



## Higher National Unit specification

### General information

**Unit title:** Environmental Chemistry: Theory and Laboratory Skills  
(SCQF level 8)

**Unit code:** H92V 35

**Superclass:** QA

**Publication date:** May 2015

**Source:** Scottish Qualifications Authority

**Version:** 01

### Unit purpose

This Unit is designed to enable learners to understand key aspects of environmental chemistry. Learners will also develop practical skills in a range of applied chemical techniques relevant to environmental chemistry. The Unit is suitable for learners studying at HND level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of environmental 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 Explain the chemical principles and environmental processes in the natural systems of the atmosphere, hydrosphere and lithosphere.
- 2 Explain the principles of chemical pollution and remediation techniques.
- 3 Perform practical experiments related to environmental chemistry.

### Credit points and level

1 Higher National Unit 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 HN Unit H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills* or equivalent, or have experience of Chemistry at Higher level.

## Higher National Unit Specification: General information (cont)

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### 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](http://www.sqa.org.uk/assessmentarrangements).

## Higher National Unit specification: Statement of standards

**Unit title:** Environmental Chemistry: Theory and Laboratory Skills  
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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

Explain the chemical principles and environmental processes in the natural systems of the atmosphere, hydrosphere and lithosphere.

#### Knowledge and/or Skills

- ◆ Atmospheric characteristics: chemical and physical
- ◆ Atmospheric reactions: chemical and biochemical
- ◆ Hydrosphere, the hydrological cycle and aquatic chemistry
- ◆ Hydrospheric interactions with other phases and biological interactions to include: aquatic life, bacteria in water, microbial transformations in water
- ◆ Soil, sediment and lithospheric properties
- ◆ Weathering processes: chemical and physical
- ◆ Agricultural chemistry: nature and properties of soil

### Outcome 2

Explain the principles of chemical pollution and remediation techniques.

#### Knowledge and/or Skills

- ◆ Pollution: forms and possible sources
- ◆ Pollution in the atmospheric environment
- ◆ Pollution in the aquatic environment
- ◆ Pollution in the lithospheric environment
- ◆ Remediation techniques: aquatic and soil systems

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

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### Outcome 3

Perform practical experiments related to environmental chemistry.

#### Knowledge and/or Skills

- ◆ Environmental 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 and 2 should be assessed using a holistic 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 90 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 sample five of the seven 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:

- ◆ Explain the principles and processes of chemical and physical characteristics of the atmosphere.
- ◆ Explain the chemical and biochemical reactions taking place in the atmosphere.
- ◆ Explain the properties of water, the hydrological cycle and aquatic chemistry.
- ◆ Explain water interactions with other phases and biological interactions to include: aquatic life, bacteria in water, microbial transformations in water.
- ◆ Explain the properties of soil, sediments and the lithosphere.
- ◆ Explain the chemical and physical aspects of the weathering process.
- ◆ Explain the nature and properties of soil in agricultural chemistry.

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

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### 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:

- ◆ Explain forms of pollution and identify possible sources.
- ◆ Explain the effects of pollution in the atmospheric environment.
- ◆ Explain the effects of pollution in the aquatic environment.
- ◆ Explain the effects of pollution in the lithospheric environment.
- ◆ Describe remediation techniques in aquatic and soil systems.

### 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 experiments related to environmental 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 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.

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.



## Higher National Unit Support Notes

**Unit title:** Environmental Chemistry: Theory and Laboratory Skills  
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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 intended as part of the framework for HNC/HND Applied Sciences, HND Applied Biological Sciences and HND Applied Chemical Sciences but may be suitable for inclusion in other HN Science awards. It is designed to develop the theoretical and practical aspects of environmental chemistry introduced in the HN Unit H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills*, and also to introduce learners to theories that are specific to the environment.

