

# A Level Chemistry

**Hydrogen (H) Callout:**

- Atomic Number: 1
- Symbol: H
- Atomic Mass: 1.008
- Name: Hydrogen

**Group Classifications:**

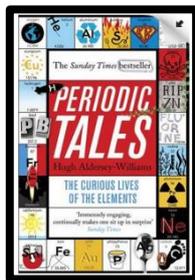
- Alkali Metal (Red)
- Alkaline Earth (Orange)
- Transition Metal (Yellow)
- Basic Metal (Green)
- Semimetal (Light Green)
- Nonmetal (Purple)
- Halogen (Pink)
- Noble Gas (Grey)
- Lanthanide (Light Blue)
- Actinide (Dark Blue)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008																	He Helium 4.002602
2 Li Lithium 6.94	Be Beryllium 9.0121831											B Boron 10.81	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.99840323	Ne Neon 20.1797
3 Na Sodium 22.98976928	Mg Magnesium 24.305											Al Aluminum 26.9815385	Si Silicon 28.085	P Phosphorus 30.973761998	S Sulfur 32.06	Cl Chlorine 35.45	Ar Argon 39.948
4 K Potassium 39.0983	Ca Calcium 40.078	Sc Scandium 44.955908	Ti Titanium 47.867	V Vanadium 50.9415	Cr Chromium 51.9961	Mn Manganese 54.938044	Fe Iron 55.845	Co Cobalt 58.933194	Ni Nickel 58.6934	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.630	As Arsenic 74.921595	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 83.798
5 Rb Rubidium 85.4678	Sr Strontium 87.62	Y Yttrium 88.90584	Zr Zirconium 91.224	Nb Niobium 92.90637	Mo Molybdenum 95.95	Tc Technetium 98	Ru Ruthenium 101.07	Rh Rhodium 102.90550	Pd Palladium 106.42	Ag Silver 107.8682	Cd Cadmium 112.413	In Indium 114.818	Sn Tin 118.710	Sb Antimony 121.760	Te Tellurium 127.60	I Iodine 126.90447	Xe Xenon 131.293
6 Cs Cesium 132.90545196	Ba Barium 137.327	57-71 Lanthanide Series	Hf Hafnium 178.49	Ta Tantalum 180.94788	W Tungsten 183.84	Re Rhenium 186.207	Os Osmium 190.23	Ir Iridium 192.222	Pt Platinum 195.084	Au Gold 196.966569	Hg Mercury 200.592	Tl Thallium 204.38	Pb Lead 207.2	Bi Bismuth 208.98040	Po Polonium 209	At Astatine 210	Rn Radon 222
7 Fr Francium 223	Ra Radium 226	89-103 Actinide Series	Rf Rutherfordium 261	Db Dubnium 268	Sg Seaborgium 269	Bh Bohrium 270	Hs Hassium 277	Mt Meitnerium 276	Ds Darmstadtium 285	Rg Roentgenium 281	Cn Copernicium 285	Uut Ununtrium 286	Fl Flerovium 289	Uup Ununpentium 288	Lv Livermorium 293	Uus Ununseptium 294	Uuo Ununoctium 294
Lanthanide Series			La Lanthanum 138.90547	Ce Cerium 140.116	Pr Praseodymium 140.90766	Nd Neodymium 144.242	Pm Promethium 145	Sm Samarium 150.36	Eu Europium 151.964	Gd Gadolinium 157.25	Tb Terbium 158.92535	Dy Dysprosium 162.500	Ho Holmium 164.93033	Er Erbium 167.259	Tm Thulium 168.93422	Yb Ytterbium 173.054	Lu Lutetium 174.9668
Actinide Series			Ac Actinium 227	Th Thorium 232.0377	Pa Protactinium 231.03588	U Uranium 238.02891	Np Neptunium 237	Pu Plutonium 244	Am Americium 243	Cm Curium 247	Bk Berkelium 247	Cf Californium 251	Es Einsteinium 252	Fm Fermium 257	Md Mendelevium 258	No Nobelium 259	Lr Lawrencium 260

This pack contains a programme of activities and resources to prepare you to start an A level in Chemistry in September. It is aimed to be used after you complete your GCSE, throughout the remainder of the summer term and over the Summer Holidays to ensure you are ready to start your course in September.

