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National
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Mark

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S826/76/02

Environmental Science Paper 2

Date — Not applicable

Duration — 2 hours 30 minutes



Fill in these boxes and read what is printed below.

Full name of centre

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Town

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Forename(s)

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Surname

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Number of seat

--

Date of birth

Day

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Month

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Year

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Scottish candidate number

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Total marks — 100

Attempt ALL questions.

Questions 8 and 9 each contain a choice.

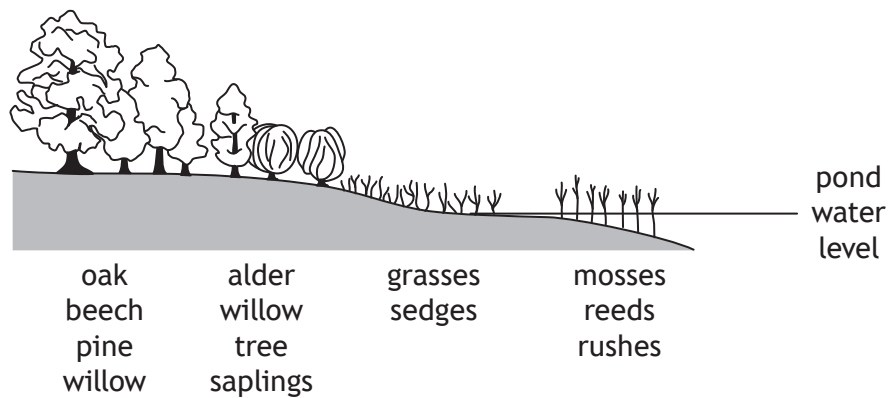
Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



1. (a) The diagram shows an example of primary succession in and around a freshwater pond ecosystem.



- (i) State what is meant by *primary succession*. 1
- (ii) Explain the changes in gross productivity that occur as succession proceeds. 2
- (iii) External factors can influence the natural sequence of succession.
Describe the sequence of changes in the plant communities that would occur as a result of draining the pond. 3

1. (a) (continued)

- (iv) Outline why ecosystem stability increases as succession proceeds through to a stable community.

2

- (b) Much of the heather moorland in Scotland is an unstable, managed ecosystem. It is maintained by sheep grazing and muirburn.

- (i) State the term used to describe a plant community where succession is prevented through persistent human interference.

1

- (ii) Describe one potential benefit of muirburn to biodiversity.

1

- (iii) Describe one potential negative impact of muirburn on the environment.

1

[Turn over



1. (continued)

- (c) Large areas of heather moorland are under threat from bracken, a type of fern that spreads vigorously by means of underground storage organs called rhizomes.

Bracken can shade out neighbouring plants. It also produces toxic compounds, some of which can reduce the germination and growth of other plant species.

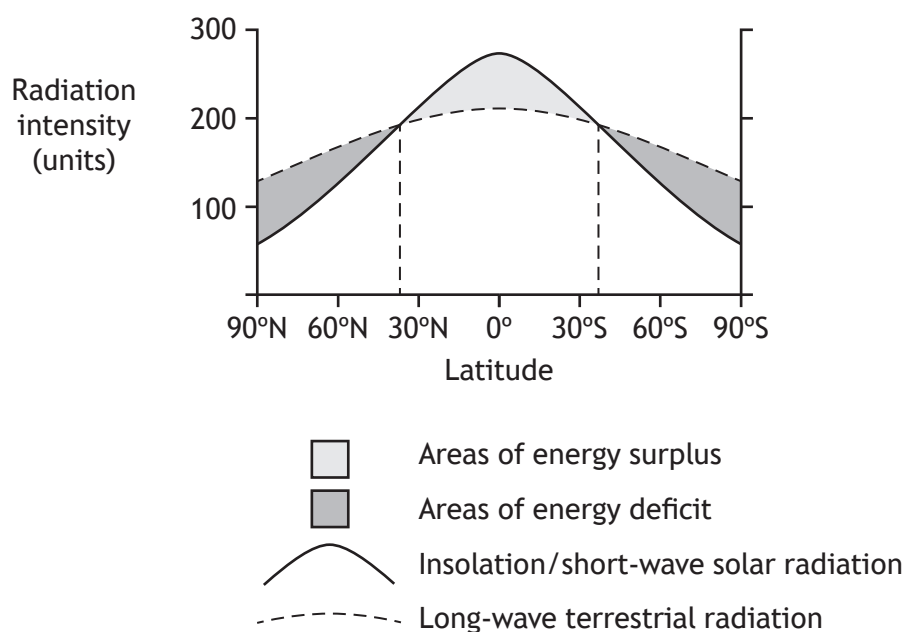


The spread of bracken on many moorland sites has been limited by mechanical control measures (cutting and rolling) and through use of the pesticide Asulam.

- (i) Explain why bracken is likely to be the dominant plant species. 2
- (ii) A ban on Asulam came into force in 2011.
Suggest two reasons why this ban may have been introduced. 2
- (iii) This ban is lifted intermittently.
Suggest a reason for this practice. 1

2. Solar energy is not equally distributed across the surface of the Earth.

The graph below shows that the area lying between 38° north and south of the equator receives a surplus of solar energy, while the areas towards the poles are in deficit.



- (a) (i) Name the type of biome typically found at 25° north of the equator. 1
- (ii) Describe two reasons for the solar energy deficit shown in the polar regions. 2

[Turn over



2. (a) (continued)

- (iii) Explain the redistribution of heat energy from areas of energy surplus to areas of energy deficit.

You should refer to the tri-cellular model in your response.

You may use a diagram in your response.

3



* S 8 2 6 7 6 0 2 0 6 *

2. (continued)

- (b) Milankovitch cycles describe cyclical variations in Earth-Sun geometry that occur over thousands of years. These impact on the amount of solar energy reaching the Earth's surface.

The cyclical variations include changes in:

- the shape of Earth's orbit around the Sun
- the tilt of Earth's axis towards or away from the Sun
- the orientation of Earth's axis of rotation.

- (i) Select **one** of these cyclical variations and describe the impact it has on the amount of solar energy reaching the Earth's surface.

2

- (ii) Milankovitch cycles have a long term impact on natural climate change.

State a factor that would have a short term impact on natural climate change.

1

- (c) Anthropogenic greenhouse gas emissions have an impact on global warming and climate change.

- (i) Name an anthropogenic greenhouse gas.

1

- (ii) State a source of the anthropogenic greenhouse gas you named in (c) (i).

