Longley Park Sixth Form Transition Pack

Chemistry

(A Level and Applied Science)

Longley Park
SIXTH FORM

longleypark.ac.uk

Chemistry (A Level and Applied Science)

This booklet contains a series of activities to help support you with the transition from GCSE to Sixth Form.

These key topics are the foundations of chemistry that should be familiar to you during your studies so far. Make sure you attempt all activities to the best of your ability.

This booklet includes:

Key Terms

Important Chemicals

Gas Tests

Chemical Formulae

Calculations

Ionic Formulae

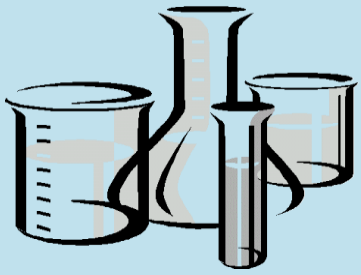
Naming Compounds

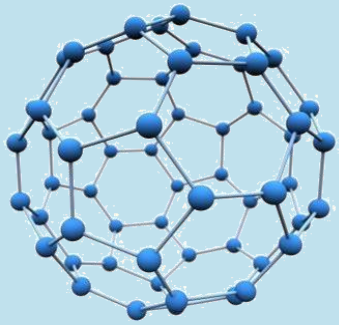
Balancing Equations

Molar Calculations

Empirical Formulas

Functional Groups





‘Pick and Mix’ Activities: Complete any two of the activities below

Activity 1: Its elementary my dear Watson…

Task: Create a personalised story, highlighting any key topic or principle from the periodic table.

You could use Mr Men/Little Miss™ style of writing. Some examples of topics you can pick from (or chose your own); atomic structure, the ordering of the periodic table, trends down a group or across a period, atoms/elements/compounds, or discovery of individual elements. You can present it however you feel most comfortable with e.g. story, comic strip, storyboard, song or even a very short animated video. e.g. “It was a warm and sunny day in element land, Little Miss Lithium was having her breakfast when she heard a knock at the door ….”

Activity 2: Isn’t it Ionic?

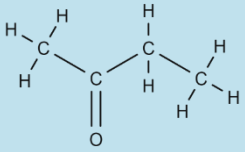
There are three main types of bonding that you should already be familiar with; Ionic, covalent and metallic.

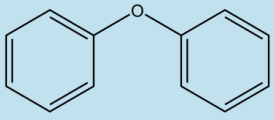
Task: Create a 1-page illustrative summary on bonding in these compounds: water, iron and Iron (III) Oxide.

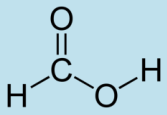
If you can, add extra information such as strengths of bonds, properties and other factors that affect these bonds. The more three dimensional your poster the better!

Activity 3: Choosing Organic

Task: Watch the video clip by typing in the link below. Then use your newfound knowledge to name the types of molecules below:







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

Activity 4: Now we’re cooking

Sheffield university’s chemistry department has some ‘sweet’ edible experiments designed to be done at home. There are some great facts to go with some everyday foods too. Have a look and see if you can do any of them at home. Practise report write ups by making observations and conclusions to your experiment.

https://www.sheffield.ac.uk/chemistry/schools/edible-experiments

***Main Activities*: These activities are designed to build your understanding of the key chemistry concepts. Work through these at your own pace, completing each task to the best of your ability.**

Key Chemistry Terms

It is important that you know some of the key terms when it comes to chemical reactions.

e.g. What do we mean by **atoms**?

What do you know about **protons, neutrons and electrons**?

What is meant by the term **reactants**?

What is meant by the term **products**?

What do we mean by **states of matter**?

Task 1: Complete the table about protons, neutrons and electrons:

Particle	Relative Mass	Relative Charge	Position in the atoms
Proton			Within the Nucleus
Neutron	1		
Electron			Shells/ Energy Levels Around the Nucleus

Task 2: The Haber Process is an industrial process that you will have studied at GCSE. The chemical equation for the Haber Process is:

$$N_2(g) + 3H_2(g) \overset{Fe}{\rightleftharpoons} 2NH_3(g)$$

(a) Name the **reactant(s)** in this reaction ……

(b) Name the **product(s)** in this reaction. ……

(c) What is the **state** of the iron in this process? ……

(d) What is the state of the reactants? ……

(e) The Iron is not used up in this reaction.

