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National
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X826/76/02

**Environmental Science
Paper 2**

TUESDAY, 30 MAY
10:15 AM – 12:45 PM



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Fill in these boxes and read what is printed below.

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Number of seat

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Date of birth

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Scottish candidate number

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Total marks — 100

Attempt ALL questions.

Questions 9 and 10 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. You should 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.



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Total marks — 100 marks

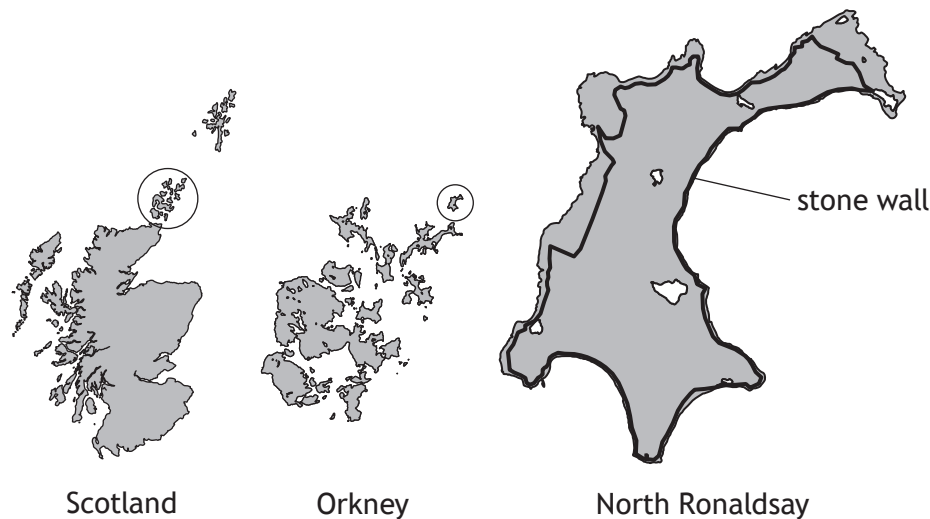
Attempt ALL questions

Questions 9 and 10 each contain a choice

1. North Ronaldsay is the most northerly island in the Orkney Islands. It is home to approximately 50 people and 2000 sheep.

In the 19th Century, islanders built a stone wall to keep the sheep on the shore in order to protect the island's grass, which was needed to feed cattle.

The map shows the island of North Ronaldsay and the stone wall.



- (a) Give one reason for the increasing global demand for farmed meat. 1
- (b) (i) The sheep population on North Ronaldsay has survived for hundreds of years on a diet of seaweed. As a result, these sheep produce much less methane than sheep reared on traditional animal feed or grass. 1
Other than from livestock farming, state one source of methane in the environment.



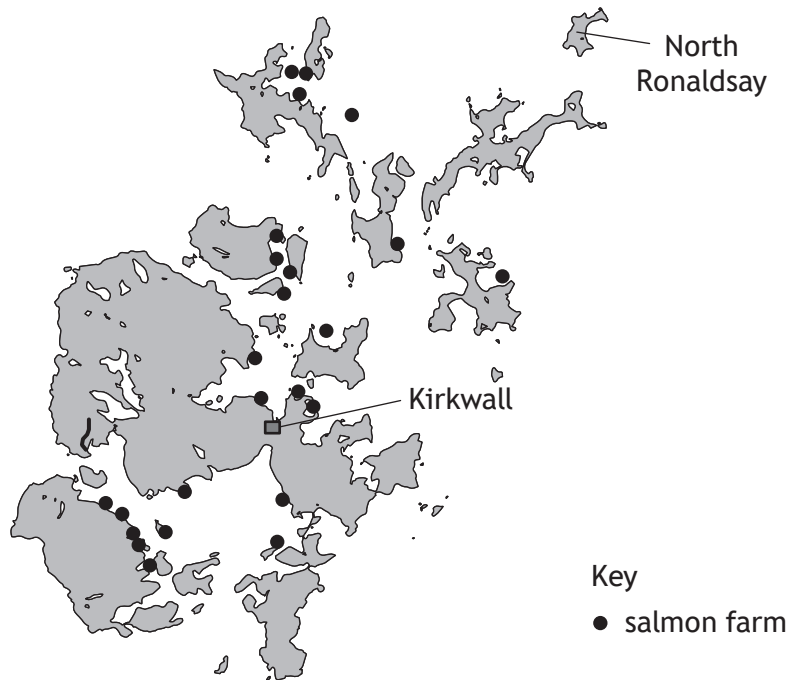
1. (b) (continued)

