## Higher National Unit specification: general information

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

**Unit code:** FV6W 35

**Superclass:** RD

**Publication date:** September 2011

**Source:** Scottish Qualifications Authority

**Version:** 01

## Unit purpose

This Unit is designed to enable candidates to understand the underpinning theory of spectroscopic analytical methods in chemistry, including concepts involved in spectrometer design. Candidates will also develop practical skills in the operation of a range of analytical instruments and correctly interpret the results. On completion of the Unit candidates should be able to:

- explain key features of spectrometer design
- interpret and explain spectral data
- perform experiments using a range of analytical instruments

## Recommended prior knowledge and skills

Candidates should have qualifications in chemistry at SCQF level 7, including a sound understanding of organic structures and nomenclature. The Unit DH2K 34 Fundamental Chemistry: Theory and Practice would constitute appropriate prior knowledge. Effective communication skills would also be required, which could for example be evidenced by the unit DG70 34 Presentation Skills in Science.

## Credit points and level

1 Higher National Unit credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**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.*

## Higher National Unit specification: general information (cont)

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

## 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.

## Assessment

Outcome 1 should be assessed by a 'closed-book' assessment using a range of question types. Outcome 2 will also be under closed-book conditions, although candidates will have access to correlation charts and exemplar spectra. It is envisaged that Outcome 2 could either be assessed in a single assessment event, or that it could be broken down into two separate assessment events such that the structural determination item is assessed in a separate event.

Outcome 3 will be assessed by the performance of practical activities, which shall be recorded with the aid of a lecturer checklist, and the completion of subsequent laboratory reports.

## Higher National Unit specification: statement of standards

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

**Unit code:** FV6W 35

The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

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. Candidates 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 key features of spectrometer design.

### Knowledge and/or Skills

- Design principles of given spectrometer.
- Functions of the components of given spectrometer.

### Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- produce a labelled block diagram, or equivalent, for a given spectrometer type
- describe the function of each of the key components

The assessment should be under closed-book conditions, and the candidates should not be aware in advance of which spectrometer type they shall be assessed on.

### Assessment Guidelines

This item could be combined into a holistic assessment with Outcome 2, or could be assessed separately. There are numerous spectrometer types which candidates could be assessed on, the component parts of which will vary accordingly.

Candidates should be able to explain in adequate detail the functions of the key components.

## Higher National Unit specification: statement of standards (cont)

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

## Outcome 2

Interpret and explain spectral data.

### Knowledge and/or Skills

- Molecular transitions involved in different types of spectroscopy.
- Extracting information from and predicting infrared (IR) spectra.
- Extracting information from and predicting nuclear magnetic resonance (NMR) spectra.
- Combined structural determinations using IR, NMR and Mass Spectrometry data.

### Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- explain the nature of the interaction of light with chemical species and how this relates to spectroscopic tools
- predict and explain key aspects of IR spectra
- predict and explain key aspects of NMR spectra
- solve combined structural problems to identify unknown substances from a combination of IR, NMR and Mass Spectral data

The assessment will be under closed-book conditions, although candidates will have access to correlation charts for NMR and IR, and also to exemplar IR spectra.

The nature of the assessment item(s) should be such that candidates are required to provide evidence of actual understanding of IR and NMR spectral patterns, rather than solely linking to data in correlation charts. Examples of how this might be achieved are given in the Assessment Guidelines.

### Assessment Guidelines

In assessing the understanding of IR and NMR, the candidates could be asked to explain the breadth or strength of IR bands, or the effect of conjugation, and to explain shielding/deshielding effects and splitting patterns in NMR. The assessment would cover sufficient breadth of content to ensure that candidates correctly understand all necessary key aspects in the interpretation of IR and NMR spectra at this level.

It is envisaged that the item on combined structural determinations would usually be assessed in a separate event to the other evidence requirements.

## Higher National Unit specification: statement of standards (cont)

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

## Outcome 3

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

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- set up and operate a range of analytical instruments to produce accurate data
- correctly analyse and interpret the data and draw conclusions
- identify and evaluate experimental errors
- record the results in an appropriate format, to be full lab reports on a minimum of three occasions

Candidates should perform a minimum of four analytical techniques, which should involve a minimum of three different types of spectrometry. The $4^{th}$ technique may be a $4^{th}$ form of spectrometry, or may involve a non-spectroscopic analytical instrument.

A checklist will be used to record the candidate's performance in the laboratory.

Candidates should produce full laboratory reports on 3 occasions, with a pro forma being permissible on the $4^{th}$ occasion.

### Assessment Guidelines

It is recommended that the candidates should perform at least eight practical assignments, four of which should be used for assessment purposes, as described above. It would be expected that the assessed practicals would each involve 2–3 hours of laboratory time, and will include the requirement to accurately prepare standard and test solutions. The analytical instruments involved may vary according to the facilities available at different centres, though it would be expected that IR and UV/V is are covered. One non-spectroscopic technique may be used for assessment purposes, with an instrumental chromatography method being suitable.

