

# Getting Started

## GCE Chemistry

### Edexcel Advanced Subsidiary GCE in Chemistry (8CH01)

First examination 2009

### Edexcel Advanced GCE in Chemistry (9CH01)

First examination 2010

Issue 2



# Edexcel GCE e-Spec

## Your free e-Spec

This specification comes with a free e-Spec, Edexcel's electronic version of the specification. You will find the e-Spec disc inside the Specification book for this qualification.

## Everything you need in one CD

The e-Spec provides a range of useful resources including:

- A Senior Examiner explaining the changes to the new specification
- A customisable student guide to help recruit students
- A course planner to make it easy to plan delivery
- Links to sample assessment materials so you can see what is expected
- Information on the products and services provided by Edexcel to support the specification.

## Easy-to-use

Just click on the walkthrough to see how easy and useful the e-Spec is and get more out of this specification today.

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## Introduction

This Getting Started book will give you an overview of the GCE 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

The course will be assessed by both examination and internal assessment. A more detailed guide to the internally assessed units can be found later in this book in the section entitled 'Internal assessment guide'.

### AS units

Unit 1: The Core Principles of Chemistry	Unit 2: Application of Core Principles of Chemistry	Unit 3: Chemistry Laboratory Skills I
External assessment: written examination paper (75 mins)	External assessment: written examination paper (75 mins)	Internal assessment: 4 aspects a General practical competence b Qualitative observation c Quantitative measurement d Preparation

### 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
External assessment: written examination paper (100 mins)	External assessment: written examination paper (100 mins)	Internal assessment: 4 aspects a General practical competence b Qualitative observation c Quantitative measurement d Preparation

## Overviews

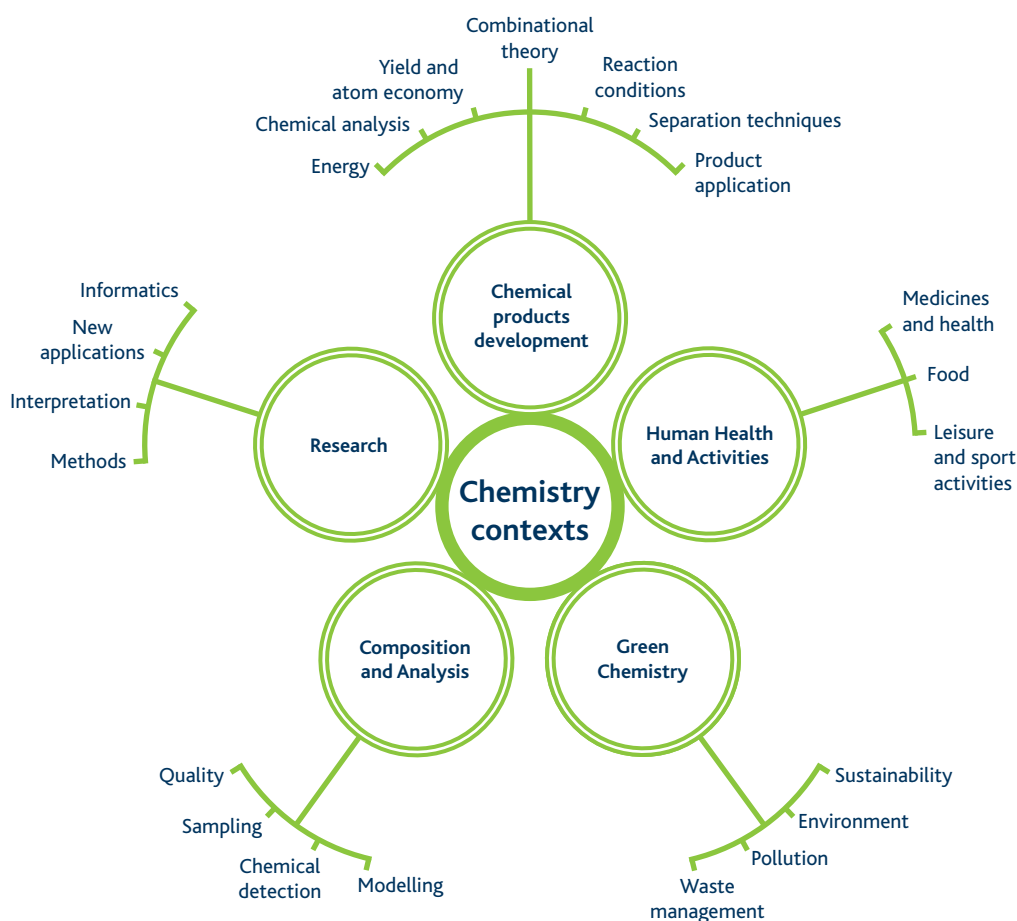
This section provides, at a glance, overviews of the course to help you see what you will need to teach. The unit overviews give a general summary of the examined units.

### Course overviews

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

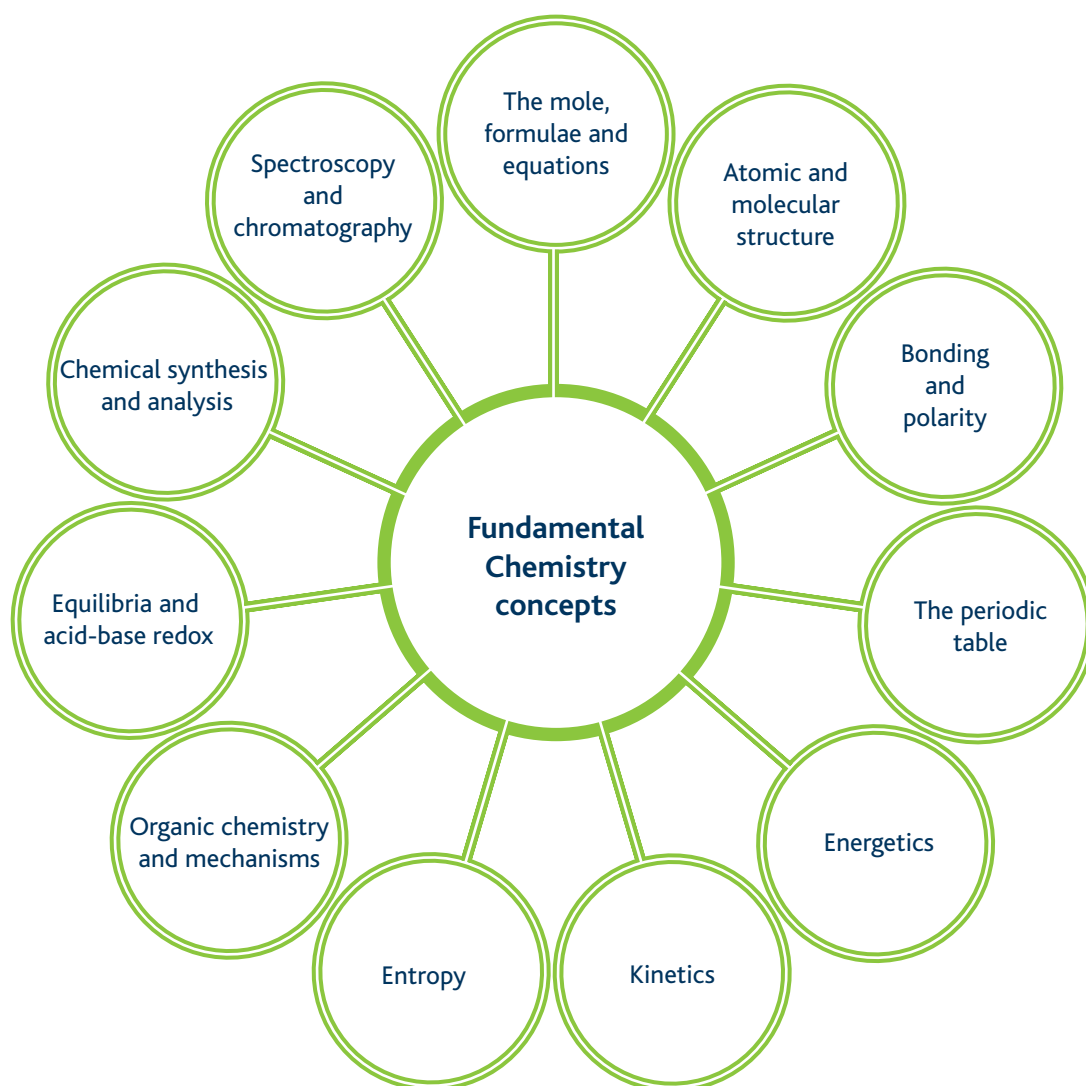
### Chemistry contexts

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 chemistry courses and provide a firm foundation for further study.





## 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 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

## What's new?

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

### Information for current Edexcel Nuffield centres

All the background reading in all topics has been deleted.

### Unit 1: The Core Principles of Chemistry

#### New material

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- E-Z naming system
- Parts per million
- Developing alternative fuels
- Use of mass spectrometers
- Hazard and risk
- Standard heats of formation values as evidence for existence of ionic compounds
- Shapes and plots of electron density for s and p orbitals
- Electrostatic attractions give strong covalent bonds based on physical properties of giant atomic structures
- Polarization and what affects the polarizing power of cations and anions
- Use of renewable resources, recycling and energy recovery to contribute to sustainability
- Mechanisms of free radical substitution and electrophilic addition (of HBr and HBr with bromine)

#### Material no longer covered

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- Types of inorganic reactions
- Uses of metals
- Dehydration of alcohols
- Electrical conductivity in periods and groups
- Uses of group 2 compounds

## Unit 2: Application of Core Principles of Chemistry

### New material

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- Solvents, focussing on the solubility of compounds and choice of solvents
- Factors affecting rates of reaction through practicals and the effect of changing factors on systematic equilibrium
- Structures formed by carbon atoms and their applications
- Green chemistry, sustainability, climate change and greenhouse gases
- Group 2 chemistry, including the reactions and trend in solubility of certain compounds of group 2 elements, and predictions about group 2 elements
- Polar and non-polar molecules

### Material no longer covered

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- Sources of the halogens
- Uses of halogens and their compounds, including their sources and role in human metabolism
- Electron arrangement and shape of carbon monoxide and nitric acid
- Limonene by steam distillation practical
- Practical of alkenes and concentrated sulphuric acid, and evaluate information from text and data book

## Unit 3: Chemistry Laboratory Skills I

All internally assessed through a general practical competence assessment and three set assessed practical tasks. These are qualitative observation, quantitative measurement and preparation. No planning is required.

## Unit 4: General Principles of Chemistry II – Rates, Equilibria and Further Organic Chemistry

### New material

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- Some aspects of equilibria (eg industrial applications being reversible, importance of buffer solutions)
- Maximising atom economy
- How the theory of acidity developed from the 19th Century to the Brønsted-Lowry theory
- Use of microwaves for heating
- Some aspects of NMR
- GC and HPLC as methods of separation of mixtures
- Some of the reactions of carbonyl compounds, carboxylic acids and acyl chlorides

### Material no longer covered

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- Acidic properties and ester formation of phenols
- Phenol and sodium hydroxide, sodium carbonate, ester formation, combustion
- Planning
- Delocalization of carboxylate group
- Cell diagrams
- Batteries and cells
- R<sub>f</sub> values
- Redox reactions of iron and vanadium
- Stability constants of complex ions
- Construction of electrode potential charts
- Relative stability of complexes
- Visible spectra

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

#### New material

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- Fuel cells and breathalysers
- Development of new catalysts
- Use of transition metals and/or their compounds
- Some organic reactions
- Importance of organic synthesis in research, monitored using sensitive methods of analysis
- Combinatorial chemistry in drug research
- Relate changes in oxidation number to stoichiometry
- Uncertainty and validity of results
- Relate disproportionation reactions to standard electrode potentials and E<sub>cell</sub>

#### Material no longer covered

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- Special studies topics deleted

### Unit 6: Chemistry Laboratory Skills II

All internally assessed through a general practical competence assessment and three set assessed practical tasks. These are qualitative observation, quantitative measurement and preparation. There is a choice of completing the quantitative measurement and preparation either as separate assessed practical tasks, or together in one multi-stage practical assessment. No planning is required.

## Information for current Edexcel centres

### Unit 1: The Core Principles of Chemistry

#### New material

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- E-Z naming system
- Parts per million
- Developing alternative fuels
- Use of mass spectrometers
- Hazard and risk
- Standard heats of formation values as evidence for existence of ionic compounds
- Shapes and plots of electron density for s and p orbitals
- Electrostatic attractions give strong covalent bonds based on electron density maps for simple molecules
- Representing data on elements in a graphical way to explain periodic property

#### Material no longer covered

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- Bonding in hydrated metal ions
- Interpretation of changes of state
- Shapes of sulfate, nitrate and carbonate ions
- Electric conductivity of elements in a period
- All Group 1 chemistry except flame tests and decomposition of nitrates and carbonates
- Tests for halogens
- Relative strengths as oxidising agents and extraction of bromine from sea water

### Unit 2: Application of Core Principles of Chemistry

#### New material

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- Solvents, focusing on the solubility of compounds and choice of solvents
- Factors affecting rates of reaction through practicals and the effect of changing factors on systematic equilibrium
- Structures formed by carbon atoms and their applications
- Green chemistry, sustainability, climate change and greenhouse gases
- Investigating electrostatic forces on jets of liquid

### Material no longer covered

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- Reactions of alkanes and bromine
- Uses of polymers and their disposal problems, comparison of liquid and gaseous fuels
- All Industrial inorganic chemistry, all the tests for simple ions and gases, but those known at GCSE could be asked
- Planning exercises

### Unit 3: Chemistry Laboratory Skills I

All internally assessed through a general practical competence assessment and three set assessed practical tasks. These are qualitative observation, quantitative measurement and preparation. No planning is required.

