WJEC LEVEL 3

Diploma in Environmental Science

SPECIFICATION

For teaching from September 2015

First certification from Summer 2016

Contents

1. INTRODUCTION

1.1 Qualification title and code

WJEC Level 3 Diploma in Environmental Science QAN code: 601/4550/X

1.2 Statement of purpose

The Level 3 Diploma in Environmental Science has been developed for learners aged 16+, who have enjoyed and already been successful in science. Typically, learners starting this qualification will already have science qualifications at level 2, e.g. GCSEs in science subjects, GCSE Additional Applied Science or equivalent level 2 vocational science qualifications, e.g. WJEC Award in Applied Science and WJEC Award in Science for Work.

The Level 3 Diploma in Environmental Science is an Applied General qualification which is the same size as one GCE A level. It should fill approximately one third of a learner's timetable. This allows for the study of additional vocational or academic qualifications alongside it, e.g. two GCE A levels in biology, chemistry, physics or geography; or a combination of GCE AS and GCE A level sciences and/or geography.

The main purpose of the qualification is to provide learners with the knowledge, understanding and skills in key scientific principles to support progress to higher education or employment in areas related to environmental science. The qualification requires learners to apply biological, chemical and physical principles to environmental issues and to provide solutions to environmental problems.

Learners who follow this qualification will study four units. The units that will be studied are:

- Managing energy for a sustainable future;
- The living environment and conservation;
- Monitoring our physical environment;
- Scientific principles and the environment.

Each unit has a clear environmental purpose which focuses the learning of scientific principles and skills in the unit in a meaningful environmental context. The units have been written to help develop the:

- knowledge and understanding of biological, chemical and physical principles underlying environmental science;
- skills necessary to perform laboratory and field work;
- ability to solve problems in an environmental context;
- skills needed to do project based research and presentation;
- ability to learn in work-related contexts;
- ability to work alongside others in a professional manner;
- skills for independent learning and development. These are very important to employers and higher education.

Learners who complete the qualification should have a broad appreciation of work in the environmental sector allowing for progression into further education, employment or training.

Progression

When supported by other appropriate qualifications such as GCSE English and mathematics, and at level 3, such as GCE AS/A levels, e.g. in biology, chemistry, physics or geography or another vocational qualification in science, the WJEC Level 3 Diploma in Environmental Science will enable progression to higher education. The qualification is designed to support progression on to degree courses in areas such as Environmental Studies, Environmental Science etc.

A significant proportion of career opportunities in this sector are at degree level. There are opportunities for suitably qualified individuals to work as pollution scientists, biodiversity officers, water quality experts, environmental managers, waste managers, conservation officers, environmental consultants etc.

Employability

The qualification equips learners with a range of laboratory skills, as well as scientific knowledge and understanding related to environmental science. In addition, the qualification is intended to develop the ability to work alongside others. These skills are required by technicians working in laboratories and support staff (e.g. conservation wardens) in the environmental and related sectors.

Examples of employers who offer opportunities for suitably qualified individuals include: conservation organisations; the Environment Agency; Natural Resources Wales; water companies; waste management companies; DEFRA; local authorities and private sector industry.

2. *QUALIFICATION STRUCTURE*

WJEC Level 3 Diploma in Environmental Science

The units are summarised in the table below.

Unit number	WJEC entry code	Unit title	Mandatory/ optional	Assessment (external/ internal)	GLH
1.	xxxxx	Managing energy for a sustainable future	mandatory	internal	90
2.	xxxxx	The living environment and conservation	mandatory	external	90
3.	xxxxx	Monitoring our physical environment	mandatory	internal	90
4.	xxxxx	Scientific principles and the environment	mandatory	external	90

Learners need to complete the **four** units to achieve the WJEC Level 3 Diploma in Environmental Science. Unit 4 is synoptic for the qualification.

3. ASSESSMENT

WJEC Level 3 Diploma in Environmental Science is assessed using a combination of internal and external assessment. The relative weighting of the internal and external assessment is shown in the table below.

	Internal		External	
Unit no.	1	3	2	4
%	24	24	24	28

3.1 External assessment

3.1.1 Unit 2

This unit is externally assessed by an assignment which is set and marked by WJEC. The assessment for the unit will be provided annually by WJEC in September of the academic year in which they are to be taken via the WJEC secure website. The assessment must be completed and submitted for marking in the same academic year as it is set. Centres are **not** allowed to modify the provided assignment for unit 2.

The assessment is carried out by the learners under controlled conditions. The controls (time, supervision, resources and collaboration) for task taking are described within the assessment. The general principles for the control of the external assessment of unit 2 are outlined below.

Controls for task taking (external assessment)

There are five areas of task taking that are controlled: time, resources, supervision, collaboration and resubmission.

Time

Each assessment will specify the total amount of time available for summative external assessment.

Resources

The supervisor should ensure suitable resources are provided to all learners to ensure fair and valid assessment takes place. Where specific resource controls must be in place, these will be stated in the assignment.

Supervision

Learners must be supervised whilst completing externally set assessment tasks. Assessments will specify the level of supervision required. Centres must have in place systems to ensure learners cannot access evidence they have been developing outside of supervised activities.

Authentication

Supervision is in place to ensure the authenticity of evidence produced for summative assessment. Supervisors should **not** provide input or guidance to learners during the controlled assessment time. This includes providing formative feedback on the evidence being produced. Supervisors can provide guidance on the requirements of the task and remind learners of the performance bands and how they can be interpreted. Assessors must intervene where there a health and safety issue is observed.

Learners can review and redraft evidence independently within the time controls for the assessment.

Learners must sign a declaration to confirm that all evidence submitted for marking by WJEC is their own work and that any sources used have been acknowledged.

Supervisors must sign a declaration to confirm that evidence submitted for marking by WJEC was completed under the controlled conditions set out in the assignment.

Collaboration

The assessment will indicate whether:

- group work may take place;
- group work is forbidden.

3.1.2 Unit 4

Unit 4 is assessed through one written **two hour** (**90 marks**) examination available in the summer of each year. Unit 4 is a synoptic unit and is intended to examine the underpinning scientific concepts of units 1 to 3. Each paper will consist of two sections (Section A and B). All questions in the paper will be compulsory.

Section A

- Questions will be based upon a pre-release article and connected specification content.
- The pre-release article is intended to provide an environmental context for questions in section A. It will also contain environmental data and information for analysis and/or evaluation.
- Between 22 and 25 marks will be available for Section A.

Section B

- Questions set within an environmental context related to units 1 - 3. All questions will require the learner to engage with stimulus material. Stimulus material may include images, diagrams, photographs, graphs and information.

All papers will include synoptic questions that link to the context of units 1 to 3.

Assessment criteria from each learning outcome from unit 4 will be assessed in the examination. Marks will be apportioned to each learning outcome of unit 4 as follows:

Learning Outcome	AO1	AO2	AO3	AO4	Total
Allowed range	18-24	18-24	18-24	23-29	90

3.1.3 Administration of pre-release material (unit 4)

The pre-release article will be available for centres to download from the WJEC website from the last week of April. Teachers can use the pre-release material in lessons with learners after it has been released on the WJEC website.

Learners will be issued with a clean copy of the pre-release article for the examination. Learners are not permitted to take an annotated copy of the pre-release article into the examination.

3.1.4 Resitting external assessment

Learners are allowed **one** resit of each external unit. The highest grade will contribute towards the overall grade for the qualification.

3.2. Internal assessment

These units are internally assessed and externally moderated:

Unit 1 Managing energy for a sustainable future;

Unit 3 Monitoring our physical environment.

For internal assessment, WJEC Level 3 Diploma in Environmental Science have adopted the principles of controlled assessment as set out in the Joint Council for Qualifications document 'GCSE, GCE, ELC, Functional skills, Principal Learning in the Diploma and Project Qualifications – instructions for conducting controlled assessment'. This document can be accessed through the JCQ website (www.jcq.org.uk). Each centre must ensure that internal assessment is conducted in accordance with these controls.

The following principles apply to the assessment of each internally assessed unit.

- Units are assessed through summative controlled assessment.
- Controls for assessment of each internally assessed unit are provided in a model assignment.
- Each internally assessed unit must be assessed independently. Learners may produce a piece of evidence that contributes to assessment criteria for more than one unit. This is acceptable provided it can be clearly attributed to a specified assessment criterion and has been produced under the appropriate controlled conditions for each unit.
- Performance bands are provided to enable centres to mark the controlled assessment.

There are three stages of assessment that will be controlled:

- task setting;
- task taking;
- task marking.

Controls

Task setting

For internal assessment, WJEC has produced model assignments for each unit. Centres are, however, allowed to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs.

The model assignment has been written to ensure the following controls are in place.

- Each unit is assessed through one assignment.
- Each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the rationale in Section 1.2.
- The assignment can specify a number of tasks but tasks must be coherent, i.e. show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment.

- The assignment must provide each learner with the opportunity to address all assessment criteria and all performance band requirements.
- The assignment must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignment.
- Where a centre has adapted the model assignment, there must be evidence of quality assuring its fitness for purpose. Sample documentation for this activity is provided with each model assignment.

Model assignments are available from the WJEC secure website.

Task taking

There are five areas of task taking that are controlled: time, resources, supervision, collaboration and resubmission.

Time

Each model assignment will specify the total amount of time available for summative assessment. Centres have the discretion for how that time is allocated to each task.

Resources

The assessor can determine which resources should be provided to all learners to ensure fair and valid assessment takes place. Where specific resource controls must be in place, these will be stated in the model assignment.

Supervision

Learners must normally be supervised by an assessor whilst completing controlled assignment tasks. Model assignments will specify if supervision is not required. Centres must have in place systems to ensure learners cannot access evidence they have been developing outside of supervised activities.

Authentication

Supervision is in place to ensure the authenticity of evidence produced for summative assessment. Assessors are not expected to provide input or guidance to learners during the controlled assessment time. This includes providing formative feedback on the evidence being produced. Assessors can provide guidance on the requirements of the task and remind learners of the performance bands and how they can be interpreted. Assessors must intervene where there is a Health and Safety hazard observed.

Learners can review and redraft evidence independently within the time controls for the assessment.

Learners must sign a declaration to confirm that all evidence submitted for moderation is their own work and that any sources used have been acknowledged.

Assessors must sign a declaration to confirm that evidence submitted for moderation was completed under the controlled conditions set out in the model assignments.

Collaboration

The model assignment will indicate whether:

- group work must take place;
- group work is forbidden;
- centres can elect to complete tasks through group work.

Where group work takes place, the following principles must be applied.

- Tasks should allow each member of the group to have full access to all performance bands for all assessment criteria;
- Learners must provide an individual response as part of any task outcome;
- Evidence of individual response may include written evidence (e.g. notes, evaluations, mind maps, etc.) and/or audio-visual evidence (e.g. recordings, photographs, drawings, designs, etc.);
- Evidence must be clearly attributable to each individual member of the group;
- Individual contributions must be clearly identified and stated on the accompanying authentication sheet which must be signed by both the teacher and the candidate;
- Assessment of the individual must be based on the individual contribution to the evidence produced;
- Learners achievement must not be affected by the poor performance of other group members;
- Learners' achievement must not benefit from the performance of other group members.

Resubmission

Learners may resubmit internally assessed units. The learner must submit a new assessment, completed within the same levels of control. They cannot improve previously submitted work.

Learners have one resit opportunity for each assessed unit.

Where an individual learner who has previously submitted group work for assessment wishes to resit an internally assessed unit, one of the following options **must** be taken:

- the candidate must create a new piece of work within the same group;
- the candidate must create a new piece of work within a new group;
- the candidate must create a new piece of work with non-assessed candidates;
- the candidate must create an individual piece of work.

The same levels of control for group work, as outlined above, will apply to candidates who choose to re-sit.

Task marking

All marking of evidence must be made against the assessment criteria and performance band statements given in each unit specification. Evidence marked must comply with the controlled requirements set out in the model assignment.

Written evidence must be annotated to show how it relates to the assessment criteria and performance band requirements.