1

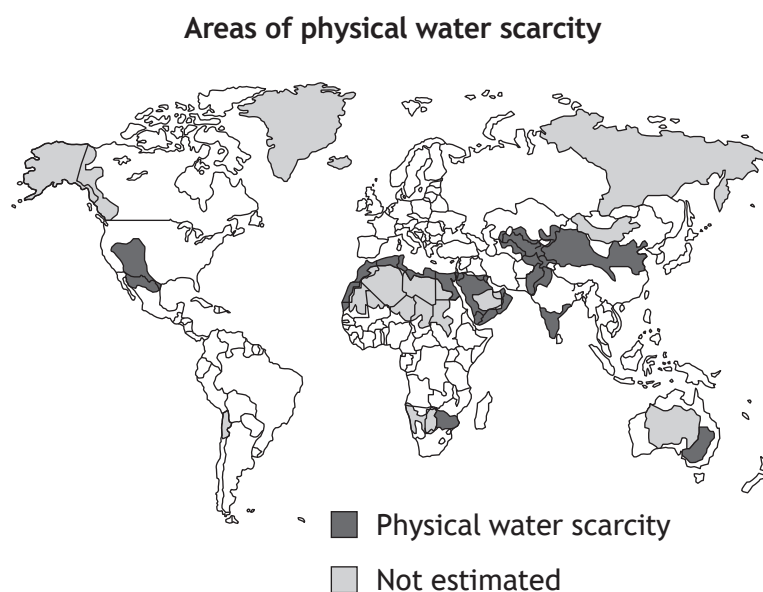
[Turn over



* S 8 2 6 7 6 0 2 0 7 *

3. Water covers over 70% of the Earth's surface, but 97% of it is too salty to drink.

(a) The map below shows areas of physical water scarcity around the world.



(i) Explain how atmospheric circulation influences the distribution of areas of physical water scarcity. 2

(ii) Countries with hot, dry climates often build dams across major rivers to create large reservoirs.

Explain the impact of this approach on water security. 2

(b) Drinkable water can be extracted from seawater.

Name the process used to extract drinkable water from seawater. 1



3. (continued)

(c) The table below shows levels of water withdrawal in 2010 around the world.

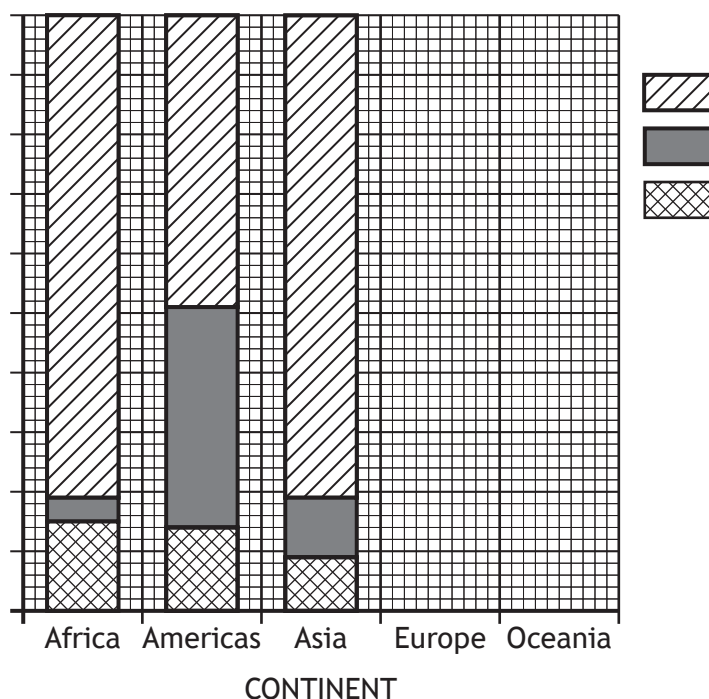
Continent	Total water withdrawal by sector in 2010						Total water withdrawal km ³ year ⁻¹
	Municipal		Industrial		Agricultural		
	km ³ year ⁻¹	% of total	km ³ year ⁻¹	% of total	km ³ year ⁻¹	% of total	
Africa	33	15	9	4	184	81	227
Americas	123	14	321	37	415	48	859
Asia	234	9	253	10	2069	81	2556
Europe	69	21	180	54	84	25	333
Oceania	5	20	4	15	16	65	25

(i) The 100% stacked bar chart below shows the percentage of total water withdrawal by sector.

Use the information in the table to complete the bar graph and key by:

2

- completing the y-axis and key
- plotting the bars for Europe and Oceania.



(Additional graph, if required, can be found on page 26.)



3. (c) (continued)

- (ii) Calculate, as a simple whole number ratio, the total water withdrawal by sector for Europe.

1

Space for calculation

_____	:	_____	:	_____
Municipal		Industrial		Agricultural

- (iii) There is pressure on sectors to reduce water use.

State one water conservation method which could be used in the industrial sector and one which could be used in the agricultural sector.

(A) Industrial

1

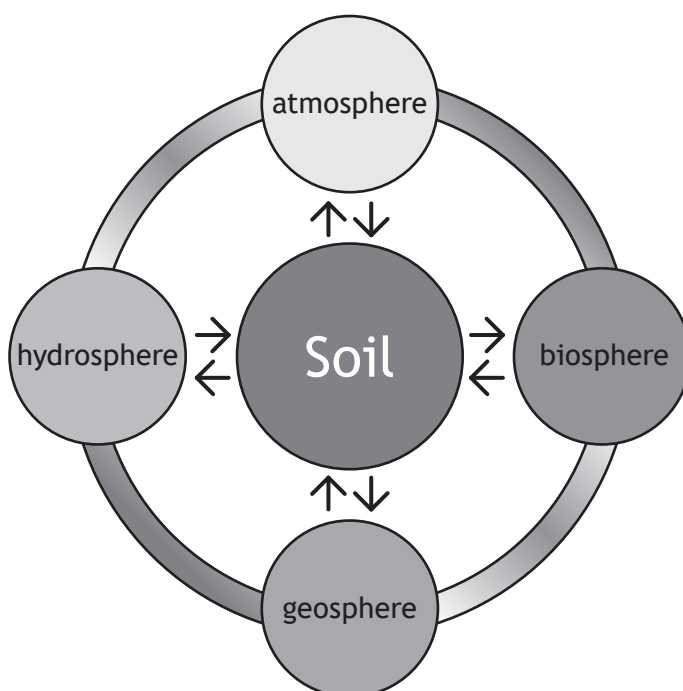
(B) Agricultural

1



* S 8 2 6 7 6 0 2 1 0 *

4. Soil is a product of interactions between the four main Earth systems.



- (a) Soil formation requires five main inputs. These include climate and time.
Name two other soil formation inputs.

