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INTERNATIONAL ADVANCED LEVEL

Chemistry

Getting Started

Pearson Edexcel International Advanced Subsidiary in Chemistry (XCH01)

Pearson Edexcel International Advanced Level in Chemistry (YCH01)

For first teaching in September 2013
First examination January 2014

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www.edexcel.com/ial

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A Getting started for teachers

Introduction

This *Getting Started* book will give you an overview of the International Advanced Level (IAL) in Chemistry course and what it means for you and your students. The guidance in this book is intended to help you plan the course in outline and to give you further insight into the principles behind the content to help you and your students succeed in the course.

Key principles

The specification has been developed with the following key principles:

A focus on choice

You can choose the contexts and practicals you use, allowing you to tailor the specification to the needs of your students.

A motivating specification

This specification enables motivating, contemporary contexts to be included in the teaching and learning programme.

A practical specification

This specification contains practical activities embedded within each unit, to reflect the nature of chemistry.

Assessment overview

AS units

Unit 1: The Core Principles of Chemistry	Unit 2: Application of Core Principles of Chemistry	Unit 3: Chemistry Laboratory Skills I Alternative
External assessment: written examination paper (90 mins)	External assessment: written examination paper (90 mins)	External assessment: written examination paper (75 mins)

A2 units

Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry	Unit 5: General Principles of Chemistry II – Transition metals and Organic Nitrogen Chemistry	Unit 6: Chemistry Laboratory Skills II Alternative
External assessment: written examination paper (100 mins)	External assessment: written examination paper (100 mins)	External assessment: written examination paper (75 mins)

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Overviews

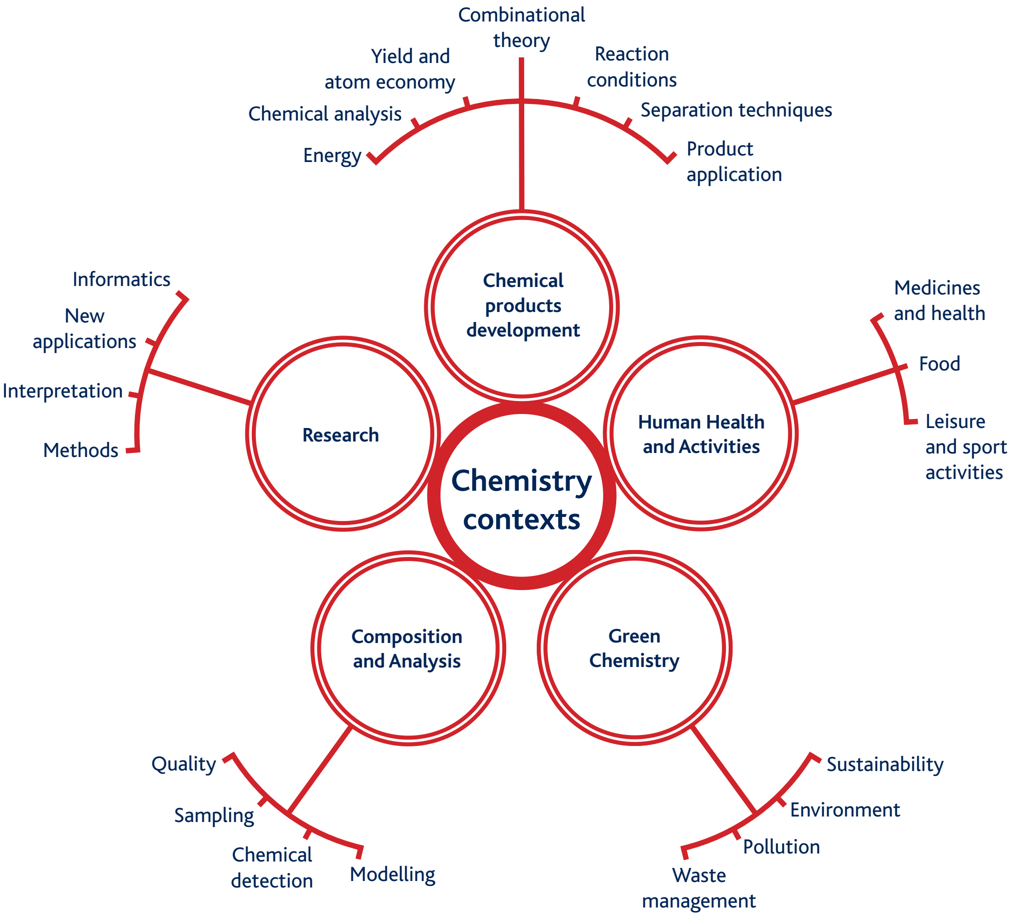
This section provides, at a glance, overviews of the course to help you see what you will need to teach. The unit overviews give a general summary of the examined units.

Course overviews

This section provides, at a glance, overviews of the course to help you see what you will need to teach.