Performance evidence, for example of giving a presentation, must be made on observation records. Observation records will include a description of learner performance as well as a summative statement on the quality of that performance. Where performance is observed by someone other than an assessor, the 'witness' must complete a witness statement. Assessors will need to authenticate the statement either through scrutiny of supporting evidence and/or questioning of the learner and/or witness. If the statement is authenticated, it can be allowed to contribute to the evidence for assessment. Evidence of authentication will also need to be included. Each model assignment that allows performance evidence will include a sample observation record and witness statement.

Marking should only be undertaken by a designated assessor. An assessor should have appropriate expertise in the subject and level for a specified unit. The assessor is responsible for ensuring that:

- Assessment is conducted under specified controlled conditions;
- They are clear about the requirements of the learning outcomes, assessment criteria and performance band statements prior to commencing controlled assessment;
- Evidence presented for assessment is authentic;
- Assessment decisions are accurately recorded;
- Evidence is appropriately annotated;
- Observation records contain sufficient detail for objective corroboration of decisions;
- Judgements are only made against the performance band statements.

3.3 Synoptic assessment

Synoptic assessment

'requires a candidate to identify and use effectively in an integrated way an appropriate selection of skills, techniques, concepts, theories, and knowledge from across the course content.'

'Level 3 Vocational Qualifications for 16-19 year olds. Technical Guidance for Awarding Organisations' DfE p14

Unit 4, in the WJEC Level 3 Diploma in Environmental Science, is an externally assessed synoptic unit that examines learners understanding of key underpinning biological, chemical and physical principles used in the qualification. It has been designed to enable learners to identify and use skills, techniques, concepts, theories, and knowledge from across the qualification content. The unit will seek to examine learners understanding of these principles utilising the contexts provided by units 1 to 3 through external examination.

3.4 Standardisation

Centres are expected to standardise internal assessment decisions. This is the process by which centres ensure that all learners are judged to the same standard across different assessors, teaching groups and from year to year. Evidence of standardisation should be submitted with learner evidence.

Where more than one assessor is involved, the centre must appoint a Lead Assessor. The role of the Lead Assessor is to:

- Document all activities;
- Ensure that the assignment presented to learners is fit for purpose and complies with all controls;
- Ensure all assessors have appropriate documentation in place to support fair and valid assessment decisions;
- Ensure all assessment activities are in accordance with the task taking controls for the unit;
- Sample assessment judgements at appropriate times to ensure the performance bands are correctly and consistently applied;
- Provide feedback to assessors;
- Provide support to assessors on interpretation of performance band requirements.

4. GRADING

This is a unitised specification which allows for an element of staged assessment. Learners can only resit an internally or externally assessed unit once (with the better result counting) before aggregation for the qualification award. Results for a unit have a shelf-life limited only by the shelf-life of the specification.

4.1 Unit grading

Unit grades (Pass, Merit or Distinction) will be awarded on the basis of the grading descriptions. Grading descriptions are provided to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades for assessment. The descriptions must be interpreted in relation to the content specified by the unit; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met these overall. Shortcomings in some aspects of the assessment may be balanced by better performances in others. Learners who fail to achieve a Pass grade in a particular unit will be awarded a U (unclassified grade) for that unit.

Individual unit results are reported on a uniform mark scale (UMS). The grade equivalences for the Level 3 Diploma in Science are given in the following table.

Unit	Assessment type	Raw Mark	weighting %	UMS mark	UMS grade boundaries		
					D	M	P
1	Internal	120	24	120	96	72	48
2	**External**	120	24	120	96	72	48
3	Internal	120	24	120	96	72	48
4	**External**	90	28	140	112	84	56

4.2 Qualification grading

The Level 3 Diploma in Environmental Science qualification is reported on a four point scale: Pass, Merit, Distinction, Distinction*. The attainment of learners who do not reach the minimum standard for a pass grade will receive a U (unclassified) grade and will not receive a qualification certificate.

Learners may only resit a unit once, with the better result counting, before aggregation for the qualification award. A learner may retake the whole qualification more than once.

To achieve a Pass qualification grade learners must score a minimum of 200 uniform marks overall.

To achieve a Merit, Distinction or Distinction* learners must obtain:

- the minimum UMS mark for the qualification grade (see **Table:** UMS and qualification grade);

and

- a minimum of a pass grade in unit **4**.

Table: UMS and qualification grade

Grade	Distinction*	Distinction	Merit	Pass	Max. Mark
Mark	450	400	300	200	500

Units 1 to 4 are common to the WJEC Extended Diploma in Environmental Science.

5. UNITS

Unit 1 Managing energy for a sustainable future

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of how energy can be managed to provide a sustainable energy future for the planet. The unit will develop an understanding of the principles of energy transfer; their application to the use of both renewable and non-renewable energy sources, and the transfer of heat energy.

The unit will enable the learners to gain skills to model, measure and analyse energy transfers in the context of both generation of electricity and energy use. Learners will make recommendations to manage energy generation and energy use for a sustainable future.

Unit introduction

How do we deal with the problems of increased World energy demand? The multiple factors of increased population, industrialisation, living standards, mass global transport and diminishing resources are exerting extreme and complex strains on our global ecosystems. How do we manage our thirst for energy whilst developing a sustainable future? How are renewable and non-renewable energy sources converted to electricity? How do we control the transfer of heat energy to ensure the maximum efficiency of its usage? This unit will help you analyse sustainability and the transfer of energy using modelling and mathematical skills. Physicists and engineers work within the wider energy sector. They are employed by large and small scale energy generation and usage companies in addition to the large number employed by technology companies all over the World developing energy-efficient devices, processes, systems and buildings. The physicists and engineers employed by these organisations must have practical problem solving and mathematical skills in order to model and develop new ways of harnessing and using energy whilst not compromising our sustainable future.

This unit is designed to help you understand the ways that scientists and engineers involved with the energy sector work so that you will be able to develop a sustainable model of energy usage. You will be taught how to measure and analyse numerically the transfer of energy in a range of contexts and learn the necessary practical skills and techniques to carry out investigations into energy generation and heat transfer. In addition, you will gain the necessary skills to carry out an energy audit of a system (e.g. engine, machine, building).

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 know principles of sustainable energy	**AC1.1** describe the concept of sustainable energy	**Sustainable energy** • definitions • reduced dependence on non-sustainable energy sources • improving efficiency of systems using energy • differences with low-carbon energy, alternative energy **Technologies that support sustainability** • renewable energy sources (e.g. geothermal, solar, wind, tidal) • technologies to improve efficiency
	AC1.2 describe drivers of sustainable energy	**Drivers of sustainable energy** e.g. • government policy • intergovernmental agreements and protocols • future energy needs • energy security

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO2 understand principles of energy	**AC2.1** describe fundamental concepts relating to energy	**Scientific terms** • forms of energy • useful, wasted energy • energy, work, power • specific heat capacity • specific latent heat • thermal conductivity coefficient • U-values, R-values • current, voltage, resistance • electrical power **Units** • e.g. amp, volt, ohm, watt, kilowatt hour, joule, joule/second
	AC2.2 explain energy transfer using scientific concepts	**Scientific concepts** • Conservation of Energy • Zeroth Law • Newton's law of cooling • thermal conductivity • conduction, convection and radiation (and factors that affect these)
	AC2.3 explain how electrical energy can be generated	**Solar energy** • generation of electrical current from PV cell • photoelectric effect **Turbine - generator systems** • energy transfer in turbine systems • systems involving generation of steam • e.g. biomass, geothermal, fossil fuels • systems not involving steam generation e.g. wind, tidal

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO3 understand how to reduce energy waste	**AC3.1** describe information required to complete an energy audit	**Purpose of an energy audit** • analysis • prioritise actions **Information** • construction • insulation • energy supplier and consumption • typical use
	AC3.2 explain how energy is lost in a system	**Systems** • power generation systems • devices e.g. refrigerators, electronic systems • buildings
	AC3.3 evaluate ways to reduce energy loss in a system	**System** • power generation systems • devices e.g. refrigerators, electronic systems • buildings **Evaluation** • effectiveness • cost • environmental impact of measures

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 be able to investigate energy transfer	**AC4.1** plan to collect energy transfer data	**Plan** • information required • procedures and equipment • timescales and sequencing of activities • proforma to record data
	AC4.2 prepare equipment to measure energy transfers	**Equipment** • relevant measuring devices and meters • relevant connection equipment (e.g. connecting wires) **Preparation** • check equipment (e.g. damage, low battery) • set up equipment e.g. • selecting correct connections • selection of appropriate range and units • zeroing
	AC4.3 obtain data relating to energy transfers	**Data** • primary data **Primary data** • data relevant to energy use • data relevant to generation/consumption electricity • data relevant to heat loss from systems (e.g. buildings - window area etc.) **Follows safe working practice**
	AC4.4 record data	**Recording documentation** • laboratory notebook • proforma • LMS/database **Records** • all key information recorded • data recorded to correct precision • entries legible

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 *continued*	**AC4.5** process data using numerical methods	**Data** • primary data, secondary data **Primary data** • defined in AC4.3 **Secondary data** • power • capacity/volume • specific heat capacity • specific latent heat • density • thermal conductivity • U-values **Numerical methods** • record raw data to appropriate significant places • process data using mathematical equations • presentation of calculations • use of significant figures in calculations
	AC4.6 interpret graphic information showing energy transfer	**Graphic information** • graphs • Sankey diagrams **Graphs** e.g. • electrical characteristics (VI graphs) • solar power graphs • temperature-time graphs **Sankey diagrams** • energy flow through systems • efficiency of systems • effect of changing efficiency on energy flow

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 *continued*	**AC4.7** evaluate data and procedures	**Evaluation** • quality of data • effectiveness of procedures **Evaluates in terms of** • accuracy (‘trueness’) • precision • repeatability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO5 be able to report on sustainability	**AC5.1** present data in tables	**Tables** • style, effectiveness, information contained (data, units)
	AC5.2 present data in graphs	**Graphs** • size, scale • labels: titles, axis labels, key, units, captions • relevant best fit lines/curves • using software and handwritten
	AC5.3 present data in Sankey diagrams	**Sankey diagrams** • drawn to scale • software, hand
	AC5.4 make recommendations on energy sustainability	**Sustainability** • energy generation systems • systems to improve efficiency of energy use **Recommendations** *Based upon:* • evidence • cost • practicality • effectiveness, improved efficiency, reduction in dependence on unrenewable energy sources

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO5 *continued*	**AC5.5** communicate outcome of investigation	**Reporting style** • technical and scientific language • clarity • language style • spelling, punctuation and grammar • structure of report **Communication method** • written

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO1 know principles of sustainable energy	**AC1.1** describe the concept of sustainable energy	Gives a description of some aspects of the concept of sustainable energy 1	Gives a mainly clear description of the concept of sustainable energy 2-3	Gives a clear and detailed description of the concept of sustainable energy *4*
	AC1.2 describe drivers of sustainable energy	Gives a description of some drivers of sustainable energy 1-2	Gives a mainly clear description of significant drivers of sustainable energy *Some parts may be in detail* 3-4	Gives a clear and detailed description of a range of drivers, including significant drivers, of sustainable energy 5-6
LO2 understand principles of energy	**AC2.1** describe fundamental concepts relating to energy	Gives a description of some fundamental concepts relating to energy 1-3	Gives a mainly clear description of a range of fundamental concepts relating to energy *Some concepts are described in detail* *4-6*	Gives a clear and detailed description of a range of fundamental concepts relating to energy 7-9
	AC2.2 explain energy transfer using scientific concepts	Gives an explanation of energy transfer using some relevant scientific concepts *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of energy transfer using mostly relevant scientific concepts *3-4*	Gives an accurate and coherent explanation showing detailed reasoning of energy transfer using relevant scientific concepts 5-6
	AC2.3 explain how electrical energy can be generated	Gives an explanation of how electrical energy is generated *Low level explanations may not always clearly show reasoning* 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how electrical energy is generated 4-6	Gives an accurate, detailed and coherent explanation showing detailed reasoning of how electrical energy is generated 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO3 understand how to reduce energy waste	**AC3.1** describe information required to complete an energy audit	Gives a description of some information required for an energy audit 1-2	Gives a mainly clear description of the significant information required for an energy audit *Some parts are in detail* 3-4	Gives a clear and detailed description of the significant information required for an energy audit 5-6
	AC3.2 explain how energy is lost in a system	Gives an explanation of ways in which energy is lost in a system *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of ways in which energy is lost in a system 3-4	Gives an accurate and coherent explanation with detailed reasoning of ways in which energy is lost in a system 5-6
	AC3.3 evaluate ways to reduce energy loss in a system	Makes some suitable judgements of ways to reduce energy loss from a system *Low level evaluations may not always clearly show reasoning* 1-3	Makes mainly suitable judgements with some clear reasoning of significant ways to reduce energy loss from a system 4-6	Makes suitable judgements with clear and detailed reasoning of significant ways to reduce energy loss from a system *7-9*

