Foundations in Chemistry

PREPARATION FOR A LEVEL CHEMISTRY

Name ______________________________________

Study Pack

Contents

What you need to be able to do 3
References 3
Exercises 4
Chemical substances 4
(1) Names for chemical particles 4
(2) Symbols for elements 6
(3) Terminology quiz 9
(4) Formulae of ionic compounds 10
(5) Formulae of covalent compounds 14
Chemical reactions 16
(6) Writing chemical equations 16
(7) Reactions of acids 19
Mathematical skills 22
(8) Significant figures 23
(9) Standard form 25
(10) Rearranging algebraic equations 28
(11) Maths quiz 31
Summary exercise 36
(12) Correct the errors 36
Practical work 38
(A) Making observations 38
Summary 40
List of key ions important for A Level Chemistry 40
List of key formulae for A Level Chemistry 41
Reactions of acids 42
Review activities 43
(i) Ions puzzle 43
(ii) Acid reactions dominoes game 44
Glossary 45
Check your knowledge 46

What you need to be able to do

By the time you have worked through all the exercises in this study pack, you should be confident in:

- The use of correct words to describe chemical particles
- How to represent elements in symbol equations
- How to work out whether a substance is ionic or covalent
- Recall from memory, or work out from the periodic table, the formulae of common ions
- Writing the formulae of ionic compounds
- Recall from memory, or work out from the name, the formulae of common covalent molecules
- How to write balanced symbol equations for chemical reactions
- Recall from memory, the products of the reactions between an acid and a reactive metal, a metal oxide, a metal hydroxide and a metal carbonate respectively.
- The correct use of significant figures in calculations
- The use of standard form to represent numbers
- How to rearrange algebraic expressions
- How to record observations from chemical experiments

References

The notes included in this study pack should be sufficient to help you revise all these topics.

If you want further support, you may find the Chemistry and Maths sections of the BBC GCSE Bitesize website useful.

https://www.bbc.co.uk/bitesize/levels/z98jmp3

If you are very keen and want to look ahead at what we cover at A Level Chemistry, we recommend you visit the Chemguide website.

https://www.chemguide.co.uk/

Exercises

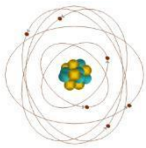
Chemical substances

(1) Names for chemical particles

The study of Chemistry is about how substances interact with each other. When we talk about these substances, we need to be careful to use the correct words so there is no confusion.

Here is a quick reminder of terms you have encountered at GCSE, but the exact meanings may not have been made explicit to you.

Atoms



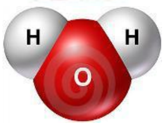
An atom is a particle. It is made up of protons, neutrons and electrons. An atom is the smallest particle of an element that has the properties of that element. Atoms are the building blocks of chemicals.

Elements

Elements contain only one type of atom. The term "element" describes the **type** of atom: it is NOT a word interchangeable with "atom".

An analogy is that elements are like *flavours* of ice-cream (type); an atom is a *scoop* of ice-cream (the actual thing you can build desserts with).

Molecules



Molecules are groups of 2 or more atoms joined together by **covalent** bonds (and ONLY by covalent bonds).

H_2, O_2, H_2O and CO_2 are all examples of molecules. Note that molecules may be made up of atoms of only one element (elemental) or of more than one element (compound).

Compounds

Compounds are substances made when atoms of more than one element bond together chemically. Examples of compounds include water, H_2O, and sodium chloride, NaCl.

Compounds may have **ionic** or **covalent** bonding. Typically

- **ionic** compounds are made by combining **a metal and a non-metal;**
- **covalent** compounds are made by combining **non-metals only**.

Ions

Ions are charged particles. They are formed when atoms or groups of atoms gain or lose electrons. Because electrons are negatively charged, particles that **gain electrons** turn into **negatively charged** ions, those that **lose electrons** turn into **positive** ions.

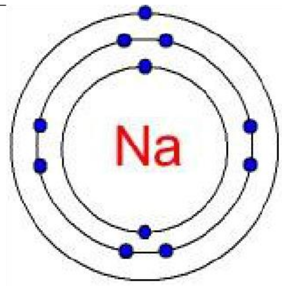
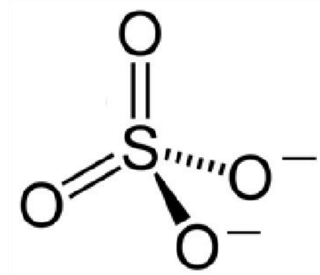
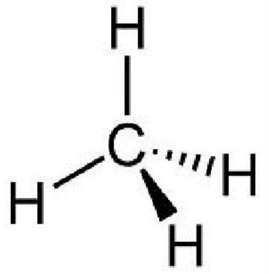
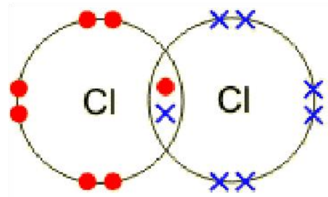
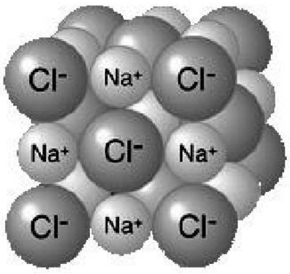
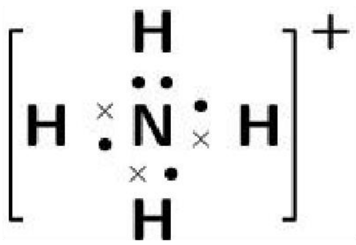
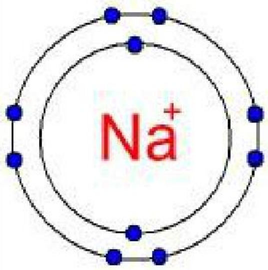
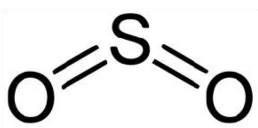
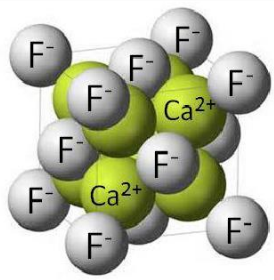
The formula of an ion always has a **+** or **–** sign.

Name:

PRINT

Exercise 1: Types of particles

Classify these substances as **atom**, **element**, **molecule**, **compound** or **ion**. Some substances may have more than one classification.

O=C=O (a)	 (b)	 (c)
Au (d)	 (e)	 (f)
 (g)	N≡N (h)	 (i)
 (j)	 (k)	 (l)

☑ Using a different coloured pen, mark your answers against these in the answers document.

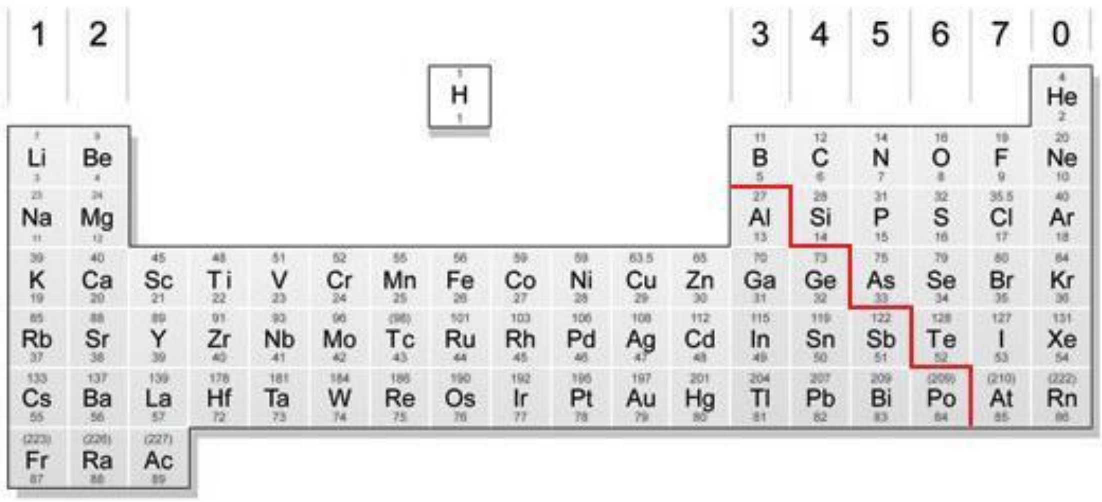
Mark	/15

(2) Symbols for elements

In A level Chemistry, you will be writing a lot of symbol equations. You need to know how to represent common elements using their chemical formulae.

