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**A LEVEL
CHEMISTRY
TRANSITION
MATERIAL**

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Preparation for September.

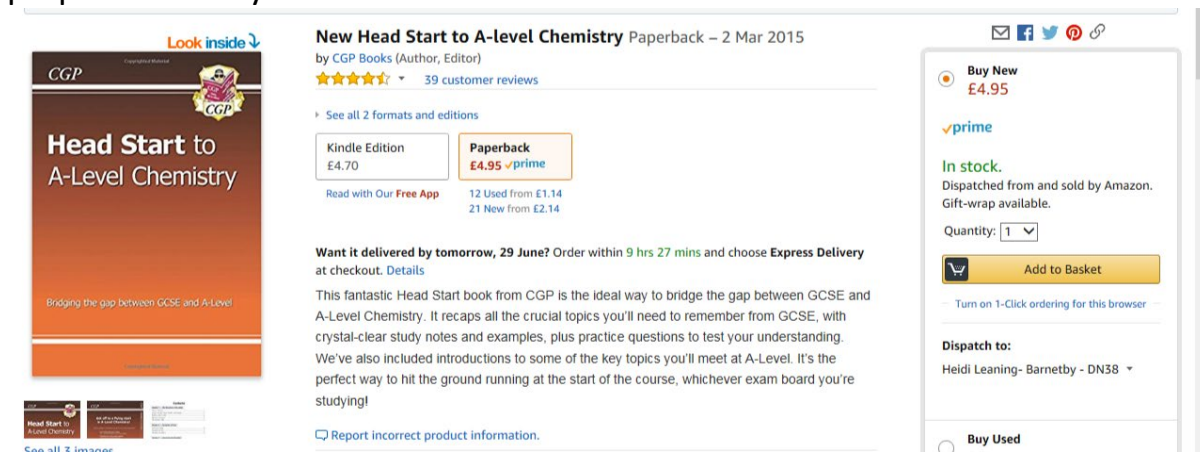
Course: OCR Chemistry A

Start preparing for the course by downloading a copy of the Specification from <http://www.ocr.org.uk/qualifications/as-a-level-gce-chemistry-a-h032-h432-from-2015/>

Print out section two 'Content of Modules 1-6' to use alongside your notes. You will need a scientific calculator (one good enough for GCSE maths) and you may wish to buy a labcoat.

Summer reading

A more detailed reading list will be issued in September, in the meantime reading and working through the CGP Headstart book would be excellent preparation for your course.



New Head Start to A-level Chemistry Paperback – 2 Mar 2015
by CGP Books (Author, Editor)
★★★★☆ 39 customer reviews

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This fantastic Head Start book from CGP is the ideal way to bridge the gap between GCSE and A-Level Chemistry. It recaps all the crucial topics you'll need to remember from GCSE, with crystal-clear study notes and examples, plus practice questions to test your understanding. We've also included introductions to some of the key topics you'll meet at A-Level. It's the perfect way to hit the ground running at the start of the course, whichever exam board you're studying!

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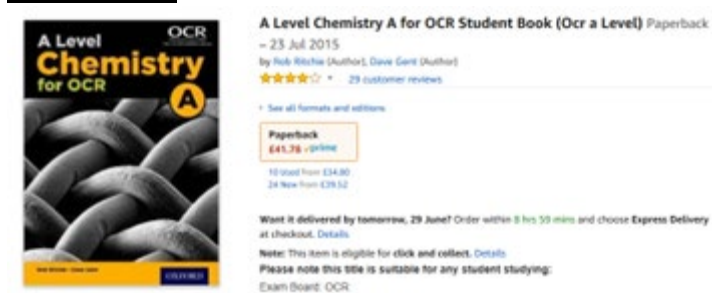
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You can also work through a booklet called **Science A level transition pack – Chemistry** which is available as a PDF file.

Text books



A Level Chemistry A for OCR Student Book (Ocr a Level) Paperback
– 23 Jul 2015
by Rob Ritchie (Author), Dave Gent (Author)
★★★★☆ 29 customer reviews

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Please note this title is suitable for any student studying:
Exam Board: OCR

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book in September but strongly recommend that you also buy this book. Our current Y12 and Y13 students rate it very highly. You may be able to find them

