

Name: \_\_\_\_\_

Tutor Group: \_\_\_\_\_

# A Level Chemistry Introduction Pack

## Guidance:

- Spend approximately 6 hours on the pack. Some worked examples are included to help. This will include time to answer questions; think in detail about the concepts introduced; make a record of difficult areas for discussion with peers and teachers and use the internet to research unfamiliar terms and ideas. As a result, it is strongly suggested that you don't leave it until late August to begin and have a go at this pack before you enrol on to the course.
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If you are interested in studying Chemistry at A level we advise you read around the subject such as:

- Read an edition of *The Mole* – the Royal Society of Chemistry's online magazine for students interested to dig deeper into Chemistry.

(Find The Mole here: <http://www.rsc.org/eic/mole>)

- Consider subscribing to RSC Chemnet, which provides chemistry help and support for students between 14-18.

(<http://chemnet.rsc.org/home>)

- Read a popular Science book eg. Ben Goldacre, Natalie Angier, Bill Bryson

## 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  $\lambda$  which is used for wavelength).

The Greek alphabet is shown below.

A	$\alpha$	alpha
B	$\beta$	beta
$\Gamma$	$\gamma$	gamma
$\Delta$	$\delta$	delta
E	$\epsilon$	epsilon
Z	$\zeta$	zeta
H	$\eta$	eta
$\Theta$	$\theta$	theta
I	$\iota$	iota
K	$\kappa$	kappa
$\Lambda$	$\lambda$	lambda
M	$\mu$	mu

N	$\nu$	nu
$\Xi$	$\xi$	ksi
O	$\omicron$	omicron
$\Pi$	$\pi$	pi
P	$\rho$	rho
$\Sigma$	$\varsigma$ or $\sigma$	sigma
T	$\tau$	tau
Y	$\upsilon$	upsilon
$\Phi$	$\phi$	phi
X	$\chi$	chi
$\Psi$	$\psi$	psi
$\Omega$	$\omega$	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
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Name of a mathematician
-------------------------

Ωκεανος
---------

Atlantic, Pacific or Arctic...
--------------------------------

μόνος
-------

Single
--------

Τηλε
------

Far or distant
----------------

Τρωγλοδύτης
-------------

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	$\mu$	$10^{-6}$	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  $0.001 \text{ m}^3$ .

### 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.  $10 \text{ cm}^3$  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

(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	24.3 Na sodium 11	40.1 Ca calcium 20	47.9 Ti titanium 22	50.9 V vanadium 23	54.9 Cr chromium 24	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	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
23.0 Na sodium 11	24.3 Mg magnesium 12	39.1 K potassium 19	40.1 Ca calcium 20	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	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
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	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	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	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	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac † actinium 89	[267] Rf rutherfordium 104	[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	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

1.0  
H  
hydrogen  
1

**Key**  
relative atomic mass  
symbol  
name  
atomic (proton) number

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	[247] Am americium 95	[251] Cm curium 96	[247] Bk berkelium 97	[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

### 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. THlNk 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,  $\text{CO}_2$  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  $\text{Mg(OH)}_2$  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  $\text{MgO}$
2. Sodium hydroxide  $\text{NaOH}$
3. Copper sulfate  $\text{CuSO}_4$
4. Ammonium chloride  $\text{NH}_4\text{Cl}$
5. Ammonium sulfate  $(\text{NH}_4)_2\text{SO}_4$

## Common ions

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

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<sup>+</sup> or O<sup>2-</sup>) 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

<b>(1)</b>	<b>(2)</b>			<b>(3)</b>	<b>(4)</b>	<b>(5)</b>	<b>(6)</b>	<b>(7)</b>	<b>(8)</b>	<b>(9)</b>	<b>(10)</b>	<b>(11)</b>	<b>(12)</b>	<b>(13)</b>	<b>(14)</b>	<b>(15)</b>	<b>(16)</b>	<b>(17)</b>	<b>(18)</b>
6.9 Li lithium 3	9.0 Be beryllium 4			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	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	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	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12			88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	98 Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	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
85.5 Rb rubidium 37	87.6 Sr strontium 38			88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	98 Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	68.7 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
132.9 Cs caesium 55	137.3 Ba barium 56			138.9 La lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	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	222 Rn radon 86
[223] Fr francium 87	[226] Ra radium 88			[227] Ac actinium 89	[267] Rf rutherfordium 104	[268] Db dubnium 105	[271] Sg seaborgium 106	[272] Bh bohrium 107	[270] Hs hassium 108	[276] Mt meitnerium 109	[287] Ds darmstadtium 110	[280] Rg roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						
			* 58 - 71 Lanthanides																
			† 90 - 103 Actinides																

1.0  
H  
hydrogen  
1

Key  
relative atomic mass  
symbol  
name  
atomic (proton) number

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 <sup>+</sup>	Cl <sup>-</sup>
+1	-1

MgO	
Mg <sup>2+</sup>	O <sup>2-</sup>
+2	-2

MgCl <sub>2</sub>	
Mg <sup>2+</sup>	Cl <sup>-</sup>
	Cl <sup>-</sup>
+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

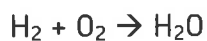


## Balancing equations

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

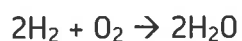
When hydrogen and oxygen react to make water:

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