



Rewarding Learning

ADVANCED
General Certificate of Education
2023

Environmental Technology

Assessment Unit A2 1

assessing

Building and Managing a
Sustainable Future

[AET11]

FRIDAY 2 JUNE, MORNING

**MARK
SCHEME**

Foreword

Introduction

Mark Schemes are published to assist teachers and students in the preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of 17- and 18-year-old students in schools and colleges. The job of the examiners is to set the questions and the mark schemes, and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes therefore are regarded as a part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

1 (a) (i) Biohydrometallurgy/Biorefining [1]

(ii) Energy intensive process. [1] Highly polluting. [1] [2]

All relevant, valid responses will be given credit.

(b) (i)

Name of Plant	Metal extracted
White Mustard	Copper
Sunflower	Gold

[2]

(ii) Phytoextraction: Metal to be extracted is identified by testing the soil and the correct species of plant is planted. [1]
Plants 'uptake' metals from contaminated soils [1]
and concentrate them in above-ground plant tissue/biomass. [1]
This is then harvested for disposal and/or metal recovery. [1] [4]

All relevant, valid responses will be given credit.

2 (a) (i) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ [3]

(ii) Sucrose is the sugar found in sugar cane. The sucrose is broken down into simpler sugars – fructose and glucose by the process of hydrolysis. [1]
An enzyme, in this case in yeast, is added and it breaks down the chemical structure of the sugar. [1]
This process is called fermentation. [1] [3]

All relevant, valid responses will be given credit.

(b) Any **two** named strategies and any **two** relevant comments on the effectiveness of each strategy such as:

- Extending the public transport network [1] decreases journey times, increases capacity [1] and increases the ease of access to the network which increases use. [1]
- Dedicated bus and cycle lanes [1] decreases journey times thereby increasing the attractiveness of using these modes of transport [1] compared with driving. [1]
- Fuel and vehicle taxation [1] increase the cost of driving. This increases the use of public transport, cycling and car sharing [1] which reduces the number of vehicles on the road. [1] [6]

Award [2] for a full explanation and [1] for a limited explanation.

All relevant, valid responses will be given credit.

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3 (a) (i) The U value of a material is the rate at which heat is conducted away [1] through 1m² of the material, for each 1 degree difference in temperature between the outside and the inside of the material. [1] [2]

(ii) Area = 2.4 × 6 = 14.4 [1]
Temp diff = 19 – 10 = 9 [1]
Rate of heat loss = U value × Area × Temp Diff
12.96 = U value × 14.4 × 9
12.96 = U value × 129.6 [1]
U value = $\frac{12.96}{129.6}$
U value = 0.1 W/m²K [1] [4]

(b) (i) Any **two** of the following:
• Poor workmanship [1] – If construction work for improvements are carried out poorly this may lead to more problems, e.g. draughts, etc. [1]
• Difficult to implement [1] – Designers and builders are not legally bound to carry out work in line with the Code for Sustainable Homes and there is difficulty with knowing who will enforce it. [1]
• Economic implications [1] – Improving existing housing will cost a lot of money. It is difficult to justify the extra cost to the client. [1] [4]

Award [2] for a full explanation and [1] for a limited explanation.

All relevant, valid responses will be given credit.

(ii) BREEAM Assessment [1] [1]

All relevant, valid responses will be given credit.

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- 4 (a) Any **four** from:
Natural gas reacts with steam [1] to form hydrogen gas and carbon monoxide. [1]
The process requires temperatures of 700°C to 1000°C/very high temperatures. [1]
A process pressure of 3 – 25bar/high pressure [1] and a catalyst. [1] [4]

All relevant, valid responses will be given credit.

- (b) 1. Electrolysis of water. [1]
2. Photocatalytic water splitting. [1] [2]

All relevant, valid responses will be given credit.

- (c) Gas **A**: Hydrogen [1]
Gas **B**: Oxygen [1]
Electrode **C**: Cathode [1]
Waste product **D**: water [1] (accept heat) [4]

- (d) Any **two** from:
- Generation of electricity as a back-up to traditional methods in case of emergency. [1] Hydrogen fuel cells provide back-up power for critical communication network infrastructures in wireless, fixed and broadband telecom applications. [1]
 - Use as a source of power in remote locations where a mains supply is not available. [1] Hydrogen-fuelled primary power units are being developed to replace the grid, for areas where there is little or no grid infrastructure. This may be more cost-effective than extending the grid to these locations. [1]
 - As portable power generators/replacement for batteries. [1] Fuel cells have longer run-times compared with batteries, rapid recharging and significant weight reduction potential. [1] [4]

Award [2] for a full description and [1] for a limited description.

All relevant, valid responses will be given credit.

