CHEMISTRY (Revised)
Higher

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National Course specification

CHEMISTRY (Revised) Higher

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Course structure

The course has four mandatory Units as follows:

FE4H 12	***Periodicity, Polarity and Properties (H)***	***0.5 credit (20 hours)***
FE4F 12	***Consumer Chemistry (H)***	***1 credit (40 hours)***
FE4D 12	***Principles to Production (H)***	***1 credit (40 hours)***
FE4J 12	***Researching Chemistry (H)***	***0.5 credit (20 hours)***

All Courses include 40 hours over and above the 120 hours for the Units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for Course assessment.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- ♦ Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- ♦ the Intermediate 2 Chemistry course at grade B or better

and

- ♦ Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

National Course specification: (cont)

COURSE Chemistry (Revised) Higher

Credit value

The Higher Course in Chemistry (Revised) is allocated 24 SCQF credit points at SCQF level 6*.

**SCQF points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Course specification: Course details (cont)

COURSE Chemistry (Revised) Higher

Rationale

Whilst articulating well with the current Standard Grade or Intermediate 2 courses, the Higher Chemistry course provides well-mapped concept and skill development pathways linking the underlying Curriculum for Excellence levels to Advanced Higher. In addition to providing a grounding for the future study of chemistry and chemistry-related subjects in higher education, the course also serves to equip all candidates with an understanding of the impact of Chemistry on everyday life, with the knowledge and skills to be able to reflect critically on scientific and media reports and to make their own reasoned decisions on many issues within a modern society increasingly dependent on science and technology. The Course content has been selected to allow candidates to study key chemical concepts within situations of personal relevance using up-to-date contexts.

The development of skills is a central feature of the course. Skills of scientific investigation, communication skills, literacy and numeracy are all specifically developed and assessed within the course. There also exist many opportunities to develop the skills associated with working with others. The Units offer a wealth of opportunities for collaborative and independent learning set within familiar and unfamiliar contexts. Practical investigative practical work is central to all scientific endeavours. This is reflected in an abundance of opportunities for high quality experimental work within all of the course Units.

The course supports progression in many aspects of health and wellbeing. Collaborative and co-operative practical work is promoted throughout the ‘Possible contexts and activities’ contained within Unit Specification appendices. A collaborative approach is also suggested for when candidates investigation a topical issues in chemistry as part of the Researching Chemistry Unit. By working with others in the laboratory, candidates can achieve self-awareness and develop an enhanced sense of self-worth and respect for others. The course allows candidates to acquire a good understanding of the central concepts of chemistry within contexts that allow candidates to gain a scientific insight into the food they eat, the products they buy and of the environmental and economic impact of their manufacture or production. In this way the Higher Chemistry course equips candidates with the knowledge and understanding to make well-informed personal decisions and to maintain a healthy lifestyle.

As a result of following a Higher Chemistry course, learners should acquire:

- knowledge and understanding of chemical facts, theories and symbols
- the ability to solve chemical problems
- the ability to think creatively and independently
- apply critical thinking within new or unfamiliar contexts
- the ability to make reasoned evaluations based on the evidence available
- the skills required to communicate facts, ideas and theories clearly with others
- positive attitudes, by helping candidates to be open-minded and willing to recognise alternative points of view, and to be interested in science and aware that they can take decisions which affect the well-being of themselves and others, and the quality of their environment.
- the ability to critically assess scientific claims made in the media
- an understanding of the need to assess the risk associated with practical activities.

During the course candidates will be expected to:

- select and present information
- carry out calculations
- plan, design and evaluate investigative practical work
- draw conclusions and give explanations
- make generalisations and predictions
- communicate their findings and critical evaluations in an appropriate format.

The study of Higher Chemistry should also foster an interest in current developments in, and applications of Chemistry, the willingness to make critical and evaluative comment, and the acceptance that Chemistry is a changing subject.

National Course specification: Course details (cont)

COURSE Chemistry (Revised) Higher

Course content

The course is made up of four mandatory Units: Periodicity, Polarity and Properties; Consumer Chemistry; Principles to Production and Researching Chemistry. The Researching Chemistry Unit is a skills development Unit equipping candidates with the investigative and reporting skills demanded by employers and Further and Higher Education. While these Units are valuable in their own right, candidates will gain considerable additional benefit from completing this course, since there will be opportunities for the integration of skills developed through study of the Units, and for tackling problem solving of a more complex nature than that required for attainment of the Performance Criteria of the Units

COURSE Chemistry (Revised) Higher

Assessment

To gain the award of the course, the candidate must achieve all the component Units of the course as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When Units are taken as component parts of a course, candidates will have the opportunity to demonstrate achievement beyond that required to attain each of the Unit Outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates, and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment are provided in the paper *Assessment* (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998).

Details of the instruments for external assessment

The instrument of assessment will be an externally set question paper of 2 hours 30 minutes duration. The question paper will sample the content and skills developed of all component Units.

The paper will assess a candidate's ability to demonstrate and apply knowledge and understanding in familiar and unfamiliar contexts.

The candidate will be required to:

1. Make accurate statements about facts, concepts and relationships.
2. Apply knowledge to solve problems.
3. Use knowledge to explain observations and phenomena.

The paper will also assess a candidate's ability to demonstrate skills of scientific experimentation and investigation. The paper will sample a range of skills and candidates may be required to:

1. Select relevant information from texts, tables, charts, graphs and diagrams.
2. Present information in a variety of forms.
3. Process information accurately using calculations where appropriate.
4. Plan and design experimental procedures to test given hypotheses or to illustrate particular effects.
5. Evaluate experimental procedures.
6. Draw valid conclusions supported by evidence or justification.
7. Make predictions and generalisations based upon available evidence.

The examination will consist of one paper of 2 hours 30 minutes with a total allocation of 100 marks.

The paper will consist of two sections.

Candidates will be expected to answer all of the questions.

Section A

Section A will be made up of 30 multiple-choice questions and is worth 30 marks.

Section B

Section B will be made up of questions requiring:

- a short answer (a few words);
- a response in the form of a numerical calculation;
- a restricted or open-ended response (a few sentences or paragraphs).

Mark allocation to Knowledge and Understanding

Between 70 and 75 marks will be allocated to questions that require candidates to demonstrate and apply Knowledge and Understanding.

Of these marks:

14 ± 4 marks will assess a candidate's ability to make accurate statements about facts, concepts and relationships.

45 ± 5 marks will assess a candidate's ability to apply knowledge to solve problems of which 15 ± 3 marks will involve the use of calculation(s) to solve problems.

12 ± 3 marks will assess a candidate's ability to use knowledge to explain observations and phenomena.

Mark allocation to Skills of Scientific Experimentation and Investigation

Between 25 and 30 marks will be allocated to questions that require candidates to demonstrate skills of scientific experimentation and investigation.

The questions assessing skills will sample from a number of different skill areas including:

- Selecting relevant information from texts, tables, charts, graphs and diagrams.
- Presenting information in a variety of forms.
- Processing information accurately using calculations where appropriate.
- Planing or designing experimental procedures to test given hypotheses or to illustrate particular effects.
- Evaluating experimental procedures.
- Drawing valid conclusions supported by evidence or justification.
- Making predictions and generalisations based upon available evidence.

Of the marks available:

8 ± 2 will be available for the processing of information using calculations
10 ± 3 will be available for the application of the skills developed within the Researching Chemistry Unit.

Mark allocation across Units

Within the examination candidates will be required to answer both Knowledge and Understanding and Skills based questions relating to all three of the content-based Units.

The minimum number of marks closely linked to the content of each of the content-based Units is shown below.

Periodicity, Polarity and Properties	minimum of 18 marks
Consumer Chemistry	minimum of 28 marks
Principle to Production	minimum of 28 marks

Candidates will be required to demonstrate the application of Knowledge and Understanding and of Skills of Scientific Experimentation and Investigation in a number of unfamiliar contexts.

Candidates will be required to demonstrate that they can integrate the Knowledge and Understanding acquired through study of the component Units.

20±3 marks within the exam will be associated with questions which assess candidate performance as described by the ‘Grade A’ grade description.

National Course specification: Course details (cont)

COURSE Chemistry (Revised) Higher

Grade Descriptions at A and C

Grade C

Candidates at Grade C will have demonstrated success in achieving the component Units of the course. In the course assessment candidates achieving a Grade C will have demonstrated an overall satisfactory level of performance by:

- retaining knowledge and understanding over a longer period of time
- integrating knowledge and understanding across the component Units of the course
- displaying problem solving skills in less familiar contexts
- applying skills of scientific experimentation and investigation in straightforward contexts with data of limited complexity.

Grade A

In addition candidates achieving a Grade A will have demonstrated a high overall level of performance by:

- retaining knowledge and understanding over a longer period of time
- showing a deeper level of knowledge and understanding
- integrating knowledge and understanding across the three component Units of the course
- displaying problem solving skills in less familiar and more complex contexts
- applying skills of scientific experimentation and investigation in complex contexts that involve more complex data.

Estimates and appeals

Estimates

In preparing estimates, evidence must take account of performance across the Course and must be judged against the Grade Descriptions. Further advice on the preparation of estimates is given in the Course Assessment specification.

Quality Assurance

All National Courses are subject to external marking and/or verification. Externals Markers, visiting Examiners and Verifiers are trained by SQA to apply national standards.

The Units of all Courses are subject to internal verification and may also be chosen for external verification. This is to ensure that national standards are being applied across all subjects.

Courses may be assessed by a variety of methods. Where marking is undertaken by a trained Marker in their own time, Markers meetings are held to ensure that a consistent standard is applied. The work of all Markers is subject to scrutiny by the Principal Assessor.

To assist centres, Principal Assessor and Senior Verifier reports are published on SQA's website **www.sqa.org.uk**.

Details of the instruments for internal assessment

The three content based Units (*Periodicity, Polarity and Properties*; *Consumer Chemistry* and *Principles to Profit*) are each assessed by means of a closed-book test. The test should include items covering all of the Performance Criteria associated with both Outcomes 1 and 2. The test should take approximately 45 minutes and should be sat under supervised examination conditions. Details of the breadth and depth of content to be covered by each Unit test are provided within in the appendix to the specification in addition to the specification of the formats within which data is to be processed in the assessment of Outcome 2.

For the *Researching Chemistry* Unit, evidence is required to demonstrate that candidates have met the requirements of the three Unit Outcomes. Assessors should use their professional judgement to determine the most appropriate instruments of assessments for generating evidence and the conditions and contexts in which they are used.

Outcome 1

Candidates will be provided with a briefing document which contains focus questions relating to key points of background information and/or chemical theory likely to be unfamiliar to the candidate. Candidates must produce:

- A clear and accurate answer to a focus question selected from those contained in the brief.
- A record of at least two sources of information relating to the answer provided. These should be identified in sufficient detail to allow a third party to retrieve the source article.

Outcome 2

Candidates will contribute to the planning and carrying out of investigative practical work. The assessor should record the date upon which the candidate was observed to have achieved the assessment standards.

Outcome 3

Outcome 3 is assessed by a single scientific communication describing the investigative activity and its findings. The scientific communication must be the individual work of the candidate. Depending on the activity, the collection of information may involve group work. The scientific communication can take any format in which the results of scientific research are commonly reported including: conference poster format, scientific paper format, PowerPoint presentation, video presentation, web page or traditional lab report.

Written and/or video and/or electronic and/or recorded oral evidence may be used to provide evidence that: the aim of the investigative work is clearly identified; information is analysed and presented in an appropriate format; valid conclusions are drawn and procedures are evaluated with respect to the selection of apparatus, the details of experimental method and/or the reliability of results as appropriate.

National Course specification: Course details (cont)

COURSE Chemistry (Revised) Higher

Guidance on learning and teaching approaches for this Course

Appropriate selection from a variety of learning and teaching approaches is required to deliver both knowledge-based and skill-based objectives to candidates with different needs and abilities. In doing so, opportunities should be provided for candidates to work independently, sometimes collaboratively or co-operatively and on other occasions as a whole class. Exposition, used in conjunction with questioning and discussion, is a very effective way of developing candidates' knowledge and understanding of the more theoretical chemical concepts as well as a good means of introducing new topics and consolidating completed topics. Both teachers and candidates should make full use of opportunities to use models to help the understanding of concepts in chemistry and to use information technology to support learning and to process data.

The course is made up of four mandatory Units: Periodicity, Polarity and Properties; Consumer Chemistry; Principles to Productions and Researching Chemistry. The Researching Chemistry Unit is a skills development Unit equipping candidates with the investigative skills and reporting skills demanded by employers and Further and Higher Education. While these Units are valuable in their own right, candidates will gain considerable additional benefit from completing this course, since there will be opportunities for the integration of skills developed through study of the Units, and for tackling problem solving of a more complex nature than that required for attainment of the Performance Criteria of the Units

Centres are free to deliver the three content-rich course Units in whichever order best meets the needs of their learners. It is likely that most centres will prefer to cover the intermolecular forces elements of the Periodicity, Polarity and Properties Unit before attempting the Consumer Chemistry Unit. This would allow candidates to acquire the appreciation of the factors determining the strength of Van der Waals interactions needed to relate solubility and volatility to molecular structure. In the school context it is common for candidates to start the Higher course shortly before the summer vacation. Where this is the case some schools may wish to consider introducing the Higher course through the study of reaction rates from the Principles to Productions Unit.

Calculations based on the mole and balanced equations are central to chemistry. In terms of internal Unit assessments, these items are only assessed within the National Assessment Bank tests associated with the Principles to Productions Unit. It is advisable that candidates are given the opportunity to practise solving problems relating to the mole and balanced equations throughout the course. By revisiting the mole at different points of the course, candidates are given the opportunity to consolidate earlier learning and may progressively develop a more in-depth and secure understanding of the mole concept through applying their knowledge in different contexts.

