## SQA Advanced Unit specification

## General information for centres

**Unit title:** Aromatic Chemistry: Theory and Laboratory Skills (SCQF level 8)

**Unit code:** HV0W 48


**Superclass:** RD

**Publication date:** November 2017

**Source:** Scottish Qualifications Authority

**Version:** 01


## Unit purpose

This Unit is designed to enable learners to understand key aspects of aromatic chemistry, and it will develop knowledge of synthetic routes to a wide range of aromatic compounds. Learners will also develop practical skills in techniques relevant to aromatic synthesis. The Unit is suitable for learners studying at SQA Advanced Diploma level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of aromatic chemistry at degree level or to seek employment in science based industries.

## Outcomes

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

1 Explain the concepts of aromaticity.
2 Devise synthetic routes and explain reaction mechanisms of a range of aromatic compounds.
3 Perform practical experiments related to aromatic syntheses.

## Credit points and level

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

## Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the Unit HV0L 47 *Organic Chemistry: Theory and Laboratory Skills* or equivalent.

## 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

## Unit title: Aromatic Chemistry: Theory and Laboratory Skills (SCQF level 8)

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

Explain the concepts of aromaticity.

### Knowledge and/or Skills

- Benzene
- Multi-ringed compounds
- Heterocyclic ringed compounds

## Outcome 2

Devise synthetic routes and explain reaction mechanisms of a range of aromatic compounds.

### Knowledge and/or Skills

- Mono-substituted compounds
- Di-substituted benzene compounds
- Multi-ringed compounds
- Heterocyclic compounds

## Outcome 3

Perform practical experiments related to aromatic syntheses.

### Knowledge and/or Skills

- Synthesis of aromatic compound 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. It is recommended that the assessment be completed within 1 hour 30 minutes.

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:

- Explain aromaticity in benzene.
- Apply Huckel's rule to identify aromatic multi-ringed compounds; explain aromaticity in multi-ringed compounds.
- Apply Huckel's rule to identify aromatic heterocyclic compounds; explain aromaticity in heterocyclic ringed compounds.

**Outcome 2**

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:

- Devise synthetic routes and explain reaction mechanisms of mono-substituted compounds.
- Devise synthetic routes and explain reaction mechanisms of di-substituted benzene compounds.
- Devise synthetic routes and explain reaction mechanisms of multi-ringed compounds.
- Devise synthetic routes and explain reaction mechanisms of heterocyclic compounds.

**Outcome 3**

Learners will perform a minimum of two practical experiments, the content of which will be related to Outcome 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 aromatic syntheses.
- 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 must report one of the two practical experiments by production of a full laboratory report. Learners may report the remaining practical experiment 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 experiments 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 a different practical experiment 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

## Unit title: Aromatic Chemistry: Theory and Laboratory Skills (SCQF level 8)

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 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 HV0L 47 *Organic Chemistry: Theory and Laboratory Skills*, and also to introduce learners to theories of aromaticity and aromatic synthesis.

**Outcome 1 — Explain the concepts of aromaticity**

This Outcome should cover the concept of aromaticity. Learners should use the Huckel rule to explain the aromatic nature of benzene. Learners should also use the Huckel rule to identify and explain multi-ringed and five and six membered heterocyclic compounds. Examples of multi-ringed compounds could include naphthalene, anthracene and phenanthracene. Examples of five and six membered heterocyclic compounds could include furan, thiophene, pyrole and pyridine.

**Outcome 2 — Devise synthetic routes and explain reaction mechanisms of a range of aromatic compounds**

This Outcome should cover the synthesis and reaction mechanisms of a range of aromatic compounds. The effect of functional groups on an aromatic ring. Any changes in the aromatic nature of the ring and the reactivity of the functional group should be explained.

Electrophilic aromatic substitution should be covered. Learners should know the mechanism and main reagents required for halogenation, sulphonation, nitration, alkylation and acylation. These reactions should be covered for the range of aromatic compounds listed in Outcome 1.