- 5 (a) Any **two** of the following:
- Packaging
 - Waste Electrical and Electronic Equipment (WEEE)
 - End of life vehicles
 - Tyres
 - Batteries
- [2]

(b) Indicative Content

The graph shows that amount of waste being sent to landfill has dropped by over 100,000 tonnes between 2006 and 2018.

Any **two** of the following:

- The EU Waste Framework Directive requires the establishment of waste management strategies and plans and sets out the elements that must be contained within them.
 - The EU Landfill Directive aims to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste and contains targets for the reduction of biodegradable municipal waste going to landfills.
 - The Roadmap to a Resource Efficient Europe (RE Roadmap) defines medium and long term objectives to manage waste and recognise it as a resource and thereby create a ‘circular economy’ with residual waste reduced as far as possible.
- [6]

All relevant, valid responses will be given credit.

Response	Mark
<p>Level 3</p> <p>The candidate demonstrates very good knowledge of the key EU strategies and directives identified in the Northern Ireland Waste Management Strategy and the trend in landfill use in Northern Ireland. The candidate displays a very good understanding of how these policies have driven changes represented in Fig 3. Appropriate specialist terms are used throughout. The candidate uses very good spelling, punctuation and grammar and the form and style are of an excellent standard.</p>	[5]–[6]
<p>Level 2</p> <p>The candidate demonstrates good knowledge of the key EU strategies and directives identified in the Northern Ireland Waste Management Strategy and the trend in landfill use in Northern Ireland. The candidate displays a good understanding of how these policies have driven changes represented in Fig 3. Some appropriate specialist terms are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of a reasonable standard.</p>	[3]–[4]
<p>Level 1</p> <p>The candidate demonstrates limited knowledge of the key EU strategies and directives identified in the Northern Ireland Waste Management Strategy and the trend in landfill use in Northern Ireland. The candidate displays limited understanding of how these policies have driven changes represented in Fig 3. The candidate uses limited spelling, punctuation and grammar and the form and style are of a basic standard.</p>	[1]–[2]
Response not worthy of credit	[0]

- 6 (a)** Low solids: the feedstock is around 15% solid material. [1]
 Residence time: the time taken for the full degradation of the material in an anaerobic digestion system. [1]
 Single stage: The biological reactions occur in one holding tank. [1] [3]
- (b)** Anaerobic digestion produces biogas, a mixture of methane and carbon dioxide. If this gas is of suitable purity,[1] it can be used as the fuel in a CHP plant to produce steam which is used to drive a turbine linked to an electricity generator. [1]
 Instead of losing the heat to the atmosphere, as in traditional power plants, it is diverted into local heating systems [1] via a system of heat exchangers. It can also produce steam for a secondary electricity generator. [1] [4]

All relevant, valid responses will be given credit.

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7 (a) Indicative Content

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MARKS

Zero carbon

Any **two** from:

- Use of high U value building materials in new constructions.
- Retrofitting existing homes with insulation and triple glazing.
- Using wind, solar and biomass to deliver electricity.

Sustainable transport

Any **two** from:

- Offering subsidies for hybrid/electric vehicles.
- Extending the public transport network.
- Developing good online services.

[8]

All relevant, valid responses will be given credit.

Response	Mark
<p>Level 3 The candidate demonstrates a very good understanding of the principles of zero carbon and sustainable transport within the context of One Planet Living. The candidate includes a very good discussion of two specific examples of how each of the principles could be applied to an urban community to deliver sustainability. Appropriate specialist terms are used throughout. The candidate uses very good spelling, punctuation and grammar, and the form and style are of an excellent standard.</p>	[7]–[8]
<p>Level 2 The candidate demonstrates a good understanding of the principles of zero carbon and sustainable transport within the context of One Planet Living. The candidate includes a good discussion of specific examples of how each of the principles could be applied to an urban community to deliver sustainability. Some appropriate specialist terms are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of a reasonable standard.</p>	[4]–[6]
<p>Level 1 The candidate demonstrates a limited understanding of the principles of zero carbon and sustainable transport within the context of One Planet Living. The candidate includes a limited discussion of specific examples of how each of the principles could be applied to an urban community to deliver sustainability. Little use is made of specialist terms. The candidate uses limited spelling, punctuation and grammar and the form and style are of a basic standard.</p>	[1]–[3]
Response not worthy of credit	[0]

(b) Concept of an ecological footprint:

An ecological footprint is the impact of a person or community on the environment, expressed as the amount of land and sea required to support their use of natural resources. [1] It is a measure of the demand for natural resources in relation to the earth’s ability to restore or replenish the resources consumed. The graph shows that the US has the highest ecological footprint per person (8.04 gha) which is almost double that of a UK citizen (4.20 gha) and more than 3 times that of an Algerian citizen (2.30 gha). [1]

Measurement of an ecological footprint:

The ecological footprint can be measured for a region or population by taking into account resource consuming activities that support human life and the Earth's bio-capacity, its ability to replace those resources and absorb the waste. [1] Factors that are measured include land usage, sea usage, energy land (forests) and built land usage. A value greater than 1 indicates that resource consumption exceeds the earth's bio-capacity and is unsustainable. [1]

Link between an ecological footprint and a carbon footprint:

A carbon footprint also deals with resource usage but focuses strictly on the greenhouse gases released due to burning of fossil fuels. [1] Greenhouse gas calculations make up a portion of an ecological footprint, but are not used in the same way as those in a carbon footprint. Both calculations illustrate the impact of human activity on the environment. There is a correlation between carbon and ecological footprint. The graph shows that Algeria has both the smallest ecological footprint and carbon footprint whereas the US has the largest. [1] [6]

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Award [2] for a full discussion and [1] for a limited discussion.

All relevant, valid responses will be given credit.

8 (a) Cost:

Linking isolated dwellings to services is more expensive than linking higher density housing. [1] This cost may be carried by the homeowner which pushes up house prices and excludes those on lower incomes from living in rural communities. [1]

Environmental Impact:

The excavation and installation of sufficient services, such as roads and underground pipes, for these isolated dwellings causes major land upheaval with noise and visual pollution. [1] The planning of isolated dwellings must be carefully managed so that it doesn't interfere with heritage sites or areas of outstanding natural beauty. [1] [4]

Award [2] for a full discussion and [1] for a limited discussion.

All relevant, valid responses will be given credit.

- (b) (i)** Use independent, indigenous energy solutions, e.g. biomass, agricultural waste treatment, wind power and small-scale district heating solutions. [1] This will localise energy supplies and limit the infrastructure required. [1]
- (ii)** Improve mobile phone/broadband signals in rural areas to enhance accessibility to, e.g. online working, education medical appointments. [1] This will reduce transport demand and connect rural dwellers to essential services. [1]
- (iii)** Use of small-scale waste water treatment solutions, e.g. the provision and operation of septic tanks. [1] This will reduce water pollution issues and the requirement to install expensive infrastructure. [1] [6]

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Award [2] for a full description and [1] for a limited description.

All relevant, valid responses will be given credit.

Explain what is meant by a smart system.

Smart systems have a wide range of applications and generally involve the use of a miniaturised sensor which 'senses' a change in the environment and informs an actuator to respond appropriately.

There are three main processes:

- Sensing of changes in the environment being controlled and monitored.
- Actuation of devices in response to the changes identified.
- Controlling the situation taking account of the changing variables in the surrounding environment.

Describe the range of applications offered by a smart system with reference to transportation and waste management.

- Transportation – there could be an increase in the development of more energy efficient devices for mobility, e.g. hybrid vehicles and electric traction and the efficient control of traffic movement in our cities.
- Waste management – the use of smart systems to optimise waste collection rates, frequencies and vehicle loads. This would also allow us to dispose of waste more efficiently and/or economically.

Discuss the potential environmental and economic benefits offered by the use of smart systems.**Environmental Benefits**

- Sensors can be used in the home to automatically turn off/on appliances as needed therefore saving electricity/heating fuel, meaning less fossil fuels have to be burnt, e.g. thermostat on a heating system.
- Sensors can be used to help sort waste and redirect it to a more suitable place rather than landfill.
- A smart grid is a smart system which can make the most efficient use of the available energy mix using renewables and nuclear in place of traditional fossil fuel burning power plants, therefore emitting less carbon dioxide.
- A hybrid car uses sensors to detect when the car is most efficiently run by the battery and when it is most efficient to use the petrol or diesel engine. This reduces the amount of fossil fuels being used as the process is much more efficient.

Economic Benefits

- If sensors are used to switch off appliances/heating system when not in use the resident will save money on electricity and heating bills.
- If waste can be redirected from landfill and sorted, money could be saved, e.g. if glass is recycled then less raw materials and manufacturing has to be purchased.
- A smart grid allows for a larger energy mix meaning power companies will have to make their prices more competitive in the market.
- A hybrid car will use less fuel therefore saving money on a fuel bill. [15]

Response	Mark
Level 3 The candidate demonstrates a very good knowledge of smart systems and their uses. The candidate displays a very good understanding of the potential environmental and economic benefits of smart systems. Appropriate specialist terms are used throughout. The candidate uses very good spelling, punctuation and grammar and the form and style are of an excellent standard.	[11]–[15]
Level 2 The candidate demonstrates good knowledge of smart systems and their uses. The candidate displays a good understanding of the potential environmental and economic benefits of smart systems. Some appropriate specialist terms are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of a reasonable standard.	[6]–[10]
Level 1 The candidate demonstrates limited knowledge of smart systems and their uses. The candidate displays limited understanding of the potential environmental and economic benefits of smart systems. The candidate uses limited spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[5]
Response not worthy of credit	[0]

AVAILABLE MARKS
15
100

Total