# OCR ADVANCED SUBSIDIARY GCE
# IN CHEMISTRY (SALTERS) (3887)

# OCR ADVANCED GCE
# IN CHEMISTRY (SALTERS) (7887)

## Foreword to the Third Edition

This booklet contains OCR's Advanced Subsidiary GCE (AS) and Advanced GCE (A level) in **Chemistry (Salters)** specifications for teaching from September 2003. It has been revised to take account of concerns from Centres about the balance of content in the AS and A2 courses. Also, the mark descriptors for the AS and A2 Experimental and Investigative Skills have been clarified. There are now separate mark descriptors for the AS and A2 coursework.

**Significant changes are sidelined. The major changes are in Section 5 (Units 2851 and 2853) and in Appendices D and E.**

**The AS course** **Unit 2850** is unchanged

**Unit 2851** has been shortened: the last teaching module*, What's in a Medicine?* (WM), has been deleted from this unit, except for the properties of alcohols, which have been moved to *The Polymer Revolution* (PR). Unit 2851 has been given a new name and number, 2848 *Chemistry of Natural Resources.* **2851 will be last examined in January 2004. 2848 will be first examined in June 2004**.

**The A2 course** **Unit 2853** now contains *What's in a Medicine?* (WM) (minus the work on alcohols). The effect of complexing on redox reactions has been deleted from *The Steel Story* (SS). Unit 2853 has been given a new name and number, 2849 *Chemistry of Materials*. **2853 will be last examined in June 2004, 2849 will be first examined in January 2005**.

**Unit 2854** has been shortened by removing the work on soils and the structure of silicates and clays, and ion exchange equilibria, from *Aspects of Agriculture* (AA). The section on the factors governing the sizes of ions, previously taught in *Aspects of Agriculture* (AA) has been moved to *The Oceans* (O). **The revised version Unit 2854 will be first examined in January 2005.**

**Coursework Units 2852 and 2855**

The criteria for the assessment of coursework have also been revised. There are now separate mark descriptors for the AS *Experimental Skills*, 2852/02, and for the A2 *Individual Investigation*, 2855. The AS criteria will first apply for assessment in June 2004. The A2 criteria will first apply for assessment in January 2005.

The new criteria may be found in Appendix E of this specification.

A revised version of the Teacher Support: Coursework Guidance will be produced in the Autumn term.

The Advanced Subsidiary GCE is assessed at a standard appropriate for candidates who have completed the first year of study of a two year Advanced GCE course i.e. between GCSE and Advanced GCE. It forms the first half of the Advanced GCE course in terms of teaching time and content. When combined with the second half of the Advanced GCE course, known as 'A2', the Advanced Subsidiary forms 50% of the assessment of the total Advanced GCE. However, the Advanced Subsidiary can be taken as a 'stand-alone' qualification. A2 is weighted at 50% of the total assessment of the Advanced GCE.

In these specifications, the term **module** is used to describe teaching and learning requirements. The term **unit** describes a unit of assessment.

Each teaching and learning module is assessed by its associated unit of assessment.

These specifications meet the requirements of the *Common Criteria* (QCA, 1999), the *GCE Advanced Subsidiary and Advanced Level Qualification-Specific Criteria* (QCA, 1999) and the relevant Subject Criteria (QCA, 1999).

Qualification Accreditation Numbers:

Advanced Subsidiary GCE: 100/0596/1

Advanced GCE: 100/0424/5

## Contents

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## SPECIFICATION SUMMARY

### Outline

The OCR Advanced Subsidiary GCE and Advanced GCE **Chemistry (Salters)** specifications are post-16 chemistry specifications that build on GCSE Balanced Science. They relate to the Salters Advanced Chemistry Course and are supported by a comprehensive set of candidate and teacher materials. The course provides an innovative approach to teaching and learning chemistry in which chemical principles are developed in the context of applications of chemistry.

### Specification Content

All modules draw, as appropriate, on the content identified in the QCA Subject Criteria for Chemistry. The content is chosen to provide a balanced and coherent study of chemistry, in which chemical principles are developed, revisited and reinforced throughout the course. Examples of the use of basic chemical principles are drawn from modern applications of chemistry, in industry, in everyday life and in the environment.

### Scheme of Assessment

The Advanced Subsidiary forms 50% of the assessment weighting of the full Advanced GCE. Advanced Subsidiary is assessed at a standard between GCSE and Advanced GCE and can be taken as a stand-alone specification or as the first part of the full Advanced GCE course.

Assessment is by means of **three Units of Assessment** for Advanced Subsidiary and **six Units of Assessment** for Advanced GCE.

| | |
|---|---|
| Advanced Subsidiary GCE: | Candidates take Units 2850, 2851 or 2848, and 2852. |
| Advanced GCE: | Candidates take Units 2850, 2851 or 2848, 2852, 2853 or 2849, 2854 and 2855. |

There are no optional units and no choice of content within units. Unit 2852 contains two compulsory components.

## Units of Assessment

| Unit/ Component (where relevant) | Level | Unit Title and Content | Duration | Mode of Assessment | Weighting | |
|---|---|---|---|---|---|---|
| | | | | | AS | Advanced GCE |
| **2850** | **AS** | **Chemistry for Life** [The Elements of Life and Developing Fuels] | 1 hour 15 mins | Written Examination | 30% | 15% |
| **2848** | **AS** | **Chemistry of Natural Resources** [From Minerals to Elements, The Atmosphere and The Polymer Revolution] | 1 hour 30 mins | Written Examination | 40% | 20% |
| **2852** | **AS** | **Skills for Chemistry** | | | | |
| **/01** | | Open-Book Paper | | Coursework | 15% | 7.5% |
| **/02** | | Experimental Skills | | Coursework | 15% | 7.5% |
| **2849** | **A2** | **Chemistry of Materials** [What's in a Medicine?, Designer Polymers, Engineering Proteins and The Steel Story] | 1 hour 30 mins | Written Examination | - | 15% |
| **2854** | **A2** | **Chemistry by Design** [Aspects of Agriculture, Colour by Design, The Oceans, Medicines by Design and Visiting the Chemical Industry] | 2 hours | Written Examination | - | 20% |
| **2855** | **A2** | **Individual Investigation (Salters Chemistry)** | - | Coursework | - | 15% |

The two components in Unit 2852 are compulsory. Note that the coursework in Unit 2852, Component 01, Open-Book Paper, is externally marked by OCR.

## Question Paper Requirements

The question papers for Units 2850, 2848, 2849 and 2854 have a common format. They are all written papers made up of structured questions. These questions reflect the nature of the course and are set in context. There are some questions on each of the papers that require more extended writing. All questions on these papers are compulsory.

Quality of written communication is assessed within those parts of the questions that require more extended answers.

The question paper for Unit 2854 is a synoptic paper and contains a greater proportion of questions that require extended answers.

## Coursework requirements

The written paper for Component 01 of Unit 2852 is an open-book paper taken over a two week period during the second or third term of the AS course. The two week period is chosen by the Centre, between dates specified by OCR. Although classed as coursework (internal assessment), this paper is externally set and marked and there is no choice of questions. Marks for this paper take into account the quality of written communication used by the candidate.

The experimental and investigative skills developed by candidates are assessed through coursework. The assessment criteria are similar for both AS and Advanced GCE and cover four skill areas. The differences reflect the progression from AS to Advanced GCE and the synoptic nature of part of the A2 assessment.

For Advanced Subsidiary (Unit 2852, Component 02), candidates are assessed on the four skill areas separately using a number of activities, many of which can be drawn directly from the course materials.

In A2 (Unit 2855), candidates are assessed on the four skill areas in the context of a single extended practical investigation.

In both cases, one mark per skill must be awarded for each candidate. Work is marked by the teacher, internally standardised in the Centre, and externally moderated by OCR.

## Key Skills

Key Skills signposting appears in three sections of OCR specifications:

(1) *Key Skills Coverage* – the matrix aids curriculum managers in mapping the potential Key Skills coverage within each OCR Advanced Subsidiary/Advanced GCE specification.

(2) *Specification Content (sections 4 and 5)* – the specific evidence references enable subject teachers to identify opportunities for meeting specific Key Skills evidence requirements within the modules they are delivering.

(3) *Appendix A* – provides guidance to teachers in trying to identify those parts of their normal teaching programme which might most appropriately be used to develop or provide evidence for the Key Skills signposted.

These specifications provide opportunities for the development of the Key Skills of *Communication*, *Application of Number, Information Technology, Working With Others, Improving Own Learning and Performance* and *Problem Solving*.

Through classwork, coursework and preparation for external assessment, candidates may produce evidence for Key Skills at Level 3. However, the extent to which this evidence fulfils the requirements of the QCA Key Skills specifications at this level will be dependent on the style of teaching and learning adopted for each module. In some cases, the work produced may meet the evidence requirements of the Key Skills specifications at a higher or lower level.

Throughout sections 4 and 5 the symbol is used in the margin to highlight where Key Skills development opportunities are signposted. The following abbreviations are used to represent the above Key Skills:

C = Communication

N = Application of Number

IT = Information Technology

WO = Working with Others

LP = Improving Own Learning and Performance

PS = Problem Solving

These abbreviations are taken from the QCA Key Skills specifications for use in programmes starting from September 2000. References in section 5 and Appendix A, for example **IT3.1**, show the Key Skill (IT), the level (3) and subsection (1).

Centres are encouraged to consider the OCR Key Skills scheme to provide certification of Key Skills for their candidates.

## Key Skills Coverage

For each module, the following matrix indicates those Key Skills for which opportunities exist for at least some coverage of relevant Key Skills specification.

| | Communication | Application of Number | IT | Learning Performance | Working with Others | Problem Solving |
|---|---|---|---|---|---|---|
| Module | Level 3 | Level 3 | Level 3 | Level 3 | Level 3 | Level 3 |
| 2850 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2848 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2852 | ✓ | ✓ | ✓ | ✓ | | ✓ |
| 2849 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2854 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2855 | ✓ | ✓ | ✓ | ✓ | | ✓ |

Opportunities are signposted in the Scheme of Assessment in **Section 4** and in the Specification Content in **Section 5**. More detailed information is given in **Appendix A**.

## Links with VCE

The skills-based and applications-led approach of the Salters Advanced GCE Chemistry materials fit well into VCE Science courses. There is a considerable overlap of content and much of the material in Units 2850, 2848, 2849 and 2854 can be used to support the chemistry-based units in VCE Science courses.

Further details are given in section 1.4.

# 1 Introduction

These OCR specifications lead to qualifications at Advanced Subsidiary GCE and Advanced GCE in **Chemistry (Salters).** Candidates take three Units of Assessment for Advanced Subsidiary and a further three for A2. Advanced Subsidiary and A2 combined constitute the full Advanced GCE specification. There is coursework in both Advanced Subsidiary and A2.

The specifications relate to the Salters Advanced Chemistry course, an innovative approach to teaching and learning advanced Chemistry that was developed by an extensive team of teachers and subject experts and trialled in a wide range of schools and colleges before publication.

The course has many characteristic features. The most notable is the fact that chemical principles are developed in the context of the applications of chemistry (see **Section 5**, Specification Content). Other notable features are the introduction of important ideas gradually, rather than all in one go, the wide range of types of activities and the emphasis on the development of key skills. The 'drip-feed' approach to teaching and learning chemical principles allows candidates to revisit a particular topic several times during the course, each time taking their knowledge and understanding a step further.

The coursework in the Advanced Subsidiary specification (Unit 2852) is made up of two components. The first is an open-book paper in which candidates are supplied with two (or more) scientific articles on a related topic. Candidates are required to research the topic and produce a 1000 word report addressing the issues listed on the question paper, together with a 50 word summary of their report. This allows candidates to demonstrate research and communication skills in the context of their knowledge and understanding of chemistry. The second component is an assessment of the separate experimental and investigative skills, which may be done through activities within the course. Together these two components allow candidates to build up the skills necessary to tackle the coursework in A2 (Unit 2855). This is a single extended practical investigation (Individual Investigation (Salters Chemistry)) through which the four experimental and investigative skills are assessed.

All modules in these specifications cover content identified in the **QCA Subject Criteria for Chemistry (QCA 1999)**, such that the specification content in the criteria for AS comprises approximately 60% of the AS specification, and that for AS and A2 combined comprises approximately 60% of the Advanced GCE specification. The remaining content is chosen to provide a balanced and up-to-date study of the theory and practice of modern chemistry in which chemical principles are developed in a coherent way.

It is expected that social, economic, ethical, environmental, medical and technological aspects of chemistry will be incorporated into the delivery of these specifications. References to these aspects of chemistry are integrated into modules throughout the course.

These specifications are fully supported by the *Salters Advanced Chemistry* course materials, written and developed by the University of York Science Education Group in collaboration with OCR and with sponsorship from The Salters' Institute of Industrial Chemistry, The Association of the British Pharmaceutical Industry, BP Chemicals, British Steel, Esso UK, Zeneca Agrochemicals, The Royal Society of Chemistry and Shell UK. Six sections of teaching and learning materials support the Advanced Subsidiary GCE specification and a further seven sections support A2.

A structured visit to a chemical industry is a highly recommended part of the course. This aspect of the course is supported by a further teaching section called 'Visiting the Chemical Industry' in the course materials. It is recommended that candidates use relevant parts of this section to support their work throughout the course.

These specifications have been developed for candidates who wish to continue with a study of chemistry. The Advanced Subsidiary specification builds on from grade CC in GCSE Science: Double Award and grade C in GCSE Chemistry and these qualifications should be seen as a prerequisite for progression to Advanced Level courses.

## 1.1 Certification Title

These qualifications are shown on a certificate as

- OCR Advanced Subsidiary GCE in Chemistry.
- OCR Advanced GCE in Chemistry.

## 1.2 Language

These specifications and assessment materials are available in English only.

## 1.3 Links with Key Stage 4

The Advanced Subsidiary GCE specification builds on from grade CC in GCSE Science: Double Award courses, or equivalent. Recommended prior knowledge within AS modules is described in terms of National Curriculum statements.

The coursework assessment of experimental and investigational skills also builds on from GCSE. The four skills assessed are the same as in Sc1 of GCSE and the mark descriptors are formulated in the same way as the GCSE mark descriptors.

## 1.4 Links with VCE and other qualifications

The skills-based and applications-led approach of the Salters Advanced Chemistry materials fits well into VCE Science courses. The is a considerable overlap of content and much of the material in Units 2850, 2848, 2849 and 2854 can be used to support the chemistry-based units in VCE Science courses.

There is overlap of content between the OCR Advanced GCE Science specification (Specification 7885) and the following areas of these specifications:

- Atomic structure (EL)
- Molecules and binding (EL)
- Reaction rates (DF)
- Enzymes (EP)
- Electronic structures (M)
- Enthalpy changes (EP)
- Infrared spectroscopy (WM)
- Intermolecular bonding (PR)

## 1.5 Exclusions

Candidates who enter for this Advanced Subsidiary GCE specification may **not** also enter for any other Advanced Subsidiary GCE specification with the certification title **Chemistry** in the same examination session.

Candidates who enter for this Advanced GCE specification may **not** also enter for any other Advanced GCE specification with the certification title **Chemistry** in the same examination series.

Every specification is assigned to a national classification code indicating the subject area to which it belongs.

Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code, will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

The classification code for this specification is 1110.

## 1.6 Code of Practice requirements

These specifications will comply in all respects with the revised Code of Practice requirements for courses starting from September 2000.

# 2 Specification Aims

These **Advanced Subsidiary GCE and Advanced GCE specifications** in Chemistry aim to encourage candidates to:

- develop essential knowledge and understanding of the concepts of chemistry, and the skills needed for the use of these in new and changing situations;
- develop an understanding of the link between theory and experiment;
- be aware of how advances in information technology and instrumentation are used in chemistry;
- appreciate the contributions of chemistry to society and the responsible use of scientific knowledge and evidence;
- sustain and develop their enjoyment of, and interest in, chemistry.

In addition, the Advanced GCE specification aims to encourage candidates to:

- bring together knowledge of ways in which different areas of chemistry relate to each other.

The specifications are related to the **Salters Advanced Chemistry Course**, which provides a stimulating and worthwhile range of experiences which aims to engage candidates, motivate them to the study of chemistry and encourage them to:

- acquire knowledge and understanding of the theory and practice of modern chemistry
- develop intellectual and practical skills that will be of value in their future life and in the study of chemistry
- develop the ability to study both independently and co-operatively
- develop positive attitudes of mind, including interest, initiative, open-mindedness and a positive attitude towards the study and applications of chemistry
- become aware of the nature of scientific and technological endeavour and of the various contexts in which the work of chemists is important to society.

The course provides a firm foundation for those candidates progressing to chemistry, medicine and related courses in Higher Education. It also provides knowledge, understanding and skills to allow those candidates who do not wish to carry their study of chemistry further to make reasoned and informed decisions about chemical issues affecting their lives.

## 2.1 Spiritual, Moral, Ethical, Social and Cultural Issues

These specifications provide an opportunity for candidates to discuss and appreciate the following issues related to chemistry:

- the origin of the chemical elements and how elements came together to form the molecules of life (Module 2850);
- oceans and the history of life (Modules 2850, 2848 and 2854);
- the scale and impact of natural processes and phenomena (Modules 2848 and 2854);
- the effect of humans on the natural environment (Modules 2850, 2848, 2852 and 2854);
- moral implications of some of the applications of chemistry and chemical technology (e.g., control of carbon dioxide emissions, genetic engineering, renovation of paintings) (Modules 2848, 2849 and 2854).

## 2.2 Environmental Education

Aspects of environmental education permeate the whole course of study but the following are explicitly covered:

- reduction of pollution from car exhausts (Module 2850);
- environmental implications of mineral extraction (Module 2848);
- depletion of ozone in the stratosphere (Module 2848);
- greenhouse effect and global warming (Module 2848);
- global influence of processes occurring when carbon dioxide dissolves in water (Module 2848);
- disposal of polymers and conservation of resources used in polymer manufacture (Module 2849);
- design of pesticides that combine maximum efficacy with minimum environmental damage (Module 2854);
- ocean circulation system and climate (Module 2854);
- control of pollution from chemical manufacturing processes (Modules 2848 and 2854).

## 2.3 European Dimension

Although the specifications do not make specific reference to chemical aspects of the European Dimension, it may be drawn into the course of study in many ways. European contexts (such as specific examples of chemical industries and local environmental issues) may be used to replace those from the UK.

## 2.4 Health Education

The following aspects of Health Education feature in these specifications:

- use of radioisotopes as tracers in medicine (Module 2850);
- health and safety precautions associated with the storage, transport and use of hazardous chemicals (Module 2848);
- procedures used in developing and establishing the safety of a medicine (Module 2849);
- ways in which chemists can help improve food production (Module 2854);
- importance of understanding molecular recognition and the way biologically active molecules interact with receptor sites in designing new medicines (Module 2854).

## 2.5 Economic and Industrial Understanding

These specifications include studies of a number of chemical manufacturing processes showing how chemical principles can be applied to optimise efficiency and safety and to minimise environmental damage and economic cost. The following industrial activities are studied:

- production and blending of petrol (Module 2850);
- extraction of a pure metal from its ore (Module 2848);
- manufacture of polymers (Modules 2848 and 2849);
- genetic engineering (Module 2849);
- steelmaking (Module 2849);
- manufacture of fertilizers, pesticides and herbicides (Module 2854);
- pharmaceutical industry (Modules 2848 and 2854);
- stages in the manufacture of a new chemical product (Module 2854).

## 2.6 Avoidance of Bias

OCR has taken great care in the preparation of these specifications and assessment materials to avoid bias of any kind.

# 3 Assessment Objectives

Knowledge, understanding and skills are closely linked. The specifications require that candidates demonstrate the following assessment objectives in the context of the content and skills prescribed. Assessment Objectives AO1-AO3 are the same for Advanced Subsidiary GCE and Advanced GCE; AO4 applies only to the A2 part of the Advanced GCE course.

**AO1 Knowledge with Understanding**

Candidates should be able to:

(a) recognise, recall and show understanding of specific chemical facts, terminology, principles, concepts and practical techniques;

(b) draw on existing knowledge to show understanding of the responsible use of chemistry in society;

(c) select, organise and present relevant information clearly and logically, using specialist vocabulary where appropriate.

**AO2 Application of Knowledge and Understanding, Analysis and Evaluation**

Candidates should be able to:

(a) describe, explain and interpret phenomena and effects in terms of chemical principles and concepts, presenting arguments and ideas clearly and logically, using specialist vocabulary where appropriate;

(b) interpret and translate, from one form to another, data presented as continuous prose or in tables, diagrams and graphs;

(c) carry out relevant calculations;

(d) apply chemical principles and concepts to unfamiliar situations, including those related to the responsible use of chemistry in society;

(e) assess the validity of chemical information, experiments, inferences and statements.

**AO3 Experiment and Investigation**

Candidates should be able to:

(a) devise and plan experimental and investigative activities, selecting appropriate techniques;

(b) demonstrate safe and skilful practical techniques;

(c) make observations and measurements with appropriate precision and record these methodically;

(d) interpret, explain, evaluate and communicate the results of their experimental and investigative activities clearly and logically using chemical knowledge and understanding, and using appropriate specialist vocabulary.

 

**AO4 Synthesis of Knowledge, Understanding and Skills**

Candidates should be able to:

(a) bring together knowledge, principles and concepts from different areas of chemistry, including experiment and investigation, and apply them in a particular context, expressing ideas clearly and logically and using appropriate specialist vocabulary;

(b) use chemical skills in contexts which bring together different areas of the subject.

The assessment objectives are weighted as follows:

| | Advanced Subsidiary | A2 | Advanced GCE |
|---|---|---|---|
| AO1 | 46.6% | 25.0% | 35.8% |
| AO2 | 38.4% | 15.0% | 26.7% |
| AO3 | 15.0% | 20.0% | 17.5% |
| AO4 | 0.0% | 40.0% | 20.0% |

## 3.1 Specification Grid

The relationship between the assessment objectives and the units of assessment is shown in the specification grid below.

| Unit of Assessment | | Level | Percentage of Advanced GCE | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | AO1 | AO2 | AO3 | AO4 | |
| 2850 | | AS | 10.0 | 5.0 | 0 | 0 | 15 |
| 2848 | | AS | 13.3 | 6.7 | 0 | 0 | 20 |
| 2852 | Component 01 | AS | 0 | 7.5 | 0 | 0 | 7.5 |
| | Component 02 | AS | 0 | 0 | 7.5 | 0 | 7.5 |
| 2849 | | A2 | 7.5 | 7.5 | 0 | 0 | 15 |
| 2854 | | A2 | 5.0 | 0 | 0 | 15.0 | 20 |
| 2855 | | A2 | 0 | 0 | 10.0 | 5.0 | 15 |
| Total | | | 35.8 | 26.7 | 17.5 | 20.0 | 100 |

## 3.2 Quality of Written Communication

The requirement for all Advanced Subsidiary and Advanced GCE specifications to assess candidates' quality of written communication is met through all four assessment objectives. At Communication Level 3, candidates should be able to:

- select and use a form of writing that is appropriate to the purpose of complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate;
- ensure text is legible and spelling, grammar and punctuation are accurate, so the meaning is clear.

Questions which provide an assessment of quality of written communication are included in question papers for Units 2848, 2849 and 2854.

The Open-Book Paper in Unit 2852 (Component 01) assesses quality of written communication for an extended piece of writing, as does the assessment of experimental and investigative skills in Unit 2852 (Component 02) and in Unit 2855.

# 4 Scheme of Assessment

Candidates take three Units of Assessment, one of which is a coursework unit, for Advanced Subsidiary GCE, followed by a further three Units of Assessment, one of which is a coursework unit, at A2 if they are seeking an Advanced GCE award.

## Units of Assessment

| Unit/ Component (where relevant) | Level | Name and content | Duration | Mode of Assessment | Weighting | |
|---|---|---|---|---|---|---|
| | | | | | AS | Advanced GCE |
| 2850 | AS | **Chemistry for Life**<br>[The Elements of Life and Developing Fuels] | 1 hour 15 mins | Written Examination | 30% | 15% |
| 2848 | AS | **Chemistry of Natural Resources**<br>[From Minerals to Elements, The Atmosphere and The Polymer Revolution] | 1 hour 30 mins | Written Examination | 40% | 20% |
| 2852 | AS | **Skills for Chemistry** | | | | |
| /01 | | Open-Book Paper | | Coursework | 15% | 7.5% |
| /02 | | Experimental Skills | | Coursework | 15% | 7.5% |
| 2849 | A2 | **Chemistry of Materials**<br>[What's in a Medicine?, Designer Polymers, Engineering Proteins and The Steel Story] | 1 hour 30 mins | Written Examination | - | 15% |
| 2854 | A2 | **Chemistry by Design**<br>[Aspects of Agriculture, Colour by Design, The Oceans, Medicines by Design and Visiting the Chemical Industry] | 2 hours | Written Examination | - | 20% |
| 2855 | A2 | **Individual Investigation (Salters Chemistry)** | – | Coursework | - | 15% |

In Unit 2852, candidates take two compulsory components (01 and 02). Component 01 is externally marked by OCR. Component 02 is internally marked by Centres, and externally moderated by OCR.