2

- (b) It has been estimated that in Britain over 2 million tonnes of topsoil are lost annually through soil erosion.

- (i) Suggest two human activities that are likely to increase soil erosion rates.

2

- (ii) Describe an environmental impact associated with soil loss.

1

- (iii) Suggest a method that could be used to reduce soil loss.

1



4. (continued)

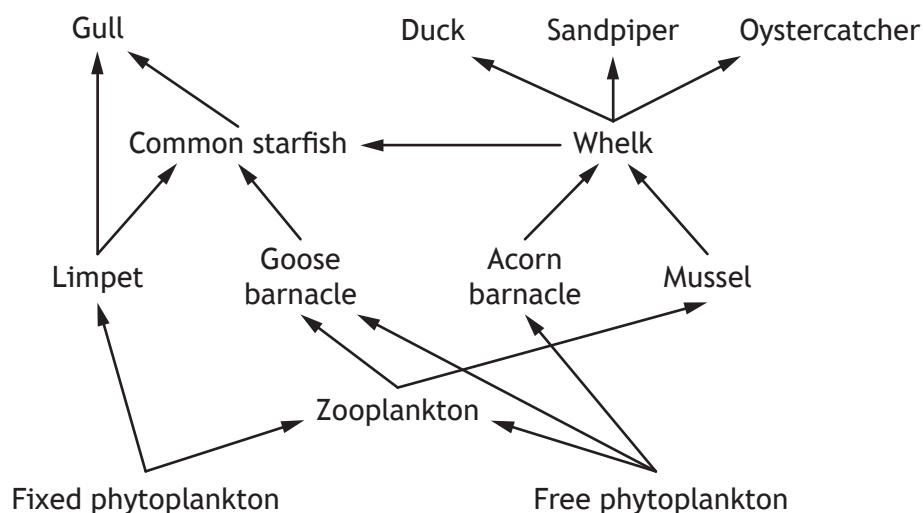
- (c) Describe the short-term impacts that a named event occurring in the geosphere would have on **each** of the other main Earth systems.

3



* S 8 2 6 7 6 0 2 1 2 *

5. The food web below shows the interaction of some species in a Scottish sea loch.



- (a) (i) Goose barnacles and acorn barnacles occupy a similar niche.
Describe one similarity and one difference between the niches of these barnacle species.

2

- (ii) Suggest why goose barnacles and acorn barnacles can survive within the same habitat.

1

[Turn over

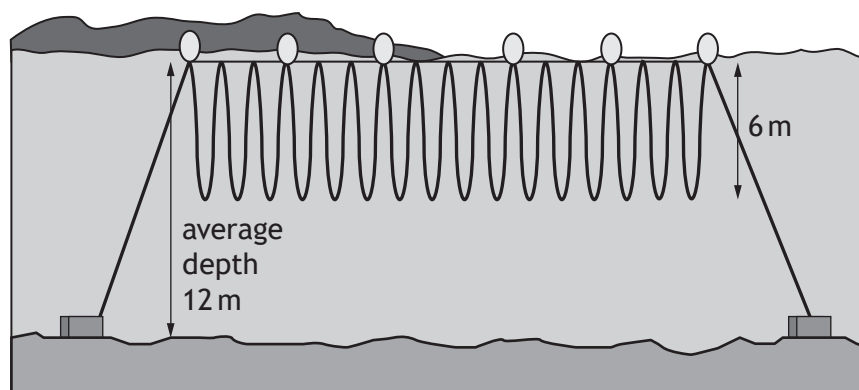


5. (continued)

- (b) Mussel farming in Scottish sea lochs is a growth industry.

Mussel farms use long ropes anchored to the seabed, and young mussels attach themselves to the ropes. The mussels are left to mature and are ready for harvest after two years.

The mussels being cultivated occur naturally in this ecosystem.



- (i) The numbers of common starfish were observed to have increased near to the mussel farm ropes.

Using information from the food web, suggest a reason for this increase in common starfish numbers.

1

- (ii) Predict one negative impact on the sea loch ecosystem resulting from the introduction of the mussel farm.

Justify your answer.

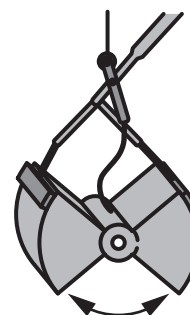
2

5. (continued)

- (c) A group of scientists conducted an environmental assessment of the seabed below four mussel farms located in sea lochs.

The scientists used a grab sampler to sample the seabed. The samples collected included mussel shell fragments, known as shell-hash.

The mass of shell-hash in each sample was measured. The results are shown in the table.



Sea loch sample site	Minimum shell-hash mass (g m^{-2})	Maximum shell-hash mass (g m^{-2})	Mean shell-hash mass (g m^{-2})	Median shell-hash mass (g m^{-2})	Number of samples collected at site
Creran 1	0	21 160	2260	230	12
Creran 2	0	19 200	2640	100	10
Etive 1	120	1260	460	280	7
Etive 2	60	3160	1440	1210	12
Leven 1	0	11 630	4430	7560	12
Spelve 1	190	3710	1150	970	12
Spelve 2	30	4450	850	520	11

- (i) The scientists were investigating the relationship between shell-hash and organic pollutants in the sediments of the sea lochs. A shell-hash mass of 1900 g m^{-2} in the sediment can reduce organic pollution.

Using the information in the table, identify the sea loch sample site which is most likely to have the least organic pollution.

Justify your answer.

2

- (ii) Explain why the results shown in the table cannot be considered valid.

1



5. (c) (continued)

- (iii) Shell-hash forms when mussels become dislodged from the farm ropes.

Describe one abiotic factor **and** one biotic factor that could be responsible for dislodging the mussels.

(A) Abiotic factor

1

(B) Biotic factor

1

- (iv) Loch Creran has a Marine Protected Area (MPA) designation.

Describe the role of an MPA.