### Unit 4: General Principles of Chemistry II – Rates, Equilibria and Further Organic Chemistry

#### New material

---

- Some aspects of equilibria (eg industrial applications being reversible, importance of buffer solutions)
- Maximising atom economy
- How the theory of acidity developed from the 19th Century to the Brønsted-Lowry theory
- Use of microwaves for heating
- Some aspects of NMR
- GC and HPLC as methods of separation of mixtures
- Physical properties of aldehydes, ketones and carboxylic acids

#### Material no longer covered

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- All Period 3 and group 4 chemistry
- Calculation of partial pressure from  $K_p$  for binary gaseous equilibrium
- $\Delta H_{\text{neutralisation}}$  related to acid or base strength
- Chemistry of Grignard reagents
- Reactions of nitriles
- Reactions of amides

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

### New material

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- Fuel cells and breathalysers
- Development of new catalysts
- Use of transition metals and/or their compounds
- Some organic reactions
- Importance of organic synthesis in research, monitored using sensitive methods of analysis
- Combinatorial chemistry in drug research
- $E_{\text{cell}}^{\ominus}$  directly proportional to the total entropy change
- Relate relative stability of complex ions to entropy changes of ligand exchange reactions

### Material no longer covered

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- Corrosion
- Storage cells
- Sodium hydroxide with cobalt (II) ions
- Vanadium chemistry
- Recall of examples of catalysts
- Oxidation of aromatic side chains
- Nucleophilic mechanism of cyanide ions and halogenoalkanes
- UV and visible spectra
- Principles of fractional distillation

## Unit 6: Chemistry Laboratory Skills II

All internally assessed through a general practical competence assessment and three set assessed practical tasks. These are qualitative observation, quantitative measurement and preparation. There is a choice of completing the quantitative measurement and preparation either as separate assessed practical tasks, or together in one multi-stage practical assessment. No planning is required.

## Course planners

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

- Course planner 1 follows the specification through in topic order, and would enable students to complete units 1 and 4 before the January assessment opportunity.
- Course planner 2 is an alternative route through the specification, grouped by areas of chemistry which naturally fit together at AS and A2. This does not allow for units 1 and 4 to be completed for the January assessment opportunity. However, 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/gce2008/chemistry/8CH01/Pages/as.aspx](http://www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx)

## 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		



The following tables show the suggested timings of each topic.

## Course planner 1

Each unit is taught separately so that units 1 and 4 can be completed before the end of the autumn term, and exams to be taken in January. This allows for a modular approach to GCE 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
<b>Total teaching time (hours)</b>		<b>55</b>
<i>Internal assessments: ASC2, ASC4, ASB3, ASD1, ASD2</i>		5
<b>Total time (hours)</b>		<b>60</b>

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
<b>Total teaching time (hours)</b>		<b>53</b>
<i>Internal assessments: ASB1, ASB2, ASB3, ASB4, ASC1, ASC3, ASD3</i>		7
<b>Total time (hours)</b>		<b>60</b>

**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
<b>Total teaching time (hours)</b>		<b>51</b>
<i>Internal assessments: A2B4, A2C1, A2C2, A2C4, A2D3</i>		5
<b>Total time (hours)</b>		<b>56</b>

**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
<b>Total teaching time (hours)</b>		<b>43</b>
<i>Internal assessments: A2B1, A2B2, A2B3, A2B4, A2C3, A2D1, A2D2, A2M1</i>		9
<b>Total time (hours)</b>		<b>52</b>

## 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 linear approach to GCE Chemistry.

AS Chemistry	
Autumn term	Time (approx hours)
Calculations in chemistry – reacting quantities and energetics	30
Atomic structure, the periodic table and bonding	25
<b>Total teaching time (hours)</b>	<b>55</b>
<i>Internal assessments: ASC1, ASC2, ASC4, ASD1, ASD2</i>	5
<b>Total time (hours)</b>	<b>60</b>

AS Chemistry	
Spring and Summer terms	Time (approx hours)
Organic chemistry and analytical techniques	27
Inorganic chemistry	17
Kinetics and Equilibria	8
<b>Total teaching time (hours)</b>	<b>52</b>
<i>Internal assessments: ASB1, ASB2, ASB3, ASB4, ASC3, ASD3,</i>	6
<b>Total time (hours)</b>	<b>58</b>

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
<b>Total teaching time (hours)</b>	<b>49</b>
<i>Internal assessments: A2C1, A2C2, A2C4,</i>	3
<b>Total time (hours)</b>	<b>52</b>

A2 Chemistry	
Spring and Summer terms	Time (approx hours)
Redox and the chemistry of the transition metals (part 2)	6
Further organic chemistry	36
<b>Total teaching time (hours)</b>	<b>42</b>
<i>Internal assessments: ASB1, ASB2, ASB3, ASB4, ASC3, ASD3,</i>	8
<b>Total time (hours)</b>	<b>50</b>

## Context studies

These context studies have been designed to introduce some of the contemporary contexts that can be taught with the new Edexcel GCE 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/gce2008/chemistry/8CH01/Pages/as.aspx](http://www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx)

### 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

## Green Chemistry

This context study looks at what can be done by the scientific community to reduce the amount of greenhouse 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

With the search for more environmentally friendly ways of producing energy and electricity fuel cells are extremely important. This context study will explain what fuel cells are, why we need them and how they produce electricity. It will also explain the environmental impact of fuel cells compared to the standard methods of burning fossil fuels to produce electricity.



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.

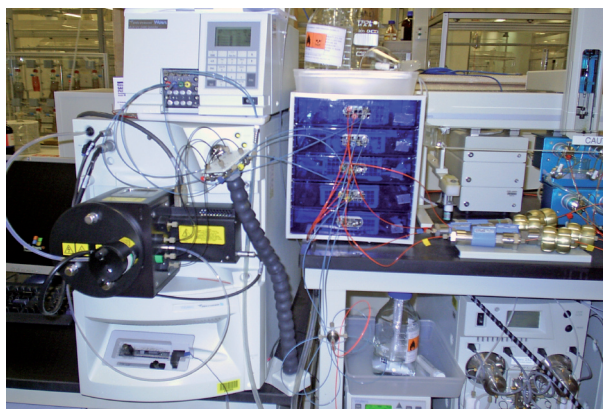


The A2 context study looks at how important organic synthesis, stereo-specific drugs and combinatorial chemistry are to the pharmaceutical industry.



## 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

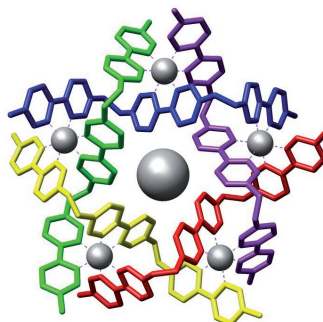


HPLC apparatus (on the right) linked to a mass spectrometer (on the left)

## 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 these 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 GCE.



An example of a supramolecule

## Microscale chemistry

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### 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 <sub>2</sub> CO <sub>3</sub> ) 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 <sup>-3</sup> 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 <sub>3</sub> ) 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 $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$	1.4a 1.4d-
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: $\text{CaCO}_3(\text{s}) \longrightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ 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



Practical	Description	Link
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 <sup>-</sup> , Br <sup>-</sup> and I <sup>-</sup> ?	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 <sub>2</sub> , Br <sub>2</sub> , I <sub>2</sub> ) 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 <sub>3</sub> in its reaction with HCl; the concentration of HCl in its reaction with CaCO <sub>3</sub> ; the effect of a catalyst on the decomposition of H <sub>2</sub> O <sub>2</sub> .	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 $[\text{Co}(\text{H}_2\text{O})_6](\text{aq}) + 4\text{Cl}^-(\text{aq}) \rightleftharpoons [\text{CoCl}_4^{2-}](\text{aq}) + 6\text{H}_2\text{O}(\text{l})$ is investigated by observing the colour changes that occur.	1.3b 1.3i
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 <sub>5</sub> .	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

## 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 $\text{Ag}^+(\text{aq})$ and $\text{Fe}^{2+}(\text{aq})$ of known concentrations are mixed and left to reach equilibrium. $\text{Fe}^{2+}(\text{aq}) + \text{Ag}^+(\text{aq}) \rightleftharpoons \text{Fe}^{3+}(\text{aq}) + \text{Ag}(\text{s})$ 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 $\text{NO}_2$ and $\text{N}_2\text{O}_4$ is captured in a pipette and subjected to changes in temperature. $2\text{NO}_2 \rightleftharpoons \text{N}_2\text{O}_4$ 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 alkali 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
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



Practical	Description	Link
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 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ by dissolving a copper(II) salt in water b $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ by adding excess aqueous ammonia to a solution of a Cu(II) salt c $[\text{CuCl}_4]^{2-}$ by adding a solution of a copper(II) salt to concentrated hydrochloric acid d $[\text{Zn}(\text{NH}_3)_6]^{2+}$ by adding excess aqueous ammonia to a solution of a zinc(II) salt e $[\text{Cr}(\text{NH}_3)_6]^{3+}$ by adding excess aqueous ammonia to a solution of a chromium(III) salt	5.3.2e 5.3.2f 5.3.2g
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/secpbfr.htm](http://www.cleapss.org.uk/secpbfr.htm)

*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

<a href="http://www.rsc.org">www.rsc.org</a>	The Royal Society of Chemistry
<a href="http://www.chemistryteachers.org">www.chemistryteachers.org</a>	
<a href="http://www.nuffieldcurriculumcentre.org">www.nuffieldcurriculumcentre.org</a>	Nuffield Curriculum Centre (for teachers and technicians)

## Internal Assessment Guide

This section explains how the practicals are assessed and suggests some tasks and practicals that can be used. At the end you will find a table that maps the practical work to the specification.

### Introduction

There are two internal assessment units: Unit 3 and Unit 6.

#### AS Unit 3: Chemistry Laboratory Skills I

The student's laboratory skills will be tested in four different ways, so there will be four separate activities which constitute this assessment unit. The four activities must cover the areas of physical, organic and inorganic chemistry.

**Activity a: General Practical Competence (GPC).** This will confirm that students have completed a range of practicals over the whole year and developed their laboratory skills. Students must have carried out at least five practicals in class. The practicals that the students complete must cover the three areas of physical, organic and inorganic chemistry. Verification of completion is required as well as the core practical code (or title), field and dates the experiments were carried out.

**Activity b: Qualitative observation.** The students must complete one qualitative observation, from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 14.

**Activity c: Quantitative measurement.** The student must complete one quantitative measurement, from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 14.

**Activity d: Preparation.** The student must complete one preparation (making a chemical), from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 12.

These assessed practicals must all be carried out under controlled conditions. Students will be allowed to write up their practical reports in a separate lesson, but their materials must be collected at the end of the session, and handed back at the beginning of the next session. Students are not permitted to work on their practical sheets out of the lesson. The students' work must be individual and they may not work with other students in groups.

The practical sheets for activities b, c and d are confidential and must not be shown to the students prior to their completion of them. These will be available on a secure Edexcel website for teachers to download in preparation for delivery.

## A2 Unit 6: Chemistry Laboratory Skills II

As with AS Unit 3, the student's laboratory skills will be tested in four different ways; however there is a choice in how these can be delivered. The whole laboratory skills assessment must cover the areas of physical, organic and inorganic chemistry.

**All students will have to complete activities a and b as described below, as in AS.**

**Activity a: General Practical Competence (GPC).** This will confirm that students have completed a range of practicals over the whole year. Students must have carried out at least five practicals in class. The practicals that the students complete must cover the three areas of physical, organic and inorganic chemistry. Verification of completion is required as well as the core practical code (or title), field and dates the experiments were carried out.

**Activity b: Qualitative observation.** The students must complete one qualitative observation, from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 14.

**Students then have a choice of completing either pathway 1 or pathway 2 as detailed below.**

**Pathway 1:** Students complete activities c and d as in AS as described below:

**Activity c: Quantitative measurement.** The student must complete one quantitative measurement, from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 14.

**Activity d: Preparation.** The student must complete one preparation (making a chemical), from the selection provided by Edexcel. This activity will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 12.

**Pathway 2:** Students could complete a multi-stage experiment, which comprises a quantitative measurement and a preparation. This covers the same criteria as activities c and d, but allows the students experience of a longer and different practical activity. This activity must be chosen from the selection provided by Edexcel. It will include a student sheet, teacher and technician notes and a mark scheme. This activity is marked out of 26.