If a candidate re-takes Unit 2852 within 12 months, they have the opportunity to carry forward the mark for Component 02.

All candidates for Unit 2852 should be entered under the relevant unit code with one of the following option codes.

| Entry Option | Components to be taken | |
|---|---|---|
| **A** | 01 | Open- Book Paper |
| | 02 | Experimental Skills |
| **B** | 01 | Open-Book Paper |
| | 82 | Experimental Skills mark carried forward |

**Rules of Combination**

Candidates must take the following combination of units:

| | |
|---|---|
| Advanced Subsidiary GCE | Units 2850, 2851 or 2848, and 2852 |
| Advanced GCE | Units 2850, 2851 or 2848, 2852, 2853 or 2849, 2854 and 2855. |

**Unit Availability**

There are two unit sessions each year, in January and June.

The availability of units is shown below, in their normal sequence. Note that 2851 will not be available after January 2004. 2853 will not be available after June 2004.

| Unit | Level | Unit Title | Jan 2004 | June 2004 | Jan 2005 | June 2005 |
|---|---|---|---|---|---|---|
| **2850** | **AS** | **Chemistry for Life** | ✓ | ✓ | ✓ | ✓ |
| **2851** | **AS** | **Minerals to Medicines** | ✓ | – | – | – |
| **2848** | **AS** | **Chemistry of Natural Resources** | – | ✓ | ✓ | ✓ |
| **2852** | **AS** | **Skills for Chemistry** | – | ✓ * | – | ✓ * |
| **2853** | **A2** | **Polymers, Proteins and Steel** | ✓ | ✓ | – | – |
| **2849** | **A2** | **Chemistry of Materials** | – | – | ✓ | ✓ |
| **2854** | **A2** | **Chemistry by Design** | ✓ | ✓ | ✓ | ✓ |
| **2855** | **A2** | **Individual Investigation (Salters Chemistry)** | ✓ | ✓ | ✓ * | ✓ * |

*** Revised mark descriptors apply in these sessions**

**The availability for January 2005 and June 2005 will be repeated in subsequent years.**

**Sequence of Units**

Units may be taken in any sequence. The normal sequence in which the units could be taken is Units 2850, 2851 or 2848, and 2852 in the first year of a course of study, leading to an Advanced Subsidiary GCE award, then Units 2853 or 2849, 2854 and 2855 in the second year, together leading to the Advanced GCE award. However, the units may be taken in other sequences.

Alternatively, candidates may take all units at the end of their Advanced Subsidiary GCE or Advanced GCE course in a 'linear' fashion, if desired.

**Synoptic Assessment**

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. The emphasis of synoptic assessment is on understanding and application of the principles included in the specifications. Assessment Objective AO4 relates specifically to synoptic assessment. It accounts for 20% of the total Advanced GCE marks and is assessed only in A2 Units 2854 and 2855.

Synoptic assessment:

- requires candidates to make connections between different areas of chemistry, for example, by applying knowledge and understanding of principles and concepts of chemistry in planning experimental work and in the analysis and evaluation of data;

- includes opportunities for candidates to use, in contexts which may be new to them, skills and ideas which permeate chemistry, for example, writing chemical equations, quantitative work, relating empirical data to knowledge and understanding.

Questions are set in the question papers for Unit 2854 that require candidates to demonstrate these abilities. The planning, analysing and drawing conclusions aspects of the Individual Investigation (Skills **P** and **A**) also contribute to the synoptic assessment.

**For Advanced GCE, Units 2854 and 2855, which include synoptic assessment, should normally be taken at the end of a candidate's course of study but this is not a requirement.**

**Aggregation**

Candidates may enter for:

- Advanced Subsidiary GCE aggregation
- Advanced Subsidiary GCE aggregation, bank the result, and complete the A2 assessment at a later date.
- Advanced GCE aggregation.

Candidates must enter the appropriate Advanced Subsidiary and A2 units to qualify for a full Advanced GCE award.

Individual unit results, prior to certification of the qualification, have a shelf life limited only by that of the qualification.

**Re-sits of Units of Assessment**

Candidates are permitted to re-sit units without limit, before seeking an Advanced Subsidiary GCE or Advanced GCE award, and the better result will count.

**Re-sits of Advanced Subsidiary GCE and Advanced GCE**

Candidates may retake the whole qualification more than once.

## 4.1 Question Papers

There are five written question papers in the Scheme of Assessment. Three of these are Advanced Subsidiary papers (Units 2850 and 2851 or 2848 and Component 01 of Unit 2852); two are A2 papers (Units 2853 or 2849 and 2854).

Questions on the examination papers in Units 2850, 2851 or 2848, 2853 or 2949 and 2854 reflect the nature of the course and are set in context. The contexts may be familiar ones from the course materials or they may be unfamiliar to candidates, requiring them to apply knowledge and understanding in new situations. In all four examination papers, a substantial proportion of the questions are presented in a context of the applications of chemistry and the work of chemists. (See also **Section 4.1.3** on questions relating to the chemical industry.)

The questions on these papers are concerned principally with the teaching module specified. (The detailed content of these is provided in **Section 5.2**.) However, it is assumed that candidates have knowledge and understanding related to earlier modules, in keeping with the 'drip-feed' development of concepts in the course. Thus, questions may be set on a chemical concept used or developed in the specified teaching module, even though that concept may have been first introduced in an earlier module. (The concept maps in the course materials provide a useful guide to the chemistry used and developed in each teaching module.) Questions will **not** be set on chemical ideas covered in earlier units, **when these chemical ideas are not revisited in the specified module.**

All four papers include questions relating to the quantitative aspects of chemistry.

Further general points concerning the written papers can be found in **Appendix B**.

## 4.1.1 Advanced Subsidiary

**C3.3**

**Unit 2850: Chemistry for Life (1 hour 15 minutes) (75 marks)**

(Teaching sections: The Elements of Life and Developing Fuels)

**Unit 2848: Chemistry of Natural Resources (1 hour 30 minutes) (90 marks)**

(Teaching sections: From Minerals to Elements, The Atmosphere and The Polymer Revolution )

The question papers for Units 2850 and 2848 have a common format. Each paper consists of structured questions, in which introductory information is followed by a series of related questions. The papers consist of a mixture of types of question: some require relatively short responses but there are some questions on each paper (approximately 10%) that require more extended answers. All questions on these examination papers are compulsory. Quality of written communication is assessed in Unit 2848 within those parts of the questions which require more extended answers.

**C3.2, C3.3; IT3.1, IT3.2, IT3.3** | **LP3.1, LP3.2, LP3.3**

**Unit 2852 Component 01: Open-Book Paper (2 weeks) (45 marks)**

This component, though classed as coursework, is externally marked by OCR. All candidates take the same question paper over a two week period during the second or third term of the AS course. The two week period is chosen by the Centre between dates specified by OCR. The question paper requires candidates to make use of knowledge and understanding of the learning outcomes of Modules 2850 and 2848 of this specification to interpret scientific information and data. The questions paper contains two (or more) articles on a topic of current chemical interest. These may include scientific information in the form of graphs, diagrams and tables of data. Whilst the articles themselves may be set in a context which is unfamiliar to candidates, the chemistry that they are asked to use should be familiar to them.

Candidates are required to research the topic of the articles and write a 1000 word report concerning the issues listed on the question paper. They are required to list their sources of reference and acknowledge where they have made use of information from these sources in their report. This should include reference to the articles in the question paper. They are also required to write a 50 word summary of their report. Quality of written communication is assessed on this paper.

Centres are required to certify that, to the best of their knowledge, each response is the candidate's own, unaided work. Such certification takes the form of declarations signed by their teacher.

Detailed notes for guidance about this component can be found in **Appendix C**.

## 4.1.2 A2

**C3.3**

**Unit 2849: Chemistry of Materials (1 hour 30 minutes) (90 marks)**

(Teaching sections: What's in a Medicine?, Designer Polymers, Engineering Proteins and The Steel Story)

**Unit 2854 Chemistry by Design (2 hours) (120 marks)**

(Teaching sections: Aspects of Agriculture, Colour by Design, The Oceans, Medicines by Design and Visiting the Chemical Industry)

The question papers for Units 2849 and 2854 have a common format with the question papers for Units 2850 and 2848. They are made up of structured questions, some parts of which require more extended answers. In Unit 2849 approximately 10% of the marks (9 marks) will be for more extended answers. Paper 2854 is the synoptic paper and contains a greater proportion of questions requiring extended answers, approximately 20% (24 marks). All questions on these examination papers are compulsory. Quality of written communication is assessed within those parts of the questions which require more extended answers.

Unit 2854 focuses on the last four teaching sections in the course (*Aspects of Agriculture, Colour by Design, The Oceans* and *Medicines by Design*). It may also include questions on *Visiting the Chemical Industry*. Because of the 'drip-feed' approach to learning chemical principles, these teaching sections summarise and draw together much of the chemistry from earlier modules.

For example, *Medicine by Design* requires candidates to revise and make connections between all aspects of the organic chemistry they have learned throughout the course, including the use of spectroscopic techniques for the elucidation of structure; *Aspects of Agriculture* brings together much of the inorganic chemistry; *Colour by Design* revisits and extends work on the interaction of radiation and matter, the relationship between structure and properties, types of reactions and chromatography; *The Oceans* brings together much of the physical chemistry in the course.

### 4.1.3 Questions Relating to the Chemical Industry

Examples of industrial chemistry are a recurrent theme in the course and it is recommended that candidates use relevant parts of 'Visiting the Chemical Industry' in the *Chemical Storylines* textbook to support their work in each module.

A structured visit to some chemical industry is a recommended part of the Salters Advanced Chemistry Advanced GCE course. The visit enriches candidates' experience of the chemical industry and supports their work done on this topic. The visit may be done at any stage but for those taking a staged assessment route to Advanced GCE, it is best to undertake it during the first four terms, if possible. The visit is not necessary for candidates taking only the Advanced Subsidiary course.

Questions relating to the chemical industry may be set in any of the question papers in Units 2850, 2848, 2849 and 2854. The chemistry involved will be appropriate to the teaching modules specified in the unit. Questions specifically related to the *Visiting the Chemical Industry* section may be asked in Unit 2854.

## 4.2 Coursework: Experimental and Investigative Skills

| | |
|---|---|
| **C3.2, C3.3; IT3.1, IT3.2, IT3.3** | **LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3** |

**Unit 2852, Component 02: Experimental Skills (AS) (45 Marks)**

**Unit 2855: Individual Investigation (Salters Chemistry) (A2) (90 Marks)**

The candidates' experimental and investigative work is marked by the teacher and moderated externally by OCR.

### The Skills

The experimental and investigative skills assessed are:

**Skill P Planning**

Candidates should:

- identify and define the nature of the question or problem using available information and knowledge of chemistry;
- retrieve and evaluate information from multiple sources, including IT where appropriate;
- choose effective and safe procedures, selecting appropriate apparatus and materials and deciding the measurements and observations likely to generate useful and reliable results.

**Skill I Implementing**

Candidates should:

- use apparatus and materials in an appropriate and safe way;
- carry out work in a methodical and organised way with due regard for safety;
- make and record detailed observations in a suitable way, and make measurements to an appropriate degree of precision, using IT where appropriate.

**Skill A Analysing Evidence and Drawing Conclusions**

Candidates should:

- communicate chemical information and ideas in appropriate ways, including tabulation, line graphs, continuous prose and annotated diagrams;
- recognise and comment on trends and patterns in data;
- draw valid conclusions by applying chemical knowledge and understanding.

**Skill E Evaluating Evidence and Procedures**.

Candidates should:

- assess the reliability and precision of experimental data and draw conclusions drawn from it;
- evaluate the techniques used in the experimental activity, recognising their limitations.

In Advanced Subsidiary Unit 2852, Component 02, Skills **P**, **A** and **E** are each marked out of 11 and Skill **I** is marked out of 12. One mark per skill must be submitted for each candidate. Thus, **a mark out of 45** is submitted for each candidate for this component.

In Advanced Subsidiary Unit 2852, Component 02, the skills are assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise.

In Unit 2855, Skills **P**, **A** and **E** are marked out of 11 and Skill **I** is marked out of 12. In order to reflect the time which the candidates are expected to spend on the extended individual investigation, the total of these marks is doubled. Thus, **a mark out of 90** is submitted for each candidate for this unit.

In A2 Unit 2855, the skills are assessed in the context of a single extended individual investigation in which each candidate pursues his or her own assignment.

## Marking Criteria

A different set of mark descriptors is used for Unit 2852, Component 02 and Unit 2855. These descriptors have been written to provide clear continuity from the assessment of Sc1 in GCSE Science. The difference in standard at Advanced Subsidiary and A2 is a product of the level of demand of the related chemical knowledge and understanding expected, the requirement at A2 to bring together knowledge, principles and concepts from different areas of chemistry and to apply them in the context of a single extended practical investigation and the requirement at A2 to use chemical skills in an investigation that brings together different areas of the subject.

**At AS**, experimental and investigative work is likely to require processing in a context that is familiar to the candidate.

- Planning activities focus on apparatus and techniques which have been encountered before, based on knowledge and understanding from a limited part of the AS specification.
- Implementing involves the manipulation of simple apparatus and the application of easily recognised safety procedures.
- Analysing and concluding involves simple data handling and reaching conclusions based on a limited part of the AS specification.
- Evaluation requires the recognition of the main sources of error and direct methods of improving accuracy.

**At A2**, assessment requires greater levels of sophistication and higher levels of skill.

- Planning the individual investigation requires research to provide a satisfactory solution to a problem which may be addressed in more than one way. The underlying knowledge, understanding and skills required may be drawn from several parts of the AS and A2 specifications.
- Implementing involves the formulation of a detailed risk assessment and the careful use of sophisticated techniques or equipment to achieve data that are precise and reliable.
- Analysing and concluding involves sophisticated data handling and the synthesis of several strands of evidence. In drawing conclusions candidates are required to bring together principles and concepts from different parts of the AS and A2 specifications.
- Evaluation requires recognition of the key experimental limitations and other sources of error as well as an understanding of the methods that may be used to limit their effect. The evaluation is likely to draw together principles and concepts from different parts of the specification.

Notes for Guidance on the submission and assessment of experimental and investigative skills are given in **Appendix D**. Mark descriptors for the experimental and investigative skills are fully detailed in **Appendix E**.

**Detailed guidance on the choice of suitable experimental work for assessment in AS, on the choice of suitable individual investigations for A2 and on the application of the assessment descriptors in AS and in A2 to exemplar tasks is provided in the Chemistry (Salters) Coursework Handbook which can be ordered from the OCR Publications Department.**

## 4.2.1 Assessment and Moderation

All coursework for experimental and investigative skills, i.e. Unit 2852, Component 02 and Unit 2855, is marked by the teacher. The marking is internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

The sample of work which is submitted to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

## 4.2.2 Minimum Coursework Requirements

If a candidate submits no work for an experimental and investigative coursework unit or component, then the candidate should be indicated as being absent from that unit or component on the coursework mark sheets submitted to OCR. If a candidate completes any work at all for the coursework unit or component then the work should be assessed according to the mark descriptors and marking instructions and the appropriate mark awarded, which may be 0 (zero).

## 4.2.3 Authentication of Experimental and Investigative Coursework

As with all coursework, the teacher must be able to verify that the work submitted for assessment is the candidate's own. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

## 4.3 Special Arrangements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Inter-Board Regulations and Guidance Booklet for Special Arrangements and Special Consideration*. In such cases advice should be sought from OCR as early as possible during the course.

Applications for special consideration in coursework components should be accompanied by Coursework Assessment Forms, giving the breakdown of marks for each skill.

## 4.4 Differentiation

In the question papers, differentiation is achieved by setting questions which are designed to assess candidates at their appropriate levels of ability and which are intended to allow all candidates to demonstrate what they know, understand and can do.

In experimental and investigative coursework, differentiation is by task and by outcome. Candidates will undertake assignments which enable them to display positive achievement.

## 4.5 Awarding of Grades

The Advanced Subsidiary has a weighting of 50% when used in an Advanced GCE award. An Advanced GCE award is based on the aggregation of the weighted Advanced Subsidiary (50%) and A2 (50%) marks.

Both Advanced Subsidiary GCE and Advanced GCE qualifications are awarded on the scale A to E, or U (unclassified).

## 4.6 Grade Descriptions

The following grade descriptions indicate the level of attainment characteristic of the given grade at **Advanced GCE**. They give a general indication of the required learning outcomes at each specified grade. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

## Grade A

Candidates recall and use chemical knowledge from the whole specification with few significant omissions and show good understanding of the principles and concepts they use. They are thoroughly conversant with the construction of chemical equations and use them quantitatively in a range of contexts. They select chemical knowledge relevant to most situations and present their ideas clearly and logically, making use of chemical terminology.

Candidates carry out calculations in a logical manner even when little guidance is given. They demonstrate good understanding of principles, applying them in familiar and new contexts, *for example, in determining the order of reaction from empirical results, in predicting the conditions which might be used in an industrial process, in using knowledge of the Periodic Table to predict reactions of unfamiliar elements or compounds or in predicting the reactions of organic compounds containing specific functional groups*. They bring together and use knowledge and understanding from more then one area of the specification, *for example, in suggesting a method for synthesising a particular compound or in interpreting evidence relating to the structure of a molecule or ion*.

In experimental activities, candidates independently formulate a clear and accurate plan. They use a range of manipulative techniques safely and skilfully, making and recording observations with appropriate precision. They interpret, explain and evaluate results, using appropriate chemical knowledge and terminology.

## Grade C

Candidates recall chemical knowledge from many parts of the specification and show good understanding of some fundamental principles and concepts. They routinely represent most reactions, *for example, those for inorganic redox processes*, by chemical equations and use them quantitatively. They frequently select chemical knowledge relevant to a particular situation or context and present their ideas clearly and logically, making use of chemical terminology.

Candidates carry out a range of calculations, making progress in some where little guidance is given. They show knowledge of fundamental principles in applying these in some new contexts, *for example, in using information about reactions to distinguish between compounds containing different functional groups*. They bring together information from more than one area of the specification in interpreting information, *for example, in explaining trends in* $K_a$ *for a range of organic acids.*

In experimental activities, candidates formulate a plan which may need some modification. They use a range of techniques safely, making and recording observations and measurements which are adequate for the task. They interpret and explain experimental results, relating these to chemical knowledge and understanding and, with help, evaluate how good their results are.

## Grade E

Candidates recall chemical knowledge from some parts of the specification and demonstrate some understanding of fundamental principles and concepts, *for example, in relating the properties of some compounds to the bonding found in them*. They write chemical equations for straightforward, frequently-encountered chemical reactions and use simple equations quantitatively. They select discrete items of knowledge in response to structured questions and use basic chemical terminology.

Candidates carry out straightforward calculations where guidance is given. They apply knowledge and chemical principles contained within the specification to materials presented in a familiar or closely related context, *for example, in using information about reactions to identify the functional* *groups in some organic compounds*. They use some fundamental chemical skills in contexts which bring together different areas of the subject.

In experimental activities, candidates formulate some elements of a practical approach when provided with guidance. They carry out frequently encountered practical procedures in a reasonably skilful manner, recognising the risks in familiar procedures and obtain some appropriate results. They interpret and explain some experimental results but need assistance to relate these to chemical knowledge and understanding.

# 5 Specification Content

## 5.1 Structure of the Course

The course materials are set out in 13 teaching sections.

The titles of the teaching sections are:

**Advanced Subsidiary**

| | | |
|---|---|---|
| **EL** | The Elements of Life | Module 2850 |
| **DF** | Developing Fuels | |
| **M** | From Minerals to Elements | Module 2848 |
| **A** | The Atmosphere | |
| **PR** | The Polymer Revolution | |

**A2**

| | | |
|---|---|---|
| **WM** | What's in a Medicine? | Module 2849 |
| **DP** | Designer Polymers | |
| **EP** | Engineering Proteins | |
| **SS** | The Steel Story | |
| **AA** | Aspects of Agriculture | Module 2854 |
| **CD** | Colour by Design | |
| **O** | The Oceans | |
| **MD** | Medicines by Design. | |

A structured industrial visit is a recommended part of the full Advanced GCE course. This is supported by a further teaching section:

**VCI** Visiting the Chemical Industry.

This section, however, has a wider relevance and supports the industrial aspects of modules in both the Advanced Subsidiary and Advanced GCE specifications. It is recommended that candidates use appropriate parts of 'Visiting the Chemical Industry' in the *Chemical Storylines* and *Chemical Ideas* textbooks to support their work in each module.

**Timing**

Teaching sections are designed to occupy 3 or 4 weeks of classroom time on average, together with an appropriate amount of private study time. They are not designed to be of equal length. The two teaching sections (EL and DF) in Module 2850 may take longer than 4 weeks depending on the backgrounds of the candidates.

**Course publications**

Each teaching module is supported by materials for both teachers and candidates. There are three components.

- A **storyline** provides the context within which chemical ideas and skills are developed. Each storyline is self-contained, and worth studying in its own right.
- **Activities** of many kinds include laboratory practical work, research activities, group discussions, data analysis, applications of IT, and so on.
- The course is supported by a book of **Chemical Ideas**, treated in a systematic and coherent manner so as to draw together the many chemical principles arising in different modules.

The course publications (see **Section 7**) provide full details of the intended coverage of the material that appears in the specifications.

**Presentation of Content**

In the following pages, the detailed content of the course is presented in two ways.

- **Section 5.2** presents the content as it appears in the teaching modules of the course and their associated units of assessment.
- **Section 5.3** presents **the same** content, organised under major chemical principles.

Thus Section 5.2 shows the content as it appears in the course, while Section 5.3 summarises the overall coverage of chemistry.

## 5.2 Content Organised by Modules

This part of the specification provides guidance on organisation of the content. The content is presented in order of the modules for AS and A2, and organised under the headings for the teaching sections within each module.

Each teaching module is assessed by its associated unit of assessment.

Opportunities for the development of Key Skills are signposted. Further information about Key Skills is provided in **Appendix A**.

# AS Module 2850: Chemistry for Life

This module covers the following teaching sections:

EL The Elements of Life

DF Developing Fuels

# EL The Elements of Life

| | |
|---|---|
| **C3.1, C3.2, C3.3; N3.2; IT3.1, IT3.2, IT3.3** | **WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3** |

## EL1 Synopsis

A study of elements, in the human body, the solar system and the universe. Main topics:

- constituent elements of the body;
- case studies of important elements in the human body: iron and calcium;
- the development of the Periodic Table;
- occurrence and origin of the elements in the universe;
- elements in the solar system;
- molecules in outer space and in living things.

## EL2 Learning outcomes

Candidates should be able to:

(a) describe protons, neutrons and electrons in terms of their mass and relative charge;

(b) describe the structure of atoms in terms of protons, neutrons and electrons;

(c) explain and use the terms: atomic number, mass number, isotope, Avogadro constant, relative isotopic mass, relative atomic mass, relative formula mass, relative molecular mass;

(d) describe the elementary principles underlying the operation of a mass spectrometer;

(e) use data from a mass spectrometer to determine relative atomic mass and the relative abundance of isotopes;

(f) use the concept of amount of substance to perform calculations involving: masses of substances, empirical and molecular formulae, percentage composition; **N3.2**

(g) outline the formation of elements in stars by nuclear fusion processes;

(h) explain the occurrence of absorption and emission atomic spectra;

(i) interpret the atomic emission spectrum of hydrogen in terms of changes in electronic energy levels;

(j) recall that the nuclei of some atoms are unstable, and that these atoms are radioactive;

(k) recall the different properties of alpha, beta and gamma radiations;

(l) use nuclear symbols to write equations for nuclear processes, both fusion and radioactive decay;

(m) explain the use of radioactive tracers;

(n) recall that the Periodic Table lists elements in order of atomic (proton) number and groups elements together according to their common properties;

(o) understand the way that ideas behind the Periodic Table developed historically; **C3.1b**

(p) relate the position of an element in the Periodic Table to its electron structure (in terms of electron shells) and vice versa;

(q) interpret periodic trends in the properties of elements, in terms of:

   (i) melting point and boiling point,

   (ii) electrical conductivity,

   (iii) ionisation enthalpy; **IT3.1**

(r) relate ease of ion formation to ionisation enthalpy;

(s) write equations for the first and successive ionisation enthalpies of an element;

(t) use given data to describe trends in a group of the Periodic Table and to make predictions concerning the properties of an element in the group; **IT3.1**

(u) write and interpret balanced chemical equations;

(v) describe and compare the following properties of the elements Mg, Ca, Sr, Ba in Group 2:

   (i) reactions of the elements with water,

   (ii) acid-base character of the oxides and hydroxides,

   (iii) thermal stability of the carbonates,

   (iv) solubilities of hydroxides and carbonates;

(w) draw and use simple electron ‘dot-cross’ diagrams to show how atoms bond through ionic, covalent and dative covalent bonds;

(x) describe a simple model of metallic bonding;

(y) use the electron pair repulsion principle to predict the shapes of simple molecules (such as $CH_4$, $NH_3$ and $H_2O$) and ions (such as $NH_4^+$) with up to four outer pairs of electrons (any combination of bonding pairs and lone pairs) (no treatment of hybridisation or molecular orbitals is expected);

(z) explain molecular shape in terms of bond angles.