Synthetic routes of di-substituted benzene compounds, with learners able to determine the electron withdrawing or donating effects of functional groups as well as the directing effects of these groups.

Activated and non-activated nucleophilic substitution should be covered.

Curly arrows should be used to show the correct mechanism of reaction.

Reactions of five and six membered heterocyclic rings should be covered.

The use of blocking groups to obtain the correct product could be introduced to learners.

**Outcome 3 — Perform practical experiments related to aromatic syntheses**

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 Outcome 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

This Unit will require a mixture of delivery methods. The main theory is likely to be delivered in taught classes however there is the potential for project work to research topics and group work. Tutorial classes may be useful in the support of theory classes and project work.

It is envisaged that delivery of Outcomes 1 and 2 could commence with an overview of aromatic compounds to set the scene, this could involve explaining the basic differences between aliphatic and aromatic compounds and examples of each compound and their uses. Huckel's rule and aromaticity of compounds could then be delivered to give learners a fundamental understanding of the behaviours and reactions of aromatic compounds. The kekule structure could also be explained at this point.

The classic reaction of aromatic chemistry is Electrophilic Aromatic Substitution. Learners will need to understand the effect of electron donating and electron withdrawing groups, and the impact that these groups have on position of a group being added to an aromatic compound. This topic will require several hours of delivery to ensure that learner's knowledge is developed, and several typical reactions of this type should be covered.

The benzyne reaction could then be covered, along with nucleophilic substitutions. This could be followed by the benzene reaction, after which learners could be introduced to multi-ring systems, and their substitution patterns. Learners should also be aware of diazonium salts and their reactions, and the reactions of heterocyclic aromatics (nucleophilic substitution and electrophilic substitution), both five membered and six membered ring systems.

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 synthesis of suitable aromatic compounds.

Care should be taken to ensure that experiments are suitable in terms of the compounds used. It is the responsibility of the delivering centre to ensure that compounds are handled safely (eg in a fume cupboard) and that no particularly toxic compounds are used (eg carcinogens, compounds that may affect fertility, pregnancy). Delivering centres should check and risk assess every compound to be used.

It would be expected that learners analyse their products using IR and/or boiling/melting point to determine they have correctly synthesised the required product. Literature melting /boiling points should be referenced by the learners.

## 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. Assessment should be carried out in supervised conditions, and it is recommended that the assessment be completed within 90 minutes.

In Outcome 3 learners are required to undertake two assessed practical experiments, the content of which will be related to Outcome 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 Outcome 3 are:

- Preparation of iodobenzoic acid
- Preparation of p-bromoaniline

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 8.

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. They will be required to reach sound conclusions on the basis of the data collected and the inherent errors.

**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.

## History of changes to Unit

| Version | Description of change | Date |
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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: Aromatic Chemistry: Theory and Laboratory Skills (SCQF level 8)

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 8, which you are likely to be studying as part of the second year of an SQA Advanced science programme. Before progressing to this Unit it would be beneficial to have completed the Unit HV0L 47 *Organic Chemistry: Theory and Laboratory Skills*, where you will have learned underpinning aspects of aromatic chemistry and developed your practical skills.

On completion of this Unit you should be able to:

1 Explain the concepts of aromaticity.
2 Devise synthetic routes and explain reaction mechanisms of a range of aromatic compounds.
3 Perform practical experiments related to aromatic syntheses.

**Outcome 1**

In this Outcome you will learn about the concepts of aromaticity. You will cover benzene, multi-ringed systems and heterocyclic compounds, and you will learn how these compounds can be described as being aromatic.

**Outcome 2**

In this Outcome you will learn about the effect on a range of functional groups when they are attached to an aromatic compound. Electrophilic substitution reactions will be covered in depth, as will the directing nature of various functional groups. Other reactions of aromatic compounds will be covered, such as nucleophilic substitution.

**Outcome 3**

In this Outcome you will undertake practical experiments, based on the content of Outcome 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 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 a full laboratory report, or by completion of a pro forma report. You must produce a full laboratory report for at least one practical experiment.

## Core Skills

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