SQA Advanced Unit Specification

General information for centres

Unit title: Fundamental Concepts of Inorganic Chemistry

Unit code: HV96 47

Unit purpose: The Unit is designed as part of the SQA Advanced Certificate/Diploma awards in Applied Sciences and Chemistry and will give candidates an understanding of the properties of elements and compounds in terms of chemical bonding and structure, and to develop the practical skills required to investigate and exploit those properties.

On completion of the Unit the candidate should be able to:

1 Describe and explain atomic properties and predict and explain the properties of chemical substances.
2 Describe electron transfer processes in redox reactions and electrochemical cells.
3 Perform experiments to investigate the properties of chemical substances and analyse the results.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Entry is at the discretion of the centre, however it is recommended that candidates should have completed the SQA Advanced Unit Fundamental Chemistry: Theory and Practice (HV4H 47) or equivalent, or have recent experience of Chemistry at Higher level.

Core skills: There may be opportunities to gather evidence towards core skills in Numeracy, Communication and Problem Solving at SCQF level 6 in this Unit, although there is no automatic certification of core skills or core skills components.

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. This Unit is included within the SQA Advanced Diploma in Applied Sciences and SQA Advanced Diploma in Chemistry frameworks but may also be offered as part of other SQA Advanced programmes.

Assessment: Outcomes 1 and 2 will be assessed using a, closed-book, end of Unit assessment. Questions will assess all Knowledge and Skills items and should reflect a representative sample from the content suggested in the support notes. Outcome 3 will be assessed by means of a report and a checklist based on practical activities related to the topics in Outcomes 1 and 2.

Unit specification: statement of standards

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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

Describe and explain atomic properties and predict and explain the properties of chemical substances

Knowledge and/or skills

- atomic properties of maingroup elements
- prediction and consequences of bond character and polarity
- intermolecular forces and properties of covalent substances
- bonding and structure in the maingroup elements
- physical properties and chemical characteristics of maingroup elements
- physical properties and chemical characteristics of selected compounds of maingroup elements

Evidence requirements

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

- describe and explain period and group trends in atomic properties in terms of atomic structure
- predict bond character, molecular shape and polarity from electronic structure and electronegativity
- apply intermolecular forces to predict the physical properties of covalent substances
- describe and explain bonding and structure in the maingroup elements of periods 1–3
- use bonding and structure principles to explain and determine the physical and chemical characteristics of groups 1–3
- relate the physical and chemical characteristics of selected compounds of maingroup elements to bonding and structure in those compounds

Evidence for Outcomes 1 and 2 should be gathered using a holistic closed-book assessment under supervised conditions.

The questions set in the assessment should cover all Knowledge and Skills although a representative sample of the topics covered in the support notes should be covered. It is envisaged the assessment will entail a mixture of short answer and structured questions. The allocation of marks per question should be weighted on the basis of the level of response and the amount of effort required. The assessment should test the candidate's ability to link atomic structure and properties, through bonding and structure, with the behaviour of chemical substances.

Assessment guidelines (Outcomes 1 and 2)

The written/oral assessments should be undertaken as a combined end of Unit test. The pass mark for the assessment should be 60%. Should candidates fail to gain 60% they should be offered a second attempt after suitable remediation.

A time limit of 75 minutes is suggested; this is at the discretion of the centre.

Outcome 2

Describe electron transfer processes in redox reactions and electrochemical cells

Knowledge and/or skills

- Electron transfer processes and reactivity of metals and non metals
- Electrochemical series, electrode potential and reaction feasibility
- Electrochemical cells and calculation of electromotive force
- Electrolytic cells and calculation of quantity of products at electrodes

Evidence requirements

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

- describe electron transfer processes using balanced ion-electron equations and use these to describe reactions of metals and of halogens
- use the electrochemical series and electrode potential to describe, and predict feasibility of, redox reactions
- describe voltaic cells in terms of electron flow and use electrode potential to calculate emf under standard conditions
- describe electrolytic cells, predict products at electrodes and calculate amounts of products

Outcomes 1 and 2 will be assessed using a closed-book assessment. At least three out of four of the Knowledge and Skills items from Outcome 2 and all Knowledge and Skills items from Outcome 1 must be assessed on each occasion, with approximately equal marks assigned to each of the Knowledge and Skills items covered. Questions should be set using a representative sample of the content outlined in the support notes, with an appropriate mixture of short answer and structured questions based on the properties of electrochemical and/or electrolytic cells. The holistic nature of the assessment should ensure that the pass mark represents understanding drawn from each of the Knowledge and Skills areas assessed.