## EL3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- atomic structure;
- bonding;
- representing reactions;
- quantitative chemistry;
- the Periodic Table;
- the electromagnetic spectrum;
- radioactivity.

## EL4 Links to Other Teaching Modules

The following topics are introduced in this teaching module but are developed further in later modules:

- amount of substance (DF and M);
- the electronic structure of atoms (M);
- the Periodic Table and periodicity (M, SS, AA and O);
- the interpretation of structural formulae (DF, A, PR, WM, DP, EP, AA, CD and MD);
- electronegativity and bond polarity (A and PR);
- shapes of molecules (DF, PR, EP and MD);
- the principles of spectroscopy and spectroscopic techniques (WM, EP, CD and MD).

# DF Developing Fuels

**C3.1, C3.2, C3.3; N3.2, N3.3; IT3.1, IT3.2, IT3.3**

**WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3**

## DF1 Synopsis

A study of fuels and the contribution that chemists make to the development of better fuels. Main topics:

- desirable properties of a fuel;
- hydrocarbons and alcohols as fuels;
- available energy in fuels;
- overcoming the problem of auto-ignition: alternatives to lead compounds;
- exhaust emissions and control of exhaust pollutants;
- alternative fuels.

## DF2 Learning outcomes

Candidates should be able to:

(a) use the concept of amount of substance to perform calculations involving: volumes of gases, balanced chemical equations, enthalpy changes; **N3.2**

(b) explain and use the terms: exothermic, endothermic, standard state, enthalpy change of combustion, enthalpy change of reaction, enthalpy change of formation;

(c) interpret the pattern of enthalpy changes of combustion for successive members of an homologous series; **N3.3; PS3.1, PS3.2, PS3.3**

(d) calculate enthalpy changes from experimental results; **N3.2**

(e) use Hess's Law and enthalpy cycles to calculate enthalpy changes; **IT3.2; N3.2**

(f) recall that bond-breaking is an endothermic process and bond-making is exothermic;

(g) explain and use the term: bond enthalpy;

(h) relate bond enthalpy to the length and strength of a bond;

(i) recognise members of the following homologous series: alkanes, cycloalkanes, alkenes, arenes, alcohols, ethers;

(j) explain and use the terms: aliphatic, aromatic;

(k) use systematic nomenclature to name alkanes and alcohols;

(l) explain and use the term isomerism;

(m) recognise structural isomers;

(n) draw and interpret structural formulae (full, shortened and skeletal);

(o) relate molecular shape to structural formulae and be familiar with the use of models to represent molecular shape; **IT3.1**

(p) describe and write balanced equations for the combustion (oxidation) of alkanes and alcohols;

(q) describe the effect of chain length and chain branching on the tendency of petrol towards auto-ignition which causes ‘knocking’ in a car engine;

(r) explain what is meant by the octane number of a petrol and describe how it may be increased;

(s) describe the origin of pollutants from car exhausts: unburnt hydrocarbons, CO, $CO_2$, $NO_x$, $SO_x$, and show awareness of the environmental implications;

(t) explain the formation of nitrogen monoxide (NO) in an internal combustion engine;

(u) explain and use the terms catalysis, catalyst, catalyst poison;

(v) outline a simple model to explain the function of a heterogeneous catalyst;

(w) describe the use of isomerisation, reforming and cracking reactions to improve the performance of hydrocarbon fuels;

(x) show awareness of the use of catalysts in isomerisation, reforming and cracking processes and in the control of exhaust emissions;

(y) discuss entropy in a qualitative manner, interpreting it as a measure of the number of ways that molecules can be arranged;

(z) show awareness of the differences in magnitude of the entropy of a solid, a liquid, a solution and a gas;

(aa) discuss the desirable properties of a fuel; **C3.1a; WO3.1, WO3.2, WO3.3**

(bb) show awareness of the work of chemists in improving fuels and in searching for and developing fuels for the future: use of oxygenates, the hydrogen economy. **C3.1,C3.2, C3.3**

## DF3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- bonding (covalent compounds);
- representing reactions;
- quantitative chemistry;

- rates of reactions (role of catalyst);
- energy transfer in reactions;
- useful products from oil.

From other teaching modules in the course:

- amount of substance (EL);
- chemical formulae (EL);
- covalent bonding (EL);
- molecular shape (EL).

## DF4 Links to Other Teaching Modules

The following topics in this teaching module are developed further in other modules:

- alcohols (PR, WM, DP and MD);
- aromatic compounds (WM, DP, CD and MD);
- entropy (O).

The following topics in this teaching module are also treated in other modules:

- nomenclature of organic compounds (A, PR, WM, DP, EP, CD and MD);
- isomerism (PR, EP and SS);
- enthalpy changes in reactions (A and O);
- bond enthalpies (A);
- catalysis (A, EP, SS and AA);
- processes in the chemical industry (VCI).

# AS Module 2848: Chemistry of Natural Resources

**This module replaces Module 2851 and will be assessed for the first time in June 2004.**

This module covers the following teaching sections:

M From Minerals to Elements

A The Atmosphere

PR The Polymer Revolution

# M From Minerals to Elements

**C3.1a, C3.1b, C3.2, C3.3** **LP3.1. LP3.2, LP3.3**

## M1 Synopsis

A study of the extraction and uses of two elements, used to introduce major classes of chemical reactions. Main topics:

- extraction of bromine from sea water;
- transportation and uses of bromine;
- mining and extraction of copper;
- copper as a commodity;
- environmental implications of mineral extraction;
- major classes of chemical reactions: acid-base, redox and precipitation.

## M2 Learning outcomes

Candidates should be able to:

(a) use the concept of amount of substance to perform calculations involving concentrations of solutions; **N3.2**

(b) use conventions for representing the distribution of electrons in atomic orbitals (no treatment of the shapes of atomic orbitals is expected);

(c) recall the classification of elements into *s*, *p* and *d* blocks;

 

(d) deduce (given the atomic number) the electronic configuration of atoms from hydrogen to krypton in terms of main energy levels and *s*, *p* and *d* atomic orbitals;

(e) recall the following physical properties of the halogens:

  (i) appearance and state at room temperature,

  (ii) volatility,

  (iii) solubility in water and organic solvents;

(f) assign oxidation states to the elements in a compound;

(g) use oxidation states to decide which species have been oxidised and which reduced in a redox reaction;

(h) describe redox reactions of s- and *p*-block elements in terms of electron transfer, using half-equations to represent the oxidation and reduction reactions;

(i) explain the redox changes which take place when chlorine, bromine and iodine react with other halide ions;

(j) explain the redox changes occurring in the extraction of bromine from sea water;

(k) compare the relative reactivity of the halogens;

(l) recall the reaction between halide ions and silver ions;

(m) show awareness of the health and safety precautions needed in industry when hazardous chemicals are being stored, transported and used; **C3.1b**

(n) show awareness of the economic importance of bromine and chlorine and their compounds;

(o) describe the structure of an ionic lattice, exemplified by sodium chloride;

(p) write ionic equations to represent precipitation reactions and other reactions involving ionic compounds;

(q) describe the hydration of ions in aqueous solution;

(r) describe and explain the major stages in the extraction of a pure metal from its ore; **C3.1b**

(s) show awareness of the scale and importance of mineral extractive industries and discuss the environmental implications of mineral extraction; **C3.1a, C3.1b**

(t) interpret flow diagrams showing the sequence of operations in a chemical process;

(u) recognise from the balanced equation for a reaction whether it is an acid-base, redox or precipitation reaction;

(v) recall that acid-base reactions involve proton transfer;

(w) identify the proton donor and proton acceptor in an acid-base reaction;

(x) recall the procedure for carrying out an acid-alkali titration and be able to work out the results; **N3.2**

(y) recall the procedure for vacuum filtration;

(z) describe examples of giant covalent (network) structures, such as diamond and silicon(IV) oxide;

(aa) interpret differences in the physical properties of $CO_2$ and $SiO_2$ in terms of their different structures.

## M3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- bonding (ionic compounds);
- useful products from metal ores and rocks;
- quantitative chemistry;
- the Periodic Table (halogens).

From other teaching modules in the course:

- atomic structure (EL);
- amount of substance (EL and DF);
- bonding (EL);
- the Periodic Table (EL).

## M4 Links to Other Teaching Modules

The following topics in this teaching module and are developed further in other modules:

- hydration (O);
- acid-base reactions (O);
- redox (SS);
- precipitation (O).

The following topics in this teaching module are also treated in other modules:

- extraction of metals (SS);
- processes in the chemical industry (VCI).

# A The Atmosphere

| | |
|---|---|
| **C3.1a, 3.1b, C3.2, C3.3; N3.2; IT3.1,** | **WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3** |

## A1 Synopsis

A study of chemical processes occurring in the atmosphere which have an important influence on life on Earth. The section focuses particularly on the ozone layer and the greenhouse effect, the way these are affected by human activities, and the role of chemistry in understanding and controlling the resulting problems. Main topics:

- absorption of the Sun's radiation by matter, particularly by atmospheric gases;
- ozone and its atmospheric chemistry;
- halogenoalkanes and their effect on the ozone layer;
- approaches to the control of the ozone layer depletion problem;
- origins of the greenhouse effect; greenhouse gases in the atmosphere;
- carbon dioxide and its role in the greenhouse effect and global warming;
- the global carbon cycle and ways of reducing atmospheric carbon dioxide.

## A2 Learning outcomes

Candidates should be able to:

(a) recall the gases present in the atmosphere, including some major pollutants; **IT3.1**

(b) understand values for composition by volume measured in percentage concentration and in parts per million (ppm); **N3.2**

(c) recall that rotational, vibrational and electronic energies are quantised;

(d) describe qualitatively the changes in rotational, vibrational and electronic energy caused by the absorption of radiation of appropriate frequency;

(e) use the equation $E = h\nu$ to relate quantitatively the frequency and energy of electromagnetic radiation; **N3.2**

(f) use given data about absorption ranges to make predictions about the effect of substances on radiation;

(g) recall the structure and reactivity of ozone and the way it is formed and destroyed in the stratosphere;

(h) explain how ozone acts as a sunscreen in the stratosphere;

(i) recall the factors that affect the rate of a chemical reaction and use collision theory to give simple explanations;

(j) explain and use the terms: enthalpy profile, activation enthalpy;

(k) use the concept of activation enthalpy to explain the qualitative effect of temperature changes on rate of reaction;

(l) explain the role of catalysts in providing alternative routes of lower activation enthalpy;

(m) distinguish between homolytic and heterolytic bond fission;

(n) recall the formation, nature and reactivity of radicals;

(o) explain the mechanism of a radical chain-reaction involving initiation, propagation and termination;

(p) describe and explain the reaction of alkanes with halogens;

(q) recognise members of the following homologous series: halogenoalkanes;

(r) use systematic nomenclature to name halogenoalkanes;

(s) explain and use the terms: hydrolysis, substitution, nucleophile, carbocation;

(t) describe in outline the preparation of a halogenoalkane from an alcohol;

(u) describe and explain the principle stages in the purification of an organic liquid product;

(v) describe and explain the characteristic properties of halogenoalkanes, comparing fluoro-, chloro-, bromo- and iodo- compounds. The following aspects are to be considered:

  (i) boiling points,

  (ii) formation of radicals by interaction with ultraviolet radiation,

  (iii) nucleophilic substitution with water, hydroxide ions, ammonia;

(w) explain the mechanism of nucleophilic substitution in halogenoalkanes (reference to $S_N1$ and $S_N2$ is not required);

(x) use relative electronegativity values to predict bond polarity in a covalent bond;

(y) relate reactivity of halogenoalkanes to bond enthalpy and bond polarity;

(z) recall the nature and uses of chlorofluorocarbons (CFCs);

(aa) describe the chemical basis of the depletion of ozone in the stratosphere due to halogenoalkanes, in simple terms involving the formation of halogen atoms and the catalytic role of these atoms in ozone destruction;

(bb) outline a simple model to explain homogeneous catalysis in terms of the formation of intermediates;

(cc) discuss the relative advantages and disadvantages of replacement compounds for chlorofluorocarbons: hydrochlorofluorocarbons (HCFCs), hydrofluororocarbons (HFCs) and alkanes; **C3.2, 3.3**

(dd) relate the ‘greenhouse effect’ in the troposphere to the absorption characteristics of atmospheric gases;

 

(ee) discuss and evaluate different approaches to the control of global warming through the control of carbon dioxide emissions; **C3.1a, C3.1b, C3.2, C3.3; WO3.1, WO3.2, WO3.3**

(ff) explain and apply the term: dynamic equilibrium;

(gg) describe the physical and chemical changes occurring when carbon dioxide dissolves in water, and the associated equilibria;

(hh) use Le Chatelier's Principle to explain and predict, in a homogeneous reaction, the qualitative effects on the position of equilibrium of changes in the following conditions

(i) concentration,

(ii) temperature,

(iii) pressure.

## A3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- changes to the atmosphere;
- rates of reactions;
- reversible reactions;
- the electromagnetic spectrum.

From other teaching modules in the course:

- interaction of radiation with matter (EL);
- electronegativity and bond polarity (EL);
- catalysis (DF);
- enthalpy changes and enthalpy cycles (DF).

## A4 Links to Other Teaching Modules

The following topics in this teaching module are developed further in other modules:

- enthalpy changes (DF and O);
- bond enthalpies (DF);
- chemical equilibrium (EP, SS, AA and O);

- rate of reaction (EP and AA).

The following topics in this teaching module are also treated in other modules:

- interaction of radiation with matter (EL, WM, SS, CD and MD);
- electronegativity and bond polarity (EL, PR and DP);
- reactions of radicals (PR and CD);
- interaction of carbon dioxide with water (O).

# PR The Polymer Revolution

| C3.1b, C3.2, C3.3; IT3.1 | LP3.1, LP3.2, LP3.3 |
|---|---|

## PR1 Synopsis

The story of the development of addition polymers, from the first discoveries to the present day, emphasising the chance nature of many of the discoveries. Main topics:

- what is a polymer?;
- the discovery of poly(ethene) and the properties of thermoplastics;
- different kinds of poly(ethene);
- conducting and light-emitting polymers;
- dissolving polymers.

## PR2 Learning outcomes

Candidates should be able to:

(a) show awareness of the historical development of addition polymers: discovery of poly(ethene), different kinds of poly(ethene), Ziegler-Natta catalysts, conducting and light-emitting polymers, dissolving polymers; **C3.1b, C3.2, C3.3; IT3.1**

(b) show awareness that scientific discoveries are often made by accident and give some examples of polymers discovered in this way; **C3.1b, C3.2, C3.3; IT3.1**

(c) explain and use the term: addition polymerisation;

(d) predict the structural formula of the addition polymer formed from given monomer(s), and vice versa;

(e) use systematic nomenclature to name alkenes;

(f) recognise *cis-trans* (geometric) isomers;

(g) build models and draw and interpret diagrams to represent *cis-trans* isomers; **IT3.1**

(h) describe and explain the addition reactions of alkenes with the following:

(i) bromine,

(ii) hydrogen bromide,

(iii) hydrogen in the presence of a catalyst,

(iv) water in the presence of a catalyst;

(i) explain and use the terms: addition, electrophile;

(j) explain the mechanism of the electrophilic addition reaction between bromine and alkenes;

(k) decide whether a molecule is polar or non-polar from its shape and the polarity of its bonds;

(l) describe and exemplify the following types of intermolecular forces:

(i) instantaneous dipole–induced dipole attractions,

(ii) permanent dipole–permanent dipole attractions,

(iii) hydrogen bonding;

(m) describe and explain the principal features of the molecular structure of water:

(i) bonding and shape of the water molecule,

(ii) hydrogen bonding in water and ice;

(n) explain the properties of addition polymers and other substances in terms of intermolecular attractions;

(o) explain the meaning of the terms: thermoplastic and thermoset, co-polymer;

(p) describe the meaning and significance of crystallinity in polymers;

(q) relate the typical properties of addition polymers to their molecular structure, and make predictions about the properties of a given polymer. In particular, the following factors should be considered

(i) chain length,

(ii) side-groups,

(iii) chain branching,

(iv) chain flexibility,

(v) cross-linking,

(vi) stereoregularity; **C3.2, C3.3**

(r) relate the properties of a dissolving polymer to its molecular structure;

(s) distinguish between primary, secondary and tertiary alcohols from their structures;

(t) recognise members of the following homologous series: aldehydes, ketones, carboxylic acids;

(u) describe and explain the following properties of alcohols:

(i) oxidation of alcohols to carbonyl compounds and carboxylic acids with acidified dichromate(VI) solution;

(ii) dehydration of alcohols to form alkenes;

(v) explain and use the term: elimination reaction.

## PR3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- useful products from oil (polymers).

From other teaching modules in the course:

- isomerism (DF);
- reaction mechanisms (A);
- electronegativity and bond polarity (EL).
- alcohols (DF)

## PR4 Links to Other Teaching Modules

The following topics in this teaching module are also treated in other modules:

- polymers and polymerisation (DP);
- isomerism (DF, EP and SS);
- electronegativity and bond polarity (EL, A and DP);
- intermolecular attractions and their influence on properties (DP, EP, CD and O);
- hydrogen bonding in water (O);
- reaction mechanisms (A, CD and MD);
- alcohols and carboxylic acids (WM, DP, CD and MD)
- processes in the chemical industry (VCI).

# A2 Module 2849: Chemistry of Materials

**This module replaces Module 2853 and will be assessed for the first time in January 2005.**

This module covers the following teaching sections:

WM What's in a Medicine?

DP Designer Polymers

EP Engineering Proteins

SS The Steel Story

# WM What's in a Medicine?

| | |
|---|---|
| **C3.1a, C3.2, C3.3; IT3.1** | **LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3** |

## WM1 Synopsis

A study of aspirin, its chemistry and synthesis, illustrating some of the features of the history of pharmaceuticals and the pharmaceutical industry. Main topics:

- medicines based on natural products;
- identification of the active principle of aspirin by spectroscopic methods;
- chemical aspects of aspirin;
- synthesis of salicylic acid and aspirin;
- formulation and delivery of medicines;
- development and testing of medicines.

## WM2 Learning outcomes

Candidates should be able to:

(a) recognise members of the following homologous series: phenols, acyl chlorides, esters;

(b) use systematic nomenclature to name carboxylic acids and esters;

(c) describe and explain the acidic nature of carboxylic acids;

 

(d) describe and explain the reaction of alcohols with carboxylic acids to form esters;

(e) describe and explain the following properties of phenols :

(i) acidic nature,

(ii) test with iron(III) chloride solution,

(iii) reaction of phenols with acyl chlorides to form esters;

(f) account for the increasing relative strengths as acids of alcohols, phenols and carboxylic acids;

(g) recall the technique of heating under reflux for reactions involving volatile liquids;

(h) recall the technique of thin layer chromatography (t.l.c.) and interpret results;

(i) describe how the following forms of spectroscopy can be used for the elucidation of molecular structure:

(i) mass spectrometry (m.s.),

(ii) infrared spectroscopy (i.r.);

(j) interpret mass spectra (molecular ion and significance of the fragmentation pattern) for salicylic acid and simple compounds containing a limited range of functional groups (hydroxyl, carbonyl, carboxylic acid and ester groups) given relevant information; **IT3.1**

(k) interpret infrared spectra for salicylic acid and simple compounds containing a limited range of functional groups (hydroxyl, carbonyl, carboxylic acid and ester groups) given relevant information; **IT3.1**

(l) show awareness that more effective medicines can be obtained by modifying the structure of existing medicines;

(m) show awareness of the procedures used in developing and establishing the safety of a medicine. **C3.1a, C3.2, C3.3**

## WM3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- the electromagnetic spectrum.

From other teaching modules in the course:

- interaction of radiation with matter (EL and A);
- mass spectrometry (EL);
- alcohols (DF and PR).

# WM4 Links to Other Teaching Modules

The following topics in this teaching module are developed further in other modules:

- spectroscopy (EL, EP, CD and MD);
- carboxylic acids and esters (DP, CD and MD);
- pharmaceutical chemistry (MD).

The following topics in this teaching module are also treated in other modules:

- alcohols (DF, PR, DP and MD);
- processes in the chemical industry (VCI).

# DP Designer Polymers

| C3.1, C3.2, C3.3; IT3.1 | LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3 |
|---|---|

## DP1 Synopsis

The development of condensation polymers and modern 'designer polymers'. Main topics:

- the invention of nylon, a polyamide;
- polyesters;
- aramids and Kevlar;
- designing polymers for purposes;
- the problem of disposal.

## DP2 Learning outcomes

Candidates should be able to:

(a) show awareness of the historical development of condensation polymers (polyamides and polyesters); **C3.1b, C3.2, C3.3; IT3.1**

(b) distinguish between addition and condensation polymerisation;

(c) predict the structural formula of the condensation polymer formed from given monomer(s), and vice versa;

(d) describe the hydrolysis of esters (details of mechanism are not required);

(e) recognise members of the following homologous series: amines and amides;

(f) use systematic nomenclature to name primary amines;

(g) describe and explain the characteristic properties of the amino group, including:

(i) basic nature,

(ii) acylation;

(h) describe the reaction between a primary amine and an acyl chloride to produce an amide;

(i) describe the hydrolysis of amides;

(j) recall the procedure for purifying an organic solid product;

(k) explain the properties of condensation polymers in terms of intermolecular attractions;

(l) describe and explain the effect of temperature changes on polymers;

(m) relate the properties of polymers to their molecular structure, and make predictions about the properties of a polymer;

(n) show awareness of the ways that chemists can modify the properties of a polymer by physical and chemical means (including the use of co-polymers), to meet particular needs; **C3.1b, C3.2, C3.3; PS3.1, PS3.2, PS3.3**

(o) use given data to design a polymer for a particular purpose;

(p) discuss issues relating to the disposal of polymers and the conservation of resources used in polymer manufacture. **C3.1a**

## DP3 Recommended Prior Knowledge

From other teaching modules in the course:

- polymers and polymerisation (PR);
- intermolecular attractions and their influence on properties (PR);
- relationship between structure and bonding, and properties (M and PR);
- alcohols (DF, PR and WM).

# DP4 Links to Other Teaching Modules

The following topics in this teaching module are developed further in other modules:

- amines and amides (EP);
- alcohols (DF, PR, WM and MD);
- carboxylic acids and related compounds (WM, EP and MD).

The following topics in this teaching module are also treated in other modules:

- polymers and polymerisation (PR);
- intermolecular attractions and their influence on properties (PR, EP, CD and O);
- processes in the chemical industry (VCI).

# EP Engineering Proteins

**C3.1a, C3.1b, C3.2, C3.3; N3.2, N3.3; IT3.1, IT3.2**

**WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3**

## EP1 Synopsis

The story of proteins and enzymes, the role of DNA in protein synthesis and the use of chemistry to 'engineer' proteins with specific structure and properties. Main topics:

- the biological importance of proteins;
- amino acids: the building blocks for proteins;
- enzymes;
- the structure of proteins;
- DNA: its structure and its role in protein synthesis;
- engineering proteins for particular needs.