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO4 be able to investigate energy transfer	**AC4.1** plan to collect energy transfer data	Identifies some information to collect identifies some appropriate procedures and equipment to collect information Sets some achievable times to complete some aspects of the plan Devises a proforma to collect some suitable information 1-3	Identifies most information to collect identifies mainly appropriate procedures and equipment to collect information Sets achievable times to complete most aspects of the plan Devises a mainly suitable proforma to collect most required information *4-6*	Identifies the information to collect Identifies appropriate procedures and equipment to collect the information Sets achievable times to complete all aspects of the plan Devises a suitable proforma to collect all the required information 7-9
	AC4.2 prepare equipment to measure energy transfers	Prepares equipment for use *There may be some errors in the preparation of equipment* 1	Correctly prepares equipment for use 2	
	AC4.3 obtain data relating to energy transfers	Obtains some suitable data Some data is obtained is within expected tolerance of instruments/ procedures used to obtain data 1-2	Obtains mainly suitable and sufficient data Most data is obtained is within expected tolerance of instruments/ procedures used to obtain data *3-4*	Obtains suitable and sufficient data Consistently obtains data within expected tolerance of instruments/ procedures used to obtain data 5-6

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO4 *continued*	**AC4.4** record data	Most key data is recorded Entries are generally legible Some data recorded to appropriate precision 1	All key data is recorded Most entries are legible Most data recorded to appropriate precision 2	All key data is recorded All entries are legible All data recorded to appropriate precision 3
	AC4.5 process data using numerical methods	Uses some suitable numerical methods to process data Lays out some aspects of workings Makes a limited use of significant figures 1-2	Uses suitable numerical methods to mostly accurately process data Lays out most workings clearly and logically Makes some appropriate and accurate use of significant figures 3-4	Consistently uses suitable numerical methods to accurately process data Consistently lays out workings clearly and logically Consistently makes appropriate and accurate use of significant figures 5-6
	AC4.6 interpret graphic information showing energy transfer	Makes some appropriate interpretation of graphical information 1-2	Makes a mostly accurate and appropriate interpretation of graphical information *Some parts are in detail* 3-4	Makes an accurate, appropriate and detailed interpretation of graphical information 5-6
	AC4.7 evaluate data and procedures	Gives an appropriate evaluation of some aspects of the data and procedures *Evaluation may be weighed towards data or procedures* 1-2	Gives a mostly clear and accurate evaluation of a range of aspects of the data and procedures 3-4	Gives a clear, detailed and accurate evaluation of a range of aspects of the data and procedures 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO5 be able to report on sustainability	**AC5.1** present data in tables	Tables are used to present data Some correct headings, symbols and units are used 1	Mostly suitable tables are used to present data Mostly correct headings, symbols and units are used 2	Suitable tables are used to clearly present data Correct headings, symbols and units are used 3
	AC5.2 present data in graphs	Some suitable graph styles are used Mostly suitable sizes and scales are used to construct graphs Graphs have some correct labelling Draws a line of best fit which takes into account some data 1-2	Suitable graph styles are used Suitable sizes and scales are consistently used to construct graphs Graphs are mostly fully and correctly labelled Draws a line of best fit with some accuracy taking into account the data 3-4	Suitable graph styles are used Suitable sizes and scales are consistently used to construct graphs Graphs are consistently fully and correctly labelled Accurately determines a line of best fit taking into account the data 5-6
	AC5.3 present data in Sankey diagrams	Constructs some appropriate Sankey diagrams from data with some accuracy 1	Constructs mainly appropriate and accurate Sankey diagrams from data 2	Consistently constructs appropriate and accurate Sankey diagrams from data 3
	AC5.4 make recommendations on energy sustainability	Makes some suitable recommendations with some reference to data/evidence to support the recommendation 1-2	Makes suitable recommendations with mostly suitable reference to data/evidence to support the recommendations 3-4	Makes suitable recommendations with suitable and detailed reference to data/evidence to support the recommendations 5-6

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO5 *continued*	**AC5.5** communicate outcome of investigation	Communicates some information from the investigation Uses some appropriate scientific and technical language Use some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information from the investigation Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information from the investigation Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places involved with the generation of electricity (conventional power stations; renewable energy sites etc.)
- arranging talks by visiting speakers from companies involved with the generation of electricity, energy conservation, Environmental Science/Physics/Engineering departments at local HE establishments etc.
- arranging a visit to an energy efficient building

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of managing energy.

Example 1

An engineer from a local renewable energy generation company (wind farm, solar panel farm, HEP station) could discuss with candidates the issues associated with siting the generation facility where it is. Candidates could make a site visit and take measurements/photos of the facility and write a short report on their findings.

Example 2

Candidates could visit a local energy efficient building or a building where the management of energy is important, for example a local swimming pool or sports centre. The candidates could talk to the facilities manager/engineer about how energy is managed throughout the building and how the energy bills are minimised. Candidates could write a short report about their findings.

Example 3

A local heating engineer could visit and talk to candidates about the sorts of modern hot water boilers that are available on the market, and how they are manufactured to be so efficient. The engineer could also talk about and show samples of insulation materials and systems that can be retro-fitted to buildings to increase their energy efficiency. Candidates could write a short report on their findings.

Making Contacts

Examples of organisations that may be approached to provide help include:

- National energy companies – most of whom can be contacted through their trade association - energy-uk.org.uk
- National Renewable Energy companies – most of which can be contacted through their trade association - renewableuk.com
- The Energy Saving Trust-energysavingtrust.org.uk
- Department of Energy and Climate Change (DECC) – https://www.gov.uk/government/organisations/department-of-energy-climate-change

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Websites

Energy sustainability

http://en.wikipedia.org/wiki/Sustainable_energy

http://www.rsc.org/science-activities/sustainable-energy/

http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/introduction-sustainable-energy/content-section-0

http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/energy-resources-wind-energy/content-section-0

Solar power output activity

http://heliotronics.com/papers/SPGraphs_rev4.pdf

Energy audit

http://energyauditinstitute.com/energy-audits.html

Sankey Diagrams

http://ipodphysics.com/sankey-diagrams-work.php

http://www.sankey-diagrams.com/tag/energy-efficiency/

http://appsci.tinopolis.com/contents/?article=7

http://www.doka.ch/sankey.htm

http://www.foe.co.uk/news/up_in_smoke_graphic_36417

Fundamental Concepts

http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html#c1
http://en.wikipedia.org/wiki/R-value_(insulation)

http://www.thermalcalconline.com/

Concepts of evidence

http://community.dur.ac.uk/rosalyn.roberts/Evidence/CofEv_Gott%20et%20al.pdf

Unit 2 The living environment and conservation

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of biodiversity, interdependence of organisms and conservation. Learners investigate key environmental concepts, and develop the skills needed to monitor ecosystems and to know how various agencies work for the protection of the environment.

The unit will enable the learners to acquire knowledge and understanding of the interrelationships within ecosystems, how they are affected by human activity and how they may be conserved. Learners will also develop skills to monitor and measure the effect these influences are having.

Unit introduction

How do living and non-living factors interact within an ecosystem? Why have ecosystems developed in the way they have? How has human activity impacted on ecosystems? Does all human activity have to be negative? Can we conserve the environment for future generations? How can ecosystems be monitored? This unit helps provide you with the skills to understand and carry out assessment of ecosystems.

Environmental scientists need to understand the relationship between living and non-living factors on the environment. An understanding of how we as humans affect the planet on which we live is fundamental for developing more sustainable ways of living. Environmental scientists work for government agencies, universities and private companies. Environmental scientists usually begin their careers in the field; while more experienced workers will spend more time inside the office or laboratory. Some of the features which characterise the work of environmental scientists such as meeting deadlines, attention to detail, methodical approach and analytical thinking are important transferable skills, applicable in all aspects of life and work. They must also have good communication skills as liaison with other agencies is often necessary.

This unit is designed to help you to understand how an environmental biologist/scientist works so that you will be able to tackle problems and answer questions in an environmental context. You will be taught about how living and non-living factors are interdependent and how we, as humans have affected the delicate balance within ecosystems. You will learn how to measure species in their natural surroundings and the limitations of the techniques used. At the end of this unit you will have gained the relevant knowledge, understanding and practical techniques to analyse ecosystems.

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 understand the inter-relationships within ecosystems	**AC1.1** define an ecosystem	**Definition**
	AC1.2 explain energy transfers between organisms in an ecosystem	**Energy transfers** • producers, primary consumers, secondary consumers, tertiary consumers, decomposers • role of photosynthesis • energy losses from food chains • efficiency of energy transfer between trophic levels • gross and net production • pyramids of number, biomass and energy
	AC1.3 explain the role of decomposers in ecosystems	**Decay, nitrogen and carbon cycles** • requirements for decay • decomposers • nitrogen fixation • nitrification • denitrification
	AC1.4 explain how factors affect ecosystem populations	**Factors** • biotic factors e.g. inter-specific and intra-specific competition, predation, mutualism, commensalism, immigration and emigration, density dependent and independent factors, birth and death rate • abiotic factors e.g. sunlight, temperature, soil, water, height and pressure • carrying capacity
	AC1.5 analyse patterns in population data	**Patterns in population data** • lag phase • log/exponential phase • stationary phase • decline phase

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 *continued*	**AC1.6** describe how variation within a species brings about change	**Variation and change** • natural selection and evolutionary change • outline how variation, adaptation and natural selection relate to evolution • role of mutations in causing change (egg. MRSA, peppered moth, Warfarin resistance in rats) • supporting evidence (e.g. DNA, fossil evidence, molecular evidence) • relationship between phylogeny and classification
	AC1.7 explain the process of succession	**The process of succession** • primary succession • secondary succession • pioneers • sere • climax community

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO2 understand how human activity impacts on ecosystems	**AC2.1** describe human activity in an environment	**Types of human activity:** • agricultural practices • fishing methods • forestation / deforestation • mining / industrial activity including historical activity • development (road construction, housing and shopping developments, recreational developments (e.g. golf courses)) • management of grass areas (e.g. frequently cut, mowed, managed) • conservation programmes
	AC2.2 explain how human activity affects ecosystems	**Human activity** • agricultural practices e.g. o intensive methods (e.g. pesticide and insecticide use, use artificial fertilisers) o traditional and organic methods farming • forestation / deforestation • mining / industrial activity e.g. o impacts waste on the environment (soil, waterways) • development (road construction, housing and shopping developments, recreational developments (e.g. golf courses)) e.g. habitat loss • conservation programmes Explanation in terms of how activity affects ecosystems

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO3 understand how ecosystems can be conserved	**AC3.1** describe what is meant by conservation	**Conservation** • definition
	AC3.2 explain why conservation of ecosystems is necessary	**Reasons** • environmental • aesthetic • ethical • social • economic
	AC3.3 describe different conservation methods	**In-situ conservation** • habitat protection or cleaning • environmental preservation • defending the species from predators. **Ex-situ conservation** • e.g. colony relocation, human care, captive breeding and release programmes, seed banks, crypopreservation **Preservationist method** • non-interference **Mechanisms** • legal protection e.g. The Wildlife & Countryside Act (1981 & 1984) • protected environments e.g. Protected Sites of Special Scientific Interest (SSSIs), National Nature Reserves, National Parks) • trade controls e.g. CITES
	AC3.4 explain the reasons for extinction	**Reasons for extinction** • habitat degradation/loss • predation • competition • disease • genetics and demographics • climate change