What is the function of the iron in this process? ……

(f) What does the double-headed arrow show?

……

Task 3: Link each term to the correct definition with a clear line or arrow

Element	Chemicals containing two or more elements chemically bonded together
Compound	Chemicals containing more than one element or compound that are physically mixed but not chemically bonded together
Mixture	The simplest chemicals – they cannot be broken down into simpler chemicals

Task 4: Identify each of the following species as an element, compound or mixture.

	Chemical	Element (E), Compound (C) or Mixture (M)?
1)	Fe	
2)	Cl_2	
3)	HCl	
4)	HI	
5)	Water	
6)	Air	
7)	Crude Oil	
8)	H_2O_2	
9)	CO	
10)	Co	
11)	H_2SO_4	
12)	Ozone	

Common molecules

- An **atom** is a single particle of an element
- A **molecule** is made up of atoms joined by covalent bonds

These are a number of common molecules that you should know:

Name	Chemical Formula	State at room temp
Carbon dioxide	CO_2	Gas
Carbon monoxide	CO	Gas
Oxygen	O_2	Gas
Hydrogen	H_2	Gas
Nitrogen	N_2	Gas
Chlorine	Cl_2	Gas
Ethene	C_2H_4	Gas
Water	H_2O	Liquid
Sulfur	S_8	Solid
Phosphorus	P_4	Solid

Note that the Noble Gases (Group 8) such as Helium and Argon exist as **single atoms** and so their formula is simply their chemical symbol, e.g. He

Other gases exist as **diatomic molecules**, which means that they exist in pairs, e.g. Oxygen (O_2) and Nitrogen (N_2)

Task 5: Research which gases exist as **diatomic molecules** and write them below

Task 6: One group of organic molecules are the 'alkanes' with the general formula C_nH_{2n+2}. Complete the table below:

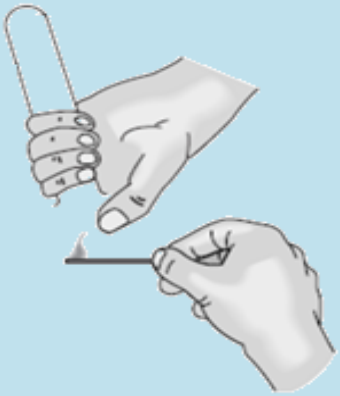
Number of C	Number of H	Formula	Name
1	*4*	*CH_4*	*Methane*
2			
3			
4			
5			
6			
7			
8			

Testing for gases

You should have learnt the tests for different gases.

Task 7: Complete the diagrams or description for each test:

(a) Testing for Hydrogen



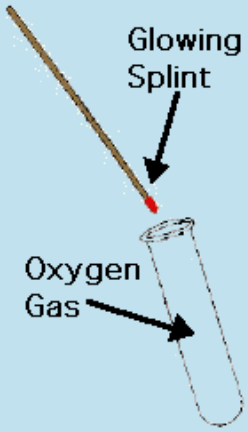
Description:

(b) Testing for Carbon Dioxide

Diagram:

Limewater will turn from a colourless solution to white, cloudy solution if carbon dioxide is bubbled through it. This is because a precipitate of calcium carbonate forms.

(c) Testing for Oxygen



Description:

Chemical Formulae

The chemical formula indicates the **number of atoms of each element** present.

Example 1:

Ammonia has the chemical formula: NH_3

This means there are: 1 Nitrogen atom

3 Hydrogen atoms

Example 2:

Copper Sulfate has the chemical formula: $CuSO_4$

This means there are: 1 Copper atom

1 Sulfur atom

4 Oxygen atoms

When the chemical formula contains brackets, all of the **components inside the brackets are multiplied** by the number outside the brackets.

Example 3:

Magnesium Nitrate: $Mg(NO_3)_2$

This means there are: 1 Magnesium atom

(1 x 2) = 2 Nitrogen atoms

(3 x 2) = 6 Oxygen atoms

Task 8: What do the following Chemical Formulae **indicate**?

