SQA Advanced Unit specification

General information for centres

Unit title: Instrumental Techniques 1 (SCQF level 8)

Unit code: HV10 48

Superclass: RA

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Version: 01

Unit purpose

This Unit is designed to enable learners to develop knowledge and understanding of a range of instruments used in analytical laboratories. Learners will also develop the practical skills required to use these instruments. This 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 instrumental techniques or to seek employment in science based industries.

Outcomes

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

1 Select the appropriate analytical method for a particular analysis.
2 Describe and explain the function and method of operation of a range of analytical instruments.
3 Perform practical experiments using a range of analytical instruments.

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 Units HV00 47 *Fundamental Chemistry: Theory and Laboratory Skills* and HV0J 47 *Laboratory Skills for Science Industries* or equivalent, or have experience of chemistry at SCQF level 7. Prior experience of working in a science laboratory would be advantageous.

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skill:

Complete Core Skill	Problem Solving at SCQF level 6
Core Skill component	None

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

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

Select the appropriate analytical method for a particular analysis.

Knowledge and/or Skills

- Purpose of the analysis
- Range of analytical methods available for the analysis
- Analytical method to be used
- Choice made

Outcome 2

Describe and explain the function and method of operation of a range of analytical instruments.

Knowledge and/or Skills

- Qualitative and quantitative analysis
- Types of analysis performed on a range of analytical instruments
- Instrument design and function of its main components
- Range of options available for the key components of instrument
- Methods of optimising the performance of the instrument

Outcome 3

Perform practical experiments using a range of analytical instruments.

Knowledge and/or Skills

- Preparation of the instrument for the required analysis
- Calibration of the instrument
- 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 Outcome 1 should be assessed using an open-book assessment under supervised conditions. It is recommended that the assessment be completed within one hour. Learners can only have access to any notes or books that they have previously gathered in preparation for the assessment.

Written and/or oral recorded evidence for Outcome 2 should be assessed using a 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 45 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:

- Identify correctly the purpose of the analysis.
- Identify a range of suitable analytical methods available for the analysis.
- Select the most appropriate analytical method to be used.
- Explain the reasons to support the choice made.

There are at least two groups of instrumental techniques (spectrophotometric and chromatographic) which learners could be assessed on.

One analytical problem will be presented. For this problem, the learner will identify the purpose of the analysis, consider the range of analytical methods available before deciding on the most appropriate method to use. The analytical problem presented should be such that more than one technique is feasible in order to allow the learner to evaluate which is the most appropriate and to justify their choice.

Outcome 2

The assessment will sample four of the five 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:

- Describe and explain how the analytical instrument performs quantitative and/or qualitative analysis.
- Describe at least one viable application of analysis that can be performed on the analytical instrument.
- Describe the analytical instrument in terms of the design and function of its main components.
- Identify two options available for the key components of the analytical instrument.
- Explain at least one method to optimise the performance of the analytical instrument.

A selected instrumental technique will be presented. There are at least two groups of instrumental techniques (spectrophotometric and chromatographic) which learners could be assessed on.

Outcome 3

Learners will perform a minimum of four practical experiments, the content of which will be related to four different analytical instruments that will include the requirement to accurately prepare standard and test solutions. At least one practical experiment on Spectroscopic instrumentation and one practical experiment on Chromatographic techniques should be covered. However, the analytical instruments involved may vary according to the facilities available. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Prepare the instrument for the required analysis.
- Calibrate the instrument.
- 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 two of the four practical experiments by production of a full laboratory report. Learners may report the remaining practical experiments 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 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: Instrumental Techniques 1 (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 Certificate/Diploma in Applied Sciences, the SQA Advanced Diploma in Chemical Sciences and the SQA Advanced Diploma in Biological 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 a range of instrumental techniques to allow learners to operate efficiently as a technician. The nature of this Unit allows integration with other science based Units, with practical experiments being drawn from theoretical Units.

Outcomes 1 and 2

Learners should be introduced to a range of instrumental techniques, and the chosen instruments should be appropriate to the science covered. It is expected that the design of spectrometers and chromatography instruments form the main part of this Unit. For example, it would be expected that Chemistry learners would cover more on spectroscopy, while Biotechnology learners would focus more on separation techniques.

Outcomes 1 and 2 should feature general information about each analytical technique, instrument and methods of operation. Labelled block diagrams of the instrument could be used to highlight the different options available within one specific type of analytical instrument, and technical videos are a good alternative should the instrument not be available in the centre. Case studies with different types of samples can be used to help the learner gain experience in identifying the most appropriate analytical technique for a given scenario as well as becoming aware of the importance of using various types of analysis to perform within that technique.

