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National
Qualifications
2026

Mark

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X826/76/02**Environmental Science
Paper 2**

WEDNESDAY, 22 APRIL

2:00 PM – 4:30 PM



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

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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 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.

Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.



Total marks — 100

Attempt ALL questions

Questions 9 and 10 each contain a choice

1. Grey wolves (*Canis lupus*) were reintroduced into Yellowstone National Park, USA in 1995, after hunting removed the last wolf pack in the 1920s. The wolves are considered a keystone species for the rewilding process.



- (a) Define *rewilding*.

1

- (b) The table shows the estimated population of grey wolves living in the park between 1996 and 2020.

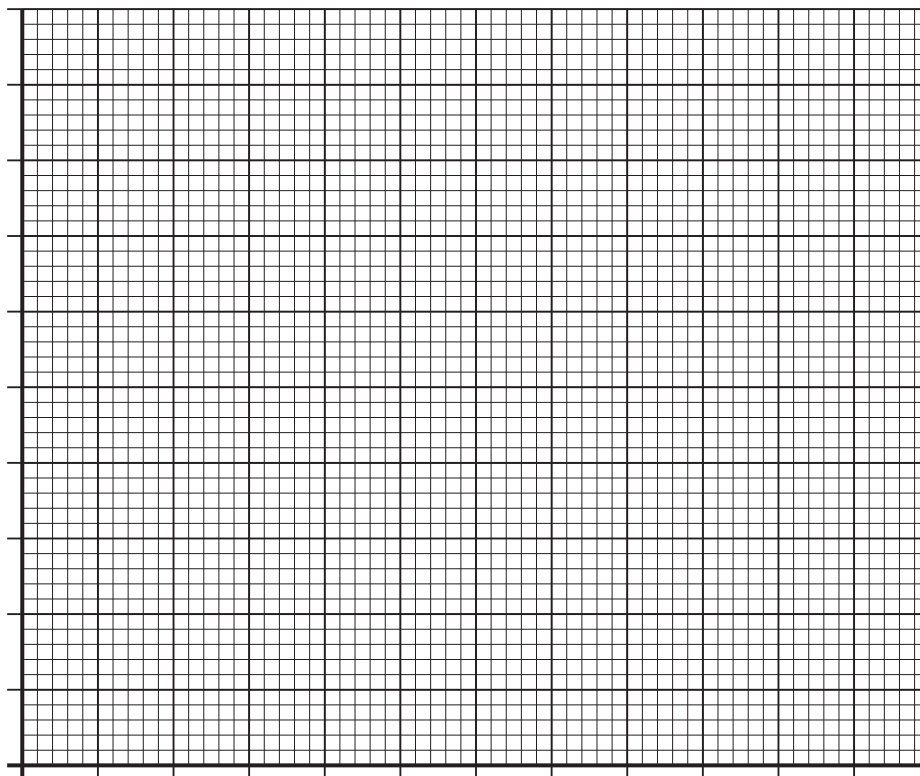
	Year						
	1996	2000	2004	2008	2012	2016	2020
Estimated population of grey wolves	51	119	171	124	83	108	123

1. (b) (continued)

Using information from the table, draw a line graph to show the estimated population of grey wolves in the park from 1996 to 2020.

3

(An additional graph, if required, can be found on *page 37*.)

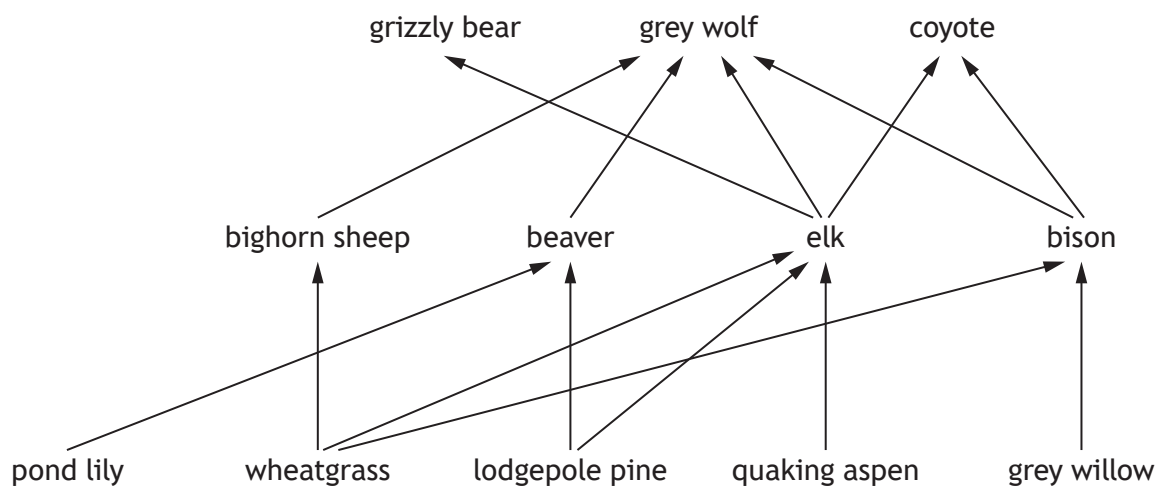


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1. (continued)

- (c) The food web shows some of the interactions between species in Yellowstone National Park.