These assessed practicals must be carried out under controlled conditions. Students will be allowed to write up their practical reports in a separate lesson, but their materials must be collected at the end of the session, and handed back at the beginning of the next session. Students are not permitted to work on their practical sheets out of the lesson. The students' work must be individual and they may not work with other students in groups. The practical sheets for activities b, c, d and the multi-stage experiment are confidential and must not be shown to the students prior to their completion of them. These will be available on a secure Edexcel website for teachers to download in preparation for delivery.



## Teacher Guide

This section contains information for teachers on the internal assessment of practical skills for AS and A2 Chemistry.

There will also be a User Guide for Students for guidance on the internal assessment of practical skills. This will be published on our website in due course:

[www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx](http://www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx)

The AS tasks are based upon the content of Units 1 and 2 of the specification. The A2 tasks are based upon the content of Units 4 and 5 of the specification. Included with the tasks are mark schemes, technician's notes and marking grids. The chemistry in each task is classified as being inorganic, organic or physical.

Teachers should note that they are responsible for safe practice and the necessity to act in accordance with relevant COSHH regulations. There is no requirement for any of the experiments described to be carried out if it is deemed inappropriate.

A Risk Assessment should always be carried out before commencing any of the tasks.

### Activities to be assessed

The activities to be assessed and the maximum mark for each at both AS and A2 are:

- a** General practical competence (GPC) (Verification)
- b** Qualitative observation (14 marks)
- c** Quantitative measurement (14 marks)
- d** Preparation (12 marks)

The maximum total mark at both AS and A2 is 50 marks.

### The AS scheme of assessment

Details of the requirements of the AS scheme are given in the table.

Activity	Number of practicals required	Marks	Comments
a General Practical Competence (GPC)	Five	Verification	Must include experiments on each of the areas of inorganic, organic and physical chemistry.
b Qualitative observation	One	14	
c Quantitative measurement	One	14	
d Preparation	One	12	
<b>Total</b>		<b>40</b>	

## The A2 scheme of assessment

Two alternative pathways are available for the internal assessment of practical skills at A2.

Pathway 1 has the same requirements as the AS scheme but is based on the content of Units 4 and 5.

Pathway 2 allows activities c and d to be assessed by means of a multi-stage experiment.

Details of each pathway are given in the table below.

### Pathway 1:

Activity	Number of practicals required	Marks	Comments
a General Practical Competence (GPC)	Five	Verification	Must include experiments on each of the areas of inorganic, organic and physical chemistry.
b Qualitative observation	One	14	
c Quantitative measurement	One	14	
d Preparation	One	12	
<b>Total</b>		<b>40</b>	

### Pathway 2:

Activity	Number of practicals required	Marks	Comments
a General Practical Competence (GPC)	Five.	Verification	Must include experiments on each of the areas of inorganic, organic and physical chemistry.
b Qualitative observation	One	14	
m (c+d) Multi-stage experiment	One	26	Must include experiments on at least <b>two</b> of the areas of inorganic, organic and physical chemistry.
<b>Total</b>		<b>40</b>	

### Activity a – General Practical Competence

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The verification of General Practical Competence is on a student's laboratory work over the whole period of the AS or A2 course and not on any one specific occasion. A student will be expected to carry out at least five practicals for completion of the GPC at AS and A2.

### Activities b, c and d

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- A student must complete at least one task for each of activities b, c and d at AS and A2 (Pathway1). Each task must be marked using the appropriate mark scheme.
- Students may carry out more than the minimum one task for each of activities b, c and d. Only the highest mark for each activity will then be included in the total mark.
- Only the tasks that have counted towards the final mark for each of activities b, c and d will be subject to moderation by the Edexcel moderator.
- For A2 (Pathway 2) activities c and d will be assessed together by a student carrying out one multi-stage experiment.
- Each of the assessment tasks in this booklet is classified as being based on organic, inorganic or physical chemistry. In order to ensure that students carry out tasks on a range of topics from the specification the conditions relating to the types of task must be satisfied. These are explained in section 3 and 4 of this document.

### Centre-devised assessments

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There will be a selection of practical activities provided to use with students to assess Units 3 and 6. However, you are also able to choose your own activities so you can tailor the practical activities to suit student interests and resources in your centre.

If you wish to devise your own assessment tasks you must contact Edexcel for further details to ensure that the task covers all the criteria.

## Assessed practical tasks

The following tasks will be used to assess practical skills in Units 3 and 6.

### AS Tasks

Task		Area of chemistry
Activity b – Qualitative observation*		
ASB1	Observation exercise on three inorganic compounds – 1	Inorganic
ASB2	Observation exercise on three inorganic compounds – 2	Inorganic
ASB3	Observation exercise on three organic compounds	Organic
ASB4	Observation exercise on two organic compounds	Organic
Activity c – Quantitative measurement		
ASC1	Acid-base titration – finding the molar mass of a solid acid	Physical
ASC2	Finding the enthalpy change for the reaction between an acid and a base	Physical
ASC3	Sodium thiosulfate(v)-iodine titration	Physical
ASC4	Hess's Law	Physical
Activity d – Preparation		
ASD1	Preparation of a double salt	Inorganic
ASD2	Preparation of a salt	Inorganic
ASD3	Preparation of an organic compound	Organic

\*The tasks for Activity b – Qualitative observation will change each year. The tasks listed above (ASB1, ASB2, ASB3 and ASB4) are only valid from September 2008 to August 2009. New tasks will be available for each following year, on the Edexcel website, as secure files. The new files will have different codes (eg ASB5) to make them easily identifiable.



## A2 Tasks

Task		Area of chemistry
Activity b – Qualitative observation*		
A2B1	Observation exercise on two inorganic compounds	Inorganic
A2B2	Observation exercise on three transition metal ions	Inorganic
A2B3	Observation exercise on two inorganic salt solutions	Inorganic
A2B4	Observation exercise on three organic compounds	Organic
Activity c – Quantitative measurement		
A21	pH titration – finding the $K_a$ value of a weak acid	Physical
A2C2	Following the rate of a reaction	Physical
A2C3	Potassium manganate (VII) titration	Inorganic
A2C4	Finding the activation energy of a reaction	Physical
Activity d – Preparation		
A2D1	Preparation of aspirin	Inorganic
A2D2	Preparation of a transition metal complex salt	Inorganic
A2D3	Preparation of an ester	Organic
Activity m (c+d) – Multi-stage experiment		
A2M1	The synthesis of aspirin in two stages	Organic

\*The tasks for Activity b – Qualitative observation will change each year. The tasks listed above (A2B1, A2B2, A2B3 and A2B4) are only valid from September 2009 to August 2010. New tasks will be available for each following year, on the Edexcel website, as secure files. The new files will have different codes (eg A2B5) to make them easily identifiable.

## Suggested practicals

The variety of activities available should provide plenty of choice of assessment activities to carry out.

Each practical contains everything you need to use the activity with students:

- a front sheet for students to fill in
- a student brief
- mark schemes
- technicians notes
- marking grid where appropriate.

Some samples of the assessed practicals start on the page opposite.

## Summary of practical work in the specification

Core practicals should be carried out, as part of your normal teaching, and are in the specification in the following areas:

### Unit 1: The Core Principles of Chemistry

1.3j, 1.3k, 1.4f

### Unit 2: Application of Core Principles of Chemistry

2.4d, 2.5c, 2.7.1g, 2.7.2b, 2.7.2c, 2.7.2d, 2.8f, 2.10.1d, 2.10.2c, 2.10.2e

### Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry

4.3c, 4.3e, 4.4g, 4.8.2c, 4.8.3d, 4.8.4b, 4.8.4c

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

5.3.1d, 5.3.1g, 5.3.2g, 5.3.2j, 5.4.1d, 5.4.1e, 5.4.2b, 5.4.2d, 5.4.2i, 5.4.3f

A full explanation of this practical work is available on the Edexcel website:

[www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx](http://www.edexcel.com/gce2008/chemistry/8CH01/Pages/as.aspx)


**SAMPLE**
**ASB Observation exercise on three inorganic compounds**

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's use only</i>	Mark _____ /14

<b>Category</b>	Inorganic Chemistry
<b>Specification topics</b>	Unit 2 Topic 2.7 The periodic table — groups 2 and 7
<b>Activity assessed</b>	Activity b — Qualitative observation
<b>Materials allowed</b>	Student brief, writing materials, apparatus and chemicals supplied. No other books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written results must be handed in at the end of the session.
<b>Time allowed</b>	One hour of laboratory time.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise. Your teacher may demonstrate the test using concentrated sulfuric acid which is corrosive.  Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## ASB Observation exercise on three inorganic compounds

### Student brief

In this exercise you are given solid samples of three inorganic compounds. Each compound contains one cation and one anion.

You are to carry out tests on each compound recording your observations in the spaces provided. You do not need to explain your observations for each test but you must suggest the identity of each compound following the tests by writing its formula.

### Information

You are supplied with

- Samples of three compounds labelled **D**, **E** and **F**.
- The apparatus and chemicals needed to carry out the tests.

(a) (i) Carry out a flame test on about half of the sample of **D**.

Observation

**(1)**

(ii) Dissolve about a quarter of the sample of **D** in about **5cm<sup>3</sup>** of distilled water in a test tube. To the solution add 6 drops of dilute nitric acid followed by 6 drops of aqueous silver nitrate.

Observation

**(1)**





- (iii) **Working in a fume cupboard** add 6 drops of concentrated sulfuric acid to the remaining quarter of the sample of **D** in a test tube standing in a test tube rack. Do not carry out any tests on the reaction products. Leave the test tube in the fume cupboard.

Observations

(2)

- (iv) Based on the observations in tests (a)(i) to (a)(iii) suggest the identity of **D** by writing its formula in the box below.

--

(1)

- (b) (i) Carry out a flame test on about half of the sample of **E**.

Observation

(1)

- (ii) Transfer the remaining sample of **E** to a dry test tube. Heat the test tube, testing any gas evolved with a glowing splint. Continue to heat until there is no further change then allow the test tube to cool.

Observations

(2)

- (iii) Based on the observations in tests (b)(i) to (b)(ii) suggest the identity of **E** by writing its formula in the box below.

	<b>(1)</b>
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- (iv) Write an equation to show the reaction occurring when **E** is heated in test (b)(ii).

**(1)**

---

- (c) (i) Carry out a flame test on about half of the sample of **F**.

<b>Observation</b>

**(1)**

- (ii) Transfer the remaining sample of **F** to a test tube. Add a few drops of dilute hydrochloric acid testing any gas evolved with lime water.

<b>Observations</b>

**(2)**

- (iii) Based on the observations in tests (c)(i) and (ii) suggest the identity of **F** by writing its formula in the box below.

	<b>(1)</b>
--	------------

**Mark scheme****Activity b Qualitative observation**

- (a) (i) Carry out a flame test on about half of the sample of **D**.

Observation
<p style="text-align: center;"><b><i>Lilac/mauve/purple (1)</i></b></p>

**(1)**

- (ii) Dissolve about a quarter of the sample of **D** in about **5**cm<sup>3</sup> of distilled water in a test tube. To the solution add 6 drops of dilute nitric acid followed by 6 drops of aqueous silver nitrate.

Observation
<p style="text-align: center;"><b><i>Cream precipitate (1)</i></b></p> <p style="text-align: center;">Accept pale yellow or off-white but not white alone.</p>

**(1)**

- (iii) **Working in a fume cupboard** add 6 drops of concentrated sulfuric acid to the remaining quarter of the sample of **D** in a test tube standing in a test tube rack. Do not carry out any tests on the reaction products. Leave the test tube in the fume cupboard.

Observations
<p style="text-align: center;"><b><i>Vigorous reaction/steamy fumes/white fumes (1)</i></b></p> <p style="text-align: center;"><b><i>Any yellow/brown gas or vapour (1)</i></b></p>

**(2)**

- (iv) Based on the observations in tests (a)(i) to (a)(iii) suggest the identity of **D** by writing its formula in the box below.

<b><i>KBr</i></b> (1)	<b>(1)</b>
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- (b) (i) Carry out a flame test on about half of the sample of **E**.

<b>Observation</b>	
<b><i>Yellow/orange</i></b> (1)	<b>(1)</b>

- (ii) Transfer the remaining sample of **E** to a dry test tube.  
Heat the test tube, testing any gas evolved with a glowing splint. Continue to heat until there is no further change then allow the test tube to cool.

<b>Observations</b>	
<b><i>Solid melts/liquid formed</i></b> (1) Not solution <b><i>Splint re-lights</i></b> (1)	<b>(2)</b>

- (iii) Based on the observations in tests (b)(i) to (b)(ii) suggest the identity of **E** by writing its formula in the box below.

<b><i>NaNO<sub>3</sub></i></b> (1)	<b>(1)</b>
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(iv) Write an equation to show the reaction occurring when **E** is heated in test (b)(ii).



(c) (i) Carry out a flame test on about half of the sample of **F**.

Observation
<i>Red/brick red/yellow-red (1)</i>

(1)

(ii) Transfer the remaining sample of **F** to a test tube. Add a few drops of dilute hydrochloric acid testing any gas evolved with lime water.