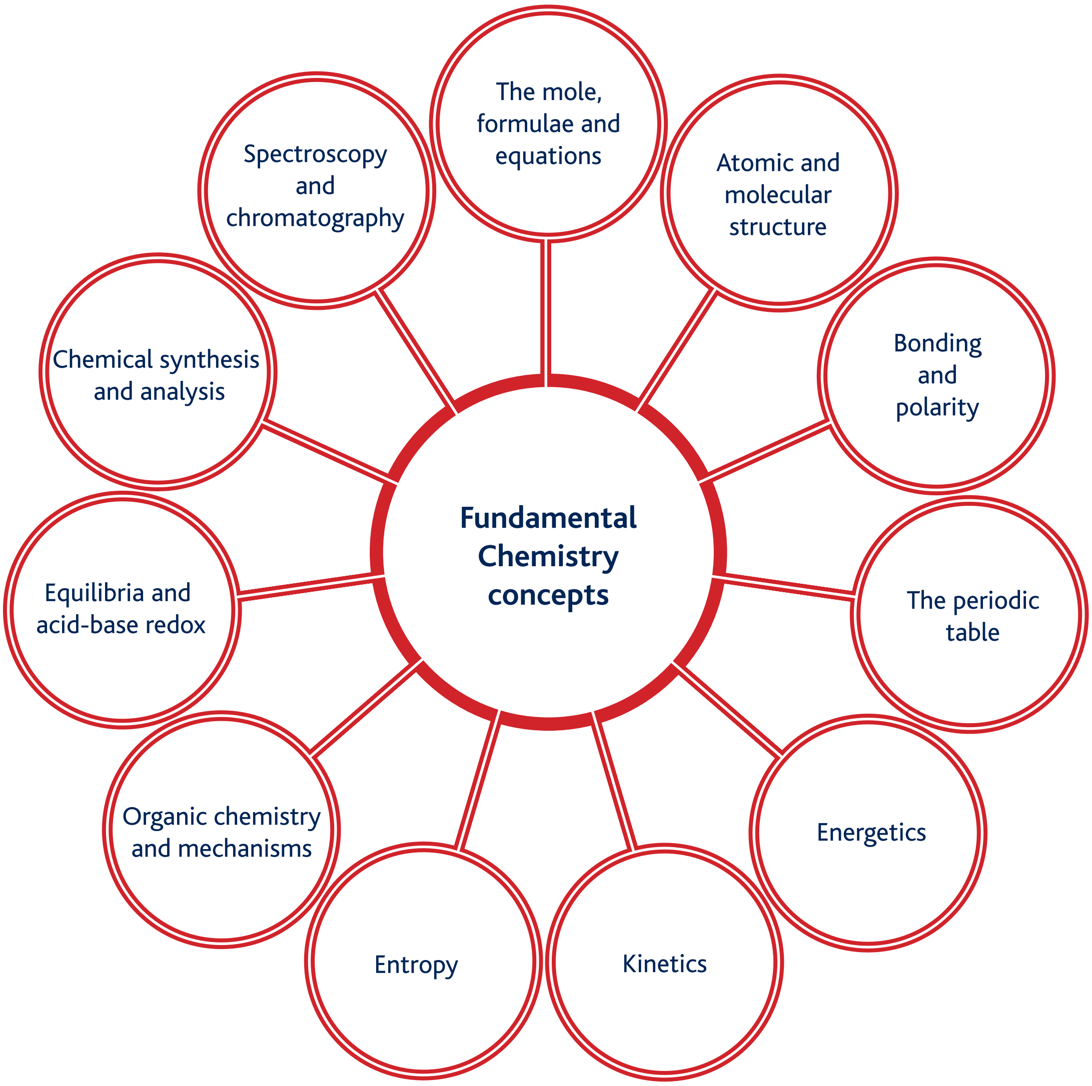
Chemistry contexts

The course can be approached through the contexts shown in the diagram.



Chemistry concepts

This diagram identifies the fundamental concepts in chemistry that students will learn on this course. These concepts build on those studied in GCSE/International GCSE chemistry courses and provide a firm foundation for further study.



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Unit overviews

The unit overviews give a summary of the content of each unit so that you can organise your teaching effectively.

Unit 1 – The Core Principles of Chemistry	
Topics	**Suggested contexts**
Formulae, equations and amounts of substance Energetics Atomic structure and the periodic table Bonding Introductory organic chemistry – alkanes and alkenes	Biological systems Climate change Pollution Fuels Atom economy Analytical techniques

Unit 2 – Application of Core Principles of Chemistry		
Topics		**Suggested contexts**
Shapes of molecules and ions Intermediate bonding and bond polarity Intermolecular forces Redox The periodic table – groups 2 and 7 Kinetics Chemical equilibria	Organic chemistry – alcohols and halogenoalkanes Mechanisms Mass spectra and IR Green chemistry	Climate change Sustainability Food processing Pharmaceutical industry Nanotechnology Informatics New uses of chemicals

Unit 3 – Chemistry Laboratory Skills I Alternative
Students are expected to develop experimental skills, and a knowledge and understanding of the necessary techniques, by carrying out a range of practicals while they study Units 1 and 2. This unit will assess students' knowledge and understanding of practical procedures and techniques that they develop.

Unit 4 – General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry		
Topics		**Suggested contexts**
How fast? – rates How far? – entropy Equilibria Application of rates and equilibrium Acid/base equilibria	Further organic chemistry – chirality, carbonyl compounds, carboxylic acids and their derivatives Spectroscopy and chromatography	Biological systems Food Yields and atom economy Manufacturing Quality control

Unit 5 – General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry	
Topics	**Suggested contexts**
Redox and the chemistry of the transition metals Organic chemistry – arenes, nitrogen compounds and synthesis	Fuel cells Catalysts Pharmaceutical industry New applications

Unit 6 – Chemistry Laboratory Skills II Alternative
Students are expected to develop experimental skills, and a knowledge and understanding of the necessary techniques, by carrying out a range of practicals while they study Units 4 and 5. This unit will assess students' knowledge and understanding of practical procedures and techniques that they develop.

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The Specification

This section outlines the aspects of the specification and assessment and the aspects that have been removed, for both current Edexcel Nuffield centres and current Edexcel centres.

FAQs

What is the difference between the International Advanced Level (IAL) specification and the current GCE specification?

The IAL specification is made up of 6 units which are examined by externally marked written papers while the current 2008 GCE specification is made up of 6 units, 2 of which are internally assessed coursework/practicals.

Also, the IAL examinations are available in January and June while the GCE examinations are available in June only.

Another difference is that IALs are regulated by Pearson, therefore the award is IAL while GCEs are regulated by Ofqual and the award is GCE.

Which award will a student receive if he/she completes written papers for the AS course and completes a coursework/practical assessment in the A2 course?

The student will be awarded an IAL.

Are there any content or structural changes in the IAL specification?

No. There are no changes to content or structure, so teachers can carry on planning and teaching in the normal way.

If a student has already completed some GCE units, would it be possible to combine them with IAL units to complete an IAL award?

Yes. *HOWEVER*, only relevant GCE units which have been *banked up to and including June 2013 can be used* in combination with IAL units for a full IAL award. This service is available until June 2015 only.

How many times can a student re-sit a unit examination?

A student can re-sit a unit examination once i.e. each unit examination can be taken twice and the higher of the two marks will be used to calculate the overall subject grade.

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Course Planners

This section contains two course planners for the Edexcel IAL Chemistry specification.

- Course planner 1 follows the specification through in topic order.
- Course planner 2 is an alternative route through the specification, grouped by areas of chemistry which naturally fit together at AS and A2. This may suit your particular teaching style.

These are only suggested course planners and do not need to be followed. However, they may be useful in working through the specification for the first time.

A full course planner will be available on our website *www.edexcel.com/ial*

Timings

Estimated teaching time available			
Unit 1	60 hours	**AS** 120 hours	To include practical assessment
Unit 2	60 hours		
Unit 4	60 hours	**A2** 120 hours	To include practical assessment (plus extra time if you start teaching A2 after summer AS exams)
Unit 5	60 hours		

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The following tables show the suggested timings of each topic.

Course planner 1

Each unit is taught separately. This allows for a modular approach to the study of IAL Chemistry.

