Rewarding Learning

ADVANCED
General Certificate of Education
2016

Environmental Technology

Unit A2 1
Building and Managing a Sustainable Future

[A2EA1]

TUESDAY 17 MAY, MORNING

MARK SCHEME

MARK SCHEMES

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 16- 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.

AVAILABLE MARKS

1 **(a)** Low solids:
Low solid digestion is where the feedstock is around 15% solid material [1]
High solids:
High solid digestion is where the feedstock is around 55% 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 and the biogas comes from this tank. [1]
Multistage:
Hydrolysis, acetogenesis and acidogenesis occurs in one tank whilst the methanogenesis which produces the biogas occurs in a separate tank. [1]

All relevant, valid responses will be given credit. [5]

(b) Biogas from an AD plant can be burnt in a CHP plant to generate power (electricity) and heat [1]; Instead of losing the heat, as in traditional power plants, it is diverted into local heating systems. [1]

All relevant, valid responses will be given credit. [2]

(c) Any **three** from:
- Lawn clippings. [1]
- Shredded stalks. [1]
- Vegetable peelings. [1]
- Hedge clippings. [1]
- Cut flowers. [1]
- Tea bags. [1]
- Leaves. [1]
- Eggshells. [1]

All relevant, valid responses will be given credit. [3]

(d) Cooked food must never be used in composting because it will attract vermin.

All relevant, valid responses will be given credit. [1]

11

2 **(a)** U-value calculation:
Rate of heat flow = Area × U value × Temperature Difference. [1]
Rate of heat flow (window) = 6.0 m^2 × 2.6 $W m^{-2} K^{-1}$ × 19 °C = 296.4 W. [1]
Rate of heat flow (wall) = 12.2 m^2 × 0.25 $W m^{-2} K^{-1}$ × 19 °C = 57.95 W. [1]
Total rate of heat flow = 296.4 + 57.95 = 354.35 W. [1]

All relevant, valid responses will be given credit. [4]

(b) Any **one** measure and explanation from:
- Sealing around the edges of the window [1]; this will improve airtightness and reduce heat loss caused by draughts. [1];
- Installing double (or triple) glazed windows [1]; These will have improved U-values and will reduce heat loss through window. [1];

All relevant, valid responses will be given credit. [2]

			AVAILABLE MARKS
(c)	Economic benefits: Any **one** from: • reduced heating costs. • improving the value of your home. • grant assistance available for the work. Environmental benefits: Any **one** from: • reduced carbon emissions. • increased levels of home comfort. • reducing likelihood of condensation and mildew. All relevant, valid responses will be given credit.	[2]	
(d)	An outline which covers at least **two** of the following: • turning down their heating controls/thermostat could reduce boiler running time. [1] • closing windows and doors when heating is on could reduce heat loss through openings. [1] • turning heating off at night and when house is unoccupied could reduce boiler running time. [1] • putting draught excluders on doors to reduce heat loss through draughts. [1] All relevant, valid responses will be given credit.	[2]	10
3 **(a)**	Explanation as follows: A barrage is built across an estuary with gates and turbines built into the wall of the dam [1]; As the tide flows in the gates are open and the turbines are operated producing electricity [1]; At high tide the gates are closed trapping the water inside [1]; When water level outside has fallen sufficiently (e.g. 5 m) the gates are opened [1]; The released water turns the turbines again producing electricity. [1] All relevant, valid responses will be given credit.	[5]	
(b)	Name: Tidal stream generator [1] Any **two** advantages from: • They are cheaper to construct. [1] • They are smaller and have less environmental impact. [1] • The turbine blades turn slowly and have less effect on sea life. [1] All relevant, valid responses will be given credit.	[3]	
(c)	Any **one** example and associated explanation from: • Cloud seeding [1] where clouds are injected with crystals to produce 'rain on demand'. [1] • Space reflectors [1] which block a proportion of the sun's rays from entering the earth's atmosphere thereby reducing global warming. [1] • Afforestation [1] whereby global scale planting of trees absorbs CO_2 from the atmosphere. [1] • Biochar [1], the process of 'charring' biomass so that the carbon it contains is locked up in the soil. [1] All relevant, valid responses will be given credit.	[2]	

			AVAILABLE MARKS
	(d)	Bio-Photovoltaic (BPV) devices generate electricity from light energy [1] by exploiting the photosynthesis of living organisms such as moss, algae, cyanobacteria and vascular plants. [1] All relevant, valid responses will be given credit. [2]	12
4	**(a)**	Adding micro-organisms to soil [1] to remove contaminants. [1] [2]	
	(b)	**Indicative content** Bioremediation: • Bioremediation can be carried out under atmospheric conditions. • Bioremediation can be carried out in situ so soil is not removed from the site. • The contaminants are reduced to (almost) zero. • The by-products are non-toxic so water and air pollution is minimised. • Bioremediation uses bacteria that occur naturally in the soil so the ecosystem is maintained. • Bioremediation is economical because it does not require large energy inputs. Traditional treatment: • Traditional treatment is expensive because of the high energy costs (heating). • Greenhouse gases such as carbon dioxide are produced. • Soil may need to be treated ex situ/off site which requires heavy machinery. • Traditional treatment can produce toxic by-products which require further treatment. • Soil may need to be disposed of after treatment which leads to increased landfill. All relevant, valid responses will be given credit. [6]	

Response	Mark
Level 3 The candidate demonstrates very good understanding of the advantages of using bioremediation technology for land decontamination. The candidate discusses relevant factors in depth referring to environmental and economic aspects of bioremediation technology and traditional treatment methods. The argument is clear and concise. Appropriate specialist terms are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
Level 2 The candidate demonstrates satisfactory understanding of the advantages of using bioremediation technology for land decontamination. The candidate discusses some factors referring to environmental and economic aspects of bioremediation technology and traditional treatment methods. The argument is satisfactory. Some specialist terms are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of a reasonable standard.	[3]–[4]
Level 1 The candidate demonstrates a limited understanding of the advantages of using bioremediation technology for land decontamination. Limited reference is made to environmental and economic aspects of bioremediation technology and traditional treatment methods. The argument is limited. 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.	[1]–[2]
Response not worthy of credit	[0]

AVAILABLE MARKS

(c) **(i)** Any **two** points from below:
Micro-organisms can be genetically engineered to:

- decontaminate a site more rapidly than unmodified micro-organisms;
- tolerate harsher conditions;
- remove toxic materials (such as heavy metals).

All relevant, valid responses will be given credit. [2]

(ii) Any **two** from:

- Genetically engineered micro-organisms may wipe out existing bacteria.
- They may affect the existing soil ecology with unknown consequences.
- They may not behave the same way in the field as they do under laboratory conditions.

All relevant, valid responses will be given credit. [2] 12

AVAILABLE MARKS

5 (a) Location:

Any **two** points from:

- Planning permission is required which can delay the landfill becoming operational by several years. [1]
- A permit is required for operation which requires that full surveys have been carried out. This process is time consuming and adds to the up-front costs for the operator. [1]
- There may be objections from local residents due to noise/odour issues. This will delay planning permission being granted and subsequent award of a permit. [1]
- Suitable transport links are required so that waste can be brought to the site in heavy goods vehicles. [1] [2]

Development:

Any **two** points from:

- Once a permit/licence has been granted it takes a further 18 months from beginning of construction to operation adding to up-front investment costs. [1]
- The site must be geologically suitable so that the polluting leachates from the site cannot affect the surrounding land and water. [1]
- A detailed site survey is required prior to operation to ensure that the landfill site will not cause movement of the surrounding land. [1]
- An environmental assessment is required to confirm that the effect of the landfill site on the local environment is minimal. [1]
- The landfill must include leachate and landfill gas treatment measures to minimise water and air pollution. [1]
- Leak detection is required as flammable methane gas can be released. Methane gas is a greenhouse gas. [1]

All relevant, valid responses will be given credit. [2]

(b) Any **one** from:
Municipal waste/Commercial and industrial waste/Construction, demolition and excavation wastes/Hazardous waste/Agricultural waste. [1]

(c) Any **four** points from:

- The quantity of waste going to landfill has decreased year on year with the exception of 1998 to 1999. [1]
- The proportion of waste that has been recycled or composted has increased from 1998 to 2011. [1]
- The total volume of waste generated from 1998 to 2011 has not changed significantly at around 1,000,000 tonnes per annum. [1]
- The volume of waste going to landfill did not reduce immediately following publication of the Northern Ireland Waste Management Strategy. [1]
- The levels of recycling and composting are rising steadily from 50,000 tonnes in 1998 to almost 400,000 tonnes in 2011. [1]
- The rate at which waste was recycled and composted increased after 2002. [1]

All relevant, valid responses will be given credit. [4] 9

AVAILABLE MARKS

6 **(a)** Any **two** from:

- Hydrogen has a high energy density (per unit mass).
- The only by-product from hydrogen is water.
- Hydrogen fuels cells are more energy efficient than internal combustion engines/electricity generators.

All relevant, valid responses will be given credit. [2]

(b) Electrodes are placed in water. [1]
An electric current is passed through the electrodes. [1]
The water is split into hydrogen and oxygen.[1]
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
or $2H_2O \rightarrow 2H_2 + O_2$ [2]

All relevant, valid responses will be given credit. [5]

(c) Photocatalytic water splitting or steam reforming of fossil gases. [1]

(d) Any **two** points from:

- The cost of producing hydrogen gas is high due to the electricity requirement (for electrolysis). [1]
- If the cost of hydrogen as a fuel is more than the cost of petrol or diesel the consumer will not switch to it (which will discourage investment in the technology). [1]
- Methane can be used to produce hydrogen. There are concerns over using a fossil fuel as the raw material as it is non-renewable. [1]
- Hydrogen gas must be liquefied in order to make storage feasible. This adds to the production costs as compression equipment must be used and low storage temperatures must be maintained. [1]
- The low storage temperatures required for hydrogen mean that specialist delivery vessels and pipelines that can withstand these temperatures are required. [1]
- Hydrogen is explosive so great care must be taken to ensure that it is stored safely. It must be stored in thick-walled leak-proof tanks which add to the production costs. [1]

All relevant, valid responses will be given credit. [2]

10

AVAILABLE MARKS

7 Indicative Content

Energy use for heating/cooling and microgeneration (including the use of smart grid technology):

- reduced energy use for heating and cooling; passive ventilation; natural cooling; better insulation, glazing, orientation.
- microgeneration of electricity (using solar power and micro wind linked via smart grid) and heat using heat pumps, biomass etc.

Integrated and flexible transport facilities/versatile buildings:

- public transport, cycling, walking, park and ride, etc.
- lower cost and more comfortable and versatile buildings/design for re-use etc.

Waste management/land use (brownfield sites):

- planned waste management systems that deal with the waste source (e.g. waste management strategies; recycling; composting; biomass etc.).
- the reuse of brownfield sites (e.g. building on previously developed land)

Dealing with water shortages/sustainable urban drainage.

- systems to deal with water shortage (e.g. managing water usage; water metering; low water usage sanitaryware; rainwater harvesting; greywater recycling; etc.).
- sustainable urban drainage schemes (e.g. flood mitigation measures; SUDS).

Green spaces – environmental benefits:

- using green spaces to moderate the urban heat island (e.g. using trees to create shade/ local microclimate/ heat sinks).
- using green spaces that work for people and wildlife, for example food production in urban areas.

All relevant, valid responses will be given credit. [10]

Response	Mark
Level 3 The candidate provides a detailed answer and significant reference has been made to the scenario in the question. The candidate shows a detailed understanding of the issues surrounding the development of sustainable urban communities and has described a range of relevant technologies which can underpin these. A wide range of relevant technical terms has been used. The candidate has shown good use of spelling, grammar and punctuation and the style and form are excellent throughout.	[8]–[10]
Level 2 The candidate provides an answer with satisfactory detail making reference to the scenario in the question. The candidate shows a satisfactory understanding of the issues surrounding the development of sustainable urban communities and has described some supporting technologies. There is evidence of some technical terms being used. The candidate uses good spelling and grammar, and form and style are of a reasonable standard.	[4]–[7]
Level 1 The candidate's answer is lacking in detail with little or no reference to the scenario in the question. The candidate shows limited understanding of the issues surrounding the development of sustainable urban communities. Few specialist technical terms are used. The candidate shows only a basic level of spelling, punctuation and grammar, and form and style are of a basic standard.	[1]–[3]
Response not worthy of credit	[0]

10

AVAILABLE MARKS

8 **(a)** Any **two** from:
Hydrogen-fuelled vehicles. [1]
Biofuelled vehicles. [1]
Electric vehicles. [1]
Hybrid vehicles.[1]

All relevant, valid responses will be given credit. [2]

(b) Any **three** valid points from:

- The use of cars went down by more than a third following the introduction of congestion charging which is evidence that it was effective. [1]
- The use of public transport such as taxis and buses increased following congestion charging which reflects movement away from private to public transport. [1]
- The number of buses increased by more than 50%. [1]
- The number of bicycles in use has more than doubled. [1]
- The overall number of vehicles entering London has gone down since congestion charging was introduced which reflects the success of congestion charging in relieving congestion. [1]

All relevant, valid responses will be given credit. [3]

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

Subsidised public transport [1] makes it economically beneficial to use which increases the use of public transport. [1]

Extending the public transport network [1] decreases journey times, increases capacity 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 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 which reduces the number of vehicles on the road. [1]

All relevant, valid responses will be given credit. [6] 11

AVAILABLE MARKS

9 Indicative Content

- What trends you deduce from **Fig. 7** above with relation to environmental impact of various countries and why this might be so:
  - More economically developed countries have a higher ecological footprint per person than less economically developed countries.
  - They consume more goods and services, have a more energy-intensive lifestyle and create more waste.
- How ecological footprints are likely to change with economic progress in developing countries:
  - As countries become more economically developed their ecological footprint is likely to increase.
  - This may be due to improved education, health/life expectancy, affluence, lifestyle etc. which drives demand for resources.
- Population: how population size affects demand for resources and waste generated:
  - More population means greater demand for natural resources.
  - More food and water required.
  - More demand for clothing, shelter, goods and energy to produce these
  - Less resources available for other species (wildlife, habitat etc.).
- Affluence: how lifestyle affects demand for resources and waste generated:
  - Greater affluence = greater consumption and more waste generated.
  - It is unsustainable to continue living a high consumption western lifestyle.
  - Developing countries wish to have a similar affluent lifestyle to the US.
- Technology: How countries convert natural resources into real goods and services that we can use:
  - Industrially-driven societies are energy intensive by nature.
  - There are limits to how far we can improve technology in terms of resource use and reduce waste generation.
  - Less advanced technology used in developing countries is likely to cause more environmental impact.
  - Renewable resources still require non-renewable resources during manufacture and are expensive to harness.

All relevant, valid responses will be given credit. [15]

Response	Mark	AVAILABLE MARKS
Level 3 The candidate provides a detailed answer and significant reference has been made to the figure and the issues in the question. The candidate shows a full understanding of the issues and trends relating to ecological footprint of different world regions and how these are affected by population, affluence and technology. A wide range of relevant technical terms has been used. The candidate has shown good use of spelling, grammar and punctuation and the style and form are excellent throughout.	[11]–[15]	
Level 2 The candidate provides an answer with satisfactory detail making reference to the figure and the issues in the question. The candidate shows a reasonable understanding of the issues and trends relating to ecological footprint of different world regions and how these are affected by population, affluence and technology. There is evidence of some technical terms being used. The candidate uses good spelling and grammar, and form and style are of a reasonable standard.	[6]–[10]	
Level 1 The candidate's answer is lacking in detail with limited reference to the figure and issues in the question. The candidate shows a limited understanding of the issues and trends relating to ecological footprint of different world regions and how these are affected by population, affluence and technology. Few specialist technical terms are used. The candidate shows only a basic level of spelling, punctuation and grammar; and form and style are of a basic standard.	[1]–[5]	
Response not worthy of credit	[0]	15
	Total	**100**

A2 2016 Marking Grid

Question		AO1	AO2	AO3	Total
1 Waste to Energy Technologies	(a)		5		
	(b)	2			
	(c)	3			
	(d)		1		11
2 Energy Building Performance	(a)	1	3		
	(b)	1	1		
	(c)	2			
	(d)		2		10
3 Emerging Technologies	(a)	1	4		
	(b)	1		2	
	(c)	1	1		
	(d)		2		12
4 Risk Management at Land Contamination	(a)		2		
	(b)	2		4	
	(c)(i)		2		
	(ii)			2	12
5 Waste Management	(a)		4		
	(b)	1			
	(c)		1	3	9
6 Hydrogen Fuel Cell Opportunities	(a)	2			
	(b)		5		
	(c)	1			
	(d)			2	10
7 Development of Urban and Rural Sustainable			2	8	10
Communities					
8 Transport System Challenges	(a)	2			
	(b)		1	2	
	(c)	3		3	11
9 Sustainability and Future Development		5		10	15
Overall Total Marks for Paper		28	36	36	100