There are standard ways of representing metals and non-metals.

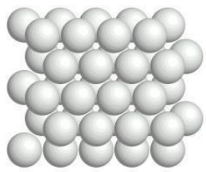
Metals are found on the **left** hand side of the Periodic Table, up to the red stepped line. **Non-metals** are on the **right** hand side, above the red line.



Metals

All metals are represented simply as their symbol on the Periodic Table.

For example:

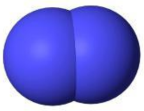


- A piece of sodium is Na, regardless of its size.
- Copper is Cu, whether it is a wire or as a powder.
- A blob of mercury is Hg, even though it is a liquid.

This is because all metals exist as **giant** structures, meaning that they are made up of lattices of a large but random size. Since we don't know how many atoms there are, we don't try to give a number.

Non-metals

Representing elemental non-metals is trickier as it depends on their structure: whether they exist as **molecules** or as an infinite (giant) **lattice** like the metals or as **single atoms**.



Diatomic molecules

Common non-metallic elements that exist as diatomic molecules are:

- Hydrogen
- Oxygen
- Nitrogen
- All the Group 7 elements, eg Chlorine

We know these elements exist normally as molecules made up of 2 atoms, so they are X_2.

LEARN THIS!! You must be able to recall that these elements exist as diatomic molecules at A Level.

Non-metallic elements with giant structures

Some common non-metallic elements that exist as giant structures of unknown size are:

Carbon (as graphite or diamond)

Silicon

Like the metals, these non-metals with giant structures do not have little numbers in their symbol.

Single atoms

The Group 0 elements, the Noble Gases, exist as single atoms. Their formulae also do not have little numbers.

In summary

Other than the Group 7 elements, hydrogen, oxygen and nitrogen that exist as diatomic molecules, $\mathbf{X_2}$, all the elements in the Periodic Table may be represented simply as their symbol.

You will be expected to be fully confident with writing the formula of *any* element, with the aid of a Periodic Table when you start your A Level course. Practise them on the next page.

Co ≠ CO!!

Take care when writing the symbols of the elements – they all start with an upper case (capital); if there is a second letter, that is written in lower case. You do not want to confuse Co (cobalt) with CO (carbon monoxide).

Name:

Exercise 2: Formulae for elements

Find these elements on the Periodic Table. (There is one available in the summer work folder.)

Write down the group (vertical column in the Periodic Table) to which these elements belong and their formulae.

Q	Name of element	Group	Formula	Mark
(a)	Potassium			
(b)	Nitrogen			
(c)	Iodine			
(d)	Zinc	Transition metal		
(e)	Xenon			
(f)	Sulfur			
(g)	Fluorine			
(h)	Tin			
(i)	Tungsten	Transition metal		
(j)	Phosphorus			

☑ Mark your answers against the answers supplied.

Mark /10

Name:

(3) Terminology quiz

Test your understanding of chemical terms.

Read the following statements carefully.

Tick ✓ if the statement is right with all the terms used correctly.

Cross ✗ if *either* the statement is wrong *or* any terms are used incorrectly.

(a) Hydrogen is an element. ☐

(b) NaOH is a molecule. ☐

(c) All compounds are molecules. ☐

(d) $CaCO_3$ is a compound. ☐

(e) The formula of bromine is Br. ☐

(f) CO_2 is a molecule. ☐

(g) Ammonia, NH_3, is a molecule made up of N_2 and H_2 bonded together. ☐

(h) All molecules are compounds. ☐

(i) O_3 is a compound. ☐

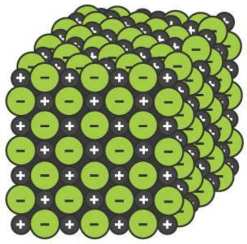
(j) O_2 is made up of oxygen elements bonded together with covalent bonds. ☐

(k) Cl_2 is a molecule. ☐

(l) The element helium is written in equations as He_2. ☐

Mark /12

(4) Formulae of ionic compounds



Ionic compounds are formed between **metals and non-metals**.

- The **metal** atoms *lose electrons* to form **positive ions**
- The **non-metal** atoms *gain electrons* to form **negative ions**.

The **electrostatic attraction** that arises between **positive and negative ions** is known as *ionic bonding*.

For further information about ionic structures and bonding, you may find this section on the BBC GCSE Bitesize website useful: https://www.bbc.co.uk/bitesize/guides/zyydng8/revision/1

Formulae for ions

Simple ions

❖ Charges of simple ions made from one atom can usually be worked out from the Periodic Table.

Group 1	1+	Group 5	3-
Group 2	2+	Group 6	2-
Group 3	3+	Group 7	1-

❖ d-block elements (elements between Gr 2 and 3) and the metals in Gr 4 can have two or more ions with different charges. In these cases the charge on the metal ion is shown by a Roman numeral.

eg copper(II) chloride contains $\mathbf{Cu^{2+}}$ ions
copper(I) oxide contains $\mathbf{Cu^{+}}$ ions
tin(II) sulfate contains $\mathbf{Sn^{2+}}$ ions.

❖ The following d-block elements only have one ion, so no Roman numeral is needed:

silver ion $\mathbf{Ag^{+}}$ zinc ion $\mathbf{Zn^{2+}}$

❖ Metals always form positive ions; non-metals form negative ions; EXCEPT hydrogen which forms both the positive **hydrogen ion, $\mathbf{H^{+}}$** (most of the time) and the negative **hydride ion, $\mathbf{H^{-}}$** (occasionally).

❖ Note how simple ions are named

Positive ions
made by metals (or hydrogen) have names that are just the name of the element with the word "ion" after,
eg Na^{+} is the sodium ion.

Negative ions
are named after the non-metal but with the name ending changed to **-ide**, eg Cl^{-} is the chlor**ide** ion, S^{2-} is the sulf**ide** ion.

Name:

Exercise 4a: Formulae for ions

Write the formulae for the following ions, with the aid of a periodic table.

(a) **lithium** ion............

(b) **magnesium** ion............

(c) **aluminium** ion............

(d) **sulfide** ion............

(e) **hydride** ion............

(f) **chromium(III)** ion ....

(g) **barium** ion............

(h) **silver** ion............

(i) **strontium** ion............

(j) **bromide** ion............

(k) **fluoride** ion ....

(l) **oxide** ion ....

(m) **nitride** ion ....

(n) **rubidium** ion ....

(o) **manganese(II)** ion ....

(p) **hydrogen** ion ....

(q) **lead(II)** ion ....

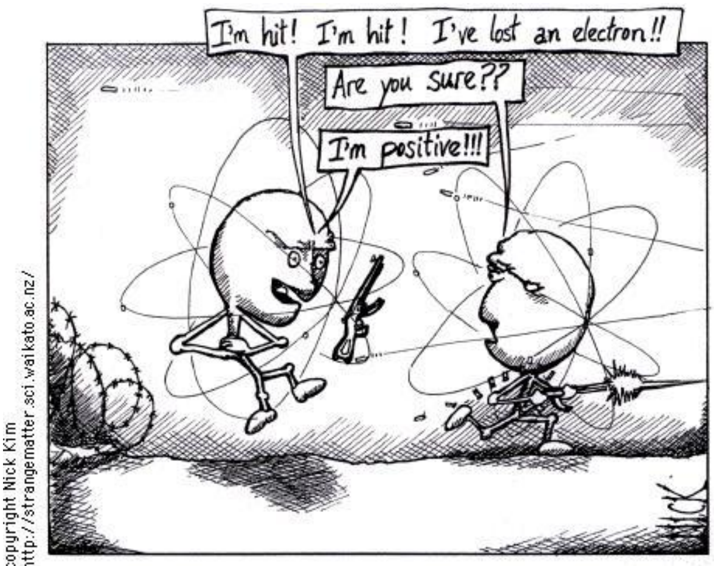
(r) **zinc** ion ....

(s) **iron(III)** ion ....

(t) **phosphide** ion ....

☑ Mark your work against the answers provided.