Laboratory reports should also be produced to assess the candidate's ability to record, analyse and discuss analytical work, to draw conclusions and to evaluate sources of error. It is envisaged that for IR spectroscopy a completed pro forma would be more appropriate than a full lab report

## Higher National Unit specification: support notes

## Unit title: Spectroscopic and Analytical Techniques: Theory and Practice

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

This Unit is intended to be part of the HNC/HND Applied Science and HND Applied Chemistry frameworks. The aim is to give candidates the underpinning 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 candidates 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 and 2

Candidates should be introduced to a range of spectroscopic techniques. The design of key spectrometer types will be covered in sufficient detail to facilitate the candidate'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 and Polarimetry. Students 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.

Candidates 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 candidates 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 candidates 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 specification: support notes (cont)

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

### Outcome 3

Candidates 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 activities should involve the candidates being required to accurately prepare samples and standards for analyses, rather than being simply given pre-prepared solutions.

## Guidance on the delivery and assessment of this Unit

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

It is envisaged that the Unit would be delivered subsequent to units covering underpinning chemistry theory, and that in particular candidates will have a sound grasp of organic nomenclature and structures. It is expected that the theoretical content of this unit would be delivered first, before candidates move onto practical assessments.

In Outcome 3 candidates will complete four assessed practicals from the range carried out during the unit. A combination of observation checklist and a written laboratory report should be used to assess the work.

Laboratory reports should be clear and concise, with all results and calculations reported. Candidates should discuss the results in terms of their accuracy and reliability, taking into account inherent experimental errors.

Should a candidate fail to carry out four experiments to the required standard, further attempts can be offered.

## Open learning

Although this Unit could be delivered by distance learning, it would require a considerable degree of planning by the centre to ensure the sufficiency and authenticity of candidate evidence. Arrangements would have to be made to ensure that:

- the closed book test for Outcomes 1 and 2 is delivered in a supervised environment
- the practical activities in Outcome 3 are supervised by a responsible person and clearly recorded (using an assessment checklist, or on video) for the assessor
- the assessor is, at some point, able to question the candidate on that performance (face-to-face, by telephone, online)

For information on open learning arrangements, please refer to the SQA guide *Assessment and Quality Assurance of Open and Distance Learning* (**www.sqa.org.uk**)

## Higher National Unit specification: support notes (cont)

**Unit title:** Spectroscopic and Analytical Techniques: Theory and Practice

## Opportunities for the use of 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 e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

## Opportunities for developing Core Skills

There will be extensive opportunities to develop core skills throughout this unit, examples of which are as follows:

*Numeracy* (using graphical information SCQF level 6) — Candidates 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. Also, candidates will be required to select appropriate forms of complex tables, charts or diagrams to communicate complex information in these forms for the purposes of laboratory reports.

*Problem Solving* (reviewing and evaluating SCQF level 6) — Following assessed practicals candidates 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* (proving/creating information SCQF level 4) — Candidates will make effective and appropriate use of ICT packages to produce laboratory reports in an appropriate format. Packages used will likely include word processing, spreadsheets, and specialist chemical structure software. It is also to be expected that certain of the analytical instruments used will be operated via computer, and that databases may be deployed.

## 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**

## History of changes to Unit

| Version | Description of change | Date |
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## General information for candidates

## Unit title: Spectroscopic and Analytical Techniques: Theory and Practice

This Unit covers a combination of the theoretical principles of various spectroscopic techniques in chemistry, and practical activities 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.

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 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.

The theoretical aspects of this unit will be assessed by 'closed-book' assessments. The practical aspects will be assessed by practical activities which will be monitored by your lecturer and which will involve 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. You will be required to prepare laboratory reports on the assessed practicals.

There will be various opportunities to develop core skills throughout this Unit. For example:

*Numeracy* (using graphical information SCQF level 6) — you 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. Also, you will be required to select appropriate forms of complex tables, charts, diagrams, or qualitative form, to communicate complex information in these forms for the purposes of laboratory reports.

*Problem Solving* (reviewing and evaluating SCQF level 6) — Following assessed practicals you will be required to review and evaluate the effectiveness of the exercise with a thorough interpretation of random and systematic sources of error. You will be required to reach sound conclusions on the basis of the data collected and the inherent errors.

*Information and Communication Technology* (proving/creating information SCQF level 4) — You will make effective and appropriate use of ICT packages to produce laboratory reports in an appropriate format. Packages used will likely include word processing, speadsheets, and specialist chemical structure software. It is also to be expected that certain of the analytical instruments used will be operated via computer, and that databases may be deployed.