- | | |
|--|---|
| (ii) Explain one economic benefit of reducing the volume of methane produced in agriculture. | 2 |
| (c) In addition to reducing methane emissions, feeding seaweed to sheep also reduces the need for farmers to maintain agricultural land to produce animal feed. This has an impact on food security. | |
| (i) State what is meant by <i>food security</i> . | 1 |
| (ii) Explain how feeding seaweed to sheep impacts upon food security. | 2 |
| (iii) Suggest why it may not be possible for farmers on mainland Scotland to adopt the practice demonstrated by farmers on North Ronaldsay. | 1 |



1. (continued)

(d) The map shows locations of existing salmon farms in the Orkney Islands.



- (i) Sea lice are a parasite of salmon and are a problem in aquaculture. Recent research suggests that nearby seaweed growth can reduce the number of sea lice present in high density cages. Suggest a benefit to the environment of reduced sea lice.

1

1. (d) (continued)

- (ii) Permission has been granted for a salmon farm with multiple cages. Each circular cage has a radius r of 13.0 m and depth d of 8.0 m. Salmon can be farmed up to a density of 17 kg m^{-3} .

The volume V of each cage can be calculated using the formula

$$V = \pi r^2 d$$

Calculate the maximum mass, to the nearest 1000 kg, of salmon that can be farmed in one of the cages at this salmon farm at any given time.

3

Space for working

- (iii) Other than increased food security, suggest one benefit of establishing new salmon farms around Scottish islands.

1

[Turn over



2. Around 1 billion plastic straws are used every day worldwide. Many countries have banned them or plan to ban them.

As part of their sustainability strategy, some companies have pledged to reduce the number of plastic straws in their restaurants by using alternative materials for the straws.

(a) Define *sustainability*.

1

(b) Alternatives to plastic drinking straws include use of straws made from:

- non-biodegradable materials such as stainless steel or glass; these straws are washable and reusable
- bamboo from whole bamboo stalks; these straws are washable and reusable
- harvested stalks from cereal crops; these stalks are a by-product of harvesting cereal and are biodegradable.

A company completed a life cycle analysis (LCA) of different types of drinking straws. The information is shown in the table.

Straw material	Energy use in production	Pattern of use	Disposal
Plastic	high	single use	waste
Glass/steel	high	multiple use	waste/recyclable
Bamboo	low	multiple use	compostable
Harvested stalk	medium/low	single use	compostable

(i) Explain why an LCA was completed by the company when it was determining a sustainable alternative to plastic straws.

1



2. (b) (continued)

(ii) Using the information in the table, identify the straw material that best fits the circular economy model.
Justify your answer.

3

(iii) State two additional pieces of information that would be required in order to complete an LCA.

2

1

2

(iv) Embedded energy includes all the direct and indirect energy required to manufacture a finished product.

Suggest one way in which the embedded energy in non-biodegradable drinking straws might be reduced.

