Next Generation Higher National Unit Specification

Chemistry and Physics for Agricultural Technology (SCQF level 7)

Unit code: J6F5 47

SCQF level: 7 (16 SCQF credit points)

Valid from: session 2022–23

Prototype unit specification for use in pilot delivery only (version 1.0) August 2022

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: August 2022 (version 1.0)

Unit purpose

This unit is an introduction to scientific concepts in chemistry and physics, and their relevance and application to agricultural technology. It gives learners knowledge and skills in foundation scientific theory, associated practical laboratory and workshop exercises, and an insight into technology applications relevant to the agriculture industry. It also gives them a basis for understanding and demonstrating the connections between scientific research, testing and successful industry technology applications.

Learners study:

- basic principles of chemistry and physics
- applications of physical chemistry in agricultural technology
- applications of inorganic chemistry in agricultural technology
- applications of electrical scientific principles in agricultural technology
- applications of mechanical scientific principles in agricultural technology

The unit is aimed at learners who want to develop their core scientific knowledge and understanding to underpin their progression in Higher National Certificate (HNC) Agricultural Technology. It is suitable for all learners, from school leavers to mature students. Learners should be interested in working in a scientific or technical capacity.

Entry to this unit is at your centre's discretion. However, we recommend that learners have one or more of the following:

- a broad knowledge and understanding of chemistry, electrical and mechanical scientific concepts at SCQF level 6
- knowledge and understanding of agricultural technology principles at SCQF level 6
- relevant industry experience or SCQF level 6 qualifications, for example Higher Physics, Higher Chemistry or a National Certificate (NC) in an engineering context

This unit provides learners with the appropriate knowledge and skills to progress to further study or employment in the agricultural technology sector.

Unit outcomes

Learners who complete this unit can:

1 explain the basic principles of physical chemistry
2 explain the basic principles of inorganic chemistry
3 demonstrate knowledge and understanding of electrical scientific principles
4 demonstrate knowledge and understanding of mechanical scientific principles

Evidence requirements

You can assess outcomes 1 to 4 holistically through written or oral recorded evidence of learners solving agricultural technology problems. You should use an assessor observation checklist to record learners' performance in practical work and ensure it complies with given instructions and health and safety requirements.

Learners generate evidence under unsupervised, untimed, open-book conditions. They can compile a portfolio of the evidence they produce.

When you assess evidence for outcomes on a sample basis, you should teach all of the content listed in the knowledge and skills section and ensure it is available for assessment. Learners should not know in advance the items on which they are being assessed, and you should sample different items on each assessment occasion.

Outcome 1

You assess learners with a sample of five of the eight knowledge and skills items. Learners' responses are satisfactory when their evidence shows they can:

- explain the nature of elements in terms of their atomic structures
- describe different types of bonding for given compounds
- explain the significance and relevance of units of measurement used in chemistry
- perform calculations to balance molecular equations
- explain the nature of chemical reactions and how their rates may be altered
- describe the radioactive decay of matter
- explain the significance of equilibrium and how it can be manipulated
- calculate the equilibrium constant for different reactions

Outcome 2

You assess learners with a sample of four of the six knowledge and skills items. Learners' responses are satisfactory when their evidence shows they can:

- explain the properties of strong and weak acids and alkalis
- describe the chemistry of water
- carry out two tests on different substances to measure their solubility in water
- carry out two tests on chemical reactions involving oxidation and reduction

- carry out two tests on buffer reagents to measure and compare rates of change in ion concentration
- calculate the hydrogen ion concentration for two different substances of known pH

Outcome 3

You assess learners on all the knowledge and skills items. Learners' responses are satisfactory when their evidence shows they can:

- describe terms, quantities and units of measurement used in electrical circuits and applications
- describe component parts of electrical circuits
- explain voltage, electro-motive force (EMF), current, resistance, capacitance, inductance and charge
- carry out these three basic electrical measurements using appropriate instrumentation: voltage, current and resistance

Outcome 4

You assess learners with a sample of six of the eleven knowledge and skills items. Learners' responses are satisfactory when their evidence shows they can:

- describe terminology, quantities and units of measurement used in mechanical engineering
- describe derived units associated with technology applications
- explain these physical properties in science and technology: solid, liquid and vapour (gas) (phases of matter)
- explain phase change and phase change applications in technology
- explain gas laws and their applications in technology
- explain osmotic pressure and diffusion according to Fick's Law
- describe the laws of thermodynamics and their applications in technology
- carry out experimental measurements on three of these physical properties of water: density, specific heat, latent heat of fusion and vaporisation, viscosity, electrical conductivity, optical properties, water impurities
- carry out experimental measurements of temperature in two substances
- carry out experimental measurements of pressure in two substances
- carry out an experimental measurement of heat transfer from a 'hot' to a 'cold' substance

Learners can also generate evidence for the outcomes while studying other HNC Agricultural Technology units.