Observations
<i>Effervescence/bubbles of gas (1)</i> <i>Lime water turns cloudy/milky/white precipitate formed (1)</i>

(2)

(iii) Based on the observations in tests (c)(i) and (ii) suggest the identity of **F** by writing its formula in the box below.

<i>CaCO<sub>3</sub> (1)</i> Accept SrCO <sub>3</sub> or LiCO <sub>3</sub>
--

(1)

## Technician's notes

### Apparatus

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5 test tubes and a test tube rack.  
Test tube clip holder  
Bunsen burner  
Dropping pipettes.  
10cm<sup>3</sup> measuring cylinder.  
Apparatus for carrying out a flame test.  
Spatula  
Splints  
Apparatus to carry out CO<sub>2</sub> lime water test.  
Access to a fume cupboard.

### Materials

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In stoppered, labelled appropriate containers;  
1g of solid potassium bromide labelled **D**.  
1g of solid sodium nitrate labelled **E**. OXIDISING  
1g of calcium carbonate labelled **F**.  
  
Access to the reagents listed below.  
Dilute hydrochloric acid; concentration approximately 2.0 mol dm<sup>-3</sup>. CORROSIVE  
Dilute nitric acid; concentration approximately 2.0 mol dm<sup>-3</sup>. CORROSIVE  
Concentrated sulfuric acid. CORROSIVE  
  
Aqueous silver nitrate; concentration approximately 0.05 mol dm<sup>-3</sup>.  
Lime water.  
Distilled water.  
  
Reagents should be in stoppered containers labelled with the name but not necessarily the concentration of the reagent. The appropriate hazard warning should be attached to the reagent container.

### Notes

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This exercise should be able to be completed in about one hour of laboratory time.

#### **Test (a)(iii)**

This test is potentially hazardous since it includes the use of concentrated sulfuric acid and the evolution of bromine vapour and sulfur dioxide. **The test must be carried out in a fume cupboard.**



## SAMPLE

### ASC The solubility of an ionic compound

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's use only</i>	Mark _____ /14

<b>Category</b>	Physical Chemistry
<b>Specification topics</b>	Unit 1 Topic 1.6 Bonding
<b>Activity assessed</b>	Activity c – Quantitative measurement
<b>Materials allowed</b>	Student brief, calculator, writing materials, apparatus and chemicals supplied. No other books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written results must be handed in at the end of the session.
<b>Time allowed</b>	One hour of laboratory time possibly plus time to draw the graph and answer the questions.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise. Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## ASC The solubility of an ionic compound

### Student brief

In this exercise you will find the solubility of potassium nitrate at different temperatures. You will measure the temperature at which crystals start to form from a hot solution as it cools.

You will be assessed on your laboratory skills in making accurate temperature recordings and using a burette to measure volumes of water. Marks will be awarded for your ability to draw and interpret a graph from your results.

### Information

You are supplied with

- A sample of 10.10g of potassium nitrate,  $\text{KNO}_3$ .
- The apparatus and materials to carry out the exercise.

Potassium nitrate has a molar mass of  $101.0\text{g mol}^{-1}$ .

### Procedure

1. Rinse and then fill a burette with distilled water.
2. Use the burette to measure  $8.00\text{cm}^3$  of distilled water into the test tube containing the potassium nitrate. Place the thermometer in the test tube and leave it there for the rest of the exercise.
3. With the tube in a test tube holder, use a Bunsen burner to heat the mixture in the tube until the potassium nitrate crystals just dissolve.
4. Allow the solution to cool stirring it **gently** with the thermometer. Hold the test tube against a matt-black card and note the temperature at which crystals begin to appear. Record the temperature, to an accuracy of at least  $0.5^\circ\text{C}$ , in **Table 1**.

If you wish to repeat this reading you may re-heat the test tube and again allow the solution to cool.

5. Add a further  $2.00\text{cm}^3$  of distilled water to the test tube. Gently heat again until the crystals dissolve. Repeat the procedure described in 4 to find the temperature at which crystals first appear. Record the temperature, to an accuracy of at least  $0.5^\circ\text{C}$ , in **Table 1**.
6. Repeat the procedure in 5 a further three more times adding exactly  $2.00\text{cm}^3$  of distilled water each time and recording the temperatures, to an accuracy of at least  $0.5^\circ\text{C}$ , in **Table 1**.



**Table 1**

<b>Volume water/cm<sup>3</sup></b>	<b>Temperature at which crystals form/°C</b>
8.00	
10.00	
12.00	
14.00	
16.00	

**(10)**

**Graph and questions.**

- (a) Draw a graph of the temperature at which crystals form against the volume of water at each temperature.

**(2)**

- (b) From the shape of your graph describe the change in solubility of potassium nitrate with temperature.

---

---

**(1)**

- (c) Describe the part of the procedure that you consider is most likely to lead to inaccuracy in your temperature readings.

---

---

**(1)**

**Total =**

## Mark scheme

### Activity c Quantitative measurement

#### 1 Table 1

Accuracy marks

Max **(9)** if any temperatures are not recorded to 1 dp.

Volume water/cm <sup>3</sup>	Expected temperature/°C	Range/°C	
8.00	66.0	± 2.0 <b>(2)</b>	± 3.0 <b>(1)</b>
10.00	56.0	± 2.0 <b>(2)</b>	± 3.0 <b>(1)</b>
12.00	49.5	± 2.0 <b>(2)</b>	± 3.0 <b>(1)</b>
14.00	44.0	± 2.0 <b>(2)</b>	± 3.0 <b>(1)</b>
16.00	39.5	± 2.0 <b>(2)</b>	± 3.0 <b>(1)</b>

**10 marks**

#### Graph, calculations and evaluation.

Only award maximum marks if graph is overall clearly and neatly drawn, and evaluation is clearly expressed.

- |   |     |  |                       |
|---|-----|--|-----------------------|
| 2 | (a) | Graph: axis sensible and labelled, points correctly plotted <b>(1)</b> and joined with smooth line. <b>(1)</b> | <b>2 marks</b>        |
| 3 | (b) | Solubility increases as temperature increases.   | <b>1 mark</b>         |
| 4 | (c) | Detecting exact point at which crystals first form.  | <b>1 mark</b>         |
|   |     |  | <b>Total 14 marks</b> |

#### Note

At the lower temperatures cooling will be slow. Teachers may consider suggesting to students that the test tube is held under cold running water to speed up crystallization.



## Technician's notes

### Apparatus and materials

---

Burette in stand and clamp.

Distilled water.

Funnel to fit burette.

Thermometer; range 0–100°C or similar (with 0.5°C divisions).

Matt-black card to hold behind test tube.

Bunsen burner and test tube holder to fit test tube.

Test tube containing 10.10g of potassium nitrate,  $\text{KNO}_3$ . OXIDIZING

### Note

---

This exercise should be able to be completed in about one hour of laboratory time. If it is not possible to complete the graph and questions in this time then all written materials should be collected in and re-issued at the start of a later session.

**SAMPLE**

**ASD Preparation of an organic compound (cyclohexene)**

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's use only</i>	Mark _____ /12

<b>Category</b>	Organic Chemistry
<b>Specification topics</b>	Unit 2 Topic 2.10 Organic chemistry
<b>Activity assessed</b>	Activity <b>d</b> – Preparation
<b>Materials allowed</b>	Student brief, writing materials, apparatus and chemicals supplied. No books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written work must be handed in at the end of each session.
<b>Time allowed</b>	One hour of laboratory time then a further session to complete the preparation.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise.  Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## ASD Preparation of an organic compound (cyclohexene)

### Student brief

In this exercise you will heat a mixture of cyclohexanol and concentrated phosphoric acid in a distillation apparatus collecting an impure sample of cyclohexene. You will then remove impurities from the cyclohexene using a separating funnel. Finally the cyclohexene is re-distilled to collect a pure sample.

You will be assessed on your laboratory skills in using laboratory apparatus and chemicals competently and safely. In particular you will need to heat the distillation flask carefully and effectively. During and following the preparation you will record your results and answer questions on the preparation.

### Information

You are supplied with

- The chemicals needed for the preparation.
- The apparatus required for the preparation.

The equation for the reaction in the preparation



The phosphoric acid acts as a dehydrating agent.

### Procedure

1. Using the glassware provided assemble a distillation apparatus with a thermometer in position so that its bulb will be at the level of the side-arm connected to the condenser. Arrange a gauze and Bunsen burner under the flask but do not light the Bunsen yet.
2. Remove the flask from the distillation set-up.
3. Using a measuring cylinder transfer 10.5 cm<sup>3</sup> of cyclohexanol into the flask.
4. Measure 4 cm<sup>3</sup> of concentrated phosphoric acid in a measuring cylinder. Using a dropping pipette add this to the flask while gently swirling the flask in order to mix the reagents. Place a few anti-bumping beads in the flask.
5. Re-assemble the distillation apparatus. **Ask your teacher to check the apparatus.**
6. Heat the flask very gently so that liquid distils over and slowly collects in the receiver. Collect the liquid that distils over between 70°C and 90°C.
7. Pour the distillate into a separating funnel and add an equal volume of saturated sodium chloride solution.

8. Place a stopper in the separating funnel before shaking it carefully. Allow the layers to settle.
9. Run off the lower aqueous layer into a small beaker then run off the cyclohexene layer into a small dry conical flask. Add a few pieces of anhydrous calcium chloride to the flask and stopper it. Gently shake the flask for a few minutes.
10. Re-assemble the apparatus for a second distillation. It will need to be clean and dry and be fitted with a thermometer.
11. Decant the cyclohexene into the distillation flask. Again ask your teacher to check your apparatus.
12. Heat the flask carefully and gently collecting the liquid that distils off at a steady temperature between 70°C and 90°C. Record the actual steady temperature, in **Table 1**, at which liquid distils off within this range.
13. Measure, and record in **Table 2**, the volume of cyclohexene that you have collected.
14. Transfer about 8 drops of the distillate to a test tube. Add 3 or 4 drops of bromine water. Stopper the tube and shake it gently. Record your observations in the space provided.

**Table 1**

<b>Distillation temperature</b>	<b>°C</b>	<b>(2)</b>
---------------------------------	-----------	------------

**Table 2**

<b>Volume of cyclohexene</b>	<b>cm<sup>3</sup></b>	<b>(2)</b>
------------------------------	-----------------------	------------

<b>Observations</b>	<b>(2)</b>

## Questions

---

- (a) Explain why the bulb of the thermometer must be arranged so that it is level with the side-arm connected to the condenser

---

---

**(1)**

- (b) (i) What is the purpose of shaking the cyclohexene layer with anhydrous calcium chloride in step 9 of the procedure?.

---

---

**(1)**

- (ii) Describe the change in appearance of the cyclohexene as you gently shake the flask containing cyclohexene and calcium chloride.

---

---

**(1)**

- (c) Explain why the cyclohexene forms the upper layer in the separating funnel.  
[Density of cyclohexene =  $0.81 \text{ g cm}^{-3}$ ]

---

---

**(1)**

- (d) Suggest a reason why the yield of cyclohexene in this preparation is likely to be quite low.

---

---

**(1)**

(e) Draw the displayed formula of the product of the reaction between bromine and cyclohexene.

**(1)**

**Total =**  $\frac{\quad}{12}$



**Mark scheme****Activity d Preparation**

1	<b>Table 1</b> Records a distillation temperature: between 80°C and 83°C (2); between 77°C and 85°C (1).	<b>2 mark</b>
2	Table 2 Records a volume of cyclohexene collected: $\geq 2.0 \text{ cm}^3$ (2) $\geq 1.0 \text{ cm}^3$ (1)	<b>2 mark</b>
3	<b>Observations:</b> Layers form (1) $\text{Br}_2$ (layer) is decolourised/goes colourless (1)	<b>2 mark</b>
4	(a) So that thermometer records the boiling temperature of the distillate.	<b>1 mark</b>
5	(b) (i) Drying agent/to remove water.	<b>1 mark</b>
	(b) (ii) Cyclohexene goes clear/cloudiness disappears	<b>1 mark</b>
6	(c) Cyclohexene is less dense than water	<b>1 mark</b>
7	(d) Reasons include; incomplete reaction/physical loss eg in separating funnel/loss due to evaporation.	<b>1 mark</b>
8	(e) Displayed formula of 1, 2-dibromocyclohexane showing all atoms and bonds separately.	<b>1 mark</b>
		<b>Total 12 marks</b>

### Note to teachers

---

Preferably this preparation should be carried out in a fume cupboard.

Students must work individually on this exercise.

The written questions must be answered individually.

This exercise will probably need two sessions of laboratory time.

All written materials must be collected in after each session and re-issued when the exercise is continued.

### Technician's notes

#### Apparatus

---

Test tube in rack.

Bunsen burner, tripod and gauze.

Distillation apparatus with 50 cm<sup>3</sup> flask.

0-100°C thermometer for distillation apparatus (measuring to 1°C).

50 cm<sup>3</sup> or 100 cm<sup>3</sup> conical flask with stopper for drying.

10 cm<sup>3</sup> and 25 cm<sup>3</sup> measuring cylinders.

100 cm<sup>3</sup> beaker.

2 dropping pipettes.

Spatula.