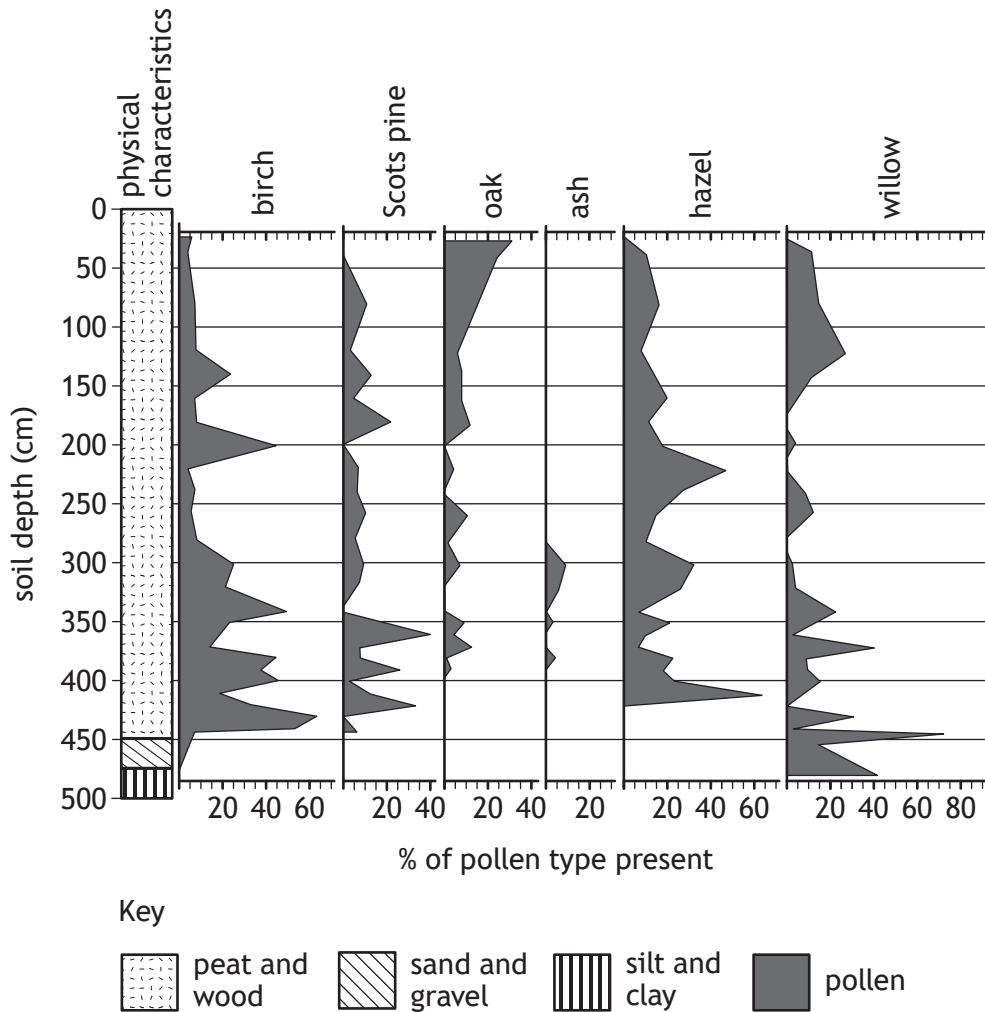
1

(v) Suggest why drinking straws made from harvested stalks from cereal crops might be classed as having a medium level of energy use in their production.

1



3. Pollen analysts study pollen grains preserved in soil. By collecting soil cores, pollen grains found at different depths can be compared with modern day distribution of the same plants. The presence or loss of native species may indicate changes in climatic conditions that have occurred at a given location over time.
- (a) The diagram shows part of a pollen profile for selected types of tree pollen extracted from a soil core. The soil core was collected on the Isle of Barra, off the northwest coast of Scotland. Sitting on solid bedrock, the sediments, peat, and pollen have accumulated since the last Ice Age.



The profile consists of a series of vertical graphs. The percentage of each type of tree pollen present in the core layers is displayed on the x -axis, while the depth of soil represented in the core is displayed on the y -axis.

3. (a) (continued)

(i) Identify the tree species that has the longest uninterrupted presence of pollen in the core sample.

1

(ii) Name the tree species not represented in the top 50 cm of the core sample.

1

(b) Radiocarbon (^{14}C) dating is an analytical method used to determine the age of organic material.

The oldest organic material present at the bottom of the peat and wood layer is estimated to be 8770 years old.

(i) Using information provided, calculate the mean annual rate of peat formation suggested by this soil core.

2

Space for working

(ii) Suggest why your calculated result can only ever be an estimate.

1

[Turn over



3. (continued)

(c) The table shows current habitat preferences of the tree species represented in the pollen profile.

