixth Form at Kingsbury High School, London, and has been teaching A-level courses and their equivalents for twenty years. He leads on A-level Law and the EPQ at the school and contributes to A-level teaching for Business and Government and Politics. He is the school's UCAS, Oxbridge and Russell Group Co-ordinator and Head of Debating and Public Speaking.

Andrew is the author of a textbook on AS Law, now in its third edition with Routledge, and an 'active tutorial guide' for Sixth Form students (Senior Press).

He is also a member of the editorial board of *A-level Law Review* magazine and a frequent contributor.

Andrew wishes to acknowledge the pioneering work of Michael Senior and the Sixth Form management team at Kingsbury High School in promoting study skills for the benefit of A-level students and for introducing new developments, and reflecting best practice, in this field. As Sixth Form and college budgets tighten, and ideas such as 'flipped learning' place more of an onus on students to work out the essentials of topics themselves, this is an ideal time to encourage students to take study skills seriously and develop the independence and scholarly approaches that A-level and degree-level courses require.

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