ST CHRISTOPHER'S SIXTH FORM

CHEMISTRY

BRIDGING UNIT

Chemistry

Introduction

The A-level course studied at St Christopher's will follow the OCR Chemistry A syllabus that can be found online: https://www.ocr.org.uk.

You may wish to download the specification from the OCR website in order to view the specification material in more detail: https://www.ocr.org.uk/qualifications/as-and-a-level/chemistry-a-h032-h432-from-2015/

The AS Chemistry course begins with a recap of the fundamentals about the structure of the atom, the arrangement of electrons, bonding in chemicals and calculations about the amount of substance.

To ensure that you are familiar with these ideas work through the following questions before you start the Lower Sixth. We need you to be confident with basic GCSE chemistry ideas, particularly formulae and balancing equations. Use the periodic table at the back for any calculations.

If you have any questions about the course at all don't hesitate to contact Mr Bailey on s.bailey@st-christophers.org

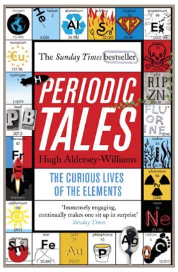
Hand this booklet in to your Chemistry teacher at your first AS Chemistry lesson.

Enjoy your summer and we'll see you in September,

Mr Bailey

Book Recommendations

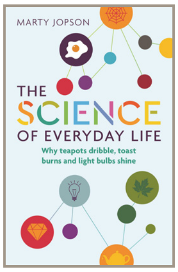
Periodic Tales: The Curious Lives of the Elements (Paperback)



Hugh Aldersey-Williams
ISBN-10: 0141041455
https://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 never even thought about.

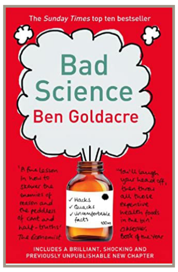
The Science of Everyday Life: Why Teapots Dribble, Toast Burns and Light Bulbs Shine (Hardback)



Marty Jopson
ISBN-10: 1782434186
https://bit.ly/pixlchembook2

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

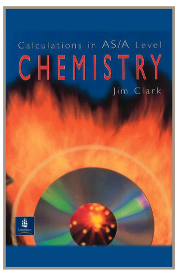
Bad Science (Paperback)



Ben Goldacre
ISBN-10: 000728487X
https://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
https://bit.ly/pixlchembook4

If you struggle with the calculations side of chemistry, this is the book for you. It covers all the possible calculations you are ever likely to come across. Brought to you by the same guy who wrote the excellent https://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://bit.ly/pixlchemvid1a
https://www.dailymotion.com/playlist/x2igjq_Rough-Science_rough-science-full-series/1#video=xxw6pr

or

https://bit.ly/pixlchemvid1b
https://www.youtube.com/watch?v=IUoDWAt2591

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 some of the cooler properties of mercury.

https://bit.ly/pixlchemvid2
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://bit.ly/pixlchemvid3
https://www.youtube.com/watch?v=0Bt6RPP2ANI

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H hydrogen 1.0																	2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89–103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		

57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium 144.9	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.2	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium	92 U uranium 238.1	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

Basic Maths Ideas

It is important that you do not lose marks in your exams because your maths is letting you down. You should be confident in using standard form and be able to give your answers for calculations to an appropriate degree of precision (often 3 sig figs **but not always**). You also need to be comfortable rearranging formula and performing multistep calculations.

Significant Figures

Rules 1

1. The first sig fig is always the first non-zero number, eg. 2304 - 4 sig figs or 0.0023 - 2 sig figs
2. The last significant number is more complicated:
    a. If the number ends in a non-zero number that is always significant, eg. 23854 - 5 sig figs 0r 2.3002 - 5 sig figs
    b. If the number has trailing zeroes (at the end) they are always significant if they are at the end of a decimal, eg. 2.30 - 3 sig figs or 0.0023060 - 5 sig figs
    c. If the trailing zeroes are before the decimal point they may or may not be significant, eg. 23000 - 2 sig figs or 3 0r 4 or 5 sig figs (who knows?!)
3. When writing to a number of sig figs find the significant number you want and then round it based on the next number only, eg. 234.499 to 3 sig figs = 234

Task 1

1. Write the following numbers to the quoted number of sig figs.

345789	4 sig figs	....	1.559	2 sig figs.	....
297300	3 sig figs	....	7.6902	3 sig figs.	....
0.07896	3 sig figs	....	0.00023185	1 sig fig.	....
6	3 sig figs	....	0.766033	4 sig figs.	....
0.001563	3 sig figs	....	0.0090829	3 sig figs.	....
0.01	4 sig figs	....	8.830585	5 sig figs.	....
674	1 sig fig.	....	165650.8	5 sig figs.	....
70.87	2 sig figs.	....	5.1127634	4 sig figs.	....