Species	Habitat preferences in Scotland	Hybridises naturally	Pioneer species	Keystone species
Birch (<i>Betula spp.</i>)	<ul style="list-style-type: none"> – silver birch: mostly in the east, on drier soils – downy birch: mostly in the west, in wetter locations 	✓	✓	
Scots pine (<i>Pinus sylvestris</i>)	<ul style="list-style-type: none"> – well-drained, mineral-rich soil – seedlings found in open areas as germination requires high light levels 			✓
Oak (<i>Quercus spp.</i>)	<ul style="list-style-type: none"> – pedunculate oak: most common in the south and east – sessile oak: most common in the north and west, and can survive at higher altitudes than pedunculate oak 	✓		✓
Ash (<i>Fraxinus excelsior</i>)	<ul style="list-style-type: none"> – generally at lower elevations – does not grow on acidic soils, so is scarce/absent from northwest Scotland and more mountainous areas 			
Hazel (<i>Corylus avellana</i>)	<ul style="list-style-type: none"> – moist soil – wide range of habitats, including steep slopes 			✓
Willow (<i>Salix spp.</i>)	<ul style="list-style-type: none"> – eared willow: throughout Scotland but most common in the north and west; prefers damp woodland, heath and moorland sites, and slightly acidic soils – goat willow: throughout Scotland, often as individuals scattered in woodlands or near rivers and lochs – grey willow: in woodland, hedgerows, and damp areas near rivers and streams – creeping willow: often in sand dunes and heathlands 	✓	✓	



* X 8 2 6 7 6 0 2 1 0 *

3. (c) (continued)

Using information from the pollen diagram on page 08 and the table on page 10, answer the following questions.

- (i) In the soil core, ash pollen is only present at a depth of 280 to 390 cm. Explain, using a named edaphic factor, a reason for this.

2

- (ii) Conclude whether silver birch or downy birch is most likely to be found at the survey site on Barra. Justify your response.

1

Birch species _____

Justification

- (iii) When found in close proximity some species will hybridise (crossbreed) naturally with close relatives, such as the sessile oak and pedunculate oak.

Explain why use of a paired statement key may prove challenging when trying to distinguish between these oak species.

2

[Turn over



* X 8 2 6 7 6 0 2 1 1 *

3. (c) (continued)

(iv) Scots pine and oak are keystone species.

Explain the impact that loss of a keystone species would have on an ecosystem.

1

(v) Birch and willow are pioneer tree species. Their seeds are dispersed by wind or water.

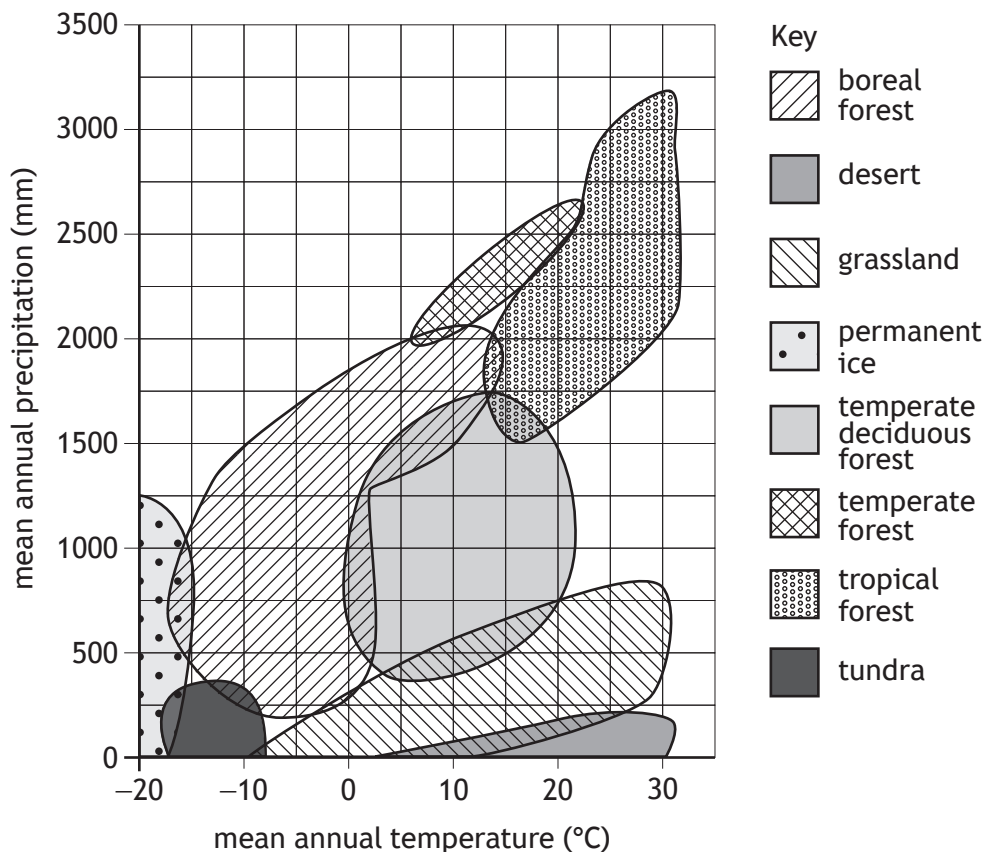
Explain why pioneer tree species develop faster in areas of secondary succession than in primary succession.

2



4. Terrestrial biomes are areas of land characterised by their plants, animals, and climate.

The graph shows the influence of two climatic factors, mean annual precipitation and mean annual temperature, on the classification of major biomes.



- (a) (i) Identify the biome that would be found in an area with a mean annual precipitation of 1000 mm and a mean annual temperature of 5 °C. 1
- (ii) Identify the range of temperatures that would define an area with a mean annual precipitation of 2250 mm as a temperate forest biome. 1

[Turn over



4. (continued)

(b) Temperature and precipitation have an effect on the net primary productivity (NPP) of terrestrial ecosystems.

(i) Define *net primary productivity*.

1

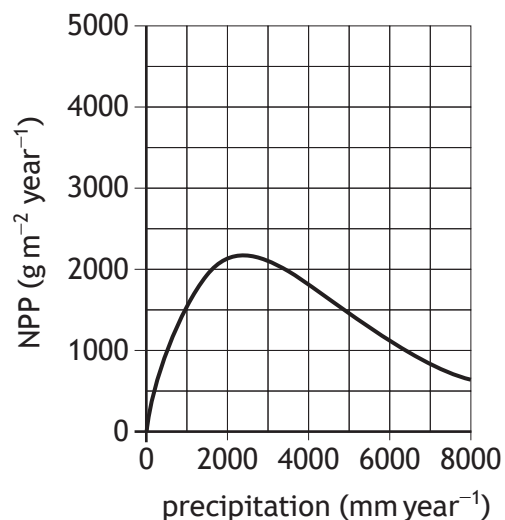
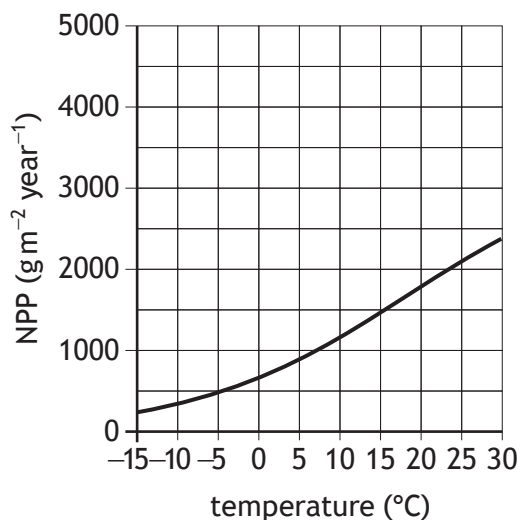
(ii) Describe a technique that could be used to measure precipitation.

2



4. (b) (continued)

(iii) The graphs below show the effect of temperature and precipitation on NPP.



Describe the trend in NPP as annual precipitation increases.

2

(iv) Using information from **all of the graphs**, select the terrestrial biome that has the greatest net primary productivity.

Justify your answer.

2

[Turn over



5. Geological records indicate a number of significant variations in Earth's climate.

As Earth orbits the Sun, cyclical variations in Earth-Sun geometry combine to produce variation in the amount of solar energy reaching Earth. These result in natural climate change.

These cyclical variations include:

- changes to the shape of Earth's orbit
- the tilt of Earth's axis
- the orientation of Earth's axis.

(a) Select one of these cyclical variations and explain why it could lead to natural climate change.