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 be able to monitor ecosystems	**AC4.1** plan to obtain data about ecosystems	**Plan** • information required • procedures and equipment • timescales and sequencing of activities • proforma to record data **Select appropriate techniques to gather data** • random sampling using quadrats • use of belt transects to record changes in species distribution • identifying species, • appropriate classification of species • numbers of each species • measuring species density and percentage cover • use of abundance scales and their limitations • equipment to measure pH, temperature
	AC4.2 draw up a health and safety risk assessment	**Risk assessment** • hazards and risks • people at risk • control measures • documentation
	AC4.3 obtain data about ecosystems	**Data** • primary data **Primary data e.g.** • number of individual species • abundance of invertebrates (as indicators of water quality) • abundance of lichens (as indicators of air quality) • pH, temperature
	AC4.4 record data from ecosystems	**Data e.g.** • species found, number of individual species • abundance of invertebrates, lichens • pH, temperature **Records** • all key information recorded • data recorded to correct precision **Format recording** • tables

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 *continued*	**AC4.5** process data from investigations	**Numerical methods processing data** • estimating population sizes using: $\frac{n_1 \times n_2}{n_m}$ • Simpsons index of biodiversity $D = \frac{N(N-1)}{\Sigma n(n-1)}$ where N = total number of organisms of all species and n = total number of organisms of a particular species • Statistical methods to compare populations (t- test) **Graphical methods processing data** • charts • graphs, trends, trend lines
	AC4.6 assess how human activity has affected an ecosystem	**Assessment based upon** • primary and secondary data o evenness, richness of biodiversity o population sizes o significance of high and low values of Simpsons index of Diversity (D) o t-test analysis o comparison with data from other sites
	AC4.8 evaluate data and procedures	**Evaluates** • quality of data • effectiveness of procedures **Evaluates in terms of** • repeatability • reliability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO1 understand the inter-relationships within ecosystems	**AC1.1** define an ecosystem	Gives a definition of an ecosystem 1-2	Gives a detailed description of an ecosystem 3	
	AC1.2 explain energy transfers between organisms in an ecosystem	Gives an explanation of how energy is transferred between organisms with some accuracy *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how energy is transferred between organisms 3-4	Gives an accurate and coherent explanation showing detailed reasoning of how energy is transferred between organisms 5-6
	AC1.3 explain the role of decomposers in ecosystems	Gives an explanation of the role of decomposers in ecosystems with some accuracy *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the role of decomposers in ecosystems 3-4	Gives an accurate, detailed and coherent explanation of the role of decomposers in ecosystems 5-6
	AC1.4 explain how factors affect ecosystem populations	Gives an explanation of how some factors affect biodiversity *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how a range of factors affect biodiversity 3-4	Gives an accurate, detailed and coherent explanation of how a range of factors affect biodiversity 5-6
	AC1.5 analyse patterns in population data	Makes some appropriate analysis of population data 1-2	Makes a mostly appropriate analysis of population data showing some detailed reasoning 3-4	Makes an appropriate analysis of population data showing detailed reasoning 5-6
	AC1.6 describe how variation within a species brings about change	Gives a description of some aspects of how variation within a species brings about change 1-2	Gives a mainly clear description of how variation within a species brings about change *Some parts are in detail* 3-4	Gives a clear and detailed description of how variation within a species brings about change 5-6
	AC1.7 explain the process of succession	Gives an explanation of the process of succession with some accuracy *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the process of succession 3-4	Gives an accurate and coherent explanation showing detailed reasoning of the process of succession 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO2 understand how human activity impacts on ecosystems	**AC2.1** describe human activity in an environment	Gives a description of some human activities in an environment. *Some aspects of the description is relevant to the environment studied* 1-2	Gives a clear, detailed and relevant description of human activities in an environment. *The description is relevant to the environment studied* 3-4	
	AC2.2 explain how human activity affects ecosystems	Gives an explanation of how human activity affects an ecosystem *Low level explanations may not always clearly show reasoning* 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how human activity affects an ecosystem 4-5	Gives an accurate and coherent explanation showing detailed reasoning of how human activity affects an ecosystem 6-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO3 understand how ecosystems can be conserved	**AC3.1** describe what is meant by conservation	Gives a mostly clear description of what is meant by conservation 1-2	Gives a clear and detailed description of what is meant by conservation 3-4	
	AC3.2 explain why conservation of ecosystems is necessary	Gives an explanation of why conservation of ecosystems is necessary *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning why conservation of ecosystems is necessary 3-6	Gives an accurate and coherent explanation showing detailed reasoning why conservation of ecosystems is necessary 7-9
	AC3.3 describe different conservation methods	Gives a description of some appropriate methods of conservation 1-2	Gives a mainly clear description of appropriate methods of conservation *Some parts are in detail* 3-4	Gives a clear and detailed description of appropriate methods of conservation 5-6
	AC3.4 explain the reasons for extinction	Gives an explanation of some relevant reasons for extinction *Low level explanations may not always clearly show reasoning* 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of relevant reasons for extinction 4-6	Gives an accurate and coherent explanation showing detailed reasoning of relevant reasons for extinction 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO4 be able to monitor ecosystems	**AC4.1** plan to obtain data about ecosystems	Identifies some information to collect Identifies some appropriate procedures and equipment to collect information Sets some achievable times to complete some aspects of the plan Devises a proforma to collect some suitable information 1-2	Identifies most information to collect Identifies mainly appropriate procedures and equipment to collect information Sets achievable times to complete most aspects of the plan Devises a mainly suitable proforma to collect most required information 3-4	Identifies the information to collect Identifies appropriate procedures and equipment to collect the information Sets achievable times to complete all aspects of the plan Devises a suitable proforma to collect all the required information 5-6
	AC4.2 draw up a health and safety risk assessment	Identifies some hazards and risks to health and safety Suggests some suitable control measures Records some parts of risk assessment accurately 1-2	Identifies significant hazards and risks to safety. Suggests some suitable control measures for significant hazards and risks to health and safety Records most aspects of the risk assessment accurately and clearly 3-4	Identifies the significant hazards and risks to safety. Suggests suitable control measures for hazards and risks to health and safety Records clearly and accurately the risk assessment 5-6
	AC4.3 obtain data about ecosystems	Obtains some suitable data about ecosystems Some data is obtained is within expected tolerance of procedures used to obtain data 1-2	Obtains mostly suitable and sufficient data about ecosystems Most data is obtained is within expected tolerance of procedures used to obtain data 3-4	Obtains suitable and sufficient data about ecosystems Consistently obtains data within expected tolerance of procedures used to obtain data 5-6

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO4 *continued*	**AC4.4** record data from ecosystems	Some key data is recorded Entries are generally legible Some data recorded to appropriate precision Some records are clear 1	Most key data is recorded Most entries are legible Most data recorded to appropriate precision Records are mostly clearly and logically presented 2-3	key data is recorded All entries are legible All data recorded to appropriate precision Records are clearly and logically presented 4
	AC4.5 process data from investigations	Uses some suitable methods to process data Some aspects of graphs/calculations are clearly presented Makes a limited use of significant figures 1-2	Uses suitable methods to mostly accurately process data Graphs/calculations are mostly clearly and logically presented Makes some appropriate and accurate use of significant figures 3-4	Consistently uses suitable methods to accurately process data Graphs/calculations are clearly and logically presented Consistently makes appropriate and accurate use of significant figures 5-6
	AC4.6 assess how human activity has affected an ecosystem	Gives an assessment of how human activity has affected biodiversity with reference to a limited range of relevant factors, with some reasoned judgements 1-2	Gives an assessment of how human activity has affected biodiversity with reference to relevant factors, with mainly reasoned judgements *Some parts are in detail* 3-4	Gives a detailed assessment of how human activity has affected biodiversity with reference to a range of relevant factors, with reasoned judgements 5-6
	AC4.7 evaluate data and procedures	Makes some suitable judgements about data and procedures some *Evaluation may be weighed towards data or procedures* 1-2	Makes mainly suitable judgements showing clear reasoning about data and procedures against a range of criteria 3-4	Makes suitable judgements showing clear and detailed reasoning about data and procedures against a range of criteria 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is externally assessed by an assignment provided by WJEC annually in September of each academic year. This assignment will be downloadable from the WJEC secure website. Further information about the assessment of this unit can be found in **section 3.1.1** of the specification.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- Arranging visits to universities with environmental Science courses
- Visits to and from companies, agencies and organisations involved with managing the environment and environmental issues. E.g. Governmental and non-governmental agencies linked to AONBs (Areas of Outstanding Natural Beauty), National Parks, Nature Reserves, SSSIs (Sites of Special Scientific Interest), Environmental Agency
- Visits to AONBs, National Parks, SSSIs to conduct fieldwork

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the living environment and conservation.

Example 1

Council representatives (e.g. from planning departments) could be invited to speak about environmental impact assessments. They could focus on the role of councils in development planning, conservation areas, ecology and landscapes. Discussion could focus around the need to balance the requirements for food, attitudes of people towards economic development and the needs of wildlife.

Example 2

A representative from a conversation group could be invited to speak about issues associated with trying to conserve species biodiversity.
For example, a proposed cull of badgers in order to reduce the spread of bovine TB. This could be followed up by learners presenting arguments for and against the proposed cull. There are numerous such issues which apply to various regions of the UK.

Example 3

Learners could visit a farm to see how human's need for food is balanced with the needs of wildlife. Learners could discuss the restrictions that apply within the farming community and issues associated with trying to reduce 'food miles'. Other issues may also be addressed depending on the farm, for example how cloning techniques may be used in plants and animals and the impact of cloning on reduction of variation.

Example 4

Representatives from the highways agency could be invited to speak or if possible learners could visit certain road building projects. They could discuss the issues surrounding destruction of habitat and how biodiversity is conserved (e.g. the construction of 'dormouse bridges' across roads). As a follow up, learners could plan their own 'road system' which balances our need for economic development with the needs of wildlife.

Making Contacts

Examples of organisations that may be approached to provide help include:

Environmental Agency

County councils (e.g. refuse collection)

Biology departments of universities

Conservation bodies

Specialist environmental laboratories

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks
There are a number of A-level Biology textbooks that can be used as a resource for this unit. Examples include
New Understanding Biology for Advanced Level (G Toole and S Toole) (4th Edition)
Advanced Biology (G Monger, M Reiss and M Roberts)

Websites

Thinkquest – lots of information on interdependence
http://library.thinkquest.org/11353/ecosystems.htm

Natural Selection simulation
http://www.biologyinmotion.com/evol/index.html

Biozone – numerous resources for the study of evolution, human impact on the environment, interdependence
http://www.thebiozone.com/links.html

Communities.gov.uk – an information resource for teachers regarding environmental impact assessments and planning
http://www.communities.gov.uk/publications/planningandbuilding/environmentalimpactassessment

Practical Biology – linked to the Society of Biology and Nuffield Curriculum Centre
www.practicalbiology.org

SEP (Science Enhancement Programme)
www.sep.org.uk

Biotechnology and Biological Sciences Research Council - many resources for teachers and student activities to teach this unit
http://www.bbsrc.ac.uk/

Natural Environment Research Council – numerous resources, probably more for teachers than learners
http://www.nerc.ac.uk/site/guides/schools.asp

The Habitable planet – simulations of effects different factors on populations
http://www.learner.org/courses/envsci/interactives/index.php

Unit 3 Monitoring our physical environment

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of how analytical science is used to gather information about our physical environment. The unit will develop an understanding of chemical testing methods, including instrumental methods of analysis that are used by analytical scientists who study the environment.

The unit will enable the learners to gain the skills necessary to carry out and analyse samples collected from a variety of environmental sources. Candidates will also learn how to draw evidence based conclusions from the outcome of their analysis.