#### **Outcome 1 — Explain the chemical principles and environmental processes in the natural systems of the atmosphere, hydrosphere and lithosphere**

- ◆ Chemical and physical characteristics of the atmosphere, energy and mass transfer in the atmosphere.
- ◆ Reactions of atmospheric oxygen and nitrogen. Atmospheric carbon dioxide, water and particles.
- ◆ Properties of water, the hydrologic cycle, and aquatic chemistry.
- ◆ Water interactions with other phases, aquatic life, bacteria in water and microbial transformations in water.
- ◆ The lithosphere, nature of solids to include minerals, macro and micronutrients, evaporates, volcanic sublimates, igneous and sedimentary rock, sediments and clays.
- ◆ The physical and chemical aspects of the weathering process, groundwater and water wells.
- ◆ Soil and agricultural chemistry, the nature, properties and importance of water, air and other particles in soil.

## Higher National Unit Support Notes (cont)

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### Outcome 2 — Explain the principles of chemical pollution and remediation techniques

- ◆ Forms of pollution and possible sources: chemical and photochemical reactions in the atmosphere including photochemical processes, ions and radicals in the atmosphere. Radioactivity as a pollutant in the aquatic environment. Organic pollutants — sewage, soaps, detergents, pesticides, polychlorinated biphenyls.
- ◆ The effects of pollution in the atmospheric environment: chemical and biochemical processes in evolution of the atmosphere.
- ◆ The effects of pollution in the aquatic environment: nature of aquatic pollution.
- ◆ The effects of pollution in the lithospheric environment: fertilisers and pesticides in soil and wastes, and other agricultural pollutants in soil.
- ◆ Remediation techniques in aquatic and soil systems: disinfection of water, municipal water treatment and industrial water treatment. Sewage treatments, methods for removal of metals and heavy metals. Treatment to remove dissolved organic pollutants, dissolved inorganic pollutants and sludge treatment.

### Outcome 3 — Perform practical experiments related to environmental 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 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

There is no particular order in which Outcomes 1 and 2 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 3 will be undertaken in similar timeframe to the underpinning theory.

It is envisaged that the delivery of Outcome 1 could commence with coverage of the importance of the atmosphere and the chemical and physical characteristics of the atmosphere, including atmospheric composition, variation of pressure and density with altitude, stratification of the atmosphere. In the study of chemical and biochemical reactions taking place it is important that learners should understand in detail the processes of oxygen, nitrogen, carbon dioxide and atmospheric water. The theories of environmental chemistry of water could commence with the properties, sources and uses of water and the hydrological cycle, including alkalinity and acidity, metal ions in water, water hardness, oxidation and reduction reactions in water, complexation and chelation in water, humic substances, water interaction with other phases, aquatic life, bacteria in water, microbial transformations in water, salinity of water, oxygen, oxidants and reductants in water. The theories of

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environmental chemistry of land should include the nature of solids and minerals, physical and chemical aspects of the weathering process, properties of soil including: inorganic components of soil, organic matter in soil and acid/base and ion exchange reactions in soil, genetic engineering and agriculture and effects on soil.

Outcome 2 is intended to provide learners with an overview of chemical pollution and remediation techniques, and to familiarise learners with key aspects for potential further study. It is envisaged that the delivery of Outcome 2 could commence with the unnatural chemical and photochemical reactions in the atmosphere, ozone interaction and chemical smog and the evolution of the atmosphere. Pollution in water should include elemental pollutants (metals, organically bound metals) and inorganic pollutants (ammonia, cyanide). Learners should have knowledge of nutrient pollution in water, algal nutrients and eutrophication. The causes and extent of radioactivity as a pollutant in the aquatic environment should be understood. Learners should be aware of disinfection of water techniques through the processes of chlorination or ozone treatment, industrial and municipal water treatment cycles, sewage treatments, methods for removal of metals and heavy metals from soil, treatment to remove dissolved organic pollutants, dissolved inorganic pollutants and sludge treatment.