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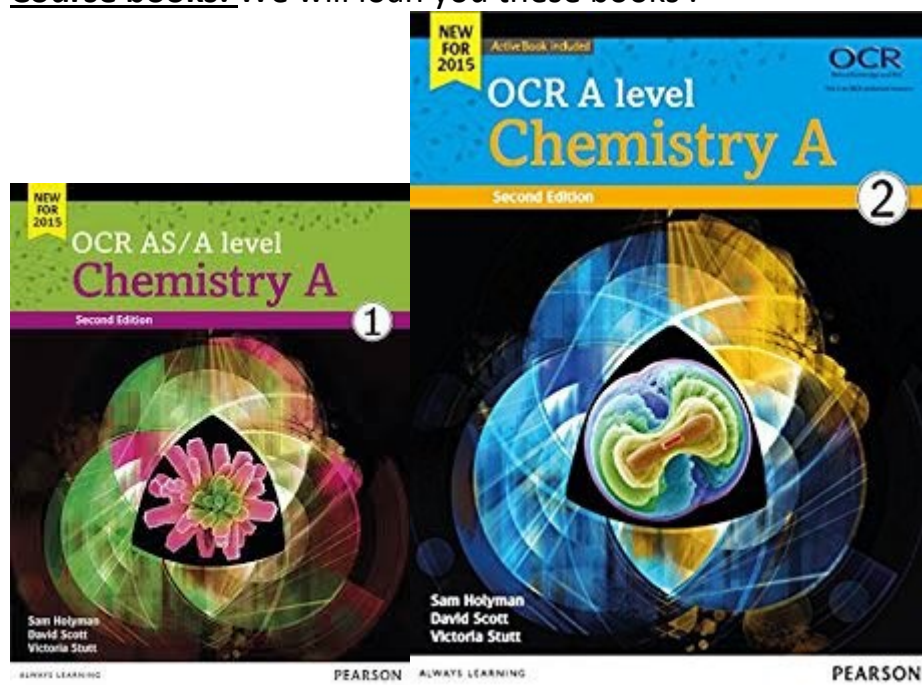
second hand. **DO NOT BUY A CGP REVISION GUIDE – THEY ARE NOT RECOMMENDED FOR A LEVEL STUDY!**

Any queries? Email: heidi.leaning@caistorgrammar.com

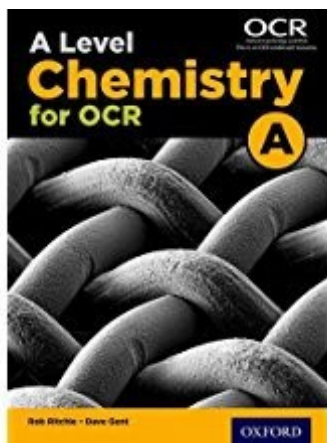
A level Chemistry Reading List.

To succeed at A level in any subject you should be working independently and completing work BEYOND that set by your teachers. As a rough guide you should spend as much time studying independently as you do in lessons, i.e. the equivalent of 4 x 70 minute lessons of study. This work could include reviewing your notes, trying questions from the text book, referring to other text books to supplement your notes and 'reading around' the subject to give you a more in depth understanding.

Course books: We will loan you these books .



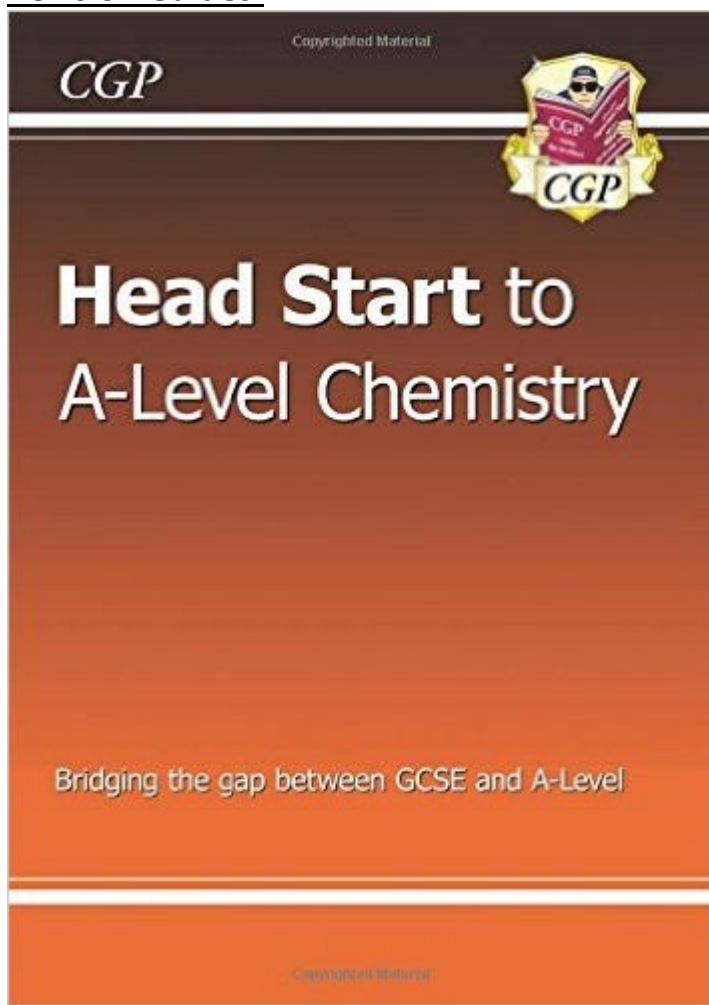
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Suggested in addition to your text book.

In addition it is recommended that you use at least one other text book. This one is recommended by previous students.

Revision Guides:



Be wary of relying on CGP revision guides for A Level; CGP may have been a great help in getting you

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through your GCSE but you will be making a big mistake if you rely on it in the same way for A level. However they can be useful as a quick reference (Health Warning; they often have errors and omissions).