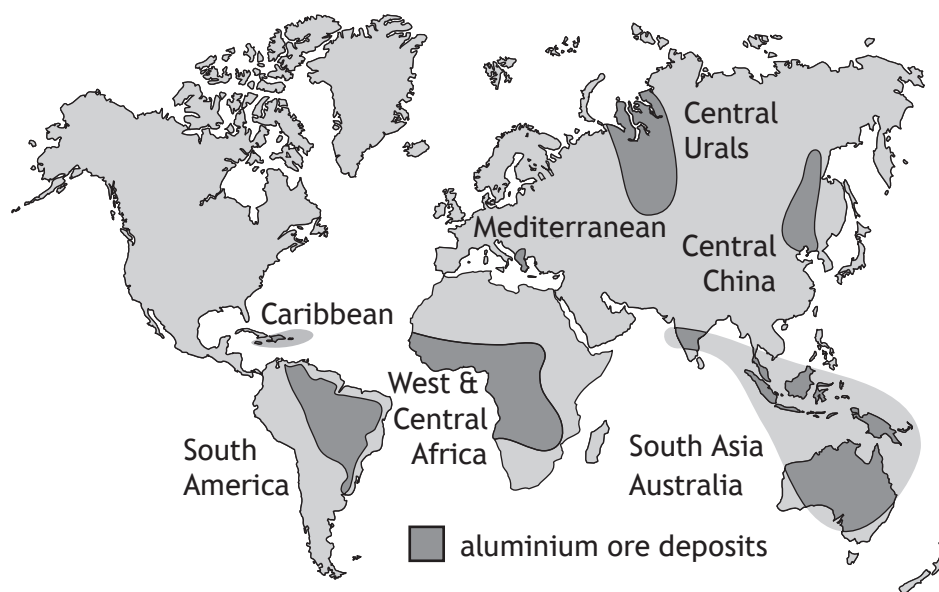
1

- (v) Name the environmental agency which has responsibility for MPAs in seas around Scotland.

1



6. Aluminium is the most abundant metal on Earth. It is extracted from the ground as a mineral ore, mainly in tropical areas. The map shows the major areas where the main mineral ore of aluminium is found.



- (a) The mineral ore is normally found in a layer averaging three to five metres in depth, located about half a metre below the surface.

(i) Name the mineral ore of aluminium.

1

- (ii) Laterite soil can be rich in aluminium ores. This soil forms in tropical areas, where climatic conditions result in extreme chemical weathering of rock.

Describe the formation of aluminium ore deposits.

3

[Turn over



6. (a) (continued)

- (iii) The majority of aluminium ore is extracted by open cast mining.

Describe an environmental impact associated with open cast mining of aluminium ore.

2

- (b) (i) The production of aluminium is a continuous process.

Suggest the most suitable renewable energy source to power this process.

1

- (ii) World production of aluminium in 2015 was 5.774×10^7 tonnes.

Each tonne of aluminium requires an input of 15 000 kilowatt hours (kWh) of electrical energy.

The entire world usage of electricity in 2015 was 1.091×10^{14} kWh.

Calculate the percentage of the entire world's electrical energy used to extract aluminium in 2015.

2

Space for calculation



* S 8 2 6 7 6 0 2 1 8 *

7. The Scottish Government launched its Zero Waste Plan in 2010. This plan sets out to minimise resource use and production of waste.

- (a) One of the aims of the Zero Waste Plan is to reduce the amount of food waste being sent to landfill.

Describe how food waste that is sent to landfill can contribute to the enhanced greenhouse effect.

2

- (b) Packaging is an issue associated with food waste.

- (i) Outline the value of packaging in relation to food.

1

- (ii) Plastic food packaging can be recycled or reused.

Compare the environmental impacts of recycling with those of reusing plastic food packaging.

2

- (iii) Explain, in terms of resources, why it is important to reprocess plastics.

1

[Turn over



7. (continued)

- (c) Waste sent for recycling may be separated into open loop or closed loop categories.

Explain the difference between open and closed loop recycling, using named examples.

2

- (d) The Zero Waste Plan supports the Waste (Scotland) Regulations 2012.

- (i) Name the environmental agency which has responsibility for enforcing the Waste (Scotland) Regulations 2012.

1

- (ii) The UK government currently looks to voluntary initiatives to deliver food waste reduction.

Suggest a way that food waste could be reduced by:

(A) individuals/families

1

(B) schools/colleges

1

(C) businesses.

1



* S 8 2 6 7 6 0 2 2 0 *

Questions 8 and 9 each contain a choice

For each question, attempt either A or B. Write your answers to questions 8 and 9 on the following pages. You may use diagrams where appropriate.

- 8. A** Global demand for food is rising because of population growth, increasing wealth and changing diets. The United Nations has forecast that global food production will have to increase by 70% by 2050 to meet demand.

Discuss the potential impacts of:

- (a) a named strategy designed to increase land-based food production
and
(b) a named strategy designed to increase aquatic food production.

10

OR

- B** Polar ice cores provide evidence for the increased release of greenhouse gases into the atmosphere since the mid-1800s. It is widely recognised that the increases are a result of human activities and are causing anthropogenic climate change.

Discuss sustainable strategies that could be used to reduce emissions of anthropogenic greenhouse gases by:

- (a) individuals and
(b) national government.

10

- 9. A** The Earth's internal heat can be captured and exploited as a resource for human development.

Discuss the benefits and challenges of using geothermal energy.

10

OR

- B** Biofuels are hailed as alternatives to current hydrocarbon-based fuels.

Discuss the advantages and disadvantages of using processed biofuels.

10

[Turn over



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MARKS

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SPACE FOR ANSWERS



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MARKS

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SPACE FOR ANSWERS (continued)



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SPACE FOR ANSWERS (continued)



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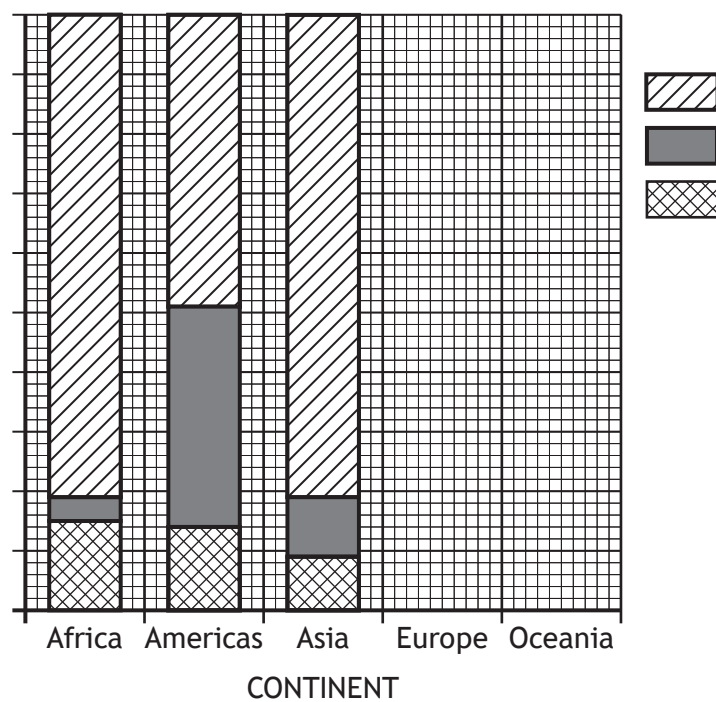
SPACE FOR ANSWERS (continued)

[END OF SPECIMEN QUESTION PAPER]



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ADDITIONAL GRAPH FOR QUESTION 3 (b) (i)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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MARKS

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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**Environmental Science
Paper 2**

Marking Instructions

These marking instructions have been provided to show how SQA would mark this specimen question paper.