Assessment guidelines

The written/oral assessments should be undertaken as a combined end of Unit assessment. Each Outcome will require a 60% pass mark, but a candidate failing to achieve the 60% mark for either Outcome may be offered a second attempt at that Outcome after appropriate remediation. The re-assessment should sample a different selection of the Knowledge and Skills items from Outcome 2 and all Knowledge and Skills items from Outcome 1. A time limit of 75 minutes is suggested; this is at the discretion of the centre.

Outcome 3

Perform experiments to investigate the properties of chemical substances and analyse the results

Knowledge and/or skills

- follow instructions to perform a range of chemical experiments
- work in a safe manner regarding current health and safety regulations
- achieve consistent and accurate results
- report the results clearly and concisely
- practical applications of electrochemistry
- identify sources of experimental errors and estimate size of errors as appropriate

Evidence requirements

Candidates will need to provide evidence to demonstrate their skills by showing that they can:

- carry out qualitative investigations of inorganic substances following instructions
- carry out risk assessments and observe appropriate safety procedures
- obtain consistent and accurate results
- record experimental observations and measurements correctly
- report accurately and concisely on methods and observations
- analyse results correctly and state valid conclusions

A checklist will be used to record the results of the candidate's practical work on at least two occasions. Candidates must also complete a laboratory diary or pro forma. For one of the experiments carried out the candidate must also produce a laboratory report which demonstrates the candidates ability to plan and evaluate the laboratory exercise.

Laboratory reports should be clear and concise, with correctly stated aims, full experimental method details, all raw data and correctly presented and interpreted calculations. Any graphs required should be presented in the appropriate format in terms of scaling, Units, best fit, title etc

It is not necessary to cover all evidence requirements on each occasion, but where a requirement is included in the assessment it must be met. Each of the assessed experiments should represent at least 2 hours' practical work. One of the assessed experiments should relate to the content of Outcome 1 and the other to the content of Outcome 2. Either of these could be the basis of the full laboratory report.

A report/worksheet which is unacceptable should be redrafted with appropriate remediation. If the redrafted report is unacceptable, re-assessment will take the form of a new report on a different experiment.

Assessment guidelines

The evidence for development of practical skills could be gathered on an ongoing basis by lecturer observation evidenced by a checklist and need not be restricted to the assessment experiments. It is expected that a series of practical exercises will be undertaken, with the aim of developing appropriate skills before assessment is attempted. Written/oral assessment evidence should be obtained from two significant practical exercises, one of which will be assessed using checklists and one by means of a report. More than two exercises suitable for assessment by these routes are likely to be undertaken, so that additional practical reassessments will be unnecessary.

This could take the form of an individual assignment with limited guidance, or of a more complex project undertaken by small groups of students. A separate report/worksheet should be completed by each candidate, which in the case of a group project should be supplemented by checklist evidence to establish the candidate's design input and practical contribution.

Administrative information

Unit code: HV96 47

Unit title: Fundamental Concepts of Inorganic Chemistry

Superclass category: RD

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FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

Unit specification: support notes

Unit title: Fundamental Concepts of Inorganic Chemistry

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 as part of the framework for SQA Advanced Certificate/Diploma in Applied Sciences and SQA Advanced Diploma in Chemistry courses but may be suitable for inclusion in other SQA Advanced Science awards. It is designed to further develop the theoretical and practical aspects of inorganic chemistry introduced in Fundamental Chemistry: Theory and Practice.