Mark	/20



ANOTHER CASUALTY IN THE WAR OF THE SODIUM ATOMS

Polyatomic ions

Polyatomic ions are groups of atoms covalently bonded together, that have gained or lost electrons, forming negative or positive ions respectively.

Eg the **carbonate ion, CO_3^{2-}**, has 1 carbon and 3 oxygen atoms held together by covalent bonds. It has an overall charge of 2- because it has gained 2 e^-s.

You must learn the names and formulae of these ions!!

1+	1-	2-	3-
ammonium NH_4^+	**hydroxide** OH^-	**carbonate** CO_3^{2-}	**phosphate** PO_4^{3-}
	nitrate NO_3^-	**sulfate** SO_4^{2-}	
	hydrogencarbonate HCO_3^-		

Note: polyatomic ions that contain oxygen as well as another element have names that end **–ate** to denote the presence of the oxygen.

Writing the formulae of ionic compounds

(1) Work out the **formulae** and **charges** of the separate ions.

(2) Work out how many of each ion is needed to get an **overall charge of zero**.

(3) Put **brackets** around any **polyatomic** ion present more than once in the formula. Simple ions do not need brackets.

(4) Note the charges of the separate ions are not shown in the formula of the compound.

Example 1 What is the formula of **sodium nitrate**?

Ions: Na^+ and NO_3^-

Balance charges: One of each is needed for an overall charge of zero.

Formula: $NaNO_3$

Example 2 What is the formula of **aluminium sulfate**?

Ions: Al^{3+} and SO_4^{2-}

Balance charges: 2 x 3+ and 3 x 2- will give an overall charge of zero.

Formula: $Al_2(SO_4)_3$

Name:

Exercise 4b: Ionic compounds

1. Write the formulae for the following compounds.

(a) lithium fluoride

(b) iron(II) bromide

(c) strontium nitrate

(d) zinc hydroxide

(e) silver iodide

(f) aluminium nitride

(g) calcium phosphate

(h) lead(II) oxide

(i) ammonium sulfate

(j) caesium oxide

(k) magnesium hydrogen carbonate

(l) barium sulfide

(m) vanadium(V) oxide

(n) tin(IV) chloride

(o) potassium carbonate

(p) sodium hydride

2. Name these compounds.

(a) NH_4OH

(b) $CaBr_2$

(c) $CoSO_4$

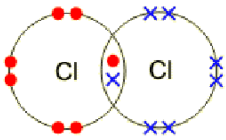
(d) $CoCl_3$

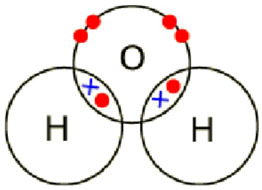
Mark	/20

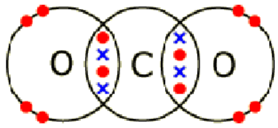
(5) Formulae of covalent compounds

Covalent compounds are formed between **non-metal atoms**. Instead of transferring electrons, as in ionic compounds, atoms bond by **sharing electrons** in covalent compounds.

A covalent bond is the strong **electrostatic attraction** between a **shared pair of electrons** and the **nuclei of the bonded atoms**.







For further information about covalent bonding, you may find this section on the BBC GCSE Bitesize website useful:
https://www.bbc.co.uk/bitesize/guides/zcpjfcw/revision/1

Writing the formulae for covalent compounds

❖ There are no simple rules for the formulae of covalent compounds, but most can be found using common sense and from their names.

mono means a single atom

di means 2 atoms

tri means 3 atoms

tetra means 4 atoms

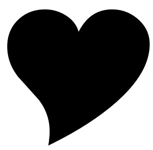
so carbon **di**oxide is CO_2

sulfur **tri**oxide is SO_3

carbon **tetra**chloride is CCl_4

❖ Some, however, you do have to learn, such as:

ammonia NH_3 methane CH_4



water H_2O ethanoic acid CH_3COOH

Name:

Exercise 5: Covalent compounds

Write the formulae for the following compounds.

(a) carbon monoxide ....

(b) nitrogen dioxide ....

(c) nitrogen triiodide ....

(d) sulfur dichloride ....

(e) ammonia ....

(f) silicon tetrachloride ....

(g) phosphorus trichloride ....

(h) dinitrogen tetroxide ....

(i) ethanoic acid ....

(j) carbon disulfide ....

(k) methane ....

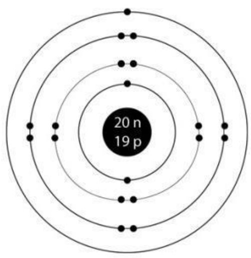
(l) dinitrogen monoxide ....

☑ Check your answers against the supplied answers.

Mark	/12

Extension

Which famous British chemist links the last compound, a miner's safety lamp and potassium?



Chemical reactions

(6) Writing chemical equations

At A Level you will be writing a lot of chemical equations to describe reactions. You will be expected always to write **balanced symbol equations**, not word equations, nor unbalanced "equations".

How to write a balanced symbol equation

(1) Write the formulae of the **reactants** on the left hand side and the formulae of the **products** on the right hand side with an **arrow** between them.

The arrow $\longrightarrow$ *signifies that the chemicals on the LHS* ***turn into*** *the substances on the RHS.*

Take care with writing these formulae – use the periodic table and the formulae of the ions you have learnt. Getting the formulae of the chemicals wrong is the most common reason for incorrect equations!

(2) Now **balance** the atoms by adding large numbers before the chemical formulae – **do not fiddle** with the small numbers in the formulae you have already written! Look out for patterns in groups of atoms.

You need to have the same number of atoms of all the elements on each side of the equation.

(3) Check that the **charges** are also balanced.

You will only need to worry about this when you learn to write ionic equations when you start your A Level course. For the time being you will be starting and finishing with neutral substances, so their charges will always balance. However if there are charged particles in the equation, the overall charge on both sides needs to be equal.

Practise balancing equations and writing equations in the following exercises.

Name:

Exercise 6a: Balancing equations

Balance these equations. Some of them are quite tricky, but there are *no* mistakes in the questions!

(a) $Na_2O + H_2O \rightarrow NaOH$

(b) $KClO_3 \rightarrow KCl + O_2$

(c) $H_2O_2 \rightarrow H_2O + O_2$

(d) $Fe + H_2O \rightarrow Fe_3O_4 + H_2$

(e) $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

(f) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + Cr_2O_3 + H_2O$

(g) $Sn + HNO_3 \rightarrow SnO_2 + NO_2 + H_2O$

(h) $PCl_5 + H_2O \rightarrow H_3PO_4 + HCl$

(i) $CuSO_4 + KI \rightarrow CuI + K_2SO_4 + I_2$

(j) $PbO_2 + HCl \rightarrow PbCl_2 + Cl_2 + H_2O$

☑ Check your answers against those provided.

Mark /10

Name:

Exercise 6b: Writing equations

Write balanced symbol equations for these reactions.

(a) Methane + oxygen → carbon dioxide + water

(b) Sodium carbonate + calcium chloride → sodium chloride + calcium carbonate

(c) Silver nitrate + copper → copper(II) nitrate + silver

(d) Potassium iodide + bromine → potassium bromide + iodine

(e) Ammonia + oxygen → nitrogen + water

(f) Lithium nitrate → lithium oxide + nitrogen dioxide + oxygen

(g) Iron metal + chlorine → iron(III) chloride

(h) Zinc sulfide + oxygen → zinc oxide + sulfur dioxide

Mark /16

(7) Reactions of acids

Acids are a common class of chemicals that react by **losing H^+ ions**. In their reactions they form **salts** which are compounds formed when the H^+ ions from an acid are replaced by a metal ion (or another positive ion). You have encountered these general reactions of acids:

Acid + metal hydroxide → salt + water

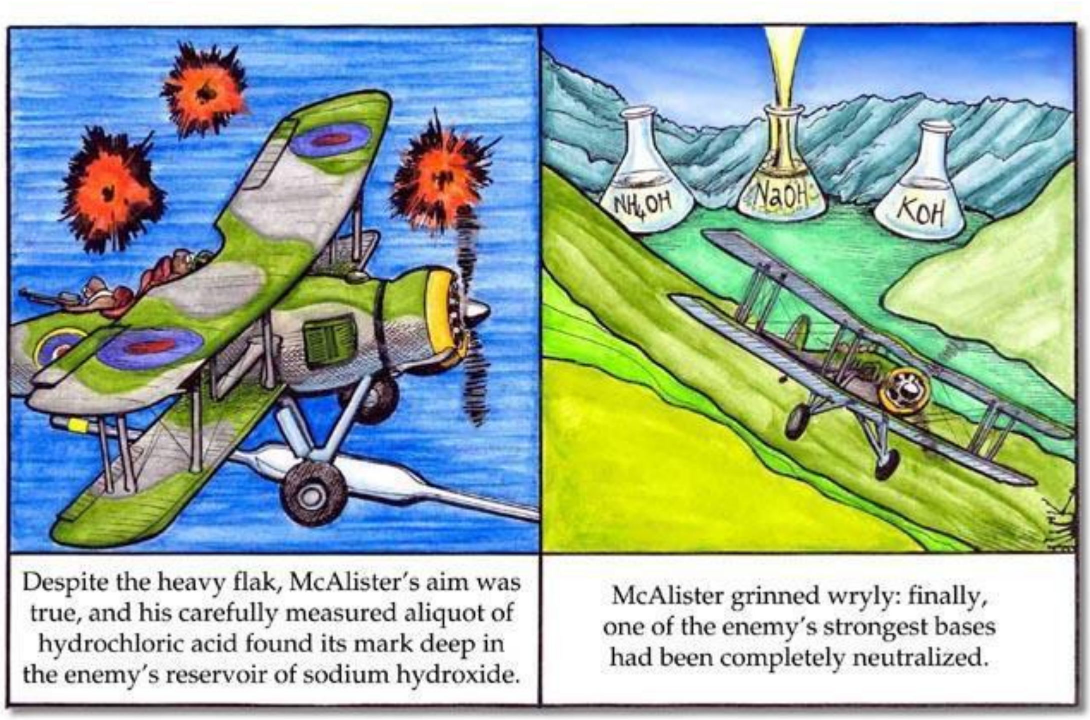
Acid + metal oxide → salt + water

Acid + metal carbonate → salt + CO_2 + water

Acid + reactive metal → salt + hydrogen

The **salt** formed is determined by the acid used:

- Hydrochloric acid, HCl, forms **chlorides**.
- Nitric acid, HNO_3, form **nitrates**.
- Sulfuric acid, H_2SO_4, forms **sulfates**.
- Phosphoric acid, H_3PO_4, forms **phosphates**.
- Ethanoic acid, CH_3COOH, forms **ethanoates** (CH_3COO^-).



From www.lab-initio.com

Metal oxides and hydroxides are commonly referred to as **bases** because they accept H^+ ions from acids.

Water soluble bases are also known as **alkalis**. Alkalis release OH^- ions in aqueous solution.

Name:

Exercise 7a: Acid reactions

1. Fill in the blanks using the words given below – you may use each word once, more than once or not at all.

carbonate	chloride	chlorine	hydrogen
hydroxide	nitrate	nitride	oxygen
salt	sulfate	sulfuric	water

acid + metal .... → .... + water + carbon dioxide

.... acid + metal oxide → metal sulfate + ...

nitric acid + metal .... → metal .... + water

metal + hydrochloric acid → metal .... + ...

2. Each of the following equations contains at least one error or omission. Circle the mistakes and rewrite the equations correctly.

(a) The reaction between aluminium hydroxide and hydrochloric acid

$AlOH_3 + 3HCl \rightarrow Al_3Cl + 3H2O$

(b) The reaction between potassium and sulfuric acid

$K_2 + H_2SO_4 \rightarrow K_2SO_4 + 2H$

(c) The reaction between sodium carbonate and nitric acid

$naCo_3 + H_2NO_3 \rightarrow naNO^3 + H_2O$

(d) The reaction between ammonium hydroxide and sulfuric acid

$Nh_3OH + H_2SO_4 \rightarrow Nh_3SO_4 + H_2$

Check your answers against those provided.

Mark /26

Name:

Exercise 7b: Acid equations

1. Complete the following word equations and re-write them as balanced symbol equations.

(a) ammonium hydroxide + sulfuric acid $\rightarrow$

(b) aluminium oxide + hydrochloric acid $\rightarrow$

(c) magnesium + nitric acid $\rightarrow$

(d) potassium carbonate + phosphoric acid $\rightarrow$

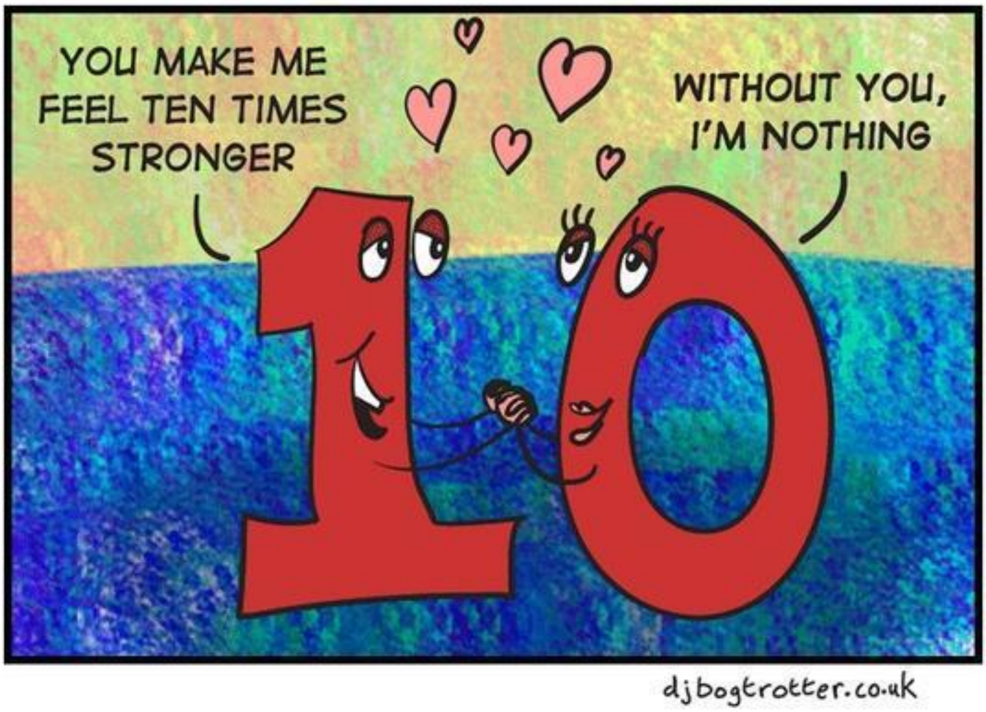
(e) sodium hydroxide + ethanoic acid $\rightarrow$

2. Ammonia is a **base**, which is a substance that accepts H^+ ions from an acid to form a salt. Predict the **single** product in this reaction and write the balanced symbol equation for this reaction.

ammonia + hydrochloric acid $\rightarrow$

Mark	/18

Mathematical skills



(8) Significant figures

When we do calculations in Chemistry, most of the numbers we use came from experimental measurements. These data are subject to measurement errors, so the answers to our calculations are not 100% accurate. Because we know the answers are not *exactly* as calculated, it is not meaningful to write down the long calculator tail to many digits. Instead we give the answer to the magnitude (rough size) of which we are confident – we say the answer is quoted to a certain number of significant figures.

Which numbers are significant?

Non-zero numbers are significant. The first significant figure is the first non-zero number reading from left to right.

Zeros *between* other, non-zero, numbers are classed as significant.

Zeros at the end may or may not be significant! Zeros following non-zero numbers beyond a decimal point are definitely significant; but if the number is quoted as a whole number, you cannot easily tell whether the zeros on the end are significant.

All the numbers below are quoted to 3 sig figs:

123	0.0000234	30.4	4.05
5.67	0.678	7.00	80.0

These numbers that follow may be considered as 3 sig figs, but without further information, you cannot be sure:

100	230	40500	600000

In these cases, standard form should be used to avoid doubt:

1.00×10^2	2.30×10^2	4.05×10^4	6.00×10^5

To how many significant figures should an answer be quoted?

A calculated value is only as good as the worst piece of data used to find it. Your final answer should not have more sig figs than the lowest number of sig figs found in the numbers used.

In multi-step calculations you should not round until you reach the final answer.

Do not forget to round your number appropriately!

