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National Qualifications 2024

Mark

X826/76/02

Environmental Science Paper 2

FRIDAY, 26 APRIL

10:15 AM – 12:45 PM

X8267602

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day

Month

Year

Scottish candidate number

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.

Total marks — 100

Attempt ALL questions

Questions 9 and 10 each contain a choice

MARKS | DO NOT WRITE IN THIS MARGIN

1. The introduction of the grey squirrel (*Sciurus carolinensis*) to the UK from North America in the 1890s has decreased the population of the native red squirrel (*Sciurus vulgaris*).

(a) State the name given to a species, such as the grey squirrel, which has a serious negative impact on native species when introduced to an area outwith its native distribution. **1**

(b) The introduction of the grey squirrel to the UK resulted in inter-specific competition with the red squirrel.

(i) Explain why the competition between red and grey squirrels is inter-specific. **1**

(ii) Suggest one reason for the increase in the grey squirrel population. **1**

(iii) It is estimated that there are 138 000 red squirrels in Great Britain.

18 000 of these are located in England and Wales.

Calculate the percentage of red squirrels in Scotland. **1**

Space for working

MARKS

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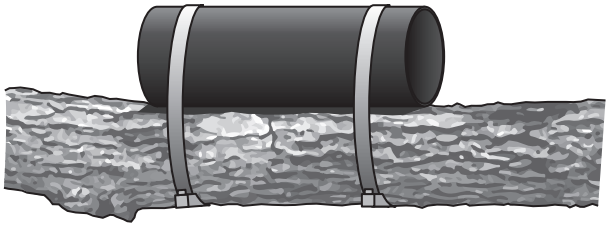
(c) After the arrival of grey squirrels to a woodland in the Scottish Highlands, the population of red squirrels was reduced to zero.

A recent project involved the reintroduction of 20 red squirrels to this woodland.

Hair samples were taken from the red squirrels before their release, in order to study genetic diversity in the population.

(i) Define *genetic diversity*. **1**

(ii) The populations of both the red and grey squirrel were monitored using hair tubes similar to the one shown.



20 hair tubes spaced approximately 100 metres apart were fixed to tree branches.

Sticky tape inside the tube collected hair samples from all squirrels passing through the tube.

State the type of random sampling used to sample the squirrel populations. **1**

(iii) Using hair tubes to collect hair samples is a non-invasive sampling technique.

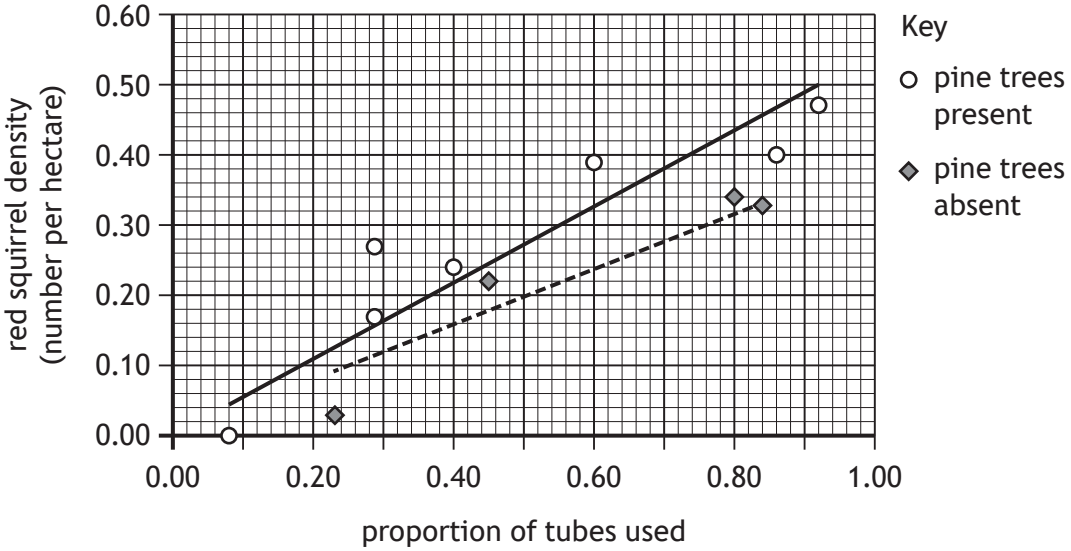
State one advantage and one disadvantage of using non-invasive sampling techniques. **2**

Advantage:

Disadvantage:

1. **(continued)**

(d) The density of the red squirrel population can be estimated using the line of best fit on the scatter graph.