The Researching Chemistry Unit develops the skills required to undertake investigative work in Chemistry. As part of this Unit, candidates are required to become familiar with commonly used experimental techniques and data-analysis skills. Within the Further Education context this Unit may well be delivered as a free-standing Unit, but in schools this Unit can be very effectively run concurrently with the other course Units. The advantage of such an approach is that each technique can be developed and practised within the real-life contexts provided by the other course Units. For example, a practical laboratory exercise involving distillation, one of the technique specified within the Researching Chemistry Unit specification, could be undertaken during the study of essential oils within the Consumer Chemistry Unit

Candidates should be encouraged to see risk assessment as a natural part of the planning process for any practical activity. Whilst candidates would **not** be expected to produce a full written risk assessment themselves, this Researching Chemistry Unit in particular provides an opportunity to assess risks and take informed decisions regarding the use of appropriate control measures during the planning stage of the practical investigation.

Use of the additional 40 hours

This time may be used:

- to provide an introduction to the course and assessment methods
- to allow candidates to develop their ability to integrate knowledge, understanding and skills acquired through the study of the different component Units
- to allow some more practical work, on an individual basis if appropriate, within the Units to enhance skills and understanding
- for consolidation and integration of learning
- for remediation
- for practice in examination techniques and preparation for the external examination
- to investigate the chemistry relating to current news stories or articles in the media
- to discuss and debate the ethical and moral implications of Chemistry related issues.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

National Unit Specification: general information

UNIT Periodicity, Polarity and Properties (SCQF 6)

CODE FE4H 12

COURSE Chemistry (Higher)

SUMMARY

This Unit develops knowledge and understanding of periodic trends and strengthens the candidate's ability to make reasoned evaluations by recognising underlying patterns and principles. Developing a deeper understanding of the concept of electronegativity allows the two key themes of the Unit to be developed. Firstly, candidates will gain an understanding of the different types of intermolecular force and their role in determining a material's physical properties. Secondly, from the starting point of electronegativity, candidates look at the ability of substances to act as oxidising or reducing agents. The Unit is intended to offer candidates the opportunity to take part in a wide range of stimulating practical activities.

OUTCOMES

1 Demonstrate and apply knowledge and understanding related to *Periodicity, Polarity and Properties*.
2 Demonstrate skills of scientific experimentation and investigation *in the context of Periodicity, Polarity and Properties.*

Administrative Information

Superclass: RD

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

National Unit Specification: general information (cont)

UNIT Periodicity, Polarity and Properties (Higher)

RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- the Intermediate 2 Chemistry course at grade B

and

- Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

0.5 credit(s) at Higher (3 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Periodicity, Polarity and Properties (Higher)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Demonstrate and apply knowledge and understanding related to *Periodicity, Polarity and Properties*.

Performance Criteria

(a) Make accurate statements about *Periodicity, Polarity and Properties* facts, concepts and relationships.
(b) Use knowledge of *Periodicity, Polarity and Properties* to solve problems.
(c) Use knowledge of *Periodicity, Polarity and Properties* to explain observations and phenomena.

OUTCOME 2

Demonstrate skills of scientific experimentation and investigation in the context of *Periodicity, Polarity and Properties.*

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to the evaluation of scientific evidence.

National Unit Specification: statement of standards (cont)

UNIT Periodicity, Polarity and Properties (Higher)

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- Trends in the Periodic Table and Bonding
- Intermolecular forces
- Oxidising and reducing agents

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2, and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided within in the appendix to the specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: chemical formulae, balanced chemical equations, diagrams depicting laboratory apparatus, line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit Specification: support notes

UNIT Periodicity, Polarity and Properties (SCQF 6)

This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the appendix to this Unit Specification.

This Unit builds knowledge of periodic trends and strengthens candidate's ability to make reasoned evaluations based upon recognising underlying patterns and principles. Developing a deeper understanding of the concept of electronegativity allows the two key themes of the Unit to be developed. Firstly, candidates will gain an understanding of the different types of intermolecular force and their role in determining a material's physical properties. Secondly, from the starting point of electronegativity, candidates look at the ability of substances to act as oxidising or reducing agents.

This Unit offers rich and diverse contexts with ample opportunities for practical work. These are highlighted in the 'Possible contexts and activities' column of the content tables in the Appendix. Opportunities exist for candidates to develop their knowledge and skills as part of a group through practical work undertaken in partnership or in teams.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

General advice on approaches to learning and teaching is contained in the course specification.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly chemical phenomena in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the core skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The appendix to this Unit Specification contains an extensive list of 'Possible Contexts and Activities' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key ICT skill s including; accessing information and providing/creating information.

The Unit appendix contains an extensive range of practical laboratory exercises which provide candidates with the opportunity to working co-operatively with others.

Problem solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) & (c) and also through Outcome 2, PCs (a) & (b).

National Unit Specification: support notes

UNIT Periodicity, Polarity and Properties (SCQF 6)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that a holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation and investigation can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS
The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments for may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements

UNIT Periodicity, Polarity and Properties (Higher)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the breadth and depth of content expected. The right-hand column gives possible contexts and activities which could be used to develop knowledge, understanding and skills. Further details on many of the activities mentioned in the final column can be obtained from **National Qualifications Online**, part of the Learning and Teaching Scotland online service. Where such online support exists the 💻 symbol appears in the text.

Content	**Notes**	**Possible Contexts and Activities**
1) Trends in the Periodic Table and Bonding		
(a) The Arrangement of elements in the Periodic Table	Elements are arranged in the Periodic Table in order of increasing atomic number. The Periodic Table allows chemists to make accurate predictions of physical properties and chemical behaviour for any element based on its position. Features of the table are; Groups- vertical columns within the table which will contain elements with similar chemical properties resulting from a common number of electrons in the outer shell, Periods- rows of elements arranged with increasing atomic number demonstrating an increasing number of outer electrons and a move from metallic to non-metallic characteristics. Key groups of elements which can be recognised are metals and non-metals, alkali metals, halogens, noble gases and transition elements. The gaseous elements are generally to be found clustered in the top right corner of the table.	Periodic trends can be illustrated by graphing properties such as first ionisation energy or covalent radius against atomic number. Interactive Periodic Tables, such as that offered by the Royal Society of Chemistry, can be used to generate a large number of plots showing periodically repeating trends. 💻 Element cards can be prepared showing atomic number, element name and symbol, properties and/or electronic arrangements, candidates can lay out the cards on a large table or lab floor and experiment with different arrangements. The story of the development of the modern Periodic Table could be explored.

(b) Bonding and structure in the first twenty elements.	The first 20 elements in the Periodic Table can be categorised according to bonding and structure: • metallic (Li, Be, Na, Mg, Al, K, Ca) • covalent molecular (H_2, N_2, O_2, F_2, Cl_2, P_4, S_8 and fullerenes (eg C_{60})) • covalent network (B, C (diamond, graphite), Si) • monatomic (noble gases)	Elements can be extracted from their compounds. Silicon (an interesting example as it is a covalent network and 'looks' metallic) can be extracted from sand using magnesium. Details of this experiment are available in 'Classic Chemistry Demonstrations', Lister T. The Royal Society of Chemistry (1995) pp. 127-129. The experiment is also available as a video download from The molecular nature of sulfur can be discussed during an exploration of the allotropes of sulfur. Details of an experimental method are also to be found in 'Classic Chemistry Demonstrations', Lister T. The Royal Society of Chemistry (1995) pp. 191-195 Molecular models can also be constructed or viewed. Entertaining video portraits of all of the elements in the Periodic Table can also be viewed online.
(c) Periodic trends in ionisation energies and covalent radii	The covalent radius is a measure of the size of an atom. The trends in covalent radius across periods and down groups can be explained in terms of the number of occupied shells, and the nuclear charge. The first ionisation energy is the energy required to remove one mole of electrons from one mole of gaseous atoms. The second and subsequent ionisation energies refer to the energies required to remove further moles of electrons. The trends in ionisation energies across periods and down groups can be explained in terms of the atomic size, nuclear charge and the screening effect due to inner shell electrons.	Interactive Periodic Tables, such as that offered by the Royal Society of Chemistry, can be used to generate a large number of plots showing periodically repeating trends. Striking 'landscapes' have been created by producing three dimensional plots of ionisation energy and covalent radii for the entire Periodic Table. These are available as both still images and in the form of animated 'fly through' across the periodic landscape.

(d) Periodic trends in electronegativity	Atoms of different elements have different attractions for bonding electrons. Electronegativity is a measure of the attraction an atom involved in a bond has for the electrons of the bond. Electronegativity values increase across a period and decrease down a group. Electronegativity trends can be rationalised in terms of nuclear charge, covalent radius and the presence of 'screening' inner electrons.	A bonding simulation can be used in which you can adjust the electronegativity of each atom, and view the effect of the resulting electron cloud. The story of Linus Pauling, after whom the most commonly used electronegativity scale is named, is available from the RSC The RSC interactive Periodic Table can be very useful for showing trends
(e) Polar covalent bonds	In a covalent bond atoms share pairs of electrons. The covalent bond is a result of two positive nuclei being held together by their common attraction for the shared pair of electrons. Polar covalent bonds are formed when the attraction of the atoms for the pair of bonding electrons is different. Delta positive and delta negative notation can be used to indicate the partial charges on atoms, which give rise to a dipole.	It is likely that candidates will have encountered a variety of molecular compounds in their earlier studies of Chemistry. Candidates can often tend to regard the predictive rule-of-thumb, 'covalent compounds are formed from non-metals only' as an absolute law. At Higher level, where candidates will be exposed to the concept of a 'bonding continuum', it is possible to illustrate the limitations of such convenient rules-of-thumb by allowing the candidates to encounter covalent molecular compounds which contain a metal. Tin(IV) iodide can be formed by gently heating tin and iodine in toluene in a small conical flask. When the mixture is allowed to cool, yellow-brown crystals form which can be collected by filtration. Melting point of SnI_4 c. 143 ^oC. Tin has an electronegativity of 1.8 and iodine has an electronegativity of 2.6 so this molecule contains polar covalent bonds.

(f) Bonding continuum	Pure covalent bonding and ionic bonding can be considered as being at opposite ends of a bonding continuum with polar covalent bonding lying between these two extremes. The larger the difference in electronegativities between bonded atoms is, the more polar the bond will be. If the difference is large then the movement of bonding electrons from the element of lower electronegativity to the element of higher electronegativity is complete resulting in the formation of ions. Compounds formed between metals and non-metals are often, but not always ionic. The properties of the compound should be used to deduce the type of bonding and structure rather than the type of elements present in the formula.	An Ionic bonding simulations can be used. A creative problem solving exercise of the 'four white powders' type could be used where candidates have white powders and must devise their own experimental method to tell them apart experimentally. The powders are; silicon dioxide, glucose, sodium chloride and calcium carbonate. Please also see the activity relating to 'Polar Covalent Bonds' above, for an example of a compound formed from a metal and non-metal where a molecular compound containing polar covalent bonds is formed between a metal and a non-metal.
2) Intermolecular forces		
(a) Van der Waals' forces	All molecular elements and compounds and monatomic elements will condense and freeze at sufficiently low temperatures. For this to occur, some attractive forces must exist between the molecules or discrete atoms. Any 'intermolecular' forces acting between molecules are known as van der Waals' forces. There are several different types of van der Waals' forces such as London dispersion forces and permanent dipole-permanent dipole interactions which includes hydrogen bonding.	Common misunderstandings arise when candidates focus upon covalent and ionic bonding and fail to appreciate other types of interaction at play. The two activities 'Interactions' and 'Spot the Bonding' allow consolidation and discussion of intramolecular and intermolecular interactions. It was published in 'Chemical misconceptions : prevention, diagnosis and cure (Volume 2)', Keith Taber, Royal Society of Chemistry 2002 which is available in both word and pdf format free of charge.