Look at these examples:

(1) Convert **102345** to 3 sig figs.

You look to the 4th significant digit which is 3. As this is less than 5, it is small enough to ignore.

The answer is **102000** (to 3sf).

(2) Convert **0.00132475** to 4 sig figs.

You look to the 5th significant digit which is 7. As this is 5 or greater, it is too big to ignore. You round up the previous digit by 1.

The answer is **0.001325** (to 4sf).

Name:

Exercise 8: Significant figures

1. Explain why 3.99521 to 3 sig figs is 4.00.

2. To how many significant figures are the following quoted?

(a) 2048

(b) 9.00043

(c) 0.0008

(d) 0.00395

(e) 0.05030

(f) 650000

3. Re-write the following to the number of significant figures required.

(a) 5462 (to 2sf)

(b) 20543 (to 2sf)

(c) 1.5952 (to 3sf)

(d) 0.039214 (to 3sf)

(e) 0.0056972 (to 3sf)

(f) 470356 (to 3sf)

4. Calculate the following to **an appropriate number** of significant figures.

(a) 3.854 + 2.06

(b) 6.52 - 2.7

(c) 1.48 x 6.2

(d) 19.5 ÷ 0.284

☑ Mark your work against the mark scheme.

Mark /16

(9) Standard form

(or scientific notation)

Chemists encounter numbers that can encompass an enormous range. For example, there are 1 700 000 000 000 000 000 000 water molecules in a drop of water, but a water molecule is approximately 0.000 000 000 15 m long (both values to 2 sig figs).

To make these numbers easier to write and to get a better sense of their size, scientists use *standard form* or *scientific notation* to represent them.

A number in standard form has the shape **A x 10$^{\mathbf{n}}$**

where A = a number between 1 and 9.9

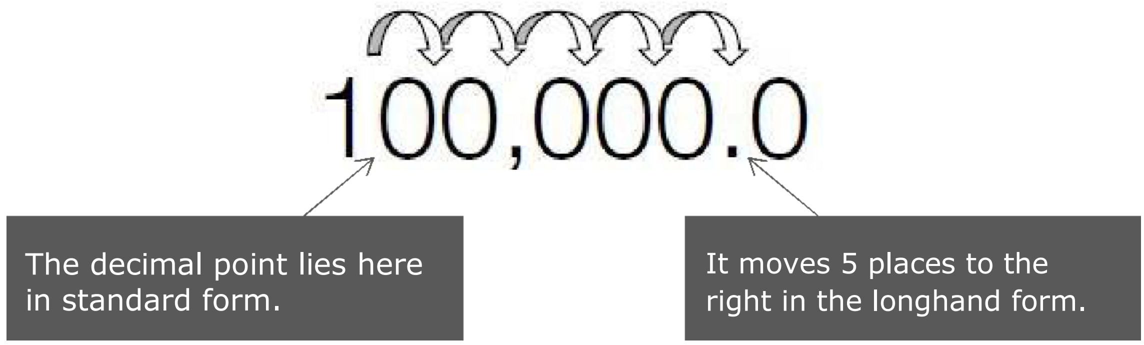
n = ± a whole number

(tells us how many places to move the decimal point.

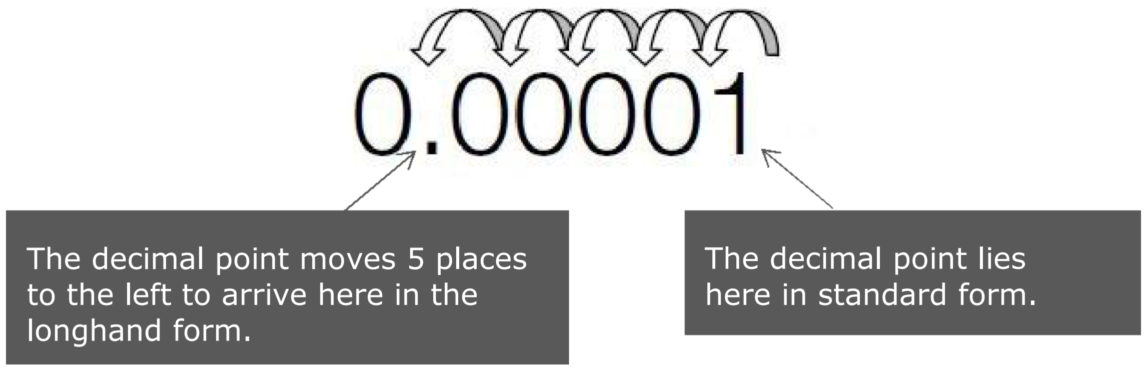
To convert from standard form back to longhand form:

+ moves the decimal point to the right; – to the left)

For big numbers, eg 100 000 = 1.0 x 10^5, n is a positive number.



For small numbers, eg 0.00001 = 1.0 x 10^{-5}, n is a negative number.



so we can say there are 1.7 x 10^{21} water molecules in a drop of water and the length of a water molecule is 1.5 x 10^{-10} m.

Name:

Exercise 9: Standard form

1. Write the following numbers in standard form to 3 significant figures.

(a) 123456

(b) 45062

(c) 0.058345

(d) 0.000259631

2. Write the following numbers in longhand ("normal numbers").

(a) 1.36×10^{4}

(b) 5.75×10^{-3}

(c) 6.02×10^{23}

(d) 1.60×10^{-19}

3. The following values in metres link to the given quantities, but they have been mixed up. Rank them in order of size in the table overleaf, and then use them to complete the calculations that follow.

2.75×10^{-15}	Length of a butane molecule
5.48×10^{-10}	Radius of a bonded carbon atom
7.50×10^{-11}	Radius of a carbon nucleus
8.78×10^{-16}	Radius of a proton

Size of particles

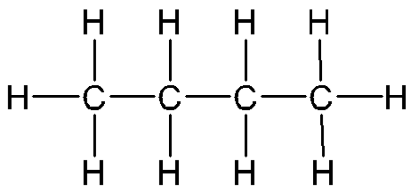
Size	Value in metres	Quantity
Smallest		
Biggest		

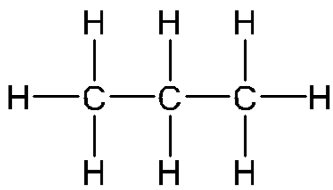
Give your answers to these calculations to 3 significant figures.

(a) The diameter of a bonded carbon atom.

(b) The width of a carbon nucleus if the width of a proton is taken off.

(c) Butane has the structure on the left below, whilst propane is on the right:





Estimate the length of a propane molecule.

(d) The length of a butane molecule is equivalent to how many bonded C atoms lined up side by side?

Why do you think this is less than the width of 4 bonded C atoms?

Check your work against the given answers.

Mark /14

(10) Rearranging algebraic equations

Mathematical equations tell you the relationship between numbers. To generalise these relationships, algebraic expressions are used. Quantities are represented as variables connected by mathematical operations such as +, −, x, or ÷ .

Operations come in opposing pairs, where one operation "undoes" the other:

Opposite operations	
+ (addition)	− (subtraction)
x (multiplication)	÷ or / (division)

In order to carry out chemical calculations, you need to be able to rearrange equations to isolate any given variable as the "subject" and show how it is equal to some combination of the other variables.

There are two basic techniques to rearranging formulae:

①

Do the same thing to both sides

This is the more rigorous method mathematically.

Example A
Make c the subject, given = − +

(1) Put c on the LHS by adding c to both sides.

+ = − + + ⇒ + = +

(2) Isolate c by subtracting a from both sides.

+ − = + − ⇒ = + −

Example B
Find M if = —

(1) Multiply both sides by M to "bring it to the top".

× = — ×⇒=

(2) Isolate M by dividing both sides by n.

— = — ⇒= —

② Flip the operation when you move it to the other side

This exploits the consequence of method ①. When you move a variable to the other side, you do the opposite operation.

Example A (again)
Make c the subject, given $= \quad - \quad +$

(1) Move c to the LHS. Because it is **–** on the RHS, it flips to **+** c on the left.

$$= \quad - \quad + \quad \Rightarrow \quad + \quad = \quad +$$

(2) Move a to the RHS. Because it is **+** on the left, it flips to **–** a on the right.

$$+ \quad = \quad + \quad \Rightarrow \quad = \quad + \quad -$$

Example B (again)
Find M if $= \quad —$

(1) Bring M to the LHS. Because it is at the **bottom** of the fraction on the RHS, it flips to the **top** on the left.

$$= \quad — \quad \Rightarrow =$$

(2) Move n to the RHS. Because it is on the **top** (multiplied) on the LHS, it flips to the **bottom** of the fraction on the right.

$$= \Rightarrow = \quad —$$

Both techniques yield the same answer – choose the method you find easier.