Separating funnel, 50 cm<sup>3</sup> with stopper.

Access to a fume cupboard.

Anti-bumping beads.

#### Materials

---

10.5 cm<sup>3</sup> cyclohexanol. HARMFUL

4 cm<sup>3</sup> concentrated (85% syrupy) phosphoric(V) acid. CORROSIVE

Anhydrous calcium chloride, granular. IRRITANT

20 cm<sup>3</sup> saturated aqueous sodium chloride.

Dilute aqueous bromine-labelled bromine water-as dilute as possible provided that the solution is observed to be decolourised when added to cyclohexene. IRRITANT, HARMFUL

**SAMPLE****A2B Observation exercise on three organic compounds**

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's use only</i>	Mark _____ /14

<b>Category</b>	Organic Chemistry
<b>Specification topics</b>	Unit 4 Topic 4.8 Further organic chemistry.
<b>Activity assessed</b>	Activity b – Qualitative observation
<b>Materials allowed</b>	Student brief, writing materials, apparatus and chemicals supplied. No other books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written results must be handed in at the end of the session.
<b>Time allowed</b>	One hour of laboratory time.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise. Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## A2B Observation exercise on three organic compounds

### Student brief

In this exercise you are given samples of three organic compounds. Each compound contains one functional group. A molecule of each compound contains **three carbon atoms**.

You are to carry out tests on each compound recording your observations in the spaces provided. Using information gained from your observations and spectroscopic data you are to answer the questions on the identity of the three compounds

### Information

You are supplied with

- Samples of three compounds labelled **S**, **T** and **U**.
- The apparatus and chemicals needed to carry out the tests.

- (a) (i) Add a small piece of sodium to 2 cm<sup>3</sup> of **S** in a small, dry evaporating basin placed on the bench top. Do not hold the basin. When you have finished this test take the basin to a fume cupboard.

Observations

**(2)**

- (ii) To 1 cm<sup>3</sup> of **S** in a test tube add an equal volume of dilute sulfuric acid followed by 6 drops of aqueous potassium dichromate(VI). Stand the test tube in a beaker of warm water.

Observation

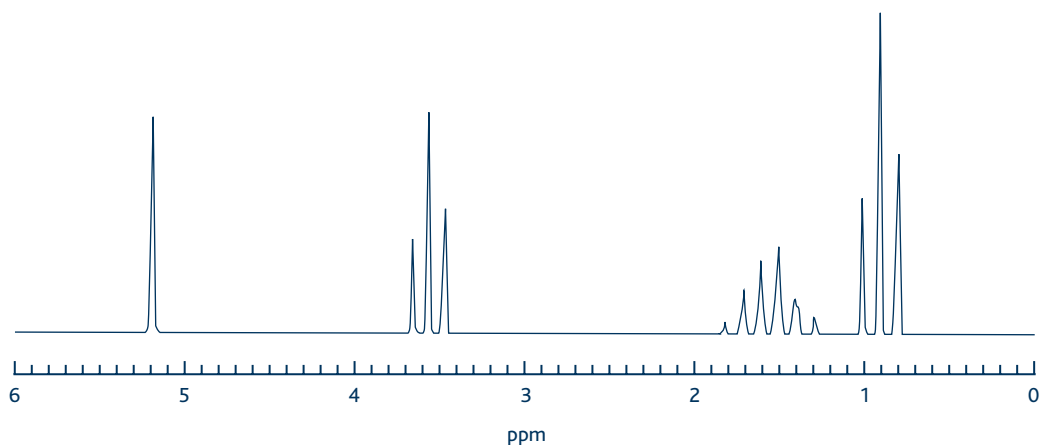
**(1)**

- (iii) Based on your observations in tests (a)(i) and (ii) and information given in the **Student brief** give the names of two isomers which could be **S**.

Isomer 1	Isomer 2

**(1)**

- (iv) The NMR spectrum of **S** is shown below.



- (v) Use information from the spectrum to identify **S** as one of the two isomers you have named in (a)(iii). Explain your choice.

**S** is \_\_\_\_\_

Explanation \_\_\_\_\_

\_\_\_\_\_ **(2)**

- (b) (i) To 2 cm<sup>3</sup> of aqueous 2,4-dinitrophenylhydrazine in a test tube, add 6 drops of **T** and shake the test tube gently.

Observation

**(1)**

- (ii) To 3 cm<sup>3</sup> of aqueous silver nitrate in a test tube add dilute sodium hydroxide solution drop by drop until a grey precipitate is formed. Allow the precipitate to settle, then pour off the supernatant liquid. To the precipitate add dilute aqueous ammonia until the precipitate just dissolves. Add 6 drops of **T**, shake the test tube gently and warm it in a beaker of hot water.

Observation

**(1)**

- (iii) Based on your results of tests (b)(i) and (ii) and the information given in the **Student brief** give the identity of **T** by writing its structural formula in the box below.

--

**(1)**

- (c) (i) To 2 cm<sup>3</sup> of **U** in a test tube, add 6 drops of aqueous sodium carbonate and shake the test tube gently.

Observation

(1)

- (ii) To 2 cm<sup>3</sup> of **U** in a test tube, add 2 cm<sup>3</sup> of **S** followed by 6 drops of concentrated sulfuric acid. Warm the test tube for about 1 minute in a water bath. Pour the mixture from the test tube into about 50 cm<sup>3</sup> of aqueous sodium carbonate in a small beaker. Cautiously smell the contents of the beaker.

Observations

(2)

- (iii) Based on your results of tests (c)(i) and (ii) and the information given in the **Student Brief** give the identity of **U** by writing its structural formula in the box below.

--

(1)

- (d) In the box below draw the structural formula of the organic compound that is formed when **S** reacts with **U**.

--

(1)

Total =

### Mark scheme

#### Activity b Qualitative observation

- (a) (i) Add a small piece of sodium to 2 cm<sup>3</sup> of **S** in a small, dry evaporating basin placed on the bench top. Do not hold the basin.

Observations
<b><i>Effervescence/bubbles/gas evolved. (1)</i></b> <b><i>Na dissolves (1)</i></b>

**(2)**

- (ii) To 1 cm<sup>3</sup> of **S** in a test tube, add an equal volume of dilute sulfuric acid followed by 6 drops of aqueous potassium dichromate(VI). Stand the test tube in a beaker of warm water.

Observation
<b><i>Green/blue/brown (1)</i></b>

**(1)**

- (iii) Based on your observations in tests (a)(i) and (ii) and information given in the **Student brief** give the names of two isomers which could be **S**.

<b>Isomer 1</b>	<b>Isomer 2</b>
<b><i>Propan-1-ol</i></b>	<b><i>Propan-2-ol</i></b> Both names for mark <b>(1)</b>

**(1)**

- (iv) The NMR spectrum of S is shown below.



- (v) Use information from the spectrum to identify **S** as one of the two isomers you have named in (a)(iii). Explain your choice.

**S** is propan-1-ol (1)

Explanation 4 peaks so four different types of proton (1)

Or explanation in terms of spin-spin coupling; Or reference to chemical shift values

(2)

- (b) (i) To 2 cm<sup>3</sup> of aqueous 2,4-dinitrophenylhydrazine in a test tube, add 6 drops of **T** and shake the test tube gently.

Observation
<p style="text-align: center;"><b>Yellow/orange precipitate (1)</b></p>

(1)

- (ii) To 3 cm<sup>3</sup> of aqueous silver nitrate in a test tube, add dilute sodium hydroxide solution drop by drop until a grey precipitate is formed. Allow the precipitate to settle, then pour off the supernatant liquid. To the precipitate add dilute aqueous ammonia until the precipitate just dissolves. Add 6 drops of **T**, shake the test tube gently and warm it in a beaker of hot water.

Observation
<p style="text-align: center;"><b>Silver (mirror)/grey/black precipitate (1)</b></p>

(1)

- (iii) Based on your results of tests (b)(i) and (ii) and the information given in the Student brief give the identity of **T** by writing its structural formula in the box below.

**Structural formula of propanal eg  $\text{CH}_3\text{CH}_2\text{CHO}$  (1)**

Must clearly show aldehyde group.

**(1)**

- (c) (i) To  $2\text{cm}^3$  of **U** in a test tube, add 6 drops of aqueous sodium carbonate and shake the test tube gently.

Observation

**Effervescence/bubbles/gas evolved (1)**

**(1)**

- (ii) To  $2\text{cm}^3$  of **U** in a test tube, add  $2\text{cm}^3$  of **S** followed by 6 drops of concentrated sulfuric acid. Warm the test tube for about 1 minute in a water bath. Pour the mixture from the test tube into about  $50\text{cm}^3$  of aqueous sodium carbonate in a small beaker. Cautiously smell the contents of the beaker.

Observations

**Effervescence (1)**  
**Sweet/fruity/ester/glue smell (1)**

**(2)**

- (iii) Based on your results of tests (c)(i) and (ii) and the information given in the Student Brief give the identity of **U** by writing its structural formula in the box below.

**Structural formula of propanoic acid**

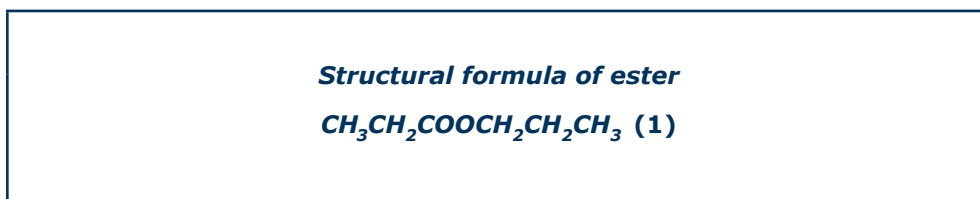
**eg  $\text{CH}_3\text{CH}_2\text{COOH}$  (1)**

Must clearly show COOH group.

**(1)**



- (d) In the box below draw the structural formula of the organic compound that is formed when **S** reacts with **U**.



(1)

**Total =**

## Technician's notes

### Apparatus

---

3 test tubes in a test tube rack.

Test tube holder.

Dropping pipettes.

10cm<sup>3</sup> measuring cylinder.

100cm<sup>3</sup> beaker.

Tweezers.

Small, dry evaporating basin.

Supply of hot water at about 70°C in a beaker for water bath (kettle of hot water)

### Materials

---

Individual samples of the following in stoppered and labelled containers:

5cm<sup>3</sup> of propan-1-ol labelled **S**. HIGHLY FLAMMABLE, IRRITANT

3cm<sup>3</sup> of propanal labelled **T**. HIGHLY FLAMMABLE, IRRITANT

Two stoppered test tubes each containing 2cm<sup>3</sup> of propanoic acid labelled **U**. CORROSIVE

Access to the reagents listed below:

Dilute sulfuric acid; concentration approximately 1.0mol dm<sup>-3</sup>. IRRITANT

Concentrated sulfuric acid. CORROSIVE

Aqueous potassium dichromate(VI); concentration approximately 0.2mol dm<sup>-3</sup>. SOLID TOXIC, CARCINOGENIC 2 (INHALATION), SENSITIZER

Small piece of sodium (supplied on demand to the candidate). FLAMMABLE, CORROSIVE

2,4-dinitrophenylhydrazine solution. Solid EXPLOSIVE, TOXIC.

About 5cm<sup>3</sup> aqueous silver nitrate; concentration approximately 0.2mol dm<sup>-3</sup>.

Dilute sodium hydroxide solution; concentration approximately 1.0mol dm<sup>-3</sup>. CORROSIVE

Dilute aqueous ammonia; concentration approximately 2.0mol dm<sup>-3</sup>.

Aqueous sodium carbonate; concentration approximately 1.0mol dm<sup>-3</sup>. Solid IRRITANT

Reagents should be in stoppered containers labelled with the name but not necessarily the concentration of the reagent. The appropriate hazard warning should be attached to the reagent container.

### Notes

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This exercise should be able to be completed in about one hour of laboratory time.

This exercise is set as an alternative to A2B4 for those centres that are unable to obtain phosphorus pentachloride.



## SAMPLE

## A2C Potassium manganate(VII) titration; finding the % iron in an iron(II) salt

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's/Edexcel use only</i>	Mark _____ /14

<b>Category</b>	Inorganic Chemistry
<b>Specification topics</b>	Unit 5 Topic 5.3 Redox and the chemistry of the transition metals.
<b>Activity assessed</b>	Activity c – Quantitative measurement
<b>Materials allowed</b>	Student brief, data booklet, calculator, writing materials, apparatus and chemicals supplied. No other books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written results must be handed in at the end of the session.
<b>Time allowed</b>	One hour of laboratory time.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise. Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.
<b>Teacher's values</b>	Remember to submit your teacher values for this practical on the <i>Teacher's Values Form</i> available from the Edexcel website.

## A2C Potassium manganate(VII) titration; finding the % iron in an iron(II) salt

### Student brief

In this exercise you will make up a solution of an iron(II) salt in dilute sulfuric acid.

You will titrate portions of the iron(II) solution against aqueous potassium manganate(VII).

You will be assessed on your laboratory skills in weighing, making up a solution, and carrying out a titration accurately. Marks will be awarded for your ability to use your results to calculate the percentage of iron in the iron(II) salt.