## EP2 Learning outcomes

Candidates should be able to:

(a) recall that proteins are condensation polymers formed from amino acid monomers;

(b) recognise and describe the generalised structure of amino acids;

(c) describe the acid-base properties of amino acids and the formation of zwitterions;

(d) describe the formation and hydrolysis of the peptide link between amino acid residues in proteins and the use of paper chromatography to identify amino acids;

(e) explain the importance of amino acid sequence in determining the properties of proteins, and account for the diversity of proteins in living things;

(f) recognise stereo-isomers: *cis-trans* and optical isomers (enantiomers);

(g) explain and use the term 'chiral' as applied to a molecule;

(h) build models and draw and interpret diagrams to represent optical isomers of simple molecules; **IT3.1, IT3.2**

(i) describe how nuclear magnetic resonance spectrscopy (n.m.r.) can be used for the elucidation of molecular structure;

(j) interpret nuclear magnetic resonance spectra for simple compounds given relevant information (reference to splitting of the resonances is not required); **IT3.1**

(k) write an expression for the equilibrium constant, $K_c$, for a given homogeneous reaction;

(l) describe the way in which changes of temperature and pressure affect the magnitude of the equilibrium constant;

(m) use values of $K_c$, together with given data on equilibrium concentrations, to calculate the composition of equilibrium mixtures; **N3.2**

(n) distinguish between the primary, secondary and tertiary structure of proteins;

(o) explain the role of hydrogen bonds and other intermolecular forces in determining the structure and properties of proteins;

(p) describe the double helix structure of DNA in terms of a sugar-phosphate backbone and attached bases (recall of detailed structure is not required);

(q) explain the significance of hydrogen bonding in the pairing of bases in DNA, and relate to the replication of genetic information;

(r) explain how DNA encodes for the amino acid sequence in a protein;

(s) use empirical rate equations of the form: rate = $k[A]^m[B]^n$ where m and n are integers; **N3.2**

(t) explain and use the terms: rate of reaction, rate constant, order of reaction (both overall and with respect to a given reagent);

(u) describe experimental methods for measuring the rate of reactions;

(v) use experimental data to find the order of a reaction (zero, first or second order) **N3.2, N3.3; PS3.1, PS3.2, PS3.3**

(w) use given data to calculate half-lives for a reaction; **N3.2**

(x) show awareness of the industrial importance of enzymes; **IT3.1**

(y) describe and explain the characteristics of enzyme catalysis, including:

- (i) specificity,
- (ii) temperature and pH sensitivity,
- (iii) inhibition;

(z) account for the specificity of enzymes in terms of a simple 'lock and key' model of enzyme action;

(aa) explain in outline the technique of 'genetic engineering';

(bb) discuss applications of genetic engineering techniques. **C3.1a, C3.1b**

## EP3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- reactions involving enzymes.

From other teaching modules in the course:

- amines and amides (DP);
- carboxylic acids and derivatives (WM and DP);
- isomerism (DF and PR);
- molecular shape (EL and DF);
- intermolecular attractions and their influence on properties (PR and DP);
- chemical equilibrium (A);
- catalysis and rate of reaction (DF and A).

## EP4 Links to Other Teaching Modules

The following topics in this teaching module are developed further in other modules:

- hydrogen bonding (PR and DP);
- carboxylic acids and their derivatives (WM, DP and MD);
- spectroscopy (EL, WM, CD and MD).

The following topics in this teaching module are also treated in other modules:

- amines and amides (DP, CD and MD);
- enzymes (MD);
- isomerism (DF, PR and SS);
- chemical equilibrium (A, SS, AA and O);
- rate of reaction (A, AA and O);
- catalysis (DF, A, SS, AA and MD);
- processes in the chemical industry (VCI).

# SS The Steel Story

C3.2, C3.3; N3.2; IT3.1 | LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3

## SS1 Synopsis

An account of the production, properties and uses of steel. Main topics:

- the nature of steel;
- manufacture of steel;
- different steels for different purposes;
- redox and electrochemical cells;
- rusting and its control;
- chemistry of transition metals.

## SS2 Learning outcomes

Candidates should be able to:

(a) show awareness of the range of types, properties and uses of steel; **IT3.1**

(b) explain the importance of the composition of a steel in determining its properties; **C3.1b**

(c) describe important redox processes occurring during steelmaking (including removal of sulphur and the reactions during the oxygen blow);

(d) understand that some substances appear coloured because they absorb in specific parts of the visible spectrum;

(e) use colorimetric measurements to determine the concentration of a coloured solution; **N3.2; PS3.1, PS3.2, PS3.3**

(f) recall the procedure for carrying out a simple redox titration involving manganate(VII) ions and be able to work out the results; **N3.2**

(g) recall that transition metals are *d*-block elements forming one or more stable ions which have incompletely filled *d* orbitals;

(h) describe the typical properties of transition metals, exemplified by the first row of the *d* block with particular reference to iron and copper, including:

  (i) the existence of more than one oxidation state for each element in its compounds,

  (ii) the formation of coloured ions in solution,

(iii) reactions with ligands to form complexes and reactions involving ligand substitution,

(iv) the catalytic behaviour of the elements and their compounds;

(i) describe the reactions of $Fe^{2+}$(aq), $Fe^{3+}$(aq) and $Cu^{2+}$(aq) ions with sodium hydroxide solution and ammonia solution;

(j) explain the variable oxidation states of transition metals in terms of electronic energy levels;

(k) explain the catalytic activity of transition metals and their compounds in terms of variable oxidation states;

(l) explain and use the terms: ligand, complex/complex ion, ligand exchange;

(m) describe the formation of complexes in terms of bonding between ligand and central metal ion;

(n) explain the term polydentate as applied to ligands, exemplified by $edta^{4-}$;

(o) discuss the shapes of complexes with coordination numbers 4 and 6;

(p) relate ligand exchange reactions of complexes to stability constants;

(q) describe redox reactions of *d*-block elements in terms of electron transfer by:

(i) using half-equations to represent the oxidation and reduction reactions,

(ii) combining half-equations to give the overal equation for the reaction;

(r) describe the construction of simple electrochemical cells involving:

(i) metal ion/metal half-cells,

(ii) half-cells based on different oxidation states of the same element in aqueous solution;

(s) explain and use the term: standard electrode potential;

(t) describe and explain how a standard electrode potential is measured;

(u) explain the action of an electrochemical cell in terms of half-equations and external electron flow;

(v) use standard electrode potentials to calculate $E_{\text{cell}}$ ; **N3.2**

(w) use standard electrode potentials to predict the feasibility of redox reactions;

(x) use standard electrode potentials to predict the relative stability of oxidation states;

(y) describe rusting in terms of electrochemical processes involving iron and oxygen, and the subsequent reactions to form rust;

(z) describe and explain:

(i) approaches to corrosion prevention;

(ii) issues involved in the recycling of iron. **C3.2,C3.3**

# SS3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- useful products from metal ores and rocks.

From other teaching modules in the course:

- extraction of metals (M);
- metallic bonding (EL);
- atomic emission spectra (EL);
- chemical equilibrium (A and EP);
- redox (M);
- catalysis (DF, A and EP);
- molecular shape (EL, DF, PR and EP).

# SS4 Links to Other Teaching Modules

The following topics in this teaching modules are developed further in other modules:

- atomic emission spectra (EL);
- chemical equilibrium (A, EP, AA and O).

The following topics in this teaching module are also covered in other modules:

- extraction of metals (M);
- oxidation numbers and redox reactions (M);
- catalysis (DF, A, EP and AA);
- processes in the chemical industry (VCI).

# A2 Module 2854: Chemistry by Design

**The revised version of this module will be assessed for the first time in January 2005**

This module covers the following teaching sections:

AA Aspects of Agriculture

CD Colour by Design

O The Oceans

MD Medicines by Design

# AA Aspects of Agriculture

| | |
|---|---|
| **C3.1, C3.2, C3.3; N3.2; IT3.1, IT3.2** | **WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3** |

## AA1 Synopsis

A study of the contribution that chemists make towards ensuring a safe and sufficient food supply. Main topics:

- nutrient needs of crops;
- the fate of nutrients in the soil;
- redox chemistry of the nitrogen cycle;
- manufacture of nitrogenous fertilisers;
- designing pesticide molecules to perform specific functions;
- the fate of pesticides in the soil: degradation and accumulation.

## AA2 Learning outcomes

Candidates should be able to:

(a) discuss ways in which chemists can help improve food production, including:

(i) providing extra nutrients,

(ii) controlling soil pH,

(iii) controlling pests; **C3.2,C3.3**

(b) recall the qualitative effect of temperature on the rate constant of a reaction; **PS3.1, PS3.2, PS3.3**

(c) discuss the redox reactions involved in the interconversion of the following species in the nitrogen cycle:

(i) nitrogen gas,

(ii) nitrate(V) ion,

(iii) nitrate(III) ion,

(iv) ammonium ion,

(v) dinitrogen oxide($N_2O$), nitrogen monoxide(NO), nitrogen dioxide($NO_2$);

(d) describe in outline the manufacture of ammonia in the Haber Process, giving essential conditions; **IT3.1**

(e) use given data to evaluate the most economical operating conditions for an industrial process such as the Haber Process, using principles of equilibrium and rates of reactions;

(f) write an expression for the equilibrium constant, $K_p$, for reactions involving gases (in terms of partial pressures);

(g) use values of $K_p$, together with given data on partial pressures, to carry out simple calculations concerning the composition of equilibrium mixtures; **N3.2**

(h) describe and explain, in terms of structure and bonding, the trends in reactions of the elements and properties of compounds across a period, including:

(i) the reactions of the elements with oxygen, chlorine and water,

(ii) the acid-base character of oxides,

(iii) the behaviour of chlorides towards water; **IT3.1, IT3.2**

(i) recall that there is a relationship between the structure and bonding of a substance and its properties, and relate the properties of substances to their structure and bonding;

(j) interpret given data in terms of the structure and bonding of a substance;

(k) describe and explain the partition equilibrium that occurs when a solute is distributed between two immiscible solvents; **N3.2**

(l) explain the role of chemistry in the design of pesticides that combine maximum efficacy with minimum environmental damage. **C3.1a**

## AA3 Recommended Prior Knowledge

From Key Stage 4 Science Double Award:

- useful products from air.

From other teaching modules in the course:

- the Periodic Table and periodicity (EL and M);
- relationship between structure and bonding, and properties (M, PR, DP, and EP);
- chemical equilibrium (A, EP, SS and O);
- redox (M and SS);
- rate of reaction (A and EP);
- organic functional groups (DF, A, PR, WM, DP and EP).

## AA4 Links to Other Teaching Modules

The following topics in this teaching module are also treated in other modules:

- catalysis and rate of reaction (DF, A, EP and SS);
- chemical equilibrium (A, EP, SS and O);
- pH and buffer solutions (O);
- volumetric analysis (M, A and SS);
- oxidation states (M and SS);
- esters (WM, DP and MD);
- the Periodic Table and periodicity (EL, M, SS and O);
- processes in the chemical industry (VCI).

# CD Colour by Design

| C3.2, C3.3; IT3.1, IT3.2 | LP3.1, LP3.2, LP3.3 |
|---|---|

## CD1 Synopsis

The chemical basis of colour, in pigments, paints and dyes, and the use of chemistry to provide colours to order. Main topics:

- the chemical origins of colour;
- aromatic compounds;
- paints and pigments;
- chemistry in the art gallery: analysing pigments and oils, restoring paintings;
- dyes and dyeing.

## CD2 Learning outcomes

Candidates should be able to:

(a) explain the absorption of ultraviolet light and visible light in terms of transitions between electronic energy levels;

(b) use ultraviolet (u.v.) and visible spectroscopy to help identify unsaturated organic molecules; **IT3.1, IT3.2**

(c) recall that colour changes may be associated with the following chemical changes:

(i) acid-base (indicators),

(ii) ligand exchange,

(iii) redox,

(iv) precipitation,

(v) polymorphism (different crystal structures);

(d) relate the desirable properties of pigments (such as colour shade, colour intensity, fastness) to relevant properties;

(e) outline the general principles of gas-liquid chromatography (g.l.c.);

(f) show awareness of the techniques used to identify the materials used in a painting, including:

  (i) gas-liquid chromatography,

  (ii) atomic emission spectroscopy,

  (iii) visible spectroscopy (reflection and transmission); **C3.2,3.3**

(g) given relevant information, interpret results from analytical techniques used to identify components of unknown materials, such as those used in paintings;

(h) recall that fats and oils consist mainly of mixed esters of propane-1,2,3-triol with varying degrees of unsaturation;

(i) describe in general terms the process of oxidative cross-linking by which unsaturated oils harden, and relate to their use as media in oil-based paints;

(j) recognise arenes and arene derivatives (aromatic compounds);

(k) relate the characteristic properties of aromatic compounds to the delocalisation of electrons in the benzene ring;

(l) describe and explain the following electrophilic substitution reactions of arenes:

  (i) halogenation of the ring,

  (ii) nitration,

  (iii) sulphonation,

  (iv) Friedel-Crafts alkylation,

  (v) Friedel-Crafts acylation;

(m) describe and explain the formation of azo dyes by coupling reactions involving diazonium compounds;

(n) describe and explain the structure of a dye molecule in terms of its functional components: chromophore, groups which modify the chromophore, groups which affect the solubility of the dye, groups which attach the dye to the fibre;

(o) explain, in terms of intermolecular forces, ionic attractions and covalent bonding, how some dyes attach themselves to fibres;

(p) relate the colour of a dye to the presence of a chromophore, and groups that modify the chromophore, in the dye molecule.

## CD3 Recommended Prior Knowledge

From other teaching modules in the course:

- interaction of radiation with matter (EL, A, WM and SS);
- atomic emission spectra (EL and SS);
- organic functional groups (DF, A, PR, WM, DP and EP);
- reaction mechanisms (A and PR);
- intermolecular attractions and their influence on properties (PR, DP and EP);
- relationship between structure and bonding, and properties (M, PR, DP, EP and AA).

## CD4 Links to Other Teaching Modules

The following topics in this teaching module are also treated in other modules:

- interaction of radiation with matter (EL, A, WM and SS);
- spectroscopy (EL, WM and MD);
- intermolecular attractions and their influence on properties (PR, DP, EP and O);
- aromatic compounds (WM, DP, AA and MD).

# O The Oceans

| N3.2, N3.3 | LP3.1, LP3.2, LP3.3 |
|---|---|

## O1 Synopsis

The story of the oceans: their role in regulating the climate, in forming rocks and in supporting life. Main topics:

- oceans and climate;
- the special properties of water;
- solids from the oceans: salt and calcium carbonate;
- dissolving and precipitation;
- acid-base processes in the oceans;
- oceans and the history of life.

## O2 Learning outcomes

Candidates should be able to:

(a) describe the factors determining the relative solubility of a solute in aqueous and non-aqueous solvents;

(b) explain and use the terms: enthalpy change of solution, lattice enthalpy, enthalpy of solvation (hydration);

(c) describe the solution of an ionic solid in terms of an enthalpy cycle involving enthalpy change of solution, lattice enthalpy and enthalpies of solvation (hydration) of ions;

(d) use enthalpy cycles to perform calculations involving enthalpy change of solution, lattice enthalpy and enthalpy of solvation (hydration); **N3.2**

(e) explain the factors determining the radii of anions and cations, including atomic number, charge and hydration, and relate ionic size to properties;

(f) construct and use a Born-Haber cycle for a simple ionic compound;

(g) discuss entropy changes in a qualitative manner, interpreting entropy as a measure of the number of ways that molecules and their associated energy quanta can be arranged;

(h) discuss qualitatively the process of dissolving in terms of energy and entropy factors;

(i) interpret the tendency of a process to occur in terms of entropy changes in the system ($\Delta S_{sys}$) and surroundings ($\Delta S_{surr}$), and the requirement that the total entropy change ($\Delta S_{total}$) should be positive;

(j) calculate entropy changes using the expression: $\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$ ; **N3.2**

(k) calculate the entropy change for a reaction given the entropies of the reactants and products;

(l) compare the following properties of water to those of other liquids, and other hydrides of Group 6 elements, and relate them to molecular structure:

- (i) specific heating capacity,
- (ii) enthalpy change of vaporisation,
- (iii) density changes on melting;

(m) account for the influence of oceans on climate in terms of the characteristic properties of water;

(n) explain and use the following terms: strong acid and strong base, pH;

(o) explain the significance of the ionic product of water, $K_w$ ;

(p) use given data to calculate the pH of solutions of strong acids and strong bases; **N3.2**

(q) explain and use the following terms: weak acid, acidity constant $K_a$ , p$K_a$;

(r) use given data to calculate the pH of solutions of weak acids; **N3.2**

(s) explain the action of buffer solutions;

(t) describe applications of buffer solutions;

(u) use given data to calculate the pH of a buffer solution; **N3.2**

(v) explain and use the term solubility product for simple ionic compounds of formula $X^{n+}Y^{n-}$;

(w) use solubility products quantitatively to perform calculations concerning dissolving and precipitation processes; **N3.2**

(x) interpret acid-base and precipitation processes in the oceans in terms of $K_a$ and $K_{sp}$;

(y) discuss the global influence of the processes occurring when carbon dioxide dissolves in water.

## O3 Assumed Prior Knowledge

From other teaching modules in the course:

- intermolecular attractions and their influence on properties (PR, DP and EP);
- solvation (hydration) of ions (M);
- enthalpy changes (DF and A);

- molecular kinetic theory (A);
- simple ideas of entropy (DF);
- chemical equilibrium (A, EP, SS and AA);
- acids and bases (M).

## O4 Links to Other Teaching Modules

The following topics in this teaching module are also treated in other modules:

- entropy (DF);
- solvation (hydration) of ions (M);
- chemical equilibrium (A, EP, SS and AA);
- interaction of carbon dioxide with water (A);
- acid-base reactions (M).

# MD Medicines by Design

| | |
|---|---|
| **C3.2, C3.3; IT3.1, IT3.2** | **LP3.1, LP3.2, LP3.3; PS3.1, PS3.2, PS3.3** |

## MD1 Synopsis

An account of the way chemical principles and techniques are used to investigate the effects of chemicals on the body, and to design and make pharmaceutical substances to meet specific needs. Main topics:

- the different kinds of chemicals that enter the body, and their effects;
- alcohol: a drug, a poison and a food;
- the effect of ethanol on the nervous system;
- molecular recognition: the basis of pharmacological activity;
- computer modelling and design of drugs;
- synthesis: making molecules to order
- using spectroscopic techniques to elucidate structure.

## MD2 Learning outcomes

Candidates should be able to:

(a) show awareness of the chemical principles behind methods which can be used to detect ethanol in the body (g.l.c. and i.r. spectroscopy);

(b) describe the following reactions involving aldehydes and ketones:

  (i) formation by oxidation of alcohols,

  (ii) oxidation to carboxylic acids,

  (iii) reduction to alcohols,

  (iv) reaction with hydrogen cyanide;

(c) explain the mechanism of the nucleophilic addition reaction between an aldehyde or a ketone and hydrogen cyanide;

(d) describe the structure of a pharmacologically active material in terms of its functional components: pharmacophore and groups which modify the pharmacophore;

(e) relate the action of biologically active chemicals to their interaction with receptor sites;

(f) discuss the factors affecting the way that species interact in three dimensions:

   (i) size,

   (ii) shape,

   (iii) bond formation,

   (iv) orientation;

(g) show awareness of the role of chemists in designing and making new compounds for use as pharmaceuticals; **C3.2,C3.3**

(h) show awareness of the application of computer modelling techniques in the design of medicines; **IT3.1**

(i) identify individual functional groups within a polyfunctional molecule, and hence make predictions about its properties;

(j) use knowledge of organic reactions mentioned elsewhere in these specifications (AS and A2), together with any further given reactions, to devise synthetic routes for preparing organic compounds;

(k) use the following terms to classify organic reactions: hydrolysis, oxidation, reduction, condensation, elimination;

(l) classify organic reactions according to their reactions mechanisms: nucleophilic substitution, electrophilic addition, electrophilic substitution, nucleophilic addition, radical;

(m) use a combination of spectroscopic techniques (m.s., i.r., n.m.r. and u.v. and visible) to elucidate the structure of organic molecules. **IT3.1, IT3.2; PS3.1, PS3.2, PS3.3**

## MD3 Assumed Prior Knowledge

From other teaching modules in the course:

- organic functional groups (units DF, A, WM, PR, DP, EP and CD);
- reaction mechanisms (units A, PR, and CD);
- proteins and enzymes (unit EP);
- molecular shape (units EL, DF and EP);
- molecular recognition (unit EP);
- chromatography (t.l.c. and g.l.c) (units DF, WM, AA and CD);
- spectroscopy (units EL, WM, EP, SS and CD).

# MD4 Links to Other Teaching Modules

The following topics in this teaching module are also treated in other modules:

- reactions of organic functional groups (DF, A, WM, PR, DP, EP and CD);
- alcohols (DF, WM and DP);
- enthalpy change of combustion (DF);
- proteins and enzymes (EP);
- interpretation of spectroscopic and g.l.c. data (EL, DF, WM, EP and CD);
- pharmaceutical chemistry (WM );
- processes in the chemical industry (VCI).

# VCI Visiting the Chemical Industry

| C3.1, C3.2, C3.3; IT3.1, IT3.2, IT3.3 | WO3.1, WO3.2, WO3.3; LP3.1, LP3.2, LP3.3 |
|---|---|

This teaching section supports the industrial aspects of AS and A2 modules

## VCI 1 Synopsis

A study of chemical manufacturing processes showing how chemical principles can be applied to optimise efficiency and safety and to minimise environmental damage and economic cost. This section centres on a structured visit to an industry or another place where chemistry is applied. Main topics:

- the characteristics of effective and successful chemical manufacturing processes;
- consideration of these characteristics in the context of processes met elsewhere in the course.

## VCI 2 Content

Candidates should be able to:

(a) describe the stages in the manufacture of a new product: research, pilot study, scaling-up, production, review;

(b) describe the characteristics of effective and successful chemical processes in terms of:

(i) raw materials and feedstock,

(ii) batch or continuous process,

(iii) rate, including use of catalysts,

(iv) product yield,

(v) nature of co–products and by-products,

(vi) waste disposal and effluent control,

(vii) location,

(viii) safety,

(ix) cost;

(c) use knowledge and understanding of chemical principles and processes to discuss and evaluate the factors mentioned in (b);

(d) use information concerning the chemical properties of reactants and products to discuss suitable materials for the construction of a chemical plant;

(e) show awareness that control of pollution from chemical plants has economic implications, and discuss associated issues.

## VCI 3 Links to Other Units

This teaching module links to the treatment of industrial processes in several other modules, including units DF, M, PR, WM, DP, EP, SS, AA and MD.

# 5.3 Content Organised by Chemical Principles

## 5.3.1 Amount of Substance

**N3.2**

Candidates should be able to:

(a) use the concept of amount of substance to perform calculations involving:

- (i) masses of substances, empirical and molecular formulae, percentage composition (**AS**, EL),
- (ii) volumes of gases, balanced chemical equations, enthalpy changes (**AS**, DF),
- (iii) concentrations of solutions (**AS**, M);

(b) understand values for composition by volume measured in percentage concentration and in parts per million (ppm) (**AS**, A);

(c) recall the procedure for carrying out the following volumetric titrations, and be able to work out the results:

- (i) an acid-alkali titration (**AS**, M),
- (ii) a simple redox titration involving manganate(VII) ions (**A2**, SS).

## 5.3.2 Chemical reactions

Candidates should be able to:

(a) write and interpret balanced chemical equations (**AS**, EL);

(b) write ionic equations to represent precipitation reactions and other reactions involving ionic compounds (**AS**, M);

(c) recognise from the balanced equation for a reaction whether it is an acid-base, redox or precipitation reaction (**AS**, M).

## 5.3.3 Atomic Structure

Candidates should be able to:

(a) describe protons, neutrons and electrons in terms of their mass and relative charge (**AS**, EL);

(b) describe the structure of atoms in terms of protons, neutrons and electrons (**AS**, EL);

(c) explain and use the terms: atomic number, mass number, isotope, Avogadro constant, relative isotopic mass, relative atomic mass, relative formula mass, relative molecular mass (**AS**, EL);

(d) use data from a mass spectrometer to determine relative atomic mass and the relative abundance of isotopes (**AS**, EL);

(e) outline the formation of elements in stars by nuclear fusion processes (**AS**, EL);

(f) recall that the nuclei of some atoms are unstable, and that these atoms are radioactive (**AS**, EL);

(g) recall the different properties of alpha, beta and gamma radiations (**AS**, EL);

(h) use nuclear symbols to write equations for nuclear processes, both fusion and radioactive decay (**AS**, EL);

(i) explain the use of radioactive tracers (**AS**, EL);

(j) use conventions for representing the distribution of electrons in atomic orbitals (no treatment of the shapes of orbitals is expected) (**AS**, M);

(k) deduce (given the atomic number) the electron configuration of atoms from hydrogen to krypton in terms of main energy levels and *s*, *p* and *d* atomic orbitals (**AS**, M).