Name:

Exercise 10: Rearranging algebraic equations

The following equations are all ones that you will eventually encounter at A Level Chemistry. You don't have to worry that you have not seen them before! However, rearrange each equation for the given subject.

(a) Find if $= \frac{}{}$

if $= \times$

(b) Find

(c) Find if $= \frac{}{}$

(d) Find Δ if $= \Delta$

(e) Find $[\,^{+}]$ if$= \frac{[\,^{+}][\,^{-}]}{}$

(f) Find $[\ ]$ if $= \frac{[\ ]^{2}}{}$

(g) Find Δ if $\Delta = \Delta - \Delta$

(h) Find Δ if $\Delta = \Delta - \Delta$

☑ Mark your work against the supplied answers.

Mark /8

Extension: Find out when these equations are used.

(11) Maths quiz

This quiz makes use of the relationships between amount of substance (moles) with mass, concentration and volumes of chemicals. A few of you may have already encountered this at GCSE, but you are not disadvantaged if you have not done this before! All students should be able to solve this quiz as all the formulae you need are provided below. You just need to apply the skills practised in the last 3 exercises.

We dig Chemistry

You will need to use the 3 formulae below to complete this exercise. You may have to rearrange them as appropriate.

① Relationship between mass and moles

$$amount\ (in\ mol) = \frac{mass\ (in\ g)}{molar\ mass\ (in\ g\ mol^{-1})}$$

② Relationship between gas volumes and moles

$$amount\ of\ gas\ (in\ mol) = \frac{volume\ (in\ cm^3)}{molar\ volume\ (in\ cm^3 mol^{-1})}$$

③ Relationship between moles and concentration of a solution

$$amount\ of\ solute\ (in\ mol) = concentration\ (in\ mol\ dm^{-3}) \times volume\ (in\ dm^3)$$

If you are keen to get ahead, learn these formulae before September! However you will be given the opportunity to learn this from scratch when you start your A Level course.

Name:

Exercise 11: Maths quiz

You will need the formulae given on the previous page to answer these questions.

Set out your workings for each answer clearly, so that any errors can be identified more easily.

If you are really stuck, have a look at the "Hints" on the answers document.

A. Find the amount, in mol, of NaCl in 10.0g of NaCl, given its molar mass is 58.5 g mol^{-1}. Give your answer to 3sf.

………….……………………. mol

B. Find the volume, in cm^3, of 4.246×10^{-4} mol of a gas, given the molar volume is 24000 cm^3 mol^{-1}. Give your answer to 4sf.

………….……………………. cm^3

C. A 0.330 dm^3 can of Coke contains 0.102 mol sucrose. What is the concentration, in mol dm^{-3} , of sucrose in this can of Coke? Give your answer to 3sf.

………….……………………. mol dm^{-3}

PRINT

D. 76.000 cm^3 CO_2 was collected in an experiment at room temperature and pressure (RTP). The molar volume of any gas is 24000 cm^3 mol^{-1} at RTP. What is the amount, in mol, of CO_2 collected in this experiment? Give your answer in standard form to 5sf.

……………………………………… mol

E. A chemist needs 1.25×10^{-3} mol of $KMnO_4$ in an experiment. He has a solution of $KMnO_4$ of 2.25×10^{-2} mol dm^{-3} concentration. Calculate the volume, in dm^3, of this solution he needs to 3sf.

……………………………………… dm^3

☑ How are you getting on? Check your work against the answers in the separate document before continuing.

Mark	/10

PRINT

F. The molar volume of gases changes according to temperature. Find the molar volume, in $cm^3\ mol^{-1}$, of a gas at 0°C if 0.125 mol of this gas occupied a volume of 2800 cm^3. Give your answer to 3sf.

…………..………………………. $cm^3\ mol^{-1}$

G. 0.2000g (5.414×10^{-4} mol) of an illegal drug caused death by overdose. Deduce the molar mass, in $g\ mol^{-1}$, of this drug. Give your answer to 4sf.

…………..………………………. $g\ mol^{-1}$

H. Sulfur dioxide emitted from industry produces sulfuric acid when it reacts with rain water. A lake of volume 4.0×10^{14} dm^3 was found to have a sulfuric acid concentration of 5.2×10^{-5} $mol\ dm^{-3}$. Calculate the amount, in mol, of H_2SO_4 present in this lake.
Give your answer in standard form to 2sf.

…………..………………………. mol

PRINT

I. In 2000, 1.94×10^8 mol of aspirin was consumed worldwide. The molar mass of aspirin is 180 g mol^{-1}. Calculate the mass, in **tonnes**, of aspirin consumed in 2000. (1 tonne = 1×10^6 g)
Give your answer to 2sf.

…………….……………………… tonnes

J. The average concentration of NaCl in the oceans is 0.60 mol dm^{-3}.
The volume of water in the oceans is approximately 1.3×10^9 **km³**.
Find, to 2sf, the amount, in mol, of NaCl found in the world's oceans.
(1 km^3 = 1×10^{12} dm^3)

…………….……………………… mol

Mark	/10

What is the chemical significance of this number?

Challenge!

Now combine the numerical values from your answers to the questions A – J in according to the following expression. Quote your final answer to 3 significant figures.

$$\frac{(A+C)}{B} \times G \times \left(\frac{E}{D} + \frac{H}{F \times I}\right) \times J$$

What is the chemical significance of this number?

Name:

Summary exercise
(12) Correct the errors

A teacher asked several groups of students to prepare samples of salts and to write up their experiments. Some of the students also carried out chemical calculations.

The relationship between amount of substance, **n**, in mol; mass of substance, **m**, in g; and molar mass (mass of one mole of substance, **M**) in g mol^{-1} is:

$$\text{amount (in mol)} = \frac{\text{mass (in g)}}{\text{molar mass (in g mol}^{-1})}$$

Here are the students' accounts. Identify the errors and correct them. There may be mistakes in the chemistry, the chemical formulae, the use of words, the calculations, or the representation of the numbers. You may assume that all balance readings are correct, as are statements in *italics*.

Bring your completed work to your lessons in September.

(a) Making copper(II) sulfide (*Hint: You should find 7 errors.*)

We decided to make copper(II) sulfide by reacting *copper(II) oxide with sulfuric acid*. The equation for the reaction is:

$$CuO + 2HSO4 \rightarrow Cu(SO_4)_2 + H_2O$$

We weighed out 0.6g (2sf) copper(II) oxide (*an excess*) and added enough sulfuric acid to react with most of the copper(II) oxide. We filtered off the unreacted copper(II) oxide and obtained a clear solution of copper(II) sulfide. We left the solution in an evaporating dish for a week and obtained *blue* molecules of copper(II) sulfide. The mass of our copper(II) sulfide was 1.55g (3sf) or 1.5g (2sf).

(b) Making potassium nitrate (*Hint: You should find 7 errors.*)

We reacted *potassium carbonate with nitric acid* to make potassium nitrate. The equation for the reaction is:

$$KCO_3 + H_2NO_3 \rightarrow KNO_3 + H_2CO_3$$

In this reaction potassium elements replaced the hydrogen atoms in the acid to make the potassium nitrate salt. We obtained 0.65g of potassium nitrate molecules (*molar mass 101.1g mol^{-1}*). This amount of potassium nitrate is 6.43×10^{-3} mol = 0.0643 mol (3sf).

(c) Making magnesium chloride

Magnesium chloride is an ionic compound made up of magnesium ions and chlorine ions. We made magnesium chloride by reacting *magnesium ribbon with hydrochloric acid*.

$$Mg_2 + 4HCl \rightarrow 2MgCL_2 + 4H$$

We added pieces of magnesium compound to hydrochloric acid in a test-tube until all the acid was used up. We knew the acid had all reacted because there was no more fizzing and some magnesium molecules were left. We found that we had used 0.08g (2sf) of magnesium metal (*molar mass 24.3g mol^{-1}*) which is 1.94 mol of magnesium. *Our teacher said we should expect the same amount of magnesium chloride (molar mass 95.3g mol^{-1}) as the amount of magnesium used.* We were disappointed that we only obtained 0.31g (2sf) of magnesium chloride.