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General marking principles for Higher Environmental Science

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

- (a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.
- (b) If a candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you should seek guidance from your team leader.
- (c) Where a candidate makes an error at an early stage in a multi-stage calculation, award marks for correct follow-on working in subsequent stages. Do not award marks if the error significantly reduces the complexity of the remaining stages. Apply the same principle in questions which require several stages of non-mathematical reasoning.
- (d) Award full marks for a correct final answer (including units if required) on its own, unless a numerical question specifically requires evidence of working to be shown.
- (e) Candidates may access larger mark allocations fully, whether they respond in continuous prose, linked statements or a series of discrete developed points.
- (f) In the detailed marking instructions, if a word is **underlined** then it is essential; if a word is **(bracketed)** then it is not essential.
- (g) In the detailed marking instructions, words separated by / are alternatives.
- (h) Do not award marks if a candidate gives two answers, where one is correct and the other is incorrect.
- (i) Where the candidate is instructed to choose one question to answer but instead answers both questions, mark both responses and award the better mark.
- (j) Award marks for a valid response, even if the response is not presented in the format expected. For example, award the mark if the response is correct but is not presented in the table as requested, or if it is circled rather than underlined as requested.
- (k) Candidates may use abbreviations (for example BOD, GPP) or chemical formulae (for example CO₂, H₂O) as acceptable alternatives to naming, unless otherwise required by the question.
- (l) Award marks, up to the maximum mark allocation for the question, for content that is outwith the course specification but used appropriately at the correct level for Higher.
- (m) If candidates are required to give a numerical answer, and units are not given in the stem of the question or in the answer space, they must supply the units to gain the mark. Do not penalise candidates repeatedly if units are required on more than one occasion.
- (n) If incorrect **spelling** is used:
 - and the term is recognisable, then award the mark;
 - and the term can easily be confused with another scientific term, then do not award the mark, for example bioaccumulation and biomagnification, or qualitative and quantitative;
 - and the term is a mixture of other terms, then do not award the mark.

(o) When presenting data:

- for marking purposes no distinction is made between bar charts (used to show discontinuous features, have descriptions on the x-axis and have separate columns) and histograms (used to show continuous features, have ranges of numbers on the x-axis and have contiguous columns)
- other than in the case of bar charts/histograms, if the question asks for a particular type of graph or chart and the wrong type is given, then do not give the mark(s) for this. Where provided, award marks for correctly labelling the axes, plotting the points, joining the points either with straight lines or curves (best fit rarely used) etc
- do not award the relevant mark if the graph uses less than 50% of the axes; if the x and y data are transposed; if 0 is plotted when no data for this is given (ie candidates should only plot the data given)

(p) Award marks only for a valid response to the question asked. For example, in response to questions that ask candidates to:

- **identify, name, give, or state**, they need only name or present in brief form
- **define**, they should give a statement of the definition
- **calculate**, they must determine a number from given facts, figures or information
- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things
- **describe**, they must provide a statement or structure of characteristics and/or features
- **evaluate**, they must make a judgement based on criteria
- **explain**, they must relate cause and effect and/or make relationships between things clear
- **outline**, they must provide a brief sketch of content— more than naming but not a detailed description
- **predict**, they must suggest what may happen based on available information
- **suggest**, they must apply their knowledge and understanding of environmental science to a new situation. A number of responses are acceptable: award marks for any suggestions that are supported by knowledge and understanding of environmental science

Marking instructions for each question

Question			Expected answer(s)	Max mark	Additional guidance
1.	(a)	(i)	The colonisation of a new site by communities of plants and animals after an event has removed all existing soil, for example glaciation or a lava flow.	1	Response must refer to the removal of previous soil or development of new soil.
		(ii)	Gross productivity increases because there is an increase in biomass AND in variety of plants. Or any other valid response.	2	1 mark for increasing biomass. 1 mark for increasing variety.
		(iii)	Mosses, reeds and rushes would die out. (1 mark) AND Pond would be taken over by primary colonisers / grasses and sedges would colonise original pond edge. (1 mark) AND Alder, willow and saplings (oak, beech, pine) would spread into the area and form the climax community. (1 mark) OR Pioneer species → intermediate stages → climax community, with named examples.	3	1 mark for loss of existing vegetation. 1 mark for intermediate stage or mention of, for example competition for resources or changes in edaphic conditions. 1 mark for climax community.
		(iv)	As succession proceeds: More plant species arrive/plant communities develop, increasing species diversity. (1 mark) OR With an increase in plant species, there is also an increase in available niches. (1 mark) OR An increase in plant species/communities encourages an increase in insect and small mammal life. (1 mark) AND Increasing animal diversity at low trophic levels reduces intraspecific competition at higher trophic levels. (1 mark) OR An increased food web complexity (will increase the stability of the ecosystem). (1 mark)	2	1 mark for any of the three outcomes from succession proceeding. 1 mark for stating how the outcome contributes to food web complexity and ecosystem stability.

Question			Expected answer(s)	Max mark	Additional guidance
1.	(b)	(i)	Plagioclimax	1	
		(ii)	A patchwork of muirburn removes old heather growth and allows for succession/a wider range of habitats, which supports a higher biodiversity. Or any other valid response.	1	Emphasis here should be on biodiversity.
		(iii)	Muirburn can destroy heather roots, killing the plant / cause soil erosion / cause air pollution. Or any other valid response.	1	Emphasis here should be on the environment.
	(c)	(i)	The bracken spreads underground via rhizomes (no requirement for pollination) and rhizomes will be protected/can survive all year. OR Bracken produces toxic compounds that reduce germination of competitors. OR The toxic compounds reduce growth of competitors. OR The bracken fronds exclude light from competitors. Or any other valid response.	2	1 mark for valid reason. 1 mark for valid explanation.
		(ii)	Asulam may affect other plant species and further reduce biodiversity. OR Asulam may run off hillsides into watercourses and destroy aquatic life. OR Asulam may find its way into the food chain/web and affect human life. OR Asulam may bioaccumulate in the food chain and affect wildlife. OR Bracken may become resistant to Asulam. Or any other valid response.	2	Any two valid points.
		(iii)	No other appropriate remedy is available (so chemical is used sparingly).	1	

Question			Expected answer(s)	Max mark	Additional guidance
2.	(a)	(i)	Hot desert	1	
		(ii)	Albedo of snow and ice / seasonality (3 months of no solar input beyond 60°N or 60°S) / curvature of the Earth means that incoming radiation has a greater surface area to heat / incoming energy in polar areas travels at an angle due to the curvature of the Earth, increasing possibility of reflection/absorption.	2	Any two valid points.
		(iii)	Tri-cellular model should include mention of Hadley, Ferrel and Polar cells. AND Explanation of how a parcel of air can move via these cells from the equator to a pole (and vice versa), redistributing heat/cold across the Earth's surface.	3	An annotated diagram could gain full marks. Award marks for correct consideration of areas of high and low pressure / jet streams.
	(b)	(i)	The shape of Earth's orbit around the Sun – varies from elliptical to nearly circular (1 mark). When circular, the amount of insolation received annually is greater than when elliptical and the Earth's temperature increases. (1 mark) The tilt of Earth's axis towards or away from the Sun – greater tilt results in more severe seasonal variation, or vice versa. (1 mark) Build-up of ice and snow increases albedo and causes additional cooling. (1 mark) The orientation of Earth's axis of rotation – is driven by tidal changes influenced by the Sun and Moon, (1 mark) resulting in one polar hemisphere being closer to the Sun and receiving more insolation than the other hemisphere. (1 mark) Or any other valid response.	2	2 marks for a correct extended description of any one of these cycles.
		(ii)	Volcanic event / sunspot activity Or any other valid response.	1	

Question			Expected answer(s)	Max mark	Additional guidance
2.	(c)	(i)	Carbon dioxide / methane / nitrous oxide / water vapour.	1	Any one valid point.
		(ii)	<p>Carbon dioxide – cement production / deforestation / combustion of fossil fuels.</p> <p>Methane – fossil fuel production, distribution, use / livestock farming / landfill and waste / combustion of biomass / rice agriculture / combustion of biofuels.</p> <p>Nitrous oxide – fertiliser runoff / fertiliser leaching / manure use / combustion of fossil fuels / vehicle emissions / industrial emissions / combustion of biomass.</p> <p>Water vapour – changes in atmospheric content relate to emissions of greenhouse gases emitted through human activities / evaporation from man-made reservoirs and canals.</p> <p>Or any other valid response.</p>	1	Any one valid point. Source must be related to the correct gas.

Question			Expected answer(s)	Max mark	Additional guidance
3.	(a)	(i)	Areas of physical water scarcity correspond with areas of high pressure (1 mark), resulting in low precipitation. (1 mark) Or any other valid response.	2	1 mark for mention of high pressure. 1 mark for mention of precipitation.
		(ii)	Increased evaporation into the atmosphere / seepage into soil (1 mark) decreases the available water which decreases water security. (1 mark) Or any other valid response.	2	1 mark for identifying the impact. 1 mark for the effect this has on water security.
	(b)		Desalination	1	
	(c)	(i)	y-axis scale should range from 0 to 100 AND should be labelled appropriately (total water withdrawal by sector (%) or percentage total water withdrawal by sector) and key should be completed. 100% stacked bars for Europe and Oceania should be correctly plotted.	2	1 mark for appropriate scale, label and key. 1 mark for correctly plotted bars. Assumed zero would be acceptable providing the scale intervals support this.
		(ii)	23 : 60 : 28	1	69 : 180 : 84 are all divisible by 3.
		(iii)	(A) process modification / new equipment / re-use greywater / re-use blackwater.	1	Any one valid point.
			(B) drip irrigation / growing drought-resistant crops. Or any other valid response.	1	Any one valid point.

Question			Expected answer(s)	Max mark	Additional guidance
4.	(a)		Parent material / organisms / relief.	2	Any two valid points.
	(b)	(i)	Deforestation / agriculture / over-grazing / use of synthetic fertilisers. Or any other valid response.	2	Any two valid points.
		(ii)	Loss of arable land / polluted watercourses / increased potential for flooding / desertification. Or any other valid response.	1	Any one valid point.
		(iii)	Afforestation / reforestation / controlled grazing / increased planting of ground cover. Or any other valid response.	1	Any one valid point.
	(c)		<p>Possible geosphere events include an earthquake/volcanic eruption/ landslide.</p> <p>Impacts on other Earth systems will depend on the geosphere event.</p> <p>Example: a volcanic eruption</p> <ul style="list-style-type: none"> • atmosphere – eruption ejects material (lava, ash, rocks, particulates, gases), which is carried by wind/falls back to Earth's surface through gravity/carried or dissolved in rainwater. • hydrosphere – ash enters watercourses and is carried away from the volcanic source /contaminates the water with toxic levels of erupted compounds. • biosphere – ash smothers areas downwind of the volcano and kills off vegetation and/or organisms. Toxic compounds dissolved in contaminated watercourses could affect life. <p>Or any other valid response.</p>	3	<p>1 mark for valid discussion of impacts on each of the Earth systems, excluding the geosphere.</p> <p>The impacts should be linked to the named event.</p>

Question			Expected answer(s)	Max mark	Additional guidance
5.	(a)	(i)	<p>Similarity: both consume free phytoplankton / the sea loch is the habitat of both. (1 mark)</p> <p>Difference: goose barnacles are consumers of zooplankton whereas acorn barnacles are not / acorn barnacles are consumed by whelks whereas goose barnacles are consumed by common starfish. (1 mark)</p>	2	Response must refer to consumption and/or predation - do not accept 'eaten'. Note that a plant can be consumed but not predated.
		(ii)	They both compete for the same food source/free phytoplankton (or are filter feeders), but interspecific competition is avoided by goose barnacles also predating/consuming zooplankton.	1	
	(b)	(i)	<p>Starfish may be attracted by an increase in whelk population which predares the mussels.</p> <p>OR</p> <p>The mussel farm ropes may offer increased protection from predators</p> <p>Or any other valid response.</p>	1	Any valid response for the starfish being attracted/protected in some biological way by the mussel farm.
		(ii)	<p>An increase in mussel numbers in this ecosystem could destabilise the food web. (1 mark)</p> <p>AND</p> <p>The zooplankton would decrease limiting the available food for goose barnacles. (1 mark)</p> <p>OR</p> <p>The zooplankton would decrease causing a population explosion of phytoplankton. (1 mark)</p> <p>Or any other valid response.</p>	2	<p>A wide range of implications could be explored.</p> <p>The justification must be credible.</p>
	(c)	(i)	<p>Leven (1 mark)</p> <p>The median is greater than the mean which indicates most of the samples at Leven are above the threshold of 1900 g m⁻². (1 mark)</p>	2	Accept both the mean and the median are above 1900 g m ⁻² .
		(ii)	<p>The number of samples collected at each location differs.</p> <p>OR</p> <p>Leven and Spelve sites were only sampled once.</p>	1	

Question			Expected answer(s)	Max mark	Additional guidance
5.	(c)	(iii)	(A) Extreme weather/wind/waves/tides/storms may dislodge mussels.	1	Any one valid point.
			(B) As mussels are predated their neighbours may be dislodged / the discarding of waste material by a predator may dislodge neighbouring mussels / increasing intraspecific competition for space could dislodge weaker mussels. Or any other valid response.	1	Any one valid point.
		(iv)	To protect nationally important marine wildlife, habitats, geology and undersea landforms.	1	
		(v)	Marine Scotland	1	

Question			Expected answer(s)	Max mark	Additional guidance
6.	(a)	(i)	Bauxite	1	Award the mark if another correct ore of aluminium is named.
		(ii)	<p>Tropical areas experience abundant rainfall and high temperatures. (1 mark)</p> <p>These factors promote abundant vegetation growth, producing organic acids when the vegetation decomposes. (1 mark)</p> <p>The rainfall and organic acids both play a role in (chemical) weathering / hydrolysis. (1 mark)</p> <p>(Acidic) water percolating through the soil leaches/translocates/eluviates soluble compounds/silica, (1 mark) leaving behind aluminium-rich insoluble compounds/clay minerals. (1 mark)</p>	3	Response should mention the relevance of rainfall AND temperature in weathering, plus translocation/eluviation of soluble compounds leaving behind insoluble aluminium compounds.
		(iii)	<p>Landscape change through removal of timber/vegetation/rock and soil/overburden.</p> <p>OR</p> <p>Erosion and runoff from the mine.</p> <p>OR</p> <p>Disturbance of the movement/quality/distribution of water in the area.</p> <p>OR</p> <p>The need for disposal of overburden/tailings/other mine waste.</p> <p>OR</p> <p>Dust/noise/emissions from mining operations/transport.</p> <p>AND</p> <p>Environmental impact associated with the disturbance through mining.</p> <p>Or any other valid response.</p>	2	<p>1 mark for the negative impact.</p> <p>1 mark for an associated effect on the environment.</p>
	(b)	(i)	<p>Hydroelectric power / geothermal power.</p> <p>Or any other valid response.</p>	1	<p>Must be a renewable source and have the potential to provide electricity 24 hours a day.</p> <p>Although there is debate over the issue, nuclear power should be regarded here as a non-renewable source of energy.</p>

Question			Expected answer(s)	Max mark	Additional guidance
6.	(b)	(ii)	0.79 (%)	2	$(5.774 \times 10^7) \times 15\,000 = 8.661 \times 10^{11}$ kW h $(8.661 \times 10^{11}) \div (1.091 \times 10^{14}) =$ 0.0079 $\times 100 = 0.79\%$ Accept 0.8% or 0.794%. 1 mark for correctly calculating the kW h value. 1 mark for correctly calculating the percentage.

Question			Expected answer(s)	Max mark	Additional guidance
7.	(a)		Decomposing food/organic waste releases methane, (1 mark) which is a greenhouse gas and enhances the natural greenhouse effect. (1 mark) OR Transportation of food waste to landfill releases carbon dioxide, (1 mark) which is a greenhouse gas and enhances the natural greenhouse effect. (1 mark) Or any other valid response.	2	Answer should make mention of the source of a named greenhouse gas and its enhancement of the natural greenhouse effect.
	(b)	(i)	Protects food from damage during transport/storage.	1	
		(ii)	Recycling requires additional energy for reprocessing, transportation etc, so contributes to emissions but reduces overall waste. Reuse requires no reprocessing other than cleaning, so saves on natural resources/reduces waste. Or any other valid response.	2	1 mark for reprocessing. 1 mark for reuse.
		(iii)	Plastic is made from crude oil, which is a finite resource. OR Plastics sent to landfill are a lost resource. OR Plastic waste degrades into micro-plastics but remains in the environment. Or any other valid response.	1	
	(c)		Open loop recycling – a loss of quality occurs with each recycling cycle, limiting the number of times the material can be recycled, for example plastic or paper. Closed loop recycling – a product can be recycled indefinitely back into itself without any impact on quality, for example aluminium or glass. Or any other valid response.	2	1 mark for open loop recycling. 1 mark for closed loop recycling.

Question			Expected answer(s)	Max mark	Additional guidance
7.	(d)	(i)	SEPA	1	
		(ii)	<p>(A) individuals/families: WRAP advice is to:</p> <ul style="list-style-type: none"> • plan shopping and buy only what you need • use what you buy • cook what you need • use up leftovers • store food properly <p>Or any other valid response.</p>	1	
			<p>(B) schools/colleges: Monitor food waste to see what meals are popular/unpopular and estimate quantities based on this assessment. OR Make students aware of the level of food waste and consider how it could be reduced, for example ask what they would like on the menu and/or in what form. Could be through a school committee. OR If possible, cook some selections to order. OR Compost food waste or send for anaerobic digestion. Or any other valid response.</p>	1	
			<p>(C) businesses:</p> <ul style="list-style-type: none"> • supermarkets could donate food that is still within the sell-by or use-by date to local charities • restaurants and bakeries could donate leftover food to local charities <p>Or any other valid response.</p>	1	

Question			Expected answer(s)	Max mark	Additional guidance
8.	A		<p>One land-based AND one aquatic strategy.</p> <p>For each strategy:</p> <ul style="list-style-type: none"> • name of strategy (1 mark) • description (1 mark) • potential impacts (1 mark for each well-structured statement, up to 4 marks in total). <p>For example:</p> <ul style="list-style-type: none"> • name of strategy: use of pesticides (1 mark) • description: pesticides are manufactured chemicals designed to kill unwanted plants/animals (1 mark) • potential impact: a rodenticide is an example of a pesticide that is used to kill rats and mice (1 mark) • positive impacts: less contamination of harvested crop by rodents increases yield (1 mark) and therefore profit (1 mark) / less contamination by rodents prevents spread of disease (1 mark) • negative impacts: may affect non-target species (1 mark) / decomposition of dead rodents/animals (1 mark) / potential for bioaccumulation of pesticides in predators/scavengers (1 mark) / biomagnification of pesticides through the food chain (1 mark) <p>Or any other valid response.</p>	10	<p>Award a maximum of 6 marks for land-based food production.</p> <p>Award a maximum of 6 marks for aquatic food production.</p> <p>For full marks candidates must name the strategy, provide a description of the strategy, AND discuss potential impacts.</p> <p>The description and impacts should relate to the named strategy, which could be selected from the following:</p> <p>Land-based food production:</p> <ul style="list-style-type: none"> • development of intensive agriculture - changes in land management: larger fields, crop rotation, drainage, hedgerow removal, cultivation of marginal land • NOT conservation practices as these are not usually aimed at increasing food production • accept diversification if discussion relates to increasing food production eg new crop type, but not for alternative non-food related activities • changes in technology: mechanisation, agrochemicals (fertilisers, pesticides), irrigation, selective breeding, high yield varieties, GM crops, hydroponics <p>Aquatic food production:</p> <ul style="list-style-type: none"> • aquaculture - high density cages, pesticide use, selective breeding, GM, hormone use • marine fisheries - stock management <p>Do not accept the same example for both land-based and aquatic strategies.</p>

Question			Expected answer(s)	Max mark	Additional guidance
8.	B		<p>For each strategy:</p> <ul style="list-style-type: none"> • name of strategy (1 mark) • description (up to 2 marks) • methods (1 mark for each well-structured statement, up to 4 marks in total). <p>For example:</p> <p><i>Individual</i></p> <ul style="list-style-type: none"> • strategy: to reduce domestic energy consumption (1 mark) • description: this will reduce emissions of CO₂ / methane / nitrous oxide / water vapour (1 mark for each up to maximum of 2 marks) and could also have financial benefits (1 mark) • methods: use energy efficient light bulbs, which use less energy than incandescent lightbulbs (1 mark)/ install solar panels, and export surplus energy to the national grid (1 mark)/ buy energy efficient appliances, which use less electricity and so cost less to run (1 mark)/ install a condensing boiler, which recovers heat from flue gases (1 mark)/ install a combi boiler that provides hot water on demand without need for a hot water cylinder (1 mark)/ set heating on a timer to reduce energy used to heat empty house (1 mark)/ get a home energy audit done to highlight areas where energy use could be reduced (1 mark) <p>Or any other valid response.</p> <p><i>National government</i></p> <ul style="list-style-type: none"> • strategy: agreeing a climate change plan (1 mark) • description: the climate change plan sets out priorities, proposals and policies to reduce GHG emissions (1 mark) • methods: improve the energy efficiency of government buildings (local and/or national) to reduce energy bills (1 mark) and save public money (1 mark)/ offer incentives to the public to improve energy efficiency of homes (by installing smart 	10	<p>Award a maximum of 7 marks for strategies by individuals.</p> <p>Award a maximum of 6 marks for strategies by national government.</p> <p>For full marks candidates must name the strategy, provide a description of aim of the strategy, AND discuss potential methods aimed at reducing GHG emissions.</p> <p>The description and methods should relate to the named strategy, which aims to:</p> <ul style="list-style-type: none"> • reduce energy consumption • reduce GHG emissions • reduce waste • mitigate against climate change <p>Do not accept the same example for both individual and national strategies.</p> <p>Award a maximum of 5 marks if candidates give a list of methods without wider discussion.</p>

Question			Expected answer(s)	Max mark	Additional guidance
8.	B		<p>meters; subsidising cost of insulation, light bulbs, secondary glazing) (1 mark for each up to maximum of 2 marks)/ support investment in low carbon energy technologies (freight, carbon capture and storage, energy efficient buildings, low carbon transport fuels, climate smart agriculture) (1 mark for each up to maximum of 2 marks)/ decarbonise the transport system by encouraging companies/individuals to switch from diesel vehicles to low emission electric or hydrogen vehicles (1 mark)/ set up 'low emission zones' in towns and cities, with restricted access to vehicles that exceed emission benchmarks (1 mark)</p> <p>Or any other valid response.</p>		

Question			Expected answer(s)	Max mark	Additional guidance
9.	A		<p>Benefits:</p> <ul style="list-style-type: none"> geothermal energy is a renewable resource, (1 mark) reducing reliance on finite carbon-based sources of energy (1 mark) is a clean source of energy, (1 mark) reducing greenhouse gas emissions/CO₂ emissions (1 mark) and the carbon footprint of countries (1 mark) provides energy security for countries where available, (1 mark) so consumer prices should be more stable over the longer term (1 mark) geothermal plants can be large or small (1 mark) and may have less of a visual impact than coal-fired power stations (1 mark) geothermal plants are less susceptible to contributing pollution in the event of natural disasters (1 mark) <p>Or any other valid response.</p> <p>Challenges:</p> <ul style="list-style-type: none"> limitations on location of plants (1 mark) as the plants need to be located in areas of geothermal activity relatively close to the Earth's surface (1 mark) geothermal sources can be hazardous (1 mark) geothermal plants have a limited output (1 mark) so are usually part of an energy mix including other sources (1 mark) cost of distribution will vary as geothermal sources are not always located near urban centres/the main market (1 mark) <p>Or any other valid response.</p>	10	<p>Award a maximum of 7 marks for benefits. Award a maximum of 7 marks for challenges.</p> <p>Statements should be well-structured and explanatory and must relate to geothermal energy.</p>

Question			Expected answer(s)	Max mark	Additional guidance
9.	B		<p>Advantages:</p> <ul style="list-style-type: none"> biofuels have the potential to minimise CO₂ emissions (1 mark) by generating energy not reliant on hydrocarbons (1 mark) could provide economic stability in energy process in times of diminishing hydrocarbon resources (1 mark) could provide a source of energy security for countries (1 mark) so that countries where biofuels are available rely less on imports of hydrocarbons (1 mark) high yield crops grown in small areas could combat socio-economic and environmental concerns (1 mark) <p>Or any other valid response.</p> <p>Disadvantages:</p> <ul style="list-style-type: none"> do not necessarily mitigate against anthropogenic climate change (1 mark) deforestation to create farmland for growing biofuel crops (1 mark) can create environmental imbalance as deforestation itself contributes to the enhanced greenhouse effect (1 mark)/ burning adds CO₂ to the atmosphere (1 mark)/ fewer trees means less CO₂ sequestration (1 mark) high yield crops require high levels of artificial fertiliser (1 mark) with potential for eutrophication if applied inappropriately (1 mark) socio-economics of food vs fuel, (1 mark) particularly in developing countries where there are poverty and food issues (1 mark) increased food prices due to diversion of crops to biofuel production (1 mark) <p>Or any other valid response.</p>	10	<p>Award a maximum of 7 marks for advantages. Award a maximum of 7 marks for disadvantages.</p> <p>Statements should be well-structured and explanatory and must relate to geothermal energy.</p>

[END OF SPECIMEN MARKING INSTRUCTIONS]