Unit introduction

How clean is the water that you drink? How can we determine what is present in river water? What pollutants may it contain and what is the concentration? How do we know if nitrates are being washed into river water from agricultural land? Does a gas flare from an oil rig contaminate crops with fall out of organic matter? How can we test to find the concentration of heavy metals contained in soil or sediment? This unit helps provide you with the analytical skills to understand and carry out these forms of environmental analysis.

Analytical scientists are employed within the environmental science sector by organisations such as the Environmental Agency, the National Laboratory Service and National Resources Wales, water companies as well as many independent analytical laboratories. Many of the skills that are developed by analytical scientists such as; challenging assumptions, attention to detail and methodical approaches are important transferable skills which are applicable in all aspects of life and work. This means the skills that analytical scientists gain also makes them ideal employees to work in sectors outside Environmental Science.

This unit is designed to help you understand the way in which an analytical scientist works so that you will be able to tackle problems and answer questions in an environmental context. You will be taught how to solve problems by working in a logical and systematic way, and to think critically about the limitations of the results you obtain from your analysis. You will learn the necessary practical and analytical skills and techniques to enable you to carry out an environmental investigation, make deductions and communicate your findings.

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO1 understand chemical notation	**AC1.1** describe families of organic molecules	**Families** • functional groups • aromatic compounds **Functional groups** • alkanes • alkenes • phenyls • alcohols • phenols • aldehydes • ketones • carboxylic acids **Methods of describing families of organic molecules** • functional group names • molecular formulae • structural formulae • aliphatic / aromatic **Aromatic compounds** • benzene, polycyclic aromatic hydrocarbons (PAH)
	AC1.2 interpret representations of organic molecules	**Representations of organic molecules** • molecular formula • structural formulae • full displayed structural formulae • skeletal formulae
	AC1.3 represent inorganic chemical species using chemical notation	**IUPAC nomenclature of inorganic species** • ions • compounds (e.g. Use of roman numerals where a metal may have more than one oxidation state, spelling of species containing sulfur)
	AC1.4 represent reactions using balanced chemical equations	**Balanced chemical equations** • full symbol equations • ionic equations • use of state symbols

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO2 understand principles of environmental analysis	**AC2.1** explain choice of methods used in analysis	**Methods** • sampling and analytical procedures **Sampling procedures** *Choice in terms of:* • representative sampling • sufficiency (Will the sampling method yield sufficient data) • storage of samples (Does the method of storing samples affect the sample?) **Sampling from** • atmosphere, waterways, soil, organic matter **Analytical procedures** *Choice in terms of:* • nature of information required (quantitative, qualitative) • nature of sample • **limitations** of the procedure **Analytical procedures** • chromatographic, instrumental, volumetric, chemical testing
	AC2.2 explain how mixtures are separated by chromatographic methods	**Chromatographic methods** • thin layer chromatography • gas chromatography • high performance liquid chromatography
	AC2.3 explain how the absorption of radiation may be used in the analysis of samples	**Methods of analysis** • atomic absorption spectroscopy • colorimetry • ultraviolet spectroscopy, ultraviolet detectors in gc/hplc **Types of samples** • samples contain metal ions • samples containing chromophores
	AC2.4 explain principles used in volumetric analysis	**Volumetric analysis** • acid-base titration • redox titration

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO3 be able to obtain analytical data on the physical environment	**AC3.1** plan to collect environmental samples	**Plan** • suitable sampling points (accessibility, safety & ease of access, alternatives) • equipment for collecting sample • equipment for storing and transporting sample
	AC3.2 label samples for analysis	**Labelling of samples** • indelible pen • date/time • location • weather conditions
	AC3.3 prepare for volumetric analysis	**Preparation** • selects appropriate equipment • check equipment (damage, cleanliness) **Equipment** • volumetric equipment
	AC3.4 obtain data using volumetric equipment	**Volumetric equipment** • balance • volumetric flasks • burette • pipette • using indicator, pH meter **Data** • endpoint • mean titre
	AC3.5 obtain data using an instrumental form of analysis	**Instrumental methods** • electrodes (e.g. pH, ion-selective) • spectroscopic (e.g. colorimeter, UV spectroscopy)

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO3 *continued*	**AC3.6** obtain data using qualitative techniques	**Qualitative techniques** • thin layer chromatography • flame tests • chemical testing • negative ions (halides, hydroxides, sulphates, sulphides, nitrates, carbonates) • cations including NH_4^+ ions • functional groups (alcohols, aldehydes, ketones, carboxylic acids, esters, phenols, amines • distinguishing aromatic and aliphatic compounds • melting point
	AC3.7 follow safe working practice	**Safe working practice** • works in accordance with risk assessment and laboratory requirements • correctly uses PPE • maintains tidy working area
	AC3.8 record experimental work	**Recording method** • laboratory notebook • proforma • laboratory information management systems **Records** • all key information recorded (sample identification/date/experimental details (e.g. mass used, titres etc.) • data recorded to correct precision • entries legible

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 be able to process analytical data	**AC4.1** process data using graphical methods	**Instrumental methods** • ion selective electrodes • pH meters • gas chromatography/high performance chromatography • colorimetry • ultraviolet spectroscopy • atomic absorption **Graphs** • pH curves • calibration curves **Graphical drawing methods** • by hand • using software (e.g. Excel/ graphical package) **Uses graphs to find** **e.g.** • endpoint • concentrations (units e.g. mol dm^{-3}, ppm)
	AC4.2 calculate concentrations	**Concentration calculations** • determine concentration of standard solutions • calculate concentrations (e.g. from volumetric data)
	AC4.3 interpret retention data from chromagraphic analysis	**Chromagraphic analysis** • paper/thin layer chromatography • GC/HPLC **Data** • retention factor (R_f value) • retention time
	AC4.4 interpret data from qualitative analysis	**Qualitative analysis** • wet testing (flame tests etc.) • functional group tests
	AC4.5 use significant figures	**Significant figures** • records raw data to appropriate number of significant places (mass readings, titration results, instrument readings) • manipulates results to appropriate number decimal places

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO5 be able to report on investigations	**AC5.1** present data in tables	**Tables** • style • effectiveness • information contained (data, units)
	AC5.2 draw evidence based conclusions	**Evidence based conclusions** • comparison of results with secondary data • conclusions based upon data • limitations of data
	AC5.3 evaluate data and procedures	**Evaluation** • quality of data • effectiveness of procedures **Evaluates in terms of** • accuracy ('trueness') • precision • repeatability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed
	AC5.4 communicate information from investigation	**Reporting style** • technical and scientific language • clarity • language style • structure of report • use of ICT **Communication method** • written

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO1 understand chemical notation	**AC1.1** describe families of organic molecules	Uses some methods to describe some families of organic molecules 1	Uses some methods, including functional group names and molecular formulae, to accurately describe a range of families of organic molecules 2-3	Uses a wide range of methods to accurately describe a range of families of organic molecules 4
	AC1.2 interpret representations of organic molecules	Interprets some representations of organic molecules correctly 1	Correctly interprets most representations of organic molecules 2	Consistently interprets representations of organic molecules correctly 3
	AC1.3 represent inorganic chemical species using chemical notation	Uses chemical notation to represent some inorganic species correctly 1	Consistently uses chemical notation to represent inorganic species correctly 2	
	AC1.4 represent reactions using balanced chemical equations	Uses balanced equations to represent some reactions Makes a limited use of state symbols *Evidence may be weighed to full symbol or ionic equations* 1	Uses accurate balanced equations to represent reactions Makes use of state symbols *Evidence of both full symbol and ionic equations* 2-3	Consistently uses accurate balanced equations to represent reactions Consistently makes an accurate use of state symbols *Evidence includes both full symbol and ionic equations* 4

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO2 understand principles of environmental analysis	**AC2.1** explain choice of methods used in analysis	Gives an explanation for the choice of methods used in analysis *Explanation may be weighed to sampling or analytical techniques used* *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the choice of methods used in analysis *Explanation may be weighed to sampling and analytical techniques used* 3-4	Gives an accurate and coherent explanation showing detailed reasoning of the choice of methods used in analysis *Explanation covers sampling and analytical techniques used* 5-6
	AC2.2 explain how mixtures are separated by chromatographic methods	Gives an explanation of how separation is achieved *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how separation is achieved 3-4	Gives an accurate and coherent explanation showing detailed reasoning of how separation is achieved 5-6
	AC2.3 explain how the absorption of radiation may be used in the analysis of samples	Gives an explanation of how radiation is used in the analysis of samples *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how radiation is used in the analysis of samples 3-4	Gives an accurate and coherent explanation showing detailed reasoning of how radiation is used in the analysis of samples 5-6
	AC2.4 explain principles used in volumetric analysis	Gives an explanation of the principles of volumetric analysis *Low level explanations may not always clearly show reasoning* 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the principles of volumetric analysis 3-4	Gives an accurate and coherent explanation showing detailed reasoning of the principles of volumetric analysis 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO3 be able to obtain analytical data on the physical environment	**AC3.1** plan to collect environmental samples	Identifies some appropriate procedures and equipment to collect and transport samples Identifies access point for collecting sample 1	Identifies mostly appropriate procedures and equipment to collect and transport samples Identifies a suitable access point for collecting sample 2	Identifies appropriate procedures and equipment to collect and transport samples Identifies suitable access points for collecting sample 3
	AC3.2 label samples for analysis	Labels samples with some key information 1	Labels samples with all key information 2	
	AC3.3 prepare for volumetric analysis	Collects equipment required for analysis 1	Collects all the appropriate equipment for analysis Checks for cleanness/ damage 2	
	AC3.4 obtain data using volumetric equipment	Obtains three titres which are concordant. Three titres show max range of 0.50 cm^3 Mean titre is within 0.50 cm^3 of expected value 1-2	Obtains three titres which are concordant. Three titres show max range of 0.30 cm^3 Mean titre is within 0.30 cm^3 of expected value Reads burette to two decimal places 3-5	Obtains three titres which are concordant. Three titres show max range of 0.15 cm^3 mean titre is within 0.10 cm^3 of expected value Reads burette to two decimal places 6-7
	AC3.5 obtain data using an instrumental form of analysis	Obtains some suitable data using an instrument Some data obtained is within expected tolerance of procedures used to obtain data 1-2	Obtains mostly suitable and sufficient data using an instrument Most data obtained is within expected tolerance of procedures used to obtain data 3-4	Obtains suitable and sufficient data using an instrument Consistently obtains data within expected tolerance of procedures used to obtain data 5-6

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO3 *continued*	**AC3.6** obtain data using qualitative techniques	Obtains some suitable data using qualitative analysis 1-2	Obtains mostly suitable and sufficient data using qualitative analysis 3-4	Obtains suitable and sufficient data using qualitative analysis 5-6
	AC3.7 follow safe working practice	Maintains tidy working area at all times Works in accordance with risk assessment and laboratory requirements Uses PPE when required 1	Maintains tidy working area at all times Works in accordance with risk assessment and laboratory requirements without reminding or prompting Correctly uses PPE without reminding or prompting 2	Maintains tidy working area at all times Consistently works in accordance with risk assessment and laboratory requirements without reminding or prompting Correctly uses PPE without reminding or prompting 3
	AC3.8 record experimental work	Some experimental information recorded in compliance with laboratory and procedure requirements Most aspects of the records are legible Some data recorded to correct precision 1-2	Records experimental information in compliance with laboratory and procedure requirements Records are mostly complete and legible Most data recorded to correct precision 3-4	Records experimental information in compliance with laboratory and procedure requirements Records are complete and legible Data recorded to correct precision 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO4 be able to process analytical data	**AC4.1** process data using graphical methods	Mostly suitable sizes and scales are used to construct graphs Graphs have some correct labelling Most data is plotted accurately Draws a line of best fit which takes into account some data Obtains some appropriate information using graphical methods 1-2	Suitable sizes and scales are consistently used to construct graphs Graphs are mostly fully and correctly labelled All data is plotted accurately and clearly Draws a line of best fit with some accuracy taking into account the data Obtains mostly accurate and appropriate information using graphical methods 3-4	Suitable sizes and scales are consistently used to construct graphs Graphs are consistently fully and correctly labelled All data is plotted accurately and clearly Accurately determines a line of best fit taking into account the data Obtains accurate and appropriate information using graphical methods 5-6
	AC4.2 calculate concentrations	Correctly performs some steps in the calculation of concentrations Some aspects of calculations are clearly presented 1-2	Correctly performs most steps in the calculation of concentrations obtaining some correct values Calculations are mostly clearly and logically presented 3-4	Correctly performs all steps in the calculation of concentration obtaining correct values Calculations are clearly and logically presented 5-6
	AC4.3 interpret retention data from chromagraphic analysis	Correctly interprets some retention data from chromagraphic analysis 1	Correctly interprets all retention data from chromagraphic analysis 2	
	AC4.4 interpret data from qualitative analysis	Draws some valid inferences from qualitative data 1-2	Draws some valid inferences with reasoning from qualitative data 3-4	Draws valid inferences with clear and detailed reasoning from qualitative data 5-6
	AC4.5 use significant figures	Makes some appropriate use of significant figures 1	Makes a mostly appropriate use of significant figures 2	Makes a consistent and appropriate use of significant figures 3