However.....CGP do produce a good book 'Head Start' to help you revise the GCSE work needed for A level that you may have forgotten over the summer.

WE STRONGLY SUGGEST YOU BUY THIS AND WORK THROUGH IT BEFORE STARTING YOUR A LEVEL COURSE Not quite as expensive as a text book...better than a CGP revision guide...

A lot of past students have liked these books as a supplement to the text book, especially if they couldn't afford the full text book or just wanted a quick reference. Stay away from CGP – it might have got you through your GCSE but it isn't good enough for your A level!

Practical Endorsement (Unit 1)

Unit 1 is taught throughout the course and if you succeed you will be given a PASS grade in the practical endorsement. It doesn't end there though as 15% of your final exam will include questions about the practicals. This book is recommended.

Useful books to help with the mathematical aspects of the course:

Websites:

<https://chemrevise.org/ocr-revision-guides/> A lot of students like this website for its clear and easy to read notes – essentially a free and straightforward text book.

<https://www.chemguide.co.uk/> Don't be fooled by its appearance. It looks quite old and basic but its one of the best websites for revision and many students recommend it.

http://www.rsc.org/chemistryworld/	Royal Society of Chemistry online magazine
http://www.chemguide.co.uk/	A good starting point, clear, concise
http://www.catalyst.org.uk/	Science magazine for 14-19 year olds

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http://www.newscientist.com/	
http://www.periodicvideos.com/	Nottingham University's Periodic Table of Videos

Social Media:

Compound interest

Chemunicate

Chemistry & physics

MOOCs - Massive Open Online Courses and Open University OpenLearn courses

These are available to anyone. There are several Chemistry courses but you might find one related to your career plans – for example there are courses related to medicine, dentistry and engineering. The courses run for two-four weeks with a 2-4 hour commitment each week. They are free but you can upgrade if you want to take an assessment.

Take a look. www.futurelearn.com

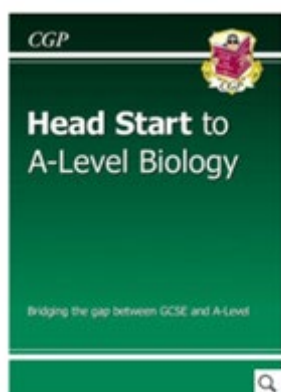
<https://www.open.edu/openlearn/>

Suggestions for wider reading:

Periodic Tales: The Curious lives of Elements	Hugh	Aldersey-Williams
Magic molecules – how drugs work	Susan	Aldridge
Reactions: The private life of atoms	Peter	Atkins
What is Chemistry?	Peter	Atkins
Four laws that drive the universe		Atkins
The elements- a very short introduction	Philip	Ball
H ₂ O – a biography of water	Philip	Ball
The science of chocolate		Beckett
The big bang – A history of explosives	GI	Brown
The Elements- the new guide to the building blocks of our universe	Jack	Challoner
The joy of chemistry- The amazing science of Familiar things		Cobb, Fetterolf
Food – the chemistry of its components		Coultate
Nature's Building blocks An A to Z guide to the Element	J	Emsley
Elements of Murder – A history of poison	J	Emsley
Molecules at an exhibition	J	Emsley

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Vanity, Vitality and Virility- the science behind the products you love to buy	J	Emsley
Healthy, Wealthy, Sustainable World	J	Emsley
The Consumer's Good Chemical Guide: Separating Facts from Fiction about Everyday Products	J	Emsley
Better looking, better living, better loving : how chemistry can help you achieve life's goals	J	Emsley
The Forensic Casebook: The Science of Crime Scene Investigation		Genge
Bad science		Goldacre
The Elements- a visual exploration of every know atom in the universe	Theodore	Gray
The Disappearing Spoon...and other true tales from the Periodic Table	Sam	Kean
Caesar's last breath	Sam	Kean
Oxygen- the molecule that made the world	Nick	Lane
The truth about hormones		Parry
The Periodic Table: A Field Guide to the Elements	Paul	Parsons
The making of the atomic bomb	Richard	Rhodes
The Chemistry of Fireworks	M S	Russell
Mendeleyev's dream: the quest for elements		Strathern



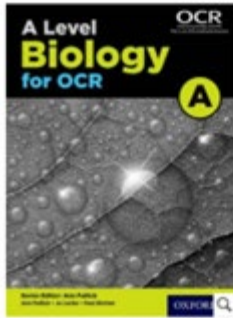
A copy of the Head Start to AS Biology revision guide from CGP that covers topics linking GCSE to A Level biology. You will be tested on similar content in September.

- Publisher: CGP
- Price: Around £5
- ISBN: 978 1 78294 279 5

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Text books

We will issue you with a text book in September but can recommend that you also buy this book. Our current Y12 and Y13 students rate it very highly. It is not an essential purchase though. **You may be able to find them second hand.**



A Level Biology for OCR A (Paperback)

Ann Fullick (author), Jo Locke (author), Paul Bircher (author)

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Transition from GCSE to A Level

Moving from GCSE Science to A Level can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

This worksheet aims to give you a head start by helping you:

- to pre-learn some useful knowledge from the first chapters of your A Level course
- understand and practise some of the maths skills you'll need.

