SQA Advanced Unit specification

General information

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

Unit code: HV00 47

Superclass: RD

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

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

Outcomes

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

1 Describe and explain atomic theory, chemical bonding and chemical formulae.
2 Apply reaction stoichiometry to chemical systems.
3 Describe and apply principles relating to organic chemistry and natural substances.
4 Explain and apply principles of chemical equilibrium and acid-base chemistry.
5 Perform practical experiments related to fundamental chemistry.

Credit points and level

2 SQA Credits at SCQF level 7: (16 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the SQA Advanced Unit HV0G 46 *Fundamental Chemistry: An Introduction* or equivalent, or have experience of Chemistry at Higher level.

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill None

Core Skill component Using Number at SCQF level 6

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

Describe and explain atomic theory, chemical bonding and chemical formulae.

Knowledge and/or Skills

- Atomic structure of elements: nuclide notation, full electron configurations
- Covalent, ionic and metallic bonding
- Properties of substances in relation to bonding, including intermolecular bonding, polar and non-polar molecules
- Chemical formulae

Outcome 2

Apply reaction stoichiometry to chemical systems.

Knowledge and/or Skills

- Balanced chemical equations
- Calculations involving chemical equations
- Calculations involving percentage yields

Outcome 3

Describe and apply principles relating to organic chemistry and natural substances.

Knowledge and/or Skills

- Functional groups
- IUPAC nomenclature
- Reactions and products
- Biomolecules: carbohydrates, lipids, proteins

Outcome 4

Explain and apply principles of chemical equilibrium and acid-base chemistry.

Knowledge and/or Skills

- Le Chatelier's principle
- Calculations involving equilibrium constants
- Strong and weak acids and bases, and their reactions
- pH and related calculations of weak acids and bases, salts and buffers

Outcome 5

Perform practical experiments related to fundamental chemistry.

Knowledge and/or Skills

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

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1–4 could be assessed using a holistic closed-book assessment under supervised conditions. Outcomes may also be assessed individually. It is recommended that the assessment — whether holistically or individually — be completed within two hours. 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 5 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 atomic structure in terms of protons, neutrons and electrons; define electron structure using full electron configuration.
- Describe covalent bonding including polar covalent bonding, ionic bonding and metallic bonding.
- Explain properties of substances in relation to their bonding, including intermolecular bonding and polar/non-polar molecules.
- Determine the chemical formula for a range of 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:

- Write balanced chemical equations for a range of reaction types.
- Calculate reacting quantities or amount of product expected for a range of reaction types.
- Calculate the percentage yield of product obtained for given reactions.

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:

- Identify the main organic functional groups.
- Apply IUPAC nomenclature to organic compounds.
- Describe reactions and products of the main organic functional groups.
- Describe the main classes of biomolecules to include: carbohydrates, lipids, proteins.

Outcome 4

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 Le Chatelier's principle and apply the principle to a range of chemical systems.
- Perform calculations involving equilibrium constants.
- Explain the properties of strong and weak acids and bases and their typical reactions.
- Perform calculations involving pH and related constants for weak acids/bases, salts and buffers.

Outcome 5

Learners will perform a minimum of five practical experiments, the content of which will be related to Outcomes 1–4 with at least one practical experiment covering Outcomes 2, 3 and 4. 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 fundamental chemistry.
- Work in a safe manner regarding current health and safety regulations.
- Achieve consistent and accurate results.
- Record experimental observations and results clearly and accurately.
- Evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

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

Learners may report results either by production of a full laboratory report, or by completion of an appropriate pro forma. Where a pro forma is used, 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 re-attempt 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: Fundamental Chemistry: Theory and Laboratory Skills (SCQF Level 7)

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 80 hours.

Guidance on the content and context for this Unit

This Unit may form part of a group award or be completed as a free-standing Unit. It is designed to develop the theoretical and practical aspects of fundamental chemistry introduced in the SQA Advanced Unit HV0G 46 *Fundamental Chemistry: An Introduction*.

Outcome 1 — Describe and explain atomic theory, chemical bonding and chemical formulae

The atomic structure of elements and the relationship between atomic number and mass number in the periodic table. The concept of nuclide notation and electron orbitals to include s, p, d and f orbitals.

