Cotswold Edge Sixth Form

Subject:	Chemistry @ YA	**Assessment Point 1 -** Coursework

Title of the project:	Maths Skills in Chemistry
Due date: First lesson back September 2018	
Learning skills and their place in the specification	Application of mathematical skills including manipulation of formulae and data handling.
Specification link	AQA Chemistry A-Level (7405) http://www.aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405
Tasks set	To work through the questions on the induction booklet. **You must ensure you print off the task booklet.**
How this links to the exam specification	3.1.1 1 Fundamental Particles : 3.1.1.2 Mass Number and Isotopes: *describe the number of protons ,neutrons and electrons in atoms*. 3.1.2.1. Relative Atomic Mass and Relative Molecular Mass: *calculate* M_r. 3.1.2.2. The Mole and Avagadro Constant: *calculate number of moles*. 3.1.2.4 Empirical and Molecular Formula: *calculate empirical formula*. 3.1.2.5 Balanced Equations and Associated Calculations: *write balanced equations and calculate % yield and concentrations.*
How to complete the task:	Work through the questions using your knowledge from GCSE. Show all calculations clearly.
Resources or links	GCSE revision guides www.chemguide.co.uk YouTube Fuse school chemistry videos
Staff contact and email address:	Mr Castellaro: simon.castellaro@yateacademy.co.uk
Number of learning hours it will take to complete	Minimum 10 hours

GCSE to A-Level Chemistry

Chemistry is a rewarding yet difficult subject that is highly valued by both employers and higher education establishments. The most challenging part of A-Level Chemistry is bridging the gap between GCSE and the A- level work.

There are 3 basic problems making the jump:

The first is making sure there are no gaps in your knowledge from GCSE. That is the main purpose of this pack.

Second is the quantity of material that you have to cover and sorting out what's important. It's useful to identify patterns that you can then 'hang' facts on as you need them.

Third, and most importantly, getting sufficient detail into your written answers is crucial. Very often students know the facts but do not know how to use them in exam situations. This will be a major focus throughout the first year.

The focus of the induction pack will be to build on skills from GCSE and extend these to include some of the basic mathematical problems that you will encounter in the first A-Level unit. This may seem daunting but will set you in good stead for a successful start in September.

There is an expectation that this pack will be completed by the beginning of term to ensure that no student is at a disadvantage by the time of the assessment. The material will be collected in for marking during the first week.

If you are struggling with any aspects of this pack, please do not hesitate to contact Mr Castellaro either in school or via email:

simon.castellaro@trfyia.org.uk

I also suggest that you have a look on www.chemguide.co.uk for some guidance.

Good luck!

Atomic Structure

Read through the relevant section of your GCSE revision guide to refresh your memory.

1)

a) What three particles are atoms made from? (3)
b) Which particles are in the nucleus? (2)
c) Explain why atoms are neutral even though they contain positive and negative particles. (2)

2)

a) Define the atomic (or proton) number of an atom. (1)

b) Define the mass number of an atom. (1)

c) Using the mass number and atomic number of an atom:

i) How do you work out the number of neutrons in an atom? (1)

ii) How do you work out the number of electrons in an atom? (1)

iii) How do you work out the number of protons in an atom? (1)

3) Complete the table below about the structure of atoms. (21)

Atom	Atomic number	Mass number	No. of protons	No. of neutrons	No. of electrons	Electron structure
^{40}Ar						
^{27}Al						
	9	19				
	4			5		
			17	18		
		1		0		

4)

a) What are isotopes? (2)

b) Explain why isotopes have the same chemical properties. (2)

Structure and Bonding

Read through the relevant section of your GCSE revision guide to refresh your memory.