## Book Recommendations

**Periodic Tales: The Curious Lives of the Elements** (Paperback) Hugh Aldersey-Williams

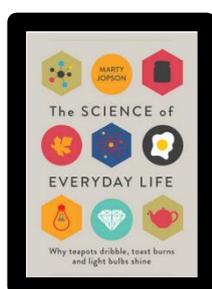


ISBN-10: 0141041455

<http://bit.ly/pixlchembook1>

This book covers the chemical elements, where they come from and how they are used. There are loads of fascinating insights into uses for chemicals you would have never even thought about.

**The Science of Everyday Life: Why Teapots Dribble, Toast Burns and Light Bulbs Shine** (Hardback) Marty Jopson

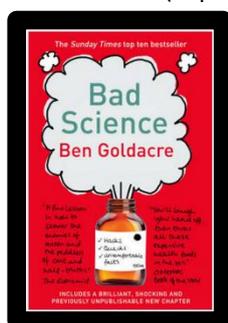


ISBN-10: 1782434186

<http://bit.ly/pixlchembook2>

The title says it all really, lots of interesting stuff about the things around you home!

**Bad Science** (Paperback) Ben Goldacre

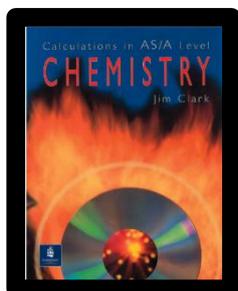


ISBN-10: 000728487X

<http://bit.ly/pixlchembook3>

Here Ben Goldacre takes apart anyone who published bad / misleading or dodgy science – this book will make you think about everything the advertising industry tries to sell you by making it sound 'sciency'.

**Calculations in AS/A Level Chemistry** (Paperback) Jim Clark



ISBN-10: 0582411270

<http://bit.ly/pixlchembook4>

If you struggle with the calculations side of chemistry, this is the book for you. Covers all the possible calculations you are ever likely to come across. Brought to you by the same guy who wrote the excellent chemguide.co.uk website.

## Videos to watch online

### **Rough science – the Open University – 34 episodes available**

Real scientists are 'stranded' on an island and are given scientific problems to solve using only what they can find on the island.

Great fun if you like to see how science is used in solving problems.

There are six series' in total

<https://www.dailymotion.com/playlist/x2igjq#video=xxw6pr>

### **A thread of quicksilver – The Open University**

A brilliant history of the most mysterious of elements – mercury. This program shows you how a single substance led to empires and war, as well as showing you come of the cooler properties of mercury.

<https://www.youtube.com/watch?v=t46lvTxHHTA>

### **10 weird and wonderful chemical reactions**

10 good demonstration reactions, can you work out the chemistry of any of them?

<https://www.youtube.com/watch?v=0Bt6RPP2ANI>

## Chemistry in the Movies

Dantes Peak 1997: Volcano disaster movie. Use the link to look at the Science of acids and how this links to the movie.

<https://www.open.edu/openlearn/science-maths-technology/science/chemistry/dantes-peak>

Fantastic 4 2005 & 2015: Superhero movie. Michio Kaku explains the "real" science behind fantastic four

<http://nerdist.com/michio-kaku-explains-the-real-science-behind-fantastic-four/>

## Research activities

Use your online searching abilities to see if you can find out as much about the topic as you can. Remember, you are a prospective A level chemist, you should aim to push **your** knowledge.

**You can make a 1-page summary for each one you research using Cornell notes:**

<http://coe.jmu.edu/learningtoolbox/cornellnotes.html>

### **Task 1: The chemistry of fireworks**

What are the component parts of fireworks? What chemical compounds cause fireworks to explode? What chemical compounds are responsible for the colour of fireworks?

### **Task 2: Why is copper sulfate blue?**

Copper compounds like many of the transition metal compounds have got vivid and distinctive colours – but why?



### Task 3: Aspirin

What was the history of the discovery of aspirin, how do we manufacture aspirin in a modern chemical process?

