CHEMISTRY

Post-16 Induction
GCSE to A Level Chemistry
- Bridging work -

Name: _____

ALL sections should be completed

Bring this booklet to your first chemistry lesson in September.

INTRODUCTION

Welcome to chemistry.

In choosing to study chemistry you will develop many useful lifelong transferable skills, in addition to developing a deeper understanding of the subject. This booklet is designed to prepare you for your first year of study and hopefully answer some of the questions you may have at this stage.

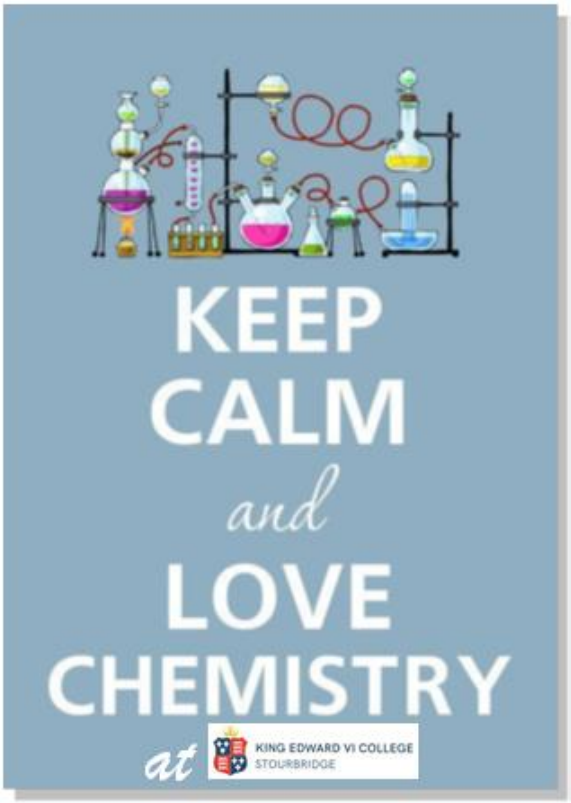
The first section gives some useful information about the subject, the details of your course, and gives you the opportunity to see course overview.

You will typically have two chemistry teachers; (covering organic and inorganic modules), and lessons will take place in the Lycett building (GL0.02 to GL0.05).

The second section (from page 6) is designed to review some of the work you will have covered at GCSE and make links with the new material you will cover in your first year of A-level chemistry.

A lot of the material we cover in year 12 chemistry you will recognise from GCSE, however, we will build on, and extend your knowledge and understanding in each area.

It would be advantageous for you to complete this booklet over the summer (use the answers at the back to self-mark) so that your subject knowledge is fresh when you start in the autumn.



THE COURSE

In Years 12 and 13 you will be studying OCR A-level Chemistry.
Course specification: https://www.ocr.org.uk/qualifications/as-and-a-level/chemistry-a-h032-h432-from-2015/

There are 6 modules that make up the course:

- Module 1 (practical work) is covered over the two years threaded throughout the course. The essential practicals are referred to as PAGs. There are 12 mandatory PAGs over the two years in addition to many other class practicals. Completing these 12 PAGs does not contribute to your overall grade, but it will give you a stand-alone award (the practical endorsement)

- Modules 2-4 are covered in the first year (much of this material you will recognise from GCSE, but it is taught in more depth to give you a greater understanding).

- Module 5 and 6 are taught in the second year of study and much of the content will be new.

ASSESSMENT

There are 3 exams at the end of the two years of study;

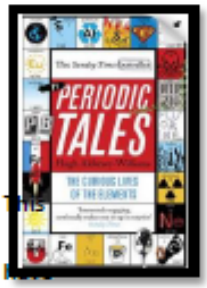
- Paper 1 covers inorganic material found in modules 1,2,3 and 5
- Paper 2 covers organic material found in modules 1,2,4 and 6
- Paper 3 is completely synoptic and covers content on both organic and inorganic chemistry

<table>
<tr><th>Content Overview</th><th colspan="2">Assessment Overview</th></tr>
<tr><td rowspan="4">Content is split into six teaching modules:
• Module 1 – Development of practical skills in chemistry
• Module 2 – Foundations in chemistry
• Module 3 – Periodic table and energy
• Module 4 – Core organic chemistry
• Module 5 – Physical chemistry and transition elements
• Module 6 – Organic chemistry and analysis
Component 01 assesses content from modules 1, 2, 3 and 5.
Component 02 assesses content from modules 1, 2, 4 and 6.
Component 03 assesses content from all modules (1 to 6).</td><td>Periodic table, elements and physical chemistry (01)
100 marks
2 hours 15 minutes written paper</td><td>37%
of total A level</td></tr>
<tr><td>Synthesis and analytical techniques (02)
100 marks
2 hours 15 minutes written paper</td><td>37%
of total A level</td></tr>
<tr><td>Unified chemistry (03)
70 marks
1 hour 30 minutes written paper</td><td>26%
of total A level</td></tr>
<tr><td>Practical Endorsement in chemistry (04)
(non exam assessment)</td><td>Reported separately
(see Section 5)</td></tr>
</table>

For course specific reading material please refer to the chemistry course slides, the material below is for wider reading around the course.

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 never even thought about.

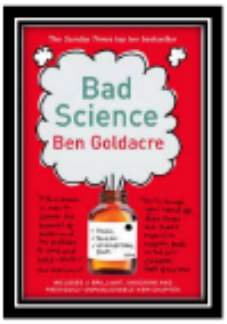
The Science of Everyday Life: Why Teapots Dribble, Toast Burns and Light Bulbs Shine (Hardback) Marty Jopson

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

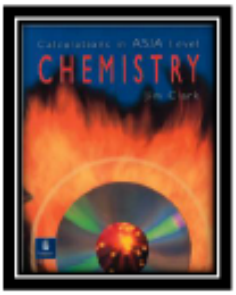


ISBN-10: 000728487X

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.

Salters' Advanced Chemistry: Chemical Storylines

Do not feel you need to buy the latest edition (unless you are doing Salters chemistry!) You can pick up an old edition for a few pounds on ebay, gives you a real insight into how chemistry is used to solve everyday problems from global pollution through feeding to world to making new medicines to treat disease.

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

http://bit.ly/pixlchemvid1a

http://www.dailymotion.com/playlist/x2igjq_Rough-Science_rough-science-full-series/1#video=xxw6pr

or

http://bit.ly/pixlchemvid1b

https://www.youtube.com/watch?v=lUoDWAt259I

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.

http://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?

http://bit.ly/pixlchemvid3

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.
http://www.open.edu/openlearn/science-maths-technology/science/chemistry/dantes-peak

http://www.flickclip.com/flicks/dantespeak1.html

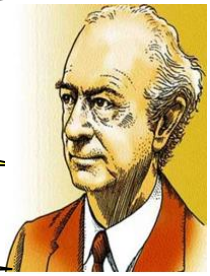
http://www.flickclip.com/flicks/dantespeak5.html

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/

http://www.flickclip.com/flicks/fantastic4.html

Yr11-12 Chemistry Bridging Project - Contents



General Guidance

You will need to know the basics as you soon as you start your chemistry lessons in September so make sure you arrive to your first lesson able to do the following tasks. This will allow you to focus on the skills required to master the more complex chemical concepts – giving you confidence rather than making you feeling like you are behind from the start! So come in to Yr 12 fresh but ready/fully prepared.

The way you study should change in Year 12, both in terms of the amount of independent study you do for each subject and the strategies you use/develop when studying – if it doesn't you are likely to be at risk of underperforming! You MUST keep on top of the workload from the start making regular summaries along the way and not leave revision until the end of year before the exams.

To show a positive attitude to learning in completing the following tasks you MUST....

- ✓ **avoid leaving gaps** - a big difference from GCSE to A Level is how YOU take ownership for your learning. If you find a question difficult or challenging YOU must take action by researching the topic to help overcome any misunderstanding.

- ✓ **be thorough** – avoid cutting corners e.g. you MUST show full working in any calculations, never just give the final answer; write in full sentences so your work is meaningful during times of revision.

- ✓ **be independent** – there is a place for 'peer learning' but this can also limit your progress if you become too reliant on others to explain how to approach a question or regularly complete tasks working together. Make sure you try to overcome any barriers yourself first by being resourceful and carrying our further reading on difficult topics, then use your peers to check if you reached the same answer.

- ✓ **Prepare for lessons** – arrive to lessons ready to submit any work due in and refresh your memory of the work covered in the previous lesson by reading through your notes and possibly re-attempting one or two questions/tasks.

The Periodic Table of the Elements

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1																	18
1 **H** hydrogen 1.0	2											13	14	15	16	17	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	3	4	5	6	7	8	9	10	11	12	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		

Key
atomic number
Symbol
name
relative atomic mass

• 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

Task 0 – common ions

There are many ions and polyatomic ions that are useful to know (names, formulae and charges) to help construct salts.
You however you only need to know 7 of them (many others you can work out using the periodic table).