Rules 2

When using sig figs in calculations your final answer should technically be written with the lowest number of sig figs from the data used, eg 6.42 x 53 x 0.1 = written to 1 sig fig or 456 x 24.5 ÷ 322 = 3 sig figs

It does not matter what simple operation we use (+, -, x, ÷) this is always true

Task 2

2. Check the following sums and correct the answers to an appropriate number of sig figs. If necessary.

a) 35.6 + 56.27 = 91.9 ....

b) 4.337 + 84.7128 = 88.050 ....

c) 6.2 + 4.114 = 10.3 ....

d) 7.331 + 12.42 = 19.75 ....

e) 22.5285 + 22.14 + 4.266 = 48.94 ....

f) 88.489 + 7.133 + 6.5 = 101.2 ....

g) 48.835 - 9.1 = 39.7 ....

h) 16.221 - 8.28 = 7.94 ....

i) 101.12 - 98.7 = 2.4 ....

j) 13.7 + 25.466 = 39.2 ....

k) 45.758 - 33.22 = 12.54 ....

l) 19.6 - 8.77 = 10.8 ....

3. Complete the following sums and write the answers to an appropriate number of sig figs.

a) 32.567 + 135.0 + 1.4567 = ...

b) 246.24 + 238.278 + 98.3 = ...

c) 658.0 + 23.5478 + 1345.29 = ...

d) 456.012 - 79.885 - 56.5 = ...

e) 6125 x 384 = ...

f) 750 ÷ 25 = ...

g) 25.00 x 0.0100 = ...

h) 0.000152 x 13 = ...

i) 13.5 ÷ 0.182 = ...

j) 0.0125 x 0.025 = ...

Standard Form / Scientific Notation

This is a really useful way to handle very large or very small numbers. However, its main benefit is the it is 100% clear how many significant figures a measurement is reported to.

A question for you. How many significant figures is this number quoted to? 386000

It's hard to say isn't it? It is definitely at least 3 but those trailing zeroes are a problem. It could be 4, 5, or 6 and we have no way of knowing. Some people say if there is a decimal point at the end all the figures are significant but that doesn't help us with the question of 4 or 5 sig figs.

Scientific notation helps clear up the confusion every time.

This is because the number has to be written in the form **a x 10^b** where 1 ≤ a > 10.

This means **a** always starts with a single non-zero number and then everything else is after the decimal point and by definition is significant.

The number of significant figures in scientific notation is the number of figures in the pre exponent number (a). The b number merely tells us the scale of the number, not its numerical value.

Tasks

1. Write the following numbers in normal notation.

a) 1.5×10^{-3} ……………………………

b) 4.6×10^{-4} ……………………………

c) 3.575×10^{5} ……………………………

d) 5.34×10^{7} ……………………………

e) 10.3×10^{5} ……………………………

f) 8.35×10^{-3} ……………………………

2. Write the following numbers in standard form.

a) 0.000167 ……………………………

d) 34500 ……………………………

b) 0.0524 ……………………………

e) 0.62 ……………………………

c) 0.000000015 ……………………………

f) 87000000 ……………………………

Quick tip for numbers less than 1 the power is the same number as zeroes at the start of the number.

3. Complete the following calculations and give the answers in scientific notation to an appropriate number of sig figs.

a) $6.125 \times 10^{-3} \times 3.5$ ……………………………

b) $4.2 \times 10^{-4} \div 7.00$ ……………………………

c) $4.00 \times 10^{6} + 35000.0$ ……………………………

d) $4.156 + 2.41 \times 10^{3}$ ……………………………

Chemistry

Rearranging Formulae

To be a successful chemistry student you need to be comfortable with simple algebra and rearranging equations.

Because an equation is an equality (both sides are equal in value) we can apply changes to the equation as long as we do the same thing to both sides. This allows us to rearrange an equation to make some other variable the subject.