## 5.3.4 Structure and Bonding

Candidates should be able to:

(a) draw and use simple electron 'dot-cross' diagrams to show how atoms bond through ionic, covalent and dative covalent bonds (**AS**, EL);

(b) describe a simple model of metallic bonding (**AS**, EL);

(c) relate ease of ion formation to ionisation enthalpy (**AS**, EL);

(d) write equations for the first and successive ionisation enthalpies of an element (**AS**, EL);

(e) describe the structure of an ionic lattice, exemplified by sodium chloride (**AS**, M);

(f) explain the factors determining the radii of anions and cations, including atomic number, charge and hydration, and relate ionic size to properties (**A2**, O ~~AA~~);

(g) use the electron pair repulsion principle to predict the shapes of simple molecules (such as $CH_4$, $NH_3$ and $H_2O$) and ions (such as $NH_4^+$) with up to four outer pairs of electrons (any combination of bonding pairs and lone pairs) (no treatment of hybridisation or molecular orbitals is expected) (**AS**, EL);

(h) explain molecular shape in terms of bond angles (**AS**, EL);

(i) describe examples of giant covalent (network) structures, such as diamond and silicon(IV) oxide (**AS**, M);

(j) use relative electronegativity values to predict bond polarity in a covalent bond (**AS**, A);

(k) decide whether a molecule is polar or non-polar from its shape and the polarity of its bonds (**AS**, PR);

(l) describe and exemplify the following types of intermolecular forces:

 (i) instantaneous dipole–induced dipole attractions,

 (ii) permanent dipole–permanent dipole attractions,

 (iii) hydrogen bonding (**AS**, PR);

(m) explain the properties of addition polymers and other substances in terms of intermolecular attractions (**AS**, PR);

(n) explain the properties of condensation polymers in terms of intermolecular attractions (**A2**, DP);

(o) explain the role of hydrogen bonds and other intermolecular forces in determining the structure and properties of proteins (**A2**, EP);

(p) recall that there is a relationship between the structure and bonding of a substance and its properties, and relate the properties of substances to their structure and bonding (**A2**, AA);

(q) interpret given data in terms of the structure and bonding of a substance (**A2**, AA);

(r) explain, in terms of intermolecular forces, ionic attractions and covalent bonding, how some dyes attach themselves to fibres (**A2**, CD).

## 5.3.5 Thermochemistry

**C3.1a; N3.2, N3.3; IT3.2**

Candidates should be able to:

(a) explain and use the terms: exothermic, endothermic, standard state, enthalpy change of combustion, enthalpy change of reaction, enthalpy change of formation (**AS**, DF);

(b) interpret the pattern of enthalpy changes of combustion for successive members of an homologous series (**AS**, DF);

(c) calculate enthalpy changes from experimental results (**AS**, DF);

(d) use Hess's Law and enthalpy cycles to calculate enthalpy changes (**AS**, DF);

(e) recall that bond-breaking is an endothermic process and bond-making is exothermic (**AS**, DF);

(f) explain and use the term: bond enthalpy (**AS**, DF);

(g) relate bond enthalpy to the length and strength of a bond (**AS**, DF);

(h) discuss the desirable properties of a fuel (**AS**, DF);

(i) discuss entropy changes in a qualitative manner, interpreting it as a measure of the number of ways that molecules can be arranged (**AS**, DF);

(j) show awareness of the differences in magnitude of the entropy of a solid, a liquid, a solution and a gas (**AS**, DF);

(k) discuss entropy changes in a qualitative manner, interpreting entropy as a measure of the number of ways that molecules and their associated energy quanta can be arranged (**A2**, O);

(l) interpret the tendency of a process to occur in terms of entropy changes in the system ($\Delta S_{sys}$) and surroundings ($\Delta S_{surr}$), and the requirement that the total entropy change ($\Delta S_{total}$) should be positive (**A2**, O);

(m) calculate entropy changes using the expression: $\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$ (**A2**, O);

(n) calculate the entropy change for a reaction given the entropies of the reactants and products (**A2**, O);

(o) construct and use a Born-Haber cycle for a simple ionic compound (**A2**, O).

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## 5.3.6 Photochemistry

**N3.2; IT3.1**

Candidates should be able to:

(a) recall that rotational, vibrational and electronic energies are quantised (**AS**, A);

(b) describe qualitatively the changes in rotational, vibrational and electronic energy caused by the absorption of radiation of appropriate frequency (**AS**, A);

(c) use the equation $E = hv$ to relate quantitatively the frequency and energy of electromagnetic radiation (**AS**, A);

(d) use given data about absorption ranges to make predictions about the effect of substances on radiation (**AS**, A);

(e) explain how ozone acts as a sunscreen in the stratosphere (**AS**, A);

(f) recall the gases present in the atmosphere, including some major pollutants (**AS**, A);

(g) relate the ‘greenhouse effect’ in the troposphere to the absorption characteristics of atmospheric gases (**AS**, A);

(h) understand that some substances appear coloured because they absorb in specific parts of the visible spectrum (**A2**, SS);

(i) use colorimetric measurements to determine the concentration of a coloured solution (**A2**, SS);

(j) explain the absorption of ultraviolet light and visible light in terms of transitions between electronic energy levels (**A2**, CD);

(k) recall that colour changes may be associated with the following chemical changes:

- (i) acid-base (indicators),
- (ii) ligand exchange,
- (iii) redox,
- (iv) precipitation,
- (v) polymorphism (different crystal structures) (**A2**, CD);

(l) relate the desirable properties of pigments (such as colour shade, colour intensity, fastness) to relevant properties (**A2**, CD);

(m) describe and explain the structure of a dye molecule in terms of its functional components: chromophore, groups which modify the chromophore, groups which affect the solubility of the dye, groups which attach the dye to the fibre (**A2**, CD);

(n) relate the colour of a dye to the presence of a chromophore, and groups that modify the chromophore, in the dye molecule (**A2**, CD).

## 5.3.7 Spectroscopy and Chromatography

**C3.2, C3.3; IT3.1, IT3.2**

Candidates should be able to:

(a) explain the occurrence of absorption and emission atomic spectra (**AS**, EL);

(b) interpret the atomic emission spectrum of hydrogen in terms of changes in electronic energy levels (**AS**, EL);

(c) describe the elementary principles underlying the operation of a mass spectrometer (**AS**, EL);

(d) describe how the following forms of spectroscopy can be used for the elucidation of molecular structure:

- (i) mass spectrometry (m.s.),
- (ii) infrared spectroscopy (i.r.) (**A2**, WM);

(e) interpret mass spectra (molecular ion and significance of the fragmentation pattern) for salicylic acid and simple compounds containing a limited range of functional groups (hydroxyl, carbonyl, carboxylic acid and ester groups) given relevant information **(A2** WM);

(f) interpret infrared spectra for salicylic acid and simple compounds containing a limited range of functional groups (hydroxyl, carbonyl, carboxylic acid and ester groups) given relevant information (**A2** WM);

(g) recall the technique of thin layer chromatography (t.l.c.), and interpret results (**A2** WM);

(h) describe how nuclear magnetic resonance spectrscopy (n.m.r.) can be used for the elucidation of molecular structure (**A2**, EP);

(i) interpret nuclear magnetic resonance spectra for simple compounds given relevant information (reference to splitting of the resonances is not required) (**A2**, EP);

(j) outline the general principles of gas-liquid chromatography (g.l.c.) (**A2**, CD);

(k) use ultraviolet (u.v.) and visible spectroscopy to help identify unsaturated organic molecules (**A2**, CD);

(l) show awareness of the techniques used to identify the materials used in a painting, including:

  (i) gas-liquid chromatography,

  (ii) atomic emission spectroscopy,

  (iii) visible spectroscopy (reflection and transmission) (**A2**, CD);

(m) given relevant information, interpret results from analytical techniques used to identify components of unknown materials, such as those used in paintings (**A2**, CD);

(n) show awareness of the chemical principles behind methods which can be used to detect ethanol in the body (g.l.c. and i.r. spectroscopy) (**A2**, MD);

(o) use a combination of spectroscopic techniques (m.s., i.r., n.m.r. and u.v. and visible) to elucidate the structure of organic molecules (**A2**, MD).

## 5.3.8 Chemical equilibrium

**C3.1b; N3.2**

Candidates should be able to:

(a) explain and apply the term, dynamic equilibrium (**AS**, A);

(b) use Le Chatelier's Principle to explain and predict, in a homogeneous reaction, the qualitative effects on the position of equilibrium of changes in the following conditions

  (i) concentration,

  (ii) temperature,

(iii) pressure (**AS**, A);

(c) write an expression for the equilibrium constant, $K_c$, for a given homogeneous reaction (**A2**, EP);

(d) describe the way in which changes of temperature and pressure affect the magnitude of the equilibrium constant (**A2**, EP);

(e) use values of $K_c$, together with given data on equilibrium concentrations, to calculate the composition of equilibrium mixtures (**A2**, EP);

(f) write an expression for the equilibrium constant, $K_p$, for reactions involving gases (in terms of partial pressures) (**A2**, AA);

(g) use values of $K_p$, together with given data on partial pressures, to carry out simple calculations concerning the composition of equilibrium mixtures (**A2**, AA);

(h) recall that acid-base reactions involve proton transfer (**AS**, M);

(i) identify the proton donor and proton acceptor in an acid-base reaction (**AS**, M);

(j) explain and use the following terms: strong acid and strong base, pH (**A2**, O);

(k) explain the significance of the ionic product of water, $K_w$ (**A2**, O);

(l) use given data to calculate the pH of solutions of strong acids and strong bases (**A2**, O);

(m) explain and use the following terms: weak acid, acidity constant $K_a$ , p$K_a$ (**A2**, O);

(n) use given data to calculate the pH of solutions of weak acids (**A2**, O);

(o) explain the action of buffer solutions (**A2**, O);

(p) describe applications of buffer solutions (**A2**, O);

(q) use given data to calculate the pH of a buffer solution (**A2**, O);

(r) explain and use the term solubility product for simple ionic compounds of formula $X^{n+}Y^{n-}$ (**A2**, O);

(s) use solubility products quantitatively to perform calculations concerning dissolving and precipitation processes (**A2**, O);

(t) interpret acid-base and precipitation processes in the oceans in terms of $K_a$ and $K_{sp}$ (**A2**, O).

## 5.3.9 Solutions

| **N3.2** | |
|---|---|

Candidates should be able to:

(a) describe the hydration of ions in aqueous solution (**AS**, M);

(b) describe and explain the partition equilibrium that occurs when a solute is distributed between two immiscible solvents (**A2**, AA);

(c) describe the factors determining the relative solubility of a solute in aqueous and non-aqueous solvents (**A2**, O);

(d) explain and use the terms: enthalpy change of solution, lattice enthalpy, enthalpy of solvation (hydration) (**A2**, O);

(e) describe the solution of an ionic solid in terms of an enthalpy cycle involving enthalpy change of solution, lattice enthalpy and enthalpies of solvation (hydration) of ions (**A2**, O);

(f) use enthalpy cycles to perform calculations involving enthalpy change of solution, lattice enthalpy and enthalpy of solvation (hydration) (**A2**, O);

(g) discuss quantitatively the process of dissolving in terms of energy and entropy factors (**A2**, O).

## 5.3.10 Rate of reaction

| **N3.2,N3.3** | |
|---|---|

Candidates should be able to:

(a) explain and use the terms catalysis, catalyst, catalyst poison (**AS**, DF);

(b) outline a simple model to explain the function of a heterogeneous catalyst (**AS**, DF);

(c) show awareness of the use of catalysts in isomerisation, reforming and cracking processes and in the control of exhaust emissions (**AS**, DF);

(d) recall the factors that affect the rate of a chemical reaction and use collision theory to give simple explanations (**AS**, A);

(e) explain and use the terms: enthalpy profile, activation enthalpy (**AS**, A);

(f) use the concept of activation enthalpy to explain the qualitative effect of temperature changes on rate of reaction (**AS**, A);

(g) explain the role of catalysts in providing alternative routes of lower activation enthalpy (**AS**, A);

(h) outline a simple model to explain homogeneous catalysis in terms of the formation of intermediates (**AS**, A);

(i) use empirical rate equations of the form: rate = $k[A]^m[B]^n$ where m and n are integers (**A2**, EP);

(j) explain and use the terms: rate of reaction, rate constant, order of reaction (both overall and with respect to a given reagent) (**A2**, EP);

(k) describe experimental methods for measuring the rate of reactions (**A2**, EP);

(l) use experimental data to find the order of a reaction (zero, first or second order) (**A2**, EP);

(m) use given data to calculate half-lives for a reaction (**A2**, EP);

(n) describe and explain the characteristics of enzyme catalysis, including:

  (i) specificity,

  (ii) temperature and pH sensitivity,

  (iii) inhibition (**A2**, EP);

(o) explain the catalytic activity of transition metals and their compounds in terms of variable oxidation states (**A2**, SS);

(p) recall the qualitative effect of temperature on the rate constant of a reaction (**A2**, AA).

## 5.3.11 Redox

| **N3.2** | |
|---|---|

Candidates should be able to:

(a) assign oxidation states to the elements in a compound (**AS**, M);

(b) use oxidation states to decide which species have been oxidised and which reduced in a redox reaction (**AS**, M);

(c) describe redox reactions of *s*- and *p*-block elements in terms of electron transfer, using half-equations to represent the oxidation and reduction reactions (**AS**, M);

(d) describe redox reactions of *d*-block elements in terms of electron transfer,

  (i) using half-equations to represent the oxidation and reduction reactions (**A2**, SS),

  (ii) combining half-equations to give the overall equation for the reaction;

(e) describe the construction of simple electrochemical cells involving:

  (i) metal ion/metal half-cells,

(ii) half-cells based on different oxidation states of the same element in aqueous solution (**A2**, SS);

(f) explain and use the term: standard electrode potential (**A2**, SS);

(g) describe and explain how a standard electrode potential is measured (**A2**, SS);

(h) explain the action of an electrochemical cell in terms of half-equations and external electron flow (**A2**, SS);

(i) use standard electrode potentials to calculate $E_{cell}$ (**A2**, SS);

(j) use standard electrode potentials to predict the feasibility of redox reactions (**A2**, SS);

(k) use standard electrode potentials to predict the relative stability of oxidation states (**A2**, SS).

## 5.3.12 Periodicity

**C3.1b; IT3.1, IT3.2**

Candidates should be able to:

(a) recall that the Periodic Table lists elements in order of atomic (proton) number and groups elements together according to their common properties (**AS**, EL);

(b) understand the way that ideas behind the Periodic Table developed historically (**AS**, EL);

(c) relate the position of an element in the Periodic Table to its electron structure (in terms of electron shells) and vice versa (**AS**, EL);

(d) interpret periodic trends in the properties of elements, in terms of:

(i) melting point and boiling point,

(ii) electrical conductivity,

(iii) ionisation enthalpy (**AS**, EL);

(e) use given data to describe trends in a group of the Periodic Table and to make predictions concerning the properties of an element in the group (**AS**, EL);

(f) recall the classification of elements into *s*, *p* and *d* blocks (**AS**, M);

(g) describe and explain, in terms of structure and bonding, the trends in reactions of the elements and properties of compounds across a period, including:

(i) the reactions of the elements with oxygen, chlorine and water,

(ii) the acid-base character of oxides,

(iii) the behaviour of chlorides towards water (**A2**, AA).

## 5.3.13 Group 2

Candidates should be able to

(a) describe and compare the following properties of the elements Mg, Ca, Sr, Ba in Group 2:

(i) reaction of the elements with water,

(ii) acid-base character of the oxides and hydroxides,

(iii) thermal stability of the carbonates,

(iv) solubility of the hydroxides and carbonates (**AS**, EL).

## 5.3.14 Group 4

**C3.1a, C3.2, C3.3**

Candidates should be able to:

(a) interpret differences in the physical properties of $CO_2$ and $SiO_2$ in terms of their different structures (**AS**, M);

(b) discuss and evaluate different approaches to the control of global warming through the control of carbon dioxide emissions (**AS**, A);

(c) describe the physical and chemical changes occurring when carbon dioxide dissolves in water and the associated equilibria (**AS**, A);

(d) discuss the global influence of the processes occurring when carbon dioxide dissolves in water (**A2**, O).

## 5.3.15 Group 5

Candidates should be able to:

(a) explain the formation of nitrogen monoxide (NO) in an internal combustion engine (**AS**, DF);

(b) discuss the redox reactions involved in the interconversion of the following species in the nitrogen cycle:

(i) nitrogen gas,

(ii) nitrate(V) ion,

(iii) nitrate(III) ion,

(iv) ammonium ion,

(v) dinitrogen oxide($N_2O$), nitrogen monoxide(NO), nitrogen dioxide($NO_2$) (**A2**, AA).

## 5.3.16 Group 6

Candidates should be able to:

(a) recall the structure and reactivity of ozone and the way it is formed and destroyed in the stratosphere (**AS**, A);

(b) describe the chemical basis of the depletion of ozone in the stratosphere due to halogenoalkanes, in simple terms involving the formation of halogen atoms and the catalytic role of these atoms in ozone destruction (**AS**, A);

(c) describe and explain the principle features of the molecular structure of water :

(i) bonding and shape of the water molecule,

(ii) hydrogen bonding in water and ice (**AS**, PR);

(d) compare the following properties of water to those of other liquids, and other hydrides of Group 6 elements, and relate them to molecular structure:

(i) specific heating capacity,

(ii) enthalpy change of vaporisation,

(iii) density changes on melting (**A2**, O);

(e) account for the influence of oceans on climate in terms of the characteristic properties of water (**A2**, O).

## 5.3.17 Group 7

Candidates should be able to:

(a) recall the following physical properties of the halogens:

(i) appearance and state at room temperature,

(ii) volatility,

(iii) solubility in water and organic solvents (**AS**, M);

(b) explain the redox changes which take place when chlorine, bromine and iodine react with other halide ions (**AS**, M);

(c) compare the relative reactivity of the halogens (**AS**, M);

(d) recall the reaction between halide ions and silver ions (**AS**, M);

(e) explain the redox changes occurring in the extraction of bromine from sea water (**AS**, M);

(f) show awareness of the economic importance of bromine and chlorine and their compounds (**AS**, M).

## 5.3.18 *d*-Block Elements

**C3.1a, C3.2, C3.3**

Candidates should be able to:

(a) recall that transition metals are *d*-block elements forming one or more stable ions which have incompletely filled *d* orbitals (**A2**, SS);

(b) describe the typical properties of transition metals, exemplified by the first row of the *d* block with particular reference to iron and copper, including:

(i) the existence of more than one oxidation state for each element in its compounds,

(ii) the formation of coloured ions in solution,

(iii) reactions with ligands to form complexes and reactions involving ligand substitution,

(iv) the catalytic behaviour of the elements and their compounds (**A2**, SS);

(c) describe the reactions of $Fe^{2+}$(aq), $Fe^{3+}$(aq) and $Cu^{2+}$(aq) ions with sodium hydroxide solution and ammonia solution (**A2**, SS);

(d) explain the variable oxidation states of transition metals in terms of electronic energy levels (**A2**, SS);

(e) explain and use the terms: ligand, complex/complex ion, ligand exchange (**A2**, SS);

(f) describe the formation of complexes in terms of bonding between ligand and central metal ion (**A2**, SS);

(g) explain the term polydentate as applied to ligands, exemplified by $edta^{4-}$ (**A2**, SS);

(h) relate ligand exchange reactions of complexes to stability constants (**A2**, SS);

(i) explain the importance of the composition of a steel in determining its properties (**A2**, SS);

(j) describe important redox processes occurring during steelmaking (including removal of sulphur and the reactions during the oxygen blow) (**A2**, SS);

(k) describe rusting in terms of electrochemical processes involving iron and oxygen, and the subsequent reactions to form rust (**A2**, SS);

(l) describe and explain:

(i) approaches to corrosion prevention;

(ii) issues involved in the recycling of iron (**A2**, SS).

## 5.3.19 Stereochemistry and Isomerism

**IT3.1, IT3.2**

Candidates should be able to:

(a) explain and use the term isomerism (**AS**, DF);

(b) recognise structural isomers (**AS**, DF);

(c) draw and interpret structural formulae (full, shortened and skeletal) (**AS**, DF);

(d) relate molecular shape to structural formulae (**AS**, DF) and be familiar with the use of models to represent molecular shape (**AS**, DF);

(e) recognise *cis-trans* (geometric) isomers (**AS**, PR);

(f) build models and draw and interpret diagrams to represent *cis-trans* isomers (**AS**, PR);

(g) recognise stereo-isomers: *cis-trans* and optical isomers (enantiomers) (**A2**, EP);

(h) explain and use the term ‘chiral’ as applied to a molecule (**A2**, EP);

(i) build models and draw and interpret diagrams to represent optical isomers of simple molecules (**A2**, EP);

(j) discuss the shape of complexes with coordination numbers 4 and 6 (**A2**, SS);

(k) describe the structure of a pharmacologically active material in terms of its functional components: pharmacophore and groups which modify the pharmacophore (**A2**, MD);

(l) relate the action of biologically active chemicals to their interaction with receptor sites (**A2**, MD);

(m) discuss the factors affecting the way that species interact in three dimensions:

    (i) size,

    (ii) shape,

    (iii) bond formation,

    (iv) orientation (**A2**, MD).

## 5.3.20 Organic Reaction Mechanisms

Candidates should be able to:

(a) distinguish between homolytic and heterolytic bond fission (**AS**, A);

(b) recall the formation, nature and reactivity of radicals (**AS**, A);

(c) explain the mechanism of a radical chain-reaction involving initiation, propagation and termination (**AS**, A);

(d) explain and use the terms: hydrolysis, substitution, nucleophile, carbocation (**AS**, A);

(e) explain the mechanism of nucleophilic substitution in halogenoalkanes (reference to SN1 and SN2 is not required) (**AS**, A);

(f) relate reactivity of halogenoalkanes to bond enthalpy and bond polarity (**AS**, A);

(g) explain and use the terms: addition, electrophile (**AS**, PR);

(h) explain the mechanism of the electrophilic addition reaction between bromine and alkenes (**AS**, PR);

(i) explain and use the term: elimination reaction (**AS**, PR);

(j) account for the increasing relative strengths as acids of alcohols, phenols and carboxylic acids (**A2**, WM);

(k) explain the mechanism of the nucleophilic addition reaction between an aldehyde or a ketone and hydrogen cyanide (**A2**, MD);

(l) use the following terms to classify organic reactions: hydrolysis, oxidation, reduction, condensation, elimination (**A2**, MD);

(m) classify organic reactions according to their reactions mechanisms: nucleophilic substitution, electrophilic addition, electrophilic substitution, nucleophilic addition, radical (**A2**, MD).

## 5.3.21 Homologous Series

Candidates should be able to:

(a) explain and use the terms: aliphatic, aromatic (**AS**, DF);

(b) recognise members of the following homologous series:

  (i) alkanes, cycloalkanes, alkenes, arenes, alcohols, ethers (**AS**, DF),

  (ii) halogenoalkanes (**AS**, A)

  (iii) aldehydes, ketones, carboxylic acids (**AS**, PR)

  (iv) phenols, acyl chlorides, esters (**A2**, WM)

  (v) amines and amides (**A2**, DP);

(c) use systematic nomenclature to name members of the following homologous series:

  (i) alkanes, alcohols (**AS**, DF),

  (ii) halogenoalkanes (**AS**, A),

  (iii) alkenes (**AS**, PR),

  (iv) carboxylic acids and esters (**A2**, WM),

(v) primary amines (**A2**, DP);

(d) identify individual functional groups within a polyfunctional molecule, and hence make predictions about its properties (**A2**, MD).

## 5.3.22 Alkanes

Candidates should be able to:

(a) describe and write balanced equations for the combustion (oxidation) of alkanes and alcohols (**AS**, DF);

(b) describe the effect of chain length and chain branching on the tendency of petrol towards auto-ignition which causes 'knocking' in a car engine (**AS**, DF);

(c) explain what is meant by the octane number of a petrol and describe how it may be increased (**AS**, DF);

(d) describe the origin of pollutants from car exhausts: unburnt hydrocarbons, CO, $CO_2$, $NO_x$, $SO_x$, and show awareness of the environmental implications (**AS**, DF);

(e) describe the use of isomerisation, reforming and cracking reactions to improve the performance of hydrocarbon fuels (**AS**, DF);

(f) describe and explain the reaction of alkanes with halogens (**AS**, A).