(a) $NaOH$ ……

……

(b) H_2O ……

……

(c) $CaCO_3$ ……

……

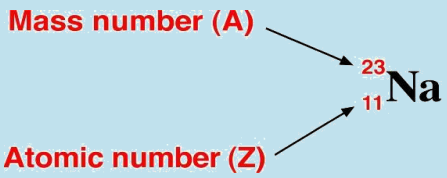
(d) $Cu(OH)_2$ ……

……

(e) $Ca(HCO_3)_2$ ……

……

Calculating Molecular Mass



- **Relative atomic mass (RAM or A_r)** is the average mass of an atom of an element relative to 1/12th of the mass of a carbon-12 atom.
- **Relative molecular mass (RMM)** is sum of the relative atomic masses of all the atoms in the molecular formula of an element or compound relative to 1/12th of the mass of a carbon-12 atom.
- **Relative formula mass (RFM)** is the sum of the relative atomic masses of all the atoms in the formula of a compound relative to 1/12th of the mass of a carbon-12 atom.
- **Molar mass (M_r)** is the mass of one mole of a compound (units g mol^{-1}).

Example Calculation 1:

Sulphuric Acid has the formula:	H_2SO_4	
This means there are:	2 Hydrogen atoms	(A_r = 1.0)
	1 Sulphur atom	(A_r = 32.1)
	4 Oxygen atoms	(A_r = 16.0)
The molar mass is therefore:	2 x 1.0	
	1 x 32.1	
	4 x 16.0	= **98.1 g mol^{-1}**

Example Calculation 2:

Calcium Hydroxide has the formula: $Ca(OH)_2$

This means there are:	1 Calcium atom	(A_r = 40.1)
	2 Oxygen atoms	(A_r = 16.0)
	2 Hydrogen atoms	(A_r = 1.0)
The molar mass is therefore:	1 x 40.1	
	2 x 16.0	
	2 x 1.0	= **74.1 g mol^{-1}**

Task 9 Calculate the molar mass of the compounds:

(a) H_2O ……

(b) CO_2 ……

(c) NH_3 ……

(d) C_2H_5OH ……

(e) C_2H_4 ……

(f) SO_2 ……

(g) SO_3 ……

(h) HBr ……

(i) PbO_2 ……

(j) HNO_3 ……

(k) NaCl ……

(l) $NaNO_3$ ……

(m) $KMnO_4$ ……

(n) $Ca(NO_3)_2$ ……

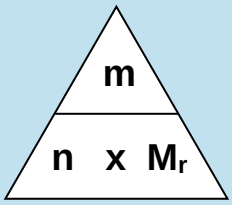
(o) $Al_2(SO_4)_3$ ……

(p) $(NH_4)_2SO_4$ ……

(q) $CuSO_4.\ 5H_2O$ ……

(This is a hydrated salt of copper sulphate containing 5 water molecules)

Molar Calculations



The **mole** is the unit for amount of substance. The units are '**mol**'.

We can calculate the number of moles using:

number of moles = mass ÷ molar mass

(n) (m) (M_r)

Example: What is the number of moles of carbon dioxide molecules in 22g?

- Atomic masses (A_r) from the periodic table; C = 12, O = 16
- So the relative formula mass (M_r) of carbon dioxide = 12 + 16 + 16 = 44
- This means that the molar mass of carbon dioxide = 44 g mol^{-1}
- The number of moles is therefore = 22g ÷ 44g mol^{-1} = **0.500 mol**

Task 10: Calculate the number of moles of substance (***Put all answers to 3 significant figures)***

(a) 6.00 g of H_2O

…… mol

(b) 35.0 g of CO_2

…… mol

(c) 11.70 g of NH_3

…… mol

(d) 230 g of C_2H_5OH

…… mol

(e) 560 g of C_2H_4

…… mol

(f) 0.641 g of SO_2

…… mol

(g) 0.083kg of NaCl

…… mol

(h) 2.25 kg of Na_2CO_3

…… mol

(i) 2 tonnes of NaOH

…… mol

Working out the molecular formula using % composition

The **empirical formula** of a compound is the **simplest whole number ratio** of each type of atom in a compound. It can be the same as the compound's **molecular formula** - but not always. An empirical formula can be calculated from information about the mass of each element in a compound or from the percentage composition.