Power = Potential difference x current $P = V \times I$

Let's divide both sides of the equation by I $\frac{P}{I} = \frac{V \times I}{I}$

Now the 2 I's on the right cancel out leaving us with $\frac{P}{I} = V$

This is the full explanation of rearranging equations, albeit with a very simple equation. Providing you understand this concept there are a few ways to visualise what is happening to make the rearrangement process quicker.

Idea 1

If you are moving a symbol from one side of the equation to the other the operation it is undergoing is reversed.
eg. moving I - it was multiplied by I on the right so on moving to the left it is divided by I.

Idea 2

Think of both sides of the equation resting on a middle line. When moving from one side to the other the symbol sits in the opposite place relative to the line.

Task

1. Can you rearrange these formulas to make all the other unknown values the subject of the equation?

$n = m / M$ ....

$n = C \times V$ ....

$n = V / 24000$ ....

$n = \frac{p \times V}{R \times T}$ ....

$Rate = k[A]^2[B]$ ....

$Ka = \frac{[H+]^2}{[HA]}$ ....

$Kc = \frac{[A][B]^2}{[C]^3[D]}$ ....

Formulae of Ionic Compounds

All ionic compounds are electrically neutral overall and we can use this fact to work out the formula of the compound providing we know the charges of the ions involved.

The formula can be found by combining appropriate numbers of cations and anions to form an overall neutral result.

The easiest way to do this is by using the lowest common multiple of the 2 charges and scaling up the number of each ion to arrive at the total charge:

eg.	Calcium chloride	Ca^{2+} Cl^{-}	LCM = 2 so total charges must be 2+ and 2- 1 x 2+ and 2 x 1-
		$CaCl_2$	
	Aluminium sulphate	Al^{3+} O^{2-}	LCM = 6 so total charges must be 6+ and 6- 2 x 3+ and 3 x 2-
		Al_2O_3	

Remember if you need to use multiples of a polyatomic/compound ion the whole ion must be placed into brackets: **$Al_2(SO_4)_3$**

Task 1: Names and Formulae of Some Common Ions

You must know all these!

Positive Ions		Negative Ions	
Name	**Formula**	**Name**	**Formula**
Hydrogen		Chloride	
Sodium		Bromide	
*Silver		Fluoride	
Potassium		Iodide	
Lithium		*Hydroxide	
*Ammonium		*Nitrate (V)	
Barium		*Hydrogencarbonate	
Calcium		Oxide	
Magnesium		Sulfide	
Copper (II)		*Sulfate (VI)	
*Zinc		*Carbonate	
Iron (II)		Nitride	
Iron (III)		*Phosphate	
Aluminium			

Most however can be found from the position in the periodic table or from the Roman numeral in the name. **The ones that have to be committed to memory are marked with an ***

Chemistry

Task 2

Write the formula for:

1)	potassium iodide	....	16)	potassium sulphate	....
2)	sodium oxide	....	17)	magnesium sulphate	....
3)	aluminium bromide	....	18)	magnesium hydroxide	....
4)	magnesium chloride	....	19)	copper (II) nitrate	....
5)	silver oxide	....	20)	zinc carbonate	....
6)	iron (II) oxide	....	21)	potassium hydroxide	....
7)	iron (III) oxide	....	22)	sodium carbonate	....
8)	calcium sulphide	....	23)	aluminium hydroxide	....
9)	copper (II) chloride	....	24)	aluminium iodide	....
10)	lithium fluoride	....	25)	ammonium chloride	....
11)	barium chloride	....	26)	ammonium hydroxide	....
12)	lead (II) sulphide	....	27)	iron (III) nitrate	....
13)	zinc iodide	....	28)	zinc chloride	....
14)	aluminium sulphide	....	29)	potassium oxide	....
15)	barium oxide	....	30)	potassium nitrate	....

Balancing Equations

When balancing an equation, you must ensure that there is the same number of atoms of each element on both the left-hand side and right-hand side of the equation.

You probably started balancing equations by constructing a tally chart of all the atoms involved and then working through the elements individually. This is OK but it takes quite some time and can be very difficult for more complicated examples.

eg. $2\ H_2 \quad + \quad O_2 \quad \rightarrow \quad 2\ H_2O$

4	~~2~~	H	~~2~~	4
2	O	1	2	

Remember the formula of the compound cannot be changed; the only way to balance the equations is to place numbers in front of the formulae (coefficients). For ionic equations you must also ensure that the charges of both sides of the equation balance.