1) a) Complete the table about the **metals** below: (10)

Element	Na	K	Mg	Ca	Al
Group number					
Number of electrons in outer shell					
Number of electrons needed to lose to get full outer shell					
Number of electrons needed to gain to get full outer shell					
Charge on the ion it forms					

b) What do you notice about the Group number and the charge on the ions for metals? (1)

2) a) Complete the table about the **non-metals** below: (10)

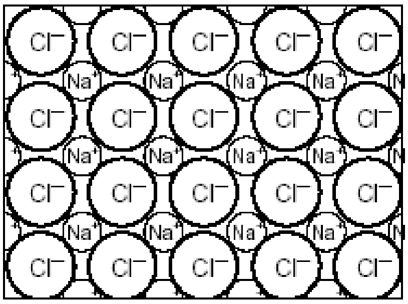
Element	Cl	Br	I	O	S
Group number					
Number of electrons in outer shell					
Number of electrons needed to lose to get full outer shell					
Number of electrons needed to gain to get full outer shell					
Charge on the ion it forms					

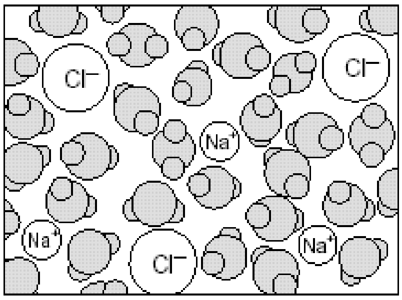
b) What do you notice about the Group number and the charge on the ions for non-metals? (1)

3) a) Draw the electron configuration of the following ions:

i) Na^{+} ii) Ca^{2+} iii) S^{2-} iv) F^{-} (4)

1) Ionic structures





Sodium chloride as a solid, NaCl(s)

Sodium chloride dissolved in water, NaCl(aq)

As a solid:

T F 1 Each molecule of sodium chloride contains one sodium ion and one chloride ion

T F 2 Each sodium ion is attracted to one chloride ion.

T F 3 The ions exist in pairs containing one sodium ion and one chloride ion.

T F 4 Each sodium ion is bonded ionically to one chloride ion, and then to others by attractive forces.

T F 5 There is a bond between the ions in each molecule, but no bonds between molecules.

T F 6 There are no molecules shown in the diagram.

T F 7 An ionic bond is when one atom donates an electron to another atom.

T F 8 A sodium ion can only form one ionic bond because it only has one electron in its outer shell.

T F 9 The sodium ions and chloride ions are not joined to each other, but are attracted to each other by electrostatic attraction.

T F 10 Each sodium ion is attracted to all the chloride ions surrounding it.

As a solution:

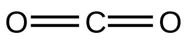
T F 11 The ions are separated.

T F 12 The sodium chloride molecules break apart when they dissolve.

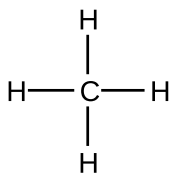
T F 13 The sodium and chloride ions move around in Na^+ Cl^- pairs.

T F 14 The solution conducts electricity because electrons can pass through the solution.

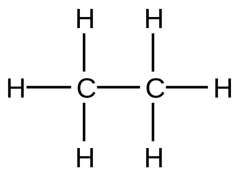
2) Simple molecular structures



molecule of carbon dioxide, CO_2



molecule of methane, CH_4



molecule of ethane, C_2H_6

T F 15 Methane is a gas at room temperature because the bonds between the atoms are weak.

T F 16 Ethane has a higher boiling point than methane because there are more bonds to break.

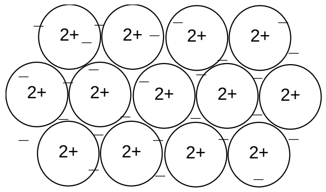
T F 17 Carbon dioxide has a higher boiling point than methane because its atoms are held together by double bonds rather than single bonds.

3) Giant covalent structures

T F 18 Diamond has a high melting point because the atoms are all joined by covalent bonds in a lattice.

T F 19 Diamond has a high melting point because there are strong covalent bonds between its molecules.

4) Metallic structures



copper metal (Cu)

T F 20 The metal is held together by the attraction between the copper ions.

T F 21 Copper has a high melting point because there are strong forces of attraction between the copper ions and the free moving outer shell electrons.

T F 22 The metal conducts electricity because the copper electrons are free to move.

T F 23 Copper has a high melting point because there are lots of strong covalent bonds to break.

T F 24 Copper can be bent because the layers of copper ions can slide relative to each other.

Formulae

Elements

Monatomic	Simple molecular	Ionic	Metallic	Giant covalent
helium He neon Ne argon Ar krypton Kr xenon Xe radon Rn	Hydrogen H_2 Nitrogen N_2 Oxygen O_2 Fluorine F_2 Chlorine Cl_2 Bromine Br_2 Iodine I_2 Phosphorus P_4 Sulphur S_8	There are no ionic elements!!	The formula is just the symbol, e.g. Magnesium Mg Iron Fe Sodium Na Nickel Ni	The formula is just the symbol Diamond C Graphite C Silicon Si

Compounds

Monatomic	Simple molecular	Ionic	Metallic	Giant covalent
There are no monatomic compounds!!	Some common molecular compounds: carbon dioxide CO_2 carbon monoxide CO nitrogen monoxide NO nitrogen dioxide NO_2 sulfur dioxide SO_2 sulfur trioxide SO_3 ammonia NH_3 methane CH_4 hydrogen sulphide H_2S	**These have to be worked out using ion charges – you have to know these at AS/A level!** **LEARN the ions in the table below ASAP.** Note these acids: hydrochloric acid HCl sulfuric acid H_2SO_4 nitric acid HNO_3	There are no metallic compounds!!	silicon dioxide SiO_2

Positive ions (Cations)	Negative ions (Anions)

Group 1 ions:	Group 3 ions:	Group 7 ions:	Other common ions:
Lithium Li^{+}	Aluminium Al^{3+}	Fluoride F^{-}	Nitrate NO_3^{-}
Sodium Na^{+}		Chloride Cl^{-}	Sulphate SO_4^{2-}
Potassium K^{+}	**Other common ions**	Bromide Br^{-}	Carbonate CO_3^{2-}
	Silver Ag^{+}	Iodide I^{-}	Hydrogencarbonate HCO_3^{-}
Group 2 ions:	Zinc Zn^{2+}		Hydroxide OH^{-}
Magnesium Mg^{2+}	Ammonium NH_4^{+}	**Group 6 ions:**	
Calcium Ca^{2+}	Hydrogen H^{+}	Oxide O^{2-}	
Barium Ba^{2+}		Sulphide S^{2-}	

How to write a formula

Given the name of the ionic compound, you should be able to write the formula.
Follow this process for the example Aluminium Bromide:

1. Identify the ions present: **Al^{3+}** **Br^{-}**
   If there is a roman numeral in brackets after the metal, that tells you the charge e.g. Iron (III) = Fe^{3+}

2. Identify how many of each is required so that the overall charge of the two combined is zero:

	1 x Al^{3+}	**+**	**3 x Br^{-}**	
Overall charge	**+3**	**+**	**-3**	**= 0**

3. Write the symbols together; remove the charges and put a subscript number to show how many ion are present (if there's only 1, you don't need to write 1):

   $AlBr_3$

4. The ratio within a formula is fixed. The subscript numbers cannot be altered when balancing equations.

Practice 1

1) silver bromide …………………………..
2) sodium carbonate …………………………..
3) potassium oxide …………………………..
4) iron (III) oxide …………………………..
5) chromium (III) chloride………………………
6) calcium hydroxide …………………………..
7) aluminium nitrate …………………………..
8) sodium sulfate …………………………..
9) lead (II) oxide …………………………..
10) rubidium carbonate ………………………….
11) zinc hydrogencarbonate ………………………
12) ammonium sulphate…………………………..
13) gallium hydroxide …………………………..
14) strontium selenide …………………………..
15) radium sulfate ………………………….
16) sodium nitride ………………………….

Practice 2

1) silver carbonate …………………………..
10) barium hydroxide …………………………..