AS Chemistry autumn term Unit 1: The Core Principles of Chemistry

Topic		Time (approx hours)
1.3	Formulae, equations and amounts of substance	12
1.4	Energetics	11
1.5	Atomic structure and the periodic table	9
1.6	Bonding	9
1.7	Introductory organic chemistry	14
Total teaching time (hours)		**55**

AS Chemistry spring and summer terms Unit 2: Application of Core Principles of Chemistry

Topic		Time (approx hours)
2.3	Shapes of molecules and ions	3
2.4	Intermediate bonding and bond polarity	2
2.5	Intermolecular forces	4
2.6	Redox	2
2.7	The periodic table – groups 2 and 7	16
2.8	Kinetics	4
2.9	Chemical equilibria	2
2.10	Organic chemistry	8
2.11	Mechanisms	4
2.12	Mass spectra and IR	3
2.13	Green chemistry	5
Total teaching time (hours)		**53**

A2 Chemistry Autumn term Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry		
Topic		**Time (approx hours)**
4.3	How fast? – rates	10
4.4	How far? – entropy	6
4.5	Equilibria	5
4.6	Application of rates and equilibrium	3
4.7	Acid/base equilibria	10
4.8	Further organic chemistry	12
4.9	Spectroscopy and chromatography	5
Total teaching time (hours)		**51**

A2 Chemistry Spring and summer terms Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry		
Topic		**Time (approx hours)**
5.3	Redox and the chemistry of the transition metals	19
5.4	Organic chemistry – arenes, nitrogen compounds and synthesis	24
Total teaching time (hours)		**43**

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Course planner 2

This course planner allows you to teach the AS units together, and the A2 units together. Therefore the exams would be taken in June for all units. This allows for a synoptic approach to IAL Chemistry.

AS Chemistry	
Autumn term	**Time (approx hours)**
Calculations in chemistry – reacting quantities and energetics	30
Atomic structure, the periodic table and bonding	25
Total teaching time (hours)	**55**

AS Chemistry	
Spring and Summer terms	**Time (approx hours)**
Organic chemistry and analytical techniques	27
Inorganic chemistry	17
Kinetics and Equilibria	8
Total teaching time (hours)	**52**

A2 Chemistry	
Autumn term	**Time (approx hours)**
Why do chemical reactions happen? – entropy and equilibria	24
Rates	12
Redox and the chemistry of the transition metals (part 1)	13
Total teaching time (hours)	**49**

A2 Chemistry	
Spring and Summer terms	**Time (approx hours)**
Redox and the chemistry of the transition metals (part 2)	6
Further organic chemistry	36
Total teaching time (hours)	**42**

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Context Studies

These context studies have been designed to introduce some of the contemporary contexts that can be taught with the new Edexcel IAL Chemistry. They give background information on the context and where to look for further information. Although aimed at teachers some of the context studies can be given to students, as part of the lesson, homework or background reading. The context studies have been designated as either AS or A2 and are mapped to areas of the specification where appropriate.

Summaries of the context studies are given here. Full versions of these studies will be available on our website: *www.edexcel.com/ial*

AS studies

The atmosphere

This context study looks at the different regions of the Earth's atmosphere, giving basic details about them. It then looks at the greenhouse gases that are constantly in the news. Explaining their natural and anthropogenic sources, their chemistry and effects on the atmosphere.

The Earth's atmosphere, as seen from space

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Green Chemistry

This context study looks at what can be done by the scientific community to reduce the amount of greenhouses gases and pollution that we create. It covers the concept of carbon neutrality and ideas such as carbon capture, biofuels, catalysts and atom economy, to ensure that our carbon footprint is reduced. Ideas about how to reduce the amount of waste we produce are also included.

Fuel Cells

This context study looks at what can be done by the scientific community to reduce the amount of greenhouses gases and pollution that we create. It covers the concept of carbon neutrality and ideas such as carbon capture, biofuels, catalysts and atom economy, to ensure that our carbon footprint is reduced. Ideas about how to reduce the amount of waste we produce are also included.

Daimler Chrysler NECar (New Electric Car), one of the earliest fuel cell powered cars developed

AS & A2 studies

The Pharmaceutical Industry

The AS context study looks at how basic concepts of chemistry are applied by the pharmaceutical industry in the preparation of various medicines. It will cover the use of mass spectrometers, the use of new substances such as carbon nanotubes and why solvents are an essential part of this industry.

The A2 context study looks at how important organic synthesis, stereo-specific drugs and combinatorial chemistry are to the pharmaceutical industry.

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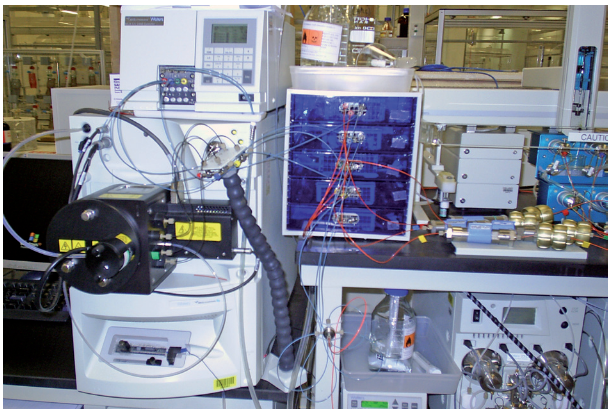
Analysis of Chemicals

The AS context study covers the analysis of chemicals by different methods such as mass spectrometry and infrared spectrometry. These methods are used in various applications, such as dating of rocks, analysis of the solar wind and the pharmaceutical industry. Detailed explanations and examples of spectra are included. The A2 context study includes information on UV spectroscopy, NMR and also gas chromatograph

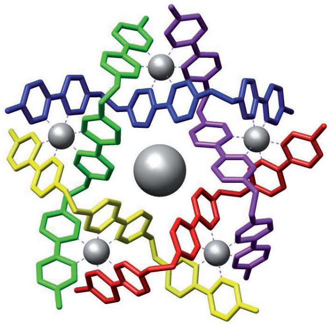


HPLC apparatus (on the right) linked to a mass spectrometer (on the left)

A2 study

Supramolecular Chemistry

This is the "chemistry of molecular assemblies and the intermolecular bonds" and this context study provides an introduction to this area. It describes its origins and why it is useful. Supramolecular chemistry is one of the main strands of nanotechnology and has many applications. One of theses is the possible construction of molecular machines, which is discussed in this study. This is a synoptic context in chemistry and draws on many areas of the IAL.



An example of a supramolecule

Microscale Chemistry

Introduction

This section gives information on where microscale chemistry practicals can be used within the specification.

Microscale chemistry experiments can be a very useful way of carrying out chemistry practicals. The experiments use fewer materials so the safety hazards are often reduced, due to the smaller volumes of reactants and the use of plastic apparatus, rather than glassware. Fume cupboards are not needed as often when carrying out microscale chemistry experiments, as due to the small volumes of reactants, small volumes of products are produced. It is recommended that a risk analysis is carried out for all chemistry practicals. Students carrying out microscale experiments still improve their practical skills in the same way as with any other chemistry practical, however it is recommended that students should have experience of traditional practical apparatus, as well as microscale apparatus.

Microscience is supported by many prestigious organizations. One of these is the Royal Society of Chemistry. This section includes a statement from the RSC with their view on the importance of microscale chemistry.