The following method works a lot of the time and should speed up the process and actually make the purpose of balanced equations more explicit. All you are trying to do is to find the coefficients in front of all the formulae in an equation (the ratio of each substance to the others).

1. Find a substance on each side that share a unique element that only occurs in those two substances. As there has to be the same of each element you can now put the ratio for these 2 substances into the equation.
2. Then repeat the process for the other substances you don't know the coefficients of yet, using your previous work as fixed numbers

..................C_7H_9 + ...HNO_3 $\rightarrow$ .... $C_7H_6(NO_2)^3$ + ... H_2O

In this case let's take the 2 carbon containing molecules. These have to be in a 1:1 ratio as they both contain 7 carbon atoms.

.........1.........C_7H_9 + ...HNO_3 $\rightarrow$ ....1.......... $C_7H_6(NO_2)^3$ + ... H_2O

Now let's try the Nitrogen containing molecules. These must be in a 3:1 ratio

.........**1**.........C_7H_9 + ...3............HNO_3 $\rightarrow$ ....**1**.......... $C_7H_6(NO_2)^3$ + ... H_2O

The final coefficient does not involve a unique element (H and O occur multiple times) so this final bit needs to be completed using simple book-keeping of either H or O

.........**1**.........C_7H_9 + ...**3**............HNO_3 $\rightarrow$ ....**1**.......... $C_7H_6(NO_2)^3$ + ...3.......... H_2O

Another idea that you probably were not told at GCSE is the fact that because the equations are only showing you ratios of substances then you are allowed to use fractions in your coefficients. In fact, there are some instances where it is necessary to use fractions by definitions.

eg. Formation of ammonia: $\frac{1}{2}\ N_{2(g)} \quad + \quad 1\frac{1}{2}\ H_{2(g)} \quad \rightarrow \quad NH_{3(g)}$

Chemistry

Task 1

Balance these Equations:

1. $Fe_3O_{4(s)}$ + $H_{2(g)}$ → $Fe_{(s)}$ + $H_2O_{(l)}$

   Fe_3O_4 and Fe must be in 1:3 ratio
   Fe_3O_4 and H_2O must be in a 1:4 ratio so if Fe_3O_4 is 1, H_2O must be 4
   H_2 and H_2O are in a 1:1 ratio so if H_2O is 4, H_2 must be 4
   1 $Fe_3O_{4(s)}$ + 4 $H_{2(g)}$ → 3 $Fe_{(s)}$ + 4 $H_2O_{(l)}$

2. $Cr_{(s)}$ + $HCl_{(aq)}$ → $CrCl_{3(aq)}$ + $H_{2(g)}$

3. $C_3H_{8(g)}$ + $O_{2(g)}$ → $CO_{2(g)}$ + $H_2O_{(l)}$

4. $Fe_2O_{3(s)}$ + $C_{(s)}$ → $Fe_{(s)}$ + $CO_{2(g)}$

5. $NH_{3(g)}$ + $O_{2(g)}$ → $NO_{(g)}$ + $H_2O_{(l)}$

6. $Zn_{(s)}$ + $H^+_{(aq)}$ → $Zn^{2+}_{(aq)}$ + $H_{2(g)}$

7. $Cu_{(s)}$ + $Ag^+_{(aq)}$ → $Cu^{2+}_{(aq)}$ + $Ag_{(s)}$

8. $Fe_2O_{3(s)}$ + $CO_{(g)}$ → $Fe_{(s)}$ + $CO_{2(g)}$

9. ZnS + AlP → Zn_3P_2 + Al_2S_3

10. NH_3 + O_2 → NO + H_2O

11. NH_3 + CuO → N_2 + H_2O + Cu

12. $KMnO_4$ + HCl → MnO_2 + KCl + Cl_2 + H_2O

Task 2

Balance the following equations using chemical formulae:

1. $Fe + H_2S04 \rightarrow Fe_2(SO_4)_3 + H_2$

2. $C_2H_6 + O_2 \rightarrow H_2O + CO_2$

3. $KOH + H_3PO_4 \rightarrow K_3PO_4 + H_2O$

4. $KNO_3 + H_2CO_3 \rightarrow K_2CO_3 + HNO_3$

5. $B_2Br_6 + HNO_3 \rightarrow B(NO_3)_3 + HBr$

6. $BF_3 + Li_2SO_3 \rightarrow B_2(SO_3)_3 + LiF$

7. $(NH_4)_3PO_4 + Pb(NO_3)_4 \rightarrow Pb_3(PO_4)_4 + NH_4NO_3$

8. $SeCl_6 + O_2 \rightarrow SeO_2 + Cl_2$

9. $Al + O_2 \rightarrow Al_2O_3$

10. $CO + H_2 \rightarrow C_8H_{18} + H_2O$

11. $H_2SO_4 + Pb(OH)_4 \rightarrow Pb(SO_4)_2 + H_2O$

12. $Ba_3N_2 + H_2O \rightarrow Ba(OH)_2 + NH_3$

13. $TiCl_4 + H_2O \rightarrow TiO_2 + HCl$

14. $CaCl_2 + Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + NaCl$

15. $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$

Chemistry

Atomic Structure

We have several models for the atom that vary in their accuracy and complexity depending on what we are trying to explain with them. At A-level we introduce a more complex model that helps to explain some of the chemical behaviours that we gloss over at GCSE because they are not explained by the GCSE model.

The model we use most often at A-level is still the GCSE one, but we expand our parameters to include ideas to explain some common chemistry not investigated at GCSE.

In atoms the number of protons and electrons are equal to balance charge, neutrons are there to help the nucleus hold together. Each different atom has its own atomic number (no of protons) and mass number (no of protons & neutrons)

In drawing out the electrons it helps to use the points of a compass to place the electrons and then go round the circle filling in once and then go round a second time until all electrons are placed. This helps as it creates pairs of electrons and unpaired electrons in the outer energy level (shell).

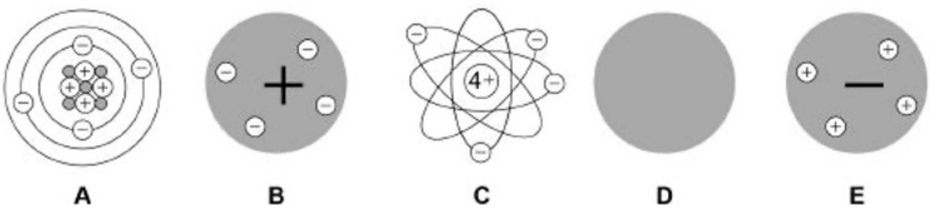
Tasks

1. Complete the following table about sub-atomic particles.

Name of particle	Location	Relative charge	Relative mass
Proton			
Neutron			
Electron			

2. The diagram below represents different models of the atom.

a. Which diagram shows the plum pudding model of the atom? Tick **one** box. **(1)**



A		B		C		D		E	

b. Which diagram shows the model of the atom developed from the alpha particle scattering experiment? Tick **one** box. **(1)**

A		B		C		D		E	

c. Which diagram shows the model of the atom resulting from Bohr's work? Tick **one** box. **(1)**

A		B		C		D		E	

3. How many protons, neutrons and electrons are there in the following atoms and ions?

Symbol	Protons	Neutrons	Electrons
$^{9}_{4}Be$			
$^{39}_{19}K$			
$^{40}_{20}Ca^{2+}$			
$^{19}_{9}F^{-}$			

4. **Work out the symbol and mass number and atomic number for the following atoms and ions:**

a. an atom with 8 protons, 8 neutrons and 8 electrons ....

b. an atom with 18 protons, 22 neutrons and 18 electrons ....

c. an ion with a charge of 1^+ and 11 protons and 12 neutrons ....

d. an ion with a charge of 2^- and 16 protons and 16 neutrons ....

e. Draw a diagram **and** use a shorthand method for the electron structure of the following atoms:

Oxygen	**Fluorine**	**Neon**
....	....	....

Nitrogen	**Potassium**	**Aluminium**
....	....	....

Chemistry
Bonding

At GCSE we come across 3 types of strong chemical bond that are characterised by how the outer electrons behave.