(b) London dispersion forces	London dispersion forces are forces of attraction which can operate between all atoms and molecules. These forces are much weaker than all other types of bonding. They are formed as a result of electrostatic attraction between temporary dipoles and induced dipoles caused by movement of electrons in atoms and molecules. The strength of London dispersion forces is related to the number of electrons within an atom or molecule. London dispersion forces are a type of van der Waals' force.	London forces are named after Fritz Wolfgang London (1900–1954) a German-born American theoretical physicist. The relationship between the strength of London forces and the number of electrons can be shown by plotting the melting or boiling points for the noble gases or for the halogens 💻
(c) Permanent dipole-permanent dipole interactions	A molecule is described as polar if it has a permanent dipole. The spatial arrangement of polar covalent bonds can result in a molecule being polar. Permanent dipole-permanent dipole interactions are additional electrostatic forces of attraction between polar molecules. Permanent dipole-permanent dipole interactions are stronger than London dispersion forces for molecules with similar numbers of electrons. Permanent dipole-permanent dipole interactions are a type of a van der Waals' force.	A practical demonstration of the polarity of molecules is provided by experiments in which liquids are deflected by a static charge. Classic experiments would include allowing candidates to experiment with the use of charged rods to deflect a stream of polar liquid flowing from a burette, but there are also more unusual variations such as the deflection of syrup by a charged balloon. The effect of the polarity of a molecule on the strength of intermolecular forces can be illustrated by comparing molecules with similar numbers of electrons but differing polarity, for example bromine and iodine monochoride. (Br_2, 70 electrons, non-polar, mp -7 ^{o}C) (ICl, 70 electrons, polar, mp +27 ^{o}C)

(d) Hydrogen Bonding	Bonds consisting of a hydrogen atom bonded to an atom of a strongly electronegative element such as fluorine, oxygen or nitrogen are highly polar. Hydrogen bonds are electrostatic forces of attraction between molecules which contain these highly polar bonds. A hydrogen bond is stronger than other forms of permanent dipole-permanent dipole interaction but weaker than a covalent bond. Hydrogen bonds are a type of van der Waals' force.	Computer animations showing the formation of a hydrogen bond are available. 💻 Water can be placed into sealed glass bottles and frozen, demonstrating the formation of the hydrogen bonded lattice structure which causes the anomalously large volume for frozen water. Hydrogen bonding is also responsible for the surface tension of water can be demonstrated using classic experiments such as the floating needle on the surface of a glass of water, or adding coins to a wine glass full of water to demonstrate the level rising above the rim of the glass. Hydrogen bonding is at the heart of 'hydrogels' materials. A range of experiments illustrating these materials is available in 'Inspirational Chemistry', Vicky Wong, Royal Society of Chemistry 2006 pp. 115 — 120 💻. Activities include 'Plant Water Storage Crystals', 'Disposable Nappies', 'Hair Gel' in addition to a practical problem- 'Hydrogels and Sugar'. 'Instant snow' is a slightly modified form of hydrogel which expands dramatically when hydrated. Teachers may wish to outline the role of hydrogen-bonding in maintaining the shape of DNA molecules. An excellent flash presentation on hydrogen bonds including their role in DNA structure. 💻

(e) Relating properties to intermolecular forces	Melting points, boiling points and viscosity can all be rationalised in terms of the nature and strength of the intermolecular forces which exist between molecules. By considering the polarity and number of electrons present in molecules, it is possible to make qualitative predictions of the strength of the intermolecular forces. The melting and boiling points of polar substances are higher than the melting and boiling points of non-polar substances with similar numbers of electrons. The anomalous boiling points of ammonia, water and hydrogen fluoride are a result of hydrogen bonding. Boiling points, melting points, viscosity and solubility/miscibility in water are properties of substances which are affected by hydrogen bonding. Hydrogen bonding between molecules in ice results in an expanded structure which causes the density of ice to be less than that of water at low temperatures.	The anomalous density of ice can be demonstrated by showing that wax beads sink when dropped into molten wax in contrast to ice which floats on water. An alternative experiment from the RSC involves placing ice cubes into vegetable oil. The ice cube floats, but on melting the liquid water descends through the oil to form a layer at the bottom of the vessel. In an investigative variation, a glass containing a layer of oil on water is placed in the freezer to see what happens. 'Bubble tubes' are sealed glass tubes containing a liquid and a small volume of air. When the tube is inverted the air rises as a bubble through the liquid. If different liquids are used, the time taken for the bubble to rise to the top end of the tube is inversely related to viscosity. These tubes allow the relationship between polarity and viscosity to be explored. Details can be found in 'Classic Chemistry Experiments', Kevin Hutchings 2000 pp. 4,5 The effect of the number of O-H bonds in a molecule on the strength of the intermolecular forces can be explored using propan-1-ol, propane-1,2-diol and propane-1,2,3-triol. Three test-tubes are set-up, one containing propan-1-ol, one containing propane-1,2-diol and one containing propane-1,2,3-triol. A small ball is dropped into each test-tube simultaneously and the rate with which they sink to the bottom of the tubes compared.

(f) Predicting solubility from solute and solvent polarities	Ionic compounds and polar molecular compounds tend to be soluble in polar solvents such as water and insoluble in non-polar solvents. Non-polar molecular substances tend to be soluble in non-polar solvents and insoluble in polar solvents. Key features to be considered are: the presence in molecules of O-H or N-H bonds, which would imply hydrogen bonding; the spatial arrangement of polar covalent bonds which could result in a molecule possessing a permanent dipole.	Experimental investigation of the solubility of molecular compounds chosen to include examples with O-H or N-H bonds, and shapes which would result in permanent dipoles.
3) Oxidising and reducing agents		
(a) Elements as oxidising or reducing agents	An oxidising agent is a substance which accepts electrons; a reducing agent is a substance which donates electrons. Oxidising and reducing agents can be identified in redox reactions. The elements with low electronegativities (metals) tend to form ions by losing electrons (oxidation) and so can act as reducing agents; the elements with high electronegativities (non-metals) tend to form ions by gaining electrons (reduction) and so can act as oxidising agents. The strongest reducing agents are found in Group 1 whilst the strongest oxidising agents come from Group 7. The electrochemical series indicates the effectiveness of oxidising and reducing agents.	Displacement reactions are a classic way to compare the relative strength of oxidising and reducing agents. To compare the strength of elements as oxidising agents experiments with halogen displacement can be used. Experiments suitable for candidate use are available in Classic Chemistry Experiments, K Hutchings, Royal Society of Chemistry 2000- halogen displacement pp. 46-48 Videos showing halogen displacement are also available. The relative strengths of other non-metals as oxidising agents can also be compared. Oxygen gas can be bubbled through solutions of potassium sulfide, chloride, bromide and iodide to establish which non-metallic elements are displaced from their compounds by oxygen. Then chlorine water is added to the same solutions to establish which elements are displaced by chlorine. To compare the strength of elements acting as reducing agents, metal displacement reactions can be used. A typical candidate experiment is described in Classic Chemistry Experiments, K Hutchings, Royal Society of Chemistry 2000- halogen displacement pp. 249-252

		Demonstration metal displacement experiments include the well known ‘snow tree’ experiment, in which copper foil cut in the shape of a pine tree is lowered into silver nitrate solution causing ‘snow’ crystals to form on the branches, and the thermit reaction. Classic Chemistry Demonstrations, Ted Lister, Royal Society of Chemistry 1995 contains details of two methods for carrying out this dramatic experiment. The thermit reaction is also available on video.
(b) Molecules and group ions can act as oxidising and reducing agents	Compounds can also act as oxidising or reducing agents. Electrochemical series contain a number of ions and molecules. The dichromate and permanganate ions are strong oxidising agents in acidic solutions whilst hydrogen peroxide is an example of a molecule which is a strong oxidising agent. Carbon monoxide is an example of a gas that can be used as a reducing agent. Oxidising and reducing agents can be selected using an electrochemical series from a databook or can be identified in the equation showing a redox reaction.	The ‘elephant’s toothpaste’ experiment provides an illustration of hydrogen peroxide’s ability to act as an oxidising agent. An adaptation of the blue bottle experiment allows candidates to see dextrose acting as a reducing agent, and oxygen acting as an oxidising agent. Every time a bottle containing an alkaline solution of methylene blue and dextrose is shaken, the methylene blue is reduced by the dextrose turning the solution colourless, but then reacts with atmospheric oxygen to return to its blue colour. A version for candidates to try for themselves is described in Classic Chemistry Experiments, Kevin Hutchings, 2000 Royal Society of Chemistry. A startling and unusual demonstration of hydrogen peroxide’s ability to act as an oxidising agent is demonstrated by the ‘Luminescent Tea’ experiment. Ethyl ethanoate and 35% hydrogen peroxide are measured into a beaker in a 5:1 ratio. A small pinch of oxalic acid-bis-(2,3-dinitrophylester) is added along with a peppermint tea bag. The hydrogen peroxide oxidises the oxalic ester producing carbon dioxide in an excited state. The carbon dioxide transfers energy to the chlorophyll in the peppermint tea causing red light to be emitted. If the room is completely darkened, every time the beaker is moved a red glow

		can be seen. Ethyl ethanoate acts as the solvent in this experiment. (Spectacular Chemistry Experiments, HW Roesky, Wiley-VCH 2007 pp. 49-50) To illustrate the oxidising nature of permanganate ions, glycerol is poured onto potassium permanganate crystals. After a short lag time, the permanganate ions oxidise the glycerol causing steam to be given off.
		An illustration of the chlorate(V) ions ability to act as oxidising agents is provided in a spectacular demonstration using chlorate(V) salts to oxidise granulated sugar. The potassium ions present result in spectacular pink flames being produced Instructions on how to carry this experiment safely are given in Contemporary Chemistry for Schools and Colleges, Vanessa Kind, Royal Society of Chemistry 2004 pp. 11-12 The potassium ions present result in spectacular pink flames being produced Instructions on how to carry this experiment safely are given in Contemporary Chemistry for Schools and Colleges, Vanessa Kind, Royal Society of Chemistry 2004 pp. 11-12 Experiments which show the ability of molecules to act as reducing agents include the reduction of copper(II) oxide using methane or hydrogen. A version of this experiment adapted for use by pairs of candidates is also available.

(c) Everyday uses for strong oxidising agents	Oxidising agents are widely employed because of the effectiveness with which they can kill fungi and bacteria, and can inactivate viruses. The oxidation process is also an effective means of breaking down coloured compounds making oxidising agents ideal for use as 'bleach' for clothes and hair.	Potassium permanganate, $KMnO_4$, is a chemical oxidising agent that will react with any organic matter in a pond including algae, bacteria, fish, particulate and dissolved organic matter, and organic bottom sediments. It has been used in fish ponds to treat common fish pathogens such as gill parasites and external bacterial and fungal infections. Bleaching reactions can be carried out using sulfur dioxide- red roses rapidly decolourise in a gas jar of SO_2. When chorine gas, generated by adding 6M HCl to $KMnO_4$ is bubbled through tomato juice, the red colour quickly disappears. (Details from 'Spectacular Chemistry Experiments', H.W. Roesky Wiley-VCH 2007 pp. 87-88.) Another demonstration which works well uses a household bleach containing sodium hypochlorite. 4 drops of yellow food colouring (E102) and 4 drops of blue food colouring (E 124) are dissolved in 40 cm^3 of water. A solution containing 4 drops of household bleach in 20 cm^3 of water is added to the solution and the mixture stirred. The hypochlorite oxidises the colourings taking the solution through a number of colour changes. This experiment will work with both thick and thin bleaches. Thicker bleaches tend to give more gradual colour changes which are easier for candidates to observe. (Details from 'Spectacular Chemistry Experiments', H.W. Roesky Wiley-VCH 2007 pp. 77-78.)

(d) Ion-electron and redox equations	Oxidation and reduction reactions can be represented by ion-electron equations. When molecules or group ions are involved, if the reactant and product species are known, a balanced ion-electron equation can be written by adding appropriate numbers of water molecules, hydrogen ions and electrons. (Candidates would not be expected to complete and balance ion-electron equations for reactions occurring in alkaline solutions.) Ion-electron equations can be combined to produce redox equations.	Redox titrations could be used to illustrate quantitatively, the relevance of balanced redox equations. Possible titrations could include; determination of vitamin C in vitamin tablets by titration with acidified permanganate, determination of the concentration of a hydrogen peroxide solution by titration with acidified potassium permanganate. There are a number of methods that allow the concentration of household bleaches to be investigated. Excess hydrogen peroxide can be added to household bleach and the volume of oxygen produced measured. The concentration of sodium hypochlorite in the bleach can be calculated. A version of this experiment adapted for use by candidates is also available. Alternatively, candidates can measure the bleach content of a variety of bleaches, and calculate their cost effectiveness, by reacting the chlorine in the bleach with iodide to form iodine and then titrating the iodine solution against sodium thiosulfate.

National Unit Specification: general information

UNIT Consumer Chemistry (SCQF 6)

CODE FE4F 12

COURSE Chemistry (Revised)

SUMMARY

This Unit develops a knowledge and understanding of Organic Chemistry within the context of everyday consumer products. The relationship between the structure of organic compounds and their physical and chemical properties is explored. Key functional groups and types of organic reaction are covered. The Unit will equip candidates with the scientific background necessary to evaluate the scientific and technological claims in order to make informed choices and decisions. The Unit provides candidates with the opportunity to solve problems and to apply critical thinking in new contexts.

OUTCOMES

1 Demonstrate and apply knowledge and understanding related to *Consumer Chemistry*.
2 Demonstrate skills of scientific experimentation and investigation within the context of *Consumer Chemistry*.

Administrative Information

Superclass: RD

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

National Unit Specification: general information (cont)

UNIT Consumer Chemistry (SCQF6)

RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- the Intermediate 2 Chemistry course at grade B

and

- Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

1 credit(s) at Higher (6 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates*.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Consumer Chemistry (SCQF6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Demonstrate and apply knowledge and understanding related to *Consumer Chemistry*.

Performance Criteria

(a) Make accurate statements about *Consumer Chemistry* facts, concepts and relationships.
(b) Use knowledge of *Consumer Chemistry* to solve problems.
(c) Use knowledge of *Consumer Chemistry* to explain observations and phenomena.

OUTCOME 2

Demonstrate skills of scientific experimentation and investigation in the context of *Consumer Chemistry*.

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to the evaluation of scientific evidence.

National Unit Specification: statement of standards

UNIT Consumer Chemistry (SCQF6)

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- Alcohols
- Carboxylic acids
- Fruit Flavours
- Fats and Oils
- Proteins
- Chemistry of cooking
- Oxidation of food
- Soaps and emulsions
- Fragrances
- Skincare products

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided within in the appendix to the specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: chemical formulae, balanced chemical equations, diagrams depicting laboratory apparatus, line graphs, scatter graphs, bar and pie charts, tables, diagrams and text. Candidates must be able to write molecular formulae, full and shortened structural formulae for straight and branched chain aliphatic alcohols, aldehydes, ketones, carboxylic acids, carboxylic acid salts and esters containing no more than eight carbon atoms in their longest chain. IUPAC naming rules must be used for these compounds. Candidates should also be familiar with the term ‘isomers’ as used to refer to molecules with the same molecular formula but different structural formulae.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit Specification: support notes

UNIT Consumer Chemistry (SCQF 6)

This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the course specification.

This Unit allows candidates to develop knowledge and understanding of Organic Chemistry within the context of everyday consumer products. The relationship between the structure of organic compounds and their physical and chemical properties is developed in details with key functional groups and types of reaction being covered in detail. The Unit will equip candidates with the scientific background necessary to evaluate the scientific and technological claims in order to make informed choices and decisions. The Unit provides candidates with the opportunity to solve problems and to apply critical thinking in new contexts.