Learn the names, formulae and charge of these 7 common ions. Make a revision aid like flash cards to help learn them (an "ate memoir")

Name of ion	Formula
Carbonate	CO_3^{2-}
Sulfate	SO_4^{2-}
Nitrate	NO_3^-
Hydroxide	OH^-
Zinc (II)	Zn^{2+}
Ammonium	NH_4^+
Silver (I)	Ag^+

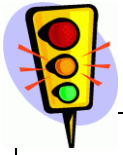
Complete the table below to show the formula of the salt when oppositely charged ions join together. The total charge must be zero and brackets are needed for 2 or more polyatomic ions e.g. $Al(NO_3)_3$ is correct because 3 nitrate ions are needed to cancel out the 3+ of the Al^{3+}.

Ion	Na^+	Ca^{2+}	Al^{3+}	Cl^-	O^{2-}	N^{3-}
CO_3^{2-}						
SO_4^{2-}						
NO_3^-						
OH^-						
Zn^{2+}						
NH_4^+						
Ag^+						

Write the formulae of ions and salts given the name…

Name	Salt	Cation	Anion
Lithium sulfate		Li^+	
Magnessium hydroxide			
Aluminium nitrate	$Al(NO_3)_3$		
Potassium Sulfide			
Zinc (II) bromide			Br^-
Ammonium Iodide			
Silver (I) Nitride			

Task 1 – Atoms, Ions & Isotopes



In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'
– note: p+ = protons; e- = electrons; n = neutrons

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Before**	**After**	
1. Describe protons, neutrons and electrons in terms of relative charge and relative mass.			
2. Describe the distribution of mass and charge within an atom.			
3. Describe the contribution of p+ & n to the nucleus of an atom, in terms of atomic (proton) number & mass (nucleon) number.			
4. Deduce the numbers of protons, neutrons and electrons in an atom given its atomic and mass number			
5. Deduce the numbers of protons, neutrons and electrons in an ion given its atomic number, mass number and ionic charge.			
6. Explain the term *isotopes* as atoms of an element with different numbers of neutrons and different masses.			
7. State that ^{12}C is used as the standard measurement of relative masses.			
8. Define the terms *relative isotopic mass* and *relative atomic mass*, based on the ^{12}C scale.			
9. Calculate the relative atomic mass of an element given the relative abundances of its isotopes.			
10. Use the terms *relative molecular mass* and *relative formula mass* and calculate values from relative atomic masses.			

Complete the following tasks – remember you must avoid leaving gaps! If you find a question or task challenging you MUST be proactive and research the answer...

1. Complete the table to show the location, relative charge and relative mass of each sub-atomic particle found within an atom (LO1, see table above).

Sub-atomic particle	Location	Relative charge	Relative mass
Neutron			
Electron			
Proton			

2. Use the table to describe the distribution of mass and charge within an atom (LO2)...

_____

_____

3. Give precise definitions for the following keyterms (LO3)....

Atomic (proton) number: _____

Mass (nucleon) number: _____

4. Complete the missing data in the table below - use the 2 definitions above, and your understanding of atomic structure (LO4)...

Atom	Atomic No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
$_{14}N$					
$_{39}K$					
	5	11			
			18		22
		40			20
				55	78

5. Complete the missing data in the table below - use the example given, and your understanding of atomic structure and how atoms become ions (LO5)...

Atom	Metal or non-metal atom	Atomic No.	Electron Configuration	Gains /loses e-	No. of e- gained/loss	Ion formula produced	Electronic configuration
Li	Metal	3	2,1	loses	1e-	Li^+	$[2]^+$
Na							
Mg							
Al							
F							
O							
S							

Atom	Atomic No.	Mass No.	Ion Formula	No. of p+	No. of e-	Electronic config.	No. of n
$_{40}Ca$							
$_{37}Cl$							

6. Use dot & cross diagrams to model the ionic bonding in a) magnesium oxide and b) aluminium oxide:
Tip – only show the ions formed (not the atoms they come from) and if more than one ion is needed show how many e.g. if 2 oxygen ions are needed, show in this format: 2 x [ ]$^{2/-}$

a) magnesium oxide:

b) aluminium oxide:

7. Give a precise definition of the keyterm 'isotope' (LO6).
Tip: within your definition include the words: proton, electron, neutron, atomic number, mass number

Isotope: _____

8. Complete the missing data on isotopes of in the table below - use your definition above, and your understanding of atomic structure and isotopes (LO6)...

Example	Atom	No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
1		6	12			
2	C					7
3				6	6	8
4					7	8

Qu: Which is NOT an isotope of carbon? Justify your choice

_____

_____

_____

Qu: Explain, if any, the difference in reactivity between the 3 carbon isotopes? Tip: ask yourself 'do they all react with oxygen to produce carbon dioxide or only some?'. Give a reason for your answer.

_____

_____

Qu: Name one physical property that may differ between the isotopes of the same element? Justify

_____

_____

How would you go about weighing something that you cannot see? This is the situation with atoms. Instead of finding the mass of atoms directly we compare the masses of different atoms, using the idea of relative mass.

Qu: What isotope has been used, since 1961, as the international standard for the measurement of relative mass? (LO7) _____

9. Give precise definitions for the following keyterms (LO8)….

Relative isotopic mass:

_____

_____

All the atoms of a single isotope are identical so the relative isotopic mass is the same as the mass number.

Qu: Therefore what is the relative isotopic mass of a) oxygen-16? b) Sodium-23?

Most elements contain a mixture of isotopes, each in a different amount and with a different mass so we have to take into account the contribution made by each isotope to the overall mass of a element which we call the 'relative atomic mass'

Relative atomic mass (A_r):

_____

_____

_____

You will now learn how to calculate the relative atomic mass based on the element's isotopes.

The relative atomic mass for an atom of a particular element can be found on the periodic table. However these are often not whole numbers (see Chemistry periodic table provided in this booklet, do NOT use your planner) as they have to take into account that each element is often a mixture of isotopes. Here's how the relative atomic masses on the periodic table have been derived…

Worked example
Q: A sample of bromine contains 53.00% of ^{79}Br and 47.00% of ^{81}Br. Determine the relative atomic mass of bromine
A: $A_r = ((53.00/100)x79.00) + ((47.00/100)x81.00) = 79.94$

10. Use the worked example above to calculate the relative atomic mass of the following elements (LO9)….

Remember for each isotope you have to take into account it mass and its relative abundance, e.g. %

a) Boron contains: 19.77% ^{10}B & 80.23% ^{11}B

Ar: _____

b) Silicon contains: 92.18% ^{28}Si, 4.70% ^{29}Si & 3.12% ^{30}Si

Ar: _____

c) Unknown X contains: 4.31% ^{50}X, 83.76% ^{52}X, 9.55% ^{53}X & 2.38% ^{54}X

Ar: _____

Use the periodic table to work out the identity of this unknown element:

11. To appreciate the mass of a molecule we have to take into account the mass of each atom it contains and the number of each type of atom. We can do this by calculating its 'relative formula mass', M_r

Give precise definitions for the following keyterms (LO10)....

Relative formula mass (M_r): the weighted mean mass of a

_____

_____

_____

To be more precise the term 'relative molecular mass' is used for molecules e.g. covalently bonded elements or compounds and the term 'relative formula mass' used for ionic compounds as they have giant lattice structures (not simple molecules)so its molecular formula is actually the empirical formula BUT effectively you are calculating the same thing!

Calculate the Mr of each compound listed below, showing full working (LO10):

a) $CaCO_3$

Mr =_____

b) $Cu(OH)_2$

Mr =_____

c) $(NH_4)_2SO_4$

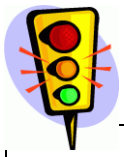
Mr =_____

d) $Ca(NO_3)_2 \cdot 4H_2O$

Mr =_____

Tip – in (d) work out the mass of each part either side of the dot & then add together

Task 2 – The Changing Atom...



In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'
– *note: p+ = protons; e- = electrons; n = neutrons*

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. Describe how the model of the atom has changed over the years.			
2. Understand that scientific knowledge is always evolving.			
3. Describe how new theories are accepted by scientists.			

You must complete the research task, detailed below, and clearly present your findings. How you choose to present your work is up to you – a written report; series of cue cards; create a podcast or video; PowerPoint presentation; poster or factsheet.

OBJECTIVE 1: How the idea of the atom has changed from the Greeks to the present day.

Within this task you MUST meet the following criteria:

1. Key philosophers/scientists: Democritus, **Dalton**, **Thomson**, **Rutherford**, **Bohr**, Moseley, de Broglie, Schrodinger & Chadwick. Those shown in **bold MUST be included in your findings** but you may also like to research some or all of the others.
2. Describe each proposed model of the atom, using labelled diagrams where appropriate.
3. Highlight the limitations of each model
4. Full bibliography: list of ***reliable*** reference materials used to compile your research.

OBJECTIVE 2: Provide a brief history of the periodic table.

Within this task you MUST meet the following criteria:

1. An annotated copy of the modern day periodic table - clearly label or list as a key the information which we can obtain from it *e.g. group names; how it is arranged; how certain elements are grouped together; any patterns shown within the periodic table etc.*
2. A timeline of philosophers/scientists that helped to develop the periodic table to how the know it today e.g. Döbereiner; Newland; Mendeleev.

Task 3: Representing Chemical Reactions using Equations

Balancing equations becomes a little more challenging at A level only because you are expected to independently derive a balanced chemical equation using given named reactants, sometimes for reactions that will be unfamiliar to you (not studied in class).