Typical instruments that could be discussed are Atomic Absorption, Atomic Emission, UV/Vis, Infra-Red, Inductively Coupled Plasma (ICP), NMR, GLC, HPLC, Electrophoresis and PCR. Learners should become familiar with the types of analysis performed on the various instruments such as quantitative or qualitative.

Methods of analysis such as calibration and internal standard methods could be covered as well as operating methods such as isothermal or temperature programming for suitable Chromatographic techniques.

The overall design and the mode of operation of the main components of a specific instrument should also be covered. For each of the instruments studied, it is recommended to cover the:

- Basic principle of the instrument.
- General block diagram of the instrument with the main components.
- Main function of the key components of the instrument.
- Range of options available for key components.
- Methods to optimise the quality of the data obtained by a specific instrument.

Learners will be also expected to know and explain some of the concepts associated with a specific analytical technique. Resolution, % composition calculations, retention time, peak area, response factor and internal standards can be part of the delivery of Chromatographic techniques. In turn, linearity, detection range, internal standard and interferences can be part of the delivery of Spectroscopic Techniques.

Outcome 3

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 to gain experience in operating a wide range of instruments. Wherever possible, learners should set the instruments from the beginning, switching them on, calibrating them, programming in the method and obtaining the required results.

Learners should be given the opportunity to learn how to record, analyse, interpret and evaluate data from a specific type of analytical instrument. It is envisaged that the learner is encouraged to identify possible sources of error within each instrumental technique by discussing the advantages and disadvantages of one specific instrument over another one.

The range of practical experiments should reflect the science being undertaken. It is not appropriate to introduce practical work which does not use some kind of instrumental technique.

Guidance on approaches to delivery of this Unit

It is recommended that all Outcomes are delivered simultaneously. It is envisaged that the delivery of the Unit starts with an overview of the basic chemistry and mathematics behind a range of instrumental techniques. The learner would benefit from being able to manipulate common units of concentration in analytical chemistry such as parts per million, grams per litre, microliters etc. The calculation of gradients, intercepts, and the understanding of statistical methods of analysis will also be an advantage. Packages used by the learners will likely include word processing, spreadsheets and specialist chemical structure software.

Outcome 1 is intended to prepare learners to be able to select the appropriate analytical method for a particular analysis. Real and hypothetical laboratory examples of analysis can be given to learners for them to discuss and evaluate the technique and method of analysis required for that specific case. Learners should be given the opportunity to plan experiments, and learners should also be encouraged to compare different analytical techniques, evaluating the advantages and disadvantages of each of the techniques when appropriate. A variety of online resources could be used by learners to obtain any information required.

Outcome 2 is intended to allow learners to become familiar with a range of analytical instruments. Learners should be given the opportunity to access SOPs and block diagrams of the instrument and be shown the main components and operation of the instrument on a real scenario when possible. Field trips, videos and simulations are recommended as possible resources when the instrument is not available within the centre. Learners are not expected to memorise commercial specifications within an instrument, and it is envisaged that some of these specifications are understood only for general purposes. Approaches of analysis such as calibration, internal standard, isothermal and temperature program methods should be covered. Beer Lambert's law, detection limits and interferences will be of particular importance when referring to spectrometric data. Resolution, retention time, peak area, % composition, purity, response factor and polarity should all be covered as well for Chromatographic techniques.

It is envisaged that Outcome 3 will be delivered alongside the theoretical based Outcomes above. 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. Learners could complete a laboratory log book throughout the practical experiment. Aspects suitable for experimental investigation might include the identification and quantification of atoms, ions or groups of ions by UV/VIS spectroscopy, AAS or FES in commercial products. ICP analysis provides fast identification and detection of trace metals content in chemical and petroleum samples, knowledge on this popular technique in commercial laboratories will be of significance advantage to the learners. Identification of representative functional groups in common organic molecules could be also carried out by Infra-Red Spectroscopy. Learners should become familiar with the use of correlation charts to identify the most characteristic IR bands. Separating mixtures of hydrocarbons and vitamins by GLC and HPLC respectively, accompanied by the quantification of a specific compound in commercial products would be also suitable for this Outcome.