2) gold …………………………..
3) platinum (II) fluoride…………………………..
4) nitric acid …………………………..
5) ammonia …………………………..
6) silicon (IV) hydride …………………………..
7) phosphorus …………………………..
8) diamond …………………………..
9) vanadium (V) oxide…………………………..
11) ammonia …………………………..
12) hydrochloric acid …………………………..
13) fluorine …………………………..
14) silicon …………………………..
15) calcium sulfide …………………………..
16) rubidium …………………………..
17) germanium (IV) oxide…………………………..
18) magnesium astatide…………………………..

Balancing Equations

Read through the relevant section of your GCSE revision guide to refresh your memory.

Balance these symbol equations where necessary:

1) $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

2) $CO + O_2 \rightarrow CO_2$

3) $Ca + O_2 \rightarrow CaO$

4) $Fe_2O_3 + HCl \rightarrow FeCl_3 + H_2O$

5) $NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

6) $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$

7) $CaO + HCl \rightarrow CaCl_2 + H_2O$

8) $NH_3 + O_2 \rightarrow NO + H_2O$

9) $Na_2O + H_2O \rightarrow NaOH$

10) $Na_2CO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

General Equations:

Acids produce H^+ ions in solution
Alkalis produce OH^- ions in solution

Acid + Base → Salt + Water

Acid + Metal → Salt + Hydrogen

Acid + Alkali → Salt + Water

Acid + Carbonate → Salt + Water + Carbon Dioxide

Work out the formulae and then write balanced symbol equations:

11) magnesium $_{(s)}$ + water $_{(g)}$ → magnesium oxide $_{(s)}$ + hydrogen $_{(g)}$

12) zinc $_{(s)}$ + hydrochloric acid $_{(aq)}$ → zinc chloride $_{(aq)}$ + hydrogen $_{(g)}$

13) chlorine $_{(g)}$ + sodium iodide $_{(aq)}$ → sodium chloride $_{(aq)}$ + iodine $_{(s)}$

14) aluminium chloride $_{(s)}$ + sodium hydroxide $_{(aq)}$ $\rightarrow$ aluminium hydroxide $_{(s)}$ + sodium chloride $_{(l)}$

Work out the products of the following reactions, then write balanced symbol equations:

15)

a) reaction of hydrochloric acid $_{(aq)}$ with potassium hydroxide $_{(aq)}$

b) reaction of potassium carbonate $_{(aq)}$ with nitric acid $_{(aq)}$

c) reaction of ammonia $_{(aq)}$ with hydrochloric acid $_{(aq)}$

d) reaction of sodium hydrogencarbonate $_{(aq)}$ with sulfuric acid $_{(aq)}$

e) precipitation of calcium sulfate from reaction between calcium chloride $_{(aq)}$ and sulfuric acid $_{(aq)}$

Formula Mass

Read through the relevant section of your GCSE revision guide to refresh your memory.

1) Calculate the relative molecular mass (M_r) of:

a) H_2

b) Ne

c) NH_3

d) CH_4

e) $MgBr_2$

f) S_8

g) $Ca(OH)_2$

h) K_2SO_4

i) NH_4NO_3

j) $Ca(NO_3)_2$

k) $Al_2(SO_4)_3$

l) $H_2C_2O_4$ (12)

2) Calculate the percentage by mass of the elements shown in the following compounds (you have worked out the M_r's of (a) to (g) in question 1).

a) C in CH_4

b) Br in $MgBr_2$

c) S in K_2SO_4

d) N in NH_4NO_3

e) N in $Ca(NO_3)_2$

f) O in $Ca(NO_3)_2$

g) O in $Ca(OH)_2$

h) O in $Fe(NO_3)_3$ (9)

3) Calculate the relative molecular mass (M_r) of:

a) sodium oxide
c) copper hydroxide

b) calcium carbonate
d) zinc nitrate (8)

4) Calculate the percentage by mass of the elements shown in the following compounds.

a) Cl in calcium chloride
b) O in iron (III) oxide (6)

Moles

Read through the relevant section of your GCSE revision guide to refresh your memory.

