NSW GOVERNMENT

NSW Education Standards Authority

Centre Number

Student Number

2023 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Earth and Environmental Science

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A Geological Time Scale is provided at the back of this paper
- Write your Centre Number and Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2–11)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13–39)

- Attempt Questions 21–35
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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1 Which of the following technologies could be used to predict the formation of an east coast low?

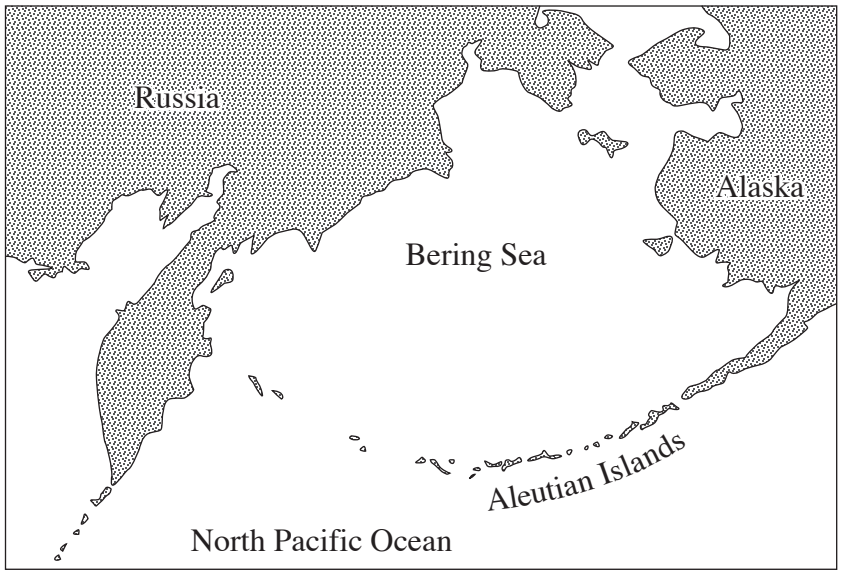
A. Barometer

B. Strain meter

C. Seismometer

D. Global positioning system

2 The Aleutian Islands are located in the North Pacific Ocean, as shown on the map. These islands are subject to both earthquakes and volcanoes.



Aleutian Islands | Historica Wiki | Fandom. CC-BY-SA

What is the most likely plate tectonic setting for these islands?

A. A hot spot

B. A transform boundary

C. An ocean–ocean divergent boundary

D. An ocean–ocean convergent boundary

3 In November 2022, a major soft plastic recycling program was paused in Australia, resulting in a less sustainable strategy being used to manage soft plastic waste.

Which of the following is the most likely effect if soft plastic is NOT recycled?

A. More space would be required for landfill.

B. Greenhouse gas emissions would decrease.

C. Composting capacity would need to be increased.

D. Other recycling industries would experience a reduction in efficiency.

4 Which of the following causes global climate change on the shortest timescale?

A. Plate tectonic supercycle

B. Massive volcanic eruptions

C. Changes in ocean circulation

D. Changes in the Earth's orbit around the Sun

5 Which of the following hazards would be the most difficult to accurately predict for a timely evacuation?

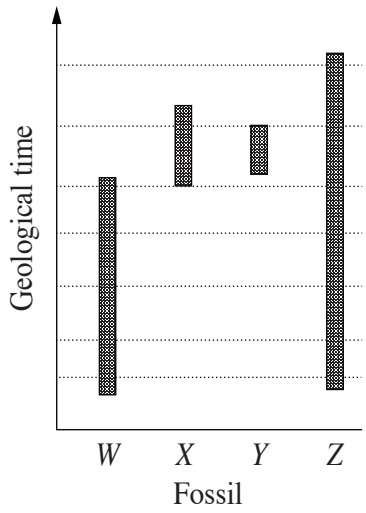
A. Tsunamis

B. Earthquakes

C. East coast lows

D. Volcanic eruptions

6 The diagram shows the time range in which four organisms *W*, *X*, *Y* and *Z* existed. Each of these organisms has been fossilised.



Which of these organisms would be the most useful as an index fossil?

A. *W*

B. *X*

C. *Y*

D. *Z*

7 Palaeontologists have discovered that fossils of aquatic and marine organisms are more common than those of terrestrial organisms.

Which of the following factors is most likely to account for this difference?

A. Hard parts fossilise more easily than soft parts.

B. There is no tectonic movement of the ocean floor.

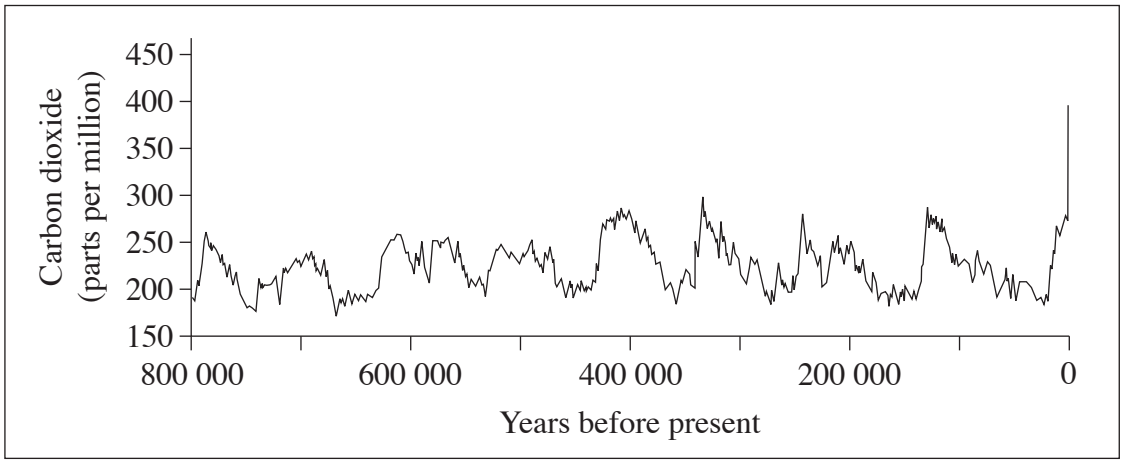
C. Rapid burial by sediments is more likely under water.

D. Dissolved oxygen in seawater prevents decomposition.

8 Which row correctly matches the tectonic boundary type with its features?

	Tectonic boundary	*Earthquakes*	*Volcano eruption type*	*Volcanic lava*
A.	Continental–continental divergence	Shallow to medium focus	Explosive	Gluggy (high viscosity)
B.	Oceanic–oceanic convergence	Shallow to deep focus	Explosive	Runny (low viscosity)
C.	Oceanic–continental convergence	Deep focus only	Effusive	Gluggy (high viscosity)
D.	Oceanic–oceanic divergence	Shallow focus only	Effusive	Runny (low viscosity)

9 The following graph shows CO_2 levels in the atmosphere over time.



Global Climate Change: Evidence." NASA Global Climate Change and Global Warming: Vital Signs of the Planet. June 15, 2008. Accessed January 14, 2015. http://climate.nasa.gov/evidence

Which of the following pieces of scientific evidence would be used to generate this graph?

A. Gas bubbles in ice cores

B. Human instrumental records

C. Pollen grains in sedimentary rocks

D. Oxygen isotope ratios in microfossils

Use the following information and graph to answer Questions 10–11.

Mining has ceased at a uranium mine. A creek flows past the mine.

Creek water is tested for the presence of uranium. If downstream uranium concentrations exceed the guideline value of 2.8 μg/L, the mine operator is required to investigate the cause and take corrective action.

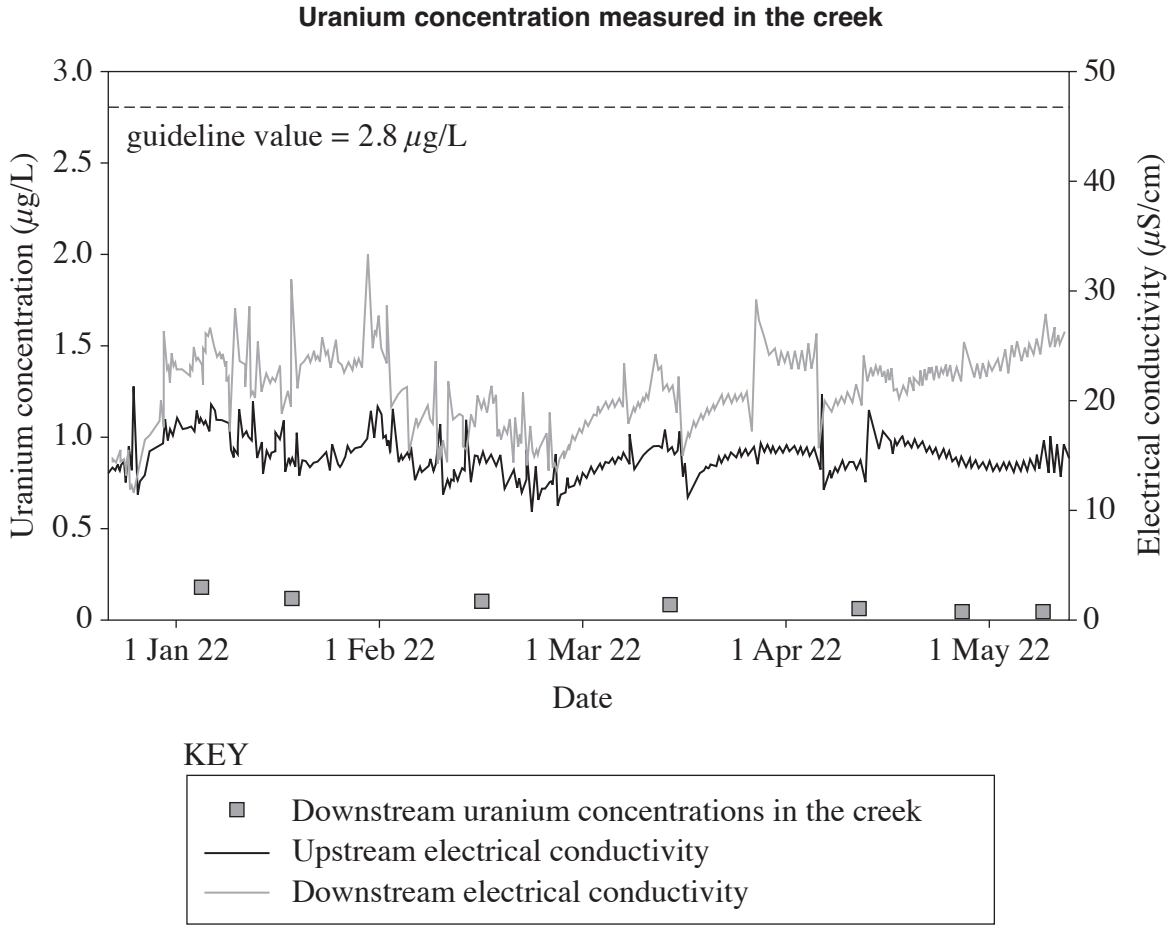


Figure 1 Continuous electrical conductivity and stage height (water level) in Gulungul Creek.
Department of Climate Change, Energy, the Environment and Water.

10 During the time period provided, which of the following statements is supported by the data?

A. Uranium levels in the creek did not exceed maximum safe levels.

B. Variable uranium concentrations in the creek were due to occasional discharges of uranium from the mine.

C. Rehabilitation of the mine was unsuccessful and downstream ecosystems were at risk of dangerous uranium contamination.

D. Uranium leakage into the environment indicates the mine rehabilitation project needs to improve the containment of uranium tailings.

11 Electrical conductivity measurements show the total concentration of all dissolved ions including uranium in creek water.

Why are electrical conductivity measurements taken both upstream and downstream of the mine?

A. Additional measurements improve the reliability of data.

B. Upstream measurements provide an experimental control.

C. Averaging upstream and downstream values improves the accuracy of measurements.

D. Electrical conductivity data shows that uranium concentrations may be higher than initial estimates.

12 A student was conducting a case study into the sustainability of timber production in an Australian forest.

Which of the following sources is most likely to provide accurate, reliable and valid information?

A. Tube, X., 1967, 'Timber Production in Leafy Green Forest', *NSW Journal of Tree Felling Practitioners,* 12(2), pp25–29.

B. Tree and Shrubbery Protection Warriors, 2021, 'Protect Our Trees', [online] available at: treeandshrubberyprotectionwarriors.org.au [accessed 16 July 2023].

C. Leafy Green Timber Mill, 2021, '2020 Production Report', *Australian Timber and Tree Cutting Industry Magazine,* 14 September 2021, pp50–51.

D. NSW Department of Timber, Trees and Wood Production, 2018, 'Forestry Management Assessment Report', Shellharbour: NSW Department of Timber, Trees and Wood Production.

13 Which of the following key features assisted animals in their conquest of the land?

A. External fertilisation, stronger legs, permeable skin

B. Permeable skin, paired limbs, leathery-shelled eggs

C. Waterproof scales, external fertilisation, paired limbs

D. Stronger legs, waterproof scales, leathery-shelled eggs

14 The plate tectonic supercycle involves the opening and closing of ocean basins between a single land mass and many smaller continents.

How does the presence of many smaller continents increase the rate of evolution?

A. Divergence of continents increases the variety of habitats.

B. Continental collisions increase the range of possible climates.

C. Convergence of continents increases nutrient transport in the oceans.

D. Rifting of the supercontinent increases the likelihood of ice caps forming and sea levels rising.

15 Which of the following phenomena is caused by large, local, vertical temperature variations in the atmosphere?

A. Droughts

B. Bushfires

C. Hailstorms

D. East coast lows

16 Which of the following ONLY lists adaptation strategies for anthropogenic climate change?

A. Planting heat tolerant crops and expanding irrigation

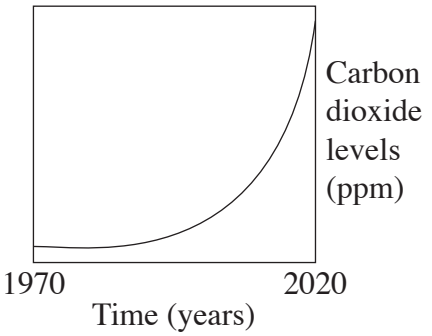
B. Replanting forests on cleared land and installing offshore wind farms

C. Fire-stick farming and incorporating earthquake resilience into building codes

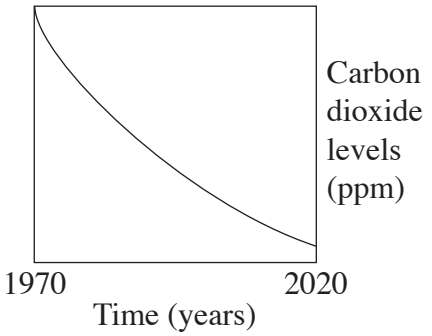
D. Constructing tall buildings to create shade and increasing use of public transport

17 Which graph best represents the trend in atmospheric carbon dioxide concentration in the atmosphere over the past 50 years?

A.



B.



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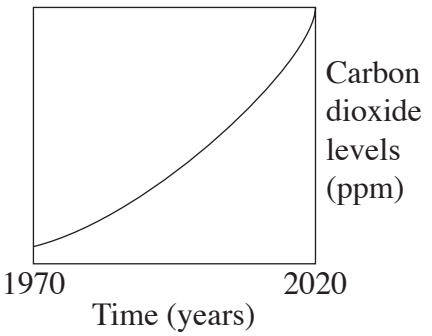

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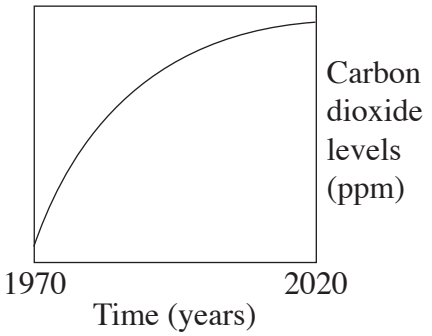


18 A fast food company conducted a litter survey to find out which types of packaging were most often discarded by customers in the restaurant carpark.

Which of the following is necessary to ensure validity of the data?

A. Gathering litter samples each morning over several days

B. Using accurately calibrated, precision scales to measure the mass of litter collected

C. Collecting litter samples on calm days to prevent lightweight litter being blown away

D. Ensuring organic litter is composted after the survey to prevent greenhouse gas production in landfill

19 The amount and location of O_2, known as free oxygen, has altered the hydrosphere, geosphere and atmosphere over the course of Earth's history.

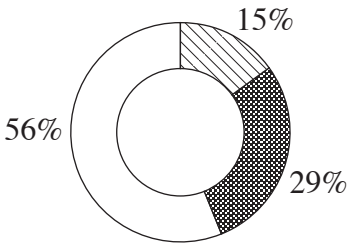
A geologist suggested the following timeline.

Event	*Time*
Photosynthesis began	Late Archean
Oceans saturated with oxygen and oxygenation of the atmosphere	Mid Proterozoic

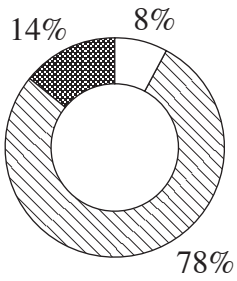
A Geological Time Scale is provided at the back of this paper.

Which graph most accurately represents the duration of these changes, as a proportion of total geological time?

A.



B.



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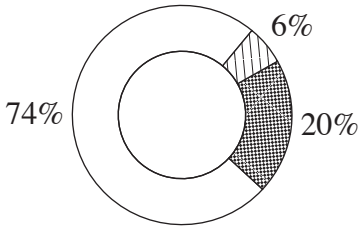

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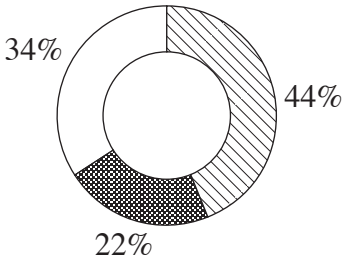

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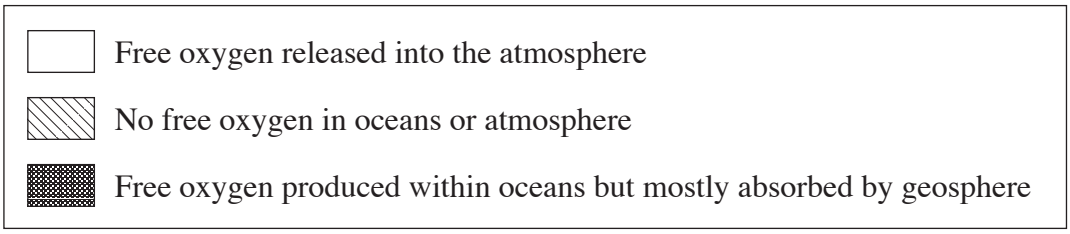

20 Oxygen isotope ratios are used as evidence to determine changes in climate.

In which of the following samples would there be an elevated level of Oxygen-18 compared to Oxygen-16?

A. Ice cores at high latitudes during a glacial period

B. Corals on a continental shelf during a glacial period

C. Stalagmites at low latitudes during an interglacial period

D. Microfossils on the bed of a lake at low latitudes during an interglacial period

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2023 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Earth and Environmental Science

Section II Answer Booklet

80 marks
Attempt Questions 21–35
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (2 marks)

Outline the conditions required for an east coast low to be classified as a disaster. **2**

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Do NOT write in this area.

Question 22 (3 marks)

Outline an effect of photosynthesis on the development of each of the identified spheres. **3**

Sphere	*Effect of photosynthesis*
Geosphere	....
Atmosphere	....

Question 23 (3 marks)

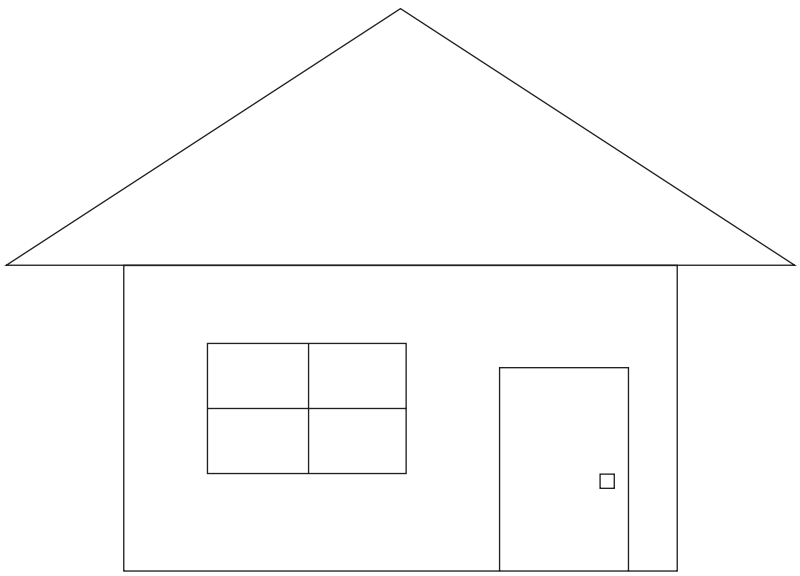
Complete the table to compare the natural and anthropogenic greenhouse effect. **3**

	Natural greenhouse effect	*Anthropogenic greenhouse effect*
Definition	Gases in Earth's atmosphere trap the Sun's heat.	
ONE greenhouse gas source		Carbon dioxide from burning fