SQA Advanced Unit specification

General information for centres

Unit title: Main Group Inorganic Chemistry (SCQF level 8)

Unit code: HV12 48

Superclass: RD

Publication date: November 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of inorganic chemistry, and of the different theories of chemical bonding at a more advanced level. Learners will also develop practical skills in techniques relevant to reactions of Main group elements. 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 inorganic chemistry at degree level or to seek employment in science based industries.

Outcomes

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

1 Describe and explain the properties of a range of compounds in terms of relevant bonding theories.
2 Explain the trends in chemical behaviour for different elements within the periodic table.
3 Perform practical experiments related to reactions of Main group elements.

Credit points and level

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

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the Unit HV0K 47 *Inorganic Chemistry: Theory and Laboratory Skills* or equivalent.

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

SQA Advanced Unit specification: Statement of standards

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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 the properties of a range of compounds in terms of relevant bonding theories.

Knowledge and/or Skills

- Molecular Orbital Theory of diatomic molecules
- Bond length, bond strength, magnetic properties
- Structures of ionic compounds
- Lattice enthalpy related to properties of ionic substances
- Crystallography and the unit cell

Outcome 2

Explain the trends in chemical behaviour for different elements within the periodic table.

Knowledge and/or Skills

- Chemical and physical properties across a period
- Detailed chemistry of selected groups in the table
- Unique properties associated with specific elements in a group

Outcome 3

Perform practical experiments related to reactions of Main group elements.

Knowledge and/or Skills

- Reactions of Main group elements experiments
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 2 should be assessed using a holistic closed-book assessment under supervised conditions. It is recommended that the assessment be completed within 120 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 the practical experiment.

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:

- Use Molecular Orbital Theory to explain the properties of diatomic molecules within Period 1 and 2.
- Predict bond length, bond strength and magnetic properties of diatomic molecules within Period 1 and 2.
- Describe structures of ionic compounds, and relate the properties of ionic compounds to their ionic structure.
- Perform calculations related to lattice enthalpy of ionic substances.
- Describe and apply fundamental principles of crystallography.

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 variations of chemical and physical properties across a period.
- Explain the detailed chemistry of elements within a group.
- Explain the reasons why specific elements within a group show unique properties.

Outcome 3

Learners will perform a minimum of two practical experiments, the content of which will be related to Outcomes 1–2. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Follow instructions to perform an experiment related to reactions of Main group elements.
- Work in a safe manner regarding current health and safety regulations.
- Achieve consistent and accurate results.
- Record experimental observations and results clearly and accurately.
- Evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

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

Learners must report one of the two practical experiments by production of a full laboratory report. Learners may report the remaining practical experiment by production of a full laboratory report or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data. A minimum of one of the assessed practical experiments should require a graphical analysis of experimental data on the part of the learners.

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 alternate practical experiment will be set.

SQA Advanced Unit Support Notes

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Unit Support Notes are offered as guidance and are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit is part of the framework for the SQA Advanced Diploma in Applied Chemical Sciences but may be suitable for inclusion in other SQA Advanced science and engineering awards. It is designed to develop the theoretical and practical aspects of inorganic chemistry of the representative groups of the periodic table. The aim is to give learners the opportunity to build knowledge on Molecular Orbital Theory, the principles of solid ionic structures and crystals lattices, and the variation of chemical properties within a period/group in the periodic table.

Outcome 1 — Describe and explain the properties of a range of compounds in terms of relevant bonding theories

This Outcome should cover the various bonding models, valence bond theory, etc before focussing on Molecular Orbital Theory. Period 1 and 2 diatomic molecules should be covered, but this should include both homo and heteronuclear systems. Molecular orbital energy level diagrams should be covered and learners shown how they can be used to explain various properties of the compounds. The effect on bond length, bond strength and magnetic behaviour when an electron is removed or added should also be discussed.

Solid state structures should be introduced starting with metallic structures, explaining cubic and hexagonal close packing and body centred cubic. The presence of octahedral and tetrahedral gap sites should be described. This work should be extended to ionic lattices, with a discussion of radius ratio and its relationship to coordination number. Specific lattices should be described, starting with the 1:1 systems caesium chloride, rocksalt, nickel arsenide, zincblende and wurtzite. 2:1 lattices could also be covered such as rutile cadmium iodide and fluorite.

The energy involved in forming ionic lattices should be covered. A revision of Born-Haber cycles should be followed by looking in more detail at lattice enthalpy. The Born-Lande equation should be covered as well as a discussion of the key terms in the expression and how they might influence the properties of the substance. Learners are expected to use Born-Lande equation to calculate lattice enthalpy of simple ionic solids.

Crystal lattices should be introduced, starting with the concept of a unit cell, explaining the four basic types of unit cells. The seven crystal systems should be described in relation to Bravais Lattices and Miller planes. The basic principles of symmetry in crystallography should also be covered. The basic principles of X-ray diffraction and the application to the study of the crystal structure should also be covered.

Outcome 2 — Explain the trends in chemical behaviour for different elements within the periodic table

Horizontal and vertical trends in the periodic table should be covered in detail focusing on the fluctuations of the trends and the reasons for these to occur. Learners should be introduced to looking at the specific chemistry of Period 3 compounds, looking at the differences in the chemistry of the oxides, halides and the hydrides. Trends across other periods could also be studied. It should be emphasised that this information gives us an insight to the nature of the elements themselves.

The chemistry of specific groups should be covered. At least two different groups should be looked at, but the choice of which is at the discretion of the centre. The topics covered should include looking at the unique nature of specific elements within the same group, ie the lightest element. Learners need to be able to explain the inert pair effect. Learners should use oxidation state diagrams to explain the chemistry of specific elements.

Outcome 3 — Perform practical experiments related to reactions of Main group elements

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 and 2.

In carrying out such activities, learners should follow Good Laboratory Practice (GLP) and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

This Unit will require a mixture of delivery methods. Formal classes will be needed to cover the main theory aspects, while extended laboratory time will be required for Outcome 3. Tutorial support could be used to enhance the learning. Self-directed study might well be a good way to cover some of the topics in Outcome 2.

The delivery of Outcome 1 first is recommended as it contains some of the basic principles of bonding theory and solid structures that might be required when covering Outcome 2.

It is envisaged that Outcome 1 could commence with a general overview on the basic principles of different bonding theories such as the Lewis theory, VSEPR theory and Molecular Orbital Theory (MOT). Learners will become familiar with the main principles and applications of MOT. Molecular orbital diagrams (MOD), bonding and antibonding, bond order, magnetic properties, length and stability of a covalent bond etc can be delivered by using a mixture of formal teaching and resources such as blank MOD of common diatomic molecules such as oxygen, fluorine, carbon monoxide, etc.

Learners are expected to understand and be able to draw basic solid structures. The delivery of the principles of solid structures such as: close packing arrangement, BCC, FCC, HCP, tetrahedral, octahedral sites can be done by using ‘molymods’ and worksheets where the learner can be encouraged to draw some of these structures. It is envisaged that learners will become familiar with the Born-Lande equation, this can be done by giving the learner the opportunity to use the equation in calculations of the lattice enthalpy for common ionic solids. It is recommended that learners are given the opportunity to evaluate the significance of the

repulsion term in relation to the attractive term, and they should have an understanding of the origin of the constants involved (Born exponent, Madelung constants, etc).

The basic idea behind the application of X-rays to the determination of the structures of crystals can be best approached by a demonstration on how to use data obtained by an X-ray diffraction instrument, where possible. Application of the Bragg equation to find the layer separation in a specific crystal would also be expected. Special software such as Chemdraw 3D and other modelling software might be used to show crystal structures in three dimensions, these resources would help the learner to grasp concepts such as unit cell, symmetry, crystal systems, imperfection within a crystal lattice, etc.

In Outcome 2 learners are expected to become familiar with the chemistry of the s and p block elements. This topic can be delivered using resources such as practical experiments, on-line simulations showing periodic trends in detail, worksheets designed for the learners to complete missing information by carrying out independent research, posters, PowerPoint presentations and other kinds of visual aids.

It is envisaged that the learner should be able to explain the specific in-depth chemistry of selected elements including anomalous behaviour if any, or unique nature. The learner is expected to use the principles of MOT, inert pair effect and lattice energy to explain some of this behaviour. A list of electronic and non-electronic resources might be given to the learner at the start of the Outcome. This Outcome should give the learner the opportunity to work independently and be autonomous with their time management. Guidance on how to interpret chemical information related to this Outcome should be always at hand for the learner.

It is envisaged that Outcome 3 will be delivered alongside the theoretical based Outcomes 1 and 2. A range of practical experiments could be utilised to both support understanding of the underlying theory and to prepare learners for undertaking the assessed practical experiment. Aspects suitable for experimental investigation might include the quantification of specific elements/ions in specific materials by redox titrations. In addition, learners could work out the stoichiometry of a particular reaction, or study the different oxidation states formed by a particular element. Tests used to identify the chemical properties of targeted compounds such as halides, oxides or chlorides can also be carried out.

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 1and 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 120 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement when sitting the assessment.

In Outcome 3 learners are required to undertake two assessed practical activities, the content of which will be related to Outcomes 1–2. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments are:

- Calcium in the presence of barium using Cyclohexane Diamine Tetraacetic Acid
- Analysis of solder for lead and tin
- Reactions of Tin(IV) halides
- Redox Chemistry of Chromium
- Preparation of chlorine using MnO_2 and HCl
- Quantitative estimation of copper(II), calcium(II) and chloride from a mixture
- Ion binding properties of zeolites
- Tetraiodotin(IV) and its Triphenylphosphine complex
- Analysis of X-ray diffraction data if XRD instrument is not available

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

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 8.

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

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Numeracy and 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 measure, analyse and interpret numerical information from volumetric techniques. Calculations involving number of moles, molar ratios, dilution factors, percentages of mass and quantification of errors will be carried out within the practical work.

Problem Solving — Reviewing and Evaluating at SCQF level 6

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

Information and Communication Technology (ICT) — Providing/Creating Information at SCQF level 4

Learners will make effective and appropriate use of ICT packages to produce laboratory reports or pro formas in an appropriate format. Packages used will likely include word processing, spreadsheets, and specialist chemical structure software.

Sustainability

Sustainability can be embedded in delivery of the Unit in a variety of ways. For example, by encouraging minimum usage, correct disposal procedures and possibly recycling 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: Main Group Inorganic Chemistry (SCQF level 8)

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

This is a 1-credit Unit at SCQF level 8, which you are likely to be studying as part of the second year of an SQA Advanced Diploma science programme. Before progressing to this Unit it would be beneficial to have completed the Unit HV0K 47 *Inorganic Chemistry: Theory and Laboratory Skills*, where you will have learned underpinning aspects of inorganic 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 the properties of a range of compounds in terms of relevant bonding theories.
2 Explain the trends in chemical behaviour for different elements within the periodic table.
3 Perform practical experiments related to reactions of Main group elements.

Outcome 1

In this Outcome you will be introduced to Molecular Orbital Theory, which is used to explain bonding in mainly covalent systems. The homomolecular and heteromolecular diatomic molecules of Period 1 and 2 will be covered, which will provide you with the foundation if you proceed to degree level chemistry. In the second part of this Outcome you will be introduced to solid state structures, firstly for metals then some basic ionic lattices. You will also look at lattice enthalpy and how it is a large energy term which can influence the chemistry of ionic salts. The basic principles of crystallography will be also covered in this Outcome.

Outcome 2

In this Outcome some general chemistry of the Main group elements will be covered. Trends in chemical behaviour will be looked at for the oxides, halides and hydrides of Period 3, before some specific groups will be studied. In particular you will learn to use oxidation state diagrams to help predict the chemistry of a particular element, as well as looking at the unique chemistry shown by specific elements within the same group, ie the lightest element.

Outcome 3

In this Outcome you will undertake practical experiments, based on the content of Outcomes 1−2.

During this practical work, you will also be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will 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 and 2 you will take a closed-book, end of Unit assessment.

Outcome 3 will be assessed after you have learned the necessary practical skills, and will take the form of two practical experiments, for which you will report your results either in a full laboratory report, or by completion of a pro forma report.

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.