SQA Advanced Unit specification

General information for centres

Unit title: Organic Chemistry: Theory and Laboratory Skills (SCQF level 7)

Unit code: HV0L 47

Superclass: RD

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of organic chemistry, encompassing mechanisms of organic chemical reactions. Learners will also develop practical skills in techniques relevant to organic chemistry. The Unit is suitable for learners studying at SQA Advanced Certificate level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of organic chemistry at SQA Advanced Diploma level or to seek employment in science based industries.

Outcomes

On successful completion of the Unit the learner will be able to:

1 Predict and explain the outcome of organic chemical reactions.
2 Apply common reaction mechanisms.
3 Perform practical experiments related to organic chemistry.

Credit points and level

1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the Unit HV00 47 *Fundamental Chemistry: Theory and Laboratory Skills* or equivalent, or have experience of Chemistry at Higher level.

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

SQA Advanced Unit specification: Statement of standards

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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.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Predict and explain the outcome of organic chemical reactions.

Knowledge and/or Skills

- Products of organic reactions
- Reagents and conditions to synthesise target molecules
- Geometric and optical isomers to include: E/Z, cis/trans, R/S
- Stereochemical outcomes of reactions

Outcome 2

Apply common reaction mechanisms.

Knowledge and/or Skills

- Substitution
- Addition
- Elimination

Outcome 3

Perform practical experiments related to organic chemistry.

Knowledge and/or Skills

- Organic chemistry experiments
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 2 should be assessed using a holistic closed-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement when sitting the assessment.

Written and/or oral recorded evidence for Outcome 3 should be assessed by production of a full laboratory report, or by completion of an appropriate pro forma. An assessor's observation checklist could be used to record performance evidence of practical experiments.

Outcome 1

The assessment will cover all of the Knowledge and/or Skills items. A learner's response will be judged satisfactory where the evidence shows that the learner can:

- Predict the products of organic reactions.
- State the reagents and conditions required to the synthesis of target molecules.
- Predict the structure and optical properties of organic reactant and/or products by applying isomerism principles.
- Explain the stereochemical outcomes of certain reactions.

Outcome 2

The assessment will sample two of the three Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Apply the concept of reaction mechanisms to substitution reactions.
- Apply the concept of reaction mechanisms to addition reactions.
- Apply the concept of reaction mechanisms to elimination reactions.

Outcome 3

Learners will perform a minimum of two practical experiments, the content of which will be related to Outcome 1 and/or 2. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Follow instructions to perform experiments related to organic chemistry.
- Work in a safe manner regarding current health and safety regulations.
- Achieve consistent and accurate results.
- Record experimental observations and results clearly and accurately.
- Evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Learners may report results either by production of a full laboratory report, or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake different practical experiments of similar complexity. Where a laboratory report or pro forma does not meet required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

SQA Advanced Unit Support Notes

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Unit Support Notes are offered as guidance and 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

This Unit is part of the framework for the SQA Advanced Certificate/Diploma in Applied Sciences and the SQA Advanced Diploma in Applied Chemical Sciences but may be suitable for inclusion in other SQA Advanced science and engineering awards. It is designed to develop the theoretical and practical aspects of organic chemistry introduced in the Unit HV00 47 *Fundamental Chemistry: Theory and Laboratory Skills*.

Outcomes 1 and 2

Learners should be able to predict the mechanism and products of simple chemical reactions. They should gain knowledge of the methods used to prepare different classes of aliphatic compounds and be able to suggest suitable mechanistic pathways.

- Nucleophilic substitution reactions (SN1 and SN2) using common nucleophiles.
- An introduction to the reactions and reactivity of the benzene ring.
- Addition reactions to carbon-carbon double bonds using, for example halogens, hydrogen halides (Markovnikov's rule) and others.
- Addition to carbon-oxygen double bonds using common reactants (such as bisulphite, hydrogen cyanide, oximes, Grignard reagents and others).
- Elimination reactions used to prepare alkenes (E1 and E2).
- Free radical reactions as in the halogenation of methane and in additions to carbon-carbon double bonds (anti-Markovnikov).

Learners will also be expected to predict the products of such reactions and to give suitable reagents and conditions. They should also be able to suggest suitable general mechanisms for representative reactions.

Where appropriate, learners should be introduced to the use of curved arrows to show electron movement.