## 5.3.23 Alkenes

Candidates should be able to:

(a) describe and explain the addition reactions of alkenes with the following:

(i) bromine,

(ii) hydrogen bromide,

(iii) hydrogen in the presence of a catalyst,

(iv) water in the presence of a catalyst (**AS**, PR);

(b) describe in general terms the process of oxidative cross-linking by which unsaturated oils harden, and relate to their use as media in oil-based paints (**A2**, CD).

## 5.3.24 Arenes

Candidates should be able to:

(a) recognise arenes and arene derivatives (aromatic compounds) (**A2**, CD);

(b) relate the characteristic properties of aromatic compounds to the delocalisation of electrons in the benzene ring (**A2**, CD);

(c) describe and explain the following electrophilic substitution reactions of arenes:

  (i) halogenation of the ring,

  (ii) nitration,

  (iii) sulphonation,

  (iv) Friedel-Crafts alkylation,

  (v) Friedel-Crafts acylation (**A2**, CD).

## 5.3.25 Halogenoalkanes

**C3.2, C3.3**

Candidates should be able to:

(a) describe in outline the preparation of a halogenoalkane from an alcohol (**AS**, A);

(b) describe and explain the characteristic properties of halogenoalkanes, comparing fluoro-, chloro-, bromo- and iodo-compounds. The following aspects are to be considered:

  (i) boiling points,

  (ii) formation of radicals by interaction with ultraviolet radiation,

  (iii) nucleophilic substitution with water, hydroxide ion and ammonia (**AS**, A);

(c) recall the nature and uses of chlorofluorocarbons (CFCs) (**AS**, A);

(d) discuss the relative advantages and disadvantages of replacement compounds for chlorofluorocarbons: hydrochlorofluorocarbons (HCFCs), hydrofluororocarbons (HFCs) and alkanes (**AS**, A).

## 5.3.26 Alcohols and Phenols

Candidates should be able to:

(a) distinguish between primary, secondary and tertiary alcohols from their structures (**AS**, PR);

(b) describe and explain the following properties of alcohols:

  (i) oxidation of alcohols to carbonyl compounds and carboxylic acids with acidified dichromate(VI) solution (**AS**, PR);

  (ii) dehydration of alcohols to form alkenes (**AS**, PR);

  (iii) reaction of alcohols with carboxylic acids to form esters (**A2**, WM).

(c) describe and explain the following properties of phenols:

  (i) acidic nature;

  (ii) test with iron(III) chloride solution;

  (iii) reaction of phenols with acyl chlorides to form esters (**A2**, WM).

## 5.3.27 Carboxylic Acids and their Derivatives

Candidates should be able to:

(a) describe and explain the following properties of carboxylic acids:

  (i) acidic nature (**A2**, WM);

  (ii) ester formation with alcohols (**A2**, DP);

(b) describe and explain the reaction of acyl cholrides with phenols to form esters (**A2**, WM)

(c) describe the hydrolysis of esters (details of mechanism are not required) (**A2**, DP);

(d) recall that fats and oils consist mainly of mixed esters of propane-1,2,3-triol with varying degrees of unsaturation (**A2**, CD).

## 5.3.28 Aldehydes and Ketones

Candidates should be able to:

(a) describe the following reactions involving aldehydes and ketones:

(i) formation by oxidation of alcohols,

(ii) oxidation to carboxylic acids,

(iii) reduction to alcohols,

(iv) reaction with hydrogen cynide (**A2**, MD).

## 5.3.29 Nitrogen Compounds

Candidates should be able to:

(a) describe and explain the characteristic properties of the amino group, including:

(i) basic nature,

(ii) acylation (**A2**, DP);

(b) describe the reaction of a primary amine with an acyl chloride to produce an amide (**A2**, DP);

(c) describe the hydrolysis of amides (**A2**, DP);

(d) recognise and describe the generalised structure of amino acids (**A2**, EP);

(e) describe the acid-base properties of amino acids and the formation of zwitterions (**A2**, EP);

(f) describe and explain the formation of azo dyes by coupling reactions involving diazonium compounds (**A2**, CD).

## 5.3.30 Proteins and DNA

**C3.1a, C3.1b; IT3.1, IT3.2**

Candidates should be able to:

(a) recall that proteins are condensation polymers formed from amino acid monomers (**A2**, EP);

(b) describe the formation and hydrolysis of the peptide link between amino acid residues in proteins and the use of paper chromatography to identify amino acids (**A2**, EP);

(c) explain the importance of amino acid sequence in determining the properties of proteins, and account for the diversity of proteins in living things (**A2**, EP);

(d) distinguish between the primary, secondary and tertiary structure of proteins (**A2**, EP);

(e) describe the double helix structure of DNA in terms of a sugar-phosphate backbone and attached bases (recall of detailed structure is not required) (**A2**, EP);

(f) explain the significance of hydrogen bonding in the pairing of bases in DNA, and relate to the replication of genetic information (**A2**, EP);

(g) explain how DNA encodes for the amino acid sequence in a protein (**A2**, EP);

(h) account for the specificity of enzymes in terms of a simple 'lock and key' model of enzyme action (**A2**, EP);

(i) explain in outline the technique of 'genetic engineering' (**A2**, EP);

(j) discuss applications of genetic engineering techniques (**A2**, EP).

## 5.3.31 Polymers

**C3.1b, C3.2, C3.3; IT3.1**

Candidates should be able to:

(a) show awareness that scientific discoveries are often made by accident and give some examples of polymers discovered in this way (**AS**, PR);

(b) explain and use the term: addition polymerisation (**AS**, PR);

(c) predict the structural formula of the addition polymer formed from given monomer(s), and vice versa (**AS**, PR);

(d) explain the meaning of the terms: thermoplastic and thermoset , co-polymer (**AS**, PR);

(e) describe the meaning and significance of crystallinity in polymers (**AS**, PR);

(f) relate the typical properties of addition polymers to their molecular structure, and make predictions about the properties of a given polymer. In particular, the following factors should be considered

  (i) chain length,

  (ii) side-groups,

  (iii) chain branching,

  (iv) chain flexibility,

  (v) cross-linking,

  (vi) stereoregularity (**AS**, PR);

(g) relate the properties of a dissolving polymer to its molecular structure (**AS**, PR);

(h) distinguish between addition and condensation polymerisation (**A2**, DP);

(i) predict the structural formula of the condensation polymer formed from given monomer(s), and vice versa (**A2**, DP);

(j) describe and explain the effect of temperature changes on polymers (**A2**, DP);

(k) relate the properties of polymers to their molecular structure, and make predictions about the properties of a polymer (**A2**, DP);

(l) show awareness of the ways that chemists can modify the properties of a polymer by physical and chemical means (including the use of co-polymers), to meet particular needs (**A2**, DP);

(m) use given data to design a polymer for a particular purpose (**A2**, DP).

## 5.3.32 Organic Synthesis

**IT3.1**

Candidates should be able to:

(a) recall the procedure for vacuum filtration (**AS**, M);

(b) describe and explain the principle stages in the purification of an organic liquid product (**AS**, A);

(c) recall the technique of heating under reflux for reactions involving volatile liquids (**A2**, WM);

(d) show awareness that more effective medicines can be obtained by modifying the structure of existing medicines (**A2**, WM);

(e) recall the procedure for purifying an organic solid product (**A2**, DP);

(f) use knowledge of organic reactions mentioned elsewhere in these specifications (AS and A2), together with any further given reactions, to devise synthetic routes for preparing organic compounds (**A2**, MD);

(g) show awareness of the application of computer modelling techniques in the design of medicines (**A2**, MD).

## 5.3.33 The Chemical Industry

**C3.1a, C3.1b, C3.2, C3.3; IT3.1**

Candidates should be able to:

(a) show awareness of the work of chemists in improving fuels and in searching for and developing fuels for the future: use of oxygenates, the hydrogen economy (**AS**, DF);

(b) show awareness of the health and safety precautions needed in industry when hazardous chemicals are being stored, transported and used (**AS**, M);

(c) describe and explain the major stages in the extraction of a pure metal from its ore (**AS**, M);

(d) show awareness of the scale and importance of mineral extractive industries and discuss the environmental implications of mineral extraction (**AS**, M);

(e) interpret flow diagrams showing the sequence of operations in a chemical process (**AS**, M);

(f) show awareness of the historical development of addition polymers: discovery of poly(ethene), different kinds of poly(ethene), Ziegler-Natta catalysts, conducting polymers, dissolving polymers (**AS**, PR);

(g) show awareness of the procedures used in developing and establishing the safety of a medicine (**A2**, WM);

(h) show awareness of the historical development of condensation polymers (polyamides and polyesters) (**A2**, DP);

(i) discuss issues relating to the disposal of polymers and the conservation of resources used in polymer manufacture (**A2**, DP);

(j) show awareness of the industrial importance of enzymes (**A2**, EP);

(k) show awareness of the range of types, properties and uses of steel (**A2**, SS);

(l) discuss ways in which chemists can help improve food production, including:

  (i) providing extra nutrients,

  (ii) controlling soil pH,

  (iii) controlling pests (**A2**, AA);

(m) describe in outline the manufacture of ammonia in the Haber Process, giving essential conditions (**A2**, AA);

(n) use given data to evaluate the most economical operating conditions for an industrial process such as the Haber Process, using principles of equilibrium and rates of reactions (**A2**, AA);

(o) explain the role of chemistry in the design of pesticides that combine maximum efficacy with minimum environmental damage (**A2**, AA);

(p) show awareness of the role of chemists in designing and making new compounds for use as pharmaceuticals (**A2**, MD);

(q) describe the stages in the manufacture of a new product: research, pilot study, scaling-up, production, review (**A2**, VCI);

(r) describe the characteristics of effective and successful chemical processes in terms of:

  (i) raw materials and feedstock,

  (ii) batch or continuous process,

  (iii) rate, including use of catalysts,

  (iv) product yield,

  (v) nature of co–products and by-products,

  (vi) waste disposal and effluent control,

  (vii) location,

  (viii) safety,

  (ix) cost (**A2**, VCI);

(s) use knowledge and understanding of chemical principles and processes to discuss and evaluate the factors mentioned in (r) (**A2**, VCI);

(t) use information concerning the chemical properties of reactants and products to discuss suitable materials for the construction of a chemical plant (**A2**, VCI);

(u) show awareness that control of pollution from chemical plants has economic implications, and discuss associated issues (**A2**, VCI).

## 5.4 Skills

### 5.4.1 Communication

These Advanced Subsidiary and Advanced GCE specifications, and the associated course materials, encourage candidates to develop communication skills in the context of their study of chemistry.

Candidates should be able to:

(a) work collaboratively in a group;

(b) work independently;

(c) carry out research using secondary sources;

(d) make a written report on work they have carried out;

(e) make a summary of a scientific document;

(f) make summaries of work they have covered;

(g) present an oral report;

(h) prepare and communicate a scientifically informed case from given information and secondary sources;

(i) analyse, interpret and evaluate data presented in different forms;

(j) represent data graphically and in other appropriate forms;

(k) use given data, in conjunction with their chemical knowledge, to solve problems;

(l) identify trends and make predictions from data;

(m) interpret and devise flow diagrams for an industrial process;

(n) make appropriate use of information technology.

## 5.4.2 Manipulative Skills

These Advanced Subsidiary GCE and Advanced GCE specifications encourage candidates to develop an understanding of the link between theory and experiment. Candidates are required to carry out experimental activities as a central feature of the course and must develop the necessary manipulative skills to enable them to do this.

Candidates should be able to select appropriate techniques, reagents and apparatus, and to manipulate chemicals and standard laboratory apparatus with confidence, accuracy and safety, including the following operations:

(a) make accurate measurements of: temperature, mass, time, volumes of liquids and gases;

(b) handle flammable, corrosive and/or toxic chemicals, including solids, liquids and gases, safely;

(c) make and record accurate observations of test-tube reactions;

(d) take steps to ensure cleanliness and purity appropriate to the experiment.

**Advanced Subsidiary**

In addition to the general experimental skills listed above, candidates should be able to:

(e) make up a standard solution (EL);

(f) perform a titration accurately (EL, M, A);

(g) use a hand-held spectroscope (EL);

(h) make thermochemical measurements (DF);

(i) carry out vacuum filtration (M);

(j) purify an organic liquid (A);

(k) measure a boiling point;

**A2**

In addition to the experimental skills listed above, candidates should be able to:

(l) carry out heating under reflux (WM);

(m) carry out paper or thin layer chromatography (WM, EP);

(n) purify an organic solid by recrystallisation (WM,DP);

(o) measure a melting point (DP);

(p) measure the time taken for a reaction to reach a particular stage (EP, AA);

(q) make electrochemical measurements (SS);

(r) use a colorimeter to determine concentrations of solution (SS, AA);

(s) use a pH meter (O);

## 5.4.3 Experiment and Investigation

These Advanced Subsidiary GCE and Advanced GCE specifications require candidates to carry out experimental and investigative activities and to use their knowledge of chemistry in planning, carrying out and evaluating their work. Candidates are encouraged to make use of IT where appropriate.

**Planning**

Candidates should be able to:

(a) identify and define the nature of a question or problem using available information and knowledge of chemistry;

(b) retrieve and evaluate information from multiple sources, including computer databases where appropriate;

(c) choose effective and safe procedures, selecting appropriate reagents and apparatus, with due regard to precision of measurement, purity of reagents and products, scale of working and the control of variables.

**Implementing**

Candidates should be able to:

(a) demonstrate the manipulative skills needed for specific chemical techniques used in the laboratory, showing a due regard for safety;

(b) make and record sufficient relevant observations and measurements to an appropriate degree of precision using, where appropriate, logging and processing of data, using information technology;

(c) carry out work in appropriate contexts, involving:

- techniques of preparation and purification;
- qualitative and quantitative exercises.

**Analysing Evidence and Drawing Conclusions**

Candidates should be able to:

(a) present work appropriately in written, graphical or other forms, using chemical nomenclature and terminology;

(b) interpret information gathered from experimental activities including:

- manipulation of data;
- recognition of patterns and trends in a set of data or information;
- identification of sources of error and recognition of the limitations of experimental measurements.

(c) draw valid conclusions by applying their knowledge and understanding of chemistry, reporting quantitative data to an appropriate number of significant figures.

**Evaluating Evidence and Procedures**

Candidates should be able to:

(a) assess the reliability of their data and the conclusions drawn from it;

(b) evaluate the techniques used in the experimental activity, recognising the limitations of these.

# 6 Further Information and Training for Teachers

In support of the Chemistry (Salters) Advanced Subsidiary and Advanced GCE specifications, OCR will make the following materials and services available to teachers:

- up-to-date copies of these specifications;
- a full range of In-ServiceTraining (INSET) Meetings;
- coursework guidance materials including a list of suggested activities for assessment of Experimental Skills in the Advanced Subsidiary course, suitable topics for the Advanced GCE Individual Investigation and marked exemplars of candidate work;
- written advice on coursework proposals for experimental and investigative work;
- specimen question papers and mark schemes;
- past question papers and mark schemes after each examination session;
- marked exemplar candidate reports for the Open Book Paper;
- individual feedback to each Centre on the moderation of coursework;
- a Report on the Examination, compiled by senior examining personnel, after each examination session;

For further information about these AS and A Level specifications, please contact OCR.

If you have enquiries concerning the course leading to the examination, including enquiries about the course materials, please contact:

The Project Secretary

The Salters Advanced Chemistry Project

Department of Chemistry

University of York, York YO10 5DD

Telephone: 01904 432601  Fax: 01904 432605

Further support available from the Project Office at the University of York includes:

- a telephone hotline for enquiries;
- training workshops for teachers and technicians taking up the course;
- a regular Salters Advanced Chemistry Newsletter;
- a network of local User Groups;
- a Salters Advanced Chemistry website and discussion forum (www.york.ac.uk/org/seg/salters/chemistry).

# 7 Course Publications

Four publications provide comprehensive coverage of the Salters Advanced Chemistry course for candidates and teachers. All are endorsed by OCR and published by Heinemann Educational Publishers, Oxford.

- The **Chemical Storylines** provide the contexts within which chemical ideas and skills are developed;
- The **Chemical Ideas** systematically draw together the chemical principles from different parts of the course;
- The **Activities and Assessment Pack** provides practical work as well as group exercises, data analysis, applications of information technology and so on, and also end-of-unit tests for each of the teaching units; a CD-ROM containing the complete **Activities and Assessment Pack** and complete **Teacher's and Technician's Guides** is also available. This CD-ROM also contains over 200 illustrations from the **Chemical Ideas** and **Chemical Storylines**.
- The **Teacher's Guide** provides guidance on planning, notes on the activities and answers to questions.

A list of additional sources of information is provided for each teaching section in the Teacher's Guide. These lists include references to relevant books, articles, videos, posters and molecular modelling software.

## Appendix A

# Key Skills

This Appendix offers detailed guidance on the Key Skills evidence that a candidate might produce during this programme of study. It focuses on the evidence required to meet the criteria for the internally assessed Key Skills portfolio. For example, in producing work for assessment as evidence of C3.2 (Read and synthesise information from two extended documents about a complex subject. One of these documents should include at least one image.) a candidate is required to:

- select and read material that contains the information you need;
- identify accurately, and compare, the lines of reasoning and main points from text and images; and
- synthesise the key information in a form that is relevant to your purpose.

The Key Skills and Evidence Requirements below are quoted from the Part B of the QCA Key Skills specifications and, as such, are addressed to the candidate. The text below the Evidence Requirements is guidance for teachers about how the specification might be used to provide teaching and learning opportunities and/or assessment opportunities for the Key Skill.

For further information about the requirements of these units, teachers should refer to QCA's Key Skills specifications for use in programmes starting from September 2000.

For further information about the assessment and certification of Key Skills, teachers should contact OCR.

## C3 Communication Level 3

**Possible opportunities**

These Advanced Subsidiary and A Level specifications, and the associated course materials, provide many opportunities for the development of Key Skills in Communication. The activities in the course, together with the Open-Book Paper (Module 2852, Component 01) and the Individual Investigation (Module 2855) could provide all the evidence needed for the assessment of Key Skills in Communication at Level 3.

## C3.1a Contribute to a group discussion about a complex subject.

**Evidence requirements**

(i) Make clear and relevant contributions in a way that suits your purpose and situation.

(ii) Listen and respond sensitively to others, and develop points and ideas.

(iii) Create opportunities for others to contribute when appropriate.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to contribute to a group discussion about a complex subject. The discussions are most likely to arise out of the course materials, particularly the Chemical Storylines and the Activities. For example:

***Module 2850***

*Developing Fuels (DF):* the research activity 'Which Fuel for the Future?' provides candidates with an opportunity to discuss the advantages and disadvantages of alternative fuels.

***Module 2848***

*The Atmosphere (A):* the research activity 'Controlling Carbon Dioxide' provides candidates with an opportunity to discuss the problems of global warming and ways of controlling carbon dioxide emissions.

***Module 2849***

*What's in a Medicine? (WM):* in the role play activity 'Which Product Should a Pharmaceutical Company Develop?' candidates analyse information and make a decision about which of two possible medicines to take to production.

*Designer Polymers (DP):* a discussion might arise from the Chemical Storyline concerning the relative merits of degrading or recycling polymers.

*Engineering Proteins (EP):* a discussion might arise from the Chemical Storyline concerning the moral implications of genetic engineering.

***Module 2854***

*Aspects of Agriculture (AA):* a discussion might arise from the Chemical Storyline concerning the environmental implications of using pesticides and herbicides.

**C3.1b** Make a presentation about a complex subject, using at least **one** image to illustrate complex points.

**Evidence requirements**

(i) Speak clearly and adapt your style of presentation to suit your purpose, subject, audience and situation.

(ii) Structure what you say so that the sequence of information and ideas may be easily followed.

(iii) Use a range of techniques to engage the audience, including effective use of images.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to make a presentation about a complex subject. Candidates must make use of at least **one** image, which could be prepared using IT skills. Topics for presentations are most likely to arise out of the course materials, particularly the Chemical Storylines and the Activities. The topics listed in C3.1a would all be suitable for a presentation, but there are many others. For example:

***Module 2850***

*Elements of Life (EL):* the activity 'How Do We Know About Atoms?' requires candidates to make presentations on the role of scientists who contributed to the current model of the atom.

***Module 2848***

*The Atmosphere (A):* presentations could be based on work in the Chemical Storylines and Activities on problems with the use of CFCs and the relative advantages and disadvantages of their replacements.

***Module 2849***

*What's in a Medicine? (WM):* the activity 'The Origins and Development of the Modern Pharmaceutical Industry' requires candidates to make presentations on different aspects of the pharmaceutical industry.

*Engineering Proteins (EP):* the activity 'Life Reveals its Twisted Secret' could lead to candidate presentations on the contributions of the key scientists involved and the implications of their achievements.

***Module 2854***

*Visiting the Chemical Industry (VCI):* candidates could make presentations about different aspects of their visit to a chemical industry site.

***Module 2855***

Opportunities for making a presentation may arise out a candidate's work for the Individual Investigation.

**C3.2** Read and synthesise information from **two** extended documents about a complex subject. One of these documents should include at least **one** image.

**Evidence requirements**

(i) Select and read material that contains the information you need.

(ii) Identify accurately, and compare, the lines of reasoning and main points from texts and images.

(iii) Synthesise the key information in a form that is relevant to your purpose.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to read, select and synthesise information from two extended documents dealing with a complex subject. Teaching and learning opportunities to develop these skills arise throughout the course, particularly through activities which require candidates to research information. The topics listed in C3.1a and C3.1b all fall into this category.

In addition, the Open Book Paper in Module 2852 (Component 01) and the Individual Investigation in Module 2855 could provide evidence for assessment.

***Module 2852 (Component 01): Open-Book Paper***

Candidates are provided with at least two extended articles about a complex chemical topic. The articles contain a variety of images. Candidates are required to read the articles and research the topic more widely using other sources of reference. They must evaluate, select and synthesise information to produce a report and also a summary of their report.

***Module 2855: Individual Investigation***

Candidates must research relevant sources of reference and synthesise information to establish the background of their investigation and to plan their procedure.

**C3.3** Write **two** different types of documents about complex subjects. One piece of writing should be an extended document and include at least **one** image.

**Evidence requirements**

(i) Select and use a form and style of writing that is appropriate to your purpose and complex subject matter.

(ii) Organise relevant information clearly and coherently, using specialist vocabulary when appropriate.

(iii) Ensure your text is legible and your spelling, grammar and punctuation are accurate, so your meaning is clear.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to produce written work of different types about a complex subject. Teaching and learning opportunities to develop these skills arise throughout the course, particularly through activities which require candidates to research information. The topics listed in C3.1a and C3.1b all fall into this category. Candidates may wish to make use of their IT skills in producing the document. Some activities in the course materials specifically require candidates to produce a piece of written work. For example:

***Module 2850***

*Elements of Life (EL):* the activity 'Radon in the Rocks' requires candidates to design and produce a leaflet to deliver to homes, giving information about the hazards associated with radioactivity from radon in the ground. Candidates could also make use of their IT skills to produce the leaflet.

***Module 2848***

*The Atmosphere (A):* the activity 'Controlling Carbon Dioxide' requires candidates to produce a written report in which they discuss the scale of carbon dioxide emissions and evaluate one method of tackling the problem.

***Module 2849***

*Engineering Proteins (EP);* the activity 'Life Reveals its Twisted Secret' asks candidates to imagine it is 1953, and to use a range of source materials to produce an article for a science magazine reporting the discovery of the structure of DNA.

***Module 2854***

*Visiting the Chemical Industry (VCI):* candidates could produce a written account of their industrial visit using a variety of formats.

In addition, the Open-Book Paper in Module 2852 (Component 01) and the Individual Investigation in Module 2855 could provide evidence for assessment.

***Module 2852 (Component 01): Open-Book Paper***

Candidates are required to produce a 1000 word report on a complex subject, making use of chemical formulae and structures, and a range of images.

***Module 2855: Individual Investigation***

Candidates are required to produce a report of their investigation under the headings, planning, implementing, analysing evidence and drawing conclusions, and evaluating evidence and procedures.

# N3 Application of Number Level 3

**You must:**

Plan and carry through at least **one** substantial and complex activity that includes tasks for N3.1, N3.2 and N3.3.