The Royal Society of Chemistry

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 45,000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

Microscale chemistry is chemistry carried out on a reduced scale using small quantities of chemicals and often (but not always) simple equipment. In the USA the term smallscale chemistry is often preferred, especially at secondary level. There, the term microscale is normally used for organic experiments done in specialised glassware.

Microscale experiments have several advantages:

- the small quantities of chemicals and simple equipment reduces material costs;
- the disposal of chemicals after the experiment is easier;
- safety hazards are often reduced and many experiments can be done quickly;
- frequently, plastic apparatus can be used rather than glassware so breakages are minimized.

Microscale chemistry is not just about doing conventional experiments on a reduced scale. Often experiments can be done in ways such as precipitation reactions in drops of liquid. Chemical reactions often proceed in small volumes of solution rather than the much larger volumes in test-tubes and beakers, and it is often possible to make observations at microscale that are not possible at normal scale. Such experiments will teach students the importance of careful observation — a skill that is vitally important in any scientific endeavour. By minimizing hazards, microscale chemistry opens up the possibility of using chemicals that are too hazardous to contemplate on a larger scale, increasing students’ experience of practical chemistry. In general, by minimizing waste, microscale chemistry encourages responsible use of chemicals, very much a current environmental concern.

Sometimes experiments may be used to complement existing methods by allowing students to perform the microscale experiments either alongside existing methods at appropriate points in the course or as quick but useful revision exercises at the end of the topic.

Because many of the experiments are novel and unusual, many students (and some teachers) may take time to get used to some of the techniques. For example, using a plastic pipette requires a steady hand and the application of the correct amount of pressure to the bulb. Nevertheless if a mistake is made the drops may be quickly mopped up with a tissue and very little chemical will have been wasted or time lost. With practice students should find the techniques are easy to use. The emphasis on microscale practicals is on maximizing the opportunities for careful observation and interpretation. Therefore, the practical parts of these experiments are often over very quickly (in only a few minutes) in contrast to traditional experiments which might last a whole lesson. However, this is not to say that experimental technique is unimportant.

Microscale chemistry practicals for use in Edexcel AS Chemistry

Practical	Description	Link
Using observations of chemical changes to write equations.	Pairs of reagents are mixed and the changes occurring are observed and recorded. Examples could include the reactions between a dilute hydrochloric acid and calcium carbonate b barium chloride solution and sodium sulfate solution c copper(II) sulfate solution and zinc d dilute sulfuric acid and magnesium. Both full and ionic equations, including state symbols, are written for each reaction.	1.3k
Using precipitates to work out chemical equations.	The stoichiometry of two reactions are worked out from the heights of the precipitates formed and finding the optimum concentration ratio from a graph of molar ratio of reactants against height of precipitate. Two suitable reactions are between solutions of a potassium chromate and barium chloride b lead nitrate and potassium iodide.	1.3b
Experiment to find the relative atomic mass of magnesium.	Known masses of magnesium ribbon are reacted with hydrochloric acid and the hydrogen produced is collected by displacement over water and its volume measured.	1.3f
Carrying out acid-base titrations using the results to calculate concentrations of solutions and molar masses.	Using microtitration apparatus, a standard solution of a dilute acid (eg HCl) is titrated against a solution of an “unknown” base (eg Na_2CO_3) using an appropriate indicator. From the results of the titration the molar concentration of the solution of the base is calculated. This may then be combined with the known concentration of the base in $g\,dm^{-3}$ to give the molar mass of the base.	1.3d 1.3c
Confirming the equation for the reaction between lithium and water. An investigation to allow a student to manipulate apparatus, make measurements and recordings and to interpret and evaluate the results.	A known mass of lithium is reacted with excess water. The volume of hydrogen gas produced is measured. The amounts of lithium and hydrogen are calculated from the results and used to confirm the balanced equation for the reaction. The investigation may be varied by titrating the lithium hydroxide solution produced against standard hydrochloric acid and using the results to calculate the relative atomic mass of lithium.	1.3b 1.3i
What is the enthalpy change for the reaction between an acid and a base?	The reactions between strong acids (eg HCl, HNO_3) and a strong alkali (NaOH) are investigated by measuring the temperature change when known volumes of solutions of known concentration are mixed. The results may be used to calculate the enthalpy of neutralisation for different combinations of acid and base. These may be compared and related to the equation $H+(aq) + OH^-(aq) \longrightarrow H_2O(l)$	1.4a 1.4d-

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Practical	Description	Link
Thermochemistry investigation. An experiment to find the enthalpy change for the thermal decomposition of calcium carbonate.	It is not possible to directly measure the enthalpy change for the thermal decomposition of calcium carbonate: $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ The enthalpy change may be calculated using Hess's Law from the enthalpy changes of the reactions between calcium carbonate and calcium oxide with hydrochloric acid. The experiment allows students to make and record observations then to interpret the results. Since the procedure is experimentally flawed students may use the opportunity to evaluate the method and to suggest improvements.	1.4e 1.4fiii
How can we distinguish between alkanes and alkenes?	Tests are carried out on a liquid alkane and a liquid alkene. The results are compared and the differences between a saturated and an unsaturated hydrocarbon are described.	1.7.2e 1.7.3f
What is the trend in reactivity of the group 2 elements?	The metals magnesium and calcium are added to water and the changes observed and recorded. Equations are written for the reactions occurring.	1.3b 2.7.1b
Investigating some group 2 compounds.	Group 2 compounds are investigated by adding them to other reagents and by forming them as precipitates. Examples may include a calcium oxide and water b magnesium oxide and dilute sulfuric acid c magnesium hydroxide and hydrochloric acid d barium chloride solution and sodium sulfate solution e magnesium sulfate solution and sodium hydroxide solution.	2.7.1c 2.7.1d
How can we distinguish between the halide ions Cl^-, Br^- and I^-?	Solutions of the halide ions are distinguished by their reactions with silver nitrate solution followed by the reactions of the silver halides with aqueous ammonia.	2.7.2d
The displacement reactions of the group 7 elements.	Solutions of the halogens (Cl_2, Br_2, I_2) are added to solutions of the potassium halides. Any displacement reactions are observed. Ionic half-equations are written for the reactions and they are explained as redox changes.	2.6.1a 2.7.2d
Reaction kinetics. The factors that affect the rate of a reaction.	The factors that affect reaction rate are changed and the effect of the change on the rate of reaction is observed eg particle size of $CaCO_3$ in its reaction with HCl; the concentration of HCl in its reaction with $CaCO_3$; the effect of a catalyst on the decomposition of H_2O_2.	2.8.1a 2.8.1f
Investigating a chemical equilibrium.	The effect of changing the concentration of chloride ions and of adding water to the equilibrium $[Co(H_2O)_6](aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4{}^{2-}](aq) + 6H_2O(l)$ is investigated by observing the colour changes that occur.	1.3b 1.3i