Where different mechanistic pathways lead to different stereochemical outcomes, either through optical isomerism or geometric isomerism, learners should be able to predict the stereochemistry and suggest reagents and conditions that may favour one mechanistic path over another. To ensure the learner can achieve this it will be necessary to cover stereochemical topics and terminology such as conformation, geometric isomerism (cis/trans; E/Z), optical isomerism, chirality, enantiomers, optical activity, racemic mixtures and racemisation, retention/inversion of configuration and resolution of an enantiomeric mixture.

The properties of benzene as the representative molecule of the Aromatic family, its reactivity towards electrophilic substitution, and its stability towards addition reactions in contrast to other unsaturated hydrocarbons should also be covered.

Outcome 3 — Perform practical experiments related to organic chemistry

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1 and 2.

In carrying out such activities, learners should follow Good Laboratory Practice (GLP) and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

It is recommended that Outcome 1 is delivered first as this Outcome contains some of basic principles of stereochemistry which are required when delivering Outcome 2.

It is envisaged that delivery of Outcome 1 could commence with a general overview on the nomenclature of organic families and the structure of common compounds used as organic reagents. Then, the principles of isomerism may be covered. Both structural isomerism and stereoisomerism can be covered, giving special attention to the geometrical isomerism of alkenes (cis/trans) and the E/Z configuration. This topic can be approached by the use of molecular modelling packs such as molymods. It is expected that the learner will get familiar with the Cahn Ingold Prelog Stereochemical priority rules. Learners are expected to understand and be able to draw the structures of the R/S configurations of enantiomers. It is envisaged that learners will get familiar with definitions such as stereoisomer, enantiomer, chiral carbon, diastereomers, optical activity, dextrorotatory, levorotatory, racemic mixture, optical purity, etc. It is important that learners are aware of the effects of polarity, electronegativity and inductive effect and mesomeric effects on the mechanism of an organic reaction. Learners should be familiar with the arrow notation used for organic mechanisms.

Learners are expected to be familiar with the organic reactions for the representative homologous series such as alkanes, alkenes, alkanols, haloalkanes, alkanals, alkanones, carboxylic acids and derivatives, amines and an introduction to the main substitution reactions taking place on a non-substituted benzene ring as well as the stability of the benzene ring towards addition processes. The delivery of the different types of reactions such as substitution, addition, elimination, oxidation, reduction, dehydrogenation esterification and hydrolysis etc is expected. A mixture of theory and a variety of exercises should be aimed to give the learner confidence when predicting the products, reactants or conditions under which these organic reactions take place. Posters, practical demonstrations, on-line simulations and videos are some possible resources to be used when teaching this topic.

In Outcome 2 learners are expected to become familiar with the mechanisms of representative organic reactions. This topic can be delivered using resources such as on-line simulations, worksheets designed for the learners to complete missing information (such as arrows, charges, structural formulas, etc), posters or other kind of visual aids.

It is envisaged that the learner should be able to show a specific mechanism by using curly arrows showing electron movement, and the steps involved in a mechanism such as activated complexes, attacks, carbocation formation etc when appropriate. Learners should be aware of the instances where Markovnikov's and Saytzev's rules apply. Learners are expected to recognised and draw the stereochemical outcome for the products of some reactions. For example, when delivering nucleophilic substitution reactions, awareness of the

inversion of stereochemistry, and/or the possibility of R/S isomers should be expected when appropriate.

It is envisaged that Outcome 3 will be delivered alongside the theoretical based Outcomes 1 and 2. A range of practical experiments could be utilised to both support understanding of the underlying theory and to prepare learners for undertaking the assessed practical experiments. Aspects suitable for experimental investigation might include the preparation of an organic product using a specific set of conditions and reagents, and this could be compared and contrasted with the outcome of using another set of conditions and/or reagents. Tests used to identify targeted organic compounds would also be suitable as would the characterisation of an organic product by IR, GLC or melting and boiling point should the resources be available. It is important that the student become familiar with some common techniques of preparation and purification of organic products, such as reflux, distillation (including rotary evaporator), filtration, crystallisation, extraction, etc when possible.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1 and 2 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Assessment should be carried out in supervised conditions, and it is recommended that the assessment be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement when sitting the assessment.

Where evidence of Outcome 2 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment, must be included in the alternative (re-sit) assessment.