Learners should gain important experience with the analytical instruments and it is expected that the practical experiments would each involve 2–3 hours of laboratory time. At least one practical experiment on spectroscopic instrumentation and one practical experiment on Chromatographic techniques should be covered. However, the analytical instruments involved may vary according to the facilities available at different centres.

This Unit lends itself to integration with other science based Units. For example, it could be integrated with the Unit HV00 47 *Fundamental Chemistry: Theory and Laboratory Skills.*

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 for learners.

Outcome 1 could be assessed by an open-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 60 minutes. Learners can only have access to any notes or books that they have previously gathered in preparation for the assessment.

Examples of some suitable analytical problems could be: to choose a suitable instrumental analytical method to investigate the presence and levels of key metals in sludges collected from contaminated water courses; or to choose a suitable instrumental analytical method to investigate the composition of the different petroleum ether fractions.

Outcome 2 could be assessed by a 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 lasts for 45 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 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 no sampled in the first assessment, must be included in the alternative (re-sit) assessment.

In Outcome 3 learners are required to undertake four assessed practical experiments, the content of which will be related to four different analytical instruments. 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:

- Determination of Phosphates in detergents by Visible Absorption Spectroscopy
- Determination of Aspirin, Caffeine and Paracetamol in Analgesics by High Performance Liquid Chromatography (HPLC)
- Infra-Red Spectroscopy of unknown organic compounds
- Determination of Vitamin C by UV Absorption Spectroscopy
- Electrophoresis of fish proteins
- Determination of the Ca content in water samples by Flame Emission Spectroscopy (FES)
- Analysis of hydrocarbons by Gas Liquid Chromatography (GLC)

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

This Unit has the Core Skill of *Problem Solving* embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved *Problem Solving* at SCQF level 6.

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

Numeracy — Using Number at SCQF level 6

Learners will be required to extract, analyse and interpret graphical, spectral and numerical information from a range of sources, and collate the information to identify and/or quantify an unknown compound/ion/atom. Learners will also be required to select appropriate types of tables, charts and diagrams to communicate complex information when writing laboratory reports.

Problem Solving — Reviewing and Evaluating at SCQF level 6

Following assessed practical experiments for Outcome 3, learners will be required to review and evaluate the effectiveness of their 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. Assessment of Outcome 1 will require learners to select, review and evaluate information and used it appropriately to solve a specific analytical problem.

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

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 where possible, learners should be encouraged to prepare small volumes of standard solutions and use solvent bottles to recycle them. Plastic pipettes and cuvettes can also be re-used during practical experiments.

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: Instrumental Techniques 1 (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 SQCF level 8, which you are likely to be studying as part of the second year of an SQA Advanced 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 chemistry and developed your practical skills. This Unit will enable you to understand the basic knowledge and practical skills you will need to undertake a role as a higher-grade technician in a wide range of science based industries. The emphasis will be on introducing you to the range of modern instruments used in laboratories.

On completion of this Unit you should be able to:

1 Select the appropriate analytical method for a particular analysis.
2 Describe and explain the function and method of operation of a range of analytical instruments.
3 Perform practical experiments using a range of analytical instruments.

Outcomes 1 and 2

In Outcome 1 and 2 you will be introduced to a range of analytical instruments. The actual instruments that you will be introduced to will depend on the subject-specific nature of your study, but will include a selection from Atomic Absorption, Atomic Emission, UV/Vis, Infra-Red, and NMR spectrometers as well as GLC, HPLC, Electrophoresis, PCR and Inductively Coupled Plasma (ICP) systems.

You will be expected to become familiar with the range of analytical techniques which can be carried out on each instrument and to use this knowledge to decide on the most appropriate method to solve a range of analytical problems. You will also be expected to know about the design of the instruments and the functions of the main components.

Outcome 3

In this Outcome you will undertake practical experiments, based on Spectroscopy and Chromatography techniques.

You will be shown how to set up and operate a range of analytical instruments. The emphasis will be on your ability to operate the instruments independently with a need to obtain satisfactory results from the experiment. During this work you will be expected to obtain accurate results, follow instructions and work in line with health and safety regulations.

Assessment

For Outcome 1 you will take an open-book assessment.

For Outcome 2 you will take a closed-book assessment.

Outcome 3 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

You will have opportunities to develop the Core Skills of *Numeracy* and *Information and Communication Technology (ICT)* at SCQF level 4.

This Unit has the Core Skill of *Problem Solving* embedded in it. This means that when you achieve the Unit, your Core Skills profile will also be updated to show you have achieved *Problem Solving* at SCQF level 6.