Higher National Unit specification

General information

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

Unit code: H937 35

Superclass: RD

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand the underpinning theory of spectroscopic analytical methods in chemistry, including concepts involved in spectrometer design. Learners will also develop practical skills in the operation of a range of analytical instruments and how to correctly interpret the results. The Unit is suitable for learners studying at HND level, and will provide the necessary underpinning knowledge and skills to enable progression to further study 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 Describe key features of spectrometer design.
2 Interpret and explain spectral data.
3 Determine molecular structures from spectroscopic data.
4 Perform experiments using a range of analytical instruments.

Credit points and level

1 Higher National Unit 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 HN Unit H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills* or equivalent.

Higher National Unit Specification: General information (cont)

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Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes of 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**.

Higher National 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

Describe key features of spectrometer design.

Knowledge and/or Skills

- Design principles of given spectrometer
- Functions and nature of the components of given spectrometer

Outcome 2

Interpret and explain spectral data.

Knowledge and/or Skills

- Molecular transitions involved in different types of spectroscopy
- Extracting information from and predicting Infra-Red (IR) spectra
- Extracting information from and predicting Nuclear Magnetic Resonance (NMR) spectra

Outcome 3

Determine molecular structures from spectroscopic data.

Knowledge and/or Skills

- Combined structural determinations of aliphatic compounds using IR, NMR and Mass Spectrometry data
- Combined structural determinations of aromatic compounds using IR, NMR and Mass Spectrometry data

Higher National Unit specification: Statement of standards (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

Outcome 4

Perform experiments using a range of analytical instruments.

Knowledge and/or Skills

- Preparation/calibration and operation of instruments
- Analysis and interpretation of data
- Identification and evaluation of experimental errors
- Record and report results

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 45 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement and correlation charts for NMR and IR when sitting the assessment.

Written and/or oral recorded evidence for Outcome 3 should be assessed using a closed-book assessment under supervised conditions. It is recommended that the assessment be completed within 30 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement and correlation charts for NMR and IR when sitting the assessment.

Written and/or oral recorded evidence for Outcome 4 should be assessed by production of full laboratory reports, 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:

- Describe spectrometer design, for a given spectrometer.
- Describe the functions and nature of key components of spectrometers.

Learners should not be aware of which spectrometer types they shall be assessed on.

Higher National Unit specification: Statement of standards (cont)

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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:

- Explain the nature of the interaction of light with chemical species and how this relates to spectroscopic tools.
- Predict and explain IR spectra.
- Predict and explain NMR spectra.

Learners are required to provide evidence of actual understanding of IR and NMR spectral patterns, rather than solely linking to data in correlation charts.

Outcome 3

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:

- Solve combined structural problems to identify unknown aliphatic compounds from a combination of IR, NMR and Mass Spectral data.
- Solve combined structural problems to identify unknown aromatic compounds from a combination of IR, NMR and Mass Spectral data.

Outcome 4

Learners will perform a minimum of four analytical techniques, which should involve a minimum of three different types of spectrometry. The fourth technique may be a fourth form of spectrometry, or may involve a non-spectroscopic analytical instrument.

A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Set up and operate a range of analytical instruments to produce accurate data.
- Analyse and interpret the data correctly and draw conclusions.
- Identify and evaluate experimental errors.
- Record the results in an appropriate format.

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 two of the four 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 activities independently on the basis of the experimental data.

Higher National Unit specification: Statement of standards (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

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.

Higher National Unit Support Notes

Unit title: Spectroscopic and Analytical Techniques (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 intended as part of the framework for HNC/HND Applied Sciences and HND Applied Chemical Sciences but may be suitable for inclusion in other HN Science awards. It is designed to develop theoretical and practical knowledge of a range of spectroscopic techniques to facilitate employment at technician level, and also to develop the advanced problem solving skills required for learners articulating to Stage 3 BSc. A key component of this latter item will be the ability to utilise a range of information in advanced problem solving activities. The nature of this Unit should allow integration with other Units from the Group Award, with practical exercises being drawn from some of the more theoretical Units in the Course.

Outcomes 1–3

Learners should be introduced to a range of spectroscopic techniques. The design of key spectrometer types will be covered in sufficient detail to facilitate the learner's understanding of their operation, set-up and basic maintenance. It is not envisaged that detailed aspects of spectrometer design will be covered as the range and complexity of modern instrument types would put that topic well beyond what could be studied, or required, at this level. Typical instruments that could be discussed are AAS, FES, ICP, UV/Vis, MS, Infra-Red, NMR, Fluorescence and Polarimetry. Learners should become familiar with the types of analyses performed on the various instruments, the overall design and the mode of operation of the main components. As chromatographic instruments are often used in conjunction with spectrometers in analytical problem solving, it will also be beneficial to cover them in brief detail.

Learners should gain a firm understanding of the underlying scientific principles, eg the nature of EMR, of quantisation of molecular energy levels, of transitions involved in different types of spectroscopy, Beer-Lambert law, etc.

The interpretation of IR spectra should be covered in detail, and as well as covering the use of correlation charts should include aspects such as the origin of overtones, effects of conjugation and molecular symmetry, etc. It is intended that learners should be able to predict and explain spectral aspects on the basis of their theoretical understanding.