Learning objectives

After completing the worksheet you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- perform maths skills including:
 - converting between units and standard form and decimals
 - balancing chemical equations
 - rearranging equations
 - calculating moles and masses
 - calculating percentage yield and percentage error
 - interpreting graphs of reactions.

Retrieval questions

You need to be confident about the definitions of terms that describe measurements and results in A Level Chemistry.

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

Practical science key terms

When is a measurement valid?	when it measures what it is supposed to be measuring
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the <i>same</i> person, using the <i>same</i> equipment, under the <i>same</i> conditions
What is reproducibility?	how precise repeated measurements are when they are taken by <i>different</i> people, using <i>different</i> equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values
What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

Atomic structure

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What does an atom consist of?	a nucleus containing protons and neutrons, surrounded by electrons
What are the relative masses of a proton, neutron, and electron?	1, 1, and $\frac{1}{1840}$ respectively
What are the relative charges of a proton, neutron, and electron?	+1, 0, and -1 respectively
How do the number of protons and electrons differ in an atom?	they are the same because atoms have neutral charge
What force holds an atomic nucleus together?	strong nuclear force
What is the atomic number of an element?	the number of protons in the nucleus of a single atom of an element
What is the mass number of an element?	number of protons + number of neutrons
What is an isotope?	an atom with the same number of protons but different number of neutrons
What is an ion?	an atom, or group of atoms, with a charge
What is the function of a mass spectrometer?	it accurately determines the mass and abundance of separate atoms or molecules, to help us identify them
What is a mass spectrum?	the output from a mass spectrometer that shows the different isotopes that make up an element
What is the total number of electrons that each electron shell (main energy level) can contain?	$2n^2$ electrons, where n is the number of the shell
How many electrons can the first three electron shells hold each?	2 electrons (first shell), 8 electrons (second shell), 18 electrons (third shell)
What are the first four electron sub-shells (orbitals) called?	s, p, d, and f (in order)
How many electrons can each orbital hold?	a maximum of 2 electrons
Define the term ionisation energy, and give its unit	the energy it takes to remove a mole of electrons from a mole of atoms in the gaseous state, unit = kJ mol^{-1}
What is the equation for relative atomic mass (A_r)?	relative atomic mass = $\frac{\text{average mass of 1 atom}}{\frac{1}{12} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is the equation for relative molecular mass (M_r)?	relative molecular mass = $\frac{\text{average mass of 1 molecule}}{\frac{1}{12} \text{ mass of 1 atom of } ^{12}\text{C}}$

Maths skills

1 Core mathematical skills

A practical chemist must be proficient in standard form, significant figures, decimal places, SI units, and unit conversion.

1.1 Standard form

In science, very large and very small numbers are usually written in standard form. Standard form is writing a number in the format $A \times 10^x$ where A is a number from 1 to 10 and x is the number of places you move the decimal place.

For example, to express a large number such as $50\,000 \text{ mol dm}^{-3}$ in standard form, $A = 5$ and $x = 4$ as there are four numbers after the initial 5.

Therefore, it would be written as $5 \times 10^4 \text{ mol dm}^{-3}$.

To give a small number such as $0.000\,02 \text{ Nm}^2$ in standard form, $A = 2$ and there are five numbers before it so $x = -5$.

So it is written as $2 \times 10^{-5} \text{ Nm}^2$.

Practice questions

- Change the following values to standard form.
 - boiling point of sodium chloride: $1413 \text{ }^\circ\text{C}$
 - largest nanoparticles: $0.0\,001 \times 10^{-3} \text{ m}$
 - number of atoms in 1 mol of water: 1806×10^{21}
- Change the following values to ordinary numbers.
 - 5.5×10^{-6}
 - 2.9×10^2
 - 1.115×10^4
 - 1.412×10^{-3}
 - 7.2×10^1

1.2 Significant figures and decimal places

In chemistry, you are often asked to express numbers to either three or four significant figures. The word significant means to 'have meaning'. A number that is expressed in significant figures will only have digits that are important to the number's precision.

It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

For example, 6.9301 becomes 6.93 if written to three significant figures.

Likewise, 0.000 434 56 is 0.000 435 to three significant figures.

Notice that the zeros before the figure are *not* significant – they just show you how large the number is by the position of the decimal point. Here, a 5 follows the last significant digit, so just as with decimals, it must be rounded up.

Any zeros between the other significant figures are significant. For example, 0.003 018 is 0.003 02 to three significant figures.

Sometimes numbers are expressed to a number of decimal places. The decimal point is a place holder and the number of digits afterwards is the number of decimal places.

For example, the mathematical number pi is 3 to zero decimal places, 3.1 to one decimal place, 3.14 to two decimal places, and 3.142 to three decimal places.