You can find further information in the 'Additional guidance' section.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Outcome 1 Learners should understand: ♦ the nature of elements in terms of their atomic structures ♦ different types of bonding for given compounds ♦ the significance and relevance of units of measurement used in chemistry ♦ the nature of chemical reactions and how their rates may be altered ♦ the radioactive decay of matter ♦ the significance of equilibrium and how it can be manipulated	**Outcome 1** Learners can: ♦ perform calculations to balance molecular equations ♦ calculate the equilibrium constant for different reactions
Outcome 2 Learners should understand: ♦ the properties of strong and weak acids and alkalis ♦ the chemistry of water	**Outcome 2** Learners can: ♦ carry out tests on different substances to measure their solubility in water ♦ carry out tests on chemical reactions involving oxidation and reduction ♦ carry out tests on buffer reagents to measure rates of change in ion concentration ♦ calculate the hydrogen ion concentration for different substances of known pH
Outcome 3 Learners should understand: ♦ terms, quantities and units of measurement used in electrical circuits and applications ♦ component parts of electrical circuits ♦ voltage, EMF, current, resistance, capacitance, inductance and charge	**Outcome 3** Learners can: ♦ carry out these three basic electrical measurements using appropriate instrumentation: voltage, current and resistance

Knowledge	Skills
Outcome 4 Learners should understand: ♦ terminology, quantities and units of measurement used in mechanical engineering ♦ derived units associated with technology applications ♦ physical properties in science and technology: solid, liquid and vapour (gas) (phases of matter) ♦ phase change and phase change applications in technology ♦ gas laws and their applications in technology ♦ osmotic pressure and diffusion according to Fick's Law ♦ the laws of thermodynamics and their applications in technology	**Outcome 4** Learners can: ♦ carry out experimental measurements of these physical properties of water: density, specific heat, latent heat of fusion and vaporisation, viscosity, electrical conductivity, optical properties, water impurities ♦ carry out experimental measurements of temperature ♦ carry out experimental measurements of pressure ♦ carry out an experimental measurement of heat transfer from a 'hot' to a 'cold' substance

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the agricultural technology sector.

Self-management

This meta-skill includes:

- focusing: concentrating on knowledge and understanding of important scientific principles, particularly in practical laboratory exercises
- filtering: prioritising essential information, particularly in practical laboratory exercises

Social intelligence

This meta-skill includes:

- leading: planning, executing and recording results in practical laboratory exercises
- communicating: developing communication skills, both written and oral; putting forward ideas during assessments and classwork
- collaborating: working with others to achieve best results, particularly in practical laboratory exercises

Innovation

This meta-skill includes:

- critical thinking: analysing approaches to chemistry and physics scientific theory and practice
- curiosity: investigating new ways of analysing and testing physics scientific theory and practice

Developing meta-skills

Skills 4.0: a skills model to drive Scotland's future, in collaboration with the Centre for Work-based Learning in Scotland, outlines the three categories of self-management, social intelligence and innovation, each with four meta-skills and a number of sub-skills. We do not expect learners to develop or reference all of these and none is, in itself, mandatory.

There are many interrelationships and dependencies between these skills and the focus should be on holistic development within the vocational context. Learners should be able to reflect in depth on the meta-skills they are developing and the relationships between them, and include references to course projects, outputs and experiences that contribute to that development.

It is the depth of reflection that is important, not the number of meta-skills referenced.

Learners should consider:

- the importance of developing meta-skills: employability, adaptability and effectiveness
- the meta-skills most relevant to their vocational context: specific meta-skills from the categories of self-management, social intelligence and innovation
- approaches to developing meta-skills:
  - self-awareness: analysing preferences, strengths and weaknesses; meta-skills self-assessment
  - goal setting and action planning
  - reflective practice: principles of reflective practice; tools and approaches for effective reflective practice

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop numeracy knowledge, understanding and skills throughout the unit as they apply mathematical methods — such as arithmetic, algebra, graph and data analysis — to chemistry and physics

Communication

Learners develop communication skills as they explore different written, graphical and oral means of expression during tutorials and practical laboratory exercise discussions, collaboration and presentations.

Digital

Learners develop digital skills including using word-processing, spreadsheets and presentation software applications.