Example method for mole calculations involving masses:

$$\text{Moles} = \frac{\text{mass (g)}}{M_r}$$

1. Read the question, underline the substances that the questions refers to and their masses. e.g.

   What mass of hydrogen is produced when 192 g of magnesium is reacted with hydrochloric acid?

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

2. Draw a table and fill in the values from the question:

	Magnesium	**Hydrogen**
Mass	192	?
Mr	24	2
Moles	?	?
Ratio from equation	1	1

3. To work out the Hydrogen mass, you first need to work out the number of moles of Magnesium:

$$\text{Moles} = \frac{\text{mass (g)}}{M_r}$$

So, moles of Mg = 192/24 = 8 moles

4. Using the ratio between the magnesium and the hydrogen from the equation (1:1 in this case) you can work out the number of moles of hydrogen and fill in the table:

	Magnesium	Hydrogen
Mass	192	?
Mr	24	2
Moles	8	8
Ratio from equation	1	1

5. Now you only have 1 unknown, the mass of hydrogen. This can be worked out using the same equation but this time rearranged:

$$\textbf{Moles} = \frac{\textbf{mass (g)}}{\textbf{M}_r} \quad \Rightarrow \quad \textbf{mass (g) = moles x M}_r$$

So, the mass of Hydrogen = 8 x 2 = 16g

Practice Questions

1) What mass of oxygen is needed to react with 8.5 g of hydrogen sulphide (H_2S)?

$$2\,H_2S + 3\,O_2 \rightarrow 2\,SO_2 + 2\,H_2O \qquad (3)$$

2) What mass of potassium oxide is formed when 7.8 g of potassium is burned in oxygen?

$$4\,K + O_2 \rightarrow 2\,K_2O \qquad (3)$$

3) Railway lines are welded together by the Thermitt reaction, which produces molten iron. What mass of iron is formed from 1 kg of iron oxide?

$$Fe_2O_3 + 2\,Al \rightarrow 2\,Fe + Al_2O_3 \qquad (3)$$

4) What mass of oxygen is required to oxidise 10 g of ammonia to NO?

$$4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O \qquad (3)$$

5) What mass of aluminium oxide is produced when 135 g of aluminium is burned in oxygen?

$$2\,Al + 3\,O_2 \rightarrow Al_2O_3 \qquad (3)$$

6) What mass of iodine is produced when 7.1 g of chlorine reacts with excess potassium iodide?

$$Cl_2 + 2\,KI \rightarrow 2\,KCl + I_2 \qquad (3)$$

7) What mass of hydrogen is needed to react with 32 g of copper oxide?

$$CuO + H_2 \rightarrow Cu + H_2O \qquad (3)$$

8) What mass of oxygen is formed when 735 g of potassium chlorate decomposes?

$$2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2 \qquad (3)$$

9) What mass of hydrogen is produced when 195 mg of potassium is added to water?

$$2\,K + 2\,H_2O \rightarrow 2\,KOH + H_2 \qquad (3)$$

10) How much calcium oxide is produced by heating 50 g of calcium carbonate?

$$CaCO_3 \rightarrow CaO + CO_2 \qquad (3)$$

11) What mass of magnesium oxide is formed when 6 g of magnesium reacts with oxygen?

$$2\,Mg + O_2 \rightarrow 2\,MgO \qquad (3)$$

12) What mass of carbon dioxide is produced when 5.6 g of butene (C_4H_8) is burned?

$$C_4H_8 + 6\,O_2 \rightarrow 4\,CO_2 + 4\,H_2O \qquad (3)$$

13) The pollutant sulphur dioxide can removed from the air by reaction with calcium carbonate in the presence of oxygen. What mass of calcium carbonate is needed to remove 1 tonne of sulphur dioxide?

$$2\,CaCO_3 + 2\,SO_2 + O_2 \rightarrow 2\,CaSO_4 + 2\,CO_2 \qquad (3)$$

Moles in Solution

The concentration of a substance is given as the number of moles of the substance dissolved in 1 litre (1 decimetre cubed, dm^3) of water.