### Task 4: The hole in the ozone layer

Why did we get a hole in the ozone layer? What chemicals were responsible for it? Why were we producing so many of these chemicals? What is the chemistry behind the ozone destruction?

### Task 5: ITO and the future of touch screen devices

ITO – indium tin oxide is the main component of touch screen in phones and tablets. The element indium is a rare element and we are rapidly running out of it. Chemists are desperately trying to find a more readily available replacement for it. What advances have chemists made in finding a replacement for it?

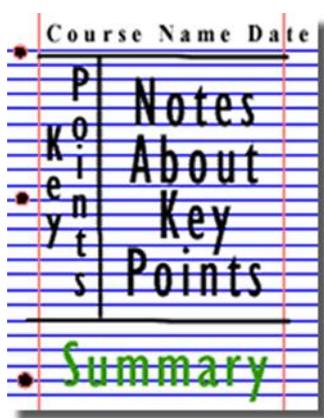


Figure 2: <http://coe.jmu.edu/learningtoolbox/images/noteb4.gif>

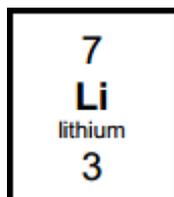
## Pre-Knowledge Topics

### Chemistry topic 1 – Electronic structure, how electrons are arranged around the nucleus

A periodic table can give you the proton / atomic number of an element, this also tells you how many electrons are in the **atom**.

**You will have used the rule of electrons shell filling, where:**

The first shell holds up to 2 electrons, the second up to 8, the third up to 8 and the fourth up to 18 (or you may have been told 8).



Atomic number = 3, electrons = 3, arrangement: 2 in the first shell and 1 in the second.

Another way of writing this is: Li = 2,1

At **A level** you will learn that the electron structure is more complex than this, and can be used to explain a lot of the chemical properties of elements.

The 'shells' can be broken down into 'orbitals', which are given letters: 's' orbitals, 'p' orbitals, 'd' orbitals and 'f' orbitals

You can read about orbitals here:

<http://bit.ly/pixlchem1>

<http://www.chemguide.co.uk/atoms/properties/atomorbs.html#top>



Now that you are familiar with s, p and d orbitals try these problems, write your answer in the format:

$1s^2, 2s^2, 2p^6$  etc.

Q1.1 Write out the electron configuration of:

a) Ca   b) Al   c) S   d) Cl   e) Ar   f) Fe   g) V   h) Ni   i) Cu   j) Zn   k) As

Q1.2 Extension question, can you write out the electron arrangement of the following *ions*:

a)  $K^+$    b)  $O^{2-}$    c)  $Zn^{2+}$    d)  $V^{5+}$    e)  $Co^{2+}$

## Chemistry topic 2 – Oxidation and reduction

At GCSE you know that oxidation is adding oxygen to an atom or molecule and that reduction is removing oxygen, or that oxidation is removing hydrogen and reduction is adding hydrogen. You may have also learned that oxidation is removing electrons and reduction is adding electrons.

At A level we use the idea of **oxidation numbers** a lot!

You know that the metals in group 1 react to form ions that are +1, i.e.  $Na^+$  and that group 7, the halogens, form -1 ions, i.e.  $Br^-$ .

We say that sodium, when it has reacted has an oxidation number of +1 and that bromide has an oxidation number of -1.

All atoms that are involved in a reaction can be given an oxidation number.

An element, Na or  $O_2$  is always given an oxidation state of zero (0), any element that has reacted has an oxidation state of + or -.

As removing electrons is **reduction**, if, in a reaction the element becomes **more** negative it has been reduced, if it becomes more positive it has been oxidised.

You can read about the rules for assigning oxidation numbers here:

<http://www.dummies.com/how-to/content/rules-for-assigning-oxidation-numbers-to-elements.html>

Elements that you expect to have a specific oxidation state actually have different states, so for example you would expect chlorine to be -1, it can have many oxidation states:  $NaClO$ , in this compound it has an oxidation state of +1

There are a few simple rules to remember:

Metals have a + oxidation state when they react.

Oxygen is 'king' it always has an oxidation state of -2

Hydrogen has an oxidation state of +1 (except metal hydrides)

The charges in a molecule must cancel.