Learning for sustainability

The unit gives learners the underlying principles required to apply scientific theory and practice to sustainable food production, land use, water resource management and energy supply. The evolution of agriculture into a technology and data-driven industry is set to not only enhance financial and production efficiency, but also significantly help to meet local and global sustainability goals.

Delivery of unit

This unit is one of six mandatory units in HNC Agricultural Technology. Your delivery should include classroom-, science laboratory- and workshop-based theory as well as practical exercises. You can teach and assess the unit alongside the Renewable Energy Systems in Agriculture unit at SCQF level 7.

The amount of time you allocate to this unit is at your centre's discretion. However, the notional design length is 80 hours. The amount of time you allocate to each outcome is flexible, but as we consider each outcome to be of equal demand, we suggest the following time distribution, including assessment:

Outcome 1 — Explain the basic principles of physical chemistry
(18 hours)

Outcome 2 — Explain the basic principles of inorganic chemistry
(18 hours)

Outcome 3 — Demonstrate knowledge and understanding of electrical scientific principles
(20 hours)

Outcome 4 — Demonstrate knowledge and understanding of mechanical scientific principles
(24 hours)

Professional recognition

While there is no formal professional recognition, as an HNC Agricultural Technology learner you can join the Institution of Agricultural Engineers (iagre.org) and gain access to a wide range of industry-focused learning opportunities in the agricultural technology sector. These continuing professional development (CPD) and knowledge-exchange opportunities include conferences, branch meetings, YouTube lecture presentations and podcasts.

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit gives learners the knowledge and skills they need to progress their learning in chemistry and physics as applied to agricultural technology:

- example applications of physical and inorganic chemistry
- electrical and mechanical scientific principles
- terminology, equations, symbols and all International System of Units (SI) units for physics and chemistry

Scientific theory in the classroom and applied practical laboratory and workshop learning exercises are appropriate throughout the unit delivery.

Outcomes 1 and 2

You introduce learners to chemistry in the form of physical chemistry elements and compounds. You can relate this to the elements and compounds found in agriculture, such as in soils, crops, water and energy studies. In more detail, this can include:

- the hydrogen ion concentrations for different soils and watercourses
- the consequences of a variety of pH values and how they affect the availability of macro-nutrients in soils
- analysing a variety of crops for their chemical composition

We suggest that you treat water as a key substance in scientific investigations in the unit, given that it plays such an important role in all its forms in agriculture. In the chemistry learning opportunities, you should include water as a solvent of different substances, and investigate its solvent properties by testing and comparing those that are more soluble, such as alcohol or sugars, or less soluble, such as oils and fats, and in experimental tests of oxidation-reduction reactions.

You could also explore the learning topics in outcomes 1 and 2 by analysing renewable technology, such as the structures and properties of semi-conductor wafers in a solar photovoltaic (PV) panel, biomass or biofuels.

Outcome 3

You should give learners the opportunity to investigate electrical scientific principles and quantify electrical circuits in agricultural technology applications. You can analyse the flow of electricity from production to use, perhaps by tracing the direct current (DC)-to-alternative current (AC) inverter process in a solar PV system, and then stepping the AC up to a useable mains supply voltage. Learners should therefore have the opportunity to consider basic electrical principles and scientific laws, and their practical applications in DC and AC circuits. It is important to introduce learners to numeracy in electrical scientific principles to provide

essential foundation mathematical knowledge and skills for later agricultural technology studies.

Outcome 4

You give learners the opportunity to investigate mechanical scientific principles as applied to agricultural technology. This should include the mechanical properties of materials (solids, liquids and gases), other aspects of mechanics (rotational force, torque and power) and thermodynamics (heating and cooling). You can introduce learners to thermodynamics by analysing temperature and pressure to test the efficiency of a heat exchanger circuit, or analysing the potential of phase change materials (PCM) as energy stores. As in outcome 3, in outcome 4, you introduce learners to numeracy in mechanical scientific principles to provide essential foundation mathematical knowledge and skills for later agricultural technology studies.

Required resources

You must ensure that appropriate personal protective equipment (PPE) is made available for workshop or laboratory practical tasks, and give learners adequate advance notice of what they are required to do.

Approaches to delivery

The unit is a combination of chemistry (outcomes 1 and 2) and physics (outcomes 3 and 4). You can deliver the unit in the order of the outcomes, dealing with chemistry first then physics; or you could arrange the timetable so that you deliver chemistry for part of a teaching session followed by physics. In this way, learners experience the holistic aspects of the sciences.