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	**Assessment criteria**	**Performance bands**		
The learner will:	*The learner can:*	**Band 1**	**Band 2**	**Band 3**
LO5 be able to report on investigations	**AC5.1** present data in tables	Tables are used to present data Some correct headings, symbols and units are used 1	Mostly suitable tables are used to present data Mostly correct headings, symbols and units are used 2-3	Suitable tables are used to clearly present data Correct headings, symbols and units are used 4
	AC5.2 draw evidence based conclusions	Makes some simple and mostly appropriate conclusions based upon evidence Some conclusions are linked to the evidence by the learner 1-2	Makes valid conclusions based upon evidence *Some parts are in detail* The conclusions are clearly linked to the evidence by the learner 3-4	Makes valid and detailed conclusions that are based upon evidence The conclusions are clearly and logically argued from the evidence by the learner 5-6
	AC5.3 evaluate data and procedures	Gives an appropriate evaluation of some aspects of the data and procedures *Evaluation may be weighed towards data or procedures* 1-2	Gives a mostly appropriate evaluation of a range of aspects of the data and procedures 3-4	Gives an appropriate and detailed evaluation of a range of aspects of the data and procedures 5-6
	AC5.4 communicate information from investigation	Communicates some information from the investigation Uses some appropriate scientific and technical language Uses some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information from the investigation Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information from the investigation Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1.

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise that the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places with an analytical laboratory (e.g. water company NLS, NRW, local universities)
- arranging talks by visiting speakers from Environmental Agency, DEFRA, Environmental Science University departments, local HE establishments etc.
- arranging a visit to a sewage treatment plant

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of monitoring our physical environment.

Example 1

An Officer from the Environmental Agency could discuss with candidates the problems associated with contamination of drinking water by nitrates. It would be useful to link the problem to the use of fertilisers on agricultural land and rainfall washing the fertiliser into the streams. Candidates could take water samples before and after rainfall to see if there is any difference in the nitrate levels in a local area.

Example 2

A laboratory manager from the National Laboratory Service or National Resources Wales could be invited to explain how they monitor metals in water. They could explain how they analyse for a variety of different chemical species taken from water or soil samples. Samples of water from ponds and water ways in the area contaminated by copper mining could be mocked up for the learners to analyse using a colorimetric procedure. Candidates would then write a short report based upon their findings.

Example 3

A member of a local water company could give a talk on legislation relating to drinking water and how they monitor water to ensure that it is safe to drink. This could give rise to simple testing e.g. using a correctly calibrated pH meter to measure pH, measurement of chlorine and nitrates in water.

Example 4

A member of a local analytical company could describe how they test 'unknown' samples that may be illegally dumped. Candidates could then be given a problem of analysing a mocked up 'dumped drum' to find what it contains.

Making Contacts

Examples of organisations that may be approached to provide help include:

- Environmental Agency
- National Laboratory Service
- National Resources Wales
- Local Water Companies

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks/Reference books

Textbook of Qualitative Chemical Analysis (Vogel)

Websites

Volumetric analysis
http://www.labskills.co.uk/resources.php

Spectroscopic techniques (UV, Colorimetry, Atomic Absorption)
http://www.ausetute.com.au/spectros.html (summary of techniques)
http://www.ausetute.com.au/aas.html (Atomic Absorption)

Chromagraphic methods (Paper/TLC/HPLC/GC)
http://chromatographyscience.blogspot.co.uk/p/introduction-to-chromatography.html#.UcwVG_nVBqV (extensive documents linked to this site; accessible to level 3 learners)
http://www.youtube.com/watch?v=kz_egMtdnL4 (6 min RSC YouTube video HPLC aimed at schools & colleges)
http://www.youtube.com/watch?v=dffeiLgeKx8 (10 min YouTube introduction to gas chromatography)
http://www.files.chem.vt.edu/chem-ed/sep/chromato.html
http://www.chemguide.co.uk/analysis/chromatogrmenu.html

Calibration curves
http://lab-training.com/2013/01/03/how-to-make-a-calibration-curve-and-calculate-sample-concentrations-using-excel-video-tutorial/ (How to use excel to generate a calibration curve)

Miscellaneous

http://www.omega.co.uk/ppt/pptsc.asp?ref=WTS_SERIES Water quality strips

Unit 4 Scientific principles and the environment

WJEC unit entry code
Guided learning hours 90

Aim and purpose

This unit is assessed externally and is the synoptic assessment for the programme of study in units 1 to 3. This unit draws and builds upon the context and content from units 1 to 3 and the key scientific principles that undergird these units. This unit aims to widen the scope of assessment of these principles. Since the content of this unit is intimately connected with the content and context of units 1 to 3, it cannot be divorced from the delivery of these units. It is advisable for centres to ensure an integrated teaching programme of unit 4 with units 1 to 3.

Unit introduction

How can biology help us understand ecosystems? Can physics help us find environmentally friendly ways of extracting or using energy? How can an understanding of chemistry help us understand how chemicals interact with the biosphere? How can environmental science help us look after our environment?

Environmental science is a broad discipline which requires a sound understanding of biology, chemistry and physics. Environmental science focuses on the application of biological, chemical and physical principles to the study of the physical environment and the solution of environmental problems. Environmental Scientists therefore need to have a broad understanding of a range of scientific principles in order to make meaningful interpretations of what is happening in the environment.

In this unit, you will be using scientific principles to examine problems that face the environment and solutions that environmental science may help provide. This will involve you analysing data on the environment and using your understanding of scientific principles to make judgements about the validity of the data and what the data tells you about the state of the environment. This will involve you examining key biological, physical and chemical principles that underlie all environmental science. These scientific principles are intimately linked with the work that you study in units 1 to 3.

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 understand biological principles of environmental science	**AC1.1** explain the role of adenosine triphosphate in biological processes	**Adenosine triphosphate** (**ATP) structure** • written description of structure • diagrammatic representation of structure **The importance of ATP** • problem with uncontrolled release of energy • ATP as the gradual release of energy in small steps: immediate energy donor **ATP and ADP interchange** • conversion of ADP to ATP phosphorylation • forms of phosphorylation • endergonic reaction: amount of energy needed • hydrolysis of ATP to release energy: reaction and energy release • ATP is not stored **Advantages of ATP as an energy source** • only requires one enzyme • energy released in small amounts • common source of energy **The roles of ATP** • metabolic processes • active transport • movement • nerve transmission • synthesis of materials within cells • secretion

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 *continued*	**AC1.2** analyse how the stages of respiration contribute to energy production	**Stages of aerobic respiration** • glycolysis, link reaction, Krebs cycle, electron transport chain, summary diagram **Glycolysis** • diagrammatic representation of process (complete chemical formulae not required) • where this takes place • written description of process of glycolysis • link reaction • diagrammatic representation of process (complete chemical formulae not required) • where this takes place • written description of the link reaction • key terms: decarboxylation and dehydrogenation **Krebs cycle** • diagrammatic representation of process (complete chemical formulae not required) • where this takes place • function of Krebs cycle • overall production of ATP • written description of the Krebs cycle **Electron transport chain** • function of electron transport chain • where this takes place: advantages • summary of chemiosmotic theory • role of oxygen **Anaerobic respiration** • definition • fermentation

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 *continued*	**AC1.3** assess the importance of photosynthesis in ecosystems	**Process of photosynthesis** • diagrammatic representation • written summary of process: overall equation • plants and algae as main producers • where photosynthesis takes place • photosynthetic pigments **Light dependant reaction** • summary of reactions • non-cyclic photophosphorylation: written summary • cyclic photophosphorylation: written summary **Light independent reaction** • diagrammatic representation of Calvin cycle (complete chemical formulae not required) • sequence of events: Calvin cycle • written summary of process **Limiting factors** • principle of limiting factors: relevance to ecosystems • temperature, carbon dioxide concentration, light intensity
	AC1.4 explain how carbon is recycled in ecosystems	**Basis of the carbon cycle** • how carbon dioxide is added • photosynthesis re-use of carbon dioxide • production of food - primary producers-food webs • role of saprobionts • diagram of the cycle **Human activity effecting carbon recycling in ecosystems** • burning fossil fuels • deforestation

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO1 *continued*	**AC1.5** explain how nitrogen is recycled in ecosystems	**Basis of the nitrogen cycle** • flow of organic and inorganic nitrogen within an ecosystem • interchange between nitrogenous compounds and atmospheric nitrogen • living organisms need for nitrogen • plants as nitrogen fixers—role in ecosystem • decomposers releasing nitrogen back into soil • diagram of the cycle **Main processes** • putrefaction • nitrification • nitrogen fixation • denitrification **Human activity effecting nitrogen recycling in ecosystems** • farming practices • artificial fixing of atmospheric nitrogen • use of micro-organisms

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO2 understand chemical principles of environmental science	**AC2.1** explain acid-base concepts in relation to environmental analysis	**Acid-base concepts** • pH definition • Bronsted-Lowry acid-base theory • neutralisation • weak acid, weak base, strong acid, strong base • total acidity, total alkalinity **Environmental analysis** • volumetric titrations • environmental samples (aquatic, rainwater)
	AC2.2 apply redox theory to environmental systems	**Redox theory** • reduction & oxidation in terms electron loss and gain • reducing agents, oxidising agents • oxidation state (oxidation numbers) • half equations **Environmental systems** • aquatic (e.g. rivers, streams) • reducing and oxidising environments
	AC2.3 explain the role of complex ion formation in environmental systems	**Complex ions** • coordination number • common ligands (monodentate, bidentate, polydentate) • chelating agents (e.g. EDTA) • ligand exchange and dynamic equilibrium • stability constants • acidity [e.g. Cu^{2+}(aq), Al^{3+}(aq) complexes] **Environmental systems** • aquatic systems (e.g. rivers, streams) sediment
	AC2.4 classify chemical reactions	**Reactions** • free radical • acid-base • redox • precipitation • complex ion formation **Precipitation Reactions** Mg^{2+}, Ca^{2+} , Ba^{2+}, Al^{3+}, Cu^{2+}, Fe^{2+}, Fe^{3+},Pb^{2+}, Sn^{2+} with OH^-, CO_3^{2-}, SO_4^{2-}, NH_3(aq)

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO2 *continued*	**AC2.5** explain how free radical reactions involving pollutants occur in the environment	**Free radicals** • free radicals as reactive species with single electron • simple dot cross diagram of free radicals ($^{\cdot}OH$, $^{\cdot}CH_3$, $^{\cdot}O^{\cdot}$, $NO^{\cdot}$, $Cl^{\cdot}$) **Free radical reactions** • *initiation, propagation and termination steps** • role of sunlight in formation of free radicals • role weather conditions in concentrating pollutants (e.g. ground level ozone, photochemical smog) • role of emissions from combustion fossil fuels (e.g. car emissions) • CFC reactions and ozone layer • photochemical smog formation • tropospheric ozone formation **Note: It is **not** required to learn detailed mechanisms but candidates must know the difference between initiation, propagation and termination steps in a given mechanism*
	AC2.6 assess the persistence of pollutants in the environment	**Pollutants** • pesticides • metal ions **kinetic stability** • first order kinetics of pesticide decomposition • half-life in pesticide decomposition • significance partition coefficients, soil adsorption coefficients and solubility • factors that affect pesticide decomposition (temperature, pH, light, soil type) **Metal ions** • mobility of metal ions • solubility metal ions and metal complexes