Examples: Sodium nitrate,  $\text{NaNO}_3$

Na +1      3x  $\text{O}^{2-}$

+1      -6

To cancel:      N = +5

sulfate ion,  $\text{SO}_4^{2-}$

4x  $\text{O}^{2-}$  and 2- charges 'showing'

-8      -2

S = +6

Q2.1 Work out the oxidation state of the underlined atom in the following:

- a)  $\text{Mg}\underline{\text{C}}\text{O}_3$       b)  $\underline{\text{S}}\text{O}_3$       c)  $\text{Na}\underline{\text{C}}\text{lO}_3$       d)  $\underline{\text{Mn}}\text{O}_2$       e)  $\underline{\text{Fe}}_2\text{O}_3$       f)  $\underline{\text{V}}_2\text{O}_5$   
g)  $\underline{\text{K}}\underline{\text{Mn}}\text{O}_4$       h)  $\underline{\text{Cr}}_2\text{O}_7^{2-}$       i)  $\underline{\text{Cl}}_2\text{O}_4$

### Chemistry topic 3 – Isotopes and mass

You will remember that an isotopes are elements that have differing numbers of neutrons. Hydrogen has 3 isotopes;  $\text{H}_1^1$        $\text{H}_1^2$        $\text{H}_1^3$

Isotopes occur naturally, so in a sample of an element you will have a mixture of these isotopes. We can accurately measure the amount of an isotope using a **mass spectrometer**. You will need to understand what a mass spectrometer is and how it works at A level. You can read about a mass spectrometer here:



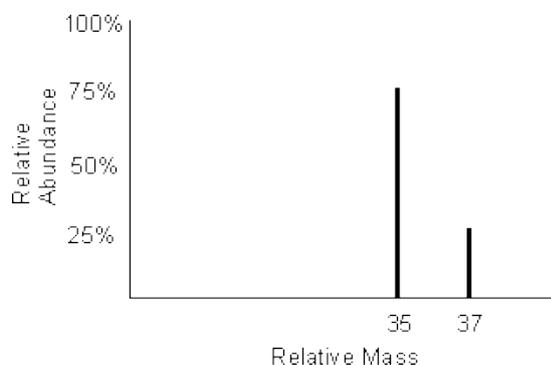
<http://bit.ly/pixlchem3>  
<http://www.kore.co.uk/tutorial.htm>  
<http://bit.ly/pixlchem4>  
<http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-TN-MASS-SPECTROMETRY.PDF>



Q3.1 What must happen to the atoms before they are accelerated in the mass spectrometer?

Q3.2 Explain why the different isotopes travel at different speeds in a mass spectrometer.

A mass spectrum for the element chlorine will give a spectrum like this:



75% of the sample consist of chlorine-35, and 25% of the sample is chlorine-37.

Given a sample of naturally occurring chlorine  $\frac{3}{4}$  of it will be  $\text{Cl-35}$  and  $\frac{1}{4}$  of it is  $\text{Cl-37}$ . We can calculate what the **mean** mass of the sample will be:

$$\text{Mean mass} = \frac{75}{100} \times 35 + \frac{25}{100} \times 37 = 35.5$$

If you look at a periodic table this is why chlorine has an atomic mass of 35.5.

<http://www.avogadro.co.uk/definitions/ar.htm>

An A level periodic table has the masses of elements recorded much more accurately than at GCSE. Most elements have isotopes and these have been recorded using mass spectrometers.

GCSE

11 <b>B</b> boron 5	12 <b>C</b> carbon 6	14 <b>N</b> nitrogen 7	16 <b>O</b> oxygen 8	19 <b>F</b> fluorine 9
27 <b>Al</b> aluminium 13	28 <b>Si</b> silicon 14	31 <b>P</b> phosphorus 15	32 <b>S</b> sulfur 16	35.5 <b>Cl</b> chlorine 17

A level

10.8 <b>B</b> 5 boron	12.0 <b>C</b> 6 carbon	14.0 <b>N</b> 7 nitrogen	16.0 <b>O</b> 8 oxygen	19.0 <b>F</b> 9 fluorine
27.0 <b>Al</b> 13 aluminium	28.1 <b>Si</b> 14 silicon	31.0 <b>P</b> 15 phosphorus	32.1 <b>S</b> 16 sulphur	35.5 <b>Cl</b> 17 chlorine

Given the percentage of each isotope you can calculate the mean mass which is the accurate atomic mass for that element.