You may wish to include a diagram in your response.

3

Cyclical variation _____



5. (continued)

(b) Describe one short term cause of **natural** climate change.

2

[Turn over



6. Lithium is a metallic element used in rechargeable batteries for products such as phones, laptops, and electric vehicles.

Chile is the second largest producer of lithium in the world. One source is an enormous natural underground reservoir of salty water that contains dissolved lithium salts.

To extract the lithium, the salty water is pumped to the surface and allowed to evaporate. The lithium carbonate residue is collected and processed into lithium.



- (a) State the source of energy for evaporation.

1

- (b) 439 kg of lithium can be extracted from 1 000 000 litres of salty water.
One brand of electric vehicle has a battery containing 12 kg of lithium.
Calculate, to the nearest litre, the volume of salty water required to produce 12 kg of lithium.

1

Space for working



6. (continued)

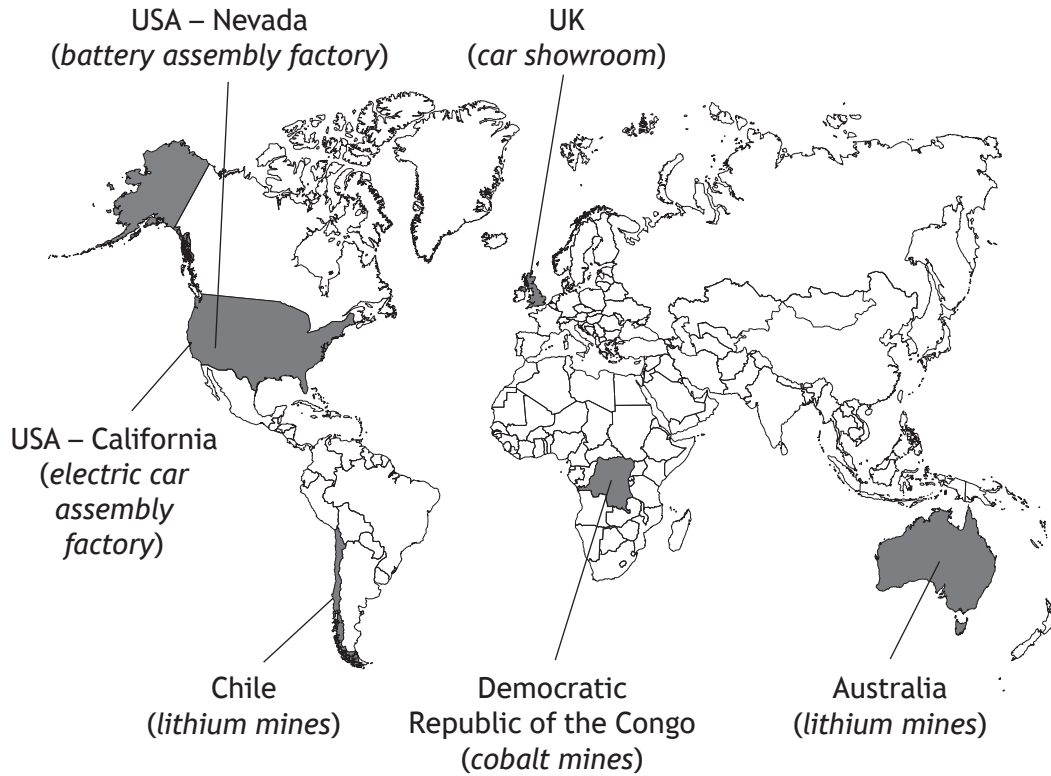
(c) Complete the table to suggest positive and negative impacts of extracting lithium for use in rechargeable batteries.

	Positive impact	Negative impact
On people		Potential contamination of freshwater resources impacts on the local population.
On the environment		

[Turn over

6. (continued)

- (d) The map shows countries involved in the production of an electric vehicle sold in the UK.



Cobalt is another element required for battery production for electric vehicles. The majority of the world's cobalt comes from the Democratic Republic of the Congo.

Suggest why obtaining a resource from a single country may not be sustainable for the electric vehicle industry.

1

6. (continued)

(e) The Scottish Government has announced that sales of new diesel and petrol vehicles will be banned by the year 2030.