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Practical	Description	Link
Reactions of alcohols.	Tests are carried out on a number of simple alcohols on a microscale eg methanol, ethanol, propan-1-ol, propan-2-ol. Observations are recorded and equations written for the reactions. The tests may include the combustion of alcohols and their reactions with sodium and PCl_5.	2.9.1c
How can we distinguish between different types of alcohols?	Primary, secondary and tertiary alcohols are warmed with potassium dichromate(VI) solution acidified with dilute sulfuric acid. If oxidation occurs there is a colour change from orange to green. Alcohols tested may include methanol, ethanol, propan-1-ol, propan-2-ol and 2-methylpropan-2-ol.	2.10.1c

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Microscale chemistry practicals for use in Edexcel A2 Chemistry

Practical	Description	Link
The kinetics of the reaction between magnesium and hydrochloric acid.	The time taken for pieces of magnesium ribbon to dissolve in a fixed volume of hydrochloric acid of various concentrations is determined. The rate data obtained may be used to calculate the rate of the reaction as the concentration of HCl changes.	4.3b 4.3c
The kinetics of the reaction between sodium thiosulfate and hydrochloric acid.	The time taken for a precipitate of sulfur to appear when sodium thiosulfate solution reacts with hydrochloric acid is measured. The concentrations of the two solutions may be changed. The rate data obtained may be used to calculate the rate of the reaction as the concentrations of the reagents change.	4.3b 4.3c
Entropy. Carry out simple experiments and explain the observed changes in terms of disorder and enthalpy changes.	Carry out simple experiments then suggest explanations for the observations in terms of disorder and enthalpy change. Changes may include a solids dissolving in water both exothermically and endothermically b the evolution of a gas when a dilute acid is added to a solid c combustion processes that leave solid product d mixing solids that react endothermically.	4.4 4.4g
Measuring an equilibrium constant.	Measured volumes of solutions of $Ag^+(aq)$ and $Fe^{2+}(aq)$ of known concentrations are mixed and left to reach equilibrium. $Fe^{2+}(aq) + Ag^+(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$ A sample of the equilibrium mixture is titrated with potassium thiocyanate solution. From the results of the titration and the volumes and initial concentrations of the reagents a value of the equilibrium constant may be calculated.	4.5d
Effect of temperature on an equilibrium.	A mixture of NO_2 and $N_2O$is captured in a pipette and subjected to changes in temperature. $2NO_2 \rightleftharpoons N_2O_4$ The colour change in the pipette is observed and explained in terms of the effect of temperature on the equilibrium constant and equilibrium composition.	4.6a
Measuring pH.	The pH of a number of different solutions is measured. Examples may include a equimolar solutions of strong and weak acids and bases b solutions of the same acid at increasing dilution c the change in pH as an alkai is added to an acid. From the readings, conclusions may be drawn concerning the way in which pH varies with concentration, the effect of adding acid and alkali to a buffer solution and the change in pH as an alkali is added to an acid.	4.7f 4.7i 4.7k

Practical	Description	Link
Reactions of aldehydes and ketones.	On a microscale a number of aldehydes and ketones (eg ethanal, propanal, propanone) are tested with reagents including a Fehling's(or Benedict's) solution b Tollens' reagent c acidified potassium dichromate(VI) d 2, 4-dinitrophenylhydrazine e iodine in alkali.	4.8.2c
The iodoform reaction.	On a microscale a number of carbonyl compounds are tested with an alkaline solution of iodine. Those giving a pale yellow precipitate are noted and a conclusion made about the structural requirement for a carbonyl compound for it to give a positive iodoform reaction. Carbonyl compounds appropriate for use in this test are ethanal, propanal, propanone, butanone, pentan-2-one.	4.8.2c
Reactions of carboxylic acids.	Ethanoic acid is used as a typical carboxylic acid to react with: a sodium carbonate solution b phosphorus(V) chloride c an alcohol in the presence of concentrated sulfuric acid. Observations are recorded and equations written for the reactions.	4.8.3d
The preparation of an ester, ethyl benzoate.	On a microscale, a mixture of ethanol, benzoic acid and concentrated sulfuric acid is warmed in a water bath. The characteristic smell of an ester is detected in the reaction mixture after warming.	4.8.3d
Redox titrations.	Carry out titrations, using microscale apparatus, using the reagents a potassium manganate(VII) b sodium thiosulfate.	5.3.1h 5.3.1i
Complex ions of transition metals.	Aqueous solutions of complex ions of transition metals are made on a microscale. Changes are observed and explained in terms of complex ion formation. Complex ions that may be formed include a $[Cu(H_2O)_6]^{2+}$ by dissolving a copper(II) salt in water b $[Cu(NH_3)_4(H_2O)_2]^{2+}$by adding excess aqueous ammonia to a solution of a Cu(II) salt c $[CuCl_4]^{2-}$by adding a solution of a copper(II) salt to concentrated hydrochloric acid d $[Zn(NH3)_6]^{2+}$ by adding excess aqueous ammonia to a solution of a zinc(II) salt e $[Cr(NH3)_6]^{3+}$ by adding excess aqueous ammonia to a solution of a chromium(III) salt	5.3.2e 5.3.2f 5.3.2g

Practical	Description	Link
The reactions of transition metal ions with aqueous sodium hydroxide and aqueous ammonia.	On a microscale, aqueous sodium hydroxide and aqueous ammonia are added drop-by-drop, until in excess, to aqueous solutions of transition metal ions. Observations including precipitate formation and, for some transition metals, the dissolving of the precipitate in excess reagent, are recorded. The reactions are interpreted by writing equations for the formation of hydroxide precipitates, amphoteric behaviour and ligand exchange reactions.	5.3.2j 5.3.2k
Reactions of primary amines.	On a microscale, primary amines (eg butylamine, phenylamine) are examined and reacted with a number of reagents.	5.4.2b
The microscale synthesis of azo dyes.	A diazotisation of an aromatic amine is followed by a coupling reaction to form a dye.	5.4.2d
Organic synthesis.	A number of organic compounds may be prepared on a microscale using some of the range of techniques listed in the specification.	5.4.3f

Resources

Microscale practical guidance

Teacher and student worksheets for microscale activities are available from the following sources:

John Skinner – *Microscale Chemistry* (The Royal Society of Chemistry, 1997)

ISBN 1-870343-49-2

LS15: Microscale Organic Chemistry (CLEAPSS, 01/96)

Available to CLEAPSS members on their website — www.cleapss.org.uk

Microchem worksheets (Edulab, S005/B) — for A-level Chemistry (for Edexcel/OCR/AQA specifications)

A CD ROM containing more information and examples of microscale chemistry practicals being carried out by students is available from Edu-Lab.