Whilst completing this Unit candidates will be exposed to a large variety of organic molecules both natural and synthetic. The emphasis should be on developing an understanding that the functional groups present in these molecules are central in determining the reactions and properties of substances.

Functional Group	***Encountered in***
hydroxyl	*alcohols, terpenes*
carboxyl	*carboxylic acids, amino acids*
ester link	*esters, fats & edible oils*
amino	*amino acids*
amide link	*proteins*
carbonyl	*aldehydes, ketones and terpenes*
carboxylate ion	*salts, soaps*
carbon double bond	*fats and edible oils, terpenes, proteins*

Candidates must be able to write molecular formulae, full and shortened structural formulae for straight and branched chain aliphatic alcohols, aldehydes, ketones, carboxylic acids, carboxylic acid salts and esters containing no more than eight carbon atoms in their longest chain. IUPAC naming rules must be used for these compounds. Candidates should also be familiar with the term ‘isomers’ as used to refer to molecules with the same molecular formula but different structural formulae.

In the contexts of flavour molecules, edible oils, essential oils and proteins, candidates will encounter larger and more complex molecules in which the ‘carbon backbone’ can often include cyclic and/or aromatic features. At Higher level, candidates are required only to consider effects related to the presence of the functional groups named in the table above. Candidates are not expected to be able to name these more complex molecules.

National Unit Specification: support notes

UNIT Consumer Chemistry (SCQF 6)

This Unit offers a diverse and rich vein of contexts and opportunities for practical work as highlighted in the 'Possible contexts and activities' column of the content tables. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams. By developing a greater understanding of the chemistry behind such substances as food preservatives, candidates are better able to make informed choices and decisions in their everyday lives.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Prior knowledge of the nature of the types of van der Waals attractions and of the ability of substances to act as oxidising or reducing agents is assumed. These topics are covered in the Higher Unit, 'Periodicity, Polarity and Properties'.

General advice on approaches to learning and teaching is contained in the course specification.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly chemical phenomena in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the core skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The appendix to this Unit Specification contains an extensive list of 'Possible Contexts and Activities' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key ICT skill s including; accessing information and providing/creating information.

The Unit appendix contains an extensive range of practical laboratory exercises which provide candidates with the opportunity to working co-operatively with others.

Problem solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) & (c) and also through Outcome 2, PCs (a) & (b).

National Unit Specification: support notes

UNIT Consumer Chemistry (SCQF 6)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that a holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation and investigation can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments for may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements

National Unit Specification: support notes

UNIT Consumer Chemistry (SCQF 6)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the breadth and depth of content expected. The right-hand column gives possible contexts and activities which could be used to develop knowledge, understanding and skills. Further details on many of the activities mentioned in the final column can be obtained from **National Qualifications Online**, part of the Learning and Teaching Scotland online service. Where such online support exists the 💻 symbol appears in the text.

Content	Notes	Possible Contexts and Activities
1) Alcohols		
(a) Ethanol production	Ethanol can be produced by the fermentation of glucose. Enzymes in yeast catalyse fermentation. There is a limit to the ethanol concentration which can be achieved by fermentation. Distillation can be used to obtain higher ethanol concentrations. In order to satisfy the industrial demand for ethanol, it is also formed by the catalytic hydration of ethene.	Ethanol can be produced by fermentation within the lab. 💻 The concentration of ethanol in a sample can be measured using a standard method used by HM Revenue and Customs. 25 cm^3 of water are added to 50 cm^3 of the solution being tested. The mixture is distilled, with the first 50 cm^3 of distillate being collected. The density of the distillate is measured and this value is converted into the concentration of alcohol using a look-up table. Details of this method in addition to volumetric and colorimetric methods are available. 💻
(b) Alcohols	An alcohol can be identified from the hydroxyl group and the '-ol' name ending. The presence of the hydroxyl group makes alcohols polar and gives rise to hydrogen bonding. Straight-chain and branched-chain alcohols, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain alcohols, structural formulae can be drawn and molecular formulae written.	A number of alcohols can be examined to establish common properties. The miscibility of alcohol in water and the pH of the resultant solutions could be tested.

(c) Uses of alcohols	Alcohols are effective solvents. Smaller alcohols evaporate easily, making them ideal for cleaning purposes. Their high flammability, and the very clean flames with which they burn has resulted in alcohols being used as fuels.	The flammability of meths in camping stoves can be demonstrated whilst methanol can be discussed as a fuel in drag racing and speedway. A spectacular demonstration of the flammability of alcohols is provided by the 'whoosh bottle' demonstration. A mixture of alcohol and air in a large polycarbonate bottle is ignited. The resulting rapid combustion reaction, often accompanied by a dramatic 'whoosh' sound and flames, demonstrates the large amount of chemical energy released in the combustion of alcohols. Equally dramatic are the 'alcohol gun' experiment or the 'flaming pumpkin'. A more mysterious element can be introduced with the 'non-burning £5 note' experiment. The heat energy release when alcohols burn can be measured. Examine a number of products such as screen wipes, disinfectant wipes and hand gels which contain isopropyl alcohol (propan-2-ol).

2) Carboxylic acids		
(a) Carboxylic acids	Carboxylic acids can be identified from the carboxyl group and the '-oic' name ending. Straight-chain and branched-chain carboxylic acids, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain carboxylic acids, structural formulae can be drawn and molecular formulae written. Carboxylic acids react with bases to form salts containing the carboxylate ion.	Vinegar offers candidates an introduction to carboxylic acids using a familiar example. To obtain a qualitative measure of the concentration of ethanoic acid in different vinegars, a modified version of the film-canister rocket experiment can be used. A marble chip is attached to the inside of the lids of a number of 35mm film canisters using a little reusable poster tack. Equal volumes of vinegars of differing types are poured into the film cans so that they are one third full. The lids are placed onto the cans and the cans all inverted at the same time. The ethanoic acid reacts with the marble liberating carbon dioxide gas which builds up until the lid seal breaks and the can shoots into the air like a rocket. The order in which the vinegar 'rockets' take off is a measure of the concentration of ethanoic acid in each. The concentration of ethanoic acid in vinegars can be determined quantitatively either by volumetric titration, or by measuring the volume of carbon dioxide liberated when an excess of a carbonate salt is added to vinegar. Many carboxylic acids have unpleasant smells. (Great care must be taken in handling undiluted carboxylic acids as they are highly corrosive.) Many candidates may describe their smell as 'like vomit'. It can be worthwhile commenting on the accuracy of their description as vomit contains carboxylic acids known as 'fatty acids' released from fats and oils during digestion.

(b) Uses of carboxylic acids	Vinegar is a solution of ethanoic acid. Vinegar is used in household cleaning products designed to remove limescale (a build up of insoluble carbonates on plumbing fixtures) and as a preservative in the food industry.	To demonstrate both the acidic nature of ethanoic acid, and its use as a food preservative, pickled eggs can be produced by placing boiled eggs (still in their shells) into jars containing vinegar. The acid will dissolve the shell to leave a pickled egg in vinegar. Pickles (food preserved in vinegar) can be stored for a long time because the low pH prevents the growth of harmful bacteria and fungi.
3) Fruit Flavours		
(a) Esters	An ester can be identified from the ester group and by names containing the '-yl -oate' endings. An ester can be named given the names of the parent alcohol and carboxylic acid or from structural formulae. Structural formulae for esters can be drawn given the names of the parent alcohol and carboxylic acid or the names of esters. Esters have characteristic smells.	A 'smelling' session is a fun way of reinforcing the use of the 'fruity' type of scent/flavour associated with these molecules. 'Foam Fruit' type sweets, pear drops and other fruit flavoured sweets often have distinctive ester scents. Examples of esters responsible for fruit smells include; 3-methyl-1-butyl ethanoate=banana, methyl butanoate=apple, benzyl butanoate =cherry, benzyl ethanoate=peach, methyl salicylate=wintergreen, octyl ethanoate=orange, propyl ethanoate=pear.
(b) Making Esters	Esters are formed by the condensation reaction between a carboxylic acid and an alcohol. The ester link is formed by the reaction of a hydroxyl group with a carboxyl group. In condensation reactions, the molecules join together with the elimination of a small molecule, in this case water.	Esters can be quickly synthesised on a test-tube scale by candidates. If candidates work in pairs, and a small selection of different alcohols and carboxylic acids are available, it is possible for each pair to synthesise a different ester. The class can then 'sniff' (appropriate safety precautions) each of the esters made to see which fruit smells can be recognised. Websites provide extensive lists of the esters found in fruit.

(c) Uses of esters	Esters are used as flavourings and fragrances. Esters are also used as non-polar industrial solvents.	Ethyl ethanoate is one of a number of solvents used to extract caffeine from coffee and tea. De-caffeinated products produced with ethyl ethanoate are often described on the packaging as 'naturally decaffeinated' because ethyl ethanoate is a chemical found naturally in many fruits. Caffeine can be extracted from tea by candidates using an aqueous solution of sodium carbonate and ethyl acetate and a rough percentage of caffeine in the tea leaves calculated. Esters are also used as solvents for dyes, inks, paints and varnishes. Applications where candidates will have encountered ester type smells from non-food products include; car spray paints, some permanent marker pens, some whiteboard pens, nail varnish removers etc The ease with which esters evaporate leads to high concentrations of esters in the air. Further information on current moves to reduce the use of esters as solvents can be found by searching for 'VOC reduction' or 'low VOC' on an internet search engine.
(d) Hydrolysis of esters	Esters can be hydrolysed to produce a carboxylic acid and an alcohol. Given the name of an ester or its structural formula, the hydrolysis products can be named and their structural formulae drawn. The parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester. In a hydrolysis reaction, a molecule reacts with water breaking down into smaller molecules.	An ester is added to distilled water. After 30 minutes, the pH of the mixture can be tested to demonstrate that an acid is forming. Old bottles of perfume can also be an interesting illustration of ester hydrolysis as the fruity notes in fragrances have frequently hydrolysed leaving the unpleasant stench of carboxylic acids.

4) Fats and oils		
(a) Edible fats and oils	Fats and oils are a concentrated source of energy. They are essential for the transport and storage of fat soluble vitamins in the body. Fats and oils are esters formed from the condensation of glycerol (propane-1,2,3-triol) and three carboxylic acid molecules. The carboxylic acids are known as ‘fatty acids’ and are saturated or unsaturated straight chain carboxylic acids, usually with long chains of carbon atoms.	Candidates can be given the opportunity to examine examples of a number of edible fats and oils which could include examples of fish oils, vegetable oils and animal fats. Vegetable oil samples can be burned to demonstrate that they are stores of chemical energy. Carrying out a demonstration fat-fire underlines the considerable energy released when fats and oils are oxidised in addition to underlining the risks associated with cooking techniques using deep oil baths. Candidates can also consider the wider use of edible oils as, for example, the use of edible oils as fuels and lubricants for some agricultural machinery in order to prevent any risk of harmful mineral oils contaminating future food stuffs.
(b) The melting points of fats and oils	The lower melting points of oils compared to those of fats is related to the higher degree of unsaturation of oil molecules. The low melting points of oils is a result of the effect that the shapes of the molecules have on close packing, hence on the strength of van der Waals’ forces of attraction.	The degree of unsaturation of fats and oils can be determined qualitatively by counting the number of drops of bromine water that can be decolourised by equal quantities of oil, or by a very simple titration in which the fat is dissolved. Alternatively, iodine values can be determined by standard methods including the use of Wij’s reagent. This solution of Iodine monochloride adds rapidly to the carbon-carbon double bonds present. The unreacted iodine monochloride was then treated with an excess of aqueous potassium iodide, forming iodine. The liberated iodine is determined by titration with sodium thiosulfate.

5) Proteins		
(a) Function of proteins	Proteins are the major structural materials of animal tissue. Proteins are also involved in the maintenance and regulation of life processes. Enzymes are proteins.	The shapes of protein molecules can be viewed with a range of free-of-charge browser plug-ins such as Chime or Jmol. 💻
(b) Amino acids	Amino acids, the building blocks from which proteins are formed, are relatively small molecules which all contain an amino group (NH_2), and a carboxyl group (COOH). The body cannot make all the amino acids required for body proteins and is dependent on dietary protein for supply of certain amino acids known as essential amino acids.	There are around twenty common amino acids. Only eight amino acids are regarded as being essential for humans although a further two are required in childhood. The amino acids in fruit juices can be identified by paper chromatography. 💻 There is also an activity on the amino acid aspartame in artificial sweeteners in 'In Search of More Solutions' Janet Taylor, Royal Society of Chemistry 1994
(c) Amide links	Proteins are made of many amino acid molecules linked together by condensation reactions. In these condensation reactions, the amino group on one amino acid and the carboxyl group on a neighbouring amino acid join together, with the elimination of water. The link which forms between the two amino acids can be recognised as an amide link (CONH). Proteins which fulfil different roles in the body are formed by linking differing sequences of amino acids together. The amide links within proteins are also known as peptide links.	Candidates can investigate the detection of protein in synthetic urine samples in a practical activity. 💻