(i) Using information provided throughout question 6, evaluate the potential negative environmental impacts of this policy.

2

(ii) Suggest one issue that may discourage consumers from making the transition to electric vehicles.

1

[Turn over



* X 8 2 6 7 6 0 2 2 1 *

7. It is estimated that 70% of Scotland's population live in the central belt area. The central belt area includes cities such as Glasgow, Stirling, and Edinburgh.



- (a) (i) Suggest why much of Scotland's population is concentrated in the central belt.

1



7. (a) (continued)

- (ii) Urban expansion has resulted in large areas of vegetation being cleared to build more houses and services. Biodiversity in the surrounding areas has decreased due to habitat loss.

Explain one other environmental impact caused by the clearing of vegetation.

2

- (b) (i) The average person in Scotland accounts for 13 tonnes of greenhouse gas emissions per year.

State, using a named anthropogenic greenhouse gas, a source of these emissions in a city.

2

- (ii) On average, individuals living in rural communities account for more emissions per year than those living in urban areas.

Suggest a reason for this difference.

1

[Turn over



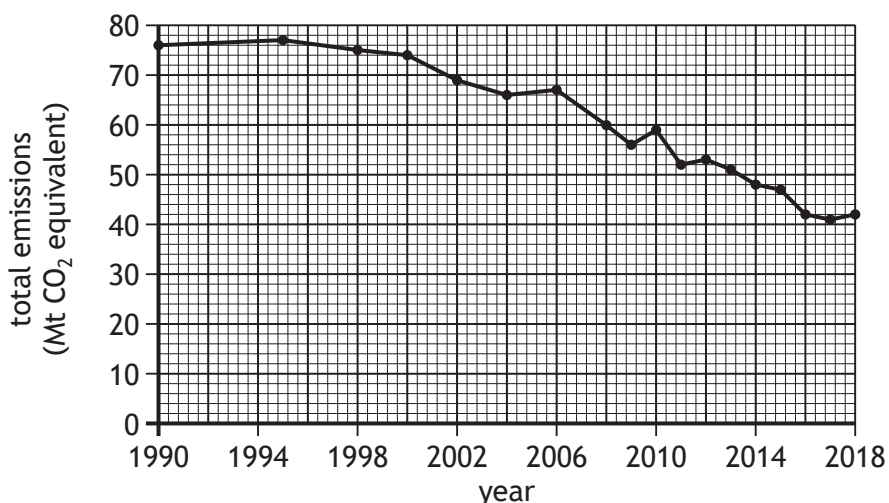
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7. (continued)

- (c) The Climate Change (Emissions Reduction Targets)(Scotland) Act 2019 aims to reduce Scotland’s emissions of all greenhouse gases to net zero by 2045.

Progress towards this target is measured against a baseline of 1990 levels of greenhouse gas emissions.

The trend in total emissions is shown in the graph.



- (i) An interim target of at least a 56% reduction by 2020 from baseline emissions, was also set.

(A) Calculate the 2020 interim target for total emissions.

2

Space for working

- (B) It was originally predicted that this target would not be met.

Based on the information in the graph, explain why this prediction was made.

1

7. (c) (continued)

- (ii) When the 2020 data was analysed, it was concluded that the target of a 56% reduction in emissions by 2020 had been achieved, partly due to the recent coronavirus pandemic.

Suggest one way in which government actions taken during the pandemic resulted in lower emissions.

1

- (iii) Describe two ways in which local authorities can support the Scottish Government's aim of reducing the country's emissions to net zero by 2045.

2

- (d) Countries around the world are aiming to cut their greenhouse gas emissions in order to minimise the impact of global warming.

Describe the link between greenhouse gas emissions and global warming.

2



* X 8 2 6 7 6 0 2 2 5 *

8. The global ocean conveyor belt is a constantly moving system of deep ocean circulation that encircles the globe.

(a) (i) State two factors that drive the global ocean conveyor belt.

2

(ii) Explain how the deep ocean currents required for the global ocean conveyor belt are initiated in polar regions.