### Information

You are supplied with

- A sample of crystals of an iron(II) salt labelled **Y**.
- An aqueous solution of potassium manganate(VII). Your teacher will give you the exact concentration of the solution.
- Dilute sulfuric acid.
- The apparatus needed to carry out the exercise.

The equation for the reaction in the titration is



### Procedure

1. Weigh the weighing bottle containing the crystals of **Y**. Record the mass, to at least 0.01g, in **Table 1**.
2. Using the method with which you are familiar dissolve the crystals of **Y** in about 150cm<sup>3</sup> of dilute sulfuric acid. Make up the solution with distilled water to exactly 250cm<sup>3</sup> in a volumetric flask which has first been rinsed out with distilled water. **Shake the flask to thoroughly mix its contents**. Weigh the emptied weighing bottle recording its mass in **Table 1**.
3. Rinse out, then fill, a burette with the aqueous potassium manganate(VII).
4. Rinse out a pipette with the solution of **Y**, then use the pipette to transfer 25.0cm<sup>3</sup> of the solution to a 250cm<sup>3</sup> conical flask.
5. Using a measuring cylinder add 15cm<sup>3</sup> of dilute sulfuric acid to the flask and swirl the flask to mix the solution.
6. Titrate the solution in the flask with the aqueous potassium manganate(VII) until the end-point is reached. Record your burette readings and titre, to the nearest 0.05cm<sup>3</sup>, in **Table 2**.
7. Repeat the procedure until you obtain two titres that differ by no more than 0.20cm<sup>3</sup>. Record all your burette readings and titres in **Table 2**.

**Table 1**

Mass of weighing bottle + <b>Y</b>	g
Mass of emptied weighing bottle	g
Mass of <b>Y</b>	g

**(1)****Table 2**

Titration numbers	1	2	3	4	5
Burette reading (final)/cm <sup>3</sup>					
Burette reading (initial)/cm <sup>3</sup>					
Titre/cm <sup>3</sup>					

**(1)**

List the numbers of the titrations that you will use to calculate the mean titre.

Calculate the mean titre. Express your answer to the nearest 0.05cm<sup>3</sup>

Write the value of the mean titre in the space below:

\_\_\_\_\_ cm<sup>3</sup> of potassium manganate(VII) reacts with 25.0cm<sup>3</sup> of the solution of **Y**. **(1)**

The concentration of the aqueous potassium manganate(VII) is \_\_\_\_\_ mol dm<sup>-3</sup>

### Calculations

For each of (a) and (b) give your answer to an appropriate number of significant figures. Show your working as fully as possible.

(a) Calculate the mass of iron(II) ions in 250cm<sup>3</sup> of solution **Y**.

[molar mass of iron: 55.8g mol<sup>-1</sup>]

(2)

(b) Using your answer to (a) and the mass of **Y** that you recorded in **Table 1** calculate the percentage of iron(II) ions in **Y**.

(1)

(c) Explain why the accuracy of your titres would be affected if drops of water were allowed to remain in the burette when it is filled with the solution of potassium manganate(VII).

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(1)

**Total =**  $\frac{\quad}{14}$



**Mark scheme****Activity c Quantitative measurement**

1	All masses in <b>Table 1</b> recorded to at least 0.01g		<b>1 mark</b>
2	All volumes in <b>Table 2</b> recorded to 0.05cm <sup>3</sup> (allow one slip) and subtractions correct.		<b>1 mark</b>
3	Correct averaging of chosen titres or choosing identical titres to nearest 0.05cm <sup>3</sup>		<b>1 mark</b>
4	<b>Titration accuracy</b> Difference(d) between student's mean titre and expected titre.	$\pm 0.30\text{cm}^3$	<b>4 marks</b>
		$\pm 0.50\text{cm}^3$	<b>3 marks</b>
		$\pm 0.70\text{cm}^3$	<b>2 marks</b>
		$\pm 0.90\text{cm}^3$	<b>1 mark</b>
5	<b>Range</b> Range(r) is difference between outermost titres used by student to calculate mean.	$\pm 0.20\text{cm}^3$	<b>3 marks</b>
		$\pm 0.40\text{cm}^3$	<b>2 marks</b>
		$\pm 0.80\text{cm}^3$	<b>1 mark</b>

**Calculations**

Only award mark if method is clearly set out and answer is to an appropriate number of significant figures. Allow 3 or 4 sfs but only penalise sf once.

$$6 \text{ (a) } \text{moles MnO}_4^- \text{ in mean titre} = \frac{\text{mean titre} \times \text{concentration KMnO}_4}{1000} \quad \text{(1)}$$

$$\text{mass Fe}^{2+} \text{ in } 250\text{cm}^3 \text{ of solution Y} = \text{above answer} \times 5 \times 10 \times 55.8 \quad \text{(1) 2 marks}$$

$$7 \text{ (b) } \% \text{ mass Fe}^{2+} = \frac{\text{mass Fe}^{2+} \text{ calculated in (a)}}{\text{Mass Y from Table 1}} \times 100 \quad \text{1 mark}$$

8 (c) Solution in burette would be diluted / titres would increase **1 mark**

**Total 14 marks****Notes on marking****Weighings/volumes/titres tables marks**

Check subtractions, correcting if necessary.

All masses should be recorded to at least 0.01 g but for mass used allow loss of second decimal point if 0 and both dps if both 0.

All volumes are expected to be recorded to 0.05 cm<sup>3</sup>

*ALLOW one slip but withhold the mark if any readings are in the wrong boxes.*

*ALLOW 0 cm<sup>3</sup> as initial volume NOT 50cm<sup>3</sup> as initial volume*

**Mean (average) titre mark**

The mark is for correct averaging of chosen values or for choosing identical values and for recording the average correct to the nearest 0.05 cm<sup>3</sup>. Allow loss of second decimal point if 0 and both dps if both 0. If the loss of second dp has been penalised in Table 2 do not penalise again here.

If there has been a subtraction error in the volumes table allow this error to carry through in the calculation of the mean titre. Award the mean titre mark on this value.

However, if the student has made a subtraction error in the volumes or titres used or an arithmetical error in calculating the mean the teacher must calculate a new mean.

- For an averaging error simply calculate a new value using the student's chosen titres.
- If a wrongly subtracted titre has been used in the mean then choose any two identical titres or take an average of the closest two titres.

*Accuracy marks*

These must be awarded by a comparison between the student's expected titre and his or her mean titre (corrected if necessary). The student's expected titre is calculated as follows.

$$\frac{\text{Student's mass } Y \times \text{Teacher's titre}}{\text{Teacher's mass } Y} = \text{Student's expected titre}$$

then finding the difference between the student's mean titre and the student's expected titre.

Graphical and spreadsheet methods may also be used to find the expected titre.

If the exercise is marked in the centre the expected titre must be written alongside the student's mean titre.

**If the exercise is marked by Edexcel the Teacher's titre and Teacher's mass Y must be included with the work sent to Edexcel.**

The difference between the student's mean titre and the expected titre is then calculated and recorded as  $d = \text{_____ cm}^3$

Accuracy marks are then awarded according to the mark scheme.

**Range marks**

The range is the difference between the outermost titres used by the student to calculate the mean. If the teacher has corrected titres because of incorrect subtraction then the range mark is awarded on the corrected titres used by the teacher to re-calculate the mean.

Show the range between the outermost titres used to calculate the mean as

$$r = \text{_____ cm}^3$$

Range marks are then awarded according to the mark scheme.



## Technician's notes

### Volumetric apparatus

---

Burette in stand and clamp.

White tile.

2 conical flasks.

25.0cm<sup>3</sup> pipette with pipette filler.

Small funnel.

100cm<sup>3</sup> and 250cm<sup>3</sup> beakers.

25cm<sup>3</sup> measuring cylinder.

250cm<sup>3</sup> volumetric flask.

### Other apparatus

---

Weighing bottle or similar.

Access to a balance weighing to at least 0.01g.

Glass rod.

### Materials

---

Between 9.4g and 9.6g of ammonium iron(II) sulfate,  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ , in a weighing bottle or similar labelled **Y**. HARMFUL

200cm<sup>3</sup> of 0.020mol dm<sup>-3</sup> aqueous potassium manganate(VII).

Dilute sulfuric acid; concentration approximately 1.0mol dm<sup>-3</sup>. IRRITANT

Distilled water.

### Note

---

Students need not have exactly the same mass of ammonium iron(II) sulfate.

The potassium manganate(VII) solution need not be exactly 0.020mol dm<sup>-3</sup>. Candidates must be given its concentration.

This exercise should be able to be completed in about one hour of laboratory time. If it is not possible to complete the calculations in this time then all written materials should be collected in and re-issued at the start of a later session.

**SAMPLE**

**A2D The hydrolysis of an ester (methyl benzoate)**

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's/Edexcel use only</i>	Mark _____ /12

<b>Category</b>	Organic Chemistry
<b>Specification topics</b>	Unit 4 Topic 4.8 Further organic chemistry. Unit 5 Topic 5.4 Organic chemistry.
<b>Activity assessed</b>	Activity <b>d</b> – Preparation.
<b>Materials allowed</b>	Student brief, calculator, writing materials, apparatus and chemicals supplied. No books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written results must be handed in at the end of the session.
<b>Time allowed</b>	At least one hour of laboratory time plus time to allow the crystals to dry then to determine their melting point.
<b>Health and safety</b>	Eye protection and laboratory coats should be worn throughout the exercise. Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## A2D The hydrolysis of an ester (methyl benzoate)

### Student brief

In this exercise you will heat under reflux a mixture of an ester, methyl benzoate, and sodium hydroxide solution. Once the hydrolysis of the ester is complete you will acidify the cooled reaction mixture at which point benzoic acid will form as a solid. The benzoic acid will be recrystallised from hot water. When its crystals are dry the melting temperature of the benzoic acid will be determined.

You will be assessed on your laboratory skills in using laboratory apparatus and chemicals competently and safely. In particular you will need to heat carefully and effectively. During and following the preparation you will record your results, carry out calculations and answer questions on the preparation.

### Information

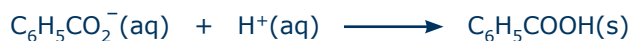
You are supplied with

- The chemicals needed for the preparation.
- The apparatus required for the preparation.

The equation for the hydrolysis of methyl benzoate by sodium hydroxide is



When the solution formed is acidified the reaction is



### Procedure

1. Assemble the apparatus provided for heating under reflux as instructed by your teacher.
2. Weigh the stopped container containing methyl benzoate, recording the mass in **Table 1**.
3. Carefully remove the flask from the apparatus and pour into it the methyl benzoate. Add a few anti-bumping beads to the flask. Re-weigh the stoppered container recording its mass in **Table 1**.
4. Using a measuring cylinder, add 15 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> sodium hydroxide solution to the flask. Switch on the water supply through the condenser. Reassemble the apparatus and ask your teacher to check it before you proceed.
5. Heat the flask very gently at first, then a little more strongly, so that the mixture in the flask boils for about 15 minutes.
6. Switch off the Bunsen and allow the flask to cool.
7. Remove the flask from the apparatus then pour off the solution into a 100 cm<sup>3</sup> beaker, leaving the anti-bumping beads in the flask.

8. Add  $2.0 \text{ mol dm}^{-3}$  dilute hydrochloric acid to the beaker a few  $\text{cm}^3$  at a time while gently stirring the solution with a glass rod. Continue to add acid until a drop of solution, removed on the glass rod, turns blue litmus paper red. At this point a white solid should have formed in the beaker. This is benzoic acid.
9. Filter off the benzoic acid by suction filtration using a Buchner funnel and flask. Rinse the beaker with distilled water and pour the rinsings into the funnel. Dry the benzoic acid as much as possible in the Buchner funnel.
10. Transfer the solid to a small conical flask.
11. Add small portions of hot water to the flask until the solid dissolves. Swirl the flask as you add the hot water.
12. Cool the flask in an ice-bath when crystals will form. Filter off the crystals by suction filtration attempting to dry them as much as possible. Transfer the crystals to a piece of filter paper and allow them to dry overnight.
13. Transfer the crystals to a small weighed bottle. Weigh the bottle and the crystals, recording the mass in **Table 1**.
14. Using the method with which you are familiar, determine the melting temperature of the crystals recording it as a range in **Table 2**.

## Results

**Table 1**

Mass of stoppered container + methyl benzoate	g	
Mass of emptied stoppered container	g	
Mass of methyl benzoate	g	
Mass of container and benzoic acid	g	
Mass of emptied container	g	
Mass benzoic acid	g	<b>(2)</b>

**Table 2**

Melting point of benzoic acid	°C to °C	<b>(2)</b>
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Description of benzoic acid formation	<b>(1)</b>

**Calculations and questions**

- (a) Using the relationship  $1 \text{ mol C}_6\text{H}_5\text{COOCH}_3 \longrightarrow 1 \text{ mol C}_6\text{H}_5\text{COOH}$   
calculate the maximum mass of benzoic acid that could be obtained from the mass of methyl benzoate you used.