Example: 3.2g of sulfur reacts with oxygen to produce 6.4g of sulfur oxide.

What is the formula of the oxide? (A_r of S = 32.1 and A_r of O = 16)

1	Write the element symbols	S	O
2	Write the masses	3.2 g	6.4 – 3.2 = 3.2 g
3	Write the A_r values	32.1	16
4	Divide mass by A_r	3.2 ÷ 32.1 = 0.0997	3.2 ÷ 16 = 0.2
5	Divide by the smallest number	0.0997÷ 0.0997= 1	0.2 ÷ 0.0997= 2
6	Write the formula	SO_2	

Task 11: Work out the empirical formula for each of these compounds using the method above. ***Show your working out.***

1) 2.4 g of magnesium reacts with 1.6 g of oxygen to form an oxide. What is the formula of this oxide?

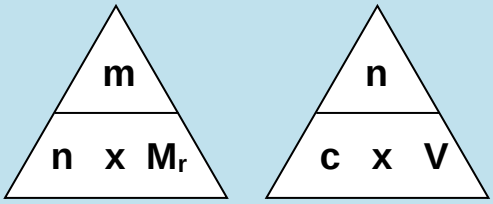
2) 10g of a compound contains 40% Ca, 12% C and 48% O by mass. What is the empirical formula of the compound?

Calculating concentration of solutions

The amount of a solute that is dissolved in a known volume of solution is called its **concentration**. The most commonly used units of concentration are **mol dm^{-3}**

Remember: 1 dm^3 is equal to 1000 cm^3

Example: Calculate the concentration of 4.12g H_2SO_4 in 100cm^3 of solution



Step 1: Calculate the molar mass of H_2SO_4

- 2 x H = 2 x 1 = 2
- 1 x S = 1 x 32.1 = 32.1
- 4 x O = 4 x 16 = 64 **Molar mass = 98.1**

Step 2: Calculate the moles of H_2SO_4

- Number of moles = mass / molar mass
  = 4.12 / 98.1
  = 0.04199796 mol = **0.042 mol**

Step 3: Convert the volume to dm^3

- To convert from cm^3 to dm^3, divide by 1000
- 100 cm^3 / 1000 = **0.1 dm^3**

IMPORTANT!

Keep the full number in your calculator and use it for later calculations.

Step 4: Calculate the concentration of the solution

- Concentration = number of moles / volume
  = 0.04199796 / 0.1
  = **0.420 mol dm^{-3}**

Task 12: Calculate the concentration of 3.33g H_3PO_4 in 250cm^3 of solution

Ionic Formulae

Ionic compounds are made up of a positively-charged metal ion (cation) and a negatively-charged non-metal ion (anion). The charges on these ions must balance and cancel out so the overall charge is zero ***e.g.*** Sodium Chloride (table salt) has the chemical formula NaCl. The cation is Na^+ and the anion is Cl^-.

Before you can work out the formulae of ionic compounds, you need to be able to work out the charges on ions.

The rules (these apply to the simpler examples)

- Metals in **group 1** always have a **+1** ionic charge
- Metals in **group 2** always have a **+2** ionic charge
- Metals in **group 3** always have a **+3** ionic charge
- Non-metals in **group 5** have a **-3** ionic charge
- Non-metals in **group 6** always have a **-2** ionic charge
- Non-metals in **group 7** always have a **-1** ionic charge

Transition metals can have more than one different ionic charge. In these cases we always label the metal ion charge using roman numerals. This is also true of some other elements and both their cationic and anionic ions.

e.g. Iron (III) chloride contains Fe^{3+} ions so the formula is $FeCl_3$

Iron (II) chloride contains Fe^{2+} ions so the formula is $FeCl_2$

Lead (II) oxide contains Pb^{2+} ions so the formula is PbO

We can use these rules to work out the formula of ionic compounds.

Example 1: What is the formula of potassium chloride?

- Potassium (K) is found in group 1 so the ion is K^+
- Chlorine (Cl) is found in group 7 so the ionic charge of a chloride ion is Cl^-
- The 1 positive charge cancels out the 1 negative charge so the formula for potassium chloride is KCl.

Example 2: What is the formula of magnesium fluoride?