**Possible opportunities**

It is very difficult within chemistry to devise a single activity that could produce all the evidence needed for the Key Skill of Application of Number at Level 3. This might be achieved in the context of a practical investigation involving rates of reaction or a series of titrations, where a large data set might be generated. There are, however, many opportunities to develop and practise the individual evidence requirements in Application of Number.

## N3.1 Plan, and interpret information from **two** different types of sources, including a large data set.

**Evidence requirements**

(i) Plan how to obtain and use the information required to meet the purpose of your activity.

(ii) Obtain the relevant information.

(iii) Choose appropriate methods for obtaining the results you need and justify your choice.

**Possible opportunities**

Experimental work throughout the Advanced Subsidiary and Advanced GCE courses provides candidates with many opportunities to plan their activities, breaking down complex activities into a series of tasks, make accurate and reliable observations over time, and to interpret numerical information. Calculations in chemistry occur in all Units and require manipulation of numbers, the correct use of units and significant figures. Candidates must understand compound measures, such as concentrations in mol $dm^{-3}$ or ppm. They must be able to read and understand ways of writing very large and very small numbers and be able to write numbers in standard form. The pH scale (in Module 2854) is a logarithmic scale used for dealing with a very wide range of numbers.

Scale drawings are not used very much in chemistry but candidates should be familiar with the use of graphs, complex tables and charts.

**N3.2** Carry out multi-stage calculations to do with:

(a) amounts and sizes;

(b) scales and proportion;

(c) handling statistics;

(d) rearranging and using formulae.

You should work with a large data set on at least **one** occasion.

**Evidence requirements**

(i) Carry out calculations to appropriate levels of accuracy, clearly showing your methods.

(ii) Check methods and results to help ensure errors are found and corrected.

**Possible opportunities**

Quantitative chemistry permeates an advanced chemistry course and there are many opportunities to develop skills in carrying out multi-stage calculations involving proportional changes, formulae, equations and expressions, powers and roots. These may arise out of theory or through practical work. Candidates are expected to work to appropriate levels of accuracy and to use checking procedures to identify errors in methods and results. However, large data sets and use of statistics are not often used, nor are scale drawings and work involving trigonometry. Examples of some of the teaching and learning opportunities are given below:

***Module 2850***

*Elements of Life (EL):* calculations of percentage composition, empirical and molecular formulae (use of proportions).

*Developing Fuels (DF):* use of balanced equations to calculate reacting masses (use of proportions) and calculation of enthalpy changes (use of correct units).

***Module 2848***

*From Minerals to Elements (M):* calculation of concentrations in mol $dm^{-3}$ and titration calculations (use of proportions, correct units, compound measures).

*The Atmosphere (A):* calculation of concentrations in ppm (compound measure) and use of the equation $E = hv$ (rearranging and using formulae).

***Module 2849***

*Engineering Proteins (EP):* use of the mathematical expression for the equilibrium constant for a reaction to calculate the quantities present at equilibrium; use of a rate equation to calculate the order of a reaction (rearranging and using formulae).

*The Steel Story (SS):* calculation of cell potentials from electrode potentials, titration calculations.

***Module 2854***

*The Oceans (O):* calculations involving entropy changes, pH (a logarithmic scale), acidity constants and solubility products.

***Module 2855: Individual Investigation***

Many of these skills may be brought together in the context of a practical investigation.

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**N3.3** Interpret results of your calculations, present your findings and justify your methods. You must use at least **one** graph, **one** chart and **one** diagram.

**Evidence requirements**

(i) Select appropriate methods of presentation and justify your choice.

(ii) Present your findings effectively.

(iii) Explain how the results of your calculations relate to the purpose of your activity.

**Possible opportunities**

Opportunities arise in all areas of the Salters Advanced Chemistry course for interpreting the results of calculations (as listed in N3.2). In addition, the Individual Investigation in ***Module 2855*** may provide candidates with opportunities to interpret the results of calculations, present their findings and justify their methods, using graphs, charts and diagrams where appropriate, in the context of a practical investigation.

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## IT3 Information Technology Level 3

**You must:**

Plan and carry through at least **one** substantial activity that includes tasks for IT3.1, IT3.2 and IT3.3.

**Possible opportunities**

It may be difficult within chemistry to devise a single activity that could produce all the evidence needed for the Key Skill of Information Technology at Level 3, though this might be achieved through an appropriate Individual Investigation. There are, however, many opportunities to develop and practise the individual evidence requirements in Information Technology.

**IT3.1** Plan, and use different sources to search for, and select, information required for two different purposes.

**Evidence requirements**

(i) Plan how to obtain and use the information required to meet the purpose of your activity.

(ii) Choose appropriate sources and techniques for finding information and carry out effective searches.

(iii) Make selections based on judgements of relevance and quality.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to use and develop their IT skills to search for and select information from a variety of sources. For example:

***Module 2850***

*Elements of Life (EL):* information about the properties of elements in the Periodic Table and their compounds can be found, and the trends in properties down groups and across periods investigated.

***Module 2848***

*The Atmosphere (A):* a vast amount of data is available on the Internet about ozone depletion in the stratosphere and concentrations of gases in the troposphere.

***Module 2854***

*Medicines by Design (MD):* candidates should be encouraged to search for spectroscopic data (m.s., i.r., n.m.r. and u.v.) on the compounds studied in this teaching module.

*Visiting the Chemical Industry (VCI):* background information on industrial processes can be searched for and relevant material selected.

In addition, the Open-Book Paper in Module 2852 (Component 01) and the Individual Investigation in Module 2855 require candidates to carry out searches for information.

***Module 2852 (Component 01): Open-Book Paper***

Candidates are required to research the topic of the articles in the question paper and select relevant information.

***Module 2855: Individual Investigation***

Candidates are required to research the background of their investigation topic in the planning stage.

**IT3.2** Explore, develop, and exchange information and derive new information to meet **two** different purposes.

**Evidence requirements**

(i) Enter and bring together information in a consistent form, using automated routines where appropriate.

(ii) Create and use appropriate structures and procedures to explore and develop information and derive new information.

(iii) Use effective methods of exchanging information to support your purpose.

**Possible opportunities**

It is unlikely that **all** the evidence requirements for IT3.2 can be developed within a chemistry course, but there are many teaching and learning opportunities for some aspects. For example, throughout the course candidates are encouraged to use IT to generate, manipulate and display data, in the form of lists, tables and charts, to generate graphs from data and to use spreadsheets. In addition, they are encouraged to use molecular modelling software to investigate chemical structures and to manipulate these structures to obtain information. For example:

***Module 2850***

*Developing Fuels (DF):* the activity 'Using Spreadsheets to Calculate Enthalpy Changes of Combustion' guides candidates through the stages in setting up a spreadsheet in order to perform routine calculations. They can then use this skill, in the activity 'Blend Your Own', to set up a spreadsheet to work out the blending mixture needed to produce a petrol within strict specifications of octane rating, volatility, quantity and price.

***Module 2849***

*Engineering Proteins (EP):* candidates are encouraged to use molecular modelling software (on the Internet or elsewhere) to investigate the 3-dimensional structures of optical isomers.

The Open-Book Paper in ***Module 2852 (Component 01)*** and the Individual Investigation in ***Module 2855*** both provide opportunities for candidates to develop some of some of the IT skills in this Section.

**IT3.3** Present information from different sources for **two** different purposes and audiences. Your work must include at least **one** example of text, **one** example of images and **one** example of numbers.

**Evidence requirements**

(i) Develop the structure and content of your presentation using the views of others, where appropriate, to guide refinements.

(ii) Present information effectively, using a format and style that suits your purpose and audience.

(iii) Ensure your work is accurate and makes sense.

**Possible opportunities**

The Salters Advanced Chemistry course provides many opportunities for candidates to develop IT skills to present information from different sources and for different purposes and audiences. For example,

***Module 2850***

*The Elements of Life (EL):* the activity ‘Radon in the Rocks requires candidates to produce a pamphlet for distribution to the public about the dangers of radiation from radon in the ground. The booklet needs to contain images and data as well as text.

In addition, the Open-Book Paper in ***Module 2852 (Component 01)*** and the Individual Investigation in ***Module 2855*** provide opportunities for candidates to develop of some of the IT skills in this Section. In both these modules, candidates are required to produce a report which may be word-processed. The report may include table, charts and diagrams, chemical equations and structural formulae, and mathematical expressions. Candidates will need to develop a suitable structure for the report, develop and refine the presentation of text, images and numbers, present the information to satisfy the requirements of the examination and ensure that the work is accurate and makes sense.

# WO3 Working with Others Level 3

**You must:**

Provide at least **one** substantial example of meeting the standard for WO3.1, WO3.2 and WO3.3 (you must show you can work in both one-to-one and group situations)l

**Possible opportunities**

These Advanced Subsidiary GCE and Advanced GCE specifications, and the associated course materials, provide many opportunities for the development of the Key Skill of Working with Others. These may involve activities in the course materials, such as a group research or practical activity, or may be centred around a field trip or an industrial visit. For example:

***Module 2850***

*Developing Fuels (DF):* the research activity 'Which Fuel for the Future?' can be organised as a group research activity, culminating in an oral presentation or a poster.

***Module 2854***

*Visiting the Chemical Industry (VCI):* the visit could be organised as a group activity with a planned outcome, such as a presentation to an invited audience (representatives from the industry visited, parents etc), a display or video.

## WO3.1 Plan complex work with others, agreeing objectives, responsibilities and working arrangements.

**Evidence requirements**

(i) Agree realistic objectives for working together and what needs to be done to achieve them.

(ii) Exchange information, based on appropriate evidence, to help agree responsibilities.

(iii) Agree suitable working arrangements with those involved.

**Possible Opportunities**

See WO3.

## WO3.2

Seek to establish and maintain co-operative working relationships over an extended period of time, agreeing changes to achieve agreed objectives.

**Evidence requirements**

(i) Organise and carry out tasks so you can be effective and efficient in meeting your responsibilities and produce the quality of work required;

(ii) Seek to establish and maintain co-operative working relationships, agreeing ways to overcome any difficulties.

(iii) Exchange accurate information on progress of work, agreeing changes where necessary to achieve objectives.

**Possible Opportunities**

See WO3.

## WO3.3

Review work with others and agree ways of improving collaborative work in the future.

**Evidence requirements**

(i) Agree the extent to which work with others has been successful and the objectives have been met.

(ii) Identify factors that have influenced the outcome.

(iii) Agree ways of improving work with others in the future.

**Possible Opportunities**

See WO3.

## LP3 Improving Own Learning and Performance Level 3

**You must:**

Provide at least **one** substantial example of meeting the standard for LP3.1, LP3.2 and LP3.3;

**Possible opportunities**

The Salters Advanced Chemistry materials stress the importance of study skills, and separate activities throughout the course encourage candidates to organise their work, monitor progress and keep good records. The learning activities for the Key Skill of Improving own Learning and Performance could be taken from the course materials, which are designed to support candidate-centred learning. They are structured to allow the teacher to hand over the planning and control of defined sections of work to the candidate, if desired.

Candidates may also produce evidence of learning from a video, a field trip or an industrial visit, or through the Open-Book Paper ***(Module 2852, Component 01)*** or the Individual Investigation *(**Module 2855**)*.

**LP3.1** Agree targets and plan how these will be met over an extended period of time, using support from appropriate people.

**Evidence requirements**

(i) Seek information on ways to achieve what you want to do, and identify factors that might affect your plans.

(ii) Use this information to agree realistic targets with appropriate others.

(iii) Plan how you will effectively manage your time and use of support to meet targets, including alternative action for overcoming possible difficulties.

**Possible Opportunities**

See LP3.

**LP3.2** Take responsibility for your learning by using your plan, and seeking feedback and support from relevant sources, to help meet targets.

Improve your performance by:

- studying a complex subject;
- learning through a complex practical activity;
- further study or practical activity that involves independent learning.

**Evidence requirements**

(i) Manage your time effectively to complete tasks, revising your plan as necessary.

(ii) Seek and actively use feedback and support from relevant sources to help you meet your targets.

(iii) Select and use different ways of learning to improve your performance, adapting approaches to meet new demands.

**Possible Opportunities**

See LP3.

**LP3.3** Review progress on **two** occasions and establish evidence of achievements, including how you have used learning from other tasks to meet new demands.

**Evidence requirements**

(i) Provide information on the quality of your learning and performance, including factors that have affected the outcome.

(ii) Identify targets you have met, seeking information from relevant sources to establish evidence of your achievements.

(iii) Exchange views with appropriate people to agree ways to further improve your performance.

**Possible Opportunities**

See LP3.

# PS3 Problem Solving Level 3

**You must:**

Provide at least **one** substantial example of meeting the standard for PS3.1, PS3.2 and PS3.3.

**Possible opportunities**

These Advanced Subsidiary GCE and Advanced GCE specifications, and the associated course materials, provide many opportunities for the development of the Key Skill of Problem Solving. These may involve activities in the course materials, and involve a research activity or a practical investigation. For example:

***Module 2849***

*The Steel Story (SS):* the practical activity 'How much manganese is there in a paper clip' could be adapted to provide a problem-solving activity.

***Module 2854***

*Aspects of Agriculture (AA):* the practical activity 'How does temperature affect the rate of a reaction?' is a good problem solving activity.

***Module 2855: Individual Investigation***

The best activity for this purpose may be the candidate's Individual Investigation.

## PS3.1

Explore a complex problem, come up with **three** options for solving it and justify the option selected for taking forward.

**Evidence requirements**

(i) Explore the problem, accurately analysing its features, and agree with others on how to show success in solving it;

(ii) Select and use a variety of methods to come up with different ways of tackling the problem; and

(iii) Compare the main features of each possible option, including risk factors, and justify the option you select to take forward.

**Possible Opportunities**

See PS3.

## PS3.2

Plan and implement at least **one** option for solving the problem, review progress and revise your approach as necessary.

**Evidence requirements**

(i) Plan how to carry out your chosen option and obtain agreement to go ahead from an appropriate person.

(ii) Implement your plan, effectively using support and feedback from others.

(iii) Review progress towards solving the problem and revise your approach as necessary.

**Possible Opportunities**

See PS3.

## PS3.3

Apply agreed methods to check if the problem has been solved, describe the results and review your approach to problem solving.

**Evidence requirements**

(i) Agree, with an appropriate person, methods to check if the problem has been solved.

(ii) Apply these methods accurately draw conclusions and fully describe the results.

(iii) Review your approach to problem solving, including whether alternative methods and options might have proved more effective.

**Possible Opportunities**

See PS3.

## Appendix B

# General Points Concerning Written Papers

The nomenclature and units used in the written papers are those recommended by the Association for Science Education, except in occasional cases where the everyday context makes recommended nomenclature or units inappropriate.

A **Data Booklet** is provided with the written papers in Units 2850, 2848, 2849 and 2854 (see Appendix G). All other necessary data is provided in the question papers.

### Numerical questions

Marks may be awarded for the use of correct units in numerical questions. A numerical answer should be quoted to an accuracy consistent with the given data.

Numerical values for enthalpy changes should always have an appropriate sign:

e.g. $\Delta H_c$ = – 1250 kJ mol$^{-1}$; $\Delta H_f$ = + 64 kJ mol$^{-1}$.

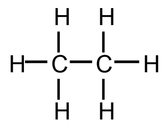
Oxidation states should have an appropriate sign, e.g. +6, +1, 0, –2, –4.

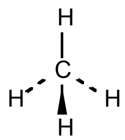
### Writing formulae

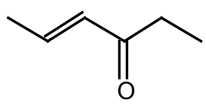
Inner shells of electrons may be omitted in dot-cross formulae (see the convention used in the course materials).

It should be clear from the question what type of structural formula is required. The following terms will be used:

molecular formula e.g. $C_3H_6O$

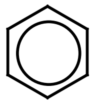
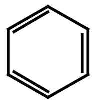
full structural formula e.g. 

3-dimensional structural formula e.g. 

skeletal formula e.g. 

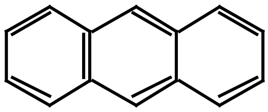
(The terms graphical formula and displayed formula will **not** be used.)

The full structural formula for benzene may be written as:

 or 

unless the question specifically asks the candidate to show carbon and hydrogen atoms, or comment about the representation of delocalised electrons.

Fused-ring arenes are best represented by Kekulé-type structures:

e.g. 

**Reaction conditions**

When a question asks for the reaction conditions for an organic reaction, these should be given as fully as possible. For example, the hydrolysis of esters is usually carried out by heating the ester with dilute acid (or alkali) under reflux. Simply saying 'heat with acid' may not gain full marks.

Note that the conditions written on the reaction arrows in the synthetic schemes in the teaching module *Medicines by Design*, are intended as summaries only and may **not** be a sufficient answer in a particular question.

## Appendix C

# Notes for Guidance on Coursework: Unit 2852, Component 01:The Open-Book Paper

The Open-Book Paper is component 01 of Unit 2852. It is taken over a two week period selected by Centres between dates specified by OCR. It is expected that candidates will write their reports in normal homework time for chemistry during this period, rather than in teaching time. The time required is normally expected to be between 5 and 8 hours.

The paper consists of **one** question only. The question is based on a collection of information (scientific papers, extracts from books, original material written for the purpose, etc.) which is supplied as part of the paper. The information is in the form of two (or more) articles comprising up to about 10 sides of A4. The articles contain scientific information in the form of graphs, diagrams, tables of data, etc., and may include references to aspects of technological, industrial, economic and social applications and implications of chemistry.

The question is worded in such a way that candidates must show understanding of the basic chemical concepts involved and also evaluate, select and synthesise information in response to the question.

Full instructions and 'Notes for Guidance' of candidates are given on the question paper. **It is important that candidates read these carefully**.

These instructions are summarised below:

- The response to the question should comprise between 800 and 1000 words. Reports which are in excess of 1000 words may indicate poor structure and unselective choice of material, so that full credit may **not** be available. The number of words should be indicated in the margin at approximately 200 word intervals.

- Candidates are encouraged to use books and other written sources of information to help them to understand or interpret the stimulus materials, **but their report should be based closely on the information given in the question paper**.

- The report should demonstrate an understanding of the **chemical** issues involved, and should be aimed at an audience with an understanding of chemistry to Advanced Subsidiary GCE. It should have a clear and helpful structure and should show evidence of planning. Technical and scientific vocabulary, structural formulae and chemical equations should be used whenever appropriate.

- Visual methods of presentation, such as pictures, diagrams, tables, flow charts, graphs, etc., should be used where appropriate, and can often be used to replace words in the text. They should be relevant, concisely labelled and positioned appropriately with links to the text. The inclusion of large blocks of text in such illustrations is discouraged; any such text is included in the word count.

- Given the length of time available, the Examiners expect that due care is given to the correct use of English and expect there to be fewer errors of presentation than in the other written papers. Marks are awarded for the quality of written communication on this paper.

- Reports may be hand-written or word-processed. The use of a word-processor to produce the report is encouraged, but this must be carried out by the candidate. Subscripts, superscripts, arrows in equations, dots on radicals, etc. must be drawn in correctly and clearly by hand if these are not available on the word-processor.

- At the end of their report, candidates should list clearly any sources they have used. The list should contain at least **two relevant sources** in addition to the articles supplied. This list is **not** included in the word count. Candidates should refer to this list in their report where appropriate. Where they have incorporated material into their report which is copied directly from the articles or from elsewhere, this must be indicated in the text and the source properly acknowledged. Extensive copying from the articles or from other sources will **not** gain credit.

- Candidates are also required to write a **summary** of up to 50 words, covering the main points of their report. They should avoid simply rephrasing the points in the question, but rather summarise their response to these points. The summary should be written on the special sheet provided.

- Reports should be written on unheaded A4 paper with a hole in the top left hand corner. Pages should be numbered and should have a clear margin on the right hand side. Candidates should **write on one side of the paper only** and each separate sheet should be marked with their name or candidate number.

- The sheets should be tied together loosely so that they turn over freely with the Summary Sheet on the top. Candidates should **not** use staples or paper clips, nor put their report in a plastic folder.

## Administration

The Open Book question paper is distributed by OCR. Question papers must be issued to candidates on or after the date specified by OCR.

A period of two weeks, within the timetabled window, is allowed from the issue of the papers to collection of completed reports. Centres must ensure that the date and time for return are clearly known by all candidates, and that candidates are reminded at regular intervals.

**Assistance from teachers or other third parties should be limited to guidance in selecting suitable additional sources of information. Teachers may open the packet of question papers once it arrives in the Centre in order to look at the paper.**

Centres are required to certify that, to the best of their knowledge, each response is the candidate's own, unaided work.

Completed papers must be handed into the Examination Officer at the Centre not later than the date on the question paper. Scripts are then posted **immediately** to the Examiner.

**Procedure for candidates who are unwell during the allocated fortnight.** There are four situations to deal with:

(i) The candidate who is sick for the whole fortnight and up to 15 May and cannot possibly take the paper should use the Part Absence procedures. A special consideration form JEB/SC should be submitted in May. Where candidates are proceeding to A2, the usual rules for absence from an AS unit apply.

(ii) The candidate who missed the whole fortnight but is well enough to come back and take the paper before 15 May should do so. If there is not enough time left to make a realistic assessment, then they should be advised to follow the first instruction.

(iii) The candidate who is ill during the part of the two weeks chosen by the Centre can have the full 10 working days in total, at another time before 15 May. If the candidate is not well enough to complete by 15 May, the Centre should follow the part-absence procedures.

(iv) If the holiday period cuts across the 10 working days re-arranged for the candidate, the Centre must give the candidate a deadline for submission during the vacation. The candidate must then make a copy of the work and post the original to the Centre by the given date.

## Assessment Criteria

The Open Book paper provides an opportunity to assess research and communication skills in the context of candidates' knowledge and understanding of chemistry. The assessment criteria reflect this and are based on **AO2**: Application of Knowledge and Understanding, Analysis and Evaluation (see **Section 3**) together with the relevant Key Skill in Communication listed in **Appendix A**.

The paper is marked according to the criteria given below. In any one year, the specific mark scheme is derived by applying these general criteria to the specific content of the paper. The question paper gives guidance to candidates on the relative weightings of each aspect of the question that are expected in their answer.

The **45 marks** available are awarded under four broad headings (a)-(d).

| | | |
|---|---|---|
| (a) | Understanding of the basic chemical content of the paper | 14 marks |
| (b) | Evaluation of the chemical content in the context of the question | 12 marks |
| (c) | Research skills | 5 marks |
| (d) | Quality of communication: | |
| | in the summary | 4 marks |
| | in the main report | 10 marks |

General criteria for the award of these marks are given below.

(a) **Understanding of the basic chemical content of the paper**

A maximum of **14 marks** is awarded for understanding of the basic chemical facts and principles provided in the stimulus materials or included in the report from other sources.

(b) **Evaluation of the chemical content in the context of the question**

A maximum of **12 marks** is awarded for evaluation of the chemical content of the stimulus materials in the context of the question. This involves evaluating, selecting and synthesising appropriate information to produce an ordered and balanced response to the question.

(c) **Research Skills**

A maximum of **5 marks** is awarded for the research skills shown in selecting, using and acknowledging sources of information. These marks are awarded as follows.

- List of sources used, which should include the articles in the question paper and at least two additional and *relevant* references of which the two Salters texts count as one (2 marks);
- Some precision (for example, chapter headings, section titles, page numbers, website descriptions) in listing sources other than articles in the paper (1 mark);
- Appropriate material selected from the question paper and elsewhere to produce a report within the required word limit (1 mark);
- Text annotated where appropriate acknowledging use of information from the sources listed (2 marks).

(d) **Quality of communication in the response**

A maximum of **14 marks** is awarded for the quality of written communication of the response.

Of these, **4 marks** are awarded for the Quality of Expression in the Summary. This is intended to be a summary of the content of the main report and it should contain four relevant chemical points which the candidate has either learned or has had reinforced by reading the articles in the paper. Candidates should avoid simply rephrasing the question.

The remaining **10 marks** are awarded for the quality of communication in the main body of the report. These marks are awarded as follows.

- Well-structured report that avoids undue repetition and provides a balanced coverage of the required points (2 marks);
- Clear and correct use of language (spelling, punctuation and grammar) (2 marks);
- Correct use of scientific and technical terms (2 marks);
- Good use of equations and structural formulae (2 marks);
- Good use of appropriate illustrations (pictures, diagrams, tables, flow charts, graphs, etc.) (2 marks).

## Appendix D

# Notes for Guidance on Coursework: Unit 2852, Component 02 and Unit 2855: Assessment and Submission for Experimental and Investigative Skills

This section is intended to provide guidance for teachers in assessing experimental and investigative skills, but should not exert an undue influence on the methods of teaching or provide a constraint on the practical work undertaken by candidates. It is not expected that all of the practical work undertaken by candidates would be appropriate for assessment.