Q3.3 Use the percentages of each isotope to calculate the accurate atomic mass of the following elements.

- Antimony has 2 isotopes: Sb-121 57.25% and Sb-123 42.75%
- Gallium has 2 isotopes: Ga-69 60.2% and Ga-71 39.8%
- Silver has 2 isotopes: Ag-107 51.35% and Ag-109 48.65%
- Thallium has 2 isotopes: Tl-203 29.5% and Tl-205 70.5%
- Strontium has 4 isotopes: Sr-84 0.56%, Sr-86 9.86%, Sr-87 7.02% and Sr-88 82.56%

#### Chemistry topic 4 – The shapes of molecules and bonding.

Have you ever wondered why your teacher drew a water molecule like this?

The lines represent a covalent bond, but why draw them at an unusual angle?

If you are unsure about covalent bonding, read about it here:

<http://bit.ly/pixlchem5>

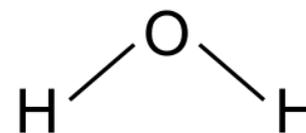
<http://www.chemguide.co.uk/atoms/bonding/covalent.html#top>

At A level you are also expected to know how molecules have certain shapes and why they are the shape they are.

You can read about shapes of molecules here:

<http://bit.ly/pixlchem6>

<http://www.chemguide.co.uk/atoms/bonding/shapes.html#top>



Q4.1 Draw a dot and cross diagram to show the bonding in a molecule of aluminium chloride ( $\text{AlCl}_3$ )

Q4.2 Draw a dot and cross diagram to show the bonding in a molecule of ammonia ( $\text{NH}_3$ )

Q4.3 What is the shape and the bond angles in a molecule of methane ( $\text{CH}_4$ )?

#### Chemistry topic 5 – Chemical equations

Balancing chemical equations is the stepping stone to using equations to calculate masses in chemistry.

There are loads of websites that give ways of balancing equations and lots of exercises in balancing.

Some of the equations to balance may involve strange chemical, don't worry about that, the key idea is to get balancing right.

<http://bit.ly/pixlchem7>

<http://www.chemteam.info/Equations/Balance-Equation.html>



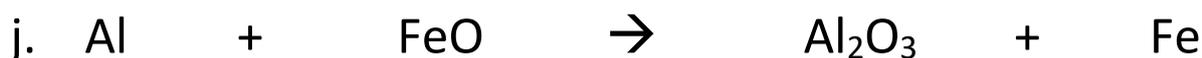
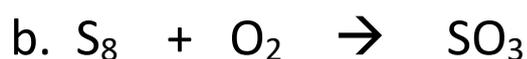
This website has a download; it is safe to do so:



<http://bit.ly/pixlchem8>

<https://phet.colorado.edu/en/simulation/balancing-chemical-equations>

### Q5.1 Balance the following equations



## Chemistry topic 6 – Measuring chemicals – the mole

From this point on you need to be using an A level periodic table, not a GCSE one you can view one here:

<http://bit.ly/pixlpertab>



[https://secondaryscience4all.files.wordpress.com/2014/08/filestore\\_aqa\\_org\\_uk\\_subjects\\_aqa-2420-w-trb-ptds\\_pdf.png](https://secondaryscience4all.files.wordpress.com/2014/08/filestore_aqa_org_uk_subjects_aqa-2420-w-trb-ptds_pdf.png)

Now that we have our chemical equations balanced, we need to be able to use them in order to work out masses of chemicals we need or we can produce.

The **mole** is the chemists equivalent of a dozen, atoms are so small that we cannot count them out individually, we weigh out chemicals.

For example: magnesium + sulfur  $\rightarrow$  magnesium sulfide



We can see that one atom of magnesium will react with one atom of sulfur, if we had to weigh out the atoms we need to know how heavy each atom is.