[Molar masses /  $\text{g mol}^{-1}$ :  $\text{C}_6\text{H}_5\text{COOCH}_3 = 136.0$        $\text{C}_6\text{H}_5\text{COOH} = 122.0$ ]

(1)

- (b) Calculate the percentage yield of benzoic acid in your preparation.

(1 + 2)

- (c) Based on your observations during the preparation suggest reasons for the following.

(i) Heating the methyl benzoate and sodium hydroxide **under reflux**.

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(1)

(ii) Using **suction** filtration in stage 12 of the procedure.

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(1)

- (d) Suggest **one** reason why the yield of benzoic acid in your preparation may be quite different to the maximum mass.

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(1)

**Total =** 

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 12

## Mark scheme

### Activity d Preparation

1	<b>Table 1:</b> records all masses <b>(1)</b> ; all masses recorded to at least 1 decimal point and subtractions correct <b>(1)</b> .	<b>2 mark</b>
2	<b>Table 2:</b> Melting temperature $122 \pm 2 \text{ }^\circ\text{C}$ <b>(2)</b> $122 \pm 5 \text{ }^\circ\text{C}$ <b>(1)</b> Compare candidate's mid range temperature with ranges above.	<b>2 mark</b>
3	Description of benzoic acid formation: white/red/pink solid/crystals -	<b>1 mark</b>
4	(a)      Maximum mass = $\frac{\text{mass methyl benzoate from Table 1}}{136.0} \times 122.0$	<b>1 mark</b>
5	(b)      % yield = $\frac{\text{mass benzoic acid}}{\text{maximum mass}} \times 100\%$ <b>(1)</b> % yield = >50%-100% <b>(2)</b> % yield $\geq$ 10%-50% <b>(1)</b>	<b>3 mark</b>
6	(c)(i) Prevents escape of reagents/returns escaping vapours to reaction mixture/description of vapours condensing and returning to flask.	<b>1 mark</b>
7	(c)(ii) Faster filtration/ allows all liquid to be removed/allows a nearly dry solid/description of filtrate passing quickly through funnel.	<b>1 mark</b>
8	(d)      If yield > 100%; possible reasons include that crystals are damp. If yield < 100%; possible reasons include reaction incomplete/some product lost in recrystallisation/other sensible reasons.	<b>1 mark</b>
		<b>Total 12 marks</b>

### Note to teachers

Students must work individually for this exercise. The written calculations and questions must be answered individually.

It is expected that students will have some previous experience of using the apparatus and of the techniques in this exercise but close supervision will still be needed. In particular it is essential that the reflux apparatus is held securely and heated very carefully.

It is expected that eye protection will be worn throughout the exercise.

Students may be advised that no more than 30 cm<sup>3</sup> of dilute hydrochloric acid should be required to acidify the reaction mixture.

This exercise may need two sessions of laboratory time and, possibly, a short further session to weigh the crystals and carry out a melting point determination. All written materials must be collected in after each session and re-issued when the exercise is continued.

Teachers should check that the benzoic acid crystals are dry before they are weighed.



## Technician's notes

### Apparatus

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Bunsen burner (micro size if possible), gauze and heatproof mat.

Tripod or retort ring.

Stand and clamp.

Water cooled Liebig condenser.

Flask of suitable size (eg 50 cm<sup>3</sup>) for heating reaction mixture.

Anti-bumping beads.

25 cm<sup>3</sup> measuring cylinder.

100 cm<sup>3</sup> beaker.

100 cm<sup>3</sup> conical flask, preferably wide neck.

Buchner funnel and flask.

Suction pump or access to a vacuum line.

Filter paper for funnel and for drying crystals.

Dropping pipette.

Glass rod.

Blue litmus paper.

Access to a balance weighing to at least  $\pm 0.1$  g.

Melting point apparatus.

Small stoppered bottle or similar for final crystals.

Labels.

### Materials

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2 cm<sup>3</sup> of methyl benzoate in a labelled stoppered container. HARMFUL

Access to bottles of:

- Dilute sodium hydroxide; concentration 2.0 mol dm<sup>-3</sup>. CORROSIVE
- Dilute hydrochloric acid; concentration 2.0 mol dm<sup>-3</sup>. IRRITANT

A supply of hot water for recrystallisation.

Crushed ice in suitable container for ice bath.

Distilled water.

**SAMPLE**

**A2M The synthesis of an ester (methyl-3-nitrobenzoate) in two stages**

Name _____	Candidate number _____
Centre number _____	Date _____
Centre name _____	
<i>For teacher's/Edexcel use only</i>	Mark _____ /26

<b>Category</b>	Organic Chemistry
<b>Specification topics</b>	Unit 5 Topic 5.4 Further organic chemistry
<b>Activity assessed</b>	Activity <b>c+d</b> — Multi-stage experiment
<b>Materials allowed</b>	Student brief, calculator, writing materials, apparatus and chemicals supplied. No other books or notes are allowed.
<b>Conditions</b>	Students work individually under supervision. Written work must be handed in at the end of each session.
<b>Time allowed</b>	Up to four hours of laboratory time.
<b>Health and safety</b>	This exercise involves the use of a number of hazardous chemicals. Eye protection, laboratory coats and plastic gloves should be worn throughout the exercise. The advice given in the procedure on dealing with the chemicals must be followed.  Follow any other safety precautions given by the teacher. The normal Health and Safety rules of the Chemistry Department must be followed.

## A2M The synthesis of an ester (methyl-3-nitrobenzoate) in two stages

### Student brief

In this extended exercise you measure out, then heat under reflux, the chemicals needed to make an ester of benzoic acid. The ester is methyl benzoate which is a liquid. It must first be extracted from the reaction mixture then removed from its solvent by distillation. The methyl benzoate is then nitrated using a mixture of concentrated nitric and sulfuric acids. The methyl-3-nitrobenzoate formed is a solid. It is purified by re-crystallisation and its melting temperature determined. Chromatography is carried out on the ethanol used to wash the product.

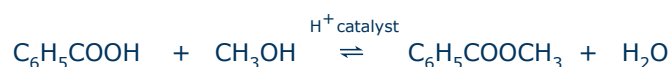
You will be assessed on your laboratory skills in using laboratory apparatus and chemicals competently and safely. During and following the exercise you will record your results, carry out calculations and answer questions on the procedure.

### Information

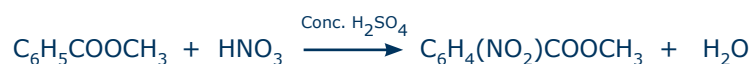
You are supplied with

- The chemicals needed for the preparation.
- The apparatus required for the preparation.

The equation for the esterification of benzoic acid is



The equation for the nitration of methyl benzoate is



### Procedure

#### *Formation of the ester, methyl benzoate.*

1. Weigh the sample bottle containing the benzoic acid, recording the mass in **Table 1**.
2. To a 50cm<sup>3</sup> pear shaped flask, add the sample of benzoic acid, 15cm<sup>3</sup> of methanol and 2cm<sup>3</sup> of concentrated sulfuric acid. Reweigh the sample bottle recording its mass in **Table 1**.
3. Fit the flask with a reflux condenser. Ask your teacher to check your apparatus before you proceed any further.  
Boil the mixture gently for about 45 minutes.

4. Allow the mixture to cool to room temperature then pour it into a separating funnel that contains 30cm<sup>3</sup> of cold water. Rinse the flask with 15cm<sup>3</sup> of hydrocarbon solvent and pour this into the separating funnel.
5. Place a stopper in the separating funnel then shake it carefully to mix the contents, removing the stopper from time to time to release the pressure. Allow the contents of the separating funnel to settle then run the lower aqueous layer into a conical flask.
6. Wash the hydrocarbon solvent layer in the separating funnel first, with 15cm<sup>3</sup> of water then with 15cm<sup>3</sup> of 0.5mol dm<sup>-3</sup> aqueous sodium carbonate.
7. Run the hydrocarbon solvent extract into a conical flask and add some anhydrous sodium sulfate which is a drying agent. Gently shake the flask for a few minutes.
8. Following the method explained by your teacher remove the hydrocarbon solvent by careful distillation. The hydrocarbon solvent is flammable so it is essential that you carry out the distillation in such a way that there is no risk of it being ignited. Complete the distillation, collecting the distillate boiling above 190 °C as methyl benzoate in a weighed container having recorded its mass in **Table 2**.
9. Weigh the container containing methyl benzoate recording the mass in **Table 2**.

#### *The nitration of methyl benzoate*

1. Add 4cm<sup>3</sup> of methyl benzoate to a small measuring cylinder. Weigh the measuring cylinder and record the mass in **Table 3**.
2. Taking great care, measure 9cm<sup>3</sup> of concentrated sulfuric acid into a dry 100cm<sup>3</sup> conical flask labelled **A**. Stopper the flask and stand it in an ice-bath, making sure that it cannot topple over.
3. In a test tube labelled **B** prepare a mixture of 3cm<sup>3</sup> of concentrated nitric acid with 3cm<sup>3</sup> of concentrated sulfuric acid. Stopper the tube and stand it in an ice-bath, making sure that it will stay upright.
4. Add the methyl benzoate to flask **A** while gently swirling the flask. Replace flask **A** in the ice-bath. Re-weigh the measuring cylinder recording its mass in **Table 3**.
5. Place a thermometer in flask **A** making sure that the flask cannot fall over. Still taking great care, add the nitric acid-sulfuric acid mixture from test tube **B**, using a dropping pipette, a drop at a time to flask **A**. Gently swirl the flask controlling the rate of addition so that the temperature stays in the range 5°C to 15°C. The addition should take 10 to 15 minutes.
6. When the addition is complete remove flask **A** from the ice-bath and allow it to stand at room temperature for about 10 minutes. Then pour the reaction mixture over about 40g of crushed ice and stir until the product solidifies. The solid is methyl-3-nitrobenzoate.
7. After waiting until the ice melts filter off the solid by suction filtration using a Buchner funnel and flask. Wash the solid product in the funnel with three portions of water sucking the product as dry as possible. Disconnect the suction pump before each addition of water.
8. Change the Buchner flask for a smaller, clean, dry Buchner flask and wash the solid with two 5cm<sup>3</sup> portions of **ice-cold** ethanol. Keep the wash liquid in the Buchner flask for later examination by chromatography.



9. Transfer the solid to a clean, dry small conical flask. Add 10cm<sup>3</sup> of ethanol then heat the mixture in a water bath using hot water from a kettle. If the solid fails to dissolve add further 2cm<sup>3</sup> portions of ethanol until a solution is obtained.
10. Cool the flask in an ice-bath when crystals will form. Filter off the crystals by suction filtration making sure that you are using a clean, dry Buchner funnel. Attempt to obtain dry crystals.
11. In the space provided give a brief description of the appearance of the crystals.
12. Transfer the crystals to a filter paper on a watch glass. Allow the crystals to stand overnight to completely dry.
13. Transfer the crystals to a weighed container having recorded its mass in **Table 4**. Weigh the container and the crystals recording the mass in **Table 4**.
14. Using the method with which you are familiar determine the melting temperature of the crystals recording it as a range in **Table 5**.

#### *Investigating the products of reaction by chromatography*

Your teacher will give you further details of this procedure.

1. Transfer the wash liquid collected earlier to an evaporating basin. Reduce the volume of the wash liquid to 1cm<sup>3</sup> either by standing it overnight or by heating it on a water-bath taking suitable precautions to prevent the ethanol from igniting.
2. Using a fine capillary tube put a drop of the solution 2cm from the bottom of a thin layer of silica on an inert support. Some of the product should be dissolved to make a second separate spot on the plate.
3. Allow the solvent to evaporate and develop with an ethoxyethane-hexane mixture containing 1 volume of ethoxyethane to 9 volumes of hexane. **This mixture is highly flammable so no source of heat should be in use in the laboratory at this time.**
4. Your teacher will help you to observe the developed chromatogram. Describe what you see.

## Results

**Table 1**

Mass of container + benzoic acid	g
Mass of emptied container	g
Mass of benzoic acid	g

**(1)**

**Table 2**

Mass of container + methyl benzoate	g
Mass of empty, dry container	g
Mass of methyl benzoate	g

**(1)**

**Table 3**

Mass of measuring cylinder + methyl benzoate	g
Mass of measuring cylinder	g
Mass of methyl benzoate	g

**(1)**

**Table 4**

Mass of container + methyl-3-nitrobenzoate	g
Mass of empty, dry container	g
Mass of methyl-3-nitrobenzoate	g

**(2)**

**Table 5**

Melting temperature of methyl-3-nitrobenzoate	From      °C to      °C
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**(3)**

Description of methyl-3-nitrobenzoate

**(1)**



### Calculations and questions

- (a) Describe the change in appearance of the hydrocarbon solvent layer when it is shaken with anhydrous sodium sulfate in step 7 of the first part of the procedure

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(1)

- (b) Suggest **two** reasons why it is important that, when adding the nitrating mixture to the methyl benzoate-sulfuric acid mixture, the temperature must be kept in the range 5°C to 15°C.