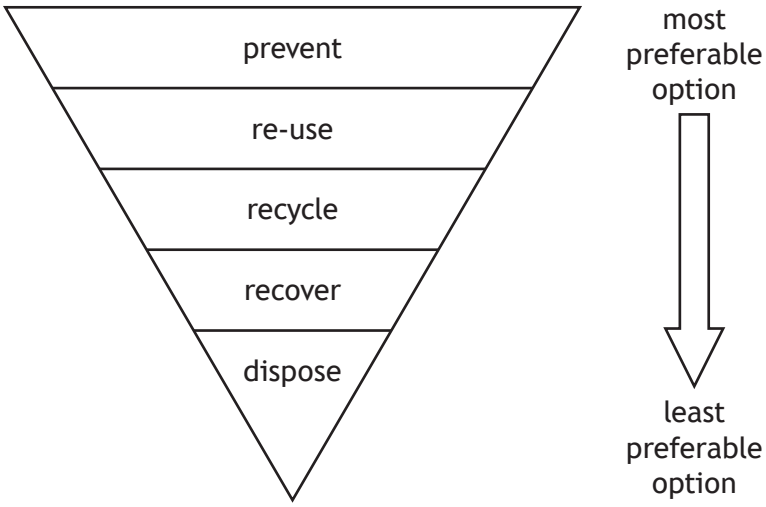


(i) Hair samples collected in the woodland indicated that a proportion of 0.40 tubes were used by squirrels in an area where pine trees were present.

Predict the red squirrel density in this area. **1**

(ii) Suggest why the red squirrel density is higher when pine trees are present. **1**

2. Waste management options are displayed in the diagram.



(a) (i) State the name given to the system that ranks waste management options according to what is best for the environment. **1**

(ii) Give two reasons why recycling is a less preferable option than prevention. **2**

1:

2:

[Turn over

2. (continued)

(b) A cheese factory produces 4000 tonnes of cheese each year.

It sends its organic waste products to a local biogas factory, where they undergo anaerobic digestion.

The process is able to produce 10 000 000 kWh of energy annually, which is expected to save 37 300 tonnes of CO_2 per year.

(i) Describe the process of anaerobic digestion. **1**

(ii) Explain the benefit to the environment of this type of waste recovery. **2**

(iii) The average UK household consumes 3700 kWh of energy per year.

Calculate the mass of CO_2 saved per household by using energy recovered from the cheese production every year. **2**

Space for working

2. (b) (continued)

(iv) Suggest why this type of waste management may benefit companies financially. **1**

(v) State whether this model of waste management is an example of a linear or circular economy.

Justify your answer. **1**

Model:

Justification:

[Turn over

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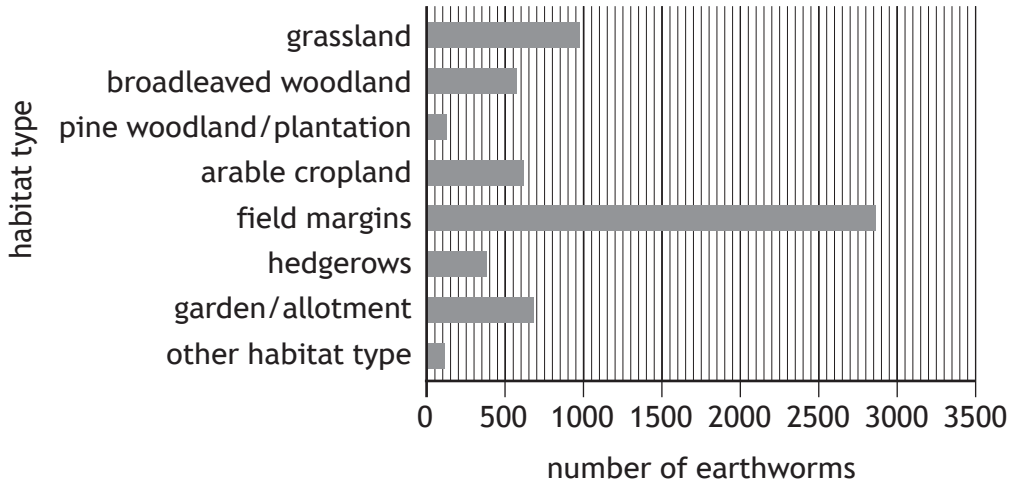
3. Earthworms are ecosystem engineers, able to change the structure and fertility of their environment.