Practical work

(A) Making observations

Chemistry is a practical science. As part of your A Level course, you will need to demonstrate ability in carrying out experiments, recording results, processing data and evaluating the practical procedures.

How much detail should we give in observations?

The purpose of recording observations is to allow other scientists to know what to expect and to be able to reproduce and verify your results.

You need to record:

- the appearance (including colour and state) of your **starting materials**;
- the appearance (including colour and state) of your **final product**;
- plus any interesting observations during the reaction, such as effervescence (bubbling), intermediate colours, smell of any gas evolved, temperature change of the mixture.

Examples

(a) Dissolving sugar in water

A white crystalline solid was added to a colourless liquid to form a colourless solution.

(b) Limescale forming in a kettle after boiling tap water

A white precipitate formed when a colourless solution was heated.

(c) Making tea with loose tea leaves

A hot colourless liquid was added to a black solid to form a brown solution. The black solid remained.

(d) Making a blackcurrant vitamin C drink with a fizzy tablet

A pink solid was added to a colourless liquid. Effervescence occurred and a purple solution formed.

Solution or liquid?

A **liquid** is a melted solid.

A **solution** is a mixture where a substance (the solute – may be solid, liquid or gas) has been dissolved into a liquid (the solvent).

If you know something has been dissolved into water, describe it as a *solution.*

Solutions are always **clear** (see-through), so it is redundant to describe them as "clear solutions". If a solution has no colour, ie looks like water, you must describe it as **colourless**.

Solid or precipitate?

A **solid** is a state of matter.

A **precipitate** is a solid that *forms* from a solution. It was not present at the start of the reaction.

A precipitate may be correctly described as a solid, but it is incorrect to call a solid that was present at the start and end of a reaction a precipitate.

You can tell if a precipitate has formed if a solution stops being clear (transparent) even if there are no obvious lumps of solid. Eg carbon dioxide turns limewater cloudy because it causes a *white precipitate* of calcium carbonate to form.

Name:

PRINT

Observations exercise

Watch the video found on our HRChem channel on Youtube.

https://youtu.be/F-gspJFPzxo

Record your observations of the different reactions in the table below.

Expt	Observations	Mark
A		
B		
C		
D		
E		

☑ Use a different coloured pen and mark your work, using the answers given in the summer work folder. Bring this page of work to show your teacher at the start of term.

Mark	/20

Summary

List of key ions important for A Level Chemistry

Positive ions

Metals always form + ions.

Negative ions

Non-metals (except H) form – ions.

These ions you can work out from the Periodic Table:

- Gr 1 metals form 1+ ions.
- Gr 2 metals form 2+ ions.
- Gr 3 metals form 3+ ions.

- Gr 7 non-metals form 1- ions.
- Gr 6 non-metals form 2- ions.
- Gr 5 non-metals form 3- ions.

Lithium ion	Li^{+}
Sodium ion	Na^{+}
Potassium ion	K^{+}
Magnesium ion	Mg^{2+}
Calcium ion	Ca^{2+}
Aluminium ion	Al^{3+}

Chloride ion	Cl^{-}
Bromide ion	Br^{-}
Iodide ion	I^{-}
Oxide ion	O^{2-}
Sulfide ion	S^{2-}
Nitride ion	N^{3-}

These ions, however, must be learnt by heart.

Hydrogen ion	H^{+}
Ammonium ion	NH_4^{+}
Silver ion	Ag^{+}
Copper(II) ion	Cu^{2+}
Zinc ion	Zn^{2+}
Iron(II) ion	Fe^{2+}
Iron(III) ion	Fe^{3+}

Hydroxide ion	OH^{-}
Nitrate ion	NO_3^{-}
Hydrogencarbonate ion	HCO_3^{-}
Carbonate ion	CO_3^{2-}
Sulfate ion	SO_4^{2-}
Phosphate ion	PO_4^{3-}

Note how ions are named:

- **Positive ions**
  made by metals have names that are just the name of the metal with the word "ion" after, eg Na^{+} is the sodium ion.
- **Negative ions made by a single non-metal element**
  are named after the non-metal but with the name ending changed to **-ide**, eg Cl^{-} is the chlor**ide** ion, S^{2-} is the sulf**ide** ion.
- **Negative ions that contain oxygen as well as another element**
  have names that end **–ate**, eg NO_3^{-} is the nitr**ate** ion.

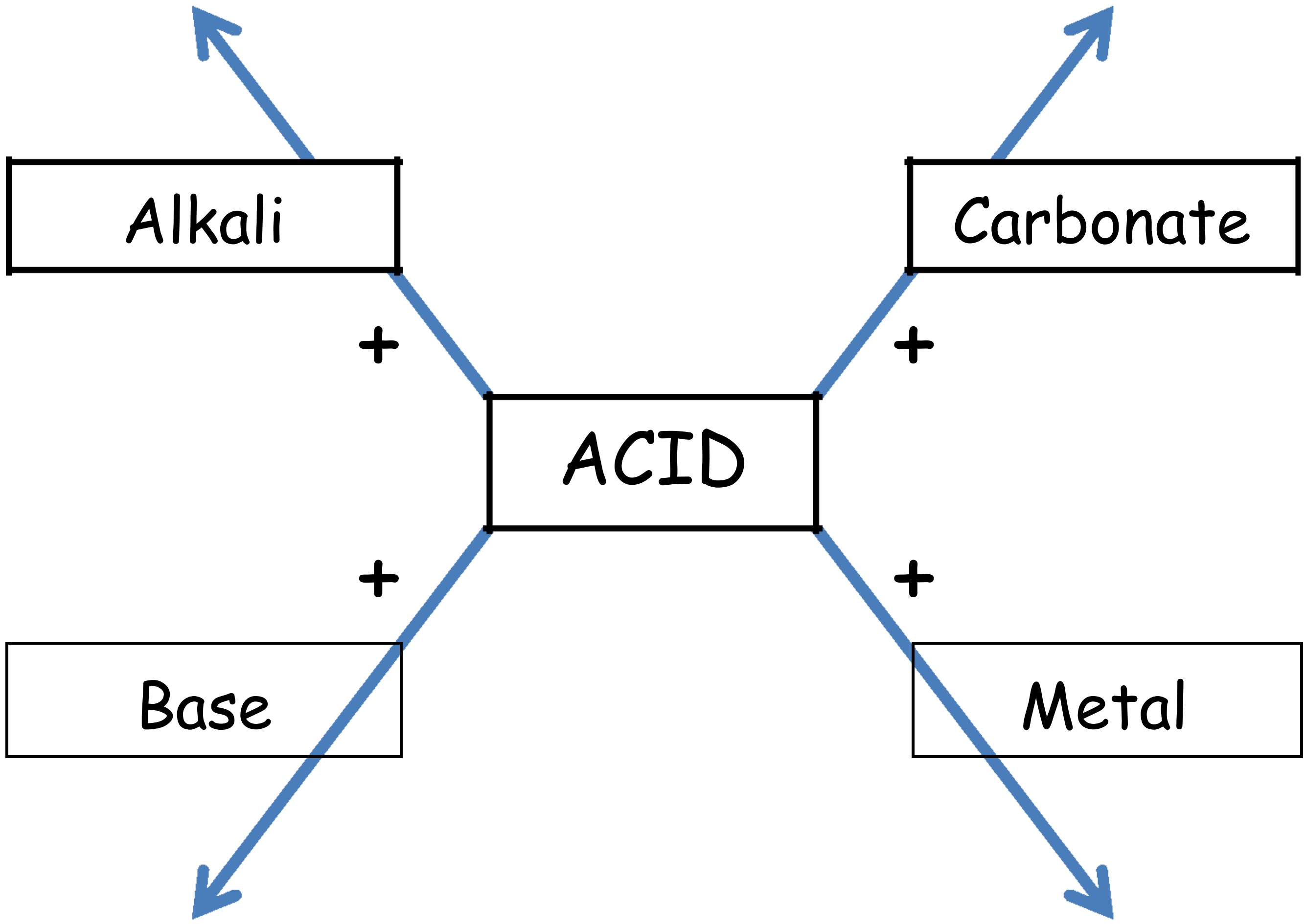
List of key formulae for A Level Chemistry

Use the information provided in this pack to complete the table. Commit these formulae to memory!