(d) Hydrolysis of protein	During digestion, enzyme hydrolysis of dietary proteins can produce amino acids. The structural formulae of amino acids obtained from the hydrolysis of proteins can be identified from the structure of a section of the protein.	Paper chromatography of the amino acid mixture produced by the hydrolysis of hair or egg whites.
6) Chemistry of Cooking		
(a) Flavour in food	Many of the flavours in foods are due to the presence of volatile molecules. By examining the functional groups present in molecules, candidates can suggest whether they are likely to be water or oil soluble. The size and functional groups present can be taken into account in predicting their relative boiling point and hence probable volatility.	To illustrate the role of volatile molecules in flavour, an experiment based on tasting foods with your nose blocked can be used. Strawberry jam works well. A blindfolded taster is fed a small amount of strawberry jam with a teaspoon. While holding his/her nose, the taster can only detect the sweetness of the jam (which is detected with the tongue). but will be unable to tell the flavour of the jam which is caused by volatile molecules detected by the nose. On releasing his/her nose, s/he will be able to tell the flavour of the jam. Other foods which can be used in this experiment include apple, parsnip, and even different flavours of crisp. In this variation the taster is given a plain crisp to taste but, without telling them, a flavoured crisp is held under their nose. The taster will report that the crisp they are tasting has the flavour of that held under their nose. A major issue in cooking is to retain molecules responsible for flavour in the food — overcooking can result in loss of these molecules. One destination for lost flavour molecules is in the cooking water. This will occur if the flavour molecules are water-soluble. This is the case for asparagus, for example, which should be cooked in oil or butter in which the flavour

		molecules are less soluble. In broccoli or green beans, the flavour molecules are more soluble in oil than in water and should be cooked in water. 'The Chemistry of Flavour' Kitchen Chemistry, Ted Lister and Heston Blumenthal, Royal Society of Chemistry contains a number of problem solving exercises allowing candidates to make predictions of best cooking methods using the structural formulae of the molecules responsible for flavour in different foods. Examples of flavour molecules are provided on websites. When using internet search engines to search for flavour compounds, using both the UK and US spelling of 'flavour/flavor' will locate the maximum number of sites.
(b) Changes in protein structure upon heating	Within proteins, the long chain molecules may be twisted to form spirals, folded into sheets, or wound around to form other complex shapes. The chains are held in these forms by intermolecular bonding between the side chains of the constituent amino acids. When proteins are heated, during cooking, these intermolecular bonds are broken allowing the proteins to change shape (denature).These changes alter the texture of foods.	Kitchen Chemistry, Ted Lister and Heston Blumenthal, Royal Society of Chemistry 2005 has an excellent video explaining how different temperatures are required for cooking meats with different levels of connective tissue. Joints containing a lot of connective tissue become tender if cooked at over 60 ^{o}C as the collagen forming the tough connective tissue, denatures. The tender lean meat found in cuts such as fillet steaks, should not be cooked at too high a temperature, because in this case the protein molecules start to bunch together resulting in the meat becoming tougher. The effect of temperature on modifying protein structures can also be explored using egg whites. In uncooked egg white, the protein molecules are globular. During cooking, the protein is denatured and the protein chains unwind and, as they can now form intermolecular bonds with neighbouring protein molecules, a network of interconnected proteins

		forms causing the egg white to solidify.
7) Oxidation of Food		
(a) Oxidation of alcohols	Alcohols can be classified as primary, secondary or tertiary. Primary alcohols are oxidised, first to aldehydes and then to carboxylic acids. Secondary alcohols are oxidised to ketones. When applied to carbon compounds, oxidation results in an increase in the oxygen to hydrogen ratio. In the laboratory, hot copper(II) oxide or acidified dichromate (VI) solutions can be used to oxidise primary and secondary alcohols. Tertiary alcohols cannot be oxidised.	The action of CuO as an oxidising agent for alcohols can be shown by placing a small amount of ethanol in an evaporating basin. A 2p coin is then heated to just below red heat in a bunsen and then wafted in the air allowing the surface to become coated in black copper(II) oxide. The warm coin is then carefully lowered into the ethanol. Instantly the bright shiny surface of the coin is restored as the CuO is reduced to copper. The process of heating the coin-forming the oxide-and reducing the oxide in alcohol is repeated until little liquid is left in the dish. At this point, if pH indicator is added it shows that an acid has formed whilst the distinctive smell of ethanal can be detected. In an alternative experiment, samples of primary, secondary and tertiary alcohols can be warmed with acidified dichromate (VI) to illustrate that only the primary and secondary will be oxidised. Ethanol can be oxidised by acidified sodium dichromate in a test-tube reaction, firstly to form ethanal (acetaldehyde), and with further oxidation, ethanoic acid (acetic acid). Using a microscale well-plate, candidates add acidified dichromate(VI) to primary, secondary and tertiary alcohols to observe the difference in their oxidation reactions. This experiment can be done by candidates in 20 minutes. The colour change of the dichromate(VI) indicates where reaction is occurring. Primary, secondary and tertiary alcohols can be distinguished by the rate of reaction, though no attempt is made to identify the products.

(b) Aldehydes and Ketones	Many flavour and aroma molecules are aldehydes. Aldehydes and ketones both contain the carbonyl functional group. Aldehydes and ketones can be identified from the '-al' and '-one' name endings respectively. Straight-chain and branched-chain aldehydes and ketones, with no more than eight carbon atoms in their longest chain, can be named from structural formulae. Given the names of straight-chain or branched-chain aldehydes and ketones, structural formulae can be drawn and molecular formulae written. Aldehydes, but not ketones, can be oxidised to carboxylic acids. Fehling's solution, Tollens' reagent and acidified dichromate solution can be used to differentiate between an aldehyde and a ketone.	Aldehydes are key components in whisky. Much of the flavour is developed as oxygen diffuses into the cask forming aldehydes. The toxicity of aldehydes can result in unfortunate symptoms such as severe headaches. Aldehydes and ketones can be differentiated by testing with acidified dichromate or Tollen's reagent. In the 'giant silver mirror' experiment a solution of ammoniacal silver nitrate is reduced by aldehydes to silver, which forms a silver mirror on the inside of a one litre large flask.
(c) Antioxidants	Oxygen reacts with edible oils giving the food a rancid flavour. Antioxidants are molecules which will prevent these oxidation reactions taking place. Ion-electron equations can be written for the oxidation of many antioxidants.	In crisp manufacture, potatoes are typically fried under an atmosphere of steam and packaged under nitrogen. www.understandingfoodadditives.org has many animations and good, jargon free text and a number of downloadable classroom activities. There is also an A-level practical investigation on the oxidation of fats and oils available from the University of York. The concentration of antioxidants in foods can be measured by a variety of means. Vitamin C (antioxidant) levels in fruit juices can be compared semi-quantitatively using a very simple method by measuring the number of drops of fruit juice needed to reduce one drop of iodine solution to iodide using starch as an indicator. This simple method can be used in investigative work exploring the effect that cooking

		methods have on the antioxidants in foods. For more quantitative results, one possible method is to use a microscale redox back titration. In this experiment a measured amount of fruit drink is added to an excess of iodine solution. The ascorbic acid in the drink reacts quantitatively with some of the iodine. The excess iodine is then titrated against standard thiosulfate solution. In a more straightforward redox titration, the level of Vitamin C in a vitamin tablet can be determined by direct redox titration with an acidified permanganate (VII) solution.
8) Soaps and Emulsions		
(a) Making soap	Soaps are produced by the alkaline hydrolysis of fats and oils. Fats and oils are esters. The hydrolysis of fats and oils produces fatty acids and glycerol in the ratio of three moles of fatty acid to one mole of glycerol. The fatty acid molecules released are neutralised by the alkali to form water soluble ionic salts called soaps.	There are a number of soap making experiments which have been developed to reduce the time taken for soap to form, and to use less corrosive alkalis. One method, producing soap from castor oil, takes approximately 40 minutes. 5 cm^3 of ethanol is added dropwise to 2 cm^3 of castor oil. 10 cm^3 of 5 mol l^{-1} sodium hydroxide is added, and the solution warmed in a waterbath containing near-boiling water for five minutes. 10 cm^3 of saturated sodium chloride solution is then added to the beaker and the mixture stirred. The mixture is cooled in a cold water bath (or an ice bath if available). Soft, white lumps of the soap will gradually form in the mixture. Leave for a few minutes to improve the yield. During this time the soap may rise to the surface and form a soft crust on cooling. One of the quickest soap preparations takes under five minutes. In this method around 2g of mutton fat is dissolved in 8 cm^3 of ethanol in a boiling tube. One pellet of KOH is

		added, and the mixture boiled in a water bath for 2 minutes during which the cloudy mixture becomes clear. When the contents of the tube are poured into a beaker containing saturated NaCl solution the soap precipitates and floats on the surface.
(b) Cleansing action of soaps	Cleaning with water alone has little effect when stains consist of non-polar substances, such as grease and sweat. Soap ions have a long non-polar tail, readily soluble in non-polar compounds (hydrophobic), and an ionic carboxylate head which is water soluble (hydrophilic). During cleaning, the hydrophobic tails dissolve in a droplet of oil or grease, whilst the hydrophilic heads face out into the surrounding water resulting in ball-like structure. The non-polar substances, such as oil and grease, are held inside the ball and suspended in water.	Many web animations are available showing this process. An experiment can be used to demonstrate the detergent action of soaps. In this experiment, very finely divided MnO_2 or very finely divided charcoal plays the part of 'dirt'. 50 cm^3 of water is placed in one 100 cm^3 measuring cylinder, and 50 cm^3 of soap solution in another. A pinch of simulated 'dirt' is added to each, and the two cylinders shaken. The two cylinders are set aside for some time. In the control cylinder containing water, the 'dirt' settles down on the bottom of the cylinder, whilst in the soap solution the powder remains suspended.
(c) Emulsions in food	An emulsion contains small droplets of one liquid dispersed in another liquid. Emulsions in food are mixtures of oil and water. To prevent oil and water components separating into layers, a soap-like molecule known as an emulsifier is added. Emulsifiers for use in food are commonly made by reacting edible oils with glycerol to form molecules in which either one or two fatty acid groups are linked to a glycerol backbone rather than the three normally found in edible oils. The one or two hydroxyl groups present in these molecules are hydrophilic whilst the fatty acid chains are hydrophobic.	Emulsifiers are added to a very large range of different foods including sauces, bread, biscuits, ice cream, low fat spread and even dried pastas where they help to prevent pasta pieces sticking to each other during cooking. Candidates can investigate the formation of emulsions in foods using the RSC practical experiments from section 3.2 of Inspirational Chemistry. This practical is very straightforward and does not take very long, although if candidates shake the boiling tubes too vigorously then the mixtures can take a while to separate. Candidates place about 2 cm^3 of vegetable oil and about 2 cm^3 of water into a boiling tube. The tube is stoppered and shaken. The oil and water separate into two layers. Candidates then experiment with adding a small quantity of substances such as mustard

		powder, sugar, flour, salt, egg white, egg yolk and washing up liquid to determine which act as emulsifiers. Eggs have a salmonella risk and only eggs bearing the lion symbol should be used. Raw egg should be handled as little as possible, and a disposable pipette should be used to transfer it to the boiling tubes. The results can be discussed in terms of the molecules present in these substances. The code E471 is one of the most common 'E-numbers' on food packaging and indicates that the food contains an emulsifying agent consisting of mono- and di-glycerides of fatty acids.
9) Fragrances		
(a) Essential oils	Essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants. They are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods. Essential oils are mixtures of organic compounds. Terpenes are key components in most essential oils.	Candidates can use steam distillation apparatus to extract essential oils from lavender, rosemary, citrus fruit, pine needles etc If quickfit-type apparatus is unavailable, steam distillation can be carried out using an ordinary boiling tube, some glass wool and a one-holed bung fitted with an L-shaped delivery tube. A wad of glass wool soaked in water is placed at the bottom of the boiling tube. A second 'plug' of dry glass wool, lodged about two-thirds of the way up the boiling tube, supporting some lemon peel, lavender or rosemary. The glass wool soaked in water at the bottom of the boiling tube is gently heated, causing steam to rise up through the plant material and pass down the delivery tube. A cold-wet paper towel can be wrapped around the tube, and fastened with an elastic band to help keep the tube cool. The distillate is collected in a small beaker or boiling tube sitting in a tub of ice cold water. Within five minutes, the tube or beaker will contain some scented distillate.

(b) Terpenes	Terpenes are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units. They are components in a wide variety of fruit and floral flavours and aromas. Terpenes can be oxidised within plants producing some of the compounds responsible for the distinctive aroma of spices.	Terpenes are responsible for the distinctive flavours of spices such as cloves, cinnamon and ginger. Terpenes can be extracted from many materials in the lab. A common experiment is the extraction of limonene from citrus fruits. Limonene can be extracted from oranges using ethyl ethanoate as a solvent (an example of solvent extraction- see content statement above). [Making Sense of Terpenes: An Exploration into Biological Chemistry, Kevin W. Glaeske and Paul R. Boehlke, The American Biology Teacher, Vol. 64, No. 3 (Mar., 2002), pp. 208-211 (article consists of 4 pages) Published by: National Association of Biology Teachers]
10) Skin Care Products		
(a) Effect of ultraviolet light	Ultraviolet radiation (UV) is a high-energy form of light, present in sunlight. Exposure to UV light can result in molecules gaining sufficient energy for bonds to be broken. This is the process responsible for sunburn and also contributes to aging of the skin. Sun-block products prevent UV light reaching the skin.	UV Photography reveals the effects of ‘photoaging’, or aging of skin caused by light. There are many websites showing this effect. UV sensitive polymer beads are now available from many educational suppliers. These beads change colour when exposed to UV light. They can provide a fun and cheap way of allowing candidates to experiment with the effectiveness of different sun-block molecules.
(b) Free radical reactions	When UV light breaks bonds free radicals are formed. Free radicals have unpaired electrons and, as a result, are highly reactive. Free radical chain reactions include the following steps: initiation, propagation and termination.	A spectacular demonstration of a free radical chain reaction is provided by the H_2/Cl_2 reaction. Initiation can be provided by a photographic flash unit, demonstrating that light energy is required to generate the initial free radicals. It can easily be shown that bromine will decolourise in the presence of an alkane faster in light than in the dark.

(c) Free-radical scavengers	Many cosmetic products contain free radical scavengers; molecules which can react with free radicals to form stable molecules and prevent chain reactions. Free radical scavengers are also added to food products and to plastics.	Adverts for anti-aging products can be examined to identify the scientific basis of the claim. Melatonin and Vitamin E are examples of natural free radical scavengers.