(a) An earthworm study sampled 333 sites, covering a wide range of habitat types.

The graph shows the total number of earthworms found in each habitat type.



(i) Field margins are the uncultivated edges of arable cropland.

Suggest a reason why higher numbers of earthworms were found in field margins compared to arable cropland. **1**

[Turn over

3. (a) (continued)

(ii) Earthworms can be separated into ecological groups (ecotypes) based on their feeding and burrowing habits. **Table 1** shows earthworm ecotypes and some of the characteristics of each ecotype.

Table 1

Earthworm ecotype	Ecotype characteristics
Epigeic	• Found in surface leaf litter and humus; do not inhabit burrows • Most abundant in woodland habitats and in moderately acidic soils • Can tolerate highly variable moisture and temperature conditions • High reproductive rate but short lifespan (around 1 year)
Endogeic	• Inhabit shallow, horizontal burrows in the A-horizon (topsoil) • Burrows fill with cast (faeces) as the worms move through the soil • Abundant in disturbed soils and sites with higher soil pH • Low reproductive rate but medium lifespan (3–5 years)
Anecic	• Inhabit permanent vertical burrows, often metres deep • Burrow entrances are marked by piles of worm cast, and plugged with a mix of cast and organic matter • At night, decaying plant parts are pulled from the soil surface deep into the burrows • Low reproductive rate but long lifespan (up to 12 years)
Compost	• Do not inhabit burrows • Found in compost, leaf litter, organic-rich soil, manure heaps • Prefer warm, moist environments • Can consume their own weight in organic matter each day • High reproductive rate but short lifespan (around 1 year)

The earthworms found during the sampling were sorted by their ecotype.

Table 2 shows the total number of earthworms by ecotype found across the 333 sites.

Table 2

Earthworm ecotype	Number of worms
Epigeic	1333
Endogeic	4684
Anecic	243
Compost	48

3. (a) (ii) (continued)

Low numbers of anecic and epigeic earthworms were found in intensively farmed arable cropland.

For each of these ecotypes, suggest why this would be the case.

(A) Anecic: **1**

(B) Epigeic: **1**

(iii) Explain why the study data provides only an estimate of the earthworm population at each sample site. **1**

(iv) The common earthworm (*Lumbricus terrestris*) belongs to the anecic ecotype. The species obtains energy from consuming dead and decaying organic matter. Other species in the ecosystem depend on the presence of such worms, and their loss would drastically change the ecosystem.

Using this information, state two ecological terms that describe the common earthworm's environmental role. **2**

1:

2:

[Turn over

MARKS

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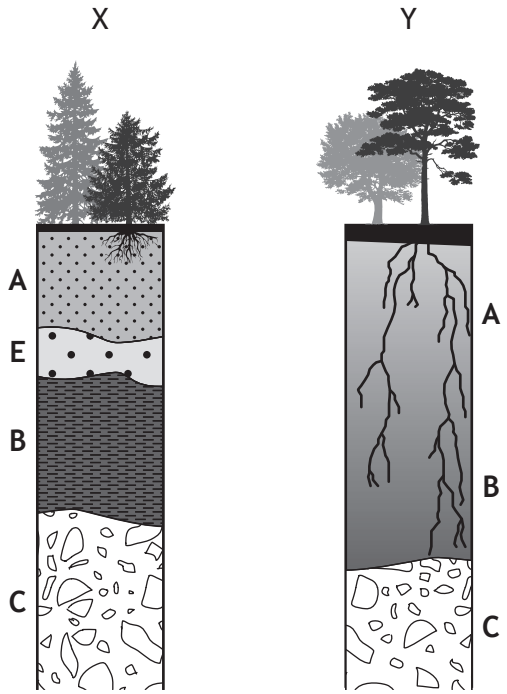
(b) The soil profiles below represent two soil types found in Scotland.



State which profile, X or Y, will contain the greatest earthworm abundance **and** range of ecotypes.

Justify your answer. **4**

Profile:

Justification:

4. The UK government has a policy in place to support efforts to reduce greenhouse gas emissions from transport.

(a) (i) Describe how the aims of a policy are achieved. **2**

(ii) In November 2021, the government amended legislation to require the introduction of E10 petrol at filling stations across England, Scotland, and Wales.

Prior to the introduction of E10 petrol, most petrol sold in the UK was E5, which contains 5% bioethanol, a processed biofuel.

E10 petrol contains 10% bioethanol and has a lower energy density than E5 petrol. This refers to the amount of energy in a given volume of petrol.