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO3 understand physical principles of environmental science	**AC3.1** explain the meaning of terms used in energy transfer	**Terms** force, energy, work, power, efficiency, units of work, force, energy, power **Contexts** e.g. • energy generation systems, electrical devices, buildings
	AC3.2 explain energy transfer using scientific concepts	**Scientific concepts** • conservation of energy • Zeroth Law • Newton's law of cooling • thermal conductivity • conduction, convection and radiation **Contexts** • energy generation systems • renewable (solar, wind, tidal, biomass) • non-renewable (coal, gas, nuclear) • electrical devices • buildings
	AC3.3 analyse energy transfer	**Contexts** • energy generation systems • renewable (solar, wind, tidal, biomass) • non-renewable (coal, gas, nuclear) • electrical devices • buildings
	AC3.4 describe how energy is generated by a nuclear power reactor	**Nuclear power** • pressurised water and gas cooled • fission reactions • nuclear reactor (fuel rods, moderator, control rods, coolant)
	AC3.5 compare impacts of energy generation systems	**Comparison** • carbon footprint (building, maintenance, production, decommission) • waste products (includes radioisotopes) • radioisotopes (α, β, γ emitters,) • impacts of radio-isotopes(short term and long term. Damage to DNA. Storage and consequences of environmental contamination) • environmental impact of combustion carbon based fuels (e.g. impact of CO_2, oxides of sulfur and nitrogen etc.) • impact on landscape

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO3 *continued*	**AC3.6** explain how design can be changed to reduce energy waste	**Designs of** • energy generation systems • electrical devices • buildings
	AC3.7 describe the characteristics of radiation	**Radiation** • electromagnetic; high energy particles(α and γ particles); ionising, non-ionising **Characteristics** • distinguishing features, properties **Electromagnetic radiation** • wave particle duality • photon as a particle with zero mass • wave properties (amplitude, wavelength, frequency, energy) **Properties electromagnetic radiation** • reflection, refraction, absorption, energy • weak ionising effect of short wave radiation **High energy particles** • α, β particles • mass, charge **Properties high energy particles** • half-life of source • penetrating power • effect of electric field • ionising effect
	AC3.8 explain how electromagnetic radiation interacts with the atmosphere	**Electromagnetic interactions** • ultraviolet light and stratospheric ozone (ozone layer) • absorption and emission of electromagnetic radiation by greenhouse gases **Atmosphere** • troposphere, stratosphere, ozone layer, tropopause, stratopause **Greenhouse effect** • qualitative explanation of greenhouse effect • natural and enhanced greenhouse effect • impact of natural and enhanced greenhouse effect on temperature • greenhouse gases (CO_2, CH_4 etc.)

Learning outcomes	Assessment criteria	Content
The learner will:	*The learner can:*	
LO4 be able to use data from environmental investigations	**AC4.1** analyse data	**Data** • primary, secondary **Biological data** • population size • population density • pH, dissolved oxygen, temperature **Chemical data** • half-life data involving pesticides and radioisotopes • partition coefficients and soil adsorption coefficients of pesticides • data from chemical analysis (e.g. analytical techniques from unit 3) **Physical data** • data on energy flow • data on Solar output • U, R values • thermal conductivities
	AC4.2 process data	**Process data** • graphical methods, calculations **Graphical methods** • linear and non-linear graphs • trend lines • e.g. calibration graphs (instrumental analysis from unit 3); concentration time graphs; temperature time graphs; solar output graphs; graphical representations of data from units 1, 2 and 3 • Sankey diagrams **Calculations** • conversion to and from log forms (e.g. pH to H^+, H^+ to pH) • molar mass, moles, concentration • interchanging units of concentration (µg/$m^{3,}$ mg/100 g; g/100 g; g dm^{-3}; mol dm^{-3}; ppm, ppb) • estimate population sizes • Simpson's index of biodiversity • half-life calculations involving pesticides and radioisotopes • use first order equations in determining concentrations over time • energy and power calculations • efficiency calculations for power generation • transformations using given relationships

Learning outcomes	**Assessment criteria**	**Content**
The learner will:	*The learner can:*	
LO4 *continued*	**AC4.3** make evidence based conclusions	**Conclusions** • comparison of data • linking of ideas • uncertainty in conclusions
	AC4.4 evaluate data	**Evaluation** • limitations of data • uncertainty • correlation coefficients • sample size • limitations of techniques • sampling method (sampling methods from units 1 to 3) • sensitivity of technique (techniques from units 1 to 3) • environmental conditions

Assessment

This unit is assessed through a written examination set each summer. Details relating to the external assessment and the management of the pre-release article accompanying the examination can be found in **section 3.1.2** and **3.1.3** of the specification.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places
- arranging talks by visiting speakers

This unit is closely related to the content and context of units 1 to 3. The content is therefore best integrated into the delivery of units 1 to 3.

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Many of the resources required for units 1-3 could be used with this unit. In addition, the following resources will also be useful.

Textbooks
A level Biology Textbooks
Environmental Chemistry Colin Baird (Useful as a teacher resource)

Websites

Encyclopaedia Environmental Science
http://espere.mpch-mainz.mpg.de/documents/pdf/Encyclopaediamaster.pdf

Environmental Chemistry
http://textbook.s-anand.net/ncert/class-11/chemistry/14-environmental-chemistry

Soil guideline values
http://www.environment-agency.gov.uk/research/planning/64015.aspx

Significance physical-chemical data
http://www.reach-serv.com/index.php?option=com_content&task=view&id=59&Itemid=129

Drinking water standards
http://dwi.defra.gov.uk/consumers/advice-leaflets/standards.pdf

Factors affecting pesticide behaviour
http://www.gpnmag.com/factors-affecting-pesticide-behavior
http://longbeach.wsu.edu/cranberries/documents/howlongdoinsecticideresiduespersist.pdf

Pesticide properties
http://npic.orst.edu/ingred/ppdmove.htm

Nuclear power
http://www.world-nuclear.org/Nuclear-Basics/How-does-a-nuclear-reactor-make-electricity-/
http://www.need.org/nuclear

In addition websites for units 1 to 3 also provide valuable material for this unit.

6. ENTRY PROCEDURES

WJEC Level 3 Diploma in Environmental Science will be available for certification from June 2016.

Thereafter, the qualification will be available for certification each June.

Centres planning to offer this qualification must be registered as an accredited WJEC centre. For details on the application and accreditation, centres should contact WJEC.

Entries for the June series must be submitted no later than 21 February.

Unit entry

Entry for individual units must be made by submitting the relevant unit codes as indicated on each unit of the specification. Entries can be made for units in the following sessions:

Unit	January 2016	June 2016	January 2017 and thereafter	June 2017 and thereafter
1.	✓	✓	✓	✓
2.		✓		✓
3	✓	✓	✓	✓
4		✓		✓
Certification (qualification award)		✓		✓

Qualification entry

Learners will be entered for the qualification when entering for aggregation (cash-in). Aggregation does not take place automatically: it is necessary to enter the relevant code for aggregation to take place.

7. EXTERNAL MODERATION

The consistency of assessment practices and decisions across centres will be assured through the external moderation of a sample of work.

Each centre will have access to a consultative moderator. The consultative moderator will be available to discuss assessment requirements with centres.

Postal moderation will take place each year in June. For each series where learners are entered, centres will submit a sample, according to the formula below.

Total number of candidates	*Work to be submitted (Numbers relate to alphabetical order)*
1 – 10	All
11 - 19	1st and every second (1, 3, 5, 7 etc.) **plus** the lowest scoring* folder and additional folders as necessary (reflecting the spread of marks) to make a total sample of 10
20 - 45	1st and every fifth (1, 6, 11, 16 etc.) **plus** the lowest scoring* folder and additional folders as necessary (reflecting a spread of marks) to make a total sample of 10
46 - 99	1st and every eleventh (1, 12, 23, 34 etc.) **plus** the lowest scoring* folder and additional folders as necessary (reflecting a spread of marks) to make a total sample of 10

** The score is based upon the marks the learners obtain for each of the units being submitted for moderation.*

Centres should ensure they keep all learner portfolios not sent to the moderator in their possession for two months after the closing date for sending samples for moderation. WJEC may require all portfolios for moderation and centres must be able to comply immediately with such a request.

Centres should submit a sample for **each unit** that includes:

- the controlled assignment brief used to set the assessment activity;
- a controlled assessment activities sheet completed and signed by the assessor to confirm that the controls for the unit, including authenticity of evidence, have been applied;
- completed mark record sheets outlining which performance bands are met by the evidence;
- all evidence produced by learners in completion of the controlled assessment, annotated appropriately by the assessor.

Moderators will review all evidence presented to ensure standards are aligned. Evidence will be judged against the following criteria:

- Task setting – were tasks set within the controls set by WJEC in the model assignment?
- Task taking – is there evidence that tasks were completed under the controlled conditions set out in the model assignment?
- Performance bands – does the evidence support assessor's judgement of a learner against national standards?
- Annotation – is the evidence produced by learners appropriately annotated?
- Authentication- is it clear that the evidence submitted was authentically produced by the learner?
- Standardisation – is there evidence of effective standardisation/internal quality assurance within the centre?

Timetable

Samples of work must be submitted for external moderation, and related mark sheets returned to WJEC by 5 May for the June series. Centres will need to ensure that internal submission dates are set sufficiently in advance of this to allow for authentication, assessment and standardisation.

Feedback

The outcome of moderation will be to either accept or amend a centre's assessment decisions. Guidance on actions needed before re-sitting of specified units at a subsequent moderation series will be also be provided.

Feedback will be provided through a centre moderator's report for each certification title, covering the units entered by the centre and will be accessible through WJEC secure website. The report will address the criteria referred to above.

A Principal Moderator's report will be provided for each series.

8. AWARDING AND REPORTING

Awarding and reporting of results in WJEC Level 3 Diploma in Environmental Science will take place in August of each year.

A **Qualification Certificate,** issued at a later date, will confirm the

- Title
- Level
- Grade of qualification (Pass, Merit, Distinction, Distinction*)
- Unit titles contributing to the qualification

Individual unit results are reported on a uniform mark scale (UMS) with the following grade equivalences:

Unit	UMS mark	UMS grade boundaries		
		D	M	P
1	120	96	72	48
2	120	96	72	48
3	120	96	72	48
4	140	112	84	56

9. ACCESS ARRANGEMENTS

Qualifications at this level often require assessment of a broad range of competencies. This is because they are vocational qualifications and prepare candidates for a wide range of occupations and higher level courses.

This specification has been designed to offer fair access for all and to minimise the need to make reasonable adjustments for learners who have particular requirements. It is expected that normally, individual learners' abilities, interests and needs will be appropriately catered for by centres through:

(a) the choice of units and qualifications available;

(b) the potential for personalisation of controlled assessment.

If there are any queries about the use of this flexibility inherent in the specification to meet learners' needs, or about the use of reasonable adjustments, centres should contact WJEC.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Regulations and Guidance Relating to Candidates who are eligible for Adjustments in Examinations.* This document is available on the JCQ website (www.jcq.org.uk).

10. POST-RESULTS SERVICES

If a centre wishes to query the outcome of the moderation and/or examination process this must be done formally by the head of the centre, notifying WJEC within 21 days of the publication of results.

The sample of work submitted for moderation will be reviewed by a moderator/examiner not involved in the original process, and the centre informed of the outcome.

Should the centre not be satisfied with the outcome of the review, there is provision for an appeal to WJEC.

11. CLASSIFICATION CODES

Every specification is assigned a national classification code (discounting code) indicating the subject area to which it belongs. The classification code for this specification is QA3.