Practice questions

- 3 Give the following values in the stated number of significant figures (s.f.).
 a 36.937 (3 s.f.) b 258 (2 s.f.) c 0.043 19 (2 s.f.) d 7 999 032 (1 s.f.)
- 4 Use the equation:
 number of molecules = number of moles \times 6.02×10^{23} molecules per mole
 to calculate the number of molecules in 0.5 moles of oxygen. Write your answer in standard form to 3 s.f.
- 5 Give the following values in the stated number of decimal places (d.p.).
 a 4.763 (1 d.p.) b 0.543 (2 d.p.) c 1.005 (2 d.p.) d 1.9996 (3 d.p.)

1.3 Converting units

Units are defined so that, for example, every scientist who measures a mass in kilograms uses the same size for the kilogram and gets the same value for the mass. Scientific measurement depends on standard units – most are *Système International* (SI) units.

If you convert between units and round numbers properly it allows quoted measurements to be understood within the scale of the observations.

Multiplication factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n

Unit conversions are common. For instance, you could be converting an enthalpy change of $488\,889 \text{ J mol}^{-1}$ into kJ mol^{-1} . A kilo is 10^3 so you need to divide by this number or move the decimal point three places to the left.

$$488\,889 \div 10^3 \text{ kJ mol}^{-1} = 488.889 \text{ kJ mol}^{-1}$$

Converting from mJ mol^{-1} to kJ mol^{-1} , you need to go from 10^3 to 10^{-3} , or move the decimal point six places to the left.

$$333 \text{ mJ mol}^{-1} \text{ is } 0.000\,333 \text{ kJ mol}^{-1}$$

If you want to convert from 333 mJ mol^{-1} to nJ mol^{-1} , you would have to go from 10^{-9} to 10^{-3} , or move the decimal point six places to the right.

$$333 \text{ mJ mol}^{-1} \text{ is } 333\,000\,000 \text{ nJ mol}^{-1}$$

Practice questions

- 6 Calculate the following unit conversions.
- a $300 \mu\text{m}$ to m
 b 5 MJ to mJ
 c 10 GW to kW

2 Balancing chemical equations

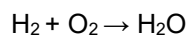
2.1 Conservation of mass

When new substances are made during chemical reactions, atoms are not created or destroyed – they just become rearranged in new ways. So, there is always the same number of each type of atom before and after the reaction, and the total mass before the reaction is the same as the total mass after the reaction. This is known as the conservation of mass.

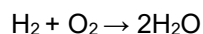
You need to be able to use the principle of conservation of mass to write formulae, and balanced chemical equations and half equations.

2.2 Balancing an equation

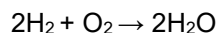
The equation below shows the correct formulae but it is not balanced.



While there are two hydrogen atoms on both sides of the equation, there is only one oxygen atom on the right-hand side of the equation against two oxygen atoms on the left-hand side. Therefore, a two must be placed before the H_2O .



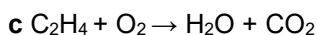
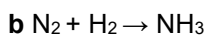
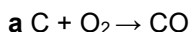
Now the oxygen atoms are balanced but the hydrogen atoms are no longer balanced. A two must be placed in front of the H_2 .



The number of hydrogen and oxygen atoms is the same on both sides, so the equation is balanced.

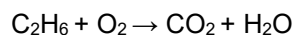
Practice questions

1 Balance the following equations.

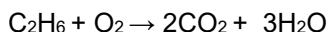


2.3 Balancing an equation with fractions

To balance the equation below:

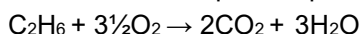


- Place a two before the CO_2 to balance the carbon atoms.
- Place a three in front of the H_2O to balance the hydrogen atoms.

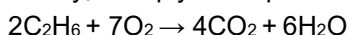


There are now four oxygen atoms in the carbon dioxide molecules plus three oxygen atoms in the water molecules, giving a total of seven oxygen atoms on the product side.

- To balance the equation, place three and a half in front of the O_2 .

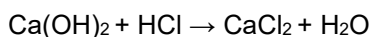


- Finally, multiply the equation by 2 to get whole numbers.



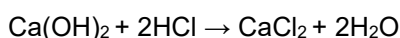
Practice questions

- 2 Balance the equations below.
- a $\text{C}_6\text{H}_{14} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- b $\text{NH}_2\text{CH}_2\text{COOH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{N}_2$

2.4 Balancing an equation with brackets

Here the brackets around the hydroxide (OH^-) group show that the $\text{Ca}(\text{OH})_2$ unit contains one calcium atom, two oxygen atoms, and two hydrogen atoms.

To balance the equation, place a two before the HCl and another before the H_2O .

**Practice questions**

- 3 Balance the equations below.
- a $\text{Mg}(\text{OH})_2 + \text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$
- b $\text{Fe}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow \text{Fe}_3(\text{PO}_4)_2 + \text{NaNO}_3$

3 Rearranging equations and calculating concentrations**3.1 Rearranging equations**

In chemistry, you sometimes need to rearrange an equation to find the desired values.

For example, you may know the amount of a substance (n) and the mass of it you have (m), and need to find its molar mass (M).