However this becomes a lot easier if you LEARN your general equations!

In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. I can balance equations when correct molecular formula is provided			
2. I can give the correct molecular formula based on ion charges.			
3. I can convert word equations to balanced chemical equations.			
4. I can give the correct balanced equation by applying a general eq.			
5. I can predict the correct equation to represent an unfamiliar reaction.			

1. Practise the concept of balancing equations using the chemical equations below (LO1):

Unbalanced equations: a) $C + O_2 \rightarrow CO$ b) $Na + O_2 \rightarrow Na_2O$

$Fe_2O_3 + CO \rightarrow Fe + CO_2$ d) $NH_3 + O_2 \rightarrow NO + H_2O$ (a toughy

2. Use the common ion bank (for ionic compounds only) provided and your understanding of GCSE, practise deducing (working out) the correct molecular formula for these named (LO2):

Ionic Compounds		Covalent elements or compounds	
Copper sulphate:		Iodine:	
Ammonium nitrate:		Carbon monoxide:	
Aluminium sulphate:		Methane:	
Ammonium carbonate:		Hexane:	
Calcium phosphate:		Ammonia:	

Help: Ion Formulae Bank *(Tip – if any are missing any, Google search or Wikipedia the ion charge)*

Cations (positive ions)	
Group 1 e.g. Li^+	1+
Group 2 e.g. Mg^{2+}	2+
Copper	Cu^{2+}
Lead	Pb^{2+}
Ammonium	NH_4^+

Anions (negative ions)			
Group 7 e.g. F^-	1-	Hydroxide	OH^-
Group 6 e.g. O^{2-}	2-	Phosphate	PO_4^{3-}
Nitrate	NO_3^-	Ethanoate	CH_3COO^-
Carbonate	CO_3^{2-}		
Sulphate	SO_4^{2-}		

3. Convert these word equations into balanced chemical equations:

a) Magnesium + hydrochloric acid → magnesium chloride + hydrogen

_____

b) Calcium hydroxide + sulphuric acid → calcium sulphate + water

_____

4. Select the correct general equation from the box below to complete the balanced chemical equations.

Tip – you may wish to construct word equation first and then convert it into a balanced equation

1. Metal + water → metal hydroxide + hydrogen
2. Metal + Acid → Salt + Hydrogen
3. Metal carbonate + acid → salt + carbon dioxide + water
4. Neutralisation: Metal oxide/hydroxide + acid → salt + water
5. Thermal decomposition: metal carbonate → metal oxide + carbon dioxide
6. Thermal decomposition: metal hydrogen carbonate → metal carbonate + water + carbon dioxide

a) Potassium is a group 1 metal that reacts vigorously with water.

_____

b) Thermal decomposition of baking powder (sodium hydrogen carbonate).

_____

c) The reaction that takes place when acid rain (sulphuric acid) corrodes buildings made of limestone.

_____

5. Predict the correct word and balanced chemical equation to represent these possibly unfamiliar reactions.

Tip - You may find the ion bank table on the previous page and the general equations above helpful.

d) The action of vinegar (ethanoic acid) on copper cans.

_____

_____

e) The action of the acid in coke (phosphoric acid) on an aluminium can

_____

_____

Task 4: Chemical Mathematics

In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. Explain the term *empirical formula.*			
2. Explain the term *molecular formula*.			
3. Calculate empirical formulae using composition by mass or %			
4. Calculate molecular formulae using composition by mass or %			

1. Give precise definitions for the following keyterms (LO1&2)....

Molecular formula: _____

Empirical formula: _____

Use your understanding from GCSE & the table below to help practise calculating the empirical formula.

1. List all of the elements in the compound
2. Underneath, write the mass or % given in the question
3. Calculate moles - ÷ each mass or % from step 2 by the Ar for each element

   If the numbers are not ALL whole numbers....
4. Identify the element in the smallest amount and divide each answer to step 3 by this.
5. Use this whole number ratio to give the simplest ratio of atoms of each element in the formula

2. A hydrocarbon has 80% carbon and 20 %hydrogen. Calculate its empirical formula.

Ratio of atoms: Empirical Formula:

3. 2.70g of aluminium is combined with 10.65g of chlorine. What is the empirical formula of this product?

Ratio of atoms: Empirical Formula:

Task 4: Chemical Mathematics

The **mole** is a **unit** for an **amount of substance** (and is given the symbol **'n'**) – it is a standard number of particles.

This count of atoms is called the **Avogadro constant (N_A)** & is equal to **6.02×10^{23} mol^{-1}**

IMPORTANT DEFINITIONS

The **Avogadro constant** (N_A) is the number of atoms per mole of the carbon-12 isotope (6.02×10^{23} mol^{-1}).

A **mole** is the amount of any substance containing as many particles as there are carbon atoms in exactly 12g of the carbon-12 isotope.

Basically if the amount of substance you want is 1 mole you would need to count out 6.02×10^{23} mol^{-1} atoms/molecules of that substance.

However, because atoms weigh different amounts (depending on the element) one mole of substance will have a different mass. For example:

1 mole of carbon-12 would contain 6.02×10^{23} carbon -12 atoms and weigh 12g

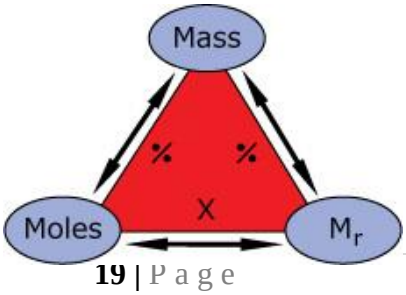
...but...

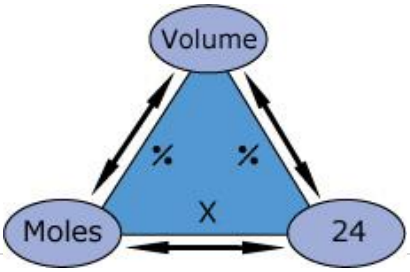
1 mole of sodium-23 would also contain 6.02×10^{23} carbon -12 atoms but weigh 23g

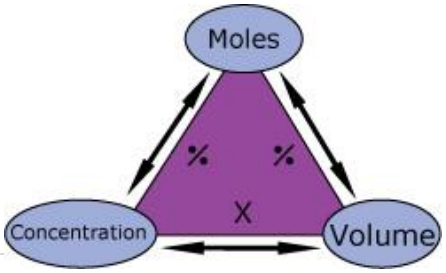
The **mass of one mole** is easy to work out as it is the **relative formula mass in grams** for that substance. This is referred to as **molar mass, Mr**, and has **the units $gmol^{-1}$**.

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. Explain the term '*amount of substance*'.			
2. Explain the term *mole* as the unit for amount of substance.			
3. Explain the term *Avogadro constant*, N_A, (6.02×10^{23} mol^{-1}).			
4. Define the term *molar mass* (units g mol^{-1})			
5. Use the term *molar mass* (units g mol^{-1})			
6. Carry out mole-based calculations involving mass			
7. Carry out mole-based calculations involving gas volume			
8. Carry out mole calculations involving solution vol. & concentration			
9. Deduce stoichiometric relationships (molar ratio) from calculations.			

Mole formulae – you will need to learn these equations as they are not provided in the exam

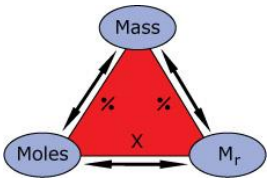






4. Use the formula triangle given to deduce the formula required to calculate mass (LO5&6):

Mass =



5. Use this formula to calculate the mass of each of the following (LO5&6)...

(a) 2.50 mol of hydrogen, H_2

Mass of H_2: _____g

(b) 0.500 mol of sodium chloride, NaCl.

Mass of NaCl: _____g

6. Again, use the formula triangle given to deduce the formula required to calculate the amount of substance (LO5&6):

Moles(n) =

7. Use this formula to calculate the amount (in mol) of each substance listed below....

a) 31.0 g of phosphorus molecules, P_4

Amount of P_4:_____mol

b) 50.0 g of calcium carbonate, $CaCO_3$.

Amount of $CaCO_3$:_____mol

8. Again, use the formula triangle given to deduce the formula required to calculate molar mass of an unknown substance

Molar mass (M_r) =

9. Use this formula to calculate the molar mass of an 11g gas sample of compound X, which is 0.25mol.

Molar mass: _____$gmol^{-1}$

Possible identity of the gas sample X:_____

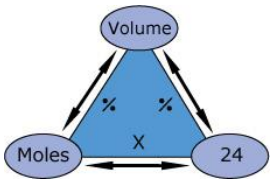
10. Use the formula triangle given to deduce the formula for calculating the amount of gas in mols …

When volume is in dm^3…

Moles (n) =

When volume is in cm^3…

Moles (n) =



11. Use this formula to calculate the amount of gas (in mol) of….

(a) 3600cm^3 of hydrogen gas, H_2

Amount of H_2 gas: _____mol

(b) 4.0 dm^3 of hydrogen gas, CO_2

Amount of CO_2 gas:_____mol

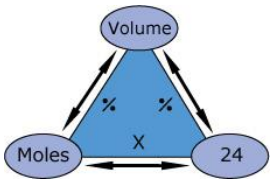
12. Use the formula triangle given to deduce the formula for calculating the volume of gas…

When volume is in dm^3…

Volume (V) =

When volume is in cm^3…

Volume (V) =



13. Use this formula to calculate the volume of gas….

(a) 6.00 mol of hydrogen gas, SO_2

Volume of SO_2 gas:_____dm^3

(b) 0.25mol of oxygen gas, O_2

Volume of CO_2 gas:_____ cm^3

14. Complete the following tasks which is more representative of a *simple A chemistry question*

Tip – you will need to use both mole formulas introduced so far (on pages 12-13)

(a) What is the mass of 84cm^3 of N_2O?