Example method for mole calculations involving solutions:

❶ Write a balanced chemical equation for the reaction (you are usually given this).

❷ Write out the information given in the question under the equation (or using a table as was done previously)

❸ You are **always** given enough information to work out how many moles there are of one reactant, so work it out.

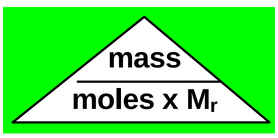
❹ Using the chemical equation, find out how many moles of the other reactant this quantity reacts with.

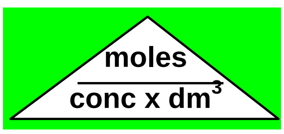
❺ Use this to then find whatever quantity the question asked you to.

You will need to know the following key equations:

$$\textbf{moles} = \frac{\textbf{mass}}{\mathbf{M_r}}$$

$$\textbf{concentration (mol/dm}^3\textbf{)} = \frac{\textbf{moles}}{\textbf{volume (dm}^3\textbf{)}}$$





Note that 1 litre = 1 dm^3 = 1000 cm^3

You must always convert the volumes given into dm^3 before using them in the equations.

E.g.

25 cm^3 = 25/1000 dm^3 = 0.025 dm^3

Practice questions

1) 25.0 cm^3 of a solution of sodium hydroxide solution required 21.50 cm^3 of 0.100 mol/dm^3 sulphuric acid for neutralisation. Find the concentration of the sodium hydroxide solution.

$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$ (3)

2) Find the volume of 1.0 mol/dm^3 hydrochloric acid that reacts with 25.00 cm^3 of 1.50 mol/dm^3 sodium hydroxide.

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ (3)

3) 25.0 cm^3 of 0.100 mol/dm^3 sodium hydroxide neutralises 19.0 cm^3 of hydrochloric acid. Find the concentration of the acid.

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ (3)

4) What volume of 0.040 mol/dm^3 calcium hydroxide solution just neutralises 25.0 cm^3 of 0.100 mol/l nitric acid?

$Ca(OH)_2(aq) + 2\ HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2\ H_2O(l)$ (3)

5) Find the mass of $CaCO_3$ that is required to neutralise 2 dm^3 of 2 mol/dm^3 nitric acid.

$CaCO_3(s) + 2\ HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$ (3)

6) 25.0 cm^3 of 1.00 mol/dm^3 sodium hydroxide neutralises 21.2 cm^3 of sulphuric acid. Find the concentration of the acid.

$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$ (3)

7) What mass of magnesium metal just reacts with 100.0 cm^3 of 2.00 M hydrochloric acid?

$Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ (3)

8) 25.0 cm^3 of 0.020 M sulphuric acid neutralises 18.6 cm^3 of barium hydroxide solution. Find the concentration of the barium hydroxide solution.

$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2\ H_2O(l)$ (3)

9) Calculate the concentration of the following solutions in mol/litre.

a) 3 moles of H_2SO_4 in 12 dm^3 of water, (1)

b) 36.5 mg of HCl in 10 cm^3 of water, (2)

c) 120 g of sodium hydroxide in 6 litres of water. (2)

10) Calculate the number of moles of solute in:

a) 2500 cm^3 of 0.1 mol/dm^3 nitric acid, (1)

b) 2 dm^3 of 0.05 mol/dm^3 potassium hydroxide. (1)

11) 0.429 g of crystalline sodium carbonate ($Na_2CO_3.xH_2O$) required 15.0 cm^3 of 0.2 mol/dm^3 HCl for neutralisation. Calculate the M_r of $Na_2CO_3.xH_2O$ and x.

$Na_2CO_3.xH_2O(s) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + (x+2)\ H_2O(l)$ (4)