In Outcome 3 learners are required to undertake two assessed practical experiments, the content of which will be related to Outcomes 1−2. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments for Outcomes 1 and 2 are:

- Bromination of *Trans*-Stilbene
- Preparation of Butyl Ethanoate
- Preparation of cyclohexane from cyclohexene
- 2,4 DNPH derivative preparation for carbonyl compound
- Selected reactions of hydrocarbons for identification
- Grignard Synthesis of Triphenylmethanol
- The Diels-Alder Reaction of a Conjugated Diene in Eucalyptus Oil
- Resolution of a racemic mixture: α-methylbenzylamine
- Introduction to chirality using ArgusLab

Assessed practical experiments will usually be performed individually. However, there may be some experiments that are suitable to be undertaken in pairs or small groups, if this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 7.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Problem Solving* at SCQF level 6 and *Information and Communication Technology (ICT)* at SCQF level 4.

Problem Solving — Reviewing and Evaluating at SCQF level 6

Following assessed practical experiments learners will be required to review and evaluate the effectiveness of the exercise with a thorough interpretation of random and systematic sources of error. Learners will be required to reach sound conclusions on the basis of the data collected and the inherent errors. Learners will be required to identify suitable reagents, reactants or products involved in a representative organic reaction. The choice of a mechanism followed by an organic process requires for the learner to select appropriate information on the chemical nature of the reactants and the suitability of the conditions employed within the reaction.

Information and Communication Technology (ICT) — Providing/Creating Information at SCQF level 4

Learners will make effective and appropriate use of ICT packages to produce laboratory reports or pro formas in an appropriate format. Packages used will likely include word processing, spreadsheets, and specialist chemical structure software.

Sustainability

Sustainability can be embedded in delivery of the Unit in a variety of ways. For example, by encouraging minimum usage, correct disposal procedures and possibly recycling (eg of solvents) during practical experiments. In addition, the learner can be given the opportunities to discuss the economic and environmental implications of some of the synthesis processes studied, ie percentage yields, opportunities for recycling.

History of changes to Unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for learners

Unit title: Organic Chemistry: Theory and Laboratory Skills (SCQF level 7)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1-credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an SQA Advanced Certificate/Diploma science programme. Before progressing to this Unit it would be beneficial to have completed the Unit HV00 47 *Fundamental Chemistry: Theory and Laboratory Skills*, where you will have learned underpinning aspects of organic chemistry and developed your practical skills. The Unit is designed to give you knowledge of the mechanisms used to explain simple reactions in organic chemistry and to introduce you to the ideas and concepts of stereochemistry.

On completion of the Unit you should be able to:

1 Predict and explain the outcome of organic chemical reactions.
2 Apply common reaction mechanisms.
3 Perform practical experiments related to organic chemistry.

Outcomes 1 and 2

In these Outcomes you will learn about fundamental organic chemical reactions and their mechanisms. You will also become familiar with the stereochemistry involved within these chemical reactions.

You will learn about Substitution reactions (SN1, SN2, Aromatic), Addition reactions and Elimination reactions (E1 and E2).

You will be expected to predict the products of such reactions and to give suitable reagents and conditions. You will also be able to give general mechanisms for representative reactions.

You will learn how to predict the stereochemical outcome of a particular type of organic chemical reaction, and you will be able to suggest reagents and conditions that may favour one mechanistic path over another.

Stereochemical topics and terminology such as conformation, geometric isomerism (cis/trns, E/Z), optical isomerism, chirality, enantiomers, optical activity, racemic mixtures and racemisation, retention/inversion of configuration and resolution of an enantiomeric mixture will be covered in these Outcomes.

Outcome 3

In this this Outcome you will undertake practical experiments, based on the content of Outcomes 1 and 2.

During this practical work, you will also be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will also be encouraged to develop safe working practices and to strive constantly to improve the

accuracy and reliability of your results. The reporting and analysis of experimental data is an important aspect of the practical sessions.

Assessment

For Outcomes 1 and 2 you could take a closed-book, end of Unit assessment.

Outcome 3 will be assessed after you have learned the necessary practical skills, and will take the form of two practical experiments, for which you will report your results either in full laboratory reports, or by completion of pro forma reports.

Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills *Problem Solving* at SCQF level 6 *and Information and Communication Technology (ICT)* at SCQF level 4.