Bonding within elements should be explained; this will include covalent and metallic bonding. Bonding within compounds should then be covered, to include polar and non-polar molecules and their shape. The effect of bond type, ionic or covalent on properties of substances should be covered. Hydrogen bonding and the way in which this affects a compound's physical properties should be explained.

The rules for determination of chemical formulae across a range of compounds, which will include complex ions, should be covered.

Outcome 2 — Apply reaction stoichiometry to chemical systems

By learning to balance chemical equations, learners should be introduced to the mole and the concept of ratios within chemical equations. The balancing of equations should cover a range of reaction types, eg acid/base, redox, and precipitation. Learners should be able to assign physical state to the equations being balanced.

Calculations of reacting quantities or expected product amount over a range of reaction types should be performed. Percentage yield should be calculated from either experimental data collected by the learner or data that is provided to the learner.

Outcome 3 — Describe and apply principles relating to organic chemistry and natural substances

Learners should be introduced to the main organic functional groups; these should include at least:

- Alkanes
- Alkenes
- Alkanals

- Alkanones
- Alkanols
- Haloalkanes
- Carboxylic acids
- Amines
- Esters

and could include:

- Thiols
- Alkynes
- Acid chlorides
- Ethers

Learners should be introduced to IUPAC nomenclature for the organic compounds they are working with.

Learners should be able to predict products of reactions of the organic compounds they are familiar with, and in doing so will cover the main organic reaction types of:

- Nucleophilic substitution
- Oxidation
- Reduction
- Elimination
- Hydrolysis
- Esterification
- Electrophilic Addition
- Free radical Substitution

The main classes of biomolecules should be introduced.

Outcome 4 — Explain and apply principles of chemical equilibrium and acid-base chemistry

Learners should be introduced to the concept of acidity and alkalinity, to strong and weak acids and bases. This will lead into the concept of equilibrium and Le Chatelier's principle. Calculations of equilibrium constant, pH and dissociation constant for a variety of solutions, including salts and buffers. Where possible examples could be used that contextualise the topic.

Outcome 5 — Perform practical experiments related to fundamental chemistry

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1–4.

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

There is no particular order in which Outcomes 1–4 would be best delivered. 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 5 will be undertaken in a similar timeframe to the underpinning theory.

The natural progression for Unit delivery is:

- Atomic structure
- Bonding
- Chemical formulae
- Balancing equations
- Calculations on chemical reactions
- Organic chemistry
- Equilibrium and acid/base chemistry

It is envisaged that delivery of Outcome 1 could commence with atomic structure. Delivery should cover protons, neutrons and electrons. The structure of the atom, the configuration of electrons in shells around atoms, and the full electron structure should be covered.

The topic of bonding should cover bonding in elements and compounds. The different bonding types should be covered to include ionic, metallic and covalent bonding. Non-polar and polar covalent bonding should also be covered and this will lead on to hydrogen bonding between molecules. Learners' knowledge of bonding could then be developed in order that they can use this knowledge to explain the physical properties of elements and compounds.

Writing chemical formulae and balancing equations are fundamental to understanding chemical reactions. Learners could develop these skills using simple compounds before progressing to writing chemical formulae for compounds that contain complex ions. Learners' knowledge could then be developed in order for them to be able to write and balance chemical equations. Once learners can balance chemical equations, delivery could focus on how to use these equations to carry out calculations related to the balanced equations. Learners should also be able to calculate theoretical and actual yield, based on balanced equations and experimental results.

Outcome 3 is almost standalone and could commence with the introduction of IUPAC nomenclature for organic functional groups. The reactions and products of the organic compounds could then be covered. Using structural formulae will assist learning when working with reactions, as the formulae will help learners to visualise the reaction sites. Models can also be used to help learners gain an understanding of the shape and structure of molecules. Leaners should be introduced to biomolecules; this should include carbohydrates, proteins and lipids, although other relevant biomolecules may also be covered.

Outcome 4 involves the study of acids/bases and chemical equilibria, and learners should be introduced to pH, strong acids and weak acids. Chemical equilibrium and the associated principles could then be covered before progressing to dissociation constants and pH calculations for salts and buffer solutions. The topic of buffers should be contextualised for learners and systems discussed could include blood buffering, or the need for buffered solutions in aquatic systems.

It is envisaged that Outcome 5 will be delivered alongside the more theory-based Outcomes 1–4. 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 organic synthesis, volumetric analysis, and a variety of chemical techniques.