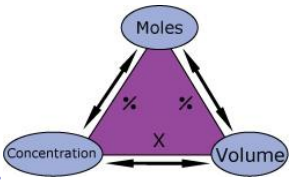
Mass of N_2O gas:_____g

(b) What is the volume of 1.26g of propene, C_3H_6

Volume of C_3H_6 gas:_____dm^3

15. Use the formula triangle given to deduce the formula for calculating the amount of moles in solution ...

When volume is in dm^3...	When volume is in cm^3...
Moles (n) =	Moles (n) =



16. Use this formula to calculate the amount of substance (in mol) for the following solutions....

(a) $4dm^3$ of a 2 $moldm^{-3}$ solution

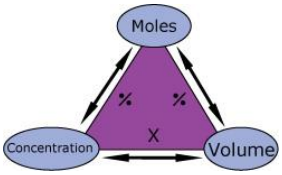
Amount of solution: _____ mol

(b) $25.0dm^3$ of a 0.15 $moldm^{-3}$ solution

Amount of solution: ____ mol

17. Use the formula triangle given to deduce the formula for calculating the volume of solution needed...

When volume is in dm^3...	When volume is in cm^3...
Volume (V) =	Volume (V) =



18. Use this formula to calculate the volume produced in the following solutions....

(a) a solution with a concentration of 2 $moldm^{-3}$ that contains 2 moles of solute.

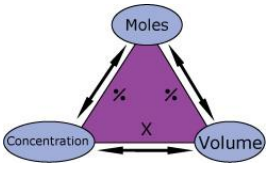
Volume of solution: ___ dm^3

(b) a solution with a concentration of 0.25 $moldm^{-3}$ that contains 0.005 moles of solute.

Volume of solution: __ dm^3

19. Use the formula triangle given to deduce the formula for calculating the concentration of the solution...

When volume is in dm^3...	When volume is in cm^3...
Concentration (c) =	Concentration (c) =



20. Use this formula to calculate the concentration (in $moldm^{-3}$) for the following solutions....

(a) 0.5 moles of solid dissolved in $250cm^3$ of solution

Concentration: _____$moldm^{-3}$

(b) 0.00875 moles of solid dissolved in $25cm^3$ solution

Concentration: _____$moldm^{-3}$

Task 4: Chemical Mathematics (LO9)

Complete the following tasks, which is more representative of a *simple A chemistry question…*

Tip – you will need to use more than one of the mole formulas introduced & use the balanced equation to find the molar ratio

21. Find the mass concentration, in gdm^{-3}, for the following solutions:

(a)0.0042 moles of HNO_3 dissolved in $250cm^{-3}$ of solution

Mass concentration:_____ gdm^{-3}

(b)0.50 moles of HCl dissolved in 4.0 dm^3 of solution

Mass concentration: _____ gdm^{-3}

22. The following reaction can take place, shown in this equation: $NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$

(a)Balance the equation shown above

(b)What volume of CO_2 is formed by the decomposition of 5.04g of $NaHCO_3$?

Volume of CO_2: _____dm^3

23. The following reaction can take place, shown in this equation:

$$MgCO_{3(s)} + HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

(a)Balance the equation shown above

(b)2.529g of $MgCO_3$ reacts with an excess of HNO_3. What volume of CO_2 is formed?

Volume of CO_2: _____dm^3

(c) The final volume of the solution is $50.0cm^3$. What is the concentration of $Mg(NO_3)_{2(aq)}$ formed?

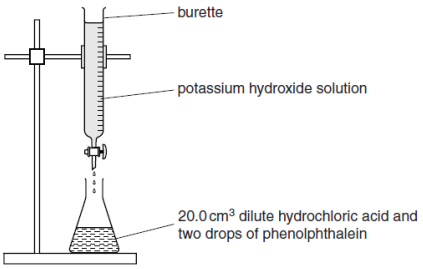
Concentration: _____ $moldm^{-3}$

Task 4: GCSE Past Exam Questions related to moles

Look at the equation for the reaction between potassium hydroxide and hydrochloric acid.

$$KOH + HCl \longrightarrow KCl + H_2O$$

Look at the apparatus she uses.



Calculate the **concentration** of potassium hydroxide in mol/dm^3.

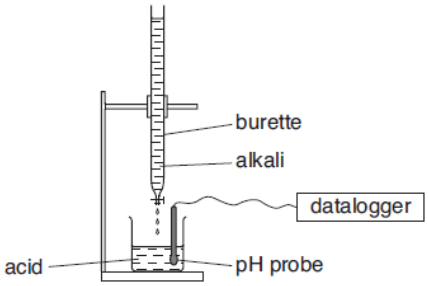
These steps may help.

Work out the:

- number of moles in 20.0 cm^3 of 0.200 mol/dm^3 hydrochloric acid
- number of moles of potassium hydroxide neutralised
- average titre, in cm^3, using titration numbers **2**, **3** and **4**.

titration number	1	2	3	4
final burette reading in cm^3	26.9	27.6	27.0	28.2
initial burette reading in cm^3	0.5	2.5	2.0	3.3
titre (volume of alkali used) in cm^3	26.4	25.1	25.0	24.9

Concentration of KOH: _____moldm^{-3}



Tina does another experiment.

This time she uses

- 25.0 cm^3 of dilute hydrochloric acid in the beaker
- sodium hydroxide solution of concentration 0.100 mol/dm^3 in the burette.

The hydrochloric acid is exactly neutralised by 20.0 cm^3 of this sodium hydroxide solution.

Look at the balanced symbol equation for the reaction.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Calculate

- the number of moles of sodium hydroxide in 20.0 cm^3 of a 0.100 mol/dm^3 solution
- the number of moles of hydrochloric acid that reacted with this amount of sodium hydroxide
- the concentration, in mol/dm^3, of the hydrochloric acid.

Concentration of HCl: _____ $moldm^{-3}$

Answers

Task 0 – common ions

There are many ions and polyatomic ions that are useful to know (names, formulae and charges) to help construct salts.
You however you only need to know 7 of them (many others you can work out using the periodic table).

Learn the names, formulae and charge of these 7 common ions. Make a revision aid like flash cards to help learn them (an "ate memoir")

Name of ion	Formula
Carbonate	CO_3^{2-}
Sulfate	SO_4^{2-}
Nitrate	NO_3^-
Hydroxide	OH^-
Zinc (II)	Zn^{2+}
Ammonium	NH_4^+
Silver (I)	Ag^+

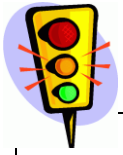
Complete the table below to show the formula of the salt when oppositely charged ions join together. The total charge must be zero and brackets are needed for 2 or more polyatomic ions e.g. $Al(NO_3)_3$ is correct because 3 nitrate ions are needed to cancel out the 3+ of the Al^{3+}.

Ion	Na^+	Ca^{2+}	Al^{3+}	Cl^-	O^{2-}	N^{3-}
CO_3^{2-}	Na_2CO_3	$CaCO_3$	$Al_2(CO_3)_3$			
SO_4^{2-}	Na_2SO_4	$CaSO_4$	$Al_2(SO_4)_3$			
NO_3^-	$NaNO_3$	$Ca(NO_3)_2$	$Al(NO_3)_3$			
OH^-	$NaOH$	$Ca(OH)_2$	$Al(OH)_3$			
Zn^{2+}				$ZnCl_2$	ZnO	Zn_3N_2
NH_4^+				NH_4Cl	$(NH_4)_2O$	$(NH_4)_3N_2$
Ag^+				$ZnCl_2$	ZnO	Zn_3N_2

Write the formulae of ions and salts given the name...

Name	Salt	Cation	Anion
Lithium sulfate	Li_2SO_4	Li^+	SO_4^{2-}
Magnessium hydroxide	$Mg(OH)_2$	Mg^{2+}	OH^-
Aluminium nitrate	$Al(NO_3)_3$	Al^{3+}	NO_3^-
Potassium Sulfide	K_2S	K^+	S^{2-}
Zinc (II) bromide	$ZnBr_2$	Zn^{2+}	Br^-
Ammonium Iodide	NH_4I	NH_4^+	I^-
Silver (I) Nitride	Ag_3N	Ag^+	N^{3-}

Task 1 – Atoms, Ions & Isotopes



In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'
– note: p+ = protons; e- = electrons; n = neutrons

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Before**	**After**	
1. Describe protons, neutrons and electrons in terms of relative charge and relative mass.			
2. Describe the distribution of mass and charge within an atom.			
3. Describe the contribution of p+ & n to the nucleus of an atom, in terms of atomic (proton) number & mass (nucleon) number.			
4. Deduce the numbers of protons, neutrons and electrons in an atom given its atomic and mass number			
5. Deduce the numbers of protons, neutrons and electrons in an ion given its atomic number, mass number and ionic charge.			
6. Explain the term *isotopes* as atoms of an element with different numbers of neutrons and different masses.			
7. State that ^{12}C is used as the standard measurement of relative masses.			
8. Define the terms *relative isotopic mass* and *relative atomic mass*, based on the ^{12}C scale.			
9. Calculate the relative atomic mass of an element given the relative abundances of its isotopes.			
10. Use the terms *relative molecular mass* and *relative formula mass* and calculate values from relative atomic masses.			