You should deliver the unit in an appropriate learning space, such as a science laboratory, technology workshop or an outdoors setting where you can use learning opportunities in the natural environment. While classroom tutorials are important for efficient introductory learning and further development of scientific principles, knowledge and understanding, you must combine these with practical tasks, experimentation, measurement and observation. This approach ensures that we continually challenge learners and enhance their understanding of chemistry and physics in agricultural technology applications.

A holistic approach to delivery of all four outcomes allows learners to see the many connections between chemistry and physics in agricultural technology applications. These include standards in scientific analyses, systems and units of measurement, electrical conduction and resistance in materials, fuel and energy studies, specific and latent heat, and phase change in heat transfer.

Approaches to assessment

You can assess learners in a variety of ways, but assessment should principally consist of reports and practical laboratory exercises. You can assess learners' knowledge and skills through coursework exercises inspired by agricultural technology case studies and mini projects. Learners should collect all evidence in their individual portfolio. They should generate evidence under unsupervised, untimed, open-book conditions.

Learners' evidence for outcomes 1 and 2 can could demonstrate an understanding of the chemistry of hydrocarbons, biomass and materials that can be used for storing energy, such as water or phase change materials (PCM). Their evidence for outcomes 3 and 4 could demonstrate an understanding of electrical and mechanical scientific principles.

You can also assess this unit alongside the Renewable Energy Systems in Agriculture unit. You could base your assessment on the principles and applications of any renewable electrical or heating energy technology, and ask learners to write a report that traces a renewable energy supply from production to use as part of a farm case study. You can use these renewable energy supply options in the holistic assessment strategy:

- solar photovoltaics (PV)
- wind turbines
- hydro power
- biomass fuel
- biodiesel
- combined heat and power (CHP)
- solar thermal
- heat pumps
- anaerobic digestors (AD)

Learners must keep a personal account, in the form of a written diary or digital blog or vlog, to measure their meta-skills, digital literacies, industry knowledge and wider employability skills. They should record this in their personal portfolio. You should provide learners with support, guidance and feedback on areas of development, and signpost development opportunities.

Opportunities for e-assessment

Assessment that is supported by information and communication technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this unit.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Chemistry and Physics for Agricultural Technology (SCQF level 7)

This section explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with skills, knowledge and understanding related to chemistry and physics, as applied to agricultural technology. It forms part of Higher National Certificate (HNC) Agricultural Technology, which is aimed at learners who want to have a professional career in the application of technologies to land-based industries, including precision farming, forestry, land use, water management and renewable energy.

This unit has been developed to give you the knowledge and skills you need to progress your learning related to chemistry and physics applied to agricultural technology.

Unit outcomes

When you have completed this unit, you should be able to:

- explain the basic principles of physical chemistry
- explain the basic principles of inorganic chemistry
- demonstrate knowledge and understanding of electrical scientific principles
- demonstrate knowledge and understanding of mechanical scientific principles

Outcomes 1 and 2 covers example applications of physical and inorganic chemistry, introducing you to chemistry in the form of physical chemistry elements and compounds.

Outcome 3 gives you the opportunity to investigate and quantify electrical scientific principles applied to agricultural technology.

Outcome 4 gives you the opportunity to investigate mechanical scientific principles applied to agricultural technology.

Entry to this unit is at your centre’s discretion. However, we recommend that you have one or more of the following:

- a broad knowledge and understanding of chemistry, electrical and mechanical scientific concepts at SCQF level 6
- knowledge and understanding of agricultural technology principles at SCQF level 6
- relevant industry experience or SCQF level 6 qualifications, for example Higher Physics, Higher Chemistry or a National Certificate (NC) in an engineering-related context

This unit provides you with the appropriate knowledge and skills to progress to further study or employment in the technology sector, whether in agriculture or beyond.

Assessment

You are assessed by a variety of means. You solve agricultural technology problems in the context of real-world case studies and mini projects. You should collate all evidence in your individual portfolio.

There is a holistic approach to assessment, where you demonstrate evidence in the context of a few overarching, complex agricultural technology scenarios.

Meta-skills

Throughout the unit, you have the opportunity to develop meta-skills to enhance your employability in the agricultural technology sector.

Meta-skills include self-management, social intelligence and innovation.

Self-management

This meta-skill includes:

- focusing: concentrating on knowledge and understanding of important scientific principles
- filtering: prioritising essential information in practical laboratory exercises

Social intelligence

This meta-skill includes:

- leading: planning, executing and recording results in practical laboratory exercises
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Administrative information

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Superclass: RK

History of changes

Version	Description of change	Date

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.