National Unit Specification: general information

UNIT Principles to Production (SCQF 6)

CODE FE4D 12

COURSE Chemistry (Revised)

SUMMARY

This Unit develops a knowledge and understanding of the principles of physical chemistry which allow a chemical process to be taken from the researcher's bench through to industrial production. Candidates will calculate quantities of reagents and products, learn how to manipulate dynamic equilibria, understand the mechanisms by which rates can be controlled and predict enthalpy changes. It introduces aspects of analytical chemistry in the context of determining the purity of reagents and products. The Unit highlights the need for chemists to think creatively to develop new processes and products. Within the Unit, candidates will evaluate the environmental issues surrounding a chemical process in order to make informed choices and decisions about the most ethical means of production.

OUTCOMES

1 Demonstrate and apply knowledge and understanding of the principles of physical chemistry that allow chemical processes to be taken through the industrial production.
2 Demonstrate skills of scientific experimentation and investigation within the context of *Principles to Production*.

Administrative Information

Superclass:

Publication date:

Source: Scottish Qualifications Authority

Version:

National Unit Specification: general information (cont)

UNIT Principles to Production (SCQF 6)

RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- ♦ Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- ♦ the Intermediate 2 Chemistry course at grade B

and

- ♦ Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

1 credit(s) at Higher (6 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Principles to Production (SCQF 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Demonstrate and apply knowledge and understanding related to *Principles to Production*.

Performance Criteria

(a) Make accurate statements about facts, concepts and relationships relevant to *Principles to Production*.
(b) Use knowledge of *Principles to Production* to solve problems.
(c) Use knowledge of *Principles to Production* to explain observations and phenomena.

OUTCOME 2

Demonstrate skills of scientific experimentation and investigation in the context of *Principles to Production.*

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to the evaluation of scientific evidence.

National Unit Specification: statement of standards

UNIT Principles to Production (SCQF 6)

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment used must sample the content in each of the following areas:

- Getting the most from costly reactants
- Controlling the rate
- Chemical energy
- Chemical analysis as a part of quality control

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: chemical formulae, balanced chemical equations, diagrams depicting laboratory apparatus, line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit Specification: support notes

UNIT Principles to Production (SCQF 6)

This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the Appendix to this Unit Specification.

This Unit develops a candidate's knowledge and understanding of the fundamental physical chemical principles which must be mastered in order to allow a chemical process to be taken from the researcher's bench through to industrial production. Candidates will learn how to calculate the quantities of reagents and products, learn how to manipulate dynamic equilibria, understand the mechanisms by which rates can be controlled and predict enthalpy changes. The Unit also introduces elements of analytical chemistry in the context of measuring the purity of reagents and products. The Unit highlights the need for Chemists to think creatively to develop new processes and products. Within the Unit, candidates will evaluate the environmental issues surrounding a chemical process in order to make informed choices and decisions about the most ethical means of production.

This Unit offers a diverse and rich vein of contexts and opportunities for practical work as highlighted in the 'Possible contexts and activities' column of the content tables in the Appendix. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

General advice on approaches to learning and teaching is contained in the course specification.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly chemical phenomena in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the core skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The appendix to this Unit Specification contains an extensive list of 'Possible Contexts and Activities' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key ICT skill s including; accessing information and providing/creating information.

The Unit appendix contains an extensive range of practical laboratory exercises which provide candidates with the opportunity to working co-operatively with others.

Problem solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) & (c) and also through Outcome 2, PCs (a) & (b).

National Unit Specification: support notes

UNIT Principles to Production (SCQF 6)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that a holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation and investigation can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments for may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements

National Unit Specification: general information

UNIT Principles to Production (SCQF 6)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the breadth and depth of content expected. The right-hand column gives possible contexts and activities which could be used to develop knowledge, understanding and skills. Further details on many of the activities mentioned in the final column can be obtained from **National Qualifications Online**, part of the Learning and Teaching Scotland online service. Where such online support exists the 💻 symbol appears in the text.

Content	Notes	Possible Contexts and Activities
1) Getting the most from costly reactants		
(a) Factors influencing the design of an industrial process	Industrial processes are designed to maximise profit and minimise the impact on the environment. Factors influencing process design include: availability, sustainability and cost of feedstock(s); opportunities for recycling; energy requirements; marketability of by-products; product yield. Environmental considerations include: minimising waste; avoiding the use or production of toxic substances; designing products which will biodegrade if appropriate.	Candidates can be given the opportunity to consider descriptions or flow diagrams for an industrial process with a view to recognising the various strategies employed to maximise profitability and to reduce the impact on the environment. The RSC 'Alchemy' resource allows candidates to look in detail at Industrial processes. 💻 An industrial case study demonstrating the ways in which concern for the environment has shaped the design of an industrial process is provided for ibuprofen. 💻 Some more general Industrial Chemistry Case Studies are available. 💻 Details of Green Chemistry can be obtained from the ChemistryTeachers website. 💻
(b) Calculation of the mass or volume (for gases) of products, assuming complete conversion of reactant(s).	Balanced equations show the mole ratio(s) of reactants and products. Using the balanced equation and the gram formula masses (GFM), mass to mass calculations can be performed. The quantity of a reactant or product can also be expressed in terms of moles.	The mole is a central concept in chemistry. It can be defined in terms of the number of particles present (Avogadro's constant). The quantitative link between the masses of reactants and products can be established experimentally.

	The molar volume (in units of litres mol^{-1}) is the same for all gases at the same temperature and pressure. The volume of a gas can be calculated from the number of moles and vice versa. The volumes of reactant and product gases can be calculated from the number of moles of each reactant and product.	A known mass of magnesium can be burned forming magnesium oxide and the relationship between the mass of magnesium metal and magnesium oxide explored. The reduction of copper(II) oxide by methane can be used to confirm the quantitative link between the mass of reactants and products. Details of how to carry out this experiment are provided in 'Classic Chemistry Demonstrations', Lister T. The Royal Society of Chemistry (1995) pp. 132-135. Videos of this experiment can be viewed. The molar volume of hydrogen can be measured by candidates using a method such as that found in 'Classic Chemistry Experiments', Kevin Hutchings 2000 pp. 171-173. Candidates can develop their own method of measuring molar volumes in a practical problem solving exercise such as that found in 'In Search of More Solutions', Janet Taylor, Royal Society of Chemistry (1994) number 36.
(c) Calculations concerning reactions which involve solutions, assuming complete conversion of reactant(s).	The concentration of a solution can be expressed in mol l^{-1}. Balanced equations can be used in conjunction with concentrations and volumes of solutions and/or masses of solutes to determine quantities of reactants and/or products.	Candidates should have the opportunity to engage in a wide range of calculations involving mass, volume and concentration of solution, GFM and balanced equations. Chemical Egg Race activities can be used to provide opportunities to practice or consolidate the mathematical skills being developed. In the 'Chemical Egg Timer', teams are given a graph showing how the concentration of potassium iodide affects the time taken for the blue-black colour to appear in a hydrogen peroxide/iodide clock reaction. The challenge for each team is to prepare 50 cm^3 of potassium iodide solution for use in a chemical egg timer which will turn blue-black one minute after the chemicals are

		mixed. ‘Colour Match Challenge’ is a far more demanding exercise and allows key calculation types to be consolidated. In the first part of the challenge, each team is given a 100 cm^3 measuring cylinder containing 5 cm^3 of 1 mol l^{-1} $CuSO_4$ solution. The aim of the egg race is to match as closely as possible two different shades of blue. The teacher/lecturer could choose shades from a paint catalogue, photograph or any two blue objects in the lab. The team must slowly add water to their measuring cylinder until the $CuSO_4$ solution matches the darker of the two shades selected. The team make a note of the total volume of solution. Further water is added until the solution matches the lighter of the two target shades. The team must now calculate the concentration of the $CuSO_4$ solutions which matched the two target colours. In the second part of the challenge, the candidates must calculate the mass of copper(II) sulfate pentahydrate ($CuSO_4.5H_2O$ GFM 249.7 g mol^{-1}) needed to produce 100 cm^3 of solution matching the darker shade of blue. They must also calculate the mass of zinc powder required to displace sufficient copper ions to lighten the solution to the point where it matches the lighter target shade. The teams weigh out copper(II) sulfate and zinc powder for use in a competition in which each team must try to reproduce the two target shades. If available, a colorimeter can be used to provide an ‘impartial’ judgement of how close the colours were to the target shades.

(d) Reversible reactions	Many reactions are reversible, so products may be in equilibrium with reactants. This may result in costly reactants failing to be completely converted into products. In a closed system, reversible reactions attain a state of dynamic equilibrium when the rates of forward and reverse reactions are equal. At equilibrium, the concentrations of reactants and products remain constant, but are rarely equal.	Candidates can investigate reversible reactions for themselves using hydrated copper(II) sulfate. A spectacular demonstration of a reversible reaction involving colour changes and clouds of white fumes can be performed using copper sulfate, concentrated hydrochloric acid and concentrated ammonia solution. The demonstration is started by making a yellow-green copper chloride complex by adding concentrated hydrochloric acid to very dilute solution of copper sulfate. When concentrated ammonia solution is added, copious quantities of white smoke are produced as HCl is driven off, heat is generated and a dark blue tetraamminocopper(II) complex forms. Adding concentrated HCl will reverse this reaction again turning the solution yellow-green colour again. Details can be found in ‘A spectacular reversible reaction’ by Colin Baker in Education in Chemistry, vol. 43, n 3, May 2006.
(e) Altering Equilibrium Position	To maximise profits, chemists employ strategies to move the position of equilibrium in favour of products. Changes in concentration, pressure and temperature can alter the position of equilibrium. A catalyst increases the rate of attainment of equilibrium but does not affect the position of equilibrium. The effects of altering pressure, altering temperature, the addition or removal of reactants or products can be predicted for a given reaction.	Experiments in which the position of equilibrium can be altered by changing conditions include; $CoCl_2/CoCl_2.2H_2O$ SSERC Bulletin 219, ‘Equilibrium and Le Chatelier’ SSERC Bulletin 220, ‘Equilibrium of Cobalt Chloride (Continued) ICl/ICl_3 equilibrium NO_2/N_2O_4 CO_2 in soda water Candidates should have the opportunity to consider industrial processes where equilibrium conditions are optimised. The

		RSC Alchemy resource contains video material and activities allowing candidates to research processes such as ammonia production (Haber process), Nitric Acid (Ostwald process) sulfuric acid (Contact process). Worksheets, fact files and videos for these processes are available. 💻 Simulation of the Haber process can also be used. 💻
(f) Percentage Yield and Atom Economy	The efficiency with which reactants are converted into the desired product is measured in terms of the percentage yield and atom economy. Percentage yields can be calculated from mass of reactant(s) and product(s) using a balanced equation. Given costs for the reactants, a percentage yield can be used to calculate the feedstocks' cost for producing a given mass of product. The atom economy measures the proportion of the total mass of all starting materials successfully converted into the desired product. It can be calculated using the formula shown below in which the masses of products and reactants are those appearing in the balanced equation for the reaction. $atom\ economy = \frac{mass\ of\ desired\ product(s)}{total\ mass\ of\ reactants} \times 100$ Reactions which have a high percentage yield may have a low atom economy value if large quantities of unwanted by-products are formed.	For a particular set of reaction conditions, the percentage yield provides a measure of the degree to which the limiting reagent is converted into the desired product. It is possible to calculate the percentage yield using equations of the type shown below. $percentage\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100$ In this expression the 'actual yield' is taken to refer to the quantity of the desired product formed under the prevailing reactions conditions whilst the 'theoretical yield' is the quantity of desired product which would be obtained, assuming full conversion of the limiting reagent, as calculated from the balanced equation. For reactions in which the masses of both the limiting reagent used and the desired product obtained are known, the actual yield and theoretical yields can be expressed in terms of masses. It is equally valid, however, to calculate percentage yields using the actual and theoretical numbers of moles of desired compound. In the debate over whether candidates should be encouraged to perform percentage yield calculations using masses or using the numbers of moles there are strong arguments on either side. For assessment purposes either method will be awarded equal credit and there is no need for candidates to be familiar with both methods.

		Atom Economy figures are of interest because they provide a measure of how successfully all of the reagents, not just the limiting reagent, are being converted into the desired product. A case study illustrating how the atom economy and percentage yields for different synthetic routes led to a switch in the method used to produce ibuprofen is available. Candidates can synthesise substances of use in everyday contexts and calculate the percentage yield and atom economy achieved. *The food additive E331 (sodium citrate) is well suited to this type of exercise. 50.0 cm^3 of 1.0 mol l^{-1} sodium hydroxide are added to 3.50 g of citric acid crystals in a beaker and the mixture stirred until all the crystals have dissolved. The solution is evaporated to dryness and the product weighed.* *Zinc sulfate is used in mineral supplements and as a paste mixed with zinc oxide to treat acne. Zinc sulfate is also an astringent; it closes up the pores of the skin to keep out bacteria and can be used for this reason to treat some skin conditions or prevent sunburn. Between 4.4 g and 5.0 g of zinc oxide is added with stirring to 50 cm^3 of warm 1.0 mol l^{-1} sulfuric acid (50 ^oC). The reaction mixture is allowed to cool and filtered. The filtrate is evaporated to dryness and the product weighed.* *Calcium benzoate (E213), a preservative in foods, can be made from the reaction between benzoic acid and calcium*

		carbonate. *Aspirin can easily be prepared without the use of quickfit or distillation apparatus using only a conical flask or on a test-tube scale using a 20 minute method.* *A range of esters can be synthesised without the use of quickfit apparatus and the yield determined.*
(g) Excess	In order to ensure that costly reactant(s) are converted into product, an excess of less expensive reactant(s) can be used. By considering a balanced equation, the limiting reactant and the reactant(s) in excess can be identified. Whilst the use of excess reactants may help to increase percentage yields, this will be at the expense of the atom economy so an economic/environmental balance must be struck.	Some candidates struggle with the concept of excess in the context of identifying which substance(s) is/are present in excess and which is the limiting reagent in a given reaction mixture. A ‘roast beef’ sandwich analogy has been reported to be useful. To make a sandwich, two slices of bread and one slice of roast beef are required. If, for example, ten slices of roast beef and sixteen slices of bread are available, how many sandwiches can be made? In this case, only eight sandwiches can be made because bread is the limiting reagent and there is excess roast beef. This analogy is part of a computer simulation available from PhET which also includes examples of chemical reactions and a game to test understanding of the concept of excess.
2) Controlling the Rate		
(a) Collision theory	Reaction rates can be controlled by chemists. If they are too low a manufacturing process will not be economically viable, too high and there is a risk of thermal explosion. Collision theory can be used to explain the effects of concentration, pressure, surface area (particle size), temperature and collision geometry on reaction rates.	There are a considerable number of experiments illustrating the factors influencing reaction rates, and a number of animations. The effect of concentration on reaction rate can be explored in a class experiment in which a strip of magnesium is dropped into various concentrations of hydrochloric acid and the time taken for the effervescence to stop recorded. The rate of reaction is calculated, and the relationship to the concentration of acid is analysed.