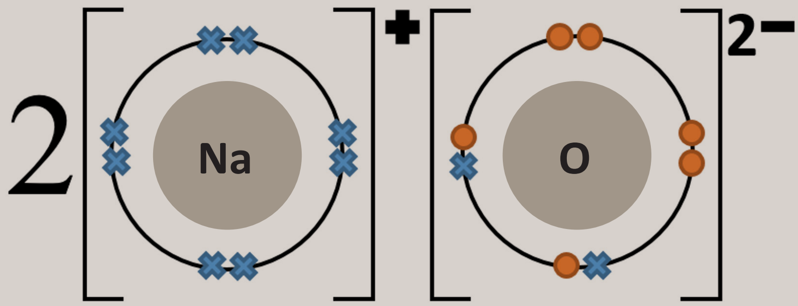
Type of Bonding	Particles involved	Electron behaviour	Type of Structure
Ionic	Metal cations and non-metal anions	Electrons transferred	Giant
Covalent	Non-metal atoms	Electrons shared	Simple or Giant
Metallic	Metal cations and delocalised electrons	Electrons delocalise – free to move.	Giant

At A-level we tighten up our definition of these types of bonding and we move away from the mantra that a full outer shell is always achieved somewhat as there are many exceptions to this rule.

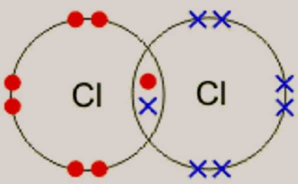
A better, more encompassing focus is to think about getting rid of single electrons by creating pairs as this is closer to how we think electrons actually arrange themselves in atoms. This is the reason for drawing out dot and cross diagrams as stated in the previous page but even this method does not always work and some chemicals exist with unpaired electrons.

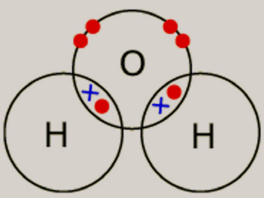
When showing bonding we use dot and cross diagrams where electrons are given unique symbols to show where they have come from.

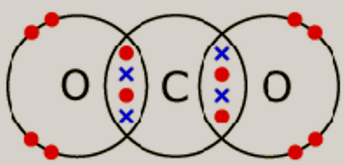
In ionic bonding we are not interested in how the ions are formed but only in how many of each type there are.



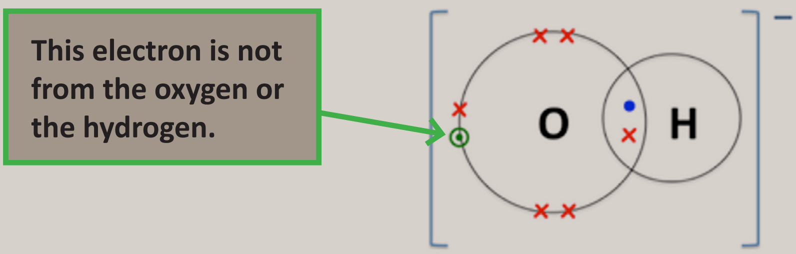
In covalent bonding we create overlaps between the atoms involved and then put at least one unpaired electron from each atom into the overlap.







Occasionally at A-level we may need to use a third symbol to denote electrons from an external source.



Task: Ions

1. **Metal atoms lose all unpaired electrons to create positive ions. Draw the structure of the following ions including the charge:**

Lithium ion **Aluminium ion** **Calcium ion**

2. **Non-metal atoms gain electrons to pair up the single electrons. Draw the dot and cross structure of the following ions including the charge:**

Oxide ion **Chloride ion** **Phosphide ion**

3. **Use dot and cross diagrams to show the bonding in the following compounds:**

Sodium chloride **Magnesium fluoride**

Ammonia NH3 **Nitrogen N2**

Chemistry

Quantitative Chemistry (Amount of Substance)

All chemicals are made up of particles of some sort, be they atoms, molecules, or giant structures. These particles all have differing masses due to their different composition.

As atoms are really tiny, we use a relative scale to talk about their mass. This means we have a reference standard which all other atoms are compared against. Originally this standard was oxygen, but we now use an atom of 12C as the standard and all other atoms are compared to this one.

Carbon-12 is assigned the mass of 12 atomic mass units because it has 12 nucleons (6 protons and 6 neutrons)

Isotopes

These are simple atoms of the same element with a different number of neutrons. The official definition is:

"atoms with the same number of protons but a different number of neutrons."

eg. Carbon exists naturally as carbon-12 (99%), carbon-13 (1%) and carbon-14 (trace). The ^{14}C is the isotope used in carbon dating as it is radioactive and has a half life of about 5700 years.

