

Transition guide

This resource is to help students make the transition from GCSE to AS or A-level Chemistry.

Contents

| | |
|---|----|
| You're studying AS or A-level Chemistry, congratulations! | 3 |
| Why study A-level Chemistry? | 3 |
| Possible degree options | 3 |
| Which career appeals to you? | 4 |
| Specification at a glance | 5 |
| Should you study an AS or A-level? | 6 |
| The assessment for the AS consists of two exams | 7 |
| The assessment for the A-level consists of three exams | 8 |
| Places to go for help | 9 |
| Useful information and activities | 11 |
| Greek letters | 11 |
| SI units | 13 |
| Important vocabulary for practical work | 16 |
| Precise language | 17 |
| The periodic table | 17 |
| Relative atomic mass | 20 |
| Relative formula mass | 21 |
| Common ions | 22 |
| Diatomic molecules | 25 |
| Common compounds | 25 |
| Balancing equations | 26 |
| Moles | 28 |
| Empirical formula | 29 |

You're studying AS or A-level Chemistry, congratulations!

Studying chemistry after your GCSEs really develops your practical and mathematical skills. If you enjoy experimenting in the lab, you'll love it.

At first, you may find the jump in demand from GCSE a little daunting, but if you follow the tips and advice in this guide, you'll soon adapt.

We recommend you keep this somewhere safe, as you may like to refer to the information inside throughout your studies.

Why study A-level Chemistry?

Chemistry students get to investigate a huge range of ideas: the big question you'll ask yourself is 'what is the world made of?' If you choose it as career, you have the potential to help solve all sorts of problems. You could work on a cure for cancer, or you might develop a new food: the possibilities are endless.

Even if you don't decide to work in chemistry, studying it still develops useful and transferable skills for other careers. You'll develop research, problem solving and analytical skills, alongside teamwork and communication. Universities and businesses regard all of these very highly.

Possible degree options

According to [bestcourse4me.com](https://www.bestcourse4me.com), the top five degree courses taken by students who have A-level Chemistry are:

- Chemistry
- Biology
- Pre-clinical medicine
- Mathematics
- Pharmacology.

For more details, go to the [bestcourse4me.com](https://www.bestcourse4me.com) website, or [UCAS](https://www.ucas.ac.uk).

Which career appeals to you?

Studying Chemistry at A-level or degree opens up plenty of career opportunities, such as:

- analytical chemist
- chemical engineer
- clinical biochemist
- pharmacologist
- doctor
- research scientist (physical sciences)
- toxicologist
- environmental consultant
- higher education lecturer or secondary school teacher
- patent attorney
- science writer.

Specification at a glance

AS and A-level

Physical chemistry

- Atomic structure
- Amount of substance
- Bonding
- Energetics
- Kinetics
- Chemical equilibria, Le Chatelier's principle and K_c
- Oxidation, reduction and redox equations

Inorganic chemistry

- Periodicity
- Group 2, the alkaline earth metals
- Group 7 (17), the halogens

Organic chemistry

- Introduction to organic chemistry
- Alkanes
- Halogenoalkanes
- Alkenes
- Alcohols
- Organic analysis

A-level only topics

Physical chemistry

- Thermodynamics
- Rate equations
- Equilibrium constant K_p for homogeneous systems
- Electrode potentials and electrochemical cells
- Acids and bases

Inorganic chemistry

- Properties of Period 3 elements and oxides
- Transition metals
- Reactions of ions in aqueous solution

Organic chemistry

- Optical isomerism
- Aldehydes and ketones
- Carboxylic acids and derivatives
- Aromatic chemistry
- Amines
- Polymers
- Amino acids, proteins and DNA
- Organic synthesis
- NMR spectroscopy
- Chromatography