The amount of substance (n) is equal to the mass you have (m) divided by the molar mass (M):

$$n = \frac{m}{M}$$

You need to rearrange the equation to make the molar mass (M) the subject.

Multiply both sides by the molar mass (M):

$$M \times n = m$$

Then divide both sides by the amount of substance (n):

$$m = \frac{m}{N}$$

Practice questions

- 1 Rearrange the equation $c = \frac{n}{V}$ to make:
- a n the subject of the equation
- b V the subject of the equation.
- 2 Rearrange the equation $PV = nRT$ to make:
- a n the subject of the equation

b T the subject of the equation.

3.2 Calculating concentration

The concentration of a solution (a solute dissolved in a solvent) is a way of saying how much solute, in moles, is dissolved in 1 dm³ or 1 litre of solution.

Concentration is usually measured using units of mol dm⁻³. (It can also be measured in g dm³.)

The concentration of the amount of substance dissolved in a given volume of a solution is given by the equation:

$$c = \frac{n}{V}$$

where n is the amount of substance in moles, c is the concentration, and V is the volume in dm³.

The equation can be rearranged to calculate:

- the amount of substance n , in moles, from a known volume and concentration of solution
- the volume V of a solution from a known amount of substance, in moles, and the concentration of the solution.

Practice questions

- 3 Calculate the concentration, in mol dm⁻³, of a solution formed when 0.2 moles of a solute is dissolved in 50 cm³ of solution.
- 4 Calculate the concentration, in mol dm⁻³, of a solution formed when 0.05 moles of a solute is dissolved in 2.0 dm³ of solution.
- 5 Calculate the number of moles of NaOH in an aqueous solution of 36 cm³ of 0.1 mol dm⁻³.

4 Molar calculations

4.1 Calculating masses and gas volumes

The balanced equation for a reaction shows how many moles of each reactant and product are involved in a chemical reaction.

If the amount, in moles, of one of the reactants or products is known, the number of moles of any other reactants or products can be calculated.

The number of moles (n), the mass of the substance (m), and the molar mass (M) are linked by:

$$n = \frac{m}{M}$$

Note: The molar mass of a substance is the mass per mole of the substance. For CaCO₃, for example, the atomic mass of calcium is 40.1, carbon is 12, and oxygen is 16. So the molar mass of CaCO₃ is:

40.1 + 12 + (16 × 3) = 100.1. The units are g mol⁻¹.

Look at this worked example. A student heated 2.50 g of calcium carbonate, which decomposed as shown in the equation:



The molar mass of calcium carbonate is 100.1 g mol^{-1} .

- a Calculate the amount, in moles, of calcium carbonate that decomposes.

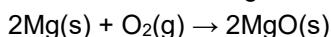
$$n = \frac{m}{M} = 2.50/100.1 = 0.025 \text{ mol}$$

- b Calculate the amount, in moles, of carbon dioxide that forms.

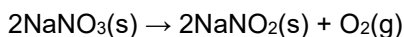
From the balanced equation, the number of moles of calcium carbonate = number of moles of carbon dioxide = 0.025 mol

Practice questions

- 1 In a reaction, 0.486 g of magnesium was added to oxygen to produce magnesium oxide.



- a Calculate the amount, in moles, of magnesium that reacted.
b Calculate the amount, in moles, of magnesium oxide made.
c Calculate the mass, in grams, of magnesium oxide made.
- 2 Oscar heated 4.25 g of sodium nitrate. The equation for the decomposition of sodium nitrate is:



- a Calculate the amount, in moles, of sodium nitrate that reacted.
b Calculate the amount, in moles, of oxygen made.
- 3 0.500 kg of magnesium carbonate decomposes on heating to form magnesium oxide and carbon dioxide. Give your answers to 3 significant figures.



- a Calculate the amount, in moles, of magnesium carbonate used.
b Calculate the amount, in moles, of carbon dioxide produced.

5 Percentage yields and percentage errors

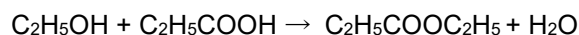
5.1 Calculating percentage yield

Chemists often find that an experiment makes a smaller amount of product than expected. They can predict the amount of product made in a reaction by calculating the percentage yield.

The percentage yield links the actual amount of product made, in moles, and the theoretical yield, in moles:

$$\text{percentage yield} = \frac{\text{actual amount (in moles) of product}}{\text{theoretical amount (in moles) of product}} \times 100$$

Look at this worked example. A student added ethanol to propanoic acid to make the ester, ethyl propanoate, and water.



The experiment has a theoretical yield of 5.00 g.

The actual yield is 4.50 g.

The molar mass of $\text{C}_2\text{H}_5\text{COOC}_2\text{H}_5 = 102.0 \text{ g mol}^{-1}$

Calculate the percentage yield of the reaction.