Oxygen gas	
Nitrogen gas	
Chlorine gas	
Magnesium metal	
Ammonia	
Methane	
Ethanoic acid	
Hydrochloric acid	
Nitric acid	
Sulfuric acid	
Sodium hydroxide	
Potassium hydroxide	

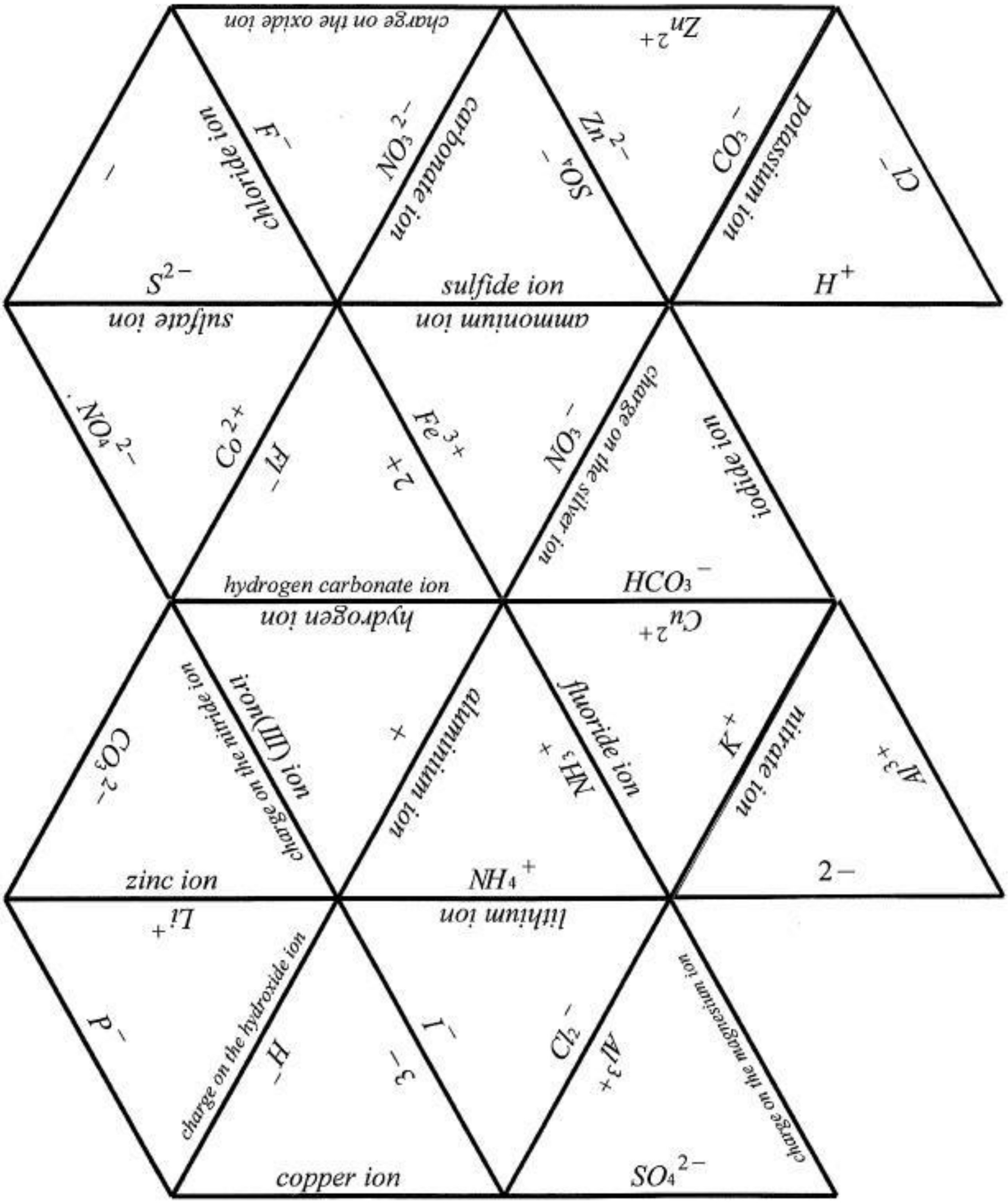
Reactions of acids

Complete the following summary diagram. Add, in a different colour, balanced symbol equations as an example of each reaction.



Review activities
(i) Ions puzzle

Print this page and cut out the triangular pieces along the bold lines. Match the correct answers to make a larger geometric shape. See how quickly you can complete this puzzle!



(ii) Acid reactions dominoes game

Print this page and cut out the dominoes along the bold lines.

Shuffle the pieces and starting with the piece that says "Start", match the correct halves of the equations until you reach "End".

Start	Acid + Metal →	Metal nitrate + water	$Zn + H_2SO_4 \rightarrow$
Salt + hydrogen	$2HCl + MgCO_3 \rightarrow$	$ZnSO_4 + H_2$	$Mg(OH)_2 + 2HCl \rightarrow$
$MgCl_2 + H_2O + CO_2$	$NaOH + HNO_3 \rightarrow$	$MgCl_2 + 2H_2O$	Sulfuric acid + metal hydroxide →
$NaNO_3 + H_2O$	Nitric acid + metal oxide →	Metal sulfate + water	$ZnO + H_2SO_4 \rightarrow$
$ZnSO_4 + H_2O$	$Na_2CO_3 + 2HNO_3 \rightarrow$	$MgCl_2 + H_2O$	Acid + base →
$2NaNO_3 + H_2O + CO_2$	Acid + metal carbonate →	Salt + water	$NaHCO_3 + HNO_3 \rightarrow$
Salt + water + carbon dioxide	$H_2SO_4 + ZnCO_3 \rightarrow$	$NaNO_3 + H_2O + CO_2$	$2HCl + Mg \rightarrow$
$ZnSO_4 + H_2O + CO_2$	$MgO + 2HCl \rightarrow$	$MgCl_2 + H_2$	*End*

Glossary

Use the information from this pack to write down the meaning of the following terms and LEARN THEM!!!

Atom	
Element	
Molecule	
Compound	
Ion	
Ionic bonding	
Covalent bond	
Acid	
Salt	
Base	
Alkali	
Effervescence	
Precipitate	

Check your knowledge

Now that you have worked through the preparation work, how confident do you feel about all the topics covered?

Fill in using the "traffic light" system, ie:

- Green = understand fully
- Amber = needs some more work before the A Level course really gets going
- Red = this area needs a lot more work – ask your teacher for help when you start in September.

Review this again at the end of September, and again at the end of the first term, by which point you should be able to colour green to all topics!

Ex	Knowledge statement	Now	Sept	Dec
1	I know the meaning of the words *atom, element, molecule, compound* and *ion*, and when to use them.			
2	I know how to write the formula for any element from the periodic table in an equation.			
4	I know by heart all the formulae of the key ions listed in the Summary section.			
	I know how to balance charges in order to write the formulae for ionic compounds.			
	I know how to name ionic compounds.			
4, 5	I know how to predict whether a compound is ionic or covalent.			
5	I know how to write the formula for a covalent compound from its chemical name.			
	I know by heart the formulae for *ammonia, methane* and *ethanoic acid.*			
6	I know that symbol equations need to balance for mass and for charge, and how to do this.			
	I know how to write balanced symbol equations when given the word equation.			
7	I know the reactions between an acid and • a reactive metal • a metal hydroxide • a metal oxide • a metal carbonate			
	I know the formulae for the common acids: *hydrochloric acid, nitric acid, sulfuric acid, phosphoric acid* and *ethanoic acid*. I know the names of their salts.			

Ex	Knowledge statement	Now	Sept	Dec
8	I know how to write a number to a given number of significant figures.			
	I know how to decide to how many significant figures a calculated answer should be quoted.			
9	I know how to convert a number into standard form; and from standard form to longhand form.			
	I know how to carry out calculations using numbers in standard form.			
10	I know how to rearrange algebraic equations.			
11	I know how to combine all the mathematical skills listed above to solve word problems.			
Prac	I know how to record observations in experiments to appropriate detail, using technical words correctly.			