- (i) Elk and bison are examples of heterotrophs.
Describe what is meant by *heterotroph*. 1
- (ii) Elk and bison occupy a similar niche.
Explain why both species can survive within the same habitat. 1
- (iii) Prior to the reintroduction of grey wolves, over-grazing by elk was damaging the environment.
State the term that refers to the maximum population size of a species that the environment can sustain indefinitely. 1

1. (c) (continued)

- (iv) Between 2004 and 2012 the estimated population of grey wolves in the park fell from 171 to 83.

Suggest a reason for this change.

1

- (v) The beaver has benefited from the reintroduction of the grey wolf, with estimated numbers increasing from one colony to nine.

Suggest why the beaver population has increased in the park.

1

- (d) Elk are a species within the deer family. As part of their natural behaviour, elk rub their antlers against trees. This damages bark and may cause trees to die. They also knock down small trees and shrubs, and trample young plants.

Explain why this disturbance may benefit some species.

2

- (e) Other than the reintroduction of a native species, suggest **two** rewilding practices that could be implemented in Yellowstone National Park.

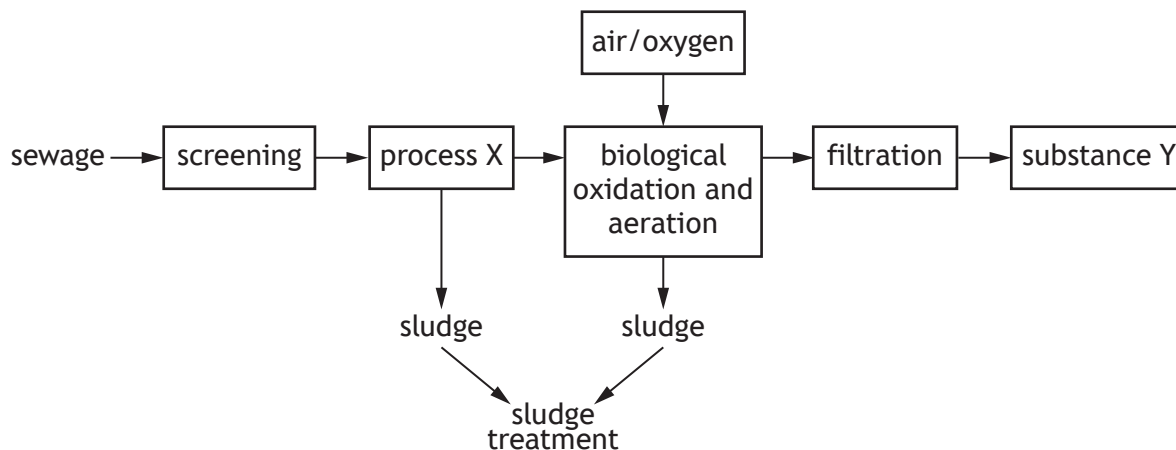
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2. (a) Sewage treatment in the UK involves the collection and treatment of wastewater.

The diagram shows the processes used at a wastewater treatment plant to remove contaminants from sewage.



Using information in the diagram, identify the following:

- (i) process X

1

- (ii) substance Y.

1

- (b) Sewage sludge from across the Glasgow area is transported via pipelines and tankers to Daldowie Fuel Plant. The sludge is dried and converted into low-odour fuel pellets.

- (i) 1000 tonnes of sludge can be converted into 23.5 tonnes of fuel pellets. The Daldowie Fuel Plant can produce a maximum of 50 000 tonnes of pellets a year.

Calculate, to the nearest 1000 tonnes, the mass of sludge required to produce the maximum number of pellets a year.

1

Space for working



2. (b) (continued)

- (ii) Sewage sludge can be heat treated for use as a fertiliser.
Suggest one advantage and one disadvantage of using sewage sludge as a fertiliser.

(A) Advantage

1

(B) Disadvantage

1

- (iii) Anaerobic digestion can be used to generate biogas from sewage sludge.
State what is meant by *anaerobic digestion*.

1

- (iv) Water released during the sludge drying process at the Daldowie Fuel Plant is discharged into the nearby River Clyde.

State the environmental agency that has responsibility for monitoring discharges to the water environment in Scotland.

1

- (v) The fuel pellets are used to heat kilns for manufacturing cement.
Manufacturing cement produces significant carbon dioxide emissions.
State one other anthropogenic source of increased carbon dioxide emissions.