Actual amount of ethyl propanoate: $n = \frac{m}{M} = 4.5/102 = 0.0441 \text{ mol}$

Theoretical amount of ethyl propanoate: $n = \frac{m}{M} = 5.0/102 = 0.0490 \text{ mol}$

percentage yield = $(0.0441/0.0490) \times 100\% = 90\%$

Practice questions

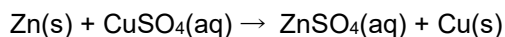
- Calculate the percentage yield of a reaction with a theoretical yield of 4.75 moles of product and an actual yield of 3.19 moles of product. Give your answer to 3 significant figures.
- Calculate the percentage yield of a reaction with a theoretical yield of 12.00 moles of product and an actual yield of 6.25 moles of product. Give your answer to 3 significant figures.

5.2 Calculating percentage error in apparatus

The percentage error of a measurement is calculated from the maximum error for the piece of apparatus being used and the value measured:

$$\text{percentage error} = \frac{\text{maximum error}}{\text{measured value}} \times 100\%$$

Look at this worked example. In an experiment to measure temperature changes, an excess of zinc powder was added to 50 cm^3 of copper(II) sulfate solution to produce zinc sulfate and copper.



The measuring cylinder used to measure the copper(II) sulfate solution has a maximum error of $\pm 2 \text{ cm}^3$.

- a** Calculate the percentage error.

$$\text{percentage error} = (2/50) \times 100\% = 4\%$$

- b** A thermometer has a maximum error of $\pm 0.05 \text{ }^\circ\text{C}$.

Calculate the percentage error when the thermometer is used to record a temperature rise of $3.9 \text{ }^\circ\text{C}$. Give your answer to 3 significant figures.

$$\text{percentage error} = (2 \times 0.05)/3.9 \times 100\% = 2.56\%$$

(Notice that two measurements of temperature are required to calculate the temperature change so the maximum error is doubled.)

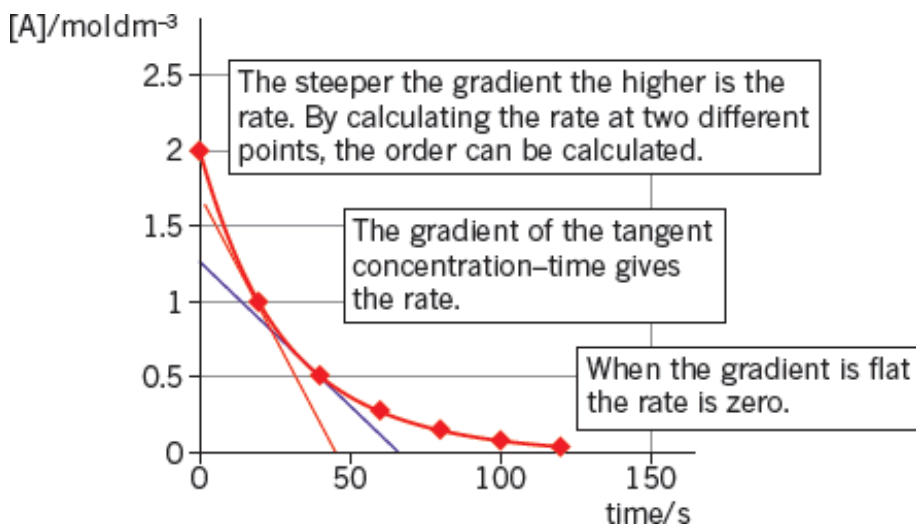
Practice questions

- A gas syringe has a maximum error of $\pm 0.5 \text{ cm}^3$. Calculate the maximum percentage error when recording these values. Give your answers to 3 significant figures.
 - 21.0 cm^3
 - 43.0 cm^3
- A thermometer has a maximum error of $\pm 0.5 \text{ }^\circ\text{C}$. Calculate the maximum percentage error when recording these temperature rises. Give your answers to 3 significant figures.
 - $12.0 \text{ }^\circ\text{C}$
 - $37.6 \text{ }^\circ\text{C}$

6 Graphs and tangents

6.1 Deducing reaction rates

To investigate the reaction rate during a reaction, you can measure the volume of the product formed, such as a gas, or the colour change to work out the concentration of a reactant during the experiment. By measuring this concentration at repeated intervals, you can plot a concentration–time graph.



Note: When a chemical is listed in square brackets, it just means ‘the concentration of’ that chemical. For example, $[O_2]$ is just shorthand for the concentration of oxygen molecules.

By measuring the gradient (slope) of the graph, you can calculate the rate of the reaction. In the graph above, you can see that the gradient changes as the graph is a curve. If you want to know the rate of reaction when the graph is curved, you need to determine the gradient of the curve. So, you need to plot a tangent.

The tangent is the straight line that just touches the curve. The gradient of the tangent is the gradient of the curve at the point where it touches the curve.

Looking at the graph above. When the concentration of A has halved to 1.0 mol dm^{-3} , the tangent intercepts the y -axis at 1.75 and the x -axis at 48 .

The gradient is $\frac{-1.75}{48} = -0.0365$ (3 s.f.).

So the rate is $0.0365 \text{ mol dm}^{-3} \text{ s}^{-1}$.

Practice questions

- Using the graph above, calculate the rate of reaction when the concentration of A halves again to 0.5 mol dm^{-3} .