Outcome 1 Periodicity and molecular structure

Periodicity in atomic properties including atomic size (covalent and metallic radius), ionic radius, ionisation energies, electron affinity and electronegativity. These should be explained in terms of atomic structure including electron energy levels and orbital structure.

Physical properties of the elements (melting and boiling temperature, density) described in general terms for the periodic table, and more specifically for elements 1–20. These should be explained in terms of bonding and structure.

The main chemical characteristics of elements considered group by group and illustrated by the formation of oxides, chlorides and hydrides of elements 1–20.

The physical and chemical properties of the oxides, chlorides and hydrides of elements 1–20 described and explained in terms of bonding and structure in these compounds. Chemical properties will include the interactions of the compounds with water.

Description and representation of metallic, ionic, covalent and polar covalent bonds; prediction of bond character from electronegativity; polarity and polarisation.

The role of non bonding electron pairs in coordinate (dative) bonding and in proton transfer reactions of water, ammonia and hydrogen halides.

Orbital hybridisation in covalent bond formation, in general terms and applied particularly to carbon. The shapes of atomic and sp^1, sp^2, sp^3, sp^4, sp^5, sp^6 hybrid orbitals and formation of sigma and pi bonds.

Prediction of molecular shape and bond angles using VSEPR theory (2 to 6 negative centres), including shapes of oxyanions; molecular polarity — prediction and consequences.

Intermolecular forces (van der Waals forces, dipole-dipole forces and hydrogen bonds) related to physical properties of elements and compounds including organic functional groups.

Outcome 2 Electrochemistry

- it is suggested that this Outcome is taught in an experimental context which emphasises the practical applications of electrochemistry and which develops the ability to apply theoretical knowledge to practical problems

Redox reactions as electron transfer; oxidation state; writing and balancing ion-electron equations and redox equations.

Reactivity and the electrochemical series; standard electrode potentials; use of these to predict feasibility of reactions under standard conditions. Applications in the area of corrosion and corrosion protection.

Voltaic and electrochemical cells and calculations of electromotive force under standard conditions. Applications in simple batteries.

Electrolytic cells; prediction of products at electrodes; calculation of amounts of products discharged at electrodes (mass of solid, volume of gas). Applications in electroplating and industrial manufacturing processes.

Practical aspects of simple electrochemical and electrolytic cells; design, construction, operation and measurements.

Outcome 3

A range of practical exercises should be carried out to illustrate the principles developed in Outcome 1 and 2. These could include:

- experiments to investigate the chemical and physical properties of a series of compounds, such as the acid/base properties of oxides or the reactions of chlorides with water
- studies on the reactions and compounds of an element
- comparing the properties of a group of elements
- setting up electrochemical and electrolytic cells and making measurements and observations

Or other appropriate experiments as selected by the offering centre

Students should follow good laboratory practice and carry out or be familiar with the risk assessments on all procedures undertaken. Reports should use appropriate chemical terminology with correct use of Units for measurements and quantities. They should also show an awareness of the sources of experimental error and of the accuracy of measurements and calculations evidenced by correct use of significant figures.

Guidance on the delivery and assessment of this Unit

This Unit is likely to form part of a group award designed to prepare candidates for employment or for progression to further academic study. The relationship between theory and experimental work should be carefully considered, and practical work should be undertaken against a clear theoretical background.

The approach to teaching, learning and assessment is likely to be different for Outcomes 1 and 2. Outcome 1 is essentially knowledge based, and practical work will focus on investigation of the properties of chemical substances with the aim of developing investigative, manipulative and

observational skills. Outcome 2 should be seen as applications based, with practical work focussed on exploitation of the theory including quantitative measurements and calculation.

Independent study should be encouraged by using candidate-centred, resource based methodologies where appropriate.

It is suggested that Outcome 1, which is essentially knowledge based, is assessed by a closed-book, end of Unit test worth 35 marks. The assessment should test the candidate's ability to link atomic structure and properties, through bonding and structure, with the behaviour of chemical substances.