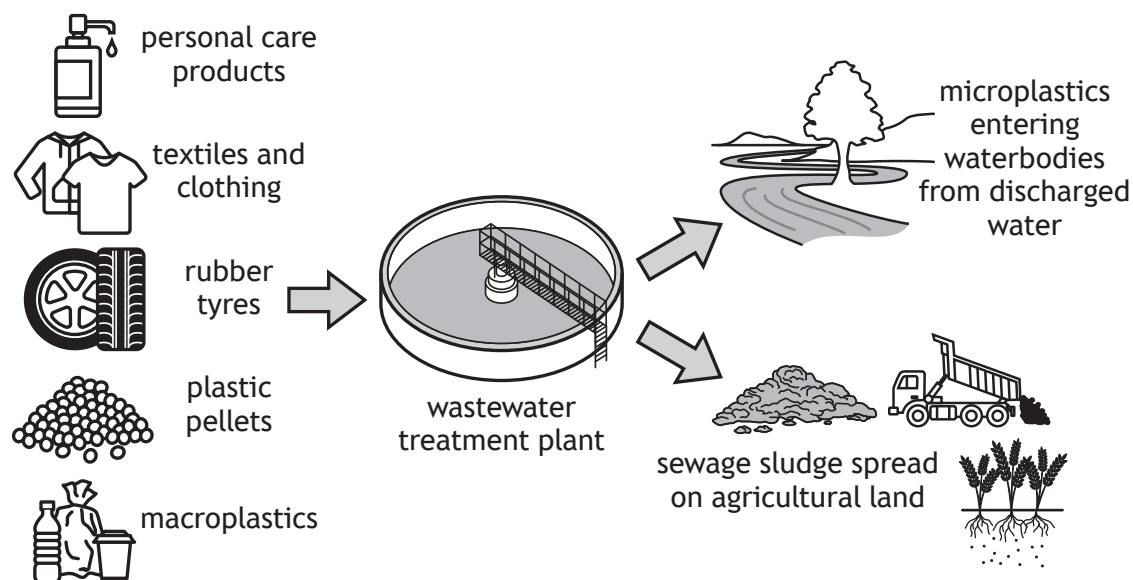
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2. (continued)

- (c) Microplastics are present in wastewater. The diagram below shows some of the sources of microplastics.



- (i) Explain why the release of microplastics from wastewater treatment can be considered as an example of **both** point and diffuse pollution.

2

- (ii) Studies have shown that the presence of microplastics in aquatic organisms has built up over time.

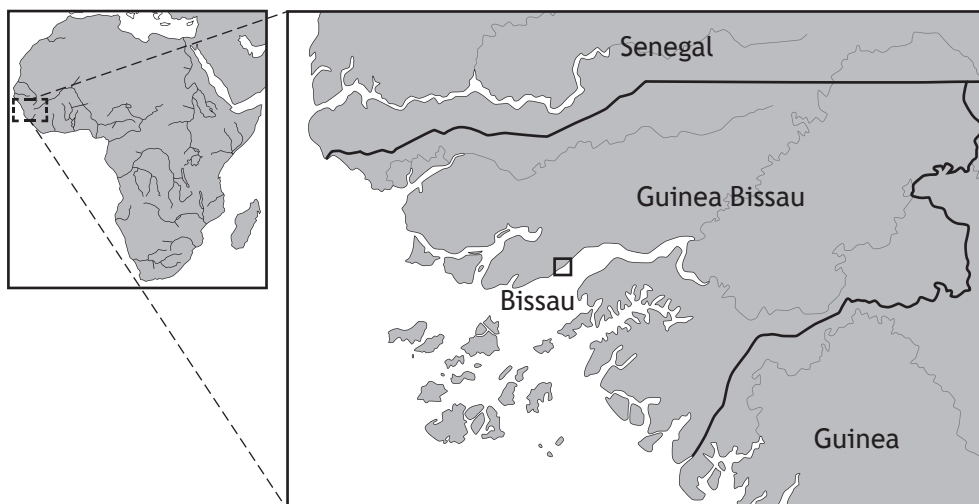
State the term used to describe the gradual build-up over time of contaminants, such as microplastics, in a living organism.

1

3. Guinea Bissau is a low-lying coastal, tropical country in West Africa.

The landscape is dominated by forests, grassland, and shrubland, with large expanses of mangrove forest concentrated around the coast.

Guinea Bissau experiences seasonal monsoon rains, with annual rainfall in excess of 1500 mm.



- (a) Describe one environmental factor that may contribute to uneven access to mains electricity in Guinea Bissau.

1

- (b) (i) Until recently, Guinea Bissau was 100% reliant on imported fuel sources for the generation of mains electricity.

Suggest an environmental impact associated with the importation of resources from abroad.