- Magnesium (Mg) is found in group 2 so the ion is Mg^{2+}
- Fluorine (F) is found in group 7 so the ionic charge of a fluoride ion is F^-
- 2 F^- ions are needed to cancel out the 2 positive charges on the magnesium ion so the formula for magnesium fluoride is MgF_2.

Task 13: What is the ionic formula of these compounds? ***Show your working out.***

(a) sodium iodide

……

(b) sodium oxide

……

(c) lithium chloride

……

(d) calcium sulfide

……

(e) potassium nitride

……

(f) aluminium oxide

……

(g) Calcium hydride

……

(g) Lithium nitride

……

Charged 'groups of atoms'

Some charged 'groups of atoms' have formulae which you cannot deduce from the periodic table. You need to learn these!

Ion	Formula and Charge
Hydroxide	OH^-
Nitrate	NO_3^-
Carbonate	CO_3^{2-}
Sulfate	SO_4^{2-}
Ammonium	NH_4^+

Example 1: What is the formula of potassium sulfate?

- Potassium (K) is found in group 1 so the ion is K^+
- The sulfate ion is SO_4^{2-}
- So 2 K^+ ions are needed to cancel out the 2 negative charges on the sulfate ion.
- Therefore the formula of potassium sulfate is K_2SO_4

Example 2: What is the formula of magnesium nitrate?

- Magnesium (Mg) is found in group 2 so the ion is Mg^{2+}
- The nitrate ion is NO_3^-
- So 2 nitrate ions are needed to cancel out the 2 positive charges on the magnesium ion.
- Therefore the formula of magnesium nitrate is $Mg(NO_3)_2$

Note: Because there is more than one nitrate ion present, a bracket must be placed it. This only applies to ions made up of groups of atoms, not regular ions.

Example 3: What is the formula of ammonium oxide?

- The ammonium ion is NH_4^+
- Oxygen (O) is group 6 so the ion is O^{2-}
- So 2 ammonium ions are needed to cancel out the 2 negative charges on the oxide ion.
- Therefore the formula of ammonium oxide is $(NH_4)_2O$

Task 14: What is the ionic formula of these compounds?

(a) lead (II) nitrate …….

(b) calcium carbonate …….

(c) ammonium fluoride …….

(d) iron (II) sulfate …….

(e) iron (III) sulfate …….

(f) ammonium sulfate …….

(g) Lithium sulfate …….

(h) The dichromate (VI) ion has a formula of $Cr_2O_7^{2-}$.
What is the formula of potassium dichromate (VI)? …….

Important Chemicals

Below are some important chemicals.

Task 15: Research and write out their chemical formulas:

Chemical	Formula
Hydrochloric acid	
Nitric Acid	
Sulfuric acid	
Ammonia	
Methane	
Sodium hydroxide	

Naming compounds

You will come across lots of new compounds in A-Level Chemistry – you need to learn the following rules in order to be able to correctly name them:

1) If the anion is a single element, the compound will end in **–ide**

   e.g. Na_2O is sodium ox**ide**

   $MgCl_2$ is magnesium chlor**ide**

   KBr is potassium brom**ide**

   LiH is lithium hydr**ide**

2) If the compound contains two non-metal atoms, a prefix is used to show the number of atoms present. **Mon-** means 1 atom; **di-** means 2 atoms; **tri-** means 3 atoms etc.

   e.g. CO_2 is carbon **di**oxide

   CO is carbon **mon**oxide

   SO_3 is sulfur **tri**oxide

3) (a) If the compound contains a metal, a non-metal and oxygen, the name will end in **-ate** or **-ite**

   e.g. Na_2CO_3 is sodium carbon**ate**

   $Mg(NO_3)_2$ is magnesium nitr**ate**

   $KMnO_4$ is potassium mangan**ate**(VII)

(b) When the compound can have different numbers of oxygen atoms, the ending **–ite** is used to show the compound with the lower number.

   e.g. $MgSO_4$ is magnesium sulf**ate**

   $MgSO_3$ is magnesium sulf**ite**

Task 16: Name these compounds:

(i) SO_2 ……

(ii) $SiCl_4$ ……

(iii) $KClO_3$ ……

(iv) $NaNO_3$ ……

(v) $NaNO_2$ ……

Task 17: Write out the formulae for these compounds:

(i) carbon tetrachloride ……

(ii) phosphorus pentachloride ……

(iii) calcium sulfite ……

(iv) sulfur hexafluoride ……

(v) Lithium nitrate ……

(vi) Sulfur monoxide ……

Balancing Equations

Chemicals equations do much more than tell us what reacts with what in a chemical reaction. They tell us how many of each type of molecule are needed and how many are produced. We can use them to work out the mass of products and reactants.