The interpretation of proton-NMR spectra should be covered in adequate depth such that learners can explain and predict splitting patterns and the effect of proton environments on delta-shift values. It would also be expected that carbon-13 NMR will be briefly covered.

Higher National Unit Support Notes (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

Outcome 4

Learners will complete analyses on a variety of instruments. The actual type of instruments involved will depend on the facilities available at the centre, but must include four distinct types of instrument and include both qualitative and quantitative analyses. The practical experiments should involve the learners being required to accurately prepare samples and standards for analyses, rather than being simply given pre-prepared solutions.

Guidance on approaches to delivery of this Unit

This Unit is likely to form part of a Group Award designed to provide learners with scientific knowledge and skills for employment at science technician level, or to articulate to advanced stages of science degree programmes.

Outcomes 1–3 would best be delivered in order. It is envisaged that laboratory work and demonstrations will feature across the delivery of each of the Outcomes, and that the assessed practical experiments for Outcome 4 will be undertaken in a similar timeframe to the underpinning theory.

It is envisaged that the Unit would be delivered subsequent to Units covering underpinning chemistry theory, and that in particular learners will have a sound grasp of organic nomenclature and structures. Learners will also require an understanding of the properties of electromagnetic radiation, and be able to interrelate quantities — wavelength, frequency, energy. It is expected that the theoretical content of this Unit would be delivered first, before learners move on to practical experiments.

Problem solving exercises would be expected to form a substantial part of the delivery of this Unit, with learners being provided with opportunities to develop these skills from a range of spectral data.

It is envisaged that Outcome 4 will be delivered alongside the theoretical based Outcomes 1–3. 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 examination of spectrometer components running spectra of pre-prepared samples, preparation of KBr discs, refraction of light, etc.

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 45 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement and correlation charts for NMR and IR when sitting the assessment.

Higher National Unit Support Notes (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

Outcome 3 could be assessed by a 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 30 minutes. Learners can only have access to the *SQA Databook for Higher/Advanced Higher Chemistry* or any suitable replacement and correlation charts for NMR and IR when sitting the assessment.

In Outcome 4 learners are required to undertake four assessed practical experiments, which should involve a minimum of three different types of spectrometry. The fourth technique may be a fourth form of spectrometry, or may involve a non-spectroscopic analytical instrument. 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 are:

- IR spectroscopy to identify function groups in a series of substances.
- UV/Vis spectroscopy to identify quantity of aspirin present as Fe-salicylate complex.
- AA spectroscopy to identify metal content in wines.
- FES spectroscopy to identify sodium content in foodstuffs.
- Fluorescence spectroscopy to identify quinine in tonic water.
- HPLC to identify analgesic content in tablets.

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**.

Higher National Unit Support Notes (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

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 Numeracy* and *Problem Solving* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 4.

Numeracy — Using Graphical Information at SCQF level 6

Learners will be required to extract, analyse, and interpret graphical and spectral information from a range of sources, and collate the information to identify an unknown compound. Learners will also be required to select appropriate forms of complex tables, charts or diagrams to communicate complex information in these forms for the purposes of the laboratory reports.

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 — 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. It is also to be expected that some analytical instruments used will be operated via computer, and that databases may be deployed.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Spectroscopic and Analytical Techniques (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 first year of an HNC/HND Science programme. Before progressing to this Unit it would be beneficial to have completed the HN Unit H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills*. The Unit covers a combination of the theoretical principles of various spectroscopic techniques in chemistry, and practical experiments involving their use. This will provide you with key skills and knowledge which should facilitate employment at technician level, and also develop the advanced problem solving skills required for articulation to Stage 2 or 3 BSc.

On completion of the Unit you should be able to:

1 Describe key features of spectrometer design.
2 Interpret and explain spectral data.
3 Determine molecular structures from spectroscopic data.
4 Perform experiments using a range of analytical instruments.

Outcomes 1–3

In these Outcomes, theoretical aspects covered will include the design of key spectrometer types. Typical instruments that could be covered are AAS, FES, ICP, UV/Vis, MS, Infra-Red, NMR, Fluoresence and Polarimetry. You will become familiar with the types of analyses performed on the various instruments, the overall design and the mode of operation of the main components.

It is intended that you should gain a firm understanding of the underlying scientific principles, eg the nature of EMR, of quantisation of molecular energy levels, of transitions involved in different types of spectroscopy, Beer-Lambert law, etc.

The interpretation of IR spectra will be covered in detail, and as well as covering the use of correlation charts should include aspects such as the origin of overtones, effects of conjugation and molecular symmetry etc. It is intended that you should be able to predict and explain spectral aspects on the basis of your theoretical understanding.

The interpretation of proton-NMR spectra will be covered in adequate depth such that you can explain and predict splitting patterns and the effect of proton environments on delta-shift values.

Outcome 4

In this Outcome you will undertake practical experiments, based on the content of Outcomes 1–3.

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.

General information for learners (cont)

Unit title: Spectroscopic and Analytical Techniques (SCQF level 8)

Assessment

For Outcomes 1 to 3 you will take a closed-book, end of Unit assessment.

Outcome 4 will be assessed after you have learned the necessary practical skills, and will take the form of four 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 of *Numeracy* and *Problem Solving* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 4.