However, because the mass of isotopes of an element are different, this needs to be taken into account when dealing with normal amounts of substances in the lab. This leads us to the idea of:

Relative Atomic Mass = weighted mean mass of an atom of an element compared to ¹⁄₁₂ the mass of one atom of Carbon-12

By changing the first line of the definition slightly this can be extended to

relative molecular mass (molecules),	-	weighted mean mass of a molecule
relative formula mass (giant structures)	-	weighted mean mass of a formula unit
relative isotopic mass.	-	mass of a atom of an isotope

To calculate RAM (Ar) you need to know the mass & abundance of the isotopes of the element.

$$A_r = \frac{\Sigma(\text{Isotopic mass x abundance})}{\text{Total abundance (usually 100)}}$$

e.g. Chlorine exists as 2 isotopes – 75% ^{35}Cl and 25% ^{37}Cl

$$Ar = \frac{(35 \times 75) + (37 \times 25)}{100} = \frac{3550}{100} = 35.5 \text{ (to 1DP)}$$

*****All relative masses of any kind are always quoted to 1 DP at A-level*****

Task 1

1. Calculate the Ar of a sample of copper:

^{63}Cu	69.2
^{65}Cu	30.8

2. Calculate the Ar of a sample of neon

^{20}Ne	90.6
^{21}Ne	0.2
^{22}Ne	9.2

To calculate a relative molecular or formula mass of a substance we simply use the sum of all the RAMs of each atom in the formula (from the periodic table).

******Remember – 1 DP!******

Task 2

1. Find the relative molecular/formula mass of:

a. Chlorine Cl^2

b. Ethanol C_2H_5OH

c. Tetrachloromethane CCl_4

d. Magnesium chloride MgC_{l2}

e. Iron (III) oxide Fe_2O_3

f. Calcium hydroxide $Ca(OH)_2$

g. Hydrated copper sulfate $CuSO_4.5H_2O$

h. Chrome Alum $KAl(SO_4)_2.12H_2O$

Chemistry
The Mole

Counting individual atoms and molecules is impossible due to their size so chemists have created a way to measure atoms using this idea of relative mass.

A magnesium atom is about twice the mass of a carbon atom so if we have the same number of atoms of both the magnesium would be twice the mass of the carbon. This idea is used to produce the unit of measurement of amount of substance called **the mole**.

There are 3 definitions of the mole (the first 2 are acceptable at A-level):

1. The amount of substance that contains exactly 6.02×10^{23} fundamental units (or particles).
2. The amount of substance that contains the same number of fundamental units (atoms, molecules etc) as there are atoms in exactly 12g of ^{12}C.
3. The amount of substance with a mass in grams equal to the formula mass. This is called the **molar mass** (M) and has units $gmol^{-1}$

The first definition is the official definition and highlights the idea that it is primarily a measure of numbers of particles.

The second definition is how the original number of particles of the mole was determined.

The third definition helps us to fix the idea into some sort of scale we can use in the lab.

Using the third definition of the mole we can construct an equation linking mass to moles.

$$\textbf{moles (mol)} = \frac{\textbf{Mass (g)}}{\textbf{molar mass (gmol}^{-1}\textbf{)}} \qquad n = \frac{m}{M}$$

Tasks

1. How many moles in the following:

a) 90 g of H_2O

....

b) 20 g of C_4H_{10}

....

c) 680 g of NH_3

....

d) 100 g of O_2

....

e) 1 kg of Al_2O_3

....

2. What is the mass of the following:

a) 2 mol methane CH_4

....

b) 1.5 mol sodium chloride NaCl

....

c) 3.16 mol glucose

....

d) 0.025 mol AgCl

....

Gases

As gas particles are so small compared with the space they take up, the effect of the size of the particles is negligible. This means that volume of gas can be used as a measure of the moles providing the temperature and pressure are constant.

At room temp and pressure (RTP) one mole of any gas occupies 24 dm^3 (or 24,000cm^3). This is called the molar gas volume (MGV)

$$\textbf{moles (mol)} = \frac{\textbf{Vol of gas (dm}^3\textbf{)}}{\textbf{MGV (24)}} \qquad \textbf{moles (mol)} = \frac{\textbf{Vol of gas (cm}^3\textbf{)}}{\textbf{MGV (24,000)}}$$

Tasks

a. How many moles of CO_2 are contained in a 0.250 dm^3 sealed flask?

b. What volume does 4.96mol of O_2 occupy at RTP?

c. Assume we have 867cm^3 of N_2 at RTP. What is the mass of the nitrogen gas?

d. How many moles of molecules are contained in 39 dm^3 of F_2 gas at RTP?