Complete the following tasks – remember you must avoid leaving gaps! If you find a question or task challenging you MUST be proactive and research the answer...

12. **Complete the table to show the location, relative charge and relative mass of each sub-atomic particle found within an atom (LO1, see table above).**

Sub-atomic particle	Location	Relative charge	Relative mass
Neutron	Nucleus	0	1
Electron	In shells/orbital surrounding the nucleus	1-	0 or 1/2000
Proton	Nucleus	1+	1

13. **Use the table to describe the distribution of mass and charge within an atom (LO2)...**
Almost all of the mass is in the nucleus and the nucleus is positively charged, surrounded by a cloud of negative charge.__

Task 1 – Atoms, Ions & Isotopes

14. Give precise definitions for the following keyterms (LO3)....

Atomic (proton) number: The number of protons in an element_____

Mass (nucleon) number: The total number of protons and neutrons in an atom/isotope/ion

15. Complete the missing data in the table below - use the 2 definitions above, and your understanding of atomic structure (LO4)...

Atom	Atomic No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
$_{14}N$	7	14	7	7	7
$_{39}K$	19	39	19	19	20
$_{11}B$	5	11	5	5	6
$_{40}Ar$	18	40	18	18	22
$_{40}Ca$	20	40	20	20	20
$_{133}Cs$	55	133	55	55	78

16. Complete the missing data in the table below - use the example given, and your understanding of atomic structure and how atoms become ions (LO5)...

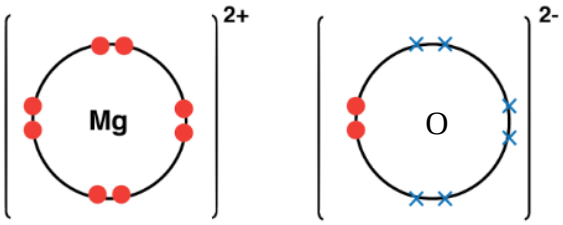
Atom	Metal or non-metal atom	Atomic No.	Electron Configuration	Gains /loses e-	No. of e- gained/loss	Ion formula produced	Electronic configuration
Li	Metal	3	2,1	loses	1e-	Li^+	$[2]^+$
Na	Metal	11	2,8,1	loses	$1e^-$	Na^+	$[2,8]^+$
Mg	Metal	12	2,8,2	loses	$2e^-$	Mg^{2+}	$[2,8]^{2+}$
Al	Metal	13	2,8,3	loses	$3e^-$	Al^{3+}	$[2,8]^{3+}$
F	Non-Metal	9	2,7	gains	$1e^-$	F^-	$[2,8]^-$
O	Non-Metal	8	2,6	gains	$2e^-$	O^{2-}	$[2,8]^{2-}$
S	Non-Metal	16	2,8,6	gains	$2e^-$	S^{2-}	$[2,8,8]^{2-}$

Atom	Atomic No.	Mass No.	Ion Formula	No. of p+	No. of e-	Electronic config.	No. of n
$_{40}Ca$	20	40	Ca^{2+}	20	20	2,8,8,2	20
$_{37}Cl$	17	37	Cl^-	17	17	2,8,7	20

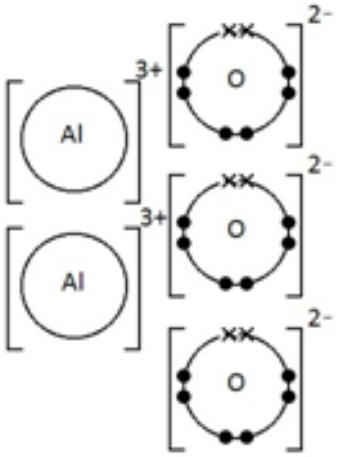
Task 1 – Atoms, Ions & Isotopes

17. Use dot & cross diagrams to model the ionic bonding in a) magnesium oxide and b) aluminium oxide:
Tip – only show the ions formed (not the atoms they come from) and if more than one ion is needed show how many e.g. if 2 oxygen ions are needed, show in this format: 2 x [ ]$^{2-}$

c) magnesium oxide:



d) aluminium oxide:



18. Give a precise definition of the keyterm 'isotope' (LO6).
Tip: within your definition include the words: proton, electron, neutron, atomic number, mass number

Isotope: atoms of the same element with different numbers of neutrons and different masses

19. Complete the missing data on the isotopes of carbon in the table below - use your definition above, and your understanding of atomic structure and isotopes (LO6)...

Example	Atom	Atomic No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
1	C	6	12	6	6	6
2	C	6	13	6	6	7
3	C	6	14	6	6	8
4	N	7	15	7	7	8

Qu: Which is NOT an isotope of carbon? Justify your choice Example 4; because it doesn't have 6 protons/ the same atomic number (like examples 1-3).

Task 1 – Atoms, Ions & Isotopes

Qu: Explain, if any, the difference in reactivity between the 3 carbon isotopes? Tip: ask yourself 'do they all react with oxygen to produce carbon dioxide or only some?'. Give a reason for your answer.

They all react exactly the same because their electron configurations are the same

---

Qu: Name one physical property that may differ between the isotopes of the same element? Justify

Isotopes have different numbers of neutrons so their masses will vary

---

How would you go about weighing something that you cannot see? This is the situation with atoms. Instead of finding the mass of atoms directly we compare the masses of different atoms, using the idea of relative mass.

Qu: What isotope has been used, since 1961, as the international standard for the measurement of relative mass? (LO7) Carbon_____.

20. Give precise definitions for the following keyterms (LO8)....

Relative isotopic mass: mass compared with 1/12th mass of carbon-12

All the atoms of a single isotope are identical so the relative isotopic mass is the same as the mass number.

Qu: Therefore what is the relative isotopic mass of a) oxygen-16? 16 b) Sodium-23? 23

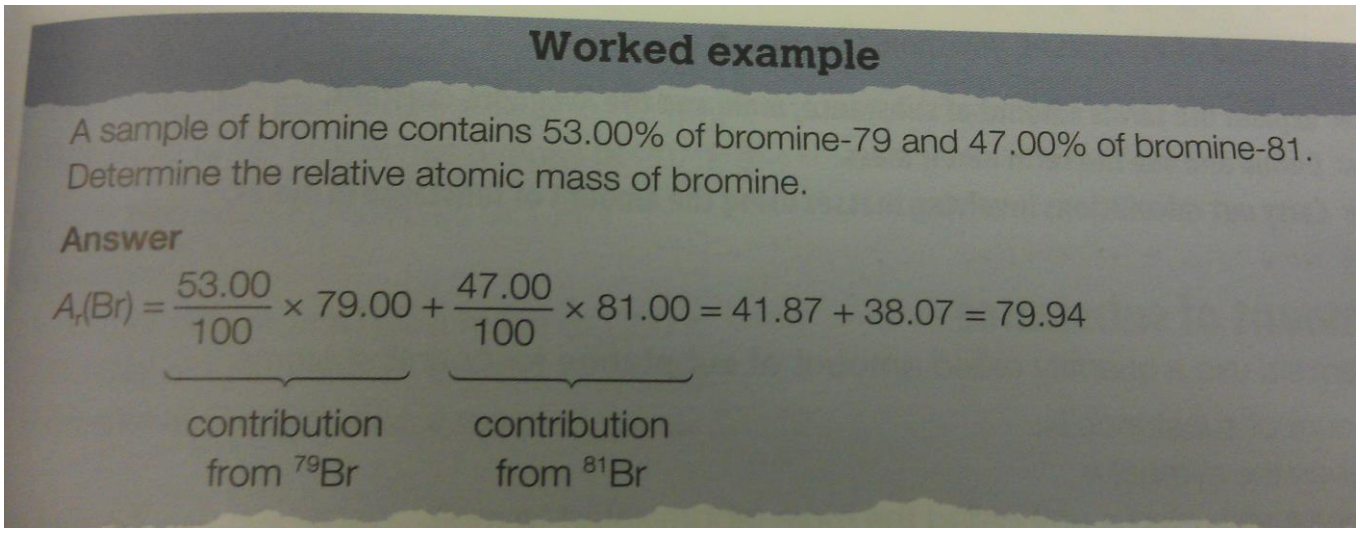
Most elements contain a mixture of isotopes, each in a different amount and with a different mass so we have to take into account the contribution made by each isotope to the overall mass of a element which we call the 'relative atomic mass'

Relative atomic mass (A_r): weighted mean/average mass compared with 1/12th mass of carbon-12

You will now learn how to calculate the relative atomic mass based on the element's isotopes.