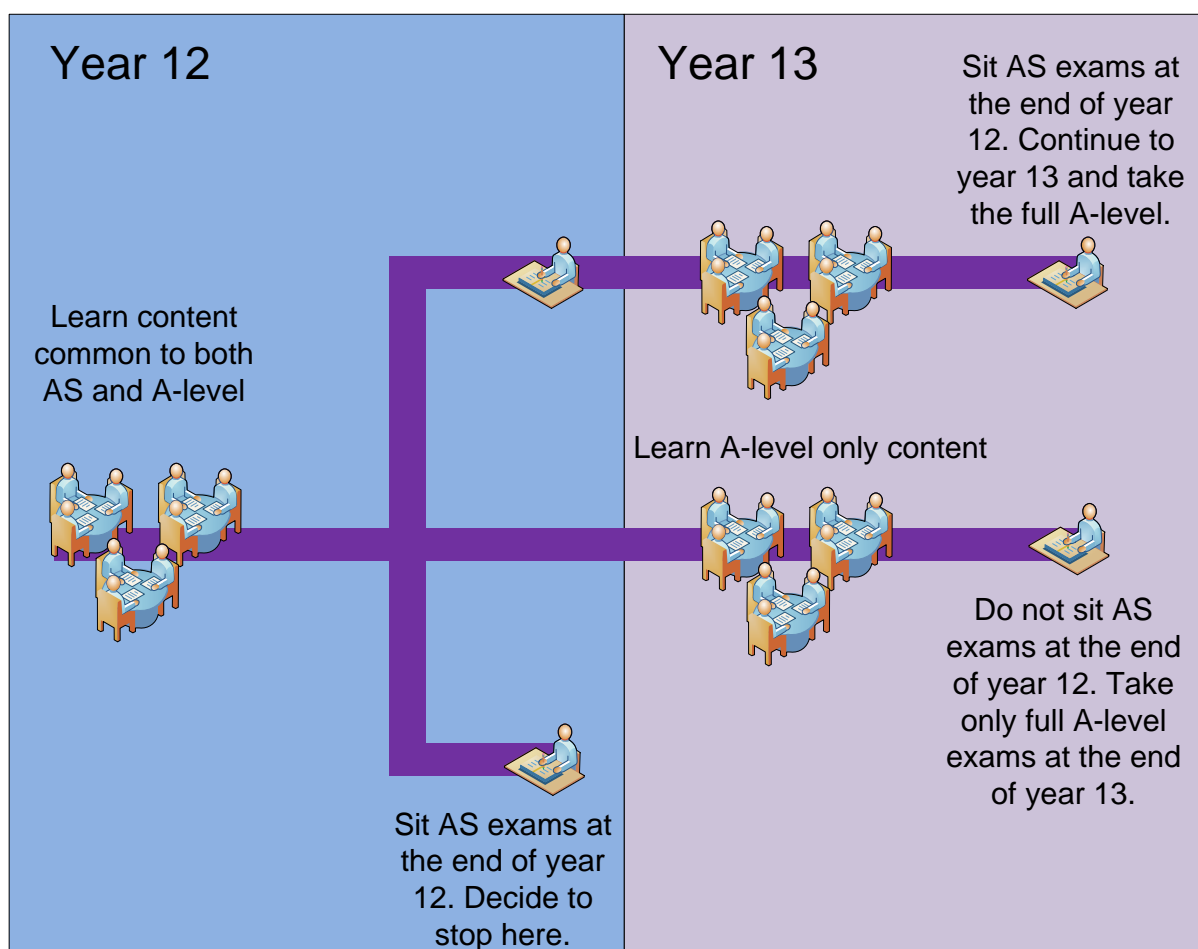
Should you study AS or A-level?

AS and A-level are separate qualifications.

An AS lasts one year. Your exam results don't count towards an A-level, but they're still valuable and AS UCAS points are accepted by higher education institutions.

Despite being separate to an A-level, AS course content is the same as the first year of A-level. If you want to switch from an AS to an A-level, you can. Your teacher will help you decide whether it's the right move for you.

All exams for the AS take place at the end of the one-year course. Exams for the A-level take place at the end of the two-year course.



The assessment for the AS consists of two exams

| Paper 1 | + | Paper 2 |
|---|---|--|
| What's assessed <ul style="list-style-type: none">• Relevant Physical chemistry topics (sections 3.1.1 to 3.1.4, 3.1.6 and 3.1.7)• Inorganic chemistry (section 3.2.1 to 3.2.3)• Relevant practical skills | | What's assessed <ul style="list-style-type: none">• Relevant Physical chemistry topics (sections 3.1.2 to 3.1.6)• Organic chemistry (section 3.3.1 to 3.3.6)• Relevant practical skills |
| How it's assessed <ul style="list-style-type: none">• Written exam: 1 hour 30 minutes• 80 marks• 50% of the AS | | How it's assessed <ul style="list-style-type: none">• Written exam: 1 hour 30 minutes• 80 marks• 50% of the AS |
| Questions <ul style="list-style-type: none">• 65 marks of short and long answer questions• 15 marks of multiple choice questions | | Questions <ul style="list-style-type: none">• 65 marks of short and long answer questions• 15 marks of multiple choice questions |

The assessment for the A-level consists of three exams

| Paper 1 | + | Paper 2 | + | Paper 3 |
|--|---|---|---|---|
| What's assessed <ul style="list-style-type: none"> • Relevant Physical chemistry topics (sections 3.1.1 to 3.1.4, 3.1.6 to 3.1.8 and 3.1.10 to 3.1.12) • Inorganic chemistry (section 3.2) • Relevant practical skills | | What's assessed <ul style="list-style-type: none"> • Relevant Physical chemistry topics (sections 3.1.2 to 3.1.6 and 3.1.9) • Organic chemistry (section 3.3) • Relevant practical skills | | What's assessed <ul style="list-style-type: none"> • Any content • Any practical skills |
| How it's assessed <ul style="list-style-type: none"> • Written exam: 2 hours • 105 marks • 35% of A-level | | How it's assessed <ul style="list-style-type: none"> • Written exam: 2 hours • 105 marks • 35% of A-level | | How it's assessed <ul style="list-style-type: none"> • Written exam: 2 hours • 90 marks • 30% of A-level |
| Questions <ul style="list-style-type: none"> • 105 marks of short and long answer questions | | Questions <ul style="list-style-type: none"> • 105 marks of short and long answer questions | | Questions <ul style="list-style-type: none"> • 40 marks of questions on practical techniques and data analysis • 20 marks of questions testing across the specification • 30 marks of multiple choice questions |

Places to go for help

1. Our website is a great place to start.

Our AS and A-level [Chemistry webpages](#) are aimed at teachers, but you may find them useful too. Information includes:

- The [specification](#) – this explains exactly what you need to learn for your exams.
- [Practice exam papers](#).
- Lists of [command words](#) and [subject specific vocabulary](#) – so you understand the words to use in exams.
- [Practical handbooks](#) explain the practical work you need to know.
- Past papers from the [old specification](#). Some questions won't be relevant to the new AS and A-level so please check with your teacher.
- [Maths skills support](#).
- [Web resources page](#) with many links to other resources to support study.