Suggest a possible economic impact of the amended legislation on drivers.

Justify your answer. **2**

[Turn over

4. (continued)

(b) In 2019, before amending the legislation, the government carried out research into the potential impacts of moving from E5 petrol to E10 petrol.

It was noted that some older cars are unable to use E10 petrol, therefore E5 petrol must still be made available.

The research assumed that the average car emits 2.17 tonnes of CO_2 per year.

The table shows the predicted impact of the switch to E10 petrol in terms of the % reduction in CO_2 emissions compared to the figure above.

Year	% reduction in CO_2 compared with 2019
2021	23
2022	24
2023	25
2024	26
2025	27
2026	28
2027	28
2028	29
2029	29
2030	29

(i) Calculate the predicted CO_2 emissions, **in tonnes**, of the average car in 2026. **2**

Space for working

(ii) Suggest a reason for the predicted reduction in CO_2 emissions changing more slowly after 2025. **1**

MARKS

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(c) Bioethanol is an example of a bioalcohol. Other bioalcohols include biomethanol, biopropanol, and biobutanol.

The table below shows information about some processed biofuels.

	Biofuel		
	Bioalcohols		Biodiesel
Feedstocks	maize wheat cassava	sugar cane sugar beet sweet sorghum	rapeseed oil sunflower oil palm oil waste oils
Process	glucose hydrolysis fermentation	fermentation	transesterification
Principle uses	transport		transport heating

Some pressure groups have raised concerns about the impact of increased use of biofuels on global food security.

(i) Explain why widespread adoption of E10 petrol may reduce food security. **1**

(ii) Suggest a way in which good waste management practices might mitigate the impact of biofuels on food security. **1**

(iii) Compare the possible impact of the production of bioalcohols and biodiesel on food security. **2**

5. The diagram shows part of the tri-cellular model. The tri-cellular model explains the redistribution of solar energy from areas of surplus to areas of deficit.

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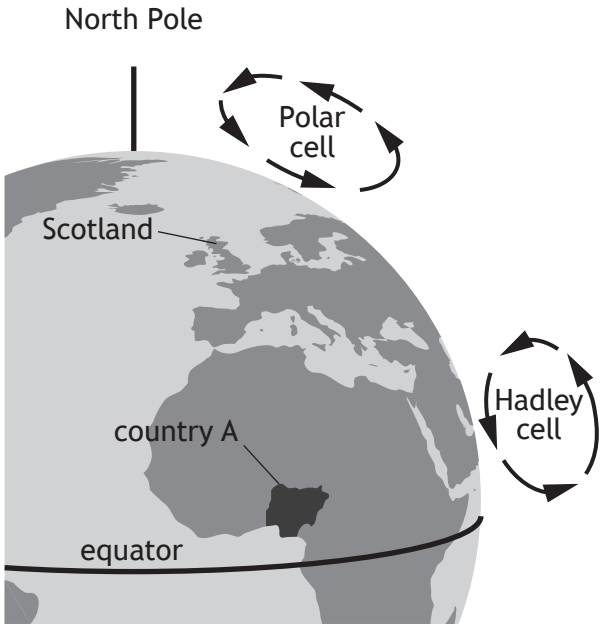


(a) State what is meant by the *global energy budget*. **1**

(b) (i) Complete the diagram above to show the missing cell. **2**

(An additional diagram, if required, can be found on *page 33*.)

(ii) Describe the redistribution of solar energy within the Hadley cell. **3**

5. (continued)

(c) Country A is close to the equator and contains a biome associated with constant low atmospheric pressure.

Name this type of biome. **1**

(d) The rotation of the Earth causes a deflection in the surface wind patterns across the globe.

State the term given to this phenomenon. **1**

[Turn over

6. The global energy crisis, which began in 2021, has resulted in energy insecurity in many countries.

(a) (i) Define *energy security*. **1**

(ii) Energy security further decreased when parts of Europe experienced drought in 2022.

Explain why drought further contributed to the energy crisis. **2**

(b) As a result of the global energy crisis, Glasgow City Council announced that investigations would take place to identify a long-term sustainable source of geothermal energy.

(i) State one source of geothermal energy. **1**

(ii) Part of the investigations will involve drilling boreholes into the Earth's crust to measure the rate of temperature change with depth.

State the term used for the rate of temperature change with depth. **1**

6. (b) (continued)

(iii) It is estimated that temperature increases by around 2.5 °C per 100 m depth in areas not close to tectonic plate boundaries.

If the investigations produce similar results, a proposal to drill a 6 km geothermal well will be submitted.

Calculate the estimated difference in temperature between the top and bottom of the well. **1**

Space for working

(c) (i) An increasing number of homes in Scotland are heated using ground source heat pumps.

Describe how ground source heat pumps deliver geothermal energy to homes. **2**

(ii) The Scottish Government offers financial incentives to homeowners to install ground source heat pumps. This initiative is intended to support the Scottish Government's aim of limiting the rise in global temperature.

Explain why this initiative may help limit the rise in global temperature. **2**

[Turn over

7. Scotland's mountains are internationally recognised for their exceptional collection of landforms, habitats, and plant and animal species.

(a) State the designation that can be applied to a terrestrial area that has extremely high conservation value because of its plants, animals, geological or landscape features. **1**

(b) The Royal Botanic Garden Edinburgh asks climbers and walkers to record sightings of vulnerable plant species.

One of the vulnerable plant species is the sow-thistle. The table shows information relating to five sow-thistle sub-species found in the UK.

Species	Plant characteristics	Habitat
Cicerbita alpina	50–200 cm height; hairy stems; matt grey-green leaves; purple-blue flowers; flower heads 20 mm wide	moist hollows on hillsides, beside upland streams, in alpine meadows
Cicerbita macrophylla	30–60 cm height; hairless stems; matt grey-green leaves; purple-blue flowers; flower heads 30–40 mm wide	wasteland, roadsides
Sonchus arvensis	60–150 cm height; spiny, hairless stems; shiny green leaves; deep yellow flowers; flower heads 40–50 mm wide	arable, wasteland, hedgerows, wet grassland
Sonchus asper	20–150 cm height; hairless stems; matt grey-green leaves; deep golden yellow flowers; flower heads 20–25 mm wide	arable, wasteland, hedgerows, open woodland
Sonchus palustris	90–300 cm height; hairy stems; matt grey-green leaves; pale yellow flowers; flower heads 30–40 mm wide	reed beds by tidal rivers, ditches, wet grassland

7. (b) (continued)

(i) Using information in the table, complete the paired statement key for all the named species. **3**

1	Has hairless stems	go to 2
	Does not have hairless stems	go to 3
2	Has purple-blue flowers	
3	Has purple-blue flowers	
4		

[Turn over

7. (b) (continued)

(ii) The alpine sow-thistle (*Cicerbita alpina*) was once widely distributed throughout the Scottish mountains. Today it is restricted to four rocky ledge sites in the Cairngorm Mountains.

Suggest a **local** human activity that might restrict the distribution of upland plants such as the alpine sow-thistle.

Justify your response. **2**

Activity:

Justification:

(iii) The alpine sow-thistle reproduces in two ways: locally via a rhizome system, and long distance via insect-pollinated seeds dispersed by wind.

A rhizome is a horizontal stem from an existing plant that forms new roots and shoots.

Predict the implication for genetic diversity where plants only reproduce via rhizomes.

Justify your answer. **2**

(iv) Suggest why reproducing naturally via seed may no longer be successful for the alpine sow-thistle. **1**

7. (b) (continued)

(v) A number of conservation practices are being used to increase populations of the vulnerable plant species.

Other than use of legislation, name a conservation practice that could be used to increase populations of vulnerable species. **1**

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

8. Droughts across the world are occurring more frequently and developing more rapidly as a result of climate change.

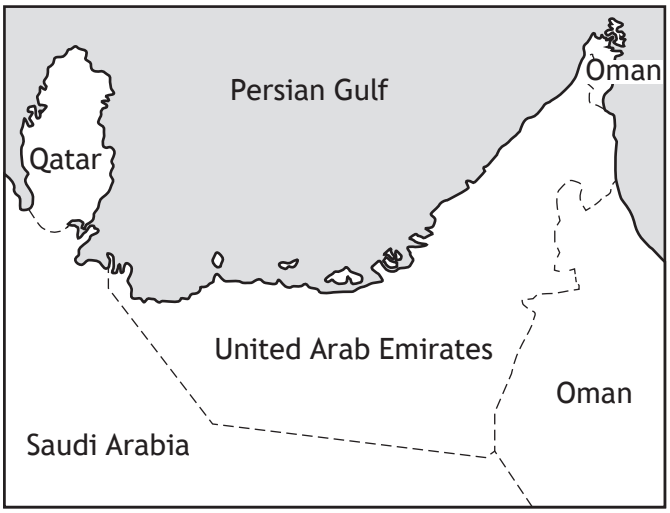
(a) An increasing number of countries have invested in weather modification technologies, such as 'cloud seeding'.

Cloud seeding works by introducing tiny water-attracting particles into growing clouds. This improves a cloud's ability to produce precipitation by encouraging water vapour to form larger water droplets.

(i) Name the process in the hydrological cycle being enhanced by cloud seeding to produce precipitation. **1**

(ii) The United Arab Emirates (UAE) has been trialling cloud seeding.

The country is located in the Middle East, bordering the Persian Gulf, and has a hot desert climate.



Particles for cloud seeding are typically dispersed from aircraft.

In 2022, the UAE conducted cloud-seeding missions lasting a total of 1000 hours. During an average 4-hour flight, costing $5000, up to 24 clouds can be seeded.

Calculate the cost of the cloud-seeding missions in the UAE in 2022. **1**

Space for working

8. (continued)

(b) (i) The UAE also relies heavily on desalination to overcome its freshwater resource shortage.

Describe what is meant by *desalination*. **1**

(ii) The agricultural sector accounts for the majority of the water consumed in the UAE.

The government has promoted the use of more efficient irrigation techniques, such as drip irrigation.

Explain why drip irrigation uses less water than more traditional irrigation techniques. **1**

(iii) Other than drip irrigation, state one method that could be used to reduce the demand for water in the agricultural sector. **1**

(iv) The industrial sector consumes around 9% of all water in the UAE. Most is used for cooling and cleaning.

State one method that could be used by industry to reduce water consumption. **1**

[Turn over

8. (b) (continued)

(v) UAE residents have one of the world's highest per capita consumptions of bottled water, averaging 450 plastic water bottles each year.

The country has a population of approximately 10 million.

24 million gallons of oil are required to produce 1 billion plastic water bottles.

Calculate, in gallons, how much oil is being used in plastic water bottle production in the UAE each year. **2**

Space for working

(c) Other than drought, state one impact of climate change. **1**

(d) The terms 'global warming' and 'climate change' are often used interchangeably, but each has a distinct meaning.

Describe the relationship between global warming and climate change. **2**

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 need to increase global food production to ensure food security for a growing global population is a complex challenge.

Other than irrigation, discuss strategies intended to increase land-based food production under the following headings:

(a) Changes in land management

(b) Changes in technology. **10**

OR

B Fission involves the splitting of atoms to release energy, which can then be harnessed. It is the main process used for generating nuclear power.

Discuss nuclear power generation under the following headings:

(a) Advantages

(b) Disadvantages. **10**

[Turn over

10 **A** Soil forms as a result of a combination of processes that occur over a long period.

Discuss the processes involved in the formation of soil. **10**

OR

B Movements at destructive plate boundaries can have significant geological consequences and are responsible for shaping the Earth's surface.

Give an account of the mechanisms of destructive plate boundaries. **10**

SPACE FOR ANSWERS

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SPACE FOR ANSWERS (continued)

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SPACE FOR ANSWERS (continued)

SPACE FOR ANSWERS (continued)

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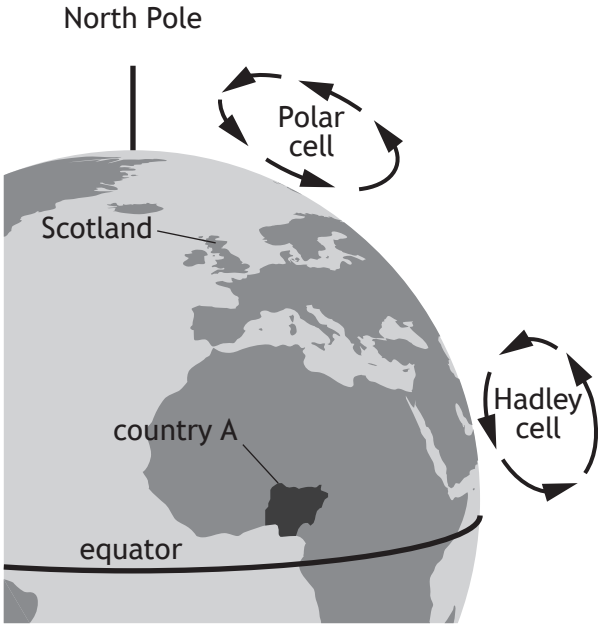
ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional diagram for question 5 (b) (i)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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