Task 1 – Atoms, Ions & Isotopes

The relative atomic mass for an atom of a particular element can be found on the periodic table. However these are often not whole numbers (see Chemistry periodic table provided in this booklet, do NOT use your planner) as they have to take into account that each element is often a mixture of isotopes. Here's how the relative atomic masses on the periodic table have been derived…



Worked example

A sample of bromine contains 53.00% of bromine-79 and 47.00% of bromine-81. Determine the relative atomic mass of bromine.

Answer

$$A_r(Br) = \underbrace{\frac{53.00}{100} \times 79.00}_{\text{contribution from } {}^{79}Br} + \underbrace{\frac{47.00}{100} \times 81.00}_{\text{contribution from } {}^{81}Br} = 41.87 + 38.07 = 79.94$$

21. Use the worked example above to calculate the relative atomic mass of the following elements (LO9)….

Remember for each isotope you have to take into account it mass and its relative abundance, e.g. %

d) Boron contains: 19.77% ^{10}B & 80.23% ^{11}B

$$RAM = \frac{(10 \times 19.77\%) + (11 \times 80.23\%)}{100}$$

=10.8023

Ar: 10.80 (4sf)

e) Silicon contains: 92.18% ^{28}Si, 4.70% ^{29}Si & 3.12% ^{30}Si

$$RAM = \frac{(28 \times 92.19\%) + (29 \times 4.70\%) + (30 \times 3.12\%)}{100}$$

=28.1122

Ar: 28.1(3sf)

f) Unknown X contains: 4.31% ^{50}X, 83.76% ^{52}X, 9.55% ^{53}X & 2.38% ^{54}X

$$RAM = \frac{(50 \times 4.31\%) + (52 \times 83.76\%) + (53 \times 9.55\%) + (54 \times 2.38\%)}{100}$$

=52.0569

Ar: 52.1 (3sf)

Use the periodic table to work out the identity of this unknown element: Cr

Task 1 – Atoms, Ions & Isotopes

22. To appreciate the mass of a molecule we have to take into account the mass of each atom it contains and the number of each type of atom. We can do this by calculating its 'relative formula mass', M_r

Give precise definitions for the following keyterms (LO10)....

Relative formula mass (M_r): the weighted mean mass of a formula unit compared with 1/12th mass of carbon-12

To be more precise the term 'relative molecular mass' is used for molecules e.g. covalently bonded elements or compounds and the term 'relative formula mass' used for ionic compounds as they have giant lattice structures (not simple molecules)so its molecular formula is actually the empirical formula BUT effectively you are calculating the same thing!

Calculate the Mr of each compound listed below, showing full working (LO10):

e) $CaCO_3$

40.1+12.0+3(16.0)

Mr = 100.1 $gmol^{-1}$

f) $Cu(OH)_2$

63.5+2(16.0)+2(1.0)

Mr = 97.5 $gmol^{-1}$

g) $(NH_4)_2SO_4$

2(14.0)+8(1.0)+32.1+4(16.0)

Mr = 116.1 $gmol^{-1}$

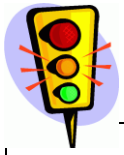
h) $Ca(NO_3)_2 \cdot 4H_2O$

40.1+2(14.0)+6(16.0) + 8(1.0)+4(16.0)

Mr = 236.1 $gmol^{-1}$

Tip – in (d) work out the mass of each part either side of the dot & then add together

Task 2 – The Changing Atom…



In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'
– *note: p+ = protons; e- = electrons; n = neutrons*

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area…	**Start**	**End**	
1. Describe how the model of the atom has changed over the years.			
2. Understand that scientific knowledge is always evolving.			
3. Describe how new theories are accepted by scientists.			

You must complete the research task, detailed below, and clearly present your findings. How you choose to present your work is up to you – a written report; series of cue cards; create a podcast or video; PowerPoint presentation; poster or factsheet.

OBJECTIVE 1: How the idea of the atom has changed from the Greeks to the present day.

Within this task you MUST meet the following criteria:

5. Key philosophers/scientists: Democritus, **Dalton**, **Thomson**, **Rutherford**, **Bohr**, Moseley, de Broglie, Schrodinger & Chadwick. Those shown in **bold MUST be included in your findings** but you may also like to research some or all of the others.
6. Describe each proposed model of the atom, using labelled diagrams where appropriate.
7. Highlight the limitations of each model
8. Full bibliography: list of ***reliable*** reference materials used to compile your research.

OBJECTIVE 2: Provide a brief history of the periodic table.

Within this task you MUST meet the following criteria:

3. An annotated copy of the modern day periodic table - clearly label or list as a key the information which we can obtain from it *e.g. group names; how it is arranged; how certain elements are grouped together; any patterns shown within the periodic table etc.*
4. A timeline of philosophers/scientists that helped to develop the periodic table to how the know it today e.g. Döbereiner; Newland; Mendeleev.

Task 3: Representing Chemical Reactions using Equations

Balancing equations becomes a little more challenging at A level only because you are expected to independently derive a balanced chemical equation using given named reactants, sometimes for reactions that will be unfamiliar to you (not studied in class).

However this becomes alot easier if you LEARN your general equations!

In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
6. I can balance equations when correct molecular formula is provided			
7. I can give the correct molecular formula based on ion charges.			
3. I can convert word equations to balanced chemical equations.			
4. I can give the correct balanced equation by applying a general eq.			
5. I can predict the correct equation to represent an unfamiliar reaction.			

5. Practise the concept of balancing equations using the chemical equations below (LO1):

Unbalanced equations: a) $C + O_2 \rightarrow CO$

$2C + O_2 \rightarrow 2CO$

b) $Na + O_2 \rightarrow Na_2O$

$4Na + O_2 \rightarrow 2Na_2O$

c) $Fe_2O_3 + CO \rightarrow Fe + CO_2$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

d) $NH_3 + O_2 \rightarrow NO + H_2O$ (a toughy!)

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

6. Use the common ion bank (for ionic compounds only) provided and your understanding of GCSE, practise deducing (working out) the correct molecular formula for these named (LO2):

Ionic Compounds		Covalent elements or compounds	
Copper sulphate:	$CuSO_4$	Iodine:	I_2
Ammonium nitrate:	NH_4NO_3	Carbon monoxide:	CO
Aluminium sulphate:	Al_2SO_4	Methane:	CH_4
Ammonium carbonate:	$(NH_4)_2CO_3$	Hexane:	C_6H_{14}
Calcium phosphate:	$CaPO_4$	Ammonia:	NH_3

Help: Ion Formulae Bank *(Tip – if any are missing any, Google search or Wikipedia the ion charge)*

Cations (positive ions)	
Group 1 e.g. Li^+	1+
Group 2 e.g. Mg^{2+}	2+
Copper	Cu^{2+}
Lead	Pb^{2+}
Ammonium	NH_4^+

Anions (negative ions)			
Group 7 e.g. F^-	1-	Hydroxide	OH^-
Group 6 e.g. O^{2-}	2-	Phosphate	PO_4^{3-}
Nitrate	NO_3^-	Ethanoate	CH_3COO^-
Carbonate	CO_3^{2-}		
Sulphate	SO_4^{2-}		

Task 3: Representing Chemical Reactions using Equations

7. Convert these word equations into balanced chemical equations:

c) Magnesium + hydrochloric acid → magnesium chloride + hydrogen

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ _____

d) Calcium hydroxide + sulphuric acid → calcium sulphate + water

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$ _____

8. Select the correct general equation from the box below to complete the balanced chemical equations.

Tip – you may wish to construct word equation first and then convert it into a balanced equation

1. Metal + water → metal hydroxide + hydrogen

2. Metal + Acid → Salt + Hydrogen

8. Metal carbonate + acid → salt + carbon dioxide + water

9. Neutralisation: Metal oxide/hydroxide + acid → salt + water

5. Thermal decomposition: metal carbonate → metal oxide + carbon dioxide

6. Thermal decomposition: metal hydrogen carbonate → metal carbonate + water + carbon dioxide

f) Potassium is a group 1 metal that reacts vigorously with water.

Reaction 1; $2K + 2H_2O \rightarrow 2KOH + H_2$ _____

g) Thermal decomposition of baking powder (sodium hydrogen carbonate).

Reaction 6; $2NaHCO_3 \rightarrow Na_2CO3 + H_2O + CO_2$ _____

h) The reaction that takes place when acid rain (sulphuric acid) corrodes buildings made of limestone.

Reaction 3; $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

10. Predict the correct word and balanced chemical equation to represent these possibly unfamiliar reactions.

Tip - You may find the ion bank table on the previous page and the general equations above helpful.

i) The action of vinegar (ethanoic acid) on copper cans.

Reaction 2. Copper + Ethanoic Acid → Copper (II) Ethanoate + Hydrogen

$Cu + 2CH_3COOH \rightarrow Cu(CH_3COO)_2 + H_2$ _____

j) The action of the acid in coke (phosphoric acid) on an aluminium can

aluminium + phosphoric acid → aluminium phosphate + Hydrogen

b) $2Al + 2H_3PO_4 \rightarrow 2AlPO_4 + 3H_2$

Task 4: Chemical Mathematics

In this task you will cover the following LO's. Traffic light your understanding 'before' & 'after'

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. Explain the term *empirical formula.*			
2. Explain the term *molecular formula*.			
3. Calculate empirical formulae using composition by mass or %			
4. Calculate molecular formulae using composition by mass or %			

24. Give precise definitions for the following keyterms (LO1&2)....

Molecular formula: the number and type of atoms of each element in a molecule

Empirical formula: the simplest whole number ratio of atoms of each element present in a compound

Use your understanding from GCSE & the table below to help practise calculating the empirical formula.