		An unusual experiment demonstrating the effect of concentration on reaction rate is provided in the decolourisation of permanganate using rhubarb. The effect of temperature can also be investigated using the reaction between sodium thiosulfate and acid in which a sulfur precipitate forms. The time taken for a certain amount of sulfur to form can be used to estimate the rate of the reaction. Candidates can react potassium iodate and bisulfite/starch solution varying concentration and temperature to affect the reaction time. When sodium thiosulfate solution is reacted with acid, a precipitate of sulfur forms. The time taken for a certain amount of sulfur to form is used to indicate the rate of reaction. The effect of temperature on the rate of reaction can be investigated. This experiment is also available as a computer simulation. A very simple practical problem solving exercise in which the rate of an industrial process must be controlled is provided within ‘In Search of Solutions’. The dramatic effect that temperature has on reaction rate can be demonstrated using the simulation. To illustrate the effect of catalysts on reaction rates a number of experiments are listed below under ‘Catalysts’. The phET initiative from the University of Colorado also has an interactive simulation.

(b) Reaction Profiles	A potential energy diagram can be used to show the energy pathway for a reaction. The enthalpy change is the energy difference between products and reactants. It can be calculated from a potential energy diagram. The enthalpy change has a negative value for exothermic reactions and a positive value for endothermic reactions. The activated complex is an unstable arrangement of atoms formed at the maximum of the potential energy barrier, during a reaction. The activation energy is the energy required by colliding particles to form an activated complex. It can be calculated from potential energy diagrams.	A number of animations showing reaction profiles are available. Entering the search terms '*'Activation energy' animation'* into an internet search engine will produce a large number of hits. 💻 The phET initiative from the University of Colorado also has an interactive simulation. 💻
(c) Temperature and Kinetic Energy	Temperature is a measure of the average kinetic energy of the particles of a substance. The activation energy is the minimum kinetic energy required by colliding particles before reaction may occur. Energy distribution diagrams can be used to explain the effect of changing temperature on the kinetic energy of particles. The effect of temperature on reaction rate can be explained in terms of an increase in the number of particles with energy greater than the activation energy.	'Effect of Temperature on Reaction Rate' could be explored using either the reaction between sodium thiosulfate solution and hydrochloric acid or the reaction between oxalic acid and an acidified solution of potassium permanganate. These experiments can be used to produce rate versus temperature graphs illustrating the exponential increase in rate with temperature. 💻
(d) Catalysts	A catalyst provides an alternative reaction pathway with a lower activation energy. A potential energy diagram can be used to show the effect of a catalyst on activation energy.	A large number of experiments are available to demonstrate the action of catalysts including; • a demonstration of the catalytic decomposition of hydrogen peroxide 💻 • a practical problem solving exercise based on the catalytic decomposition of hydrogen peroxide 💻 • a visually attractive and colourful reaction between sodium thiosulfate and hydrogen peroxide in the presence of universal indicator 💻

		• an attention grabbing demonstration is the classic cannon fire experiment. A common misconception is that 'catalysts speed up reactions without taking part'. An experiment which could help to address this issue is the Rochelle salt/sodium tartrate reaction in which the cobalt compound used as the catalyst changes colour during reaction, but returns to its original colour when the reaction is over.
3) Chemical Energy		
(a) Enthalpy	For industrial processes, it is essential that chemists can predict the quantity of heat energy taken in or given out. If reactions are endothermic, costs will be incurred in supplying heat energy in order to maintain the reaction rate. If reactions are exothermic, the heat produced may need to be removed to prevent the temperature rising. Chemical energy is also known as enthalpy. The change in chemical energy associated with chemical reactions can be measured. The specific heat capacity, mass and temperature can be used to calculate the enthalpy change for a reaction.	Test-tube scale reactions for candidates to undertake which can be used to illustrate endo- and exo- thermic reactions, and which are suitable for use in enthalpy change measurement include; dissolving a spatula of anhydrous copper(II) sulfate in 2 cm^3 of water (exothermic), adding 2 cm^3 of water to a dry mixture of one spatula of citric acid and one spatula of sodium hydrogencarbonate (endothermic), adding a spatula of zinc to 5 cm^3 of 0.5 mol l^{-1} copper(II) sulfate solution. Polystyrene cups can also be used by all candidates to explore chemical energy changes. 10 cm^3 of sodium hydroxide solution is placed in the cup, the temperature recorded, and 10 cm^3 of dilute hydrochloric acid added. The temperature is recorded whilst stirring. This procedure can be repeated using: sodium hydrogen carbonate solution and citric acid; copper(II) sulfate solution and magnesium powder; dilute sulfuric acid and magnesium ribbon. Spectacular teacher demonstrations of exothermic reactions would including the thermit/thermite reaction or the reaction between zinc and copper(II) oxide.

		Demonstrations of endothermic reactions are offered by either: the solid-phase reaction between barium hydroxide-8-water and solid ammonium chloride (or ammonium thiocyanate) in which the mixture of stoichiometric quantities results in a reaction producing a liquid, with the temperature dropping to below -20 °C; or when 25g of ammonium nitrate is added rapidly, with vigorous stirring, to 100 cm^3 of water in a beaker which is resting on paper towel soaked in water. The wet paper towel freezes fixing the beaker to the bench surface. Runaway reactions, such as those resulting in disaster at Seveso and Bhopal, occur when the rate at which a chemical reaction releases energy exceeds the capabilities of the plant to remove heat. Internet sources can provide further details of these incidents.
(b) Enthalpies of combustion	The enthalpy of combustion of a substance is the enthalpy change when one mole of the substance burns completely in oxygen. These values can often be directly measured using a calorimeter and values for common compounds are available from data books and online databases for use in Hess’s law calculations.	The enthalpy of combustion of alcohols can be measured using apparatus available in schools. The RSC has an online data book with enthalpy of combustion values.
(c) Hess’s Law	Hess’s law states that the enthalpy change for a chemical reaction is independent of the route taken. Enthalpy changes can be calculated by application of Hess’s law.	Solid potassium hydroxide can be converted into potassium chloride solution by two different routes: Route 1 is the direct route whereby potassium chloride solution is made by adding solid potassium hydroxide directly to hydrochloric acid. Route 2 is the indirect route and involves two steps. Solid potassium hydroxide first is dissolved in water and then the solution neutralised using hydrochloric acid. Hess’s law can be confirmed by comparing the total enthalpy change for single-step route 1 with two-step route 2.

		Hess's law can be used to determine enthalpy changes that cannot be measured directly. In one challenge, candidates are asked to determine the enthalpy change for the reaction in which anhydrous copper(II) sulfate reacts with water to form hydrated copper(II) sulfate. Candidates measure the temperature change observed when anhydrous copper(II) sulfate is dissolved in water to produce a solution of copper(II) sulfate. They then measure the temperature change when hydrated copper(II) sulfate is dissolved to form a solution of similar concentration. By applying Hess's law, the candidates can then calculate the enthalpy change for a reaction converting anhydrous copper(II) sulfate crystals into hydrated copper(II) sulfate crystals.
(d) Bond Enthalpies	For a diatomic molecule, XY, the molar bond enthalpy is the energy required to break one mole of XY bonds. Mean molar bond enthalpies are average values which are quoted for bonds which occur in different molecular environments. Bond enthalpies can be used to estimate the enthalpy change occurring for a gas phase reaction by calculating the energy required to break bonds in the reactants and the energy released when new bonds are formed in the products.	Use bond enthalpies to estimate, by calculation, the enthalpy change associated with various gas phase reactions and compare the values obtained with experimental values obtained from literature. A common misunderstanding amongst candidates is that bond enthalpies can only be used to estimate the enthalpy change in reactions in which all of the reactants and all of the products are in the gas phase due to the assumption that the only bonds or interactions being broken or formed are covalent bonds.
4) Chemical Analysis as part of Quality Control		
(a) Chromatography can be used to check the composition and purity of reactants and products	In chromatography, differences in the polarity and/or size of molecules are exploited to separate the components present within a mixture. Depending on the type of chromatography in use, the identity of a component can be indicated either by the distance it has travelled or by the time it has taken to travel through the apparatus (retention time). The results of a chromatography experiment can sometimes be presented graphically showing an indication of the quantity of substance present on the y-axis and retention time	Many overviews of the key chromatographic techniques are available. A gas chromatograph can be made from a U-tube filled with soap powder. Natural gas acts as the carrier gas, and is burnt after it emerges from the U-tube 'column'. A mixture of alkanes is introduced at the inlet side of the u-tube. The component alkanes each take a different amount of time to travel through the soap powder 'column' and leave the u-tube at different times. Each time a compound leaves the u-tube,

	on the x-axis. Candidates are not required to know the details of any specific chromatographic method or experiment.	the flame formed by the burning carrier gas gets much larger and smokier. Column chromatography can be inexpensively carried out by candidates. Mixtures of food dyes can be separated using a 20 cm long glass tube or glass dropper containing a slurry of starch. A computer animation showing column chromatography in action is available. An interactive computer simulation of paper chromatography is available. Case studies concerning the use of chromatography are also available. *The National Horseracing Laboratory screens samples from racehorses and other animals to detect and identify traces of prohibited substances. A case study briefly describes gas chromatography and compares it with paper chromatography. There is information and questions for candidates, and additional notes and answers for teachers.* *In 1961, the seaside town of Capitola, California became the scene of a disturbing incident in which birds were reported to have flown into glass windows, attacked people on the ground and even, in less measured coverage, 'cry like babies'. The toxin responsible for the birds' altered behaviour was isolated and identified using a series of separation techniques, including chromatography.* A most unusual example of chromatography is provided by

		wool chromatography. A length of white wool approximately 1 m long , two 100 cm^3 beakers, approximately 20 cm^3 of methylated spirit and two crocodile clips are required. A short section (approximately 1 cm long) of the wool approximately 20 cm from the end of the wool is soaked in ink and allowed to dry. The length of wool between the inked area and the nearest end is soaked in alcohol. Crocodile clips are attached to each end of the wool to act as weights. The beaker containing the alcohol is placed on the edge of the bench. The clip on the end of the wool nearest the inked section is carefully lowered into the alcohol in such a way that the wool then passes over the spout of the beaker and descends towards the floor. The empty beaker is placed on the floor beneath the hanging clip. The alcohol is wicked up the wool, passes over the lip of the beaker and, under the action of gravity, starts to descend through the wool. As the ethanol passes through the inked area the components of the ink are carried by the solvent towards the floor at different rates resulting in a series of coloured bands moving down the wool towards the floor.
(b) Volumetric titration	Volumetric analysis involves using a solution of accurately known concentration in a quantitative reaction to determine the concentration of another substance. A solution of accurately known concentration is known as a standard solution. The volume of reactant solution required to complete the reaction is determined by titration. The 'end point' is the point at which the reaction is just complete. An indicator is a substance which changes colour at the end-point. Redox titrations are based on redox reactions. Substances such as potassium manganate (VII) which can act as their	Experimental work could include any acid/base or redox titration. Interesting examples could include the determination of: • the purity of aspirin • the purity of vitamin C tablets • the concentration of ethanoic acid in vinegars (by titration with sodium hydroxide using phenolphthalein indicator); • the mass of Citric Acid in Hubba Bubba Chewing gum (by titration with sodium hydroxide solution using phenolphthalein indicator) • the calcium carbonate content of antacid tablets (back titration in which tablet is dissolved in standard

	own indicators are very useful reactants in redox titrations. The concentration of a substance can be calculated from experimental results by use of a balanced equation.	hydrochloric acid, and the excess acid determined by titration with sodium hydroxide solution using phenolphthalein indicator; • the concentration of chloride ions in river water (a precipitation titration using silver nitrate solution and potassium chromate(VI) as the indicator). A ‘desert island’ style practical problem solving exercise can be provided in which candidates investigate whether lemons or oranges contain more acid, using ash from burned plants (which contains potassium carbonate) to neutralise the acid, and an indicator made from plant material such as red cabbage.

National Unit Specification: general information

UNIT Researching Chemistry (SCQF 6)

CODE FE4J 12

COURSE Chemistry (Revised)

SUMMARY

In this Unit candidates will develop the key skills necessary to undertake research in Chemistry and demonstrate the relevance of chemical theory to everyday life by exploring the Chemistry behind a topical issue. Candidates will develop skills associated with collecting and synthesising information from a number of different sources. Equipped with a knowledge of common apparatus and techniques they will plan and undertake a practical investigation related to the topical issue. Candidates will prepare a scientific communication presenting the aim, results and conclusions of their practical investigation. The Unit offers opportunities for candidates to work in partnership and in teams set within the context of the evaluation of a current scientific issue. This Unit is suitable for candidates who are interested in pursuing a career in Chemistry, as well as those whose interest is more general.