From the periodic table: Mg = 24.3 and S = 32.1

If I weigh out exactly 24.3g of magnesium this will be 1 mole of magnesium, if we counted how many atoms were present in this mass it would be a huge number ( $6.02 \times 10^{23}$ !!!!), if I weigh out 32.1g of sulfur then I would have 1 mole of sulfur atoms.

So 24.3g of Mg will react precisely with 32.1g of sulfur, and will make 56.4g of magnesium sulfide.

Here is a comprehensive page on measuring moles, there are a number of descriptions, videos and practice problems.

You will find the first 6 tutorials of most use here, and problem sets 1 to 3.

<http://bit.ly/pixlchem9>

<http://www.chemteam.info/Mole/Mole.html>



Q6.1 Answer the following questions on moles.

- How many moles of phosphorus pentoxide ( $\text{P}_4\text{O}_{10}$ ) are in 85.2g?
- How many moles of potassium in 73.56g of potassium chlorate (V) ( $\text{KClO}_3$ )?
- How many moles of water are in 249.6g of hydrated copper sulfate(VI) ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ )? For this one, you need to be aware the dot followed by  $5\text{H}_2\text{O}$  means that the molecule comes with 5 water molecules so these have to be counted in as part of the molecules mass.
- What is the mass of 0.125 moles of tin sulfate ( $\text{SnSO}_4$ )?
- If I have 2.4g of magnesium, how many g of oxygen( $\text{O}_2$ ) will I need to react completely with the magnesium?  $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

## Chemistry topic 7 – Solutions and concentrations

In chemistry a lot of the reactions we carry out involve mixing solutions rather than solids, gases or liquids.

You will have used bottles of acids in science that have labels saying 'Hydrochloric acid 1M', this is a solution of hydrochloric acid where 1 mole of HCl, hydrogen chloride (a gas) has been dissolved in 1dm<sup>3</sup> of water.

The dm<sup>3</sup> is a cubic decimetre, it is actually 1 litre, but from this point on as an A level chemist you will use the dm<sup>3</sup> as your volume measurement.

<http://bit.ly/pixlchem10>

[http://www.docbrown.info/page04/4\\_73calcs11msc.htm](http://www.docbrown.info/page04/4_73calcs11msc.htm)



Q7.1

- What is the concentration (in mol dm<sup>-3</sup>) of 9.53g of magnesium chloride (MgCl<sub>2</sub>) dissolved in 100cm<sup>3</sup> of water?
- What is the concentration (in mol dm<sup>-3</sup>) of 13.248g of lead nitrate (Pb(NO<sub>3</sub>)<sub>2</sub>) dissolved in 2dm<sup>3</sup> of water?
- If I add 100cm<sup>3</sup> of 1.00 mol dm<sup>-3</sup> HCl to 1.9dm<sup>3</sup> of water, what is the molarity of the new solution?
- What mass of silver is present in 100cm<sup>3</sup> of 1mol dm<sup>-3</sup> silver nitrate (AgNO<sub>3</sub>)?
- The Dead Sea, between Jordan and Israel, contains 0.0526 mol dm<sup>-3</sup> of Bromide ions (Br<sup>-</sup>), what mass of bromine is in 1dm<sup>3</sup> of Dead Sea water?

## Places to visit

- Go outdoors!  
Have you actually spent any time observing the geology of the area you live in? What rocks or minerals are found in your area? Does your area have a history of extracting minerals? If so what were they, what were they used for, how did they obtain them? Are there any working or remains of mineral extraction industries?
- Are there any chemical or chemistry based businesses in your area? A big ask, but one that could be really beneficial to you, write them a letter explaining that you are taking A level chemistry and you want to see how chemistry is used in industry and you would like to visit / have some work experience.
- You could also try writing to / searching for your nearest university to see if they are running any summer schools for chemistry – they are usually free and give you the opportunity to experience the laboratories in a university.
- Science museums.  
You could visit your nearest science museum. They often have special exhibitions that may be of interest to you.

[https://en.wikipedia.org/wiki/List\\_of\\_science\\_museums#United\\_Kingdom](https://en.wikipedia.org/wiki/List_of_science_museums#United_Kingdom)