6. **List all of the elements in the compound**
7. **Underneath, write the mass or % given in the question**
8. **Calculate moles - ÷ each mass or % from step 2 by the Ar for each element**

If the numbers are not ALL whole numbers....

9. **Identify the element in the smallest amount and divide each answer to step 3 by this.**
10. **Use this whole number ratio to give the simplest ratio of atoms of each element in the formula**

25. A hydrocarbon has 80% carbon and 20 %hydrogen. Calculate its empirical formula.

	Element	
	C	H
%	80	20
Mol calculation	80/12.0	20/1.0
Ratio of moles	6.667	20
Divide by smallest	6.667/6.667	20/6.667
Ratio of moles	1	3

Ratio of atoms: 1 : 3 Empirical Formula: CH_3

26. 2.70g of aluminium is combined with 10.65g of chlorine. What is the empirical formula of this product?

	Element	
	Al	Cl
Mass /g	2.70	10.65
Mol calculation	2.70/27.0	10.65/35.5
Ratio of moles	0.1	0.3
Divide by smallest	0.1/0.1	0.3/0.1
Ratio of moles	1	3

Ratio of atoms: 1 : 3 Empirical Formula: $AlCl_3$

Task 4: Chemical Mathematics

The **mole** is a **unit** for an **amount of substance** (and is given the symbol **'n'**) – it is a standard number of particles.

This count of atoms is called the **Avogadro constant (N_A)** & is equal to **6.02×10^{23} mol^{-1}**

IMPORTANT DEFINITIONS

The **Avogadro constant** (N_A) is the number of atoms per mole of the carbon-12 isotope (6.02×10^{23} mol^{-1}).

A **mole** is the amount of any substance containing as many particles as there are carbon atoms in exactly 12g of the carbon-12 isotope.

Basically if the amount of substance you want is 1 mole you would need to count out 6.02×10^{23} mol^{-1} atoms/molecules of that substance.

However, because atoms weigh different amounts (depending on the element) one mole of substance will have a different mass. For example:

1 mole of carbon-12 would contain 6.02×10^{23} carbon -12 atoms and weigh 12g

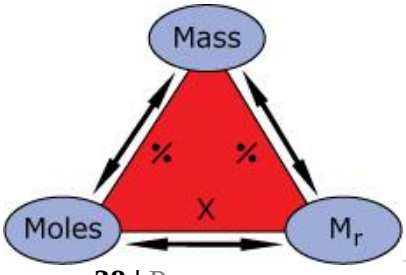
...but...

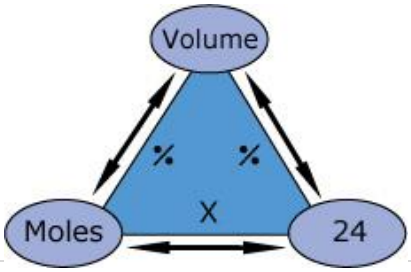
1 mole of sodium-23 would also contain 6.02×10^{23} carbon -12 atoms but weigh 23g

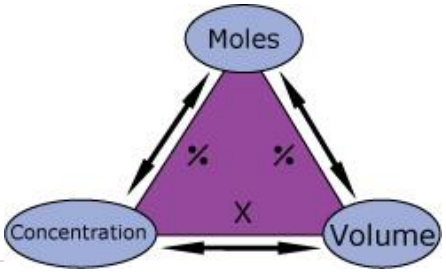
The **mass of one mole** is easy to work out as it is the **relative formula mass in grams** for that substance. This is referred to as **molar mass, Mr**, and has **the units $gmol^{-1}$**.

	Student to complete:		Teacher use only
Learning Outcomes (LO) or Skill Area...	**Start**	**End**	
1. Explain the term '*amount of substance*'.			
2. Explain the term *mole* as the unit for amount of substance.			
3. Explain the term *Avogadro constant*, N_A, (6.02×10^{23} mol^{-1}).			
4. Define the term *molar mass* (units g mol^{-1})			
5. Use the term *molar mass* (units g mol^{-1})			
6. Carry out mole-based calculations involving mass			
7. Carry out mole-based calculations involving gas volume			
8. Carry out mole calculations involving solution vol. & concentration			
9. Deduce stoichiometric relationships (molar ratio) from calculations.			

Mole formulae – you will need to learn these equations as they are not provided in the exam



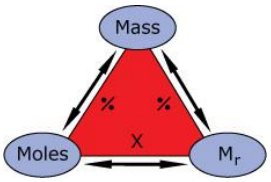




Task 4: Chemical Mathematics (LO5&6)

27. Use the formula triangle given to deduce the formula required to calculate mass (LO5&6):

Mass = n (Moles) x M_r



28. Use this formula to calculate the mass of each of the following (LO5&6)...

(c) 2.50 mol of hydrogen, H_2

Mass = n x M_r

Mass = 2.50 mol x 2.0gmol^{-1}

Mass of H_2: 5.00 g(3sf)

(d) 0.500 mol of sodium chloride, NaCl.

(e) Mass = n x M_r

Mass = 0.500 mol x 58.5gmol^{-1}

29.25g

Mass of NaCl: 29.3 g (3sf)

29. Again, use the formula triangle given to deduce the formula required to calculate the amount of substance (LO5&6):

Moles(n) = m/M_r

30. Use this formula to calculate the amount (in mol) of each substance listed below....

c) 31.0 g of phosphorus molecules, P_4

n = m/M_r
=31.0g/4(31.0gmol^{-1})

=0.250 mol

Amount of P_4: 0.250 mol

d) 50.0 g of calcium carbonate, $CaCO_3$.

n = m/M_r
=50.0g/40.1 + 12.0 + 3(16.0)gmol^{-1}

=0.4995 mol

Amount of $CaCO_3$: 0.500 mol

31. Again, use the formula triangle given to deduce the formula required to calculate molar mass of an unknown substance

Molar mass (M_r) = m/n

32. Use this formula to calculate the molar mass of an 11g gas sample of compound X, which is 0.25mol.

Molar mass (M_r) = m/n
Mr = 11g/0.25mol

= 44gmol^{-1}

Molar mass: 44 gmol^{-1}

Possible identity of the gas sample X: CO_2

Task 4: Chemical Mathematics (LO7)

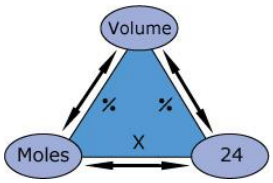
33. Use the formula triangle given to deduce the formula for calculating the amount of gas in mols …

When volume is in dm^3…

Moles (n) = $Vol/24 dm^3 mol^{-1}$

When volume is in cm^3…

Moles (n) = $Vol/24{,}000\ cm^3 mol^{-1}$



34. Use this formula to calculate the amount of gas (in mol) of….

(c) $3600cm^3$ of hydrogen gas, H_2

$n = Vol/24{,}000\ cm^3 mol^{-1}$
$= 3600cm^3/24{,}000\ cm^3 mol^{-1}$
$=0.15$ mol

Amount of H_2 gas: 0.15 mol

(d) 4.0 dm^3 of hydrogen gas, CO_2

$n = Vol/24\ dm^3 mol^{-1}$
$= 4.0dm^3/24\ dm^3 mol^{-1}$
$=0.1667$ mol

Amount of CO_2 gas: 0.17 mol

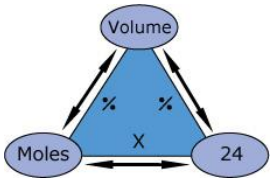
35. Use the formula triangle given to deduce the formula for calculating the volume of gas…

When volume is in dm^3…

Volume (V) = $n \times 24\ dm^3 mol^{-1}$

When volume is in cm^3…

Volume (V) = $n \times 24.000\ cm^3 mol^{-1}$



36. Use this formula to calculate the volume of gas….

(c) 6.00 mol of hydrogen gas, SO_2

Volume (V) = $n \times 24\ dm^3 mol^{-1}$
$= 6mol \times 24\ dm^3 mol^{-1}$
$= 144\ dm^3$

Volume of SO_2 gas: 144 dm^3

(d) 0.25mol of oxygen gas, O_2

Volume (V) = $n \times 24{,}000\ cm\ mol^{-1}$
$= 0.25mol \times 24{,}000\ cm^3 mol^{-1}$
$= 6{,}000\ cm^3$

Volume of CO_2 gas: 6,000 cm^3

37. Complete the following tasks which is more representative of a *simple A chemistry question*

Tip – you will need to use both mole formulas introduced so far (on pages 12-13)

(c) What is the mass of $84cm^3$ of N_2O?