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(2)

- (c) Using the relationship  $1 \text{ mol C}_6\text{H}_5\text{COOCH}_3 \longrightarrow 1 \text{ mol C}_6\text{H}_4(\text{NO}_2)\text{COOCH}_3$  calculate the maximum mass of methyl-3-nitrobenzoate that could be obtained from the mass of methyl benzoate you use.

[Molar masses /  $\text{g mol}^{-1}$ : H = 1.0, C = 12.0, N = 14.0, O = 16.0]

(1)

- (d) Calculate the percentage yield of methyl benzoate.

(3)

- (e) Using the relationship  $1 \text{ mol C}_6\text{H}_5\text{COOCH}_3 \longrightarrow 1 \text{ mol C}_6\text{H}_4(\text{NO}_2)\text{COOCH}_3$  calculate the maximum mass of methyl benzoate that could be obtained from the mass of benzoic acid you use.

[Molar masses /  $\text{g mol}^{-1}$ :  $\text{C}_6\text{H}_5\text{COOCH}_3 = 136.0$        $\text{C}_6\text{H}_4(\text{NO}_2)\text{COOCH}_3 = 181.0$ ]

(1)

- (f) Calculate the percentage yield of methyl-3-nitrobenzoate when it is prepared from methyl benzoate.

(3)

- (g) Describe what you see on the developed chromatography sheet using a sketch if necessary.

(2)

- (h) Based on your observations during the preparation suggest **two** reasons why the reaction mixture is heated **under reflux** in the first part of the procedure.

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(2)



- (i) Suggest **two** stages in the procedure that may account for a yield lower than 100%.

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(2)

Total = 

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26

## Mark scheme

### Activity c + d Multi-stage experiment

1	Table 1 completed. Withhold this mark if subtraction error.	<b>1 mark</b>
2	Table 2 completed. Withhold this mark if subtraction error.	<b>1 mark</b>
3	Table 3 completed. Withhold this mark if subtraction error.	<b>1 mark</b>
4	Table 4 completed <b>(1)</b> Withhold this mark if subtraction error. All masses in Tables 1–4 to at least 0.1 g. <b>(1)</b>	<b>2marks</b>
5	Records melting point as a range <b>(1)</b> Melting temperature of methyl-3-nitrobenzoate 76–78 °C <b>(2)</b> 73–75 °C <b>(1)</b>	<b>3 marks</b>
6	Crystals of methyl-3-nitrobenzoate are pale yellow in colour	<b>1 mark</b>
7	(a) Solvent goes clear	<b>1 mark</b>
8	(b) Exothermic reaction. <b>(1)</b> If temperature rises, further substitution in aromatic ring. <b>(1)</b>	<b>2 marks</b>
9	(c) Maximum mass = $\frac{\text{mass benzoic acid from Table 1}}{122.0} \times 136.0$	<b>1 mark</b>
10	(d) % yield = $\frac{\text{mass methyl benzoate}}{\text{maximum mass}} \times 100\%$ <b>(1)</b> % yield = >50%–100% <b>(2)</b> % yield ≥ 10%–50% <b>(1)</b>	<b>3 mark</b>
11	(e) Maximum mass = $\frac{\text{mass methyl benzoate from Table 3}}{136.0} \times 181.0$	<b>1 mark</b>
12	(f) % yield = $\frac{\text{mass methyl-3-nitrobenzoate}}{\text{maximum mass}} \times 100\%$ <b>(1)</b> % yield = >50%–100% <b>(2)</b> % yield ≥ 10%–50% <b>(1)</b>	<b>1 mark</b>
13	(g) Chromatography-spots seen on developing. Description of developed chromatography plate Yellow spot <b>(1)</b> methyl-3-nitrobenzoate described. <b>(1)</b>	<b>2 marks</b>
14	(h) Two reasons from: prevents escape of reagents/returns escaping vapours to reaction mixture/description of vapours condensing and returning to flask/prevents escape of flammable vapours	<b>2 marks</b>
15	(i) Evaluation-describes <b>two</b> points in preparation where product may have been lost, eg recrystallization, distillation, incomplete reaction	<b>2 marks</b>
<b>Total</b>		<b>26 marks</b>

### Note to teachers

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This extended exercise should only be undertaken following a careful consideration of the health and safety factors involved. A risk assessment must be carried out **taking into account the competence of the student**. There are a number of flammable liquids and concentrated acids used in the exercise so careful laboratory organisation is essential. Since the exercise will continue over a number of laboratory sessions there must be adequate and safe storage of the materials and apparatus in use.

Students must work individually for this exercise. The written calculations and questions must be answered individually.

It is expected that students will have some previous experience of using the apparatus and of the techniques in this exercise but close supervision will still be needed. If students need considerable help at any stage this must be given to allow them to make progress but should be taken into consideration in the award of marks. In particular it is essential that the reflux apparatus and distillation apparatus are held securely and heated very carefully.

If the methyl benzoate prepared in the first stage of the exercise is not suitable for conversion into methyl-3-nitrobenzoate then students may be supplied with a new sample.

It is expected that eye protection will be worn throughout the exercise and that laboratory gloves will be worn when handling concentrated acids. Steps must be taken to eliminate any possible fire risk when using flammable liquids in the preparation.

### Technician's notes

#### Apparatus

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Bunsen burner (micro size if possible), gauze and heatproof mat.

Tripod or retort ring.

Stand and clamp.

Water cooled Liebig condenser able to be connected to cold water tap.

Flask of suitable size (eg 50cm<sup>3</sup> pear shaped flask) for heating reaction mixture.

Distillation apparatus with thermometer of suitable range.

Thermometer for monitoring temperature during nitration.

10cm<sup>3</sup>, 25cm<sup>3</sup> and 50cm<sup>3</sup> measuring cylinders.

100cm<sup>3</sup> and 250cm<sup>3</sup> beakers.

100cm<sup>3</sup> conical flask with stopper.

Test tube with stopper.

100cm<sup>3</sup> separating funnel with stopper.

Buchner funnel and flasks of suitable size.

Suction pump or access to a vacuum line.

Filter paper for funnel and for drying crystals.

Watch glass.

Evaporating basin.  
 Dropping pipettes.  
 Glass rod.  
 Spatula.  
 Access to a balance weighing to at least  $\pm 0.1$  g.  
 Melting point apparatus.  
 Small stoppered bottle or similar for final crystals.  
 Labels.  
 Apparatus for thin layer chromatography on silica.  
 Ultraviolet lamp (arranged so that students cannot look directly at the light source) or a few crystals of iodine.  
 Marker pen for labelling glassware.

### Materials

8g of benzoic acid in a stoppered, labelled sample bottle or similar.  
 Access to a bottle of methanol. HIGHLY FLAMMABLE, TOXIC  
 Access to a bottle of concentrated sulfuric acid. CORROSIVE  
 Access to a bottle of concentrated nitric acid. CORROSIVE  
 Anhydrous sodium sulfate.  
 Hydrocarbon solvent, petroleum spirit (boiling range 120–160 °C). HIGHLY FLAMMABLE  
 Ethoxyethane (ether, diethylether); 1 cm<sup>3</sup>. EXTREMELY FLAMMABLE, HARMFUL  
 Hexane; 9 cm<sup>3</sup>. HIGHLY FLAMMABLE, HARMFUL, DANGEROUS FOR THE ENVIRONMENT  
 Ethanol. HIGHLY FLAMMABLE  
 Aqueous sodium carbonate; concentration approximately 0.5 mol dm<sup>-3</sup>.  
 Crushed ice in suitable container for ice-bath and crushed ice for step 6 in the nitration.  
 Distilled water.

### Notes

It is acceptable to supply candidates with a small, stoppered, conical flask, labelled **A**, containing 9 cm<sup>3</sup> of concentrated sulfuric acid and with a stoppered test tube, labelled **B**, containing 3 cm<sup>3</sup> of concentrated nitric acid and 3 cm<sup>3</sup> of concentrated sulfuric acid for the nitration stage.

\*The minor product, methyl-2-nitrobenzoate, should be visible on the silica sheet as a yellow spot. Methyl-3-nitrobenzoate can be seen under ultraviolet light or by exposing the sheet to iodine vapour. Teachers should help candidates with these procedures since both are potentially hazardous.

## Student Guide

### Why Study Edexcel GCE 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, a GCE in Chemistry allows you to develop a range of generic skills requested by both employers and universities. For instance, a successful GCE level 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 and Chemistry, 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 grade C in Chemistry or Additional Science, and a 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 GCE Chemistry gives you the opportunity to study a core of key concepts in greater detail. Many of the ideas first covered at GCSE will be revisited but with a greater emphasis on explaining rather than simply describing the behaviour of molecules. While studying GCE 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 75 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 be assessed on four aspects of your practical work. Activity a is an assessment of your practical skills over your whole year's practical work. Activity b is an assessed practical on a qualitative observation. Activity c is an assessed practical on a quantitative measurement. Activity d is an assessed practical on a preparation (making a chemical).

### 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 be assessed on four aspects of your practical work, as in Unit 3, with activities a, b, c and d. In Unit 6 you also have a choice: instead of carrying out activities c and d you could choose to carry out a multi-stage experiment which includes these activities in one longer practical.

## 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 GCE Chemistry as a clear indication of sound academic ability.

Many university courses have a significant proportion of chemistry content and a GCE 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 a GCE 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 GCE Chemistry:
  - Royal Society of Chemistry for careers, courses and industrial placements  
[www.rsc.org/Education/SchoolStudents/index.asp](http://www.rsc.org/Education/SchoolStudents/index.asp)
  - Association of the British Pharmaceutical Industry (ABPI) careers website  
[www.abpi-careers.org.uk](http://www.abpi-careers.org.uk)
- 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 GCE Chemistry.
- Visit websites to find out what courses are available at HE which include chemistry
  - UCAS website [www.ucas.com](http://www.ucas.com)
  - Specific university websites, such as  
*Bristol University School of Chemistry* [www.chm.bris.ac.uk](http://www.chm.bris.ac.uk) or  
*Surrey University School of Biomedical and Molecular Sciences*  
[www.surrey.ac.uk/SBMS](http://www.surrey.ac.uk/SBMS)
- Visit the Edexcel website, [www.edexcel.org.uk](http://www.edexcel.org.uk) to obtain a full copy of the Edexcel GCE 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

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- **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

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- **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.

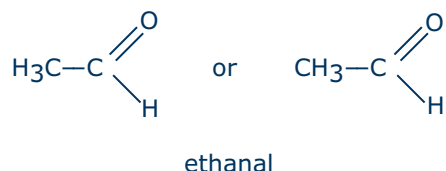
#### 1.6 Bonding

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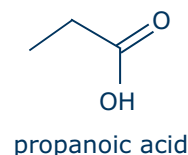
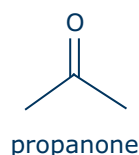
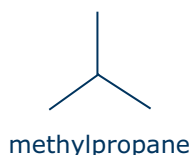
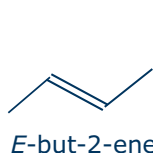
- **Dot or cross diagrams:** it is not possible to tell where electrons originated, so in the diagram for the electronic structure of an ionic compound, such as sodium chloride, the electrons can be shown as dots or crosses or any combination of dots and crosses. The same applies to a covalent compound. 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  $\pi$  bonds, thus  $\text{CH}_3\text{CHO}$  would score when identifying ethanal, but not if a structural formula were required. The structural formula of ethanal is shown below.



- **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), methylpropane, 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  $90^\circ$  or  $180^\circ$ .



- **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.

- **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:  

$$-\text{CH}_2-\text{CH}_2-$$
 and not  $-\text{CH}_2-$

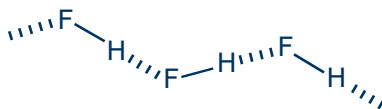
## Unit 2: Application of Core Principles of Chemistry

### 2.3 Shapes of molecules and ions

- **Drawing molecules and ions:** these should be drawn with reasonably correct bond angles, eg  $180^\circ$  for linear molecules and  $120^\circ$  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  $180^\circ$  and that around the F, O or N atom involved as an angle considerably less than  $180^\circ$  but more than  $90^\circ$ . 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.

### 2.11 Mechanisms

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- **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

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- **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.

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

### 4.3 How fast? – rates

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- **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

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- **Thermodynamic stability:** the reactants are said to be thermodynamically stable relative to the products if the value of  $\Delta S_{\text{total}}$  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

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- **Effect of change in temperature:** students should understand that an increase in temperature alters the value of  $\Delta S_{\text{surroundings}}$  and hence  $\Delta S_{\text{total}}$ . 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

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- **Buffer solution:** this is a solution that does not significantly change in pH (resists a change of pH) when small amounts of  $\text{H}^+$  or  $\text{OH}^-$  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  $\text{H}^+$  or  $\text{OH}^-$  ions added.

### 4.8 Further organic chemistry

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

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- **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

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- **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  $1\text{ mol dm}^{-3}$ , 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

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- **Condensation polymers:** the repeat unit of polyesters and polyamides must have the  $\pi$  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, 20<sup>2</sup> or 400 different dipeptides are produced, 20<sup>3</sup> 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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This document is Issue 2. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on the Edexcel website: [www.edexcel.org.uk](http://www.edexcel.org.uk).

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