6.2 Deducing the half-life of a reactant

In chemistry, half-life can also be used to describe the decrease in concentration of a reactant in a reaction. In other words, the half-life of a reactant is the time taken for the concentration of the reactant to fall by half.

Practice questions

- 2 The table below shows the change in concentration of bromine during the course of a reaction.

Time / s	[Br ₂] / mol dm ⁻³
0	0.0100
60	0.0090
120	0.0066
180	0.0053
240	0.0044
360	0.0028

- a Plot a concentration–time graph for the data in the table.
b Calculate the rate of decrease of Br₂ concentration by drawing tangents.
c Find the half-life at two points and deduce the order of the reaction.

Answers to maths skills practice questions

1 Core mathematics

- 1 a 1.413×10^3 °C b 1.0×10^{-7} m
c 1.806×10^{21} atoms
- 2 a 0.000 0055 b 290
c 11150 d 0.001 412
e 72
- 3 a 36.9 b 260
c 0.043 d 8 000 000
- 4 Number of molecules = $0.5 \text{ moles} \times 6.022 \times 10^{23} = 3.011 \times 10^{23} = 3.01 \times 10^{23}$
- 5 a 4.8 b 0.54
c 1.01 d 2.000
- 6 a 0.0003 m b 5×10^9 mJ
c 1×10^7 kW

2 Balancing chemical equations

- 1 a $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$ b $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
c $\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{H}_2\text{O} + 2\text{CO}_2$
- 2 a $\text{C}_6\text{H}_{14} + 9\frac{1}{2}\text{O}_2 \rightarrow 6\text{CO}_2 + 7\text{H}_2\text{O}$ or $2\text{C}_6\text{H}_{14} + 19\text{O}_2 \rightarrow 12\text{CO}_2 + 14\text{H}_2\text{O}$
b $2\text{NH}_2\text{CH}_2\text{COOH} + 4\frac{1}{2}\text{O}_2 \rightarrow 4\text{CO}_2 + 5\text{H}_2\text{O} + \text{N}_2$
or $4\text{NH}_2\text{CH}_2\text{COOH} + 9\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O} + 2\text{N}_2$
- 3 a $\text{Mg}(\text{OH})_2 + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{H}_2\text{O}$
b $3\text{Fe}(\text{NO}_3)_2 + 2\text{Na}_3\text{PO}_4 \rightarrow \text{Fe}_3(\text{PO}_4)_2 + 6\text{NaNO}_3$

3 Rearranging equations and calculating concentrations

- 1 a $n = cv$ b $v = \frac{n}{c}$
- 2 a $n = \frac{PV}{RT}$ b $T = \frac{PV}{nR}$
- 3 $\frac{0.2}{0.050} = 4.0 \text{ mol dm}^{-3}$
- 4 $\frac{0.05}{2} = 0.025 \text{ mol dm}^{-3}$
- 5 $\frac{36}{1000} \times 0.1 = 3.6 \times 10^{-3} \text{ mol}$

4 Molar calculations

- 1 a $\frac{0.486}{24.3} = 0.02 \text{ mol}$ b 0.02 mol
c $0.02 \times 40.3 = 0.806 \text{ g}$

2 a $\frac{4.25}{85} = 0.05 \text{ mol}$ b $\frac{0.05}{2} = 0.025 \text{ mol}$

3 a $\frac{500}{84.3} = 5.93 \text{ mol}$ b 5.93 mol

5 Percentage yields and percentage errors

1 $3.19/4.75 \times 100 = 67.2\%$

2 $6.25/12.00 \times 100 = 52.1\%$

3 a $0.5/21 \times 100 = 2.38\%$

b $0.5/43 \times 100 = 1.16\%$

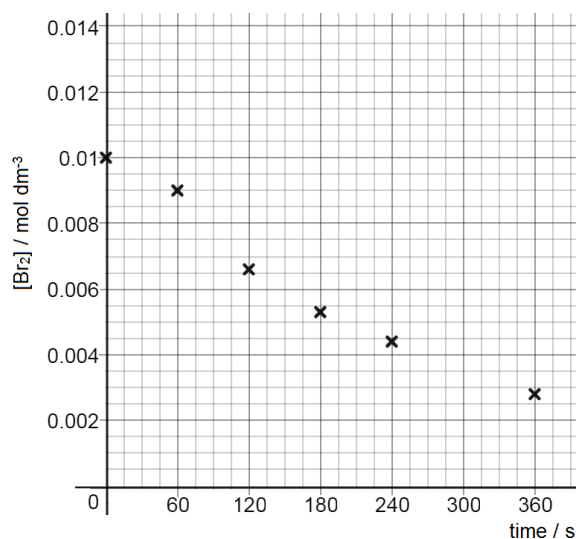
4 a $0.5 \times (2/12) \times 100 = 8.33\%$

b $0.5 \times (2/37.6) \times 100 = 2.66\%$

6 Graphs and tangents

1 $\frac{-1.25}{65} = -0.0192$

2 a



b Half-life is approximately 180 seconds

c The reaction is first order