$n = Vol/24{,}000\ cm^3 mol^{-1}$
$n = 84cm^3/24{,}000\ cm^3 mol^{-1}$
$= 0.0035$ mol of N_2O

$Mass = n \times M_r$

$Mass = 0.0035\ mol \times 2(14.0) + 16.0\ gmol^{-1}$

$= 0.154g$

Mass of N_2O gas: 0.154 g

(d) What is the volume of 1.26g of propene, C_3H_6

$n = m/M_r$
$=1.26g/8(1.0)+ 3(12.0)gmol^{-1}$

$=0.02864$ mol

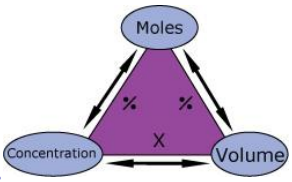
Volume (V) = $n \times 24\ dm^3 mol^{-1}$
$= 0.02864\ mol \times 24\ dm^3 mol^{-1}$
$= 0.6874\ dm^3$

Volume of C_3H_6 gas: 0.687 dm^3

Task 4: Chemical Mathematics (LO8)

38. Use the formula triangle given to deduce the formula for calculating the amount of moles in solution …

When volume is in dm^3…	When volume is in cm^3…
Moles (n) = Conc x Vol	Moles (n) = Conc x (Vol/1000)



39. Use this formula to calculate the amount of substance (in mol) for the following solutions….

(c) $4dm^3$ of a 2 $moldm^{-3}$ solution

n = Conc x Vol

= 2 $moldm^{-3}$ x 4 dm^3

Amount of solution: __8___ mol

(d) $25.0dm^3$ of a 0.15 $moldm^{-3}$ solution

n = Conc x Vol

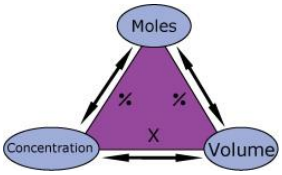
= 0.15 $moldm^{-3}$ x 25.0 dm^3

= 0.0375

Amount of solution: _0.038___ mol

40. Use the formula triangle given to deduce the formula for calculating the volume of solution needed…

When volume is in dm^3…	When volume is in cm^3…
Volume (V) = n/conc	Volume (V) = (n x1000)/conc



41. Use this formula to calculate the volume produced in the following solutions….

(c) a solution with a concentration of 2 $moldm^{-3}$ that contains 2 moles of solute.

Volume (V) = n/conc
= 2 mol/2 $moldm^{-3}$

Volume of solution: __1_ dm^3

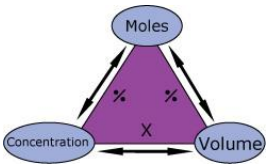
(d) a solution with a concentration of 0.25 $moldm^{-3}$ that contains 0.005 moles of solute.

Volume (V) = n/conc
= 0.005 mol/0.25 $moldm^{-3}$

Volume of solution: _0.00125_ dm^3

42. Use the formula triangle given to deduce the formula for calculating the concentration of the solution…

When volume is in dm^3…	When volume is in cm^3…
Concentration (c) = n/vol	Concentration (c) = n/(vol/1000)



43. Use this formula to calculate the concentration (in $moldm^{-3}$) for the following solutions….

(c) 0.5 moles of solid dissolved in $250cm^3$ of solution

c = n/(vol/1000)

= 0.5mol/($250cm^{-3}$/1000)

=2

Concentration: 2 $moldm^{-3}$

(d) 0.00875 moles of solid dissolved in $25cm^3$ solution

c = n/(vol/1000)

= 0.00875mol /($25cm^{-3}$/1000)

=0.35

Concentration: 0.35 $moldm^{-3}$

Task 4: Chemical Mathematics (LO9)

Complete the following tasks, which is more representative of a *simple A chemistry question…*

Tip – you will need to use more than one of the mole formulas introduced & use the balanced equation to find the molar ratio

44. Find the mass concentration, in gdm^{-3}, for the following solutions:

(c) 0.0042 moles of HNO_3 dissolved in $250cm^{-3}$ of solution

m= n x M_r

=0.0042mol x (1.0+14.0+3(16.0))

= 0.2646 g

mass concentration = m/vol

= 0.2646 g/($250cm^{-3}$/1000)

= 1.0584 gdm^{-3}

Mass concentration: 1.1 gdm^{-3}

(d) 0.50 moles of HCl dissolved in 4.0 dm^3 of solution

m= n x M_r

=0.50mol x (1.0+35.5)

= 18.25 g

mass concentration = m/vol

= 18.25 g/4.0dm^{-3}

= 4.5625 gdm^{-3}

Mass concentration: 4.6 gdm^{-3}

45. The following reaction can take place, shown in this equation: $NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$

(c) Balance the equation shown above

$2NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$

(d) What volume of CO_2 is formed by the decomposition of 5.04g of $NaHCO_3$?

n = m / M_r

=5.04g / (23.0+1.0+12.0+3(16.0))

= 0.060 mol

Vol = n x 24 dm^3 mol^{-1}

= 0.060mol x 24 dm^3 mol^{-1}

=1.44 dm^3

Volume of CO_2: 1.44 dm^3

46. The following reaction can take place, shown in this equation:

$MgCO_{3(s)} + HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

(d) Balance the equation shown above

$MgCO_{3(s)} + 2HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

(e) 2.529g of $MgCO_3$ reacts with an excess of HNO_3. What volume of CO_2 is formed?

n = m / M_r

=2.529g / (24.3+12.0+3(16.0))

= 0.03000 mol

Vol = n x 24 dm^3 mol^{-1}

= 0.03000mol x 24 dm^3 mol^{-1}

=0.72 dm^3

Volume of CO_2: 0.72 dm^3

(f) The final volume of the solution is $50.0cm^3$. What is the concentration of $Mg(NO_3)_{2(aq)}$ formed?

0.03000 mol of $MgCO_3$ produces 0.03000 mol of $Mg(NO_3)_2$ – the molar ratio is 1:1

c = n/(vol/1000)

c = 0.03000 /($50.0cm^3$/1000)

=0.600 $moldm^{-3}$

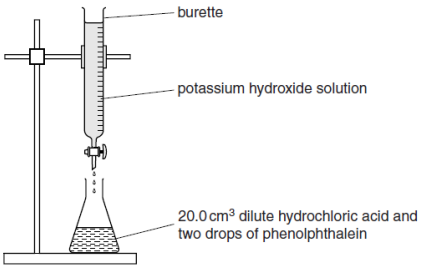
Concentration: 0.600 $moldm^{-3}$

Task 4: GCSE Past Exam Questions related to moles

Look at the equation for the reaction between potassium hydroxide and hydrochloric acid.

$$KOH + HCl \longrightarrow KCl + H_2O$$

Look at the apparatus she uses.



Calculate the **concentration** of potassium hydroxide in mol/dm^3.

These steps may help.

Work out the:

- number of moles in 20.0 cm^3 of 0.200 mol/dm^3 hydrochloric acid
- number of moles of potassium hydroxide neutralised
- average titre, in cm^3, using titration numbers **2**, **3** and **4**.

titration number	1	2	3	4
final burette reading in cm^3	26.9	27.6	27.0	28.2
initial burette reading in cm^3	0.5	2.5	2.0	3.3
titre (volume of alkali used) in cm^3	26.4	25.1	25.0	24.9

n = c x (vol/1000)

n = 0.200moldm^{-3} x (20.0cm^3 /1000)

=0.00400mol (of HCl in the concical flask)

1:1 molar ratio between acid and base

=0.00400mol (of KOH neutralised, on average from the burette)

Av titre: based on titration numbers 2,3and 4 (concordant results -all within 0.1cm^3 of each other)

=(25.1+25.0+24.9)/3

=25.0cm^3 (of KOH)

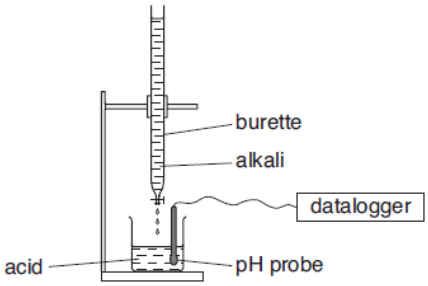
c = n/(vol/1000)

= 0.00400mol /(25.0cm^3 /1000)

=0.16 moldm-^{3}

Concentration of KOH: 0.160 moldm^{-3}

Task 4: GCSE Past Exam Questions related to moles



Tina does another experiment.

This time she uses

- 25.0 cm^3 of dilute hydrochloric acid in the beaker
- sodium hydroxide solution of concentration 0.100 mol/dm^3 in the burette.

The hydrochloric acid is exactly neutralised by 20.0 cm^3 of this sodium hydroxide solution.

Look at the balanced symbol equation for the reaction.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Calculate

- the number of moles of sodium hydroxide in 20.0 cm^3 of a 0.100 mol/dm^3 solution
- the number of moles of hydrochloric acid that reacted with this amount of sodium hydroxide
- the concentration, in mol/dm^3, of the hydrochloric acid.

n = c x (vol/1000)

n = 0.100$moldm^{-3}$ x (20.0cm^3 /1000)

=0.00200mol (of NaOH in the burette)

1:1 molar ratio between acid and base

=0.00200mol (of HCl neutralised, on average by the NaOH) in 25.0cm^3 solution (in the beaker)

c = n/(vol/1000)

= 0.00200mol /(25.0cm^3 /1000)

=0.0800 $moldm^{-3}$

Concentration of HCl: 0.0800 $moldm^{-3}$