The delivery of Outcome 1 and 2 may be supported through appropriate field trips. A visit to a local water treatment plant or sewage treatment facility would help to ensure that learners have attained a good knowledge of pollution and the water treatment process. This could be expanded by researching particular properties and substances. To ensure a good understanding of soil properties an excursion to a local agricultural site may be helpful to relate observations to the underpinning theory. A case study into soil horizons may also be beneficial to environmental chemistry of soil processes.

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 the understanding of the theory and to prepare learners for undertaking the assessed practical experiments. Aspects suitable for experimental investigation might include; alkalinity of water, hardness of water, pH measurement, suspended solid, tar and oil in water, water sampling techniques, tar and oil in soil, pH of soil, metal content in soil, air sampling techniques, flow calibration, dust particles in air, barometric pressure and pesticide residue in food.

### 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 and 2 could be assessed by a single holistic 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 be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Chemistry* or any suitable replacement when sitting the assessment.



## Higher National Unit Support Notes (cont)

**Unit title:** Environmental Chemistry: Theory and Laboratory Skills  
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Where evidence of Outcomes 1 and 2 is assessed by sampling, the whole of the 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 not sampled in the first assessment, must be included in the alternative (re-sit) assessment.

In Outcome 3 learners are required to undertake two assessed practical experiments, 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 for Outcome 3 are:

- ◆ alkalinity of water
- ◆ hardness of water
- ◆ pH measurement
- ◆ suspended solid
- ◆ tar and oil in water
- ◆ water sampling techniques
- ◆ tar and oil in soil
- ◆ pH of soil
- ◆ metal content in soil
- ◆ air sampling techniques
- ◆ flow calibration
- ◆ dust particles in air
- ◆ barometric pressure
- ◆ pesticide residue in food

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.

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### 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](http://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 decide on the steps and operations to solve complex problems, carrying out sustained and complex calculations.

#### 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 could 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. Learners will also be required to utilise internet search engines to source information on research topics.

#### 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 |
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## General information for learners

### Unit title: Environmental Chemistry: Theory and Laboratory Skills (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 HND Science programme. Before progressing to this Unit it would be beneficial to have completed the HN Unit H92X 34 *Fundamental Chemistry: Theory and Laboratory Skills*, where you will have learned underpinning aspects of environmental 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 Explain the chemical principles and environmental processes in the natural systems of the atmosphere, hydrosphere and lithosphere.
- 2 Explain the principles of chemical pollution and remediation techniques.
- 3 Perform practical experiments related to environmental chemistry.

#### Outcome 1

In this Outcome you will cover the physical characteristics of the atmosphere, energy and mass transfer in the atmosphere, reactions of atmospheric oxygen, nitrogen and carbon dioxide, reactions of atmospheric water and atmospheric particles, the properties of water, the sources and uses of water, the hydrologic cycle and aquatic chemistry.

You will also cover aspects of the geosphere; nature of solids to include minerals, macro and micronutrients, evaporates, volcanic sublimates, igneous and sedimentary rock, sediments and clays. Geochemistry will also include the physical and chemical aspects of the weathering process along with the physical and chemical aspects of groundwater and water wells, the nature of soil and agricultural chemistry, the nature, properties and importance of water, air and other particles in soil.

#### Outcome 2

In this Outcome you will gain an understanding of the chemical and photochemical reactions in the atmosphere including photochemical processes, ions and radicals in the atmosphere, chemical and biochemical processes in evolution of the atmosphere.

You will cover the nature and types of water pollution, radioactivity, organic pollutants; sewage, soaps, detergents, pesticides, polychlorinated biphenyls, fertilisers and pesticides in soil and wastes and other agricultural pollutants in soil.

You will also be introduced to the methods of water treatment; the disinfection of water, municipal and industrial water treatment, sewage treatments, methods for removal of metals and heavy metals from soil and treatment to remove dissolved organic pollutants, dissolved inorganic pollutants and sludge treatments.

## General information for learners (cont)

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### Outcome 3

In this Outcome you will undertake practical experiments, based on the content of Outcomes 1 and 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 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 could 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 full laboratory reports, or by completion of pro forma reports.

### 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.