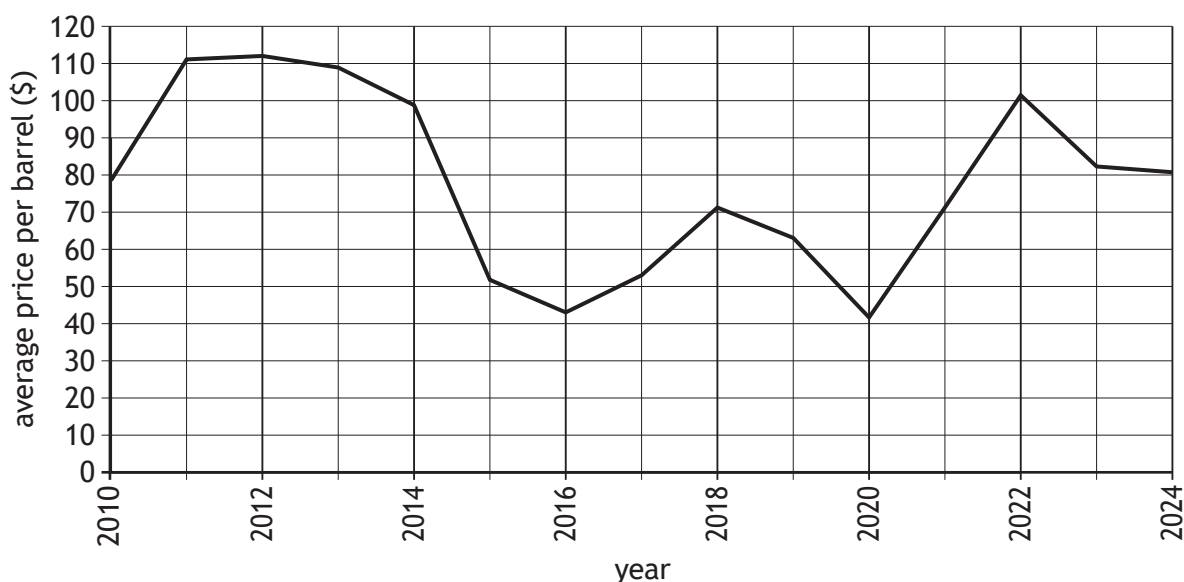
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3. (b) (continued)

- (ii) The graph shows the variation in the average annual price of crude oil (per barrel) between 2010 and 2024.



Explain how a change in global oil prices could influence the supply and demand of oil in Guinea Bissau.

2

- (c) Energy security is essential for the development of commercial agriculture. As development increases across Guinea Bissau this is likely to lead to changes in consumer demand for certain food products.

Suggest a **social** impact that may be associated with growing more crops on a commercial scale.

1

3. (continued)

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- (d) 'Green water' is a term used in agriculture to describe water sourced from the natural environment, such as rainfall.

'Blue water' refers to additional water that is sourced elsewhere, such as through irrigation, and is used to supplement the natural supply.

The table shows the average volume of water required to produce one gram (1 g) of protein content in certain types of nut.

Nut type	Volume of water (litres) required to produce 1 g of protein		
	Green water	Blue water	Total water
Groundnut	14	1	
Cashew	280	20	
Chestnut	135	10	145
Almond	46	19	65
Walnut	37	17	54
Pistachio	30	75	
Hazelnut	59	17	76

- (i) Calculate, as a simple whole number ratio, the total volume of water required to produce one gram of protein in groundnuts, cashews, and pistachios.

1

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_____ : _____ : _____
groundnut cashew pistachio

- (ii) Cashews are an important crop in Guinea Bissau.

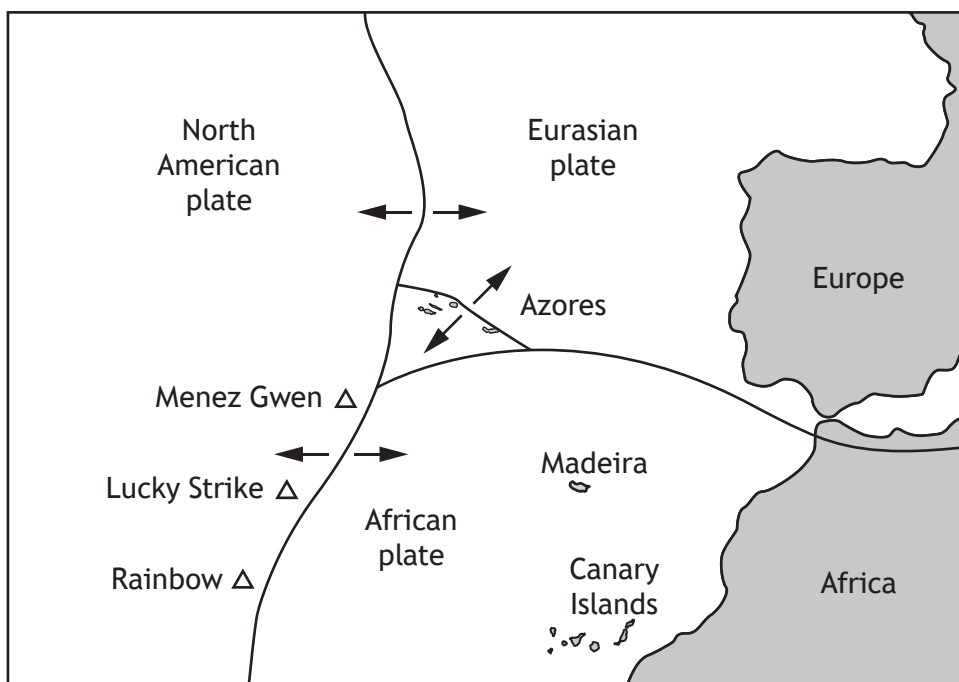
Suggest why cashews may be seen as more sustainable to grow in Guinea Bissau than pistachios.