2. The Royal Society of Chemistry (RSC)

The RSC do everything from naming new elements and lobbying MPs, to improving funding for research sciences in the UK.

You'll find lots of handy resources on their [website](#).

3. The student room

Join the A-level Chemistry forums and share thoughts and ideas with other students if you're stuck with your homework. Just be very careful not to share any details about your assessments, there are serious consequences if you're caught cheating. Visit thestudentroom.co.uk

4. Textbooks

Our [approved textbooks](#) are published by Collins, Hodder and Oxford University Press. Textbooks from other publishers will also be suitable, but you'll need to double check that the content and formula symbols they use match our specification.

5. Revision guides

These are great if you want a quick overview of the course when you're revising for your exams. Remember to use other tools as well, as these aren't detailed enough on their own.

6. YouTube

YouTube has thousands of Chemistry videos. Just be careful to look at who produced the video and why, because some videos distort the facts. Check the author, date and comments – these help indicate whether the clip is reliable. If in doubt, ask your teacher.

7. Magazines

Focus, New Scientist or Philip Allan updates can help you put the chemistry you're learning in context.

Useful information and activities

There are a number of activities throughout this resource. The answers to some of the activities are available on our secure website, e-AQA. Your teacher will be able to provide you with these answers.

Greek letters

Greek letters are used often in science. They can be used as symbols for numbers (such as $\pi = 3.14\dots$), as prefixes for units to make them smaller (eg $\mu\text{m} = 0.000\,000\,001\text{ m}$) or as symbols for particular quantities (such as λ which is used for wavelength).

The Greek alphabet is shown below.

| | | |
|-----------|------------|---------|
| A | α | alpha |
| B | β | beta |
| Γ | γ | gamma |
| Δ | δ | delta |
| E | ϵ | epsilon |
| Z | ζ | zeta |
| H | η | eta |
| Θ | θ | theta |
| I | ι | iota |
| K | κ | kappa |
| Λ | λ | lambda |
| M | μ | mu |

| | | |
|----------|-------------------------|---------|
| N | ν | nu |
| Ξ | ξ | ksi |
| O | \omicron | omicron |
| Π | π | pi |
| P | ρ | rho |
| Σ | ς or σ | sigma |
| T | τ | tau |
| Y | υ | upsilon |
| Φ | ϕ | phi |
| X | χ | chi |
| Ψ | ψ | psi |
| Ω | ω | omega |

Activity 1

A lot of English words are derived from Greek ones, but it's difficult to see as the alphabet is so different.

Many of the Greek letters are pronounced like the start of their name. For example, omega is pronounced "o", sigma is pronounced "s" and lambda is pronounced "l".

See if you can work out what the following Greek words mean by comparing the phonetic spelling with similar English words.

| |
|-------------|
| Πυθαγόρας |
| Ωκεανος |
| μόνος |
| Τηλε |
| Τρωγλοδύτης |

| |
|--------------------------------|
| Name of a mathematician |
| Atlantic, Pacific or Arctic... |
| Single |
| Far or distant |
| Cave dweller |

SI units

Every measurement must have a size (eg 2.7) and a unit (eg metres or °C). Sometimes there are different units available for the same type of measurement, for example ounces, pounds, kilograms and tonnes are all used as units for mass.

To reduce confusion and to help with conversion between different units, there is a standard system of units called the SI units which are used for most scientific purposes.

These units have all been defined by experiment so that the size of, say, a metre in the UK is the same as a metre in China.

The seven SI base units are:

| Physical quantity | Usual quantity symbol | Unit | Abbreviation |
|---------------------|-----------------------|----------|--------------|
| mass | m | kilogram | kg |
| length | l or x | metre | m |
| time | t | second | s |
| electric current | I | ampere | A |
| temperature | T | kelvin | K |
| amount of substance | N | mole | mol |
| luminous intensity | (not used at A-level) | candela | cd |

All other units can be derived from the SI base units.

For example, area is measured in square metres (written as m^2) and speed is measured in metres per second (written as ms^{-1}).

It is not always appropriate to use a full unit. For example, measuring the width of a hair or the distance from Manchester to London in metres would cause the numbers to be difficult to work with.

Prefixes are used to multiply each of the units. You will be familiar with centi (meaning 1/100), kilo (1000) and milli (1/1000) from centimetres, kilometres and millimetres.

There is a wide range of prefixes. The majority of quantities in scientific contexts will be quoted using the prefixes that are multiples of 1000. For example, a distance of 33 000 m would be quoted as 33 km.

The most common prefixes you will encounter are:

| Prefix | Symbol | Multiplication factor | | |
|--------|--------|-----------------------|-----------------------|-------------------------|
| Tera | T | 10^{12} | 1 000 000 000 000 | |
| Giga | G | 10^9 | 1 000 000 000 | |
| Mega | M | 10^6 | 1 000 000 | |
| kilo | k | 10^3 | 1000 | |
| deci | d | 10^{-1} | 0.1 | 1/10 |
| centi | c | 10^{-2} | 0.01 | 1/100 |
| milli | m | 10^{-3} | 0.001 | 1/1000 |
| micro | μ | 10^{-6} | 0.000 001 | 1/1 000 000 |
| nano | n | 10^{-9} | 0.000 000 001 | 1/1 000 000 000 |
| pico | p | 10^{-12} | 0.000 000 000 001 | 1/1 000 000 000 000 |
| femto | f | 10^{-15} | 0.000 000 000 000 001 | 1/1 000 000 000 000 000 |

Activity 2

Which SI unit and prefix would you use for the following quantities?

1. The mass of water in a test tube.
2. The time taken for a solution to change colour.
3. The radius of a gold atom.
4. The volume of water in a burette.
5. The amount of substance in a beaker of sugar.
6. The temperature of the blue flame from a Bunsen burner.

Sometimes, there are units that are used that are not combinations of SI units and prefixes.

These are often multiples of units that are helpful to use. For example, one litre is 0.001 m^3 .

Activity 3

Rewrite the following in SI units.

1. 5 minutes
2. 2 days
3. 5.5 tonnes

Activity 4

Rewrite the following quantities.

1. 0.00122 metres in millimetres
2. 104 micrograms in grams
3. 1.1202 kilometres in metres
4. 70 decilitres in millilitres
5. 70 decilitres in litres
6. 10 cm^3 in litres

Important vocabulary for practical work

There are many words used in practical work. You will have come across most of these words in your GCSE studies. It is important you are using the right definition for each word.

Activity 5

Join the boxes to link the word to its definition.

Accurate

A statement suggesting what may happen in the future.

Data

An experiment that gives the same results when a different person carries it out, or a different technique or set of equipment is used.

Precise

A measurement that is close to the true value.

Prediction

An experiment that gives the same results when the same experimenter uses the same method and equipment.

Range

Physical, chemical or biological quantities or characteristics.

Repeatable

A variable that is kept constant during an experiment.

Reproducible

A variable that is measured as the outcome of an experiment.

Resolution

This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.

Uncertainty

The interval within the true value can be expected to lie.

Variable

The spread of data, showing the maximum and minimum values of the data.

Control variable

Measurements where repeated measurements show very little spread.

Dependent variable

Information, in any form, that has been collected.

Precise language

It is essential at AS and A-level to use precise language when you write reports and when you answer examination questions. You must always demonstrate that you understand a topic by using the correct and appropriate terms.

For example, you should take care when discussing bonding to refer to the correct particles and interactions between them.

Also, when discussing the interaction between particles in an ionic solid, you would demonstrate a lack of understanding if you referred to the particles as atoms or molecules instead of ions or the interaction between these ions as intermolecular forces rather than electrostatic forces. In this case, use of the incorrect terms would result in the loss of all the marks available for that part of a question.

Take care also to use the word 'chloride' and not 'chlorine' when referring to the ions in a compound such as sodium chloride. The word 'chlorine' should only be used for atoms or molecules of the element.

The periodic table

The periodic table of elements is shown on the back page of this booklet. The A-level course will build on what you've learned in your GCSE studies.

Activity 6

On the periodic table on the following page:

- Draw a line showing the metals and non-metals.
- Colour the transition metals blue.
- Colour the halogens yellow.
- Colour the alkali metals red.
- Colour the noble gases green.
- Draw a blue arrow showing the direction of periods.
- Draw a red arrow showing the direction of groups.
- Draw a blue ring around the symbols for all gases.
- Draw a red ring around the symbols for all liquids.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 |
|--|---|---|---|---|---|---|---|---|
| | | | | | | | | (18) |
| | | | | | | | | 4.0 He helium 2 |
| | | | | | | | | 20.2 Ne neon 10 |
| | | | | | | | | 19.0 F fluorine 9 |
| | | | | | | | | 35.5 Cl chlorine 17 |
| | | | | | | | | 39.9 Ar argon 18 |
| | | | | | | | | 83.8 Kr krypton 36 |
| | | | | | | | | 126.9 I iodine 53 |
| | | | | | | | | [222] Rn radon 86 |
| | | | | | | | | 175.0 Lu lutetium 71 |
| | | | | | | | | 173.1 Yb ytterbium 70 |
| | | | | | | | | [259] No nobelium 102 |
| | | | | | | | | 168.9 Tm thulium 69 |
| | | | | | | | | [258] Md mendelevium 101 |
| | | | | | | | | 167.3 Er erbium 68 |
| | | | | | | | | [257] Fm fermium 100 |
| | | | | | | | | 164.9 Ho holmium 67 |
| | | | | | | | | [252] Es einsteinium 99 |
| | | | | | | | | 162.5 Dy dysprosium 66 |
| | | | | | | | | [251] Cf californium 98 |
| | | | | | | | | 158.9 Tb terbium 65 |
| | | | | | | | | [247] Bk berkelium 97 |
| | | | | | | | | 157.3 Gd gadolinium 64 |
| | | | | | | | | [247] Cm curium 96 |
| | | | | | | | | 152.0 Eu europium 63 |
| | | | | | | | | [243] Am americium 95 |
| | | | | | | | | 150.4 Sm samarium 62 |
| | | | | | | | | [244] Pu plutonium 94 |
| | | | | | | | | [145] Pm promethium 61 |
| | | | | | | | | [237] Np neptunium 93 |
| | | | | | | | | 144.2 Nd neodymium 60 |
| | | | | | | | | 238.0 U uranium 92 |
| | | | | | | | | 140.9 Pr praseodymium 59 |
| | | | | | | | | 231.0 Pa protactinium 91 |
| | | | | | | | | 140.1 Ce cerium 58 |
| | | | | | | | | 232.0 Th thorium 90 |
| | | | | | | | | 137.3 Ba barium 56 |
| | | | | | | | | [226] Ra radium 88 |
| | | | | | | | | 132.9 Cs caesium 55 |
| | | | | | | | | [227] Ac † actinium 89 |
| | | | | | | | | 180.9 Ta tantalum 73 |
| | | | | | | | | [268] Db dubnium 105 |
| | | | | | | | | [271] Sg seaborgium 106 |
| | | | | | | | | [272] Bh bohrium 107 |
| | | | | | | | | [270] Hs hassium 108 |
| | | | | | | | | [276] Mt meitnerium 109 |
| | | | | | | | | [281] Ds darmstadtium 110 |
| | | | | | | | | [280] Rg roentgenium 111 |
| | | | | | | | | 107.9 Ag silver 47 |
| | | | | | | | | 197.0 Au gold 79 |
| | | | | | | | | 200.6 Hg mercury 80 |
| | | | | | | | | 112.4 Cd cadmium 48 |
| | | | | | | | | 114.8 In indium 49 |
| | | | | | | | | 118.7 Sn tin 50 |
| | | | | | | | | 121.8 Sb antimony 51 |
| | | | | | | | | 127.6 Te tellurium 52 |
| | | | | | | | | 209.0 Po polonium 84 |
| | | | | | | | | 207.2 Pb lead 82 |
| | | | | | | | | 208.0 Bi bismuth 83 |
| | | | | | | | | 204.4 Tl thallium 81 |
| | | | | | | | | 114.8 In indium 49 |
| | | | | | | | | 112.4 Cd cadmium 48 |
| | | | | | | | | 65.4 Zn zinc 30 |
| | | | | | | | | 63.5 Cu copper 29 |
| | | | | | | | | 58.7 Ni nickel 28 |
| | | | | | | | | 106.4 Pd palladium 46 |
| | | | | | | | | 102.9 Rh rhodium 45 |
| | | | | | | | | 101.1 Ru ruthenium 44 |
| | | | | | | | | 55.8 Fe iron 26 |
| | | | | | | | | 54.9 Mn manganese 25 |
| | | | | | | | | [98] Tc technetium 43 |
| | | | | | | | | 96.0 Mo molybdenum 42 |
| | | | | | | | | 92.9 Nb niobium 41 |
| | | | | | | | | 91.2 Zr zirconium 40 |
| | | | | | | | | 88.9 Y yttrium 39 |
| | | | | | | | | 87.6 Sr strontium 38 |
| | | | | | | | | 186.2 Re rhenium 75 |
| | | | | | | | | 183.8 W tungsten 74 |
| | | | | | | | | 180.9 Ta tantalum 73 |
| | | | | | | | | [268] Db dubnium 105 |
| | | | | | | | | [271] Sg seaborgium 106 |
| | | | | | | | | [272] Bh bohrium 107 |
| | | | | | | | | [270] Hs hassium 108 |
| | | | | | | | | [276] Mt meitnerium 109 |
| | | | | | | | | [281] Ds darmstadtium 110 |
| | | | | | | | | [280] Rg roentgenium 111 |
| | | | | | | | | 197.0 Au gold 79 |
| | | | | | | | | 200.6 Hg mercury 80 |
| | | | | | | | | 204.4 Tl thallium 81 |
| | | | | | | | | 207.2 Pb lead 82 |
| | | | | | | | | 209.0 Bi bismuth 83 |
| | | | | | | | | [209] Po polonium 84 |
| | | | | | | | | [210] At astatine 85 |
| | | | | | | | | 126.9 I iodine 53 |
| | | | | | | | | 79.9 Br bromine 35 |
| | | | | | | | | 35.5 Cl chlorine 17 |
| | | | | | | | | 32.1 S sulfur 16 |
| | | | | | | | | 31.0 P phosphorus 15 |
| | | | | | | | | 28.1 Si silicon 14 |
| | | | | | | | | 27.0 Al aluminium 13 |
| | | | | | | | | 16.0 O oxygen 8 |
| | | | | | | | | 14.0 N nitrogen 7 |
| | | | | | | | | 12.0 C carbon 6 |
| | | | | | | | | 10.8 B boron 5 |
| | | | | | | | | 4.0 He helium 2 |

| Key | |
|------------------------|--|
| relative atomic mass | |
| symbol | |
| name | |
| atomic (proton) number | |

| |
|----------------------------------|
| 1.0 H hydrogen 1 |
|----------------------------------|

* 58 – 71 Lanthanides

† 90 – 103 Actinides

Elements with atomic numbers 112-116 have been reported but not fully authenticated

Activity 7

Use the periodic table to find the following:

1. The atomic number of: osmium, sodium, lead, chlorine.
2. The relative atomic mass of: helium, barium, europium, oxygen.
3. The number of protons in: mercury, iodine, calcium.
4. The symbol for: gold, lead, copper, iron.
5. The name of: Sr, Na, Ag, Hg.
6. THInK can be written using a combination of the symbols for Thorium, Indium and Potassium (ThInK). Which combinations of element symbols could be used to make the following words?

AMERICA, FUN, PIRATE, LIFESPAN, FRACTION, EROSION, DYNAMO

Activity 8: research activity

Research either:

The history of the periodic table

OR

The history of models of atomic structure.

Present your findings as a timeline. You should include the work of at least four people. For each, explain what evidence or experiments they used and how this changed the understanding of chemistry.

Relative atomic mass (A_r)

If there are several isotopes of an element, the relative atomic mass will take into account the proportion of atoms in a sample of each isotope.

For example, chlorine gas is made up of 75% of chlorine-35 ${}^{35}_{17}\text{Cl}$ and 25% of chlorine-37 ${}^{37}_{17}\text{Cl}$.

The relative atomic mass of chlorine is therefore the mean atomic mass of the atoms in a sample, and is calculated by:

$$A_r = \left(\frac{75.0}{100} \times 35\right) + \left(\frac{25.0}{100} \times 37\right) = 26.25 + 9.25 = 35.5$$

Activity 9

1. What is the relative atomic mass of Bromine, if the two isotopes, ${}^{79}\text{Br}$ and ${}^{81}\text{Br}$, exist in equal amounts?
2. Neon has three isotopes. ${}^{20}\text{Ne}$ accounts for 90.9%, ${}^{21}\text{Ne}$ accounts for 0.3% and the last 8.8% of a sample is ${}^{22}\text{Ne}$. What is the relative atomic mass of neon?
3. Magnesium has the following isotope abundances: ${}^{24}\text{Mg}$: 79.0%; ${}^{25}\text{Mg}$: 10.0% and ${}^{26}\text{Mg}$: 11.0%. What is the relative atomic mass of magnesium?

Harder:

4. Boron has two isotopes, ${}^{10}\text{B}$ and ${}^{11}\text{B}$. The relative atomic mass of boron is 10.8. What are the percentage abundances of the two isotopes?
5. Copper's isotopes are ${}^{63}\text{Cu}$ and ${}^{65}\text{Cu}$. If the relative atomic mass of copper is 63.5, what are the relative abundances of these isotopes?

Relative formula mass (M_r)

Carbon dioxide, CO_2 has 1 carbon atom ($A_r = 12.0$) and two oxygen atoms ($A_r = 16.0$). The relative formula mass is therefore

$$M_r = (12.0 \times 1) + (16.0 \times 2) = 44.0$$

Magnesium hydroxide $\text{Mg}(\text{OH})_2$ has one magnesium ion ($A_r = 24.3$) and two hydroxide ions, each with one oxygen ($A_r = 16.0$) and one hydrogen ($A_r = 1.0$).

The relative formula mass is therefore:

$$(24.3 \times 1) + (2 \times (16.0 + 1.0)) = 58.3$$

Activity 10

Calculate the relative formula mass of the following compounds:

1. Magnesium oxide MgO
2. Sodium hydroxide NaOH
3. Copper sulfate CuSO_4
4. Ammonium chloride NH_4Cl
5. Ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$

Common ions

| Positive ions (cations) | | Negative ions (anions) | |
|-------------------------|------------------------------|------------------------|-------------------------------|
| Name | Symbol | Name | Symbol |
| Hydrogen | H ⁺ | Hydroxide | OH ⁻ |
| Sodium | Na ⁺ | Chloride | Cl ⁻ |
| Lithium | Li ⁺ | Bromide | Br ⁻ |
| Silver | Ag ⁺ | Oxide | O ²⁻ |
| Magnesium | Mg ²⁺ | Hydrogencarbonate | HCO ₃ ⁻ |
| Calcium | Ca ²⁺ | Nitrate | NO ₃ ⁻ |
| Zinc | Zn ²⁺ | Sulfate | SO ₄ ²⁻ |
| Aluminium | Al ³⁺ | Carbonate | CO ₃ ²⁻ |
| Ammonium | NH ₄ ⁺ | Phosphate | PO ₄ ³⁻ |

Some elements have more than one charge. For example, iron can form ions with a charge of +2 or +3. Compounds containing these are named Iron(II) and Iron(III) respectively.

Other common elements with more than one charge include:

Chromium(II) and chromium(III)

Copper(I) and copper(II)

Lead(II) and lead(IV)

Activity 11

On the periodic table on the following page, colour elements that form one atom ions (eg Na⁺ or O²⁻) according to the following key:

| Charge | Colour |
|--------|--------|
| +1 | red |
| +2 | yellow |
| +3 | green |
| -1 | blue |
| -2 | brown |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|-----------------------------|----------------------------|-------------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------------------------|-------------------------------|--------------------------|----------------------------|----------------------------|----------------------------|--------------------------|-----------------------------|-------------------------------|-----------------------------|------------------------------|-----------------------------|-----------------------------|-------------------------------|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|----------------------------------|---------------------------------|----------------------------|----------------------------|--------------------------------|-------------------------------|--------------------------|-----------------------------|------------------------------|-----------------------------|--------------------------------|------------------------------|--------------------------------|-----------------------------|------------------------------|-------------------------------|---------------------------|------------------------------|-------------------------------|---------------------------|------------------------------|-------------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------------|--------------------------------|---------------------------------|-------------------------------|-------------------------------|---------------------------------|------------------------------|---------------------------------|------------------------------|-----------------------------|------------------------------|--------------------------------|-------------------------------|------------------------------|-----------------------------------|-----------------------------|--------------------------------|--------------------------------|--------------------------------|-----------------------------|----------------------------------|----------------------------------|-------------------------------|-----------------------------------|--------------------------------|----------------------------------|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | 23.3 Na sodium 11 | 24.3 Mg magnesium 12 | 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.9 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 83.8 Kr krypton 36 | 85.5 Br bromine 35 | 88.9 Sr strontium 37 | 87.6 Rb rubidium 38 | 88.9 Y yttrium 39 | 88.9 La * lanthanum 57 | 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La * lanthanum 57 | 138.9 Ac † actinium 89 | 137.3 Xe xenon 54 | 126.9 I iodine 53 | 127.6 Te tellurium 52 | 121.8 Sb antimony 51 | 118.7 Sn tin 50 | 114.8 In indium 49 | 112.4 Cd cadmium 48 | 107.9 Ag silver 47 | 106.4 Pd palladium 46 | 102.9 Rh rhodium 45 | 101.1 Ru ruthenium 44 | 101.1 Os osmium 76 | 190.2 Ir iridium 77 | 192.2 Pt platinum 78 | 195.1 Au gold 79 | 197.0 Hg mercury 80 | 200.6 Tl thallium 81 | 204.4 Pb lead 82 | 207.2 Bi bismuth 83 | 209.0 Po polonium 84 | 210 At astatine 85 | [222] Rn radon 86 | 140.1 Ce cerium 58 | 140.9 Pr praseodymium 59 | 144.2 Nd neodymium 60 | [145] Pm promethium 61 | 150.4 Sm samarium 62 | 152.0 Eu europium 63 | 157.3 Gd gadolinium 64 | 158.9 Tb terbium 65 | 162.5 Dy dysprosium 66 | 164.9 Ho holmium 67 | 167.3 Er erbium 68 | 168.9 Tm thulium 69 | 173.1 Yb ytterbium 70 | 175.0 Lu lutetium 71 | 232.0 Th thorium 90 | 231.0 Pa protactinium 91 | 238.0 U uranium 92 | [237] Np neptunium 93 | [244] Pu plutonium 94 | [243] Am americium 95 | [247] Cm curium 96 | [251] Cf californium 98 | [252] Es einsteinium 99 | [257] Fm fermium 100 | [258] Md mendelevium 101 | [259] No nobelium 102 | [262] Lr lawrencium 103 |
| <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px;">1.0 H hydrogen 1</div> <div style="border: 1px solid black; padding: 5px;">relative atomic mass symbol name atomic (proton) number</div> </div> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Elements with atomic numbers 112-116 have been reported but not fully authenticated | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| * 58 – 71 Lanthanides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| † 90 – 103 Actinides | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Ionic compounds must have an overall neutral charge. The ratio of cations to anions must mean that there is as many positives as negatives.

For example:

| NaCl | |
|-----------------|-----------------|
| Na ⁺ | Cl ⁻ |
| +1 | -1 |

| MgO | |
|------------------|-----------------|
| Mg ²⁺ | O ²⁻ |
| +2 | -2 |

| MgCl ₂ | |
|-------------------|-----------------|
| Mg ²⁺ | Cl ⁻ |
| | Cl ⁻ |
| +2 | -2 |

Activity 12

Work out what the formulas for the following ionic compounds should be:

1. Magnesium bromide
2. Barium oxide
3. Zinc chloride
4. Ammonium chloride
5. Ammonium carbonate
6. Aluminium bromide
7. Iron(II) sulfate
8. Iron(III) sulfate

Diatomic molecules

A number of atoms exist in pairs as diatomic (two atom) molecules.

The common ones that you should remember are:

Hydrogen H_2 , Oxygen O_2 , Fluorine F_2 , Chlorine Cl_2 , Bromine Br_2 , Nitrogen N_2 and Iodine I_2

Common compounds

There are several common compounds from your GCSE studies that have names that do not help to work out their formulas. For example, water is H_2O .

Activity 13: Research activity

What are the formulas of the following compounds?

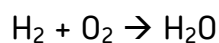
1. Methane
2. Ammonia
3. Hydrochloric acid
4. Sulfuric acid
5. Sodium hydroxide
6. Potassium manganate(VII)
7. Hydrogen peroxide

Balancing equations

Chemical reactions never create or destroy atoms. They are only rearranged or joined in different ways.

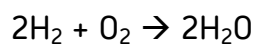
When hydrogen and oxygen react to make water:

hydrogen + oxygen \rightarrow water



There are two hydrogen atoms on both sides of this equation, but two oxygen atoms on the left and only one on the right. This is not balanced.

This can be balanced by writing:



The reactants and products in this reaction are known and you can't change them. The compounds can't be changed and neither can the subscripts because that would change the compounds. So, to balance the equation, a number must be added in front of the compound or element in the equation. This is a coefficient. Coefficients show how many atoms or molecules there are.

Activity 14

Write balanced symbol equations for the following reactions. You'll need to use the information on the previous pages to work out the formulas of the compounds. Remember some of the elements may be diatomic molecules.

1. Aluminium + oxygen \rightarrow aluminium oxide
2. Methane + oxygen \rightarrow carbon dioxide + water
3. Aluminium + bromine \rightarrow aluminium bromide
4. Calcium carbonate + hydrochloric acid \rightarrow calcium chloride + water + carbon dioxide
5. Aluminium sulfate + calcium hydroxide \rightarrow aluminium hydroxide + calcium sulfate

Harder:

6. Silver nitrate + potassium phosphate \rightarrow silver phosphate + potassium nitrate

More challenging:

7. Potassium manganate(VII) + hydrochloric acid \rightarrow
potassium chloride + manganese(II) chloride + water + chlorine

Moles

A mole is the amount of a substance that contains 6.02×10^{23} particles.

The mass of 1 mole of any substance is the relative formula mass (M_r) in grams.