Where possible, it may be appropriate during delivery of this Unit to visit an industrial laboratory to demonstrate to learners the use of GLP, risk assessment and COSHH assessments in a work based setting.

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 1–4 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score. Outcomes may also be assessed individually. Assessment should be carried out in supervised conditions, and it is recommended that the assessment — whether holistically or individually — be completed within 120 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement when sitting the assessment.

In Outcome 5, learners are required to undertake five assessed practical experiments, the content of which will be related to Outcomes 1–4, with at least one practical experiment covering Outcomes 2, 3 and 4. 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:

- Volumetric analysis — involving acid/base, redox, precipitation and titrations
- Serial dilution calculations and techniques
- Gravimetric analysis, which could include organic precipitants
- Synthesis of inorganic or organic compounds, which could include the use of reflux, distillation, extraction, recrystalisation, mpt and bpt determination

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

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

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

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of

the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

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

The delivery and assessment of this Unit will also 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.

Numeracy — Using Number at SCQF level 6

Learners will be required to decide on the steps and operations to solve complex problems, and carry out sustained and complex calculations, eg performing calculations related to percentage yields of reactions, and calculations of pH.

Problem Solving — Reviewing and Evaluating at SCQF level 6

Following assessed practical experiments, learners will be required to review and evaluate the effectiveness of the exercise, with a thorough interpretation of random and systematic sources of error. Learners will be required to reach sound conclusions on the basis of the data collected and the inherent errors.

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.

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

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: Fundamental Chemistry: Theory and Laboratory Skills (SCQF level 7)

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

This is a 2 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an SQA Advanced Certificate/Diploma Science programme. Before progressing to this Unit it would be beneficial to have completed the SQA Advanced Unit HV0G 46 *Fundamental Chemistry: An Introduction*, where you will have learned underpinning aspects of fundamental chemistry and developed your practical skills. There will be a strong emphasis on the importance of experimental data in understanding chemical principles, and on the applications of chemical knowledge in practical situations.

On completion of the Unit you should be able to:

1 Describe and explain atomic theory, chemical bonding and chemical formulae.
2 Apply reaction stoichiometry to chemical systems.
3 Describe and apply principles relating to organic chemistry and natural substances.
4 Explain and apply principles of chemical equilibrium and acid-base chemistry.
5 Perform practical experiments related to fundamental chemistry.

Outcomes 1 and 2

In Outcomes 1 and 2 you will study a range of chemistry theory. This will cover atomic theory, chemical bonding and writing chemical formulae. You will study a range of chemical reactions to ensure a broad knowledge of reaction types. These reaction types are likely to include acid/bases, redox and precipitation.

You will learn to balance chemical equations in order to understand how reactions occur, and then using these equations you will be able to calculate how much product you could make or how much material you need to start with. You will then work out how much of the potential product of a reaction you have obtained by calculating percentage yield.

Outcome 3

In Outcome 3 you will learn about organic chemistry, which is the study of chemistry related to carbon-based compounds. You will learn about different types of organic compound, how to name them using the IUPAC system, and how they react to produce other compounds.

You will also learn about important classes of biomolecules — proteins, lipids and carbohydrates.

Outcome 4

Outcome 4 covers the concept of reversible reactions, and you will learn about Le Chatelier's principle and equilibrium constants. This knowledge can then be applied to acid/bases systems, allowing calculations of pH, etc.

Outcome 5

In this Outcome you will undertake five assessed practical experiments, based on the content of Outcomes 1–4. However, as well as the assessed practical experiments, it is likely that you will carry out further practical work to support the learning of chemistry in those Outcomes.

During this work, you will also be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will also be encouraged to develop safe working practices and to strive constantly to improve the accuracy and reliability of your results. The reporting and analysis of experimental data is an important aspect of the practical sessions.

Assessment

For Outcomes 1 to 4, depending on which centre you attend, assessment may be conducted on an Outcome by Outcome basis, or by one single assessment. Assessment will be conducted under closed-book conditions.

Outcome 5 will be assessed after you have learned the necessary practical skills, and will take the form of five practical experiments, for which you will report your results either in full laboratory reports, or by completion of pro forma reports.

Core Skills

This Unit has the Core Skill component of *Using Number* at SCQF level 6 embedded in it. You will also have opportunities to develop the Core Skills of *Problem Solving* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 4.