(a) Word Equations (these will not be acceptable at A Level – they are too simple!)

Before you can write out a symbol equation, you need to write out the word equation for the reaction:

e.g. Hydrogen + Oxygen → Water

(b) Writing formulae

Using the skills learnt in the previous topics, you should now be able to write out the chemical formulae. **Remember those diatomic molecules!**

e.g. H_2 + O_2 → H_2O

(c) Balancing the equation

Atoms are rearranged in chemical reactions, but never created or destroyed. So the numbers of atoms of each element need to balance on either side of the arrow.

e.g. H_2 + O_2 → H_2O

There are 2 oxygen atoms on the left hand side

There is only 1 oxygen atom on the right hand side

→ So we add another H_2O molecule on the right hand side

H_2 + O_2 → **2**H_2O

But there are now 4 hydrogen atoms on the right hand side

There are only 2 hydrogen atoms on the left hand side

→ So we add another H_2 molecule on the left hand side

2H_2 + O_2 → **2**H_2O

The reaction is now balanced!

<u>Remember:</u> when balancing equations you cannot change the formula of the molecule. You can only change the amount of each molecule that we have!

Task 18: Balance the following equations:

(a) $NaI + Cl_2 \rightarrow NaCl + I_2$

(b) $S_8 + O_2 \rightarrow SO_2$

(c) $HCl + K_2CO_3 \rightarrow KCl + H_2O + CO_2$

(d) $HNO_3 + Al_2O_3 \rightarrow Al(NO_3)_3 + H_2O$

(e) $NH_3 + O_2 \rightarrow NO_2 + H_2O$

(f) $PbO + C \rightarrow Pb + CO_2$

Task 19: Translate the following word equations into *balanced symbol equations*:

(a) sulfur dioxide + oxygen → sulfur trioxide

(b) magnesium + hydrochloric acid → magnesium chloride + hydrogen

(c) sodium hydroxide + sulfuric acid → sodium sulfate + water

(d) potassium oxide + sulfuric acid → potassium sulfate + water

Analysing compounds

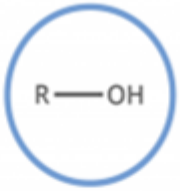
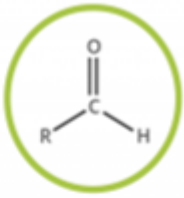
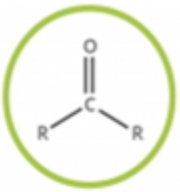
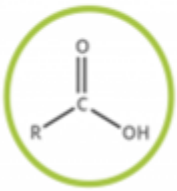
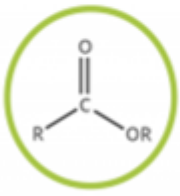
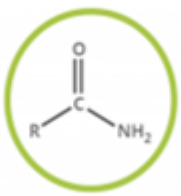
Flame tests can be used to identify the metal ions present in a compound. Learn the colours!

Metal ion	Flame colour
Barium (Ba^{2+})	Pale Green
Calcium (Ca^{2+})	Yellow-Red
Copper (Cu^{2+})	Green-Blue
Lithium (Li^{+})	Red
Sodium (Na^{+})	Orange
Potassium (K^{+})	Lilac

You will also need to understand **how** flame tests are carried out!

Functional groups

The **functional group** is responsible for many of the chemical properties of a molecule. You need to be familiar with common organic compounds and their functional groups:

				
C-C	C=C	-OH	-COH	-CO-
Alkane	Alkene	Alcohol	Aldehyde	Ketone
				
-COOH	-COO-	-$CONH_2$	-NH_2	-O-
Carboxylic Acid	Ester	Amide	Amine	Ether

*** **R-group** = any chain of atoms except H or another functional group ***

Task 20: What functional group is present in each of these compounds?