Outcome 2 could be assessed by a closed-book, end of Unit test worth 15 marks which should emphasise the applied aspects of electrochemistry, with questions based on the properties of electrochemical and electrolytic cells.

In Outcome 3 candidates will be required to develop manipulative, observation, measurement and recording skills. The acquisition of these skills should be monitored by the lecturer and formal practical assessment should be undertaken only after sufficient training has been completed. However, evidence of practical competence could be gathered from any piece of practical work; a number of experiments should be capable of generating the required evidence.

A laboratory diary or pro forma will be kept and learners should be introduced to Standard Operating Procedures (SOPs). Laboratory reports should be in an appropriate format. Health and Safety, in regard to risk and COSHH assessments should be emphasised at all times.

Laboratory work should normally be carried out individually, but it is desirable that some experiments be carried out by small groups. Group work may be appropriate specifically for the assessment of an application of electrochemistry, in which case checklist evidence of significant participation by each candidate would be required. All reporting of results and completion of worksheets must be done individually.

The laboratory report should be complete, with due regard to safety and risk assessment, and all observations, results and calculations correctly reported and presented. The accuracy and reliability of results and conclusions should be considered, and an awareness of sources of error should be evidenced. An unacceptable report should be redrafted once by the candidate. If the second draft is unacceptable, a new report should be completed on a different experiment (which might have been carried out on an earlier occasion).

Open learning

If this Unit is delivered by open or distance learning methods, additional planning and resources may be required for candidate support, assessment and quantity assurance. A combination of new and traditional authentication tools may have to be devised for assessment and reassessment purposes. In particular candidates will need detailed advice as to fulfilling the requirements of Outcome 3.

For further information and advice, please see *Assessment and Quality Assurance of Open and Distance Learning* (SQA, February 2001 — publication code A1030).

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.

General information for candidates

Unit title: Fundamental Concepts of Inorganic Chemistry

This is a 1 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an SQA Advanced Certificate or SQA Advanced Diploma science programme. Before progressing to this Unit it would be advisable to have completed Fundamental Chemistry: Theory and Practice, where you will have learned some basic Inorganic Chemistry and developed your practical skills. As before, 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. You should expect to spend a total of about 80 hours in teaching, practical sessions and private study to complete the Unit and pass the assessments.

On completion of the Unit you should be able to:

1 Describe and explain atomic properties and predict and explain the properties of chemical substances.

2 Describe electron transfer processes in redox reactions and electrochemical cells.

3 Perform experiments to investigate the properties of chemical substances and analyse the results.

The main components of the Unit content are:

Outcome 1 Periodicity and molecular structure

Here you will come to understand and explain the physical properties and the chemical behaviour of elements and compounds. Starting from principles of atomic structure you will study chemical bonding and structure and see how these lead to understanding and prediction of the characteristics of real substances. This will include consideration of the shapes and polarities of molecules, an understanding of the nature of intermolecular forces and their effect on physical and chemical properties.

The practical work associated with this Outcome will enable you to see how our knowledge of chemical bonding and structure is derived from experimental results, and also to see how chemical knowledge can be applied to the study of real substances.

Outcome 2 Electrochemistry

A study of the principles of oxidation and reduction will lead you to an understanding of how electron transfer processes can be harnessed in practical ways. You will see how redox reactions can be used to drive the production of electrical energy in voltaic cells such as batteries and fuel cells. Electrical energy can be used to bring about chemical reactions in applications such as corrosion protection, industrial manufacturing and electroplating.

In the practical work for this Outcome you will learn to construct simple electrochemical and electrolytic cells and to make measurements of their properties. You may also be required to input some experimental design and work as part of a group.

Outcome 3

The practical work will be integrated with the teaching and learning of theory in the ways described above. As well as relating the experiments to the chemistry, however, you will also be expected to 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 assessment with a 60% pass mark. If you fail either or both Outcomes on the first attempt, one further attempt will be allowed.

Outcome 3 will be assessed after you have learned the necessary practical skills, and will take the form of two practical exercises, which you must perform to the required standard and report your results of one of these practicals using worksheets and a lab report.