Examples:

One mole of carbon contains 6.02×10^{23} particles and has a mass of 12.0 g

Two moles of copper contains 12.04×10^{23} particles, and has a mass of 127 g

1 mole of water contains 6.02×10^{23} particles and has a mass of 18 g

The amount in moles of a substance can be found by using the formula:

$$\text{Amount in moles of a substance} = \frac{\text{mass of substance}}{\text{relative formula mass}}$$

Activity 15

Fill in the table.

| Substance | Mass of substance | Amount/moles | Number of particles |
|---------------|-------------------|--------------|------------------------|
| Helium | | | 18.12×10^{23} |
| Chlorine | 14.2 | | |
| Methane | | 4 | |
| Sulfuric acid | 4.905 | | |

Empirical formula

If you measure the mass of each reactant used in a reaction, you can work out the ratio of atoms of each reactant in the product. This is known as the empirical formula. This may give you the actual chemical formula, as the actual formula may be a multiple of this. For example, hydrogen peroxide is H_2O_2 but would have the empirical formula HO .

Use the following to find an empirical formula:

1. Write down reacting masses
2. Find the amount in moles of each element
3. Find the ratio of moles of each element

Example:

A compound contains 2.232 g of iron, 1.284 g of sulfur and 1.920 g of oxygen. What is the empirical formula?

| Element | Iron | Sulfur | Oxygen |
|---------------------------|-------------|-------------|-------------|
| mass/relative atomic mass | 2.232/55.8 | 1.284/32.1 | 1.920/16.0 |
| Amount in moles | 0.040 | 0.040 | 0.120 |
| Divide by smallest value | 0.040/0.040 | 0.040/0.040 | 0.120/0.040 |
| Ratio | 1 | 1 | 3 |

So the empirical formula is FeSO_3 .

If the question gives the percentage of each element instead of the mass, replace mass with the percentage of an element present and follow the same process.

Activity 16

Work out the following empirical formulas:

1. The smell of a pineapple is caused by ethyl butanoate. A sample is known to contain only 0.180 g of carbon, 0.030 g of hydrogen and 0.080 g of oxygen. What is the empirical formula of ethyl butanoate?
2. Find the empirical formula of a compound containing 0.0578 g of titanium, 0.288 g of carbon, 0.012 g of hydrogen and 0.384 g of oxygen.
3. 300 g of a substance are analysed and found to contain only carbon, hydrogen and oxygen. The sample contains 145.9 g of carbon and 24.32 g of hydrogen. What is the empirical formula of the compound?
4. Another 300 g sample is known to contain only carbon, hydrogen and oxygen. The percentage of carbon is found to be exactly the same as the percentage of oxygen. The percentage of hydrogen is known to be 5.99%. What is the empirical formula of the compound?

The Periodic Table of the Elements

1 2 3 4 5 6 7 0

(18)

| | | Key | | | | | | | | | | | | | | | | | | | | | |
|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|--------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---|--------------------------------------|---|-------------------------------------|--|--|--|-------------------------------------|--|--|--|---------------------------------------|---|--|--|
| | | relative atomic mass | | | | | | | | | | | | | | | | | | | | | |
| | | symbol | | | | | | | | | | | | | | | | | | | | | |
| | | name | | | | | | | | | | | | | | | | | | | | | |
| | | atomic (proton) number | | | | | | | | | | | | | | | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | | | | | | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 91.2 Zr zirconium 40 | 88.9 Y yttrium 39 | 138.9 La * lanthanum 57 | 132.9 Cs caesium 55 | [223] Fr francium 87 | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 4.0 He helium 2 | | | | | | |
| 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 | | | | | | |
| 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 208.98 Bi bismuth 83 | 208.98 Po polonium 84 | 209.0 At astatine 85 | 208.98 Rn radon 86 | 208.98 Fr francium 87 | 208.98 Ra radium 88 | 208.98 Ac actinium 89 | 208.98 Th thorium 90 | 208.98 Pa protactinium 91 | 208.98 U uranium 92 | 208.98 Np neptunium 93 | 208.98 Pu plutonium 94 | 208.98 Am americium 95 | 208.98 Cm curium 96 | 208.98 Bk berkelium 97 | 208.98 Cf californium 98 | 208.98 Es einsteinium 99 | 208.98 Fm fermium 100 | 208.98 Md mendelevium 101 | 208.98 No nobelium 102 | 208.98 Lr lawrencium 103 |

1.0
H
hydrogen
1

Elements with atomic numbers 112-116 have been reported but not fully authenticated

| | | | | | | | | | | | | |
|-------------------------------------|--|---------------------------------------|---------------------------------------|---------------------------------------|--|-------------------------------------|---|---|--------------------------------------|--|---------------------------------------|---|
| 140.1 Ce cerium 58 | 140.9 Pr praseodymium 59 | 144.2 Nd neodymium 60 | 150.4 Sm samarium 62 | 152.0 Eu europium 63 | 157.3 Gd gadolinium 64 | 158.9 Tb terbium 65 | 162.5 Dy dysprosium 66 | 164.9 Ho holmium 67 | 167.3 Er erbium 68 | 168.9 Tm thulium 69 | 173.1 Yb ytterbium 70 | 175.0 Lu lutetium 71 |
| 232.0 Th thorium 90 | 231.0 Pa protactinium 91 | 238.0 U uranium 92 | [237] Np neptunium 93 | [244] Pu plutonium 94 | [243] Am americium 95 | [247] Cm curium 96 | [251] Cf californium 98 | [252] Es einsteinium 99 | [257] Fm fermium 100 | [258] Md mendelevium 101 | [259] No nobelium 102 | [262] Lr lawrencium 103 |

* 58 – 71 Lanthanides

† 90 – 103 Actinides