OUTCOMES

1. Research the Chemistry underlying a topical issue to a given brief.
2. Plan and carry out investigative practical work related to a topical issue in Chemistry
3. Prepare a scientific communication which presents the aim, results and conclusions from a practical investigation related to a topical issue in Chemistry.

Administrative Information

Superclass:

Publication date:

Source: Scottish Qualifications Authority

Version:

National Unit Specification: general information (cont)

UNIT Researching Chemistry (SCQF 6)

RECOMMENDED ENTRY

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- Standard Grade Chemistry at Credit level in both Knowledge and Understanding and Problem Solving

or

- the Intermediate 2 Chemistry course at grade B

and

- Standard Grade Mathematics at Credit level or Intermediate 2 Mathematics.

CREDIT VALUE

0.5 credit(s) at Higher (3 SCQF credit points at SCQF level 6).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates*.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Researching Chemistry (SCQF 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Research the Chemistry underlying a topical issue to a given brief.

Performance Criteria

(a) Information from suitable sources relating to a focus question from a given brief is obtained and recorded.
(b) The sources of information selected are recorded.

OUTCOME 2

Plan and carry out investigative practical work related to a topical issue in Chemistry.

Performance Criteria

(a) An appropriate experimental procedure is planned.
(b) The experimental procedure is carried out effectively.

OUTCOME 3

Prepare a scientific communication which presents the aim, results and conclusions from a practical investigation related to a topical issue in Chemistry.

Performance Criteria

(a) The aim of the investigative work is clearly stated.
(b) Information is analysed and presented in an appropriate format.
(c) Valid conclusions are drawn.
(d) A valid evaluation of procedures is made.

UNIT Researching Chemistry (SCQF 6)

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes. Assessors should use their professional judgement to determine the most appropriate instruments of assessments for generating evidence and the conditions and contexts in which they are used. Exemplification of possible approaches may be found in the Appendix to this Unit and the National Assessment Bank.

Outcome 1
Candidates will be provided with a briefing document which contains focus questions relating to key points of background information and/or chemical theory likely to be unfamiliar to the candidate. Candidates must produce:

- A clear and accurate answer to a focus question selected from those contained in the brief.

- A record of at least two sources of information relating to the answer provided. These should be identified in sufficient detail to allow a third party to retrieve the source article.

Outcome 2
Candidates will contribute to the planning and carrying out of investigative practical work. The assessor should record the date upon which the candidate was observed to have achieved the assessment standards.

Outcome 3
Outcome 3 is assessed by a single scientific communication describing the investigative activity and its findings. The scientific communication must be the individual work of the candidate. Depending on the activity, the collection of information may involve group work. The scientific communication can take any format in which the results of scientific research are commonly reported including: conference poster format, scientific paper format, PowerPoint presentation, video presentation, web page or traditional lab report.

Written and/or video and/or electronic and/or recorded oral evidence may be used to provide evidence that: the aim of the investigative work is clearly identified; information is analysed and presented in an appropriate format; valid conclusions are drawn and procedures are evaluated with respect to the selection of apparatus, the details of experimental method and/or the reliability of results as appropriate.

National Unit Specification: support notes

UNIT Researching Chemistry (SCQF 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this Unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

In this Unit candidates will develop the key skills necessary to undertake research in Chemistry and demonstrate the relevance of chemical theory to everyday life by exploring the Chemistry behind a topical issue. Candidates will develop skills associated with collecting and synthesising information from a number of different sources. Equipped with a knowledge of common Chemistry apparatus and techniques they will plan and undertake a practical investigation related to the topical issue. Candidates will prepare a scientific communication presenting the aim, results and conclusions of their practical investigation. The Unit offers opportunities for candidates to work in partnership and in teams set within the context of the evaluation of a current scientific issue. This Unit is suitable for candidates who are interested in pursuing a career in Chemistry, as well as those whose interest is more general.

Learning and Teaching Scotland website (LTS) provides exemplar investigation briefs, containing focus questions, to allow centres the opportunity to select a topical issue suited to the available resources and/or the interests of their candidates. Centres may wish to develop their own investigation briefs but these must be of a comparable standard.

Outcome 1

Research briefs should allow candidates to investigate the Chemistry underlying an issue or story featured in broadcast and publishing media. The research brief should contain a number of 'focus questions' relating to key points of background information or chemical theory which are likely to be unfamiliar to candidates undertaking the Unit. The focus questions should be constructed to give a clear indication of the information required from the candidate. The information required to answer the questions must also be readily available using printed resources, video or audio materials available to the candidate, or from websites which can be identified by use of a search engine. Candidates must not be provided with extracts from any of these sources compiled by a third party. Prior to undertaking the assessment of Outcome 1, teachers/lecturers should ensure that candidates have experience of literature based research. In particular, if candidates are carrying out web-based research, then they should be familiar with issues of reliability and they should be able to clearly state the source of the information they find.

Outcome 2

In order to be able to make informed choices and decisions during the planning stage of the investigation teachers/lecturers should ensure that candidates are familiar with the following practical techniques prior to undertaking the investigation.

- ♦ Filtration
- ♦ Distillation
- ♦ Use of a balance
- ♦ Titration
- ♦ Methods for the collection of a gas: over water, using a gas syringe
- ♦ Safe Methods for heating: Bunsen burners, water baths or heating mantles

UNIT Researching Chemistry (SCQF 6)

Candidates should have knowledge of the following pieces of general laboratory apparatus:

- Conical flask
- Beaker
- Measuring cylinder
- Delivery tubes
- Dropper
- Test tubes/Boiling tubes
- Evaporating basin
- Pipette with safety filler
- Burette
- Volumetric flask
- Funnel
- Thermometer

UNIT Researching Chemistry (SCQF 6)

Outcome 3

In order to be able to evaluate their procedures, and to arrive at valid conclusions, candidates should have experience of the following techniques and concepts:

- Representing experimental data using a scatter graph.
- Sketching lines or curves of best fit.
- Calculation of averages (means) for experiments.
- Identification and elimination of 'rogue' points from the analysis of results.
- **Qualitative** appreciation of the relative accuracy of apparatus used to measure the volume of liquids. Candidates would be expected to know that the volume markings on beakers only provide a very rough indication of volume. While measuring cylinders generally provide sufficient accuracy for preparative work, analytic work will normally require the use of burettes, pipettes and volumetric flasks.
- When a measurement has been repeated, candidates should appreciate that any variations in the value obtained give an indication of the reproducibility of the technique.
- The uncertainty associated with a measurement can be indicated in the form, *measurement* ± *uncertainty.* Candidates are not expected to conduct any form of quantitative error analysis.

Teachers/lecturers should note that the external examination for this Course contains questions requiring candidates to demonstrate their ability to design and evaluate experimental procedures in addition to questions which test a candidate's ability to interpret experimental data. The bullet points for Outcomes 2 and 3 listed give a clear indication of the likely contexts and data analysis techniques candidates may be expected to employ.

The appendix to the Unit specification provides an example of a record sheet which could be used to record candidate success in overtaking the Unit Performance Criteria.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

The Researching Chemistry Unit (20 hours) develops and assesses key Chemistry skills identified by Higher Education and Industry. It is intended that the majority of this time be spent in teaching activities which develop the skills necessary to conduct investigative work in Chemistry. In addition to ensuring that candidates are suitably prepared to conduct simple background research using the internet, candidates should also have the opportunity to become familiar with the apparatus, practical techniques and data analysis strategies indicated below.

Candidates should be familiar with the following apparatus

- Conical flask
- Beaker
- Measuring cylinder
- Delivery tubes
- Dropper
- Test tubes / Boiling tubes
- Evaporating basin
- Pipette with safety filler
- Burette
- Volumetric flask
- Funnel
- Thermometer

Candidates should be familiar with the following techniques

- Filtration
- Distillation
- Use of a balance
- Titration
- Methods for the collection of a gas: over water, using a gas syringe
- Safe Methods for heating: Bunsen burners, water baths or heating mantles

Candidates should be able to process experimental results by

- Representing experimental data using a scatter graph.
- Sketching lines or curves of best fit.
- Calculation of averages (means) for experiments.
- Identification and elimination of "rogue" points from the analysis of results.
- Qualitative appreciation of the relative accuracy of apparatus used to measure the volume of liquids. Candidates would be expected to know that the volume markings on beakers provide only a rough indication of volume. While measuring cylinders generally provide sufficient accuracy for preparative work, for analytic work, burettes, pipettes and volumetric flasks are more appropriate.
- When a measurement has been repeated, candidates should appreciate that any variations in the value obtained give an indication of the reproducibility of the technique.
- The uncertainty associated with a measurement can be indicated in the form, *measurement* ± *uncertainty*. Candidates are not expected to conduct any form of quantitative error analysis.

Whilst centres are free to deliver this Unit at any point during the Higher Chemistry Course, the '*Possible Contexts and Activities'* associated with the other Units of the Course may be used to provide real-life contexts within which candidates can become familiar with all of the practical techniques and apparatus listed above. Many teachers/lecturers may wish to delay the Unit assessment investigation until the latter stages of the Course in recognition of the considerable exposure to relevant experimental techniques candidates may experience whilst undertaking the other Higher Chemistry Units. This Unit allows the candidates to link and apply different kinds of learning in new situations.

Candidates should be encouraged to see risk assessment as a natural part of the planning process for any practical activity. Whilst candidates would **not** be expected to produce a full written risk assessment for their investigation themselves, this Unit provides an excellent opportunity to assess risks and take informed decisions regarding the use of appropriate control measures during the planning stage of the practical investigation.

As with all practical investigative work in Science, centres must ensure that appropriate risk assessments have been carried out for all practical activities and must comply with current health and safety legislation and regulation.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

This Unit provides opportunities to develop Communication, Numeracy, Information and Communication Technology and Problem Solving skills in addition to providing contexts and activities within which the skills associated with Working with Others can be developed.

Outcome 1 focuses upon a candidate's ability to research a chemistry topic. Information and Communication Technology skills are developed as candidates become proficient in using the internet to retrieve information on a topical science matter.

The planning and execution of the practical investigative work, associated with Outcome 2, provides a highly effective context within which candidates can develop both Problem Solving skills and those associated with working co-operatively with others.

In overtaking Outcome 3, the preparation of a scientific communication, candidates will develop numeracy and communication skills as they process their experimental results and communicate these effectively to others.

UNIT Researching Chemistry (SCQF 6)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1 is assessed by a written and/or oral report of the candidate's review findings. The candidate's report should be the result of his/her individual research into one of the focus questions contained in the investigation brief.

- The candidate's record should contain an extract or summary of information relevant to a focus question provided in the briefing document.
- The candidate's record should contain mention of at least two sources of relevant information. The precise format in which these reference sources are to be recorded is not prescribed and any format that would successfully allow the source to be retrieved by a third party is sufficient.

Outcome 2 requires candidates to take an active part in planning, designing and carrying out a practical investigation.

If candidates are working as part of a group, it is unlikely that they will take an equal or similar role in the investigation. Teachers/lecturers should exercise professional judgement in deciding if candidates have taken an active part in the work.

Outcome 3 requires candidates to produce, individually, a scientific communication which presents the results of the practical investigation undertaken. The table below is provided to indicate what might be addressed to achieve a specific assessment standard. The relevance of the items will vary according to the research activity being undertaken. The professional judgement of the teacher/lecturer will be important in deciding if an assessment standard has been met for a particular activity.

All the assessment standards given in the left-hand column must be achieved in order to attain Outcome 3. The right-hand column gives suggestions which might aid the professional judgement of the assessor.

UNIT Researching Chemistry (SCQF 6)

Outcome 3 Performance Criteria	**Suggestions to aid professional judgement**
(a) The aim of the investigative work is clearly stated.	The communication should contain a clear statement of the aim of the research.
(b) Information is analysed and presented in an appropriate format.	The analysis might include: ♦ correctly executed calculations ♦ comparison of values with those in the literature ♦ experimental observations
(c) Valid conclusions are drawn.	The communication should contain a conclusion which is valid on the basis of the evidence available to the candidate.
(d) A valid evaluation of procedures is made. .	The evaluation might include: ♦ an assessment of the effectiveness of the procedure ♦ suggestions for alternative or modified strategies, further work, predictions or generalisations ♦ an assessment/explanation of the relevance of the results.

The relevance of the bullet points listed above will vary according to the nature of research undertaken. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to verification) against the assessment standards. It is appropriate to support candidates in producing a scientific communication to meet the assessment standards. Re-drafting of the communication after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting and resubmission of the parts requiring attention only is required ie the entire scientific communication does not need to be redone.

Conditions required to prepare the scientific communication

Teachers and lecturers may wish candidates to prepare their communications under direct supervision so that appropriate advice and support can be provided. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidates' response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Candidate absence during the Unit assessment

At the conclusion of an investigation conducted for Unit assessment purposes, it is possible that a candidate may fail to have demonstrated attainment in all Outcomes and assessment standards. This situation could arise either through absence or by the candidate failing to achieve the required standard at the first attempt. Candidates need only undertake those part(s) of an investigation required to allow them to demonstrate attainment in accordance with the evidence requirements stated in the Unit specification.

Example Teacher/lecturer Record Sheet.

This grid may be used to record candidates' achievement in the assessment standards for each Outcome.

	Literature based research		**Plan and carry out an investigation**		**Scientific Communication**			
	Report		Observation/ discussion		Report in any format			
Name	Information obtained and recorded	Sources of information recorded	Contributed to planning	Contributed to carrying out	Aim clearly identified	Results presented and analysed	Valid conclusion	Evaluation of procedure

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre, telephone 0845 279 1000.