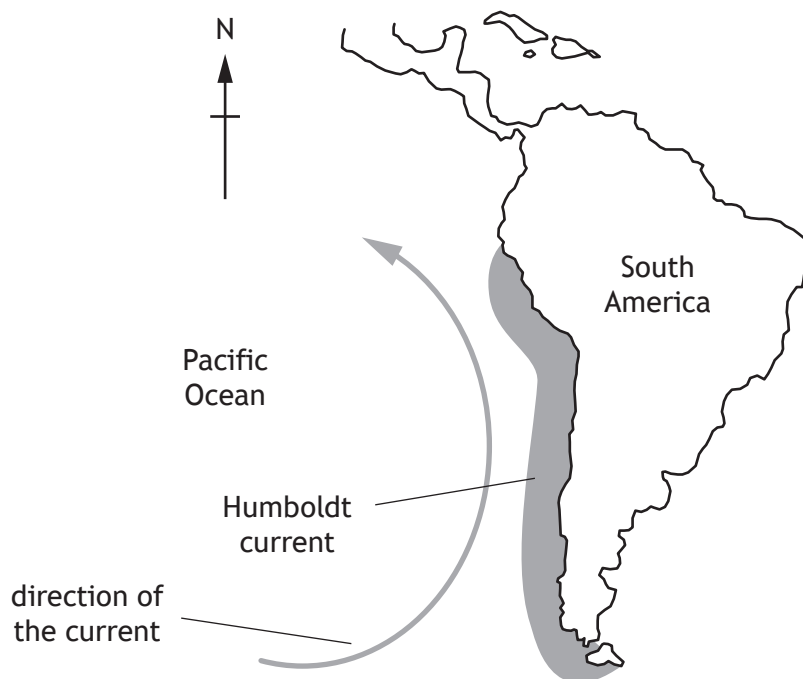
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* X 8 2 6 7 6 0 2 2 6 *

8. (continued)

- (b) The diagram shows the Humboldt current.
The Humboldt current is associated with upwelling.



- (i) Describe what is meant by *upwelling*. 1
- (ii) Explain why areas of upwelling support complex marine food webs. 2

[Turn over



Questions 9 and 10 each contain a choice

For each question, attempt either A or B. Write your answers to questions 9 and 10 on the following pages. You may use diagrams where appropriate.

9. **A** The surface of the Earth is covered by several large rigid plates and a number of smaller plates. These plates are all moving, but not in the same direction or at the same speed. This results in intense geological activity at plate boundaries.

Give an account of the mechanisms of plate boundaries in oceans under the following headings:

- (a) Oceanic constructive plate boundary mechanisms
- (b) Resulting seabed features and deposits.

10

OR

- B** Water circulates continuously between the surface of the Earth and the atmosphere, through a complex system that involves many different processes.

Discuss the hydrological cycle under the following headings:

- (a) Movement processes
- (b) Storage.

10



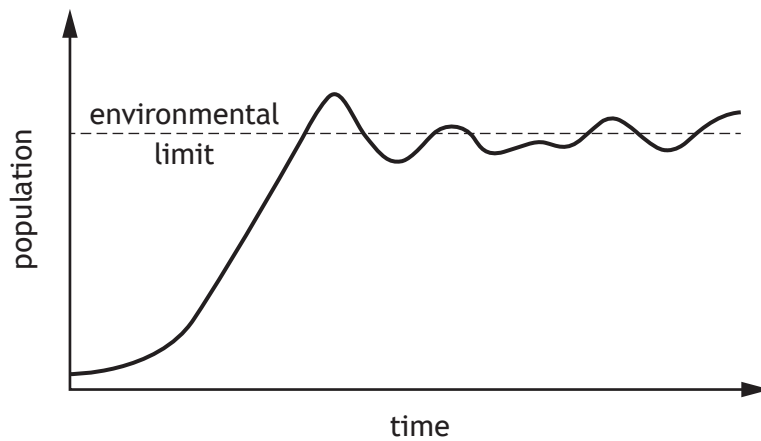
10. A Scotland has a very rich and diverse environment, which requires protection against damaging human activities.
Discuss the importance of key environmental agencies in protecting Scotland's environment.

10

OR

- B Discuss the population dynamics that result in the pattern of population growth shown in the graph.

10



[Turn over



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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