Centres should be advised that where learners take two qualifications with the same classification code, performance indicators for the centre will show that they have only achieved one of the two qualifications. The same view may be taken if learners take two specifications that have different classification codes but have significant overlap of content. The discounting system affects the calculation of performance measures for a school in the performance tables. It does not alter the awards an individual learner has achieved or limit the qualifications they can take.

Learners who have any doubts about their subject combinations should check with the institution to which they wish to progress before embarking on their programmes.

Information on performance points can be obtained from (www.education.gov.uk) and/or DAQW (www.daqw.org.uk).

12. THE WIDER CURRICULUM

Opportunities for use of technology

Candidates need to be both effective and confident users of technology in order to move on to a more advanced study of environmental science. This specification allows candidates to develop ICT skills in a wide range of different contexts.

There are numerous opportunities to use ICT throughout all units. Examples include:

- gathering data from sensors linked to data-loggers or directly to computers data logging e.g.; capturing pH and other environmental data;
- analysing data – e.g. use of spreadsheets to present graphs and calculate lines of best fit;
- using presentation software e.g. to assist in giving a presentation to an audience;
- using word processing packages to present written reports;
- using blogging software to share information to a world-wide audience
- making videos or podcasts;
- designing leaflets to communicate information.

Spiritual, Moral, Ethical, Social and Cultural Issues

The specification provides a framework and includes specific content through which individual courses may address spiritual, moral, ethical, social and cultural issues. It aims to show how science can be used to assist in the monitoring and protection of the environment. Learners will be confronted with the need of balancing human activity against potential environmental consequences. These impacts may have a local or more global impact on the environment and people.

Examples of issues which can be addressed through the specification are listed below.

- The sustainable use of energy (unit 1).
- The impacts of human activity on biodiversity (unit 2).
- Consequences of contaminating waterways (unit 3).

Citizenship

The applications and implications of science dealt with in meaningful environmental contexts, encourage the development of a responsible attitude to citizenship. An understanding that individuals have a collective responsibility is fostered in relation to various ethical issues included in the specifications such as land use, sustainable energy use, food production, waste disposal. The consequences of human activity on the environment are also examined throughout the qualification in a number of different contexts.

Environmental Issues

The qualification deals with environmental science in meaningful contexts. The whole qualification therefore highlights how science is used in aid of observing, monitoring and protecting the environment. Each unit will outline the environmental context of the science that is to be delivered. Learners are also made aware of legislation that is in place governing activities that have a potential environmental impact.

Health and Safety Consideration

Under UK law, health and safety is the responsibility of the employer. There are a number of regulations (notably Management of Health and Safety at Work Regulations 1999 and COSHH Regulations 2002 (as amended)) that require the completion of a risk assessment before commencing a procedure or activity that uses microorganisms or chemicals.

There are opportunities for learners to develop their own risk assessments when carrying out laboratory and field work in almost all units. Throughout the qualification there are also many opportunities to underscore the requirement to work in compliance with risk assessments in order to safe guard the health and safety of workers and members of the public.

The European Dimension

Environmental issues can be rarely confined to a particular place since human actions in one country can also impact another. Challenges to the environment need to be dealt with at national, European and global levels. This specification should make learners aware that environmental scientist need to cooperate with scientist from other countries. In addition, since environmental issues cannot be restricted to national boundaries, politicians from national and European governments will often seek to implement a common policy towards issues that impact on the environment.

The context led nature of the units will give centres the opportunity of examining environmental issues at a European level. Examples where a European dimension can be underscored includes international protocols and European legislation relating to climate change, a comparison of agricultural policy in different European countries and the impact on biodiversity, cooperation and legislation on emissions from e.g. coal-fired power stations, pollution control etc.

Appendix 1 Unit structure

Unit title

The title summarises in a concise manner the content of the unit.

Guided learning hours

Guided learning time represents only those hours in which a tutor is present and contributing to the learning process. In some organisations this is known as 'contact time'. This time includes lectures, supervised practical periods and supervised study time.

Aim and purpose

The aim and purpose provides a brief and clear summary of the unit. It also indicates the applied purpose for the unit.

Unit Introduction

This is written to the learner and gives a summary of the unit content. It sets the vocational context of the unit and highlights the purpose of the learning in the unit.

Learning outcomes

Learning outcomes state what the learner should know, understand or be able to do as a result of completing the learning in the unit.

Assessment Criteria

The assessment criteria specify the standard a learner is expected to meet to demonstrate that the learning outcomes of that unit have been achieved.

Unit content

The indicative content defines the breadth and depth of learning for each assessment criteria. It is expected that all the indicative content will be delivered during the programme of learning. It is not required to assess every aspect of the content when assessing the unit. Learners will be expected to apply the knowledge, understanding and skills acquired through the learning to the specifics of the assessment context.

Performance Bands

These are used to determine the overall unit mark. Performance bands do **not** add additional requirements to the assessment criteria.

Assessment

WJEC Level 3 Diploma in Environmental Science is assessed through both controlled assessment and external assessment. This section of the unit summarises the form of assessment used.

Guidance for delivery

This gives the tutor some ideas on how to deliver the unit in a vocational setting consistent with the philosophy of the qualifications and intent of the unit. Three sample contexts are provided for each unit. The guidance also gives ideas of vocational settings for the unit and suggests possible contacts that could be made in the delivery of the learning. This section also includes details of how the unit supports the development of PLTS, Wider Key Skills and Essential Skills (Wales).

Resources

This identifies useful resources to help in the delivery of the learning. Many of the resources listed are suitable for using with learners.

Appendix 2 Grade Descriptors

Grade descriptors are used by WJEC to set grade boundaries for each unit. Grade descriptors give a general indication of the levels of attainment likely to be shown by a representative learner performing at each boundary. An Award meeting involving experienced examiners and teachers will be required to set the following grade boundaries for each unit. The following grade boundaries will be set at the Award meeting:

- Distinction/Merit;
- Merit/Pass;
- Pass/ungraded

Grade descriptors are interpreted in relation to the content outlined in the specification; they are not designed to define that content. Once grade boundaries have been set by WJEC learner marks are then converted to UMS marks.

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Knowledge and understanding of environmental science	Demonstrate detailed knowledge and understanding of most principles, concepts and facts from the specification. Consistently selects and uses relevant information from the specification. Consistently organises and presents information clearly, logically and in suitable structure. Use appropriate scientific terminology and convections from the specification.	Demonstrate detailed knowledge and understanding of most principles, concepts and facts from the specification. Select and use relevant information in most cases from the specification. Organise and present information clearly and logically. Uses mostly appropriate scientific terminology and convections from the specification.	Demonstrate knowledge and understanding of some principles and facts from the specification. Select and use some relevant information from the specification. Present some information in a clear format. Use some appropriate terminology and conventions from the specification.

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Application of skills, knowledge and understanding in appropriate environmental contexts	Apply principles and concepts from the specification in familiar and new contexts involving several steps in the argument. Describe significant trends and patterns, with clear explanations, shown by complex data presented in tabular or graphical form. Interpret qualitative and quantitative data accurately; and present arguments and evaluations clearly. Evaluate critically the statements, conclusions or data. Carry out accurately complex calculations specified for environmental science. Translate successfully data presented as prose, diagrams, drawings, tables or graphs, from one form to another. Select a wide range of facts, principles and concepts from the specification. Link together appropriate facts principles and concepts from different areas of the specification.	Apply principles and concepts from the specification in familiar and new contexts involving a few steps in the argument. Describe most significant trends and patterns with some clear explanations, shown by complex data presented in tabular or graphical form. Interpret some qualitative and quantitative data without significant errors; and present arguments and evaluations clearly. Evaluate critically some statements, conclusions or data. Carry out accurately some complex calculations specified for environmental science. Translate most data presented as prose, diagrams, drawings, tables or graphs, from one form to another. Select a range of facts, principles and concepts from the specification. Link together some facts principles and concepts from different areas of the specification.	Apply given principles or concepts from the specification in familiar and new contexts involving a few steps in the argument. Describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form. Interpret some qualitative and quantitative data. Identify, when directed, inconsistencies in conclusions or data. Carry out some steps within calculations specified for environmental science. Translate data successfully from one form to another, in some contexts. Select some facts, principles and concepts from the specification. Put together some facts, principles and concepts from different areas of the specification.

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Use of practical skills within environmental contexts	Devise and plan suitable experimental and investigative activities, selecting appropriate techniques. Consistently demonstrates safe and skilful use of practical techniques to produce data within the expected range of tolerance for the technique. Make observations and measurements with appropriate precision and record these methodically. Interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.	Devise and plan mostly suitable experimental and investigative activities, selecting appropriate techniques. Demonstrates skilful and safe use of practical techniques to produce data mostly within the expected range of tolerance for the technique. Make observations and measurements with largely appropriate precision and record these methodically. Interpret, explain, evaluate and communicate most aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.	Devise and plan some aspects of experimental and investigative activities. Demonstrate safe use of practical techniques to produce some data within expected range of tolerance for the technique. Make observations and measurements and record them. Interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Reporting environmental information	Make a clear and accurate use of English (styles, spelling, punctuation and grammar) to communicate ideas and structure arguments. Produce logical and well-structured reports, showing a detailed scientific understanding of their work. Logically organise work in a coherent structure linking conclusions to supporting evidence with clarity. Clearly communicate with few minor errors in the use of technical terms, spelling, punctuation and grammar.	Make a mostly clear and accurate use of English (styles, spelling, punctuation and grammar) to communicate ideas and structure arguments. Produce mostly logical and well-structured reports, showing a mostly detailed scientific understanding of their work. Mostly logically organise work in a coherent structure linking conclusions to supporting evidence with clarity. Communicate with some clarity. There are no significant errors or omissions in the use of technical terms, spelling, punctuation and grammar.	Make some appropriate use of English (styles, spelling, punctuation and grammar to communicate ideas and structure arguments. Produce a mostly clear report, showing some understanding of their work. Some organisation and structure with some valid evidence. Communicate some suitable information without significant errors.

Appendix 3 Skills Mapping

PERSONAL, LEARNING AND THINKING SKILLS (PLTS)

	Unit			
PLTS	**1**	**2**	**3**	**4**
Independent enquirers	✓	✓	✓	✓
Creative thinkers	✓	✓	✓	✓
Reflective thinkers	✓	✓	✓	✓
Team workers	✓	✓	✓	✓
Self-managers	✓	✓	✓	✓
Effective participators	✓	✓	✓	✓

KEY SKILLS AND ESSENTIAL SKILLS (WALES)

Application of Number

	Unit			
	1	**2**	**3**	**4**
Understand numerical data	✓	✓	✓	✓
Carry out calculations	✓	✓	✓	✓
Interpret results and present findings	✓	✓	✓	✓

Communication

	Unit			
	1	**2**	**3**	**4**
Speaking and listening	✓	✓	✓	✓
Reading	✓	✓	✓	✓
Writing	✓	✓	✓	✓

ICT

	Unit			
	1	**2**	**3**	**4**
Use ICT systems	✓	✓	✓	✓
Find, select and exchange information, using ICT	✓	✓	✓	✓
Develop and present information, using ICT	✓	✓	✓	✓

Improving own learning and performance

	Unit			
	1	**2**	**3**	**4**
Set targets using information from appropriate people and plan how these will be met	✓	✓	✓	✓
Take responsibility for your learning, using your plan to help meet targets and improve your performance	✓	✓	✓	✓
Review progress and establish evidence of your achievements	✓	✓	✓	✓

Problem solving

	Unit			
	1	**2**	**3**	**4**
Explore a problem and identify ways of tackling it	✓	✓	✓	✓
Plan and implement at least one way of solving the problem	✓	✓	✓	✓
Check if the problem has been solved and review your approach to problem solving	✓	✓	✓	✓

Working with others

	Unit			
	1	**2**	**3**	**4**
Plan work with others	✓	✓	✓	✓
Seek to develop co-operation and check progress towards your agreed objectives	✓	✓	✓	✓
Review work with others and agree ways of improving collaborative work in the future	✓	✓	✓	✓