For examples of suitable tasks for assessing practical skills, and for examples of possible individual investigations, teachers should refer to the publication *Chemistry (Salters) Coursework Handbook*. Copies can be ordered from the OCR Publications Department.

The experimental and investigative skills to be assessed are:

**P** Planning;

**I** Implementing;

**A** Analysing Evidence and Drawing Conclusions;

**E** Evaluating Evidence and Procedures.

It is expected that candidates will have had opportunities to acquire experience and develop the relevant skills before assessment takes place.

The skills may be assessed at any time during the course using suitable practical activities, based on laboratory work.

In Advanced Subsidiary Unit 2852, Component 02, the skills should be assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise.

In A2 Unit 2855 they should be assessed all together in the context of a single individual investigation in which each candidate pursues his or her own assignment.

It is essential that all teachers assessing candidates' practical work should be familiar with the requirements of the specification. If teachers in a Centre are not certain that their proposed practical work will satisfy the specification requirements, then they should submit details to OCR to seek clarification **well before the proposed work is due to be carried out**.

Skills **P**, **A** and **E** are marked out of 11 and Skill **I** is marked out of 12 for both Unit 2852, Component 02 and Unit 2855. For each candidate entered for Unit 2852, Component 02, Centres are required to award **one** mark for each of Skills **P**, **I**, **A** and **E**. Hence, the maximum raw mark available for this component is 45. For each candidate entered for Unit 2855 Centres are required to award **one** mark for each of the Skills **P, I, A** and **E**.

When a skill has been assessed on more than one occasion in Unit 2852, Component 02, the better or best mark for that skill should be submitted. However, Centres are recommended **not** to assess the skills on more than two occasions in Advanced Subsidiary since this may take up time which might better be devoted to other aspects of the specification. The time required for the internal assessment of experimental and investigative skills in Advanced Subsidiary is normally expected to be between 5 and 8 hours.

It is expected that candidates will carry out a single individual investigation for A2 Unit 2855 involving 15 to 20 hours work within the laboratory.

All coursework is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

## The Demand of an Activity

The demand of an activity is an important feature of the assessment. From the bottom to the top of the mark range in a skill area the activity should involve increasing demands of associated chemical knowledge and understanding, manipulation, precision and accuracy, and complexity.

Teachers should appreciate that the choice of an activity which is comparatively undemanding (primarily in terms of the level of the scientific knowledge and understanding which can be linked to the activity and in the range/complexity of the equipment/techniques used) may prevent access to the highest marks.

Teachers should be aware of this feature of the assessment so that, when considering the award of higher marks, the activity should require a sophisticated approach and/or complex treatment. Higher marks must not be awarded for work which is simplistic or trivial.

One of the factors which determines the demand of an activity is the level of guidance given to candidates. The use of a highly structured worksheet, for example, will reduce the number of decisions and judgements required by the candidate and so will limit the range of marks available.

The difference in standard of Advanced Subsidiary and A2 is a product of the level of demand of the related scientific knowledge and understanding and the complexity and level of demand of the task set.

## Marking Candidates' Work

A different set of mark descriptors is used for Advanced Subsidiary and A2 (see **Appendix E**). The descriptors should be used to make a judgement as to which mark best fits a candidate's performance. The descriptors to be used for A2 take into account the synoptic assessment in Skills **P** and **A** at A2.

The descriptors have been written to provide clear continuity from the assessment of Sc1 for GCSE. This should ensure an effective continuation of the development of candidates' skills from GCSE to Advanced Subsidiary GCE and Advanced GCE.

The mark descriptors within a skill area have been written to be hierarchical. Thus, in marking a piece of work, the descriptors for the lowest defined mark level should be considered first and only if there is a good match should the descriptors for the next level up be considered. Therefore, if a teacher is considering awarding a high mark for a piece of work, the work must have demonstrated a good match to all the lower mark descriptors.

For each skill the scheme allows the award of intermediate marks (between the defined mark levels) and marks above the highest defined mark level and below the lowest defined level.

An intermediate mark may be awarded when the work of a candidate exceeds the requirements of a defined mark level but does not meet the requirements of the next higher defined mark level sufficiently to justify its award. Thus, an intermediate mark could be awarded if the work meets only one of the two descriptors at the higher defined mark level, provides a partial match to both or provides a complete match to one and a partial match to the other. Whether to award the lower or the higher of the intermediate marks will depend upon the closeness of the match to the higher level descriptors and this is left to the judgement of the teacher.

For Skill I, a mark above the highest defined mark level should be awarded for work which meets all the requirements of the descriptors for the highest defined mark level and is judged to be of additional merit in terms of the candidate's depth of understanding, competence, and organisational ability when carrying out practical work.

A mark below the lowest defined mark level should be awarded for work which fails to meet all the requirements of the lowest defined mark level, but where some attempt has been made to address the skill concerned and there is some evidence of positive achievement. A mark of zero should be awarded where there has been an attempt to address the skill but there is no evidence of positive achievement.

The marks awarded should be based on both the final written work and, in Skill I the teacher's knowledge of the work carried out by the candidate. In assigning a mark, attention should be paid to the extent of any guidance needed by, or given to, the candidate.

In defining the various mark descriptors it is recognised that practical tasks vary widely, both in the experimental procedures used, and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors for each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular defined level **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

## Synoptic Assessment

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. Assessment Objective AO4 relates specifically to synoptic assessment and marks from the A2 Unit 2855 (The Individual Investigation) contribute to the assessment of AO4 (see **Section 4**).

During experimental and investigative work, synoptic assessment:

- allows candidates to apply knowledge and understanding of principles and concepts from different parts of the specification in planning experimental work and in the analysis and evaluation of data;
- allows candidates to apply skills and techniques learned during the course.

The mark descriptors to be used when assessing Unit 2855 for Skill **P** (Planning) and Skill **A** (Analysing Evidence and Drawing Conclusions) include statements that relate specifically to synoptic assessment. Thus, in A2, a candidate will **not** be able to achieve more than 4 marks in each of Skills **P** and **A** without demonstrating aspects of synoptic assessment. Candidates will also bring to the assessment of Skill **I** (Implementing) their experience of practical and investigative work from throughout the course. In Skill **E** (Evaluating Evidence and Procedures), aspects of Skills **P** and **A** are evaluated.

Overall, in A2, at least 15 of the 45 marks available can thus be identified as contributing to an assessment of AO4 (synoptic assessment).

## Quality of Written Communication

Coursework must include an assessment of candidates' quality of written communication (see **Section 3.3**).

The mark descriptors for Skills **P**, and **A** have been written to include the required aspects.

## Annotation of Candidates' Work

Each piece of assessed coursework must be clearly annotated to show how the marks have been awarded in relation to the relevant skills.

The writing of comments on candidates' work can provide a means of communication between teachers during internal standardisation of coursework. The main purpose of annotating candidates' coursework should be, however, to provide a means of communication between teacher and the Moderator, showing where marks have been awarded and why. The sample of work which is submitted for moderation **must** show how the marks have been awarded in relation to the marking criteria.

Annotations should be made at appropriate points in the margins of the text. The annotations should indicate both where achievement for a particular skill has been recognised and the mark awarded. It is suggested that the minimum that is necessary is that the 'shorthand' mark descriptors (for example, P.8a, I.5b) should be written at the point on the script where it is judged that the work has met the descriptors concerned.

For Skill **I**, Implementing, more detail is necessary and the Moderator will require evidence concerning candidates' use of practical techniques and safe working practice. This evidence could take the form of checklists or written notes.

## Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for Advanced Subsidiary GCE and Advanced GCE this is likely to be the education authority or the governing body. Employees, i.e., teachers and lecturers, have a duty to cooperate with their employer on health and safety matters.

Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of *Safety in Science Education* (see below). For members, the CLEAPSS guide, *Managing Risk Assessment in Science* offers detailed advice.

Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

*Safety in Science Education,* DfEE, 1996, HMSO, ISBN 0 11 270915 X;

*Safeguards in the School Laboratory*, 10th edition, 1996, ASE ISBN 0 86357 250 2;

*Hazcards*, 1995, CLEAPSS School Science Service*;

*Laboratory Handbook,* 1988-97, CLEAPSS School Science Service*;

*Topics in Safety,* 2nd edition, 1988, ASE ISBN 0 86357 104 2;

*Hazardous Chemicals, A Manual for Science Education,* SSERC Limited 1997 ISBN 09531776 02

*Safety Reprints,* 1996 edition, ASE ISBN 0 86357 246 4.

* Note that CLEAPSS publications are only available to members or associates.

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting the CLEAPSS School Science Service (or, in Scotland, SSERC).

**When candidates are planning their own practical activities, whether individual investigations or tasks assessing individual experimental and investigative skills, the teacher or lecturer has a duty to check the plans before practical work starts and to monitor the activity as it proceeds**.

# Appendix E

## Mark Descriptors for Experimental and Investigative Skills

**The revised mark descriptors for AS 2852/02 Experimental Skills should be used for the first time in the June 2004 assessment.**

**The revised mark descriptors for A2 2855 Individual Investigation should be used for the first time in the January 2005 assessment.**

In defining the various mark descriptors, it is recognised that practical tasks vary widely, both in the experimental procedures used and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors within each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular level of performance **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

**Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range, the activity should involve increasing demands of related chemical knowledge and understanding, manipulation, precision, accuracy and complexity.**

**The descriptors for use in Unit 2852, component 02, and the descriptors for use in Unit 2855, are shown below.**

For examples of suitable tasks for assessing experimental skills at AS, and for examples of possible topics for individual investigations, teachers should refer to the publication Chemistry B *(Salters): Notes for the Guidance of Teachers on the Assessment of Experimental and Investigative Skills*. Copies can be ordered from the OCR Publications Department.

# DESCRIPTORS FOR USE IN UNIT 2852 COMPONENT 02

**These descriptors should be used for the first time in the June 2004 assessment.**

## Skill P: Planning — Total 11

| Mark | | Descriptor |
|---|---|---|
| | | The candidate: |
| **1** | | |
| **<u>2</u>** | **2a** | identifies and defines the nature of a question or problem and devises a basic practical procedure to respond to the question or problem; describes only limited detail about procedure. |
| | **2b** | chooses equipment appropriate to basic practical procedure |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | identifies and defines the nature of a question or problem and devises a more developed practical procedure to respond to the question or problem; describes key details about the procedure |
| | **5b** | chooses equipment and materials that are likely to produce useful data; includes a brief list of sources consulted; devises a basic risk assessment |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | identifies and defines a question or problem and devises a more fully developed and coherent practical procedure to respond to the question or problem; describes most expected details about the procedure. |
| | **8b** | chooses equipment and materials that are likely to produce precise and reliable results; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is both extensive and detailed; devises a risk assessment that covers most aspects of the activity and includes most appropriate details; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | identifies and defines a question or problem and devises a practical procedure that is comprehensive and coherent to respond to the question or problem; describes fine detail about the procedure. |
| | **11b** | explains how the choice of procedures and/or equipment and/or materials will ensure that the data collected is precise and reliable; retrieves and evaluates information from multiple appropriate sources; devises a risk assessment that is comprehensive, detailed and relevant; produces a clear account using specialist vocabulary appropriately and in which spelling, punctuation and grammar are accurate. |

## UNIT 2852 COMPONENT 02

## Skill I: Implementing — Total 12

| Mark | Descriptor | |
|---|---|---|
| | | The candidate: |
| **1** | | |
| **<u>2</u>** | **2a** | demonstrates competence in simple practical procedures; adopts safe working practices some of the time. |
| | **2b** | records basic data; organises data in a simple manner. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | demonstrates competence in a wider range and/or in more complex aspects of the practical procedure; adopts safe working practices most of the time; resolves problems with assistance; demonstrates a sense of purpose in the collection of data; demonstrates ability to work in an organised manner and collects most data carefully. |
| | **5b** | records a range of data, organises data systematically; records some data precisely and with suitable units. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | demonstrates effective practice in all aspects of the practical procedure; works safely throughout the activity; resolves most problems without assistance; works methodically and in an organised manner and collects almost all data carefully. |
| | **8b** | records an appropriate amount and range of data; records data that are generally of an appropriate quality; makes effective use of tables, where appropriate, most of which have appropriate labels and headings; records most data precisely and with suitable units. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | demonstrates well developed skills in all aspects of the practical procedure; works safely throughout the activity; resolves almost all problems without assistance; pays attention to fine detail in the collection of data, works methodically, carefully and in a very organised manner and collects all data carefully. |
| | **11b** | records an appropriate amount and range of data including fine detail; records data that is of high quality and identifies any obviously poor quality data; makes effective use of tables, where appropriate, all of which have appropriate labels and headings; records all data precisely and with suitable units. |
| **12** | | demonstrates highly developed skills in all aspects of practical procedures; works safely throughout the activity; pays particular attention to the fine detail in data collection; demonstrates a high degree of competence when handling equipment and materials and when recording data; is highly organised and resolves all problems without assistance. |

## UNIT 2852 COMPONENT 02

## Skill A: Analysing — Total 11

**Mark Descriptor**

The candidate:

| Mark | | Descriptor |
|---|---|---|
| **1** | | |
| **<u>2</u>** | **2a** | carries out basic calculations and/or draws basic graphs. |
| | **2b** | describes the outcomes of the activity in simple terms. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | carries out straight forward calculations correctly and/or draws simple graphs; makes some progress in more demanding calculations; explains some steps in calculations. |
| | **5b** | recognises simple patterns and trends in data where appropriate; describes the outcomes of the activity in some detail. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | carries out most expected calculations correctly and/or draws most expected graphs; includes appropriate units in most steps in calculations; explains most steps in calculations; draws most graphs of suitable quality and format. |
| | **8b** | recognises more detailed patterns and trends in data where appropriate; uses evidence from collected data to draw conclusions that are consistent with underlying chemical ideas; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | carries out all expected calculations correctly and/or draws all expected graphs; includes appropriate units in all steps in calculations; explains all steps in calculations; draws all graphs of suitable quality and format; |
| | **11b** | recognises more complex patterns and trends in data where appropriate; uses evidence from collected data to draw conclusions which are soundly based on underlying chemical ideas; produces a clear account, using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate. |

## UNIT 2852 COMPONENT 02

## Skill E: Evaluating Total 11

| Mark | Descriptor | |
|---|---|---|
| | The candidate: | |
| **1** | | |
| **<u>2</u>** | **2a** | comments in simple terms on some limitations of the practical procedure |
| | **2b** | comments in general terms on the uncertainty associated with measurements recorded during the activity or on limitations associated with equipment used during the activity. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | describes in reasonable detail some of the limitations of the practical procedure. |
| | **5b** | comments on the uncertainty associated with the use of specific equipment and/or calculates the uncertainty associated with some specific measurements. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | describes, including most appropriate detail, most limitations of the practical procedure and/or identifies some aspects of the procedure that are important in ensuring that the data collected is precise and reliable. |
| | **8b** | correctly calculates the uncertainty associated with specific examples of most types of measurements recorded during the activity. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | fully describes limitations of the practical procedure and/or identifies most aspects of the procedure that are important in ensuring that the data collected are precise and reliable; assesses the relative significance of the limitations of the practical procedures, where appropriate, in terms of their effect on the overall outcomes of the activity. |
| | **11b** | correctly calculates the uncertainty associated with specific examples of all types of measurements recorded during the activity; assesses the relative significance of uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity. |

# DESCRIPTORS FOR USE IN UNIT 2855

**These descriptors should be used for the first time in the January 2005 assessment. Descriptors from the Second Edition of the specification should be used in the January and June 2004 assessments.**

## Skill P: Planning Total 11

**Mark Descriptor**

The candidate:

| Mark | | Descriptor |
|---|---|---|
| **1** | | |
| **<u>2</u>** | **2a** | identifies and defines the nature of a question or problem and devises basic practical procedures to respond to the question or problem and chooses equipment and materials appropriate to simple techniques; describes only limited detail about procedures. |
| | **2b** | describes basic chemical knowledge in support of the general topic under investigation. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | identifies and defines the nature of a question or problem and devises more developed practical procedures to respond to the question or problem; describes key details about procedures, chooses procedures, equipment and materials that are likely to produce useful data. |
| | **5b** | describes a wider range of chemical knowledge in support of the topic under investigation; uses chemical ideas drawn from more than one area of the specification; devises a basic risk assessment; includes a brief list of sources consulted; states or implies aims of investigation. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | identifies and defines the nature of a question or problem and devises practical procedures that are likely to produce a reasonable amount of useful data to respond to the question or problem; chooses procedures, equipment and materials that are likely to produce precise and reliable data; describes most expected details about procedures, equipment and materials. |
| | **8b** | describes most expected chemical knowledge in support of the topic under investigation, most of which is relevant to the devised practical procedures and is chemically sound; uses chemical ideas drawn from more than one module of the specification; devises a risk assessment that covers most aspects of the investigation and includes appropriate details; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is quite extensive and detailed; clearly states aims of the investigation; produces a generally clear account using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | identifies and defines the nature of a question or problem and devises practical procedures that are comprehensive, coherent and likely to produce an appropriate amount of good quality data; describes fine detail about procedures, equipment and materials; explains how the choice of procedures and/or equipment and/or materials will ensure that the data collected is reliable, useful and of good quality. |
| | **11b** | describes chemical knowledge in support of all aspects of the topic under investigation that is chemically sound, comprehensive, coherent, detailed and relevant to the practical procedures; uses chemical ideas drawn from different parts of the AS and A2 parts of the specification; devises a risk assessment that is comprehensive, detailed and relevant; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is comprehensive, detailed and linked to appropriate sections of the investigation report; states the aims of the investigation clearly; produces a clear account using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate. |

## UNIT 2855

## Skill I: Implementing — Total 12

**Mark Descriptor**

The candidate:

| Mark | | Descriptor |
|---|---|---|
| **1** | | |
| **<u>2</u>** | **2a** | demonstrates competence in simple practical procedures; adopts safe working practices some of the time. |
| | **2b** | records basic data; organises data in a simple manner. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | demonstrates competence in a wider range and/or in more complex practical procedures; adopts safe working practices most of the time; resolves problems with assistance; demonstrates a sense of purpose in the collection of data; demonstrates ability to work in an organised manner and collects most data carefully. |
| | **5b** | records a greater range of data, most of which is relevant to the aims of the investigation; organises data systematically; records some data precisely and with suitable units. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | demonstrates effective practice in all practical procedures; works safely throughout the investigation; resolves most problems without assistance; demonstrates a clear sense of purpose in the collection of data; works methodically and in an organised manner and collects almost all data carefully. |
| | **8b** | records an appropriate amount and range of data that are relevant to the aims of the investigation; records data that is generally of an appropriate quality; makes effective use of tables, where appropriate, most of which have appropriate labels and headings; records most data precisely and with suitable units. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | demonstrates well developed skills in all practical procedures; works safely throughout the investigation; resolves almost all problems without assistance; pays attention to fine detail in the collection of data, works methodically, carefully and in a very organised manner and collects all data carefully. |
| | **11b** | records an appropriate amount and range of data, including fine detail, and links the data coherently to the aims of the investigation; records data that are of high quality and any poor quality data are clearly identified and/or re-investigated; makes effective use of tables, where appropriate, all of which have appropriate labels and headings; records all data precisely and with suitable units. |
| **12** | | demonstrates highly developed skills in all aspects of practical procedures; works safely throughout the investigation; pays particular attention to the fine detail in data collection; demonstrates a high degree of competence when handling equipment and materials and when recording data; is highly organised and resolves all problems without assistance. |

## UNIT 2855

## Skill A: Analysing  Total 11

| Mark | | Descriptor |
|---|---|---|
| | | The candidate: |
| **1** | | |
| **2** | **2a** | carries out basic calculations and/or draws basic graphs. |
| | **2b** | describes the outcomes of the investigation in simple terms. |
| **3** | | |
| **4** | | |
| **5** | **5a** | carries out straight forward calculations correctly and/or draws simple graphs from collected data; makes some progress in more demanding calculations; explains some steps in calculations. |
| | **5b** | recognises simple patterns and trends in data where appropriate; describes the outcomes of the investigation in some detail; uses evidence from raw and /or processed data to draw simple conclusions that are consistent with underlying chemical ideas drawn from more than one area of the specification. |
| **6** | | |
| **7** | | |
| **8** | **8a** | carries out most expected calculations correctly and/or draws most expected graphs from collected and processed data; explains main steps in calculations; draws most graphs of suitable quality and format; includes calculations and/or graphs that help meet the aims of the investigation. |
| | **8b** | recognises more detailed patterns and trends in data where appropriate; describes the outcomes of the investigation, including most details; uses evidence from raw and /or processed data to draw fuller and/or more detailed conclusions that are consistent with underlying chemical ideas drawn from more than one module of the specification; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate. |
| **9** | | |
| **10** | | |
| **11** | **11a** | carries out all expected calculations correctly and/or draws all expected graphs from collected and processed data; explains all steps in calculations; draws all graphs of suitable quality and format; includes calculations and/or graphs that are coherent and logical and help meet the aims of the investigation. |
| | **11b** | recognises more complex patterns and trends in data where appropriate; describes the outcomes of the investigation fully and in detail; uses evidence from raw and /or processed data to draw comprehensive and detailed conclusions that are soundly based on underlying chemical ideas drawn from different parts of the AS and A2 specification; produces a clear account, using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate. |

## UNIT 2855

## Skill E: Evaluating Total 11

| Mark | Descriptor | |
|---|---|---|
| The candidate: | | |
| **1** | | |
| **<u>2</u>** | **2a** | comments in simple terms on some limitations of practical procedures. |
| | **2b** | comments in general terms on the uncertainty associated with measurements recorded during the investigation or on limitations associated with equipment used during the investigation. |
| **3** | | |
| **4** | | |
| **<u>5</u>** | **5a** | describes in reasonable detail some of the limitations of the practical procedures |
| | **5b** | comments on the uncertainty associated with the use of specific equipment and/or calculates the uncertainty associated with some specific measurements. |
| **6** | | |
| **7** | | |
| **<u>8</u>** | **8a** | describes, including most appropriate detail, most limitations of the practical procedures; describes in simple terms, where appropriate, how some practical procedures might be modified to improve the reliability of the data collected. |
| | **8b** | correctly calculates the uncertainty associated with specific examples of most types of measurements recorded during the investigation. |
| **9** | | |
| **10** | | |
| **<u>11</u>** | **11a** | fully describes limitations of the practical procedures; assesses the relative significance of the limitations of the practical procedures in terms of their effect on the overall outcomes of the investigation; suggests, where appropriate, suitable changes to practical procedures to improve the reliability of data collected. |
| | **11b** | correctly calculates the uncertainty associated with specific examples of all types of measurements recorded during the investigation; assesses the relative significance of uncertainties associated with measurements in terms of their effect on the overall outcomes of the investigation; suggests, where appropriate, suitable changes to equipment to improve the precision of data collected. |

# Appendix F

# Mathematical Requirements

In order to be able to develop the knowledge, understanding and skills in these specifications, candidates need to have been taught and to have acquired competence in the areas of mathematics set out below. Material relevant to the Advanced GCE specification only is given in **bold** type.

## Arithmetic and Computation

Candidates should be able to:

- recognise and use expressions in decimal and standard form;
- use ratios, fractions and percentages;
- make estimates of the results of calculations (without using a calculator);
- **use calculators to find and use $x^n$, $1/x$, $\sqrt{x}$, $\log_{10}x$**.

## Handling Data

Candidates should be able to:

- use an appropriate number of significant figures;
- find arithmetic means.

## Algebra

Candidates should be able to:

- understand and use the following symbols: $<$, $>$, $\Delta$, $/$, $\approx$, $\propto$;
- understand use the prefixes: mega (M), kilo (k), milli (m), micro (μ);
- change the subject of an equation;
- substitute numerical values into algebraic equations using appropriate units for physical quantities;
- **use logarithms in relation to quantities which range over several orders of magnitude.**

## Geometry

Candidates should be able to:

- appreciate angles and shapes in regular 2-D and 3-D structures;
- visualise and represent 2-D and 3-D forms including two dimensional representations of 3-D objects;
- understand the symmetry of 2-D **and 3-D shapes**.

## Graphs

Candidates should be able to:

- translate information between graphical, numerical and algebraic forms;
- plot two variables from experimental or other data;
- understand that $y = mx + c$ represents a linear relationship;
- determine the slope and intercept of a linear graph;
- **draw and use the slope of a tangent to a curve as a measure of rate of change**.

## Appendix G

# Data Sheet

See over.