Heathcote School and Science College

Sixth Form

Department Transition Guide

Chemistry

Including;

- Course Overview and Specification Summary
- Department Vision for A-level and links to career pathways
- Pre-reading
- Task/project for summer

Transition guide: Chemistry

We have created this support resource to help students make the transition from GCSE to A-level Chemistry.

Contents

Chemistry faculty vision

The Chemistry faculty aims to develop students who are critical thinkers, problem solvers and innovators. At the conclusion of their school career, our students will be able of apply their scientific knowledge to contemporary issues, making connections between scientific disciplines, and their implications for other disciplines. This will empower them to act as informed citizens and help them feel more confident in the decisions they may need to make on their own.

Chemistry is sometimes called “the central science,” because it bridges physics with other natural sciences, such as biology. It is the study of matter, essentially anything in the world that takes up space and has mass. You will also learn about the chemical reactions between substances in the body and reactions that drive industrial processes.

Chemistry helps you to understand the world around you. Have you ever thought about how electronic devices can be recharged so you can use them over and over again-what enables this to happen? Have you looked at the ingredients list of a shampoo, a moisturiser or even bleach and wondered what all those long words mean? The study Chemistry gives will provide you with knowledge to understand these processes, product labels and much more which help people on a daily basis.

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

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

The links to career pathways

Chemistry applies to the food industry, retail sales, transportation, art, homemaking...really any type of work you can name. It helps you to understand current events, including news about petroleum, product recalls, pollution, the environment and technological advances. Chemistry being such a broad topic, you’re bound to find a specific area of interest, plus it opens the door to a fantastic range of interesting careers.

Many people use A-level in Chemistry in their future studies or work. Even if you don’t decide to work in Chemistry, studying it still develops useful and transferable skills for other careers. You’ll develop research, problem solving and analytical skills, alongside teamwork and communication. Universities and business regard all of these very highly.

Degree options

According to bestcourse4me.com, the degree courses taken by students who have A-level Chemistry are:

- Chemistry
- Medicine
- Toxicology and pharmacy
- Chemical engineering
- Biochemistry
- Forensic sciences
- Dentistry

This list is by no means exhaustive. Chemistry can prove useful for a wide variety of degree courses.

For more details, go to the bestcourse4me.com, or UCAS.

Careers

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

- Academic researcher
- Biotechnologist
- Chemical engineer
- Clinical scientist, biochemistry
- Forensic scientist
- Nanotechnologist
- Pharmacologist
- Research scientist (physical sciences)
- Toxicologist
- Doctor
- Vet
- Dentist

Jobs where your degree would be useful include: Civil service fast streamer, Environmental consultant, Higher education lecturer, Management consultant, Nuclear engineer, Patent attorney, Radiation protection practitioner, Science writer, Secondary school teacher. Studying Chemistry provides you with skills that will be useful for many degree courses and professions so don't restrict your thinking to the jobs listed here.

Course overview and specification summary

First year of A-level

1. Physical Chemistry
   - 1.1. Atomic Structure
   - 1.2. Amount of substance
   - 1.3. Bonding
   - 1.4. Energetics
   - 1.5. Kinetics
   - 1.6. Chemical equilibria, Le Chatelier's principle and Kc
   - 1.7. Oxidation, reduction and redox equations
2. Inorganic Chemistry
   - 2.1. Periodicity
   - 2.2. Group 2, the alkaline earth metals
   - 2.3. Group 7(17), the halogens
3. Organic Chemistry
   - 3.1. Introduction to organic chemistry
   - 3.2. Alkanes
   - 3.3. Halogenoalkanes
   - 3.4. Alkenes
   - 3.5. Alcohols
   - 3.6. Organic analysis

Second year of A-level

1. Physical Chemistry
   - 1.8. Thermodynamics
   - 1.9. Rate equations
   - 1.10. Equilibrium constant Kp for homogeneous systems
   - 1.11. Electrode potentials and electrochemical cells
   - 1.12. Acids and bases
2. Inorganic Chemistry
   - 2.4. Properties of Period 3 elements and their oxides
   - 2.5. Transition metals
   - 2.6. Reactions of ions in aqueous solution
3. Organic Chemistry
   - 3.7. Optical isomerism
   - 3.8. Aldehydes and ketones
   - 3.9. Carboxylic acids and derivatives
   - 3.10. Aromatic chemistry
   - 3.11. Amines
   - 3.12. Polymers
   - 3.13. Amino acids, proteins and DNA
   - 3.14. Organic synthesis
   - 3.15. Nuclear magnetic resonance spectroscopy
   - 3.16. Chromatography

The assessment for the A-level consists of three exams

Paper 1	+	Paper 2		Paper 3
What's assessed • Relevant Physical chemistry topics (sections 1.1 to 1.4, 1.6 to 1.8 and 1.10 to 1.12) • Inorganic chemistry (Section 2) • Relevant practical skills		What's assessed • Relevant Physical chemistry topics (sections 1.2 to 1.6 and 1.9) • Organic chemistry (Section 3) • Relevant practical skills		What's assessed • Any content • Any practical skills
Assessed • written exam: 2 hours • 105 marks • 35% of A-level		Assessed • written exam: 2 hours • 105 marks • 35% of A-level		Assessed • written exam: 2 hours • 90 marks • 30% of A-level
Questions • 105 marks of short and long answer questions		Questions • 105 marks of short and long answer questions		Questions • 40 marks of questions on practical techniques and data analysis • 20 marks of questions testing across the specification • 30 marks of multiple choice questions

Useful A-Level resources

1. The AQA website includes the following:

- The Chemistry **A-Level** specification – this explains exactly what you need to learn for your exams.
- Practice exam papers
- Lists of command words and subject specific vocabulary – so you understand the words to use in exams
- Practical handbooks explain the practical work you need to know
- Past papers and mark schemes from the old specifications. Some questions won't be relevant to the new A-level, so please check with your teacher.
- Maths skills support

2. Royal Society of Chemistry

"A single unified voice for Chemistry". They work with everyone from government policy makers to students, as well as universities and researchers studying Chemistry. Their website includes a dedicated student section. Have a look at https://www.rsc.org/.

3. The student room

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

4. Textbooks

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

5. Revision guides

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

6. YouTube

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

7. Magazines

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

Pre-reading list

To help you prepare for Chemistry A-Level and complete the activities in the next section, the following resources will be useful:

https://filestore.aqa.org.uk/resources/chemistry/specifications/AQA-8462-SP-2016.PDF

https://filestore.aqa.org.uk/resources/chemistry/specifications/AQA-7404-7405-SP-2015.PDF

https://chemguide.co.uk/

http://www.bbc.co.uk/schools/gcsebitesize/

https://www.bbc.co.uk/bitesize/guides/zgcyw6f/revision/1

https://www.s-cool.co.uk/gcse/chemistry

https://www.physicsandmathstutor.com/chemistry-revision/

Head Start to AS Chemistry Published by CGP

Knowledge Organisers

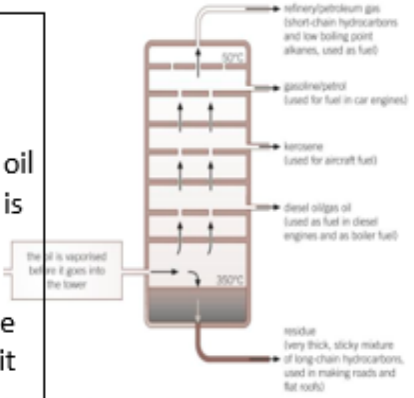
It is often useful to design a few knowledge organisers to help you recap important ideas. Below is an example on a knowledge organiser that can be used to help answer activity 15 in the next section. It may help to design a knowledge organiser for each activity using the pre-reading list above.

Knowledge Organiser – Fractional distillation and Cracking

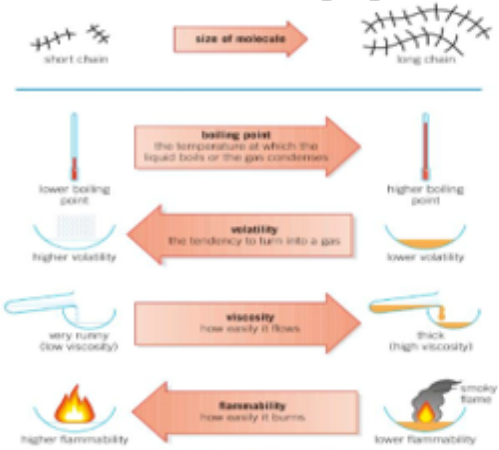
Fraction Distillation

The different chain length molecules can separated using **fractional distillation**. The crude oil mixture enters a tall column and is heated to a high temperature so that most of the molecules are **vaporised** (turned into a gas). The column is cooler at the top than it is at the bottom. As the gaseous molecules rise up the column they **condense** (turn back into a liquid) when they reach their boiling point. They are then collected and removed. The separated samples are called **fractions**.

Smaller molecules travel further up the column because they have fewer **intermolecular forces** between their chains. This means that they have lower boiling points and so they condense at lower temperatures and so remain a gas at lower temperatures.



These intermolecular forces also explain why viscosity increases in chain length gets longer while flammability increases as the chain length gets



Cracking

Long chain molecules have less uses and are in less of a demand, but they can be broken down into smaller more useful products by cracking.

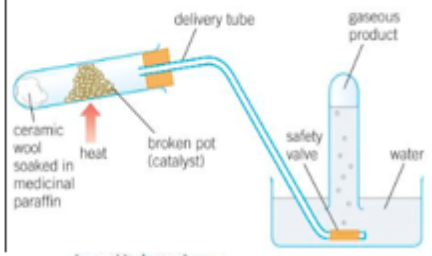
Catalytic cracking: the alkane is brought into contact with a powdered aluminium oxide catalyst at moderate pressure and a temperature of around 500°C.

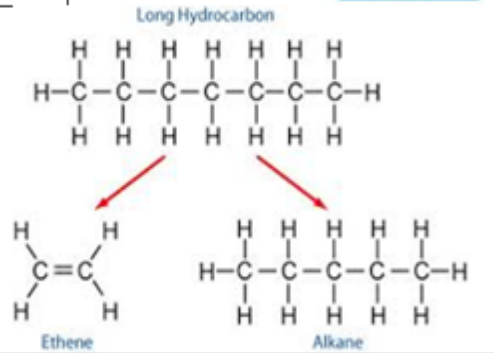
Thermal cracking: the hydrocarbon is mixed with steam and heated to a very high temperature (approximately 850°C).

Both cracking processes result in the formation of two products; an **alkane** and an **alkene**.

The Products of Cracking

The sum of the carbon and hydrogen atoms in the two products of the cracking process must be the same as the number of atoms that you started with.





Key Words

Homologous
fractional
Distillation
Intermolecular
Viscosity
Cracking
Hydrocarbon

Task for summer

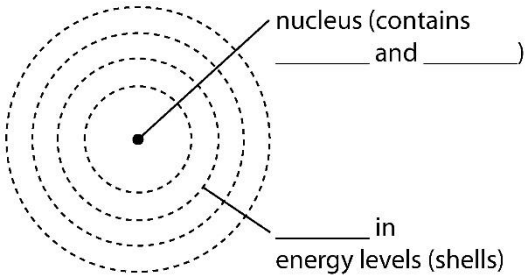
The structure of atoms

Activity 1

1 Complete the spaces to create a set of notes about the structure of atoms.

Atoms consist of a central _____ containing protons and _____. The nucleus is _____ compared to the size of the whole atom. The nucleus is surrounded by _____ in energy levels (also called _____). Atoms have no electric charge because they contain the same number of protons and _____.

Sub-atomic particle	Relative mass	Relative charge
Proton		
Neutron		
Electron		



Atomic number = number of _____.

Mass number = number of _____ + number of _____.

mass number **19**

Symbol e.g. **F**

atomic number **9**

protons = _____

neutrons = _____

electrons = _____

Atoms of the same element have the same number of _____. It is the number of _____ that determines what type of atom it is (e.g. all atoms with six protons are carbon atoms). Atoms of different elements have different numbers of _____. Isotopes are atoms of the same element. They contain the same number of _____ but a different number of _____.

2 Complete the table about some atoms.

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{23}_{11}Na$					
Li	3	7			
Ar		40	18		
K			19	20	
Al				14	13
Cl	17			18	
$^{235}_{92}U$					
$^{238}_{92}U$					

Atoms and ions

You will need to look at the Periodic Table to help you answer the following questions.

Activity 2

1a Complete the table to show the electronic structure of the following ions.

Ion	F^-	Na^+	Al^{3+}	K^+	S^{2-}	H^+	O^{2-}	Ca^{2+}	Li^+	Mg^{2+}	Cl^-	Be^{2+}
Electronic structure												

b Complete the table below to show the electronic structure of some Group 0 elements (noble gases). Place the ions from part **a** into the correct row of the table.

Element	**Electronic structure**	**Ions with the same electronic structure**
He		
Ne		
Ar		

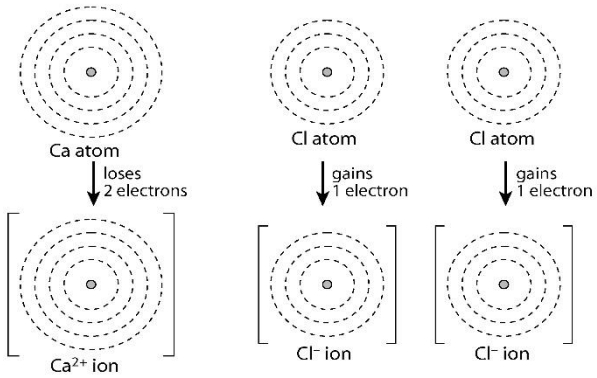
c i complete the table with the ions from part **a**. Ions for Group 1 have been done for you. Do not include the H^+ ion.

Group	1	2	3	4	5	6	7	0
Ions	Li^+ Na^+ K^+							
Charge	+1							

ii Predict the charge that the following ions would have using the Periodic Table and your table.

Strontium ions _____ iodide ions _____ rubidium ions _____

2 Calcium atoms react with chlorine atoms to form the ionic compound calcium chloride. Calcium atoms each lose two electrons to form calcium ions. Chlorine atoms each gain one electron to form chloride ions. This means that calcium atoms react with chlorine atoms in the ratio of one calcium atom for every two chlorine atoms. Complete the diagram to show the electronic structure of the calcium and chlorine atoms and the calcium and chloride ions.



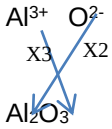
3 Complete the following table about some atoms and ions. The first row has been done for you.

Particle	**Atom or ion**	**Atomic number**	**Mass number**	**Number of protons**	**Number of neutrons**	**Number of electrons**	**Electronic structure**
$^{16}O^{2-}$	ion	8	16	8	8	10	$[2, 8]^{2-}$
^{31}P							
		13	27			13	
		13	27			10	
	atom	2	4				
		16	32				$[2, 8, 8]^{2-}$
				12	12		$[2, 8]^{2+}$

Writing formulae

Use the table of ions to write the formula of the following ionic compounds. Use the general rule of cross-multiply and then simplify where possible.

Eg: Aluminium oxide:



Positive ions				Negative ions			
aluminium	Al^{3+}	lead	Pb^{2+}	bromide	Br^{-}	oxide	O^{2-}
ammonium	NH_4^{+}	lithium	Li^{+}	carbonate	CO_3^{2-}	sulfate	SO_4^{2-}
barium	Ba^{2+}	magnesium	Mg^{2+}	chloride	Cl^{-}	sulfide	S^{2-}
calcium	Ca^{2+}	potassium	K^{+}	fluoride	F^{-}		
copper (II)	Cu^{2+}	silver	Ag^{+}	hydrogencarbonate	HCO_3^{-}		
hydrogen	H^{+}	sodium	Na^{+}	hydroxide	OH^{-}		
iron (II)	Fe^{2+}	zinc	Zn^{2+}	iodide	I^{-}		
iron (III)	Fe^{3+}			nitrate	NO_3^{-}		

Activity 3

1

a potassium iodide _____
b sodium oxide _____
c aluminium bromide _____
d magnesium chloride _____
e silver oxide _____
f iron (II) oxide _____
g iron (III) oxide _____
h calcium sulfide _____
i copper (II) chloride _____
j lithium fluoride _____
k barium chloride _____
l lead sulfide _____
m zinc iodide _____

2

a potassium sulfate _____
b magnesium sulfate _____
c magnesium hydroxide _____
d copper (II) nitrate _____
e zinc carbonate _____
f potassium hydroxide _____
g sodium carbonate _____
h aluminium hydroxide _____
i ammonium hydroxide _____
j ammonium chloride _____
k aluminium sulfate _____
l iron (III) nitrate _____
m ammonium nitrate _____

Relative masses

Element		A_r
aluminium	Al	27
bromine	Br	80
calcium	Ca	40
carbon	C	12
chlorine	Cl	35.5
copper	Cu	63.5
fluorine	F	19

Element		A_r
hydrogen	H	1
iodine	I	127
iron	Fe	56
magnesium	Mg	24
nitrogen	N	14
oxygen	O	16

Element		A_r
phosphorus	P	31
potassium	K	39
silver	Ag	108
sodium	Na	23
sulfur	S	32
zinc	Zn	65

Activity 4

Calculate the relative formula mass of the following substances. You will need to use the relative atomic masses (A_r) shown above.

(*HINTS: **1.** If there are formulae in brackets everything in the brackets need to be multiplied by the number outside.*

***2.** The dot means to add. So for $CuSO_4.5H_2O$ add $CuSO_4$ to 5 lots of H_2O).*

a $Mg(OH)_2$
b SO_3
c $Al(NO_3)_3$
d $KHCO_3$
e K_2S
f NH_4Cl
g $Fe_2(SO_4)_3$
h $Ca(HCO_3)_2$
i $(NH_4)_2SO_4$
j $CuSO_4.5H_2O$
k $Na_2CO_3.10H_2O$
l $Fe(NH_4)_2(SO_4)_2.6H_2O$

2 Calculate the percentage by mass of the element shown in each of the following substances. You will need to use the relative atomic masses shown above.

a O in $Mg(OH)_2$
b O in $Al(NO_3)_3$
c O in $Fe_2(SO_4)_3$
d H in $Ca(HCO_3)_2$
e N in $(NH_4)_2SO_4$
f O in $CuSO_4.5H_2O$
g Na in $Na_2CO_3.10H_2O$
h Fe in $Fe(NH_4)_2(SO_4)_2.6H_2O$

Balancing equations

Activity 5

Balance the following equations.

a N_2 + _____ $H_2 \rightarrow$ _____ NH_3
b _____ Ca + $O_2 \rightarrow$ _____ CaO
c Br_2 + _____ KI $\rightarrow$ _____ KBr + I_2
d _____ Fe + _____ $H_2O \rightarrow Fe_3O_4$ + ___ H_2
e C_3H_8 + _____ $O_2 \rightarrow$ _____ CO_2 + _____ H_2O
f _____ NH_3 + _____ $O_2 \rightarrow$ _____ NO + ____ H_2O

Writing symbol equations from words

Activity 6

Write symbol equations for the following reactions taking place. You will first need to convert the names of the materials into formulae and then balance the equation.

1. Zinc metal reacts with copper sulphate solution to produce solid copper metal and zinc sulphate solution.

2. Solid calcium hydroxide reacts with solid ammonium chloride on heating to produce solid calcium chloride, steam and ammonia gas.

3. When lead (II) nitrate is heated in a dry test tube lead (II) oxide, nitrogen dioxide gas and oxygen are produced.

4. Silicon tetrachloride reacts with water to produce solid silicon dioxide and hydrogen chloride gas.

5. When octane (C_8H_{18}) vapour is burned with excess air in a car engine carbon dioxide and water vapour are produced.

6. When rubidium reacts with water a solution of the hydroxide of the metal is produced as well as hydrogen gas.

7. When strontium reacts with water a solution of the hydroxide of the metal is produced as well as hydrogen gas.

8. Sodium chloride reacts with concentrated sulphuric acid to produce sodium hydrogen sulphate and hydrogen chloride.

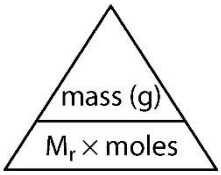
Using moles

Element		A_r
aluminium	Al	27
bromine	Br	80
calcium	Ca	40
carbon	C	12
chlorine	Cl	35.5
copper	Cu	63.5
fluorine	F	19

Element		A_r
hydrogen	H	1
iodine	I	127
iron	Fe	56
magnesium	Mg	24
nitrogen	N	14
oxygen	O	16

Element		A_r
phosphorus	P	31
potassium	K	39
silver	Ag	108
sodium	Na	23
sulfur	S	32
zinc	Zn	65

$$\text{mass (g)} = M_r \times \text{moles}$$



Activity 7

1 Complete the blank parts of the following table.

Substance	Formula	M_r	Mass	Moles
carbon monoxide	CO		560 g	
propane	C_3H_8			0.2
unknown solid	unknown		0.104 g	0.0005
methane	CH_4		6 kg	
sodium carbonate	Na_2CO_3			2.5
unknown gas	unknown		0.1 g	0.0025

2 How many moles are there in each of the following?

a 72 g of Mg moles = $\frac{\text{mass}}{M_r} = \frac{72}{24}$ = 3 moles

b 39 g of $Al(OH)_3$

_____

c 1 tonne of NaCl

_____

d 20 mg of $Cu(NO_3)_2$

_____

3 What is the mass of each of the following?

a 5 moles of Cl_2 mass = M_r × moles = 71 × 5 = 355 g

b 0.2 moles of Al_2O_3

_____

c 0.01 moles of Ag

_____

d 0.002 moles of $(NH_4)_2SO_4$

_____

e 0.3 moles of $Na_2CO_3.10H_2O$

_____

Activity 7 continued

4 An experiment was carried out to find the M_r of vitamin C (ascorbic acid). It was found that 1 g contains 0.00568 moles of vitamin C molecules. Calculate the M_r of vitamin C.

_____

_____

Reacting Mass calculations

Activity 8

Use A_r values given in task 7 for this exercise.

1 What mass of hydrogen is needed to react with 40 g of copper oxide?

$CuO + H_2 \rightarrow Cu + H_2O$

2 What mass of oxygen reacts with 192 g of magnesium?

$2\ Mg + O_2 \rightarrow 2\ MgO$

3 What mass of sulfur trioxide is formed from 96 g of sulfur dioxide?

$2\ SO_2 + O_2 \rightarrow 2\ SO_3$

4 What mass of carbon monoxide is needed to react with 480 g of iron oxide?

$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$

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

$C_4H_8 + 6\ O_2 \rightarrow 4\ CO_2 + 4\ H_2O$

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

$2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O$

7 The pollutant sulfur 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 sulfur dioxide?

$2\ CaCO_3 + 2\ SO_2 + O_2 \rightarrow 2\ CaSO_4 + 2\ CO_2$

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

$4\ K + O_2 \rightarrow 2\ K_2O$

9 What mass of oxygen is required to oxidise 34 g of ammonia (NH_3) to nitrogen monoxide (NO)?

$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

10 5.00 g of hydrated sodium sulfate crystals ($Na_2SO_4.nH_2O$) gave 2.20 g of anhydrous sodium sulfate on heating to constant mass. Work out the relative formula mass (M_r) of the hydrated sodium sulfate and the value of *n*.

$Na_2SO_4.nH_2O \rightarrow Na_2SO_4 + n\ H_2O$

Yields and atom economy

$$\% \text{ yield} = \frac{\text{mass of product obtained}}{\text{maximum theoretical mass of product}} \times 100$$

$$\text{Atom economy} = \frac{Mr \text{ wanted product from equation}}{\text{total } Mr \text{ of products from equation}} \times 100$$

Triple Science only

Activity 9

1 Balance the following equations.

a _____ $SO_2 + O_2 \rightarrow$ _____ SO_3

b $FeCl_3 +$ _____ $NaOH \rightarrow Fe(OH)_3 +$ _____ $NaCl$

c $Na_2CO_3 +$ _____ $HCl \rightarrow$ _____ $NaCl + CO_2 + H_2O$

2 Calculate the percentage yield in each of the following reactions.

	Theoretical maximum mass of product	**Mass of product obtained**
a	100 g	70 g
b	4 g	2.5 g
c	5 kg	1 kg

3 Quicklime (calcium oxide, CaO) can be made by thermal decomposition of limestone (calcium carbonate, $CaCO_3$). **$CaCO_3 \rightarrow CaO + CO_2$**

a Calculate the maximum theoretical mass of quicklime that can be made by heating 50 g of limestone (relative atomic masses: C = 12, O = 16, Ca = 40).

b In the reaction, only 26 g of quicklime was produced. Calculate the percentage yield.

4 Calculate the atom economy in each of the following reactions.

	Mass of wanted product in equation	**Total mass of products in equation**
a	71 g	100 g
b	32 g	40 g
c	56 g	56 g

5 Aluminium is made by the electrolysis of aluminium oxide. Calculate the atom economy for the production of aluminium in this reaction. (relative atomic masses: O = 16, Al = 27)

$2\ Al_2O_3 \rightarrow 4\ Al + 3\ O_2$

6 Hydrazine (N_2H_4) was used as the rocket fuel for the Apollo missions to the moon. It is made by the reaction of ammonia (NH_3) with sodium chlorate (NaOCl) (relative atomic masses: H = 1, N = 14, O = 16, Na = 23, Cl = 35.5).

ammonia	+	sodium chlorate	→	hydrazine	+	sodium chloride	+	water
$2\ NH_3$	+	NaOCl	→	N_2H_4	+	NaCl	+	H_2O

a Calculate the maximum theoretical mass of hydrazine that can be made by reacting 340 g of ammonia with an excess of sodium chlorate.

b In the reaction, only 280 g of hydrazine was produced. Calculate the percentage yield.

c Give **three** reasons why less than the maximum theoretical yield was produced.

d Calculate the atom economy for this way of making hydrazine.

Empirical and molecular formulae

Empirical formula is the simplest whole number ratio of elements. Divide the percentage or mass by the Mr of each element in the compound, divide by the smallest number and simplify to give a whole number ratio.

Element		A_r
aluminium	Al	27
bromine	Br	80
calcium	Ca	40
carbon	C	12
chlorine	Cl	35.5
copper	Cu	63.5
fluorine	F	19

Element		A_r
hydrogen	H	1
iodine	I	127
iron	Fe	56
lead	Pb	207
magnesium	Mg	24
nitrogen	N	14
oxygen	O	16

Element		A_r
phosphorus	P	31
potassium	K	39
silver	Ag	108
sodium	Na	23
sulfur	S	32
zinc	Zn	65

Activity 10

1 Copy and complete the table.

Empirical formula	M_r	Molecular formula
CH_2	42	
		C_5H_{10}
		C_4H_8
C_3H_8	44	
		H_2O_2
CH	78	

2 Find the empirical formula of each of the following substances using the data about composition by mass.

a H 5% F 95%

b Na 3.71 g O 1.29 g

c Pb 90.7% O 9.3%

d C 60.0% H 13.3% O 26.7%

3 3.53 g of iron reacts with chlorine to form 10.24 g of iron chloride. Find the empirical formula for the iron chloride.

4 Analysis of a compound consisting of carbon, hydrogen and oxygen showed it to contain 0.273 g C, 0.046 g H, and 0.182 g O. It has a relative formula mass (M_r) of 88.

a Calculate the empirical formula of the compound.

b Calculate the molecular formula of the compound.

Titration calculations

Triple Science only

Activity 11

1 Sodium hydroxide and hydrochloric acid react together according to the equation:

$$NaOH + HCl \rightarrow NaCl + H_2O$$

In a titration between sodium hydroxide solution and hydrochloric acid 25.0 cm^3 of 0.2 mol/dm^3 sodium hydroxide solution is neutralised by 27.75 cm^3 of hydrochloric acid.

Use the information to calculate the concentration of the hydrochloric acid in mol/dm^3. Give your answer to 2 decimal places. *(3 marks)*

2 Sodium hydroxide and nitric acid react together according to the equation:

$$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$$

In a titration between sodium hydroxide solution and nitric acid 10.0 cm^3 of 0.15 mol/dm^3 sodium hydroxide solution is neutralised by 12.0 cm^3 of nitric acid.

Use the information to calculate the concentration of the nitric acid in mol/dm^3. Give your answer to 3 decimal places. *(3 marks)*

3 Potassium hydroxide and hydrochloric acid react together according to the equation:

$$KOH + HCl \rightarrow KCl + H_2O$$

In a titration between potassium hydroxide solution and hydrochloric acid 10.0 cm^3 of 0.1 mol/dm^3 potassium hydroxide solution is neutralised by 0.12 mol/dm^3 hydrochloric acid.

Use the information to calculate the volume of hydrochloric acid needed to exactly neutralise the potassium hydroxide solution. Give your answer to 2 decimal places. *(3 marks)*

4 Potassium hydroxide and nitric acid react together according to the equation:

$$KOH + HNO_3 \rightarrow KNO_3 + H_2O$$

In a titration between potassium hydroxide solution and nitric acid 25.0 cm^3 of 0.25 mol/dm^3 potassium hydroxide solution is neutralised by 0.2 mol/dm^3 nitric acid.

Use the information to calculate the volume of nitric acid needed to exactly neutralise the potassium hydroxide solution. Give your answer to 2 decimal places. *(3 marks)*

Different types of structures

Activity 12

Complete the table about substances with each of the types of structures shown.

Type of structure	Simple molecular	Ionic	Giant covalent	Metallic
Description of the structure				
Type of bonding				
Melting and boiling points (with reason)				
Electrical conductivity (with reason)			**Exception: Graphite**	
Which types of substances have this structure				

Alkanes and formulae

Activity 13

1 Hydrocarbons are the main compounds in crude oil.

- **a** What are hydrocarbons? *(1 mark)*
- **b** Name the type of chemical bond present between the atoms in a hydrocarbon molecule. *(1 mark)*
- **c** What are alkanes? *(1 mark)*
- **d** Explain why alkanes are *saturated* hydrocarbons. *(1 mark)*

2 The molecular formula for propane is C_3H_8.

- **a** Explain what information this formula shows. *(2 marks)*
- **b** State one feature of a propane molecule that is not shown in the molecular formula. *(1 mark)*

3 The alkanes form a homologous series of compounds.

- **a** Apart from the same general formula, state one feature that is common to members of a homologous series. *(1 mark)*
- **b** Give the general formula for the alkanes. *(1 mark)*
- **c** Predict the molecular formula for octane, which has eight carbon atoms. *(1 mark)*
- **d** Predict the molecular formula for the next alkane after octane in the homologous series. *(1 mark)*

4 Methane, ethane and propane are alkanes with 1, 2 and 3 carbons respectively.

- **a** Give their molecular formulae. *(3 marks)*
- **b** Draw their displayed formulae. *(3 marks)*

Products from fuels

Activity 14

Burning fossil fuels

1 **a** Name the product from the complete combustion of carbon. *(1 mark)*

b Name the product from the complete combustion of hydrogen. *(1 mark)*

2 Coal is mostly carbon. Name the main product from the complete combustion of coal. *(1 mark)*

3 Paraffin wax is a hydrocarbon.

a Which two elements do hydrocarbons contain? *(2 marks)*

b Name the two products made during the complete combustion of paraffin wax. *(2 marks)*

c Which gas, found in air, is needed for combustion to happen? *(1 mark)*

d Use your answers to parts **b** and **c** to write a word equation for the complete combustion of paraffin wax. *(2 marks)*

Other products of combustion

4 Incomplete combustion happens when the supply of air is not plentiful.

a Name the solid product released during the incomplete combustion of hydrocarbon fuels. *(1 mark)*

b Name the gaseous product released during the incomplete combustion of hydrocarbon fuels. *(1 mark)*

5 Fossil fuels often contain sulfur.

a Name the gaseous product formed when sulphur is burned. *(1 mark)*

b The product named in part **a** is a cause of acid rain. NO_x form at high temperatures and are also a cause of acid rain. Which gas reacts with oxygen to form NO_x? *(1 mark)*

Balanced equations

6 Correctly balance these equations.

a C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O *(1 mark)*

b C_3H_8 + ___ O_2 → ___ CO + ___ H_2O *(1 mark)*

c C_3H_8 + ___ O_2 → C + 2CO + ___ H_2O *(1 mark)*

d ___ N_2 + O_2 → NO_2 *(1 mark)*

Fractional distillation and cracking

Activity 15

1 Use the words from the word box to complete these sentences.

boiling distillation fractions fuel gas oil vapour

The different fractions in crude _____ can be separated by fractional _____. The different fractions have different _____ points. The crude oil is turned into a _____. It travels up a fractionating column, where different fractions cool down, and the _____ turns back into a liquid. Different _____ have different uses. For example, petrol is used as a _____ for cars.

The table below shows how many barrels of different fractions of crude oil are produced in a day at an oil refinery.

Fraction	**LPG**	**petrol**	**naphtha**	**paraffin**	**diesel**
Number of barrels you produce	100	500	300	700	800
Number of barrels you can sell	100	700	300	500	800

2 Which fraction can you sell more of than you produce each day? *(1 mark)*

3 Some barrels are left over and not sold each day. Which fraction is this? *(1 mark)*

4 Write a paragraph to explain what you do with the leftover barrels. Use the following words in your answer: cracked, alkanes, alkenes, fuels, plastics. *(7 marks)*

Extension

5 Explain why cracking is useful by considering supply and demand issues. *(3 marks)*

Example A-Level exam questions (Year 1)

Activity 16

1 The table shows some data about the elements bromine and magnesium.

Element	Melting point / K	Boiling point / K
Bromine	266	332
Magnesium	923	1383

In terms of structure and bonding explain why the boiling point of bromine is different from that of magnesium. Suggest why magnesium is a liquid over a much greater temperature range compared to bromine. *(6 marks)*

2 Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and calcium nitrate as shown in the equation.

$$Ca_3(PO_4)_2 + 6HNO_3 \longrightarrow 2H_3PO_4 + 3Ca(NO_3)_2$$

A 7.26 g sample of calcium phosphate reacted completely when added to an excess of aqueous nitric acid to form 38.0 cm^3 of solution

Calculate the concentration, in mol dm^{-3}, of phosphoric acid in this solution.
Give your answer to 3 significant figures. *(5 marks)*