1



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4. The Azores is a group of volcanic islands in the North Atlantic Ocean. The islands are located in a tectonically active zone at the junction of the Eurasian, African, and North American plates.



Key

△ hydrothermal vent field

- (a) (i) The Azores sits upon a plate boundary.
Name this type of plate boundary.

1

4. (a) (continued)

(ii) Explain the formation of convection currents within the mantle.

3

(b) The Azores are close to a series of hydrothermal vents, due to their position upon an active tectonic boundary.

(i) Describe how hydrothermal vents form.

2

(ii) The water surrounding hydrothermal vents contains a high concentration of dissolved minerals. These minerals support the growth of micro-organisms.

Suggest how the presence of micro-organisms at hydrothermal vents helps to support species richness.

1



4. (b) (continued)

- (iii) *Mirocaris fortunata* is a species of shrimp often found living near hydrothermal vents.



Mirocaris fortunata

The table shows the lengths of 15 *Mirocaris fortunata* specimens collected across three different hydrothermal vent fields.

Hydrothermal vent field	Specimen length (mm)
Menez Gwen	14
	14
	18
	23
	29
Lucky Strike	17
	18
	28
	26
	31
Rainbow	17
	20
	22
	20
	23

4. (b) (iii) (continued)

The interquartile range (IQR) is calculated by listing all of the numbers in ascending order and then using the following formula

$$\text{IQR} = Q_3 - Q_1$$

where: Q_1 is the median of the lower half of the data

Q_3 is the median of the upper half of the data.

Calculate the IQR for specimen length across all 15 shrimp.

Space for working

2

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4. (b) (continued)

- (iv) A further 15 *Mirocaris fortunata* specimens were collected from a second set of three hydrothermal vents, and the data were analysed.

The IQR for the second data set was 7.

State one conclusion that can be drawn from comparison of the two IQR values.

1

- (v) Stratified random sampling was used to research biota living at different distances from vents.

Describe the process of stratified random sampling.

2



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5. (a) The table shows the approximate percentage of gases present in Earth's atmosphere.

Gas	Approximate percentage (%)
Nitrogen	78
Oxygen	21
Argon	0.9
Carbon dioxide	0.04
Other gases (for example methane, water vapour)	trace

- (i) Other than activities related to carbon dioxide emissions, describe how a named human activity may contribute to changes in the composition of Earth's atmosphere.

2

- (ii) Suggest a possible environmental consequence of the change described in (i).

1



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

5. (continued)

- (b) Sustainable energy production may reduce the human impact on the composition of Earth's atmosphere.

One possible sustainable energy alternative is a transition to processed biofuels.

(i) State what is meant by a *processed biofuel*. 1

(ii) Suggest why some people claim that use of processed biofuels does not change the composition of the atmosphere. 1

(iii) Suggest a reason why the claim in (ii) may not be true. 1

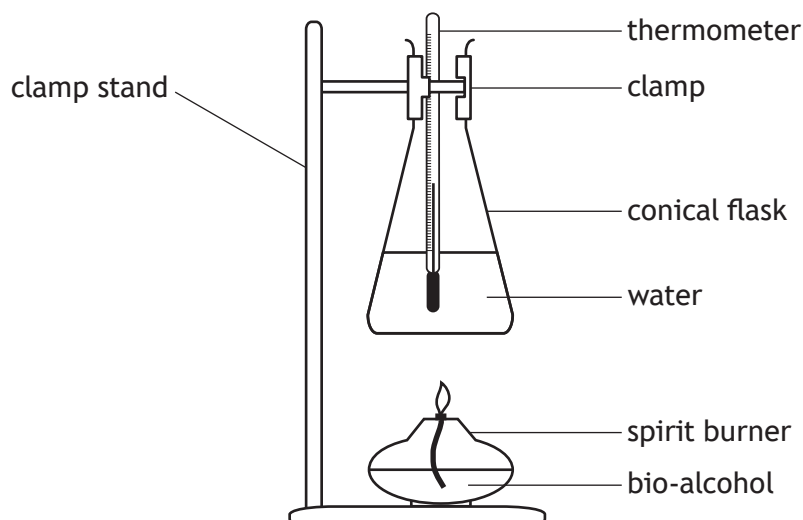
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5. (continued)

- (c) Bio-alcohols are examples of biofuels.