Equipment

Microscience equipment and materials are readily available from all the major distributors of science equipment.

For any further assistance, please contact:

EDU-LAB
Karoo Close
Bexwell Business Park
Bexwell
Norfolk PE38 9GA

Telephone: 01366 385777

Websites

www.rsc.org	The Royal Society of Chemistry
www.chemistryteachers.org	
www.nuffieldcurriculumcentre.org	Nuffield Curriculum Centre (for teachers and technicians)

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B Getting started for students

Student Guide

Why Study Edexcel IAL Chemistry?

This course will try to give you the skills and understanding to make decisions about the way chemistry affects your everyday life by applying concepts into contemporary areas of chemistry including:

- climate change
- green chemistry
- pharmaceuticals
- chemistry research.

In addition, an IAL in Chemistry allows you to develop a range of generic skills requested by both employers and universities. For instance, a successful IAL chemist will be an effective problem-solver and be able to communicate efficiently both orally and with the written word. Handling data will be a key part of your work, allowing you to demonstrate information retrieval skills as well as use of numeracy and ICT. You will build up a range of practical skills that require creativity and accuracy as well as developing a firm understanding of health and safety issues. As chemistry is a subject in which much learning stems from experimental work it is likely that you will need to work effectively as part of a group, developing team participation and leadership skills. As you become more skilled you will take responsibility for selecting appropriate qualitative and quantitative methods, recording your observations and findings accurately and precisely as well as critically analysing and evaluating the methodology, results and impact of your own and others' experimental and investigative activities.

What do I need to know, or be able to do, before taking this course?

The qualification builds on the knowledge, understanding and process skills that you achieved in GCSE Science, Additional Science, Chemistry, their equivalent in International GCSE, or applied science courses such as the BTEC First Certificate in Applied Science. It is expected that you should have at least the equivalent of a GCSE/International GCSE grade C in Chemistry or Additional Science, and a GCSE/International GCSE grade C in Mathematics. In chemistry you will need to be able to communicate effectively, be able to carry out research, work independently and critically think about problems. Good practical skills are also important as chemistry is a very practical subject.

What will I learn?

Edexcel IAL Chemistry gives you the opportunity to study a core of key concepts in greater detail. Many of the ideas first covered at GCSE/International GCSE will be revisited but with a greater emphasis on explaining rather than simply describing the behaviour of molecules. While studying IAL Chemistry you will develop practical skills that include making observations, collecting data, analysing experimental results and formulating conclusions. You will also gain an appreciation of how scientific models are developed and evolve, the applications and implications of science, the benefits and risks that science brings and the ways in which society uses science to make decisions.

Is this the right subject for me?

AS or A Level Chemistry is suitable if you:

- have an interest in, and enjoy chemistry
- want to find out about how things work in the real world
- enjoy applying your mind to solving problems
- want to use chemistry to progress onto further studies in Higher Education or support other qualifications or enter chemistry-based employment.

How will I be assessed?

AS Level

You will complete a written exam that lasts for 90 minutes for each of Units 1 and 2. The papers will contain objective questions, short answer questions and extended answer questions. For Unit 3 you will complete a written exam that lasts for 75 minutes. The practical written examination covers the content of Units 1 and 2.

A Level

You will complete a written exam that lasts for 100 minutes for each of Units 4 and 5. The papers will contain objective questions, short answer questions and extended answer questions. For Unit 6 you will complete a written exam that lasts for 75 minutes. The practical written examination covers the content of Units 4 and 5.

What can I do after I've completed the course?

Whilst many job opportunities specifically using chemistry require higher qualifications, most laboratory-based jobs benefit from a chemistry qualification, for instance dental assistant or veterinary assistant. Many employers view success at IAL Chemistry as a clear indication of sound academic ability.

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Many university courses have a significant proportion of chemistry content and a IAL in Chemistry from Edexcel is excellent preparation for such further study. UK HE institutions currently offer over 200 courses where chemistry is the primary subject. Often these courses can include an additional year's study, either in industry or at a university abroad. Some courses can include study in other related areas. Examples include:

- chemistry with medicinal chemistry
- chemistry with forensic science and toxicology
- chemistry with pharmacology.

Over 500 additional courses contain a notable element of chemistry as well as allowing a degree of breadth of study. These include:

- chemistry and sports science
- chemistry and politics
- chemistry with computer science.

In addition a number of other courses either specifically require or find it desirable to have an IAL in Chemistry. These include courses such as chemical engineering, medicine, veterinary medicine, biological sciences, environmental science, pharmacy and dentistry.

Next steps!

- Visit websites to find out more about careers involving IAL Chemistry:
    - Royal Society of Chemistry for careers, courses and industrial placements *www.rsc.org/Education/SchoolStudents/index.asp*
    - Association of the British Pharmaceutical Industry (ABPI) careers website *www.careers.abpi.org.uk/Pages/default.aspx*
- Discuss studying this subject with your chemistry or science teacher(s).
- Visit your careers office to find out more about careers and Higher Education courses that need IAL Chemistry.
- Visit websites to find out what courses are available at HE which include chemistry
    - UCAS website *www.ucas.com*
    - Specific university websites, such as *Bristol University School of Chemistry www.chm.bris.ac.uk or Surrey University School of Biomedical and Molecular Sciences www.surrey.ac.uk/subjects/biosciences-medicine*
- Visit the Edexcel website, *www.edexcel.com/ial* to obtain a full copy of the Edexcel IAL in Chemistry specification.

Glossary

This glossary includes information on the commonly used command words from the specification and assessment materials. It also includes explanations of some of the specialist terms and new areas of the specification.

Command words

Calculate

Students are expected to show their working, unless it is a simple one-step calculation.

Comment critically on

This term will most likely be used when students are being stretched and challenged. The answer must be detailed to achieve full marks. There will also be some easier marks, accessible for the average candidate.

Compare

Students must comment on both substances being compared.

Deduce

The answer must be worked out based either on data supplied in the question or in one or more previous answers in the question.

Define

All the words in bold in the question must be defined, with the exception in definitions of enthalpy changes, the term enthalpy need not be defined.

Discuss

This term will be used in more open-ended questions. There will probably be more marking points than marks, so there will be a variety of ways in which full marks can be obtained.

Explain

The answer must contain the theoretical basis for the answer which must be presented in a logical order.

Identify

Either the name or the formula is acceptable.

Justify your answer

The candidate must include the theoretical basis for the answer.

Suggest

Students are not expected to know the answer, but to be able to work it out based on their knowledge and understanding of material in the specification.

Specialist terms

Unit 1: The Core Principles of Chemistry

1.4 Energetics

- **Standard conditions**: these must be given. These are 1 atmosphere pressure (or equivalent unit) and a stated temperature (usually 298K).
- **$\Delta H_{\text{reaction}}$**: the enthalpy change for the number of moles shown in the equation.
- **$\Delta H_{\text{neutralization}}$**: refers to 1 mol of water formed.
- **$\Delta H_{\text{atomization}}$**: refers to 1 mol of gaseous atoms formed from an element in its standard state.
- **Bond energy**: the energy required to break 1 mol of the bonds and so is always endothermic.

1.5 Atomic structure and the periodic table

- **Quantum shells**: these define the energy level of the electrons. All electrons in a given quantum shell have similar, but not identical, energies and electrons in the 1st quantum shell are in the lowest energy level. A simplified view of quantum shells is that it is the region around the nucleus in which an electron is found. The 1st quantum shell or orbit is the region closest to the nucleus.
- **Sub-shells**: the 2nd and subsequent quantum shells or orbits are divided into sub-shells. These are of slightly different energy from each other.
- **Periodicity**: the properties, such as density, first ionization energy and number of valence electrons, of the elements in the periodic table recur regularly. For example, the first ionisation energies rise regularly and then fall to a minimum at each Group 1 element.

1.6 Bonding

- **Dot or cross diagrams**: it is not possible to tell where electrons originated, so in the diagram for the electronic structure of an ionic compound, such as sodium chloride, the electrons can be shown as dots or crosses or any combination of dots and crosses. The same applies to a covalent compound. Note if the question asks for the outer electrons only, cations must not be shown with zero outer electrons.
- **Lattice energy**: this is defined as the energy change when 1 mol of an ionic solid is formed from its gaseous ions infinitely far apart. Thus lattice energies are always exothermic.

1.7 Introductory organic chemistry

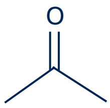
- **Molecular formula**: this shows the number of atoms of each element. It should only be used when specifically required but may be used in combustion equations.
- The formulae used in other equations and as identifiers for a substance must be unambiguous.
- **Structural formula**: this must show any π bonds, thus CH_3CHO would score when identifying ethanal, but not if a structural formula were required. The structural formula of ethanal is shown below.

ethanal

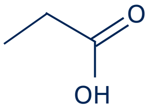
- **Displayed formula**: this must show all the atoms separately and all the bonds joining those atoms.
- **Skeletal formula**: this does not use the symbols for carbon or for hydrogen atoms that are joined to a carbon atom. A carbon atom is assumed to be at the end of every straight line and it is also assumed that the number of hydrogen atoms on each carbon atom is sufficient to complete its valency. All other atoms and the bonds (single, double or triple) between them and the carbon atom at the end of a line must be shown. The skeletal formulae for *E*-but-2-ene (*trans*-but-2-ene), methypropane, propanone and propanoic acid are shown below. Bond angles must not be wrong, ie the angles around a doubly bonded carbon atom must not be drawn as 90° or 180°.


E-but-2-ene


methylpropane



propanone



propanoic acid

- **Hazard**: this is an intrinsic property of a substance. For instance some substances are toxic, others are flammable and others can be absorbed through the skin.
- **Risk**: this relates to how the hazardous substance is dealt with. For instance the risk can be reduced by using smaller quantities or taking specific precautions, such as wearing gloves or using a water bath for heating. Hazardous materials used in small quantities with proper containment pose little risk. The risk can be lessened by using alternative routes, or replacing a compound with a less hazardous one.
- **Structural isomers**: these can arise from different carbon chain lengths (including branching), functional groups being in different positions on the chain or because of different functional groups in the two isomers.

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- **E- and Z- nomenclature**: the naming of the isomer is determined by priorities. To decide on the priority of any group or atoms, consider the atomic number of the atom attached to the carbon of the double bond. The one with the largest value takes priority. If they are the same then add up the atomic numbers of all the atoms that are attached to this first atom and again the one with the largest value takes priority. Continue doing this until there is a difference. If the atoms or groups with the lower priority are on the same side on each end of a C=C group, the isomer is called a Z-isomer (Z for zusammen or together). If on opposite sides, the isomer is called an E-isomer (E for entgegen or opposite).
- **Free radical**: a half-headed or fishhook arrow  represents the movement of a single electron and must be shown for the mechanism for the homolytic fission in the initiation step of a free radical reaction.
- **Electrophilic and nucleophilic addition and substitution**: a double-headed ("curly") arrow represents the movement of a pair of electrons and must be shown when writing the mechanisms for these types of reaction. The arrow must start from a bond or from an atom or anion. In the latter examples, the lone pair of electrons need not be shown but students should realise that a lone pair is the source of the moving electrons. The arrow should go to an atom when forming an ion or towards an atom when forming a bond.
- **Polymers**: the repeat unit must relate to the monomer, eg the repeat unit for poly(ethene) is:

$$—CH_2—CH_2— \quad \text{and not} \quad —CH_2—$$

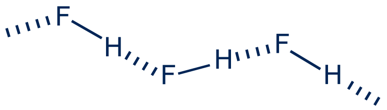
Unit 2: Application of Core Principles of Chemistry

2.3 Shapes of molecules and ions

- **Drawing molecules and ions**: these should be drawn with reasonably correct bond angles, eg 180° for linear molecules and 120° for trigonal planar molecules.
- Three-dimensional molecules: these should be drawn with wedges and dashes, where a wedge represents a bond coming out of the paper and a dash for a bond going behind the paper.

2.5 Intermolecular forces

- **Hydrogen bonds**: the angle around the hydrogen atom in a hydrogen bond must be drawn as 180° and that around the F, O or N atom involved as an angle considerably less than 180° but more than 90°. Thus in solid hydrogen fluoride the molecules are arranged in a zig-zag shape.



- **Hydrogen halides**: students should be aware that in the halogen hydrides, HCl to HI, the strongest intermolecular force is permanent dipole/dipole interactions.

2.6 Redox

- **Disproportionation**: this is defined as a reaction in which an element in a single species is simultaneously oxidised and reduced.

2.7 The periodic table — groups 2 and 7

- **Flame tests**:

Metal ion	Flame colour
sodium	yellow
potassium	lilac
calcium	yellow-red
lithium and strontium	red
barium	pale green

- **The chemical and physical properties of fluorine and astatine**: these should be predicted by extrapolation of the properties of the other halogens. For fluorine the predictions may not match the facts as, for instance, the F-F bond is weaker than the Cl-Cl bond. Other properties such as bond enthalpies between the fluorine or astatine and other elements, 1st ionisation energies, electronegativities, oxidising power and boiling temperature can be predicted with accuracy.

- **Precision, accuracy and reliability**: students must be able to distinguish between these three terms. **Precision** is the number of significant figures or decimal places that can be read on an instrument such as a thermometer. The **accuracy** of a measurement is how close that measurement is to the true value. For instance a digital thermometer can have a three decimal place precision but be extremely inaccurate. (This would not matter for measurements of temperature change providing the inaccuracy is constant, ie is a systematic error.) The **reliability** of an experiment depends on intrinsic errors such as heat losses and the skill of the person performing the experiment. Repeating an experiment will not increase the reliability of the experiment or of the accuracy of the result if the same errors are present.

2.8 Kinetics

- **The reaction profile**: this must show the relative energy levels of the (named) reactants and products, the transition state with the activation energy marked and the enthalpy of reaction. For a catalysed reaction, there should be two 'humps' with the energy level of the intermediate normally being shown at an energy level less than that of the reactants but above that of the products. Both activation energies must be smaller than that for the uncatalysed reaction.

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2.11 Mechanisms

- **Nitric oxide, NO**: students should understand that this depletes the ozone in the upper atmosphere in a free radical chain reaction. The nitric oxide produced by aircraft has more effect on the ozone layer than the nitric oxide produced by cars at ground level, as most of the latter is washed out of the atmosphere by rain.

2.13 Green chemistry

- **Atom economy**: this is defined as the percentage of the atoms of the reactants that are converted into useful products and so not wasted. For example the reaction between ethene and bromine has a 100% atom economy, but the reaction between ethane and bromine is much lower, as hydrogen bromide is a by-product. Another 100% atom economy process is the manufacture of ethanoic acid from methanol and carbon monoxide.
- **Anthropogenic climate change**: this is any change in the Earth's climate caused by activities of mankind. This is different to that caused by natural events, such as volcanic eruptions and changes in the Sun's activity or the Earth's orbit around the Sun.
- **Carbon neutrality (of a fuel)**: this is when the production of carbon dioxide when the fuel is manufactured and then burnt equals the absorption of carbon dioxide when the raw material is grown. This must be in terms of individual human lifetimes and not geological time spans. This means that no fuel is totally carbon neutral but its carbon footprint can be very small (see *carbon footprint*).
- **A carbon neutral activity**: this has no net annual carbon dioxide (greenhouse gas) emissions to the atmosphere.
- **Carbon footprint (of a fuel)**: this is the total mass of carbon dioxide produced from a fuel when it is manufactured and then burnt, in units of g per kilojoule of energy released in combustion. If the fuel was produced by growing fuel crops such as sugar or vegetable oils, the amount of carbon dioxide that was absorbed in growing the raw material of the fuel should be subtracted from this total mass of carbon.
- **Carbon footprint (in general)**: this is a measure of the amount of carbon dioxide emitted through the use of fossil fuels; in the case of an organization, business or enterprise, as part of their everyday operations; in the case of an individual or household, as part of their daily lives; in a product or commodity all processes involved in its production and in reaching the market. Often measured in tonnes of carbon dioxide.

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Unit 4: General Principles of Chemistry I — Rates, Equilibria and Further Organic Chemistry.

4.3 How fast? — rates

- **Rate of reaction**: this is measured as the change in concentration of a reactant or product per unit time. It is the gradient at a given point of the graph of concentration against time (or of other quantities that are proportional to the concentration of a reactant or product, such as volume of gas evolved).
- **The initial rate**: this is the rate at the start of the reaction.
- **Order of reaction**: this is the sum of the powers of the concentrations of the substances in the experimentally determined rate equation. If it is defined as the sum of the 'partial orders', then the term partial order must also be defined.

4.4 How far? — entropy

- **Thermodynamic stability**: the reactants are said to be thermodynamically stable relative to the products if the value of ΔS_{total} for the reaction is negative.
- **Kinetic inertness**: the reactants are said to be kinetically inert relative to the products if the activation energy for the reaction is high. This means that the rate constant will be low.

4.5 Equilibria

- **Effect of change in temperature**: students should understand that an increase in temperature alters the value of $\Delta S_{\text{surroundings}}$ and hence ΔS_{total}. Therefore the value of the equilibrium constant will change. This will then cause the position of equilibrium to shift to restore equality between the new value of K and the concentration or partial pressure term.
- **Effect of change in pressure**: students should understand that an increase in pressure will not alter the value of the equilibrium constant but may alter the value of the concentration or partial pressure term. This will cause the composition of the equilibrium mixture to change as the position shifts to restore equality.

4.7 Acid/base equilibria

- **Buffer solution**: this is a solution that does not significantly change in pH (resists a change of pH) when small amounts of H^+ or OH^- ions are added.
- Students should understand that this will only occur if the amounts of both of the acid/base conjugate pair are large relative to the small amounts of H^+ or OH^- ions added.

4.8 Further organic chemistry

- **A chiral molecule**: is a molecule which is non-superimposable on its mirror image.

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- **Transesterification**: this is the reaction of an ester with either an acid or an alcohol to produce a different ester (this is nothing to do with cis and trans isomerism).

4.9 Spectroscopy and chromatography

- **NMR spectroscopy**: students should understand that the energy of the radio frequency waves promotes some protons into a higher energy level, where their magnetic moments are antiparallel to the applied magnetic field.
- **Gas-liquid chromatography (GLC)**: this is a form of chromatography where the stationary phase is a liquid on an inert support and the moving phase is gaseous. The gaseous phase consists of a carrier gas into which a volatile sample has been injected.
- **High pressure liquid chromatography (HPLC)** (also called **high performance liquid chromatography**): this consists of a stationary phase and a flowing liquid phase which is forced through a column containing the stationary phase by high pressure.

Unit 5: General Principles of Chemistry II — Transition Metals and Organic Nitrogen Chemistry

5.3 Redox and the chemistry of transition metals

- **Standard electrode potential**: this is the electric potential difference (emf) between the electrode in a half-cell and a standard hydrogen electrode. All solutions must be at a concentration of $1\,\text{mol}\,\text{dm}^{-3}$, all gases at 1 atmosphere pressure (or equivalent in other units) and the system must be at a stated temperature (usually 298K).
- **Redox titrations**: during these burettes should be read to an accuracy of $0.05\,\text{cm}^3$. The uncertainty of the accuracy is determined by the quality of the burette. The validity or reliability of the titre is determined by the ability of the student performing the titration and making the reading.
- The idea is that the larger the volume of the titre the greater is its percentage accuracy (or the lower the percentage error).

5.4 Organic chemistry — arenes, nitrogen compounds and synthesis

- **Condensation polymers**: the repeat unit of polyesters and polyamides must have the π bond of the C=O group clearly shown.
- **Combinatorial chemistry**: this can be illustrated by the production of proteins. Amino acids can be attached to polystyrene beads. The beads are divided into a number of portions equal to the number of different amino acids being used in the synthesis. In step one a different amino acid is attached to each set of beads, then mixed and separated into portions. In step two the next amino acid is added on. If 20 different amino acids are used, 202 or 400 different dipeptides are produced, 203 or 8000 different tripeptides etc. At the end, a particular bead can be selected containing a laboratory made protein with a specific peptide sequence.

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