Solutions

The amount of chemical dissolved in a fixed volume of solvent is known as its concentration. It is measured in g dm^{-3} or more commonly mol dm^{-3}.

$$\textbf{moles (mol)} = \textbf{Concentration (mol.dm}^{-3}\textbf{) x vol(dm}^{-3}\textbf{)}$$
$$\textbf{n} = \textbf{c x v}$$

Tasks

a. How many moles of $CaCl_2$ will you need to make 250.0 cm^3 of 0.100 mol.dm^{-3} solution?

....

b. 0.02 mol of sugar is dissolved to make 150 cm^3 of solution. Calculate the concentration in mol.dm^{-3}

....

c. What is the volume of a 0.166 moldm^{-3} solution containing 0.0944 mol of solvent?

....

d. What is the concentration of the solution produced when 85.6 g of HCl is dissolved in enough water to prepare 385 cm^3 of solution?

....

Chemistry

Calculating Reacting Quantities

The concept of the mole enables us to calculate the amount of product made or reactant needed for any given reaction. All quantitative calculations follow this basic idea in some form or other.

It is important to state what you are calculating then the equation before substituting in the data and then calculating for each step of the whole calculation.

eg. How many grams of HCl are produced by the reaction of 100.0 g of CH^4?

$$CH_4 + Cl_2 \rightarrow CCl_4 + HCl$$

Step 1 - Deduce a balanced equation and identify the known and unknown

$$\frac{K}{CH_4} + 4Cl_2 \rightarrow CCl_4 + \frac{U}{4HCl}$$

Step 2 - Moles of the Known (K)

Convert your known mass into moles (particles):

$n(CH_4) = m/M = 100.0/16.0 = 6.25$ mol

Step 3 - Moles of the unknown (U)

Use the equation ratio (U/K ratio) to see how many moles of the other chemical are needed/made:

$n(HCl) = \frac{4}{1} \times n(CH_4) = \frac{4}{1} \times 6.25 = 25.0$ mol

Step 4 - Missing quantity of the unknown

Convert this number of moles back to a mass:

Mass HCl = n x M = 25.0 x 36.5 = 913 g (3 sf)

The diagram below shows the pathways for these simple steps along with the conversion factors.

Tasks

1. Precipitation reactions, in which a solid (called a precipitate) is a product, are commonly used to remove certain ions from solution. One such reaction is as follows:

$$\mathbf{Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)}$$

How many grams of Na2SO4 are needed to precipitate all the barium ions produced by 43.9 g of $Ba(NO_3)_2$?

2. Given the following unbalanced chemical equation,

$$\mathbf{H_3PO_4 + NaOH \rightarrow H_2O + Na_3PO_4}$$

What mass of H_2O is produced by the reaction of 230 g of H_3PO_4?

3. Antacids are bases that neutralize acids in the digestive tract. Magnesium hydroxide $Mg(OH)_2$ is one such antacid. It reacts with hydrochloric acid in the stomach according to the following reaction:

$$\mathbf{Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O}$$

How many grams of HCl can a 200 mg dose of $Mg(OH)_2$ neutralize?

....

....

....

4. A simplified version of the processing of iron ore into iron metal is as follows:

$$\mathbf{2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2}$$

How many grams of C are needed to produce 1.00×10^9 g of Fe?

....

....

....

For these next 3 questions you will need to construct a balanced equation first.

5. If it takes 54.0 cm^3 of 0.1 $moldm^{-3}$ NaOH to neutralize 125 cm^3 of an HCl solution, what is the concentration of the HCl?

....

....

....

6. A sample of sodium carbonate (Na_2CO_3) was dissolved in water. The solution required 23.7 cm3 of 0.200 $mol.dm^{-3}$ HCl to fully neutralise. What mass of carbonate was dissolved?

....

....

....

7. What volume of oxygen is required to completely combust 20g of methane (CH_4) ?

....

....

....

"For I know the plans I have for you," declares the Lord,
"plans to prosper you and not to harm you,
plans to give you hope and a future."

Jeremiah 29:11

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