A student carried out an investigation to compare the energy density of different bio-alcohols. The equipment used to carry out the investigation is shown below.



The student measured the mass of bio-alcohol burned while heating 0.10 kg of water by 20 °C.

The energy density was calculated using the following formula

$$\text{Energy density} = \frac{cm_1\Delta T}{m_2}$$

where: c is the specific heat capacity of water = 4.18 kJ kg⁻¹ °C⁻¹

m_1 is the mass of water heated, in kg

ΔT is the change in temperature, in °C

m_2 is the mass of bio-alcohol burned, in g.

The results are shown in the table below.

Bio-alcohol	Mass of water heated (kg)	Change in temperature (°C)	Mass of bio-alcohol burned (g)	Energy density (kJ g ⁻¹)
Biomethanol	0.10	20	0.42	20
Bioethanol	0.10	20	0.31	27
Biopropanol	0.10	20	0.27	
Biobutanol	0.10	20	0.25	33

5. (c) (continued)

- (i) Calculate the energy density of biopropanol.

Space for working

2

- (ii) Evaluate the validity of the student's experimental design.

1

- (iii) Identify one improvement that could be made to the experimental setup to increase the accuracy of the results.

1

- (iv) Suggest one way in which the student could have made their results more reliable.

1

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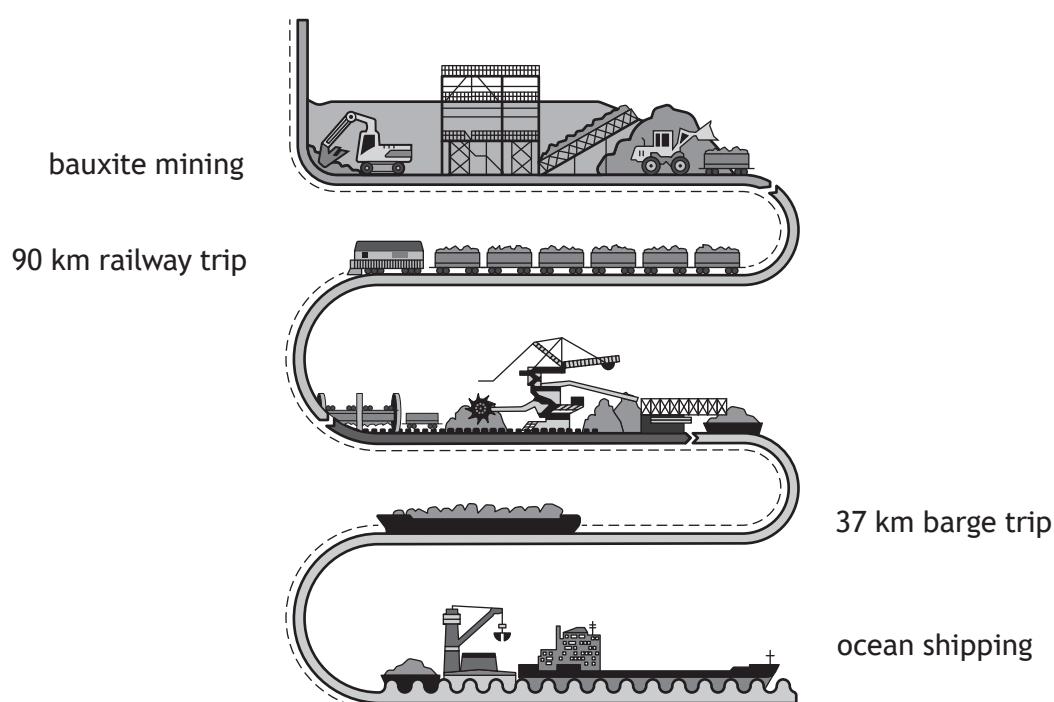


6. Bauxite is an ore rich in aluminium oxide. The ore forms as a result of extreme chemical weathering of rock and leaching of nutrients, leaving bauxite-rich ore deposits near the surface.

(a) State the type of soil found in tropical areas around the Equator that can be rich in aluminium ore.

1

(b) The diagram shows some of the stages involved in the mining and transportation of bauxite ore.



(i) State the main type of mining used to extract bauxite.

1

(ii) Other than transportation, explain one environmental issue associated with the mining of bauxite ore.

1



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

6. (b) (continued)

- (iii) The total environmental impact of a product from raw material to disposal can be assessed.

State the name given to this assessment.

1

- (iv) Explain why the disposal of materials is an important consideration in this type of assessment.

1

- (c) Some of the extracted bauxite ore is transported to Iceland, where it is smelted and processed using geothermal energy.

(i) State one advantage of using geothermal energy.

1

(ii) State one disadvantage of using geothermal energy.

1

[Turn over



7. Hydrogen can be produced from a range of sources and processes.

The hydrogen produced is classified by how environmentally friendly the source and process are.

The table shows some of the environmental classifications of hydrogen.

Environmental classification of hydrogen				
	Grey	Blue	Turquoise	Green
Source	natural gas or coal	natural gas or coal	natural gas	water
Process	steam methane reforming or gasification	steam methane reforming or gasification with carbon capture	pyrolysis	electrolysis using renewable energy

- (a) (i) Currently, most hydrogen is produced using steam methane reforming. Describe the process of steam methane reforming.

2

- (ii) Hydrogen can also be produced using gasification and pyrolysis. Describe how these two methods differ from each other.

1

- (b) By 2025, 147 countries had announced net-zero emission goals. The majority of these countries have still to introduce legislation in order to achieve this.

- (i) State the term used for the methods and principles needed to achieve goals such as net-zero emissions.

1



7. (b) (continued)

- (ii) The 'Green Hydrogen for Scotland' project aims to find approaches to reducing vehicle emissions.

The first phase involves the construction of a green hydrogen production facility on the outskirts of Glasgow.

Suggest **two** reasons why green hydrogen could help ensure long-term energy security in the UK.

2

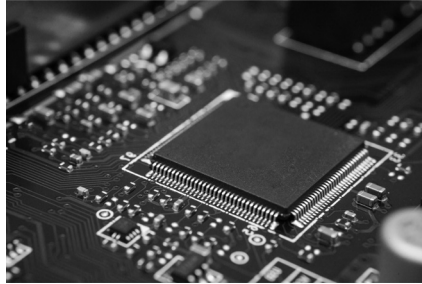
- (iii) Explain one disadvantage of using hydrogen as a fuel.

2

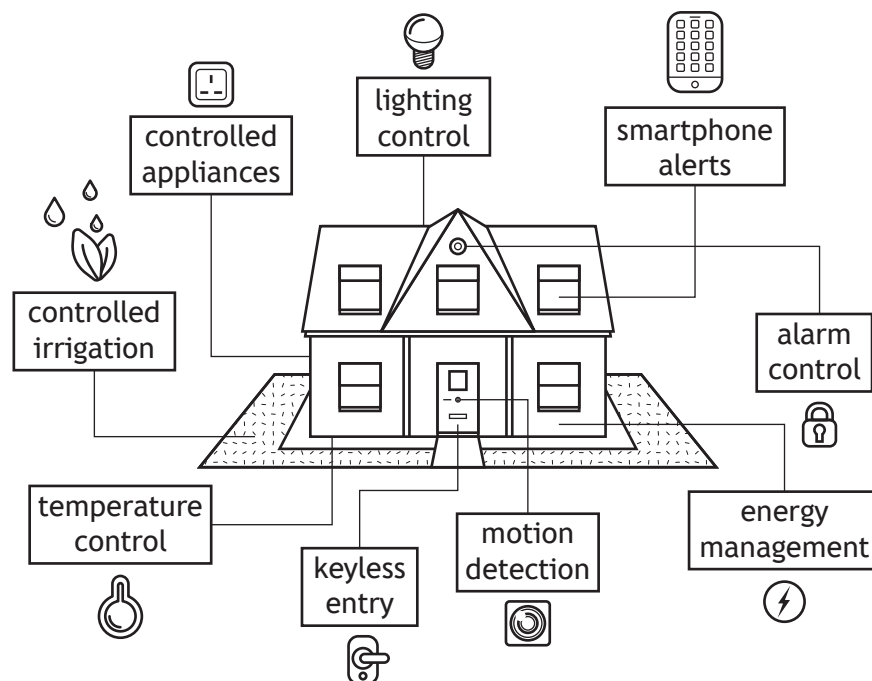
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8. Semiconductor microchips play an essential role in modern electronics. A microchip is a unit that can contain a huge number of components in a tiny surface area. A typical smartphone contains around 170 microchips, while an electric vehicle may contain more than 3500.



- (a) The diagram shows some of the systems in a 'smart' house that use microchips.



8. (a) (continued)

Using examples from the diagram, suggest one social, one economic, and one environmental benefit of using these microchip-based systems in a modern house.

(i) Social

1

(ii) Economic

1

(iii) Environmental

1

[Turn over



8. (continued)

- (b) Microchips are extremely complex to design and manufacture. Their production involves a highly specialised global supply chain.

Microchip production has four main stages. These stages and current market leaders for each stage are shown in the table.

Stage	Current market leader(s)
Sourcing of raw materials (silicon)	China
Design	USA, Netherlands
Manufacture	Taiwan, South Korea, USA, China, Israel
Packaging	USA, Japan, China, South Korea, Singapore, Netherlands

- (i) Suggest one factor that may disrupt the global supply chain.

1

- (ii) The table below shows global revenue from microchips between 2020 and 2024.

	2020	2021	2022	2023	2024
Revenue (\$ billion)	471	595		596	627
Annual growth (%)		26.3	3.9	−3.6	5.2

Calculate, to the nearest \$ billion, the global revenue from microchips for 2022.

1

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8. (b) (continued)

- (iii) Based on the revenue or annual growth results for 2020–2024, suggest whether investment in microchips would be worthwhile.

Justify your response.

1

- (iv) Economists use the percentage compound annual growth rate (% CAGR) to assess the average annual growth rate of an investment over a period of time.

Using the revenue data in the table and the formula below, calculate the % CAGR for **2023 to 2024**.

$$\% \text{ CAGR} = \left(\sqrt{\frac{EV}{BV}} - 1 \right) \times 100$$

where: EV is the end revenue value

BV is the start revenue value.

2

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8. (continued)

- (c) Component obsolescence is a major issue for companies that design and manufacture electronic equipment.

Describe what is meant by *obsolescence*.

1

- (d) Global commitment to sustainability has led many microchip companies to consider moving from a linear economic model to a circular economic model.

Explain why a circular economic model is more sustainable than a linear economic model.

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** Species can be investigated using biodiversity and biotic indices.

Discuss how **two** indices from the following list can be used to estimate the population size and/or the distribution of species:

- Simpson's biodiversity index
- Trent biotic index
- Lincoln index.

10

OR

- B** It is estimated that plants capture approximately 1% of available light energy, and convert this into chemical energy during photosynthesis.

Give an account of energy conversion, transfer, and loss through trophic levels under the following headings:

- (a) primary productivity
- (b) secondary productivity, including ecological efficiency.

10

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10. A The hydrological cycle is the process by which water is continuously transferred between the Earth's surface and the atmosphere.
Discuss water movement processes operating **within the atmosphere**.

10

OR

- B The global ocean conveyor belt is a constantly moving system of deep-ocean circulation, and plays a crucial role in regulating climate.
Discuss the role of the global ocean conveyor belt in the transfer of heat.

10



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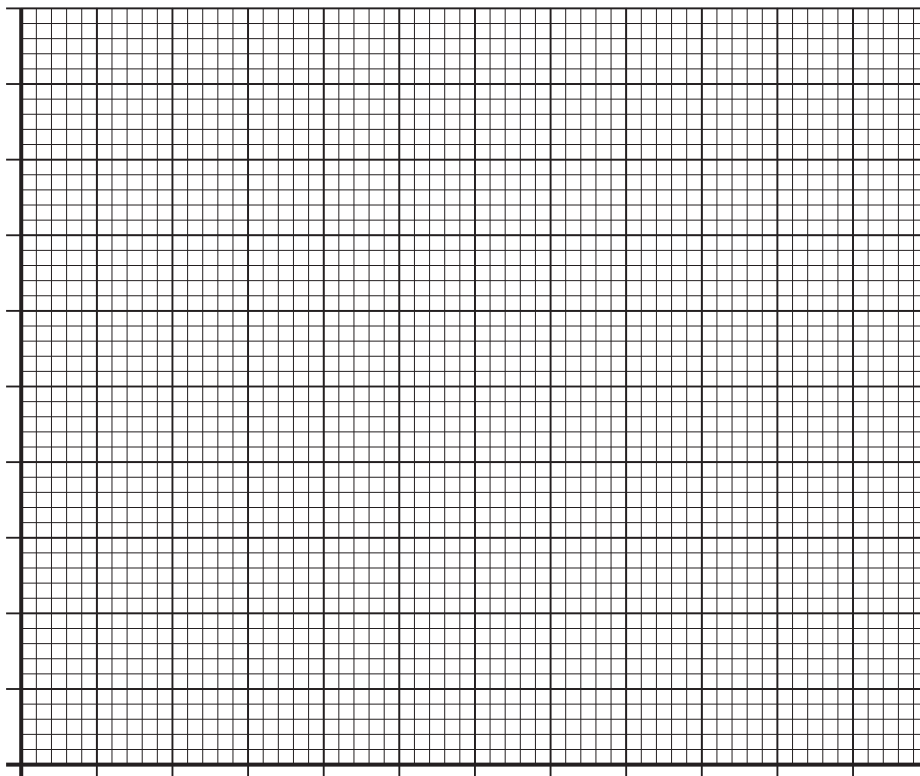
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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph for question 1 (b)



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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