H

National Qualifications 2022

Mark

X826/76/02

Environmental Science Paper 2

TUESDAY, 31 MAY

10:15 AM – 12:45 PM

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.

SQA

Total marks — 100

Attempt ALL questions

Questions 9 and 10 each contain a choice

1. Increased population and globalisation of supply chains have resulted in increased levels of waste. Options for managing this waste are often displayed in a waste hierarchy model, such as the one shown.

prevention

prepare for reuse

recycle

recovery of energy and materials from waste
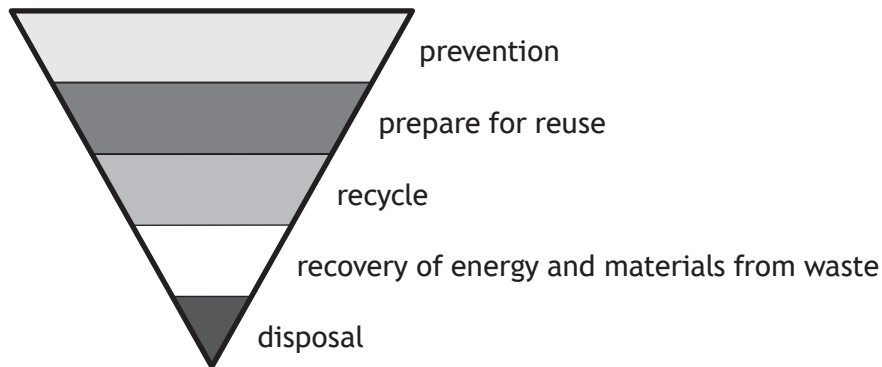
disposal

(a) State the purpose of the waste hierarchy model. **1**

(b) Disposal is the least preferred option in terms of managing waste.

Incineration, without energy recovery, is a method of waste disposal.

Describe **two** impacts of incineration, without energy recovery, on the environment. **2**

1. **(continued)**

(c) Supermarkets can play a major role in reducing food waste.

One way to reduce food waste is by labelling products with use-by dates.

(i) Describe one advantage and one disadvantage of labelling food products with use-by dates. **2**

Advantage

Disadvantage

(ii) The Scottish Government has set a target of reducing all food waste arising in Scotland by 33% by 2025, using the year 2013 as a baseline.

If the target is achieved, Scotland will produce 0.46 million tonnes less waste from food and drink in 2025.

Calculate how many million tonnes of waste from food and drink Scotland produced in 2013. **1**

Space for working

1. **(continued)**

   (d) A supermarket carried out research into reducing excess packaging. They found that juice pouches, typically sold as a multipack in a cardboard box, produced some of the highest volumes of waste.

   (i) Describe **two** benefits of packaging.   **2**

   (ii) The pouches are made from aluminium and plastic bonded together. This makes the pouches impossible to recycle and so they are discarded.

   Name the type of economic model described.   **1**

1. **(d)** **(continued)**

(iii) Plastic undergoes open loop recycling whereas aluminium undergoes closed loop recycling.

Describe **two** differences between open and closed loop recycling. **2**

(iv) Suggest how the juice could be packaged more sustainably. **1**

[Turn over

2. In North America, a motorway was constructed across an area known to be inhabited by grizzly bears (*Ursus arctos horribilis*). Twenty-three wildlife corridors were included in the project.

In a monitoring exercise, environmental scientists were trying to determine whether the construction of the motorway and the wildlife corridors above the motorway has affected the genetic diversity of the grizzly bears in the area.

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

1

(ii) Construction of the motorway has led to habitat fragmentation.

Explain why habitat fragmentation may cause a decrease in genetic diversity.

2

2. (a) (continued)

   (iii) Other than reducing genetic diversity, describe **two** environmental impacts of the construction of motorways.

                2

(b) The scientists piloted a new sampling technique in the area. This technique uses DNA obtained from hair samples to gather data for the study.

Hair traps were set up at the twenty-three wildlife corridors, similar to the one shown in the image. Each wildlife corridor is of identical size, length, and shape. The wildlife corridors are 18 km apart.

Hair samples were collected from every wildlife corridor along the motorway.

Explain why the results of this study could be considered reliable.

                1

2. (continued)

(c) The scientists used a number of techniques to determine whether use of the wildlife corridors was related to any changes in the genetic diversity of the grizzly bear population.

In addition to hair traps, scientists placed a camera trap at each wildlife corridor. They also captured some grizzly bears and carried out a physical examination before fitting them with GPS tracking collars.

The table shows the scientists' assessment of the effectiveness of each technique for meeting the objectives of their research.

Key: * suitable method   ** best method

Research objective	Sampling technique		
	Camera trap	Hair trap	Physical examination + GPS
Species identification	**	*	*
Direction of travel	*		**
Individual identification		**	*
Sex determination		**	*
Migration of new bears into the study area		**	

(i) The scientists determined that hair sampling was a better technique for identifying individual grizzly bears, rather than physical examination and fitting the bears with a GPS tracking collar.

Suggest a reason why hair sampling was determined to be the better technique.

1

2. (c) (continued)

(ii) Explain why the use of three techniques would increase the validity of the study. **2**

[Turn over

3. Scotland's bathing waters are regularly monitored to assess overall water quality. In 2019, bathing waters at 10 coastal locations were declared to be of 'poor' quality.

Kinghorn Harbour Beach, in Fife, was identified as an area with poor water quality. A stream, with a catchment of approximately 2 km^2, drains into the River Forth at this location.

The catchment consists largely of fields where mixed agriculture, of both crops and animals, takes place.

scale   0   0.5   1 km

Key

----- coast line

stream and loch

catchment

town of Kinghorn

Kinghorn Harbour Beach

—— main roads

(a) Name the environmental agency that has responsibility for monitoring the quality of Scotland's bathing waters.   **1**

3. (continued)

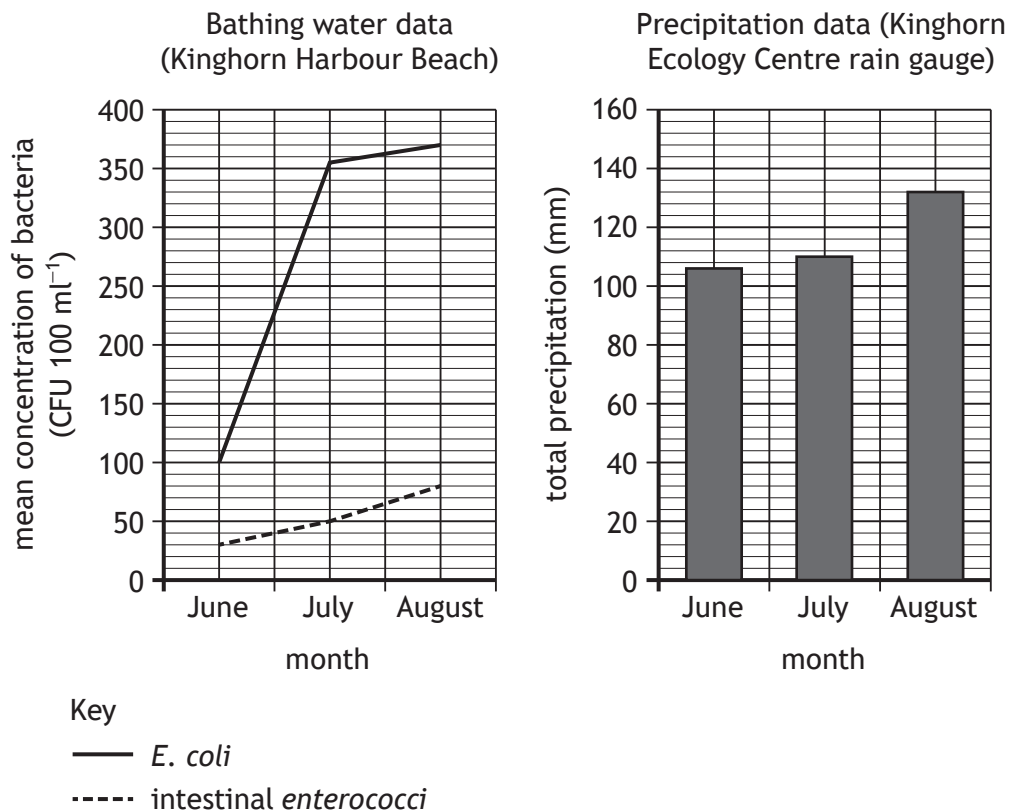(b) To assess water quality, concentrations of two species of waterborne bacteria harmful to human health are measured.

Escherichia coli (*E. coli*) and intestinal *enterococci* are both associated with faecal contamination from humans or other mammals.

The graphs show the mean concentration of these bacteria, recorded as colony forming units (CFU) per 100 ml, and the total precipitation recorded at a nearby rain gauge.

Bathing water data
(Kinghorn Harbour Beach)

Precipitation data (Kinghorn Ecology Centre rain gauge)

Key

—— *E. coli*

----- intestinal *enterococci*

(i) Identify the population growth model demonstrated by *E. coli* in the graph.

1

(ii) Describe the apparent relationship between the concentration of intestinal *enterococci* and the total precipitation.

1

3. **(b)** **(continued)**

(iii) Explain why the bacterial contamination found at Kinghorn Harbour Beach can be considered an example of both point and diffuse pollution.

2

(iv) Suggest why it is advised that swimming at Kinghorn Harbour Beach does not take place after periods of heavy rainfall.

2

(v) Suggest another pollutant that may be present at Kinghorn Harbour Beach.

1

3. (continued)

(c) Over the same time period, an unusually high concentration of algae was recorded in Fife's inland water bodies. This prompted a number of public health warnings.

    (i) Explain how algal blooms form.   **3**

   (ii) Describe a way in which the occurrence of algal blooms could be reduced in the future.   **1**

[Turn over

4. The northern spotted owl (*Strix occidentalis caurina*) is an endangered species found in North America.

The northern spotted owl relies on old-growth forest as a habitat. This habitat is under threat from the logging industry, which is a major component of the local economy.

The diagram below shows habitat fragmentation in an area of old-growth forest that is subject to environmental monitoring.

Key

habitat patch old-growth forest

logged area
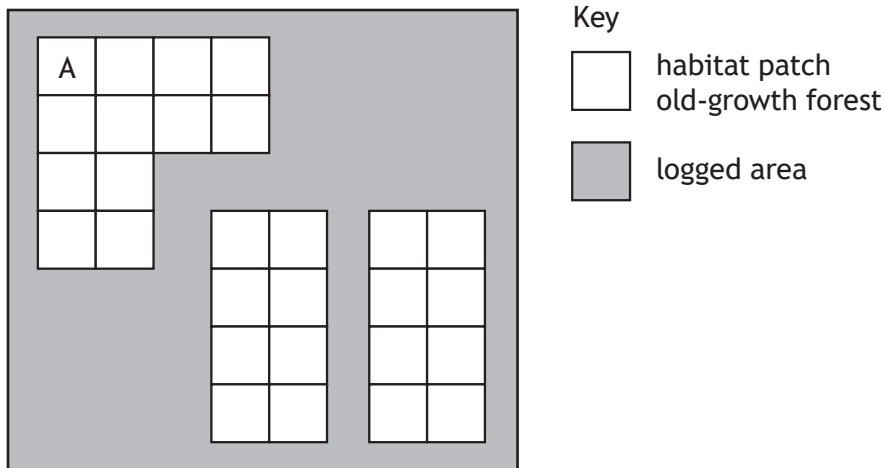
4. **(continued)**

(a) Describe the purpose of environmental monitoring. **1**

(b) The northern spotted owl has three life stages:

- juvenile, lasts for 0–1 year
- sub-adult stage, a non-reproductive life stage lasting 1–2 years
- adult, northern spotted owls reproduce from 2 years old.

The carrying capacity of each habitat patch shown in the diagram is 40 female northern spotted owls.

At the start of a year, habitat patch A contains 25 adult females and 12 sub-adult female northern spotted owls.

(i) The fecundity of the northern spotted owl is 0.40.

Fecundity refers to the number of juvenile females per adult female.

Calculate the number of juvenile females hatched by the end of the year. **1**

Space for working

[Turn over

4. (b) (continued)

(ii) The table shows the annual survival rate for female northern spotted owls at each life stage.

Female life stage	Annual survival rate
Juvenile	0.20
Sub-adult	0.75
Adult	0.92

The number of female owls present in habitat patch A at the end of the year can be estimated using the following formula

$$N = n_1 + n_2 + n_3$$

where: N is the total number of female owls at the end of the year

n_1 is the number of surviving adult females

n_2 is the number of surviving sub-adult females entering adult life

n_3 is the number of surviving juvenile females.

The data were used to estimate the number of surviving sub-adults entering adult life. This was estimated to be 9 owls. The number of surviving juvenile females was estimated to be 2 owls.

Using the formula and information in the table calculate an estimate for the total number of female owls (N) present in habitat patch A at the end of the year.

Space for working

2

(iii) Based on your calculated estimate, state whether the carrying capacity of the habitat patch would be exceeded.

Justify your answer.

1

4. **(b) (continued)**

(iv) This model is not truly representative of the northern spotted owl population.

Suggest a reason for this. **1**

(c) When the carrying capacity is exceeded, juvenile owls disperse to adjacent habitat patches.

Explain population oscillations around the carrying capacity. **3**

(d) Rewilding involves activities that initiate or accelerate the recovery of ecosystems.

Suggest one rewilding activity that could be carried out to improve the health of the old-growth forest ecosystem. **1**
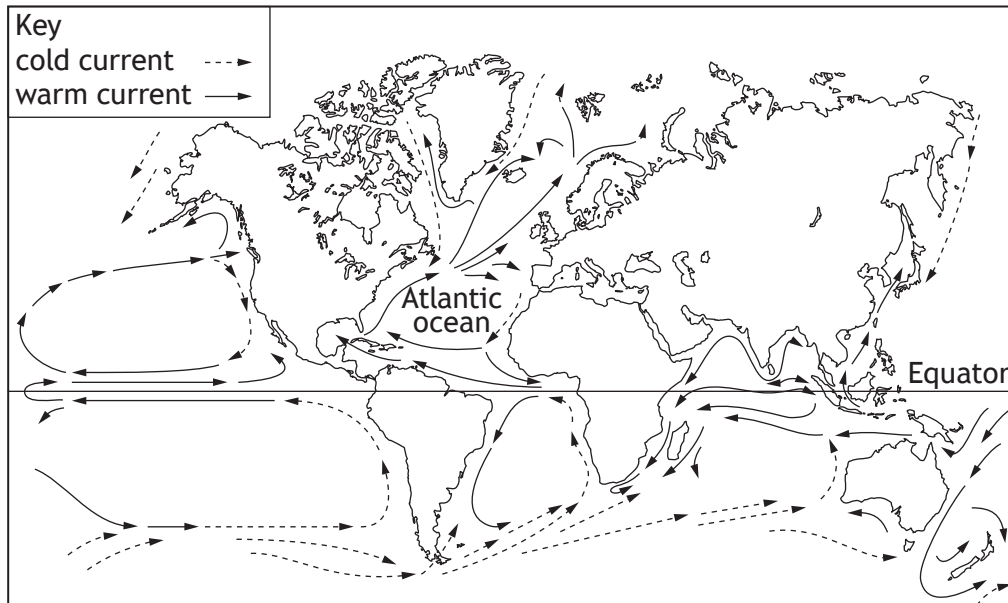
5. Ocean currents distribute heat energy around the world, forming a complex system often referred to as the global conveyer belt.

Major ocean currents are shown in the diagram.

(a)　(i)　Warm water is carried from the Equator towards polar regions by ocean currents.

Describe how differences in temperature cause the circulation of ocean currents.　　**2**

(ii)　Explain why upwelling is essential for supporting marine food webs.　　**2**

5. **(continued)**

(b) About 8400 years ago, natural ice dams holding Lake Agassiz in Canada melted and collapsed, releasing enormous volumes of freshwater into the North Atlantic Ocean.

Explain why this release of freshwater disrupted the global conveyer belt. **2**

(c) 97% of water present on Earth is saltwater. Saltwater can be converted into drinking water.

(i) Name the process used for converting saltwater into drinking water. **1**

(ii) Areas of the world with low levels of precipitation are most likely to experience water insecurity.

State one other factor that could also contribute to water insecurity. **1**

[Turn over

6. The kite diagram shows the relationship between pH and the availability of inorganic soil nutrients to plants. For each nutrient, the width of the bar indicates the degree of availability.
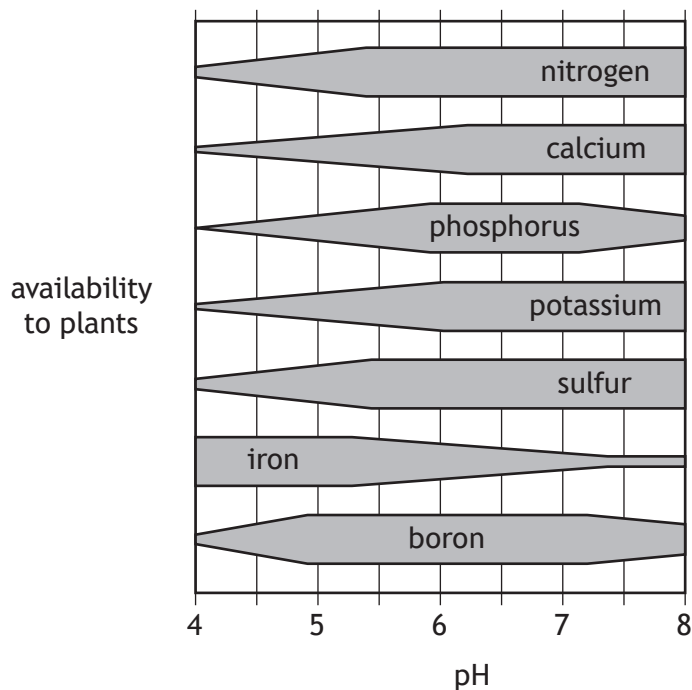
(a) Identify the pH range at which the majority of nutrients become most readily available to plants.

1

pH range
4.0–5.0
5.0–6.0
6.0–7.0
7.0–8.0

pH range _____

6. (continued)

(b) The table below shows the benefit of each nutrient to plants, and limitations associated with lack or excess of each nutrient.

Nutrient	Benefit to plant	Limitations
Nitrogen (N)	A key element for the production of plant proteins	Easily leached. Deficiency stunts leaf growth
Calcium (Ca)	Essential for root growth and leaf development	Root growth increases pore space, but >50% pore space affects drainage
Iron (Fe)	Forms compounds that regulate and promote plant growth	High levels can inhibit plant uptake of other nutrients
Phosphorus (P)	Helps transfer energy during photosynthesis, stimulates early growth, hastens maturity	pH <7.5, P reacts with Fe pH >7.5, P reacts with Ca These reactions form less soluble compounds
Potassium (K)	Increases hardiness and disease resistance of plants	Very high levels can inhibit plant uptake of other nutrients
Sulfur (S)	A constituent of plant proteins and involved in energy-producing processes in plants	Excessive levels can acidify soil, inhibit plant uptake of other nutrients, and impact on microbial activity
Boron (B)	Helps control the transport of sugars in plants, and the formation of cells in plant tissues	Deficiency reduces uptake and use of Ca. Excessive B can be toxic to plants

Use the information in the kite diagram and table.

Explain, using a named nutrient, why strongly acidic soils are generally **not** suitable for agriculture.

2

6. (continued)

(c) In addition to pH, other factors have an impact on soil.

(i) State the term which refers to the physical, chemical, or biological characteristics of soil that affect living organisms.

1

(ii) Use of heavy machinery can cause soil compaction.

Describe a hydrological impact that compaction would have on the A-horizon (topsoil).

2

(iii) Explain how compaction would affect the presence of soil bacteria.

2

[Turn over for next question

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7. The Harran Plain lies on a plateau in south-eastern Anatolia, Turkey.

The map shows the location of the Harran Plain.

(a) The table shows temperature and precipitation data for the Harran Plain.

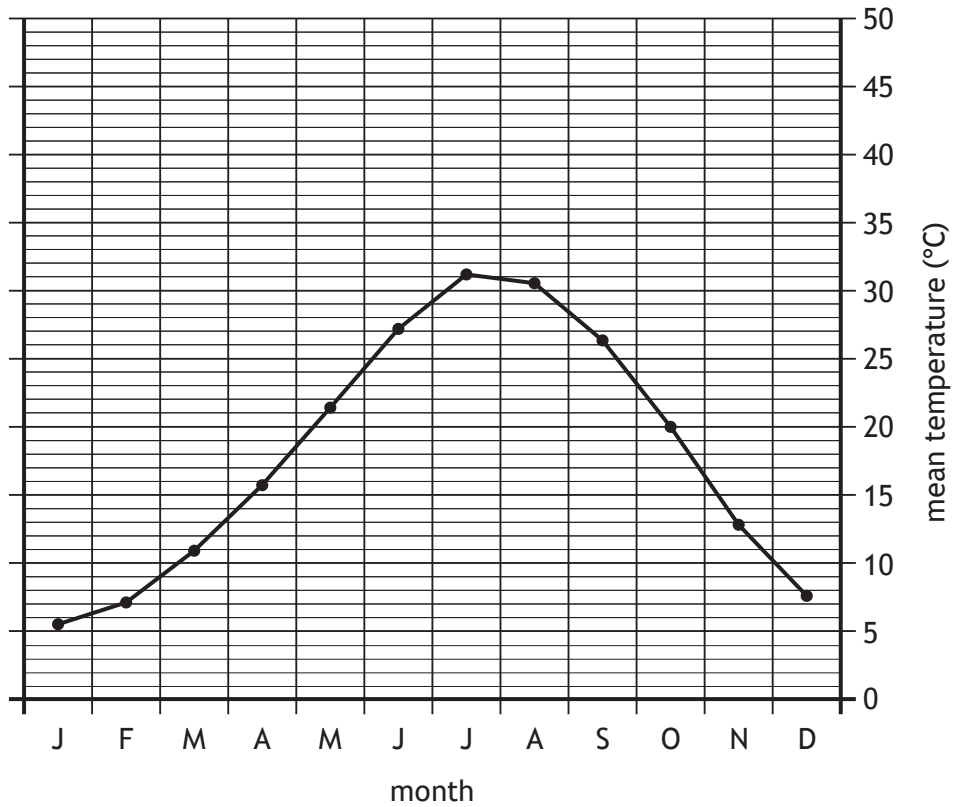| Month	Mean precipitation (mm)	Mean temperature (°C)
Jan	86	5.5
Feb	72	7.1
Mar	70	10.9
Apr	51	15.7
May	32	21.4
Jun	4	27.1
Jul	1	31.1
Aug	0	30.6
Sep	2	26.4
Oct	28	20.0
Nov	45	12.9
Dec	86	7.6

7. (a) (continued)

(i) Using information from the table, complete the graph by adding bars to show the distribution of precipitation across the year. **2**

(ii) Describe the trends shown in the graph. **2**

7. (continued)

(b) The Harran Plain is classed as steppe. This is a semi-arid biome that receives precipitation sufficient to support short grasses but not shrubs or trees.

(i) State the term that refers to the loss of water to the atmosphere from the land surface and from plant leaves.

1

(ii) The Harran Plain has no surface water but freshwater is available in two large aquifers lying below the plain.

State a type of natural water storage, other than an aquifer.

1

(iii) Agriculture in the area depends on extracting water from the aquifers for crop irrigation. This requires deep wells to be dug.

Suggest why this action would support only local crop production.

1

7. (continued)

(c) In the 1990s, a major development project was initiated to improve the economic and social welfare of local communities.
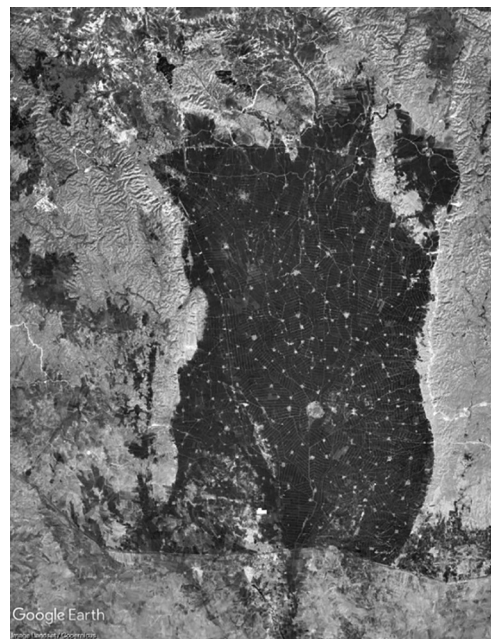
Dams were constructed on major rivers in the area, and water was transferred 25 km through tunnels to the Harran Plain and then via open channels to the fields.

The images below show the impact the transfer of water has had on the area used for cultivation on the plain.
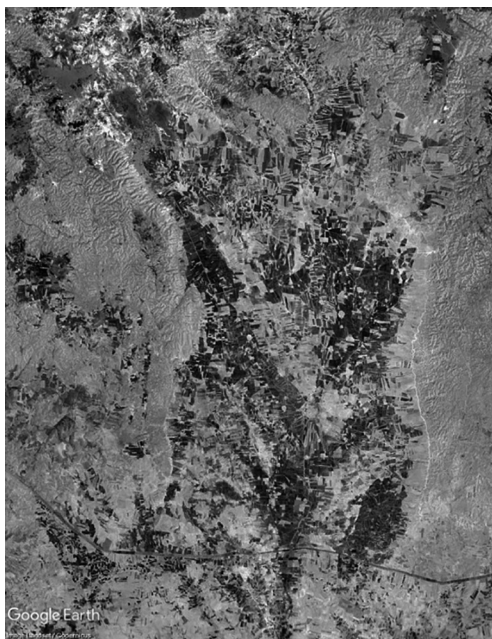
Google Earth Images Landsat / Copernicus © 2022

The Harran Plain in 1995

Google Earth Images Landsat / Copernicus © 2022

The Harran Plain in 2011

(i) The Harran Plain covers a total area of 225 000 hectares (ha).

In 1995, the area being irrigated was 15 120 ha.

By 2011, this had increased to 184 500 ha.

Calculate the percentage change in land irrigated between 1995 and 2011.

Space for working

1

7. (c) (continued)

    (ii) Cotton is the main crop cultivated in the irrigated area. Cotton is a crop with a high-water demand.

       In 2016, the area used for growing cotton was 107 474 ha.

       On average, the water demand for cotton is 7571 $m^3 ha^{-1}$.

       Calculate, to the nearest million cubic metres, the volume of water required for cotton irrigation in 2016.   **1**

       Space for working

  (d) Over-cultivation plus the climate on the Harran Plain has increased salinity of soil across a large part of the irrigated area.

    (i) Name the process that results in salts from groundwater rising to the soil surface.   **1**

   (ii) Using the data from part (a), explain why soil salinity increases during the summer months.   **2**

    (iii) Suggest a change in practice that could be used to reduce the increasing salinity of soil on the Harran Plain.   **1**

8. Intense geological activity occurs at plate boundaries, where plates move away from each other, past one another, or towards each other.

The diagram includes a subduction zone.

volcano
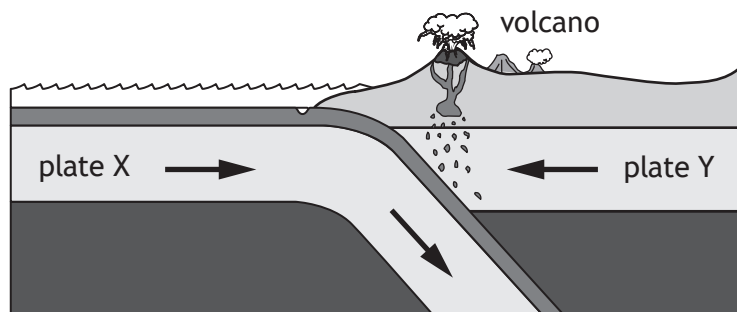
plate X →   ← plate Y

(a) Name the type of plate boundary that can result in the formation of a subduction zone.

1

(b) (i) State the type of plate represented by plate X in the diagram.

1

(ii) Explain why plate X moves below plate Y during subduction.

1

[Turn over

8. (continued)

(c) Volcanic activity is common at subduction zones.

(i) Describe the formation of extrusive rock from magma. **3**

(ii) State why volcanoes at subduction zones are often very explosive. **1**

(d) Explain why earthquakes at subduction zones can be of very high magnitude. **1**

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**   Sewage treatment refers to the process of removing contaminants, micro-organisms, and other types of pollutants from wastewater.

     Discuss under the following headings:

     (a) methods used to treat wastewater to produce effluent

     (b) end uses of sewage sludge.   **10**

   OR

   B   In 2019 the Scottish Government reaffirmed its opposition to allowing fracking in Scotland, stating that fracking was not compatible with Scottish climate change policy. Some countries allow fracking.

     Discuss extraction and use of shale gas under the following headings:

     (a) benefits

     (b) challenges.   **10**

10. **A**   The amount of solar radiation received by the Earth is not evenly distributed across the surface of the planet.

     Discuss the redistribution of solar energy from areas of surplus to areas of deficit via the tri-cellular model.   **10**

   OR

   B   Bauxite ores are the raw material for primary aluminium production.

     Discuss the environmental impacts of mining and processing of bauxite ore.   **10**

[Turn over

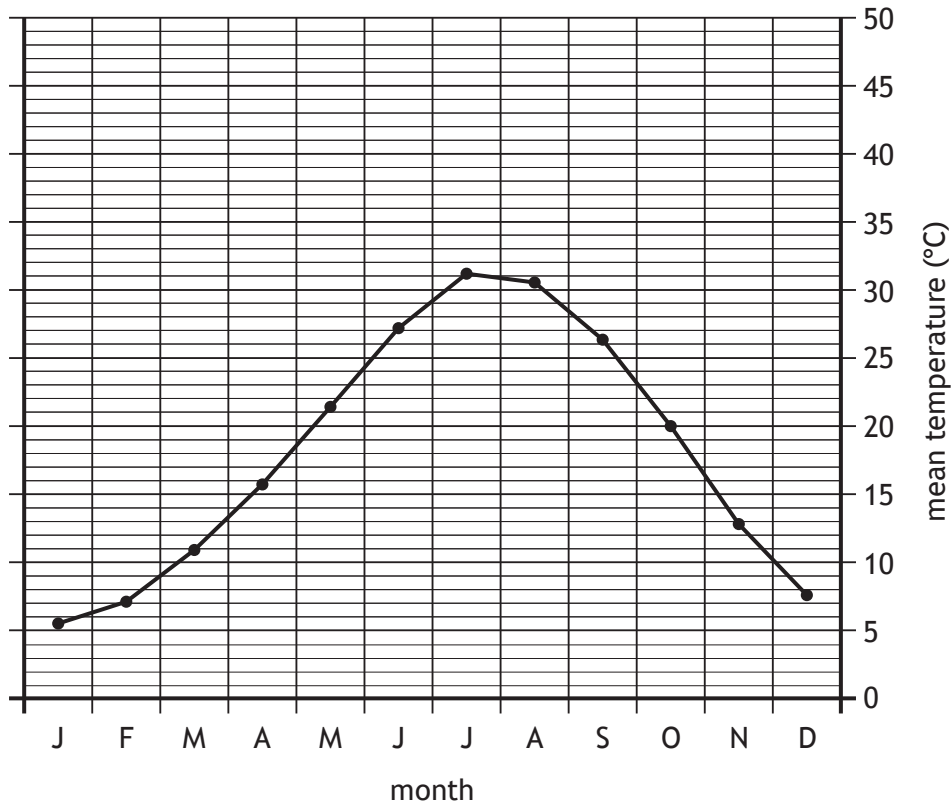**SPACE FOR ANSWERS**

SPACE FOR ANSWERS (continued)

SPACE FOR ANSWERS (continued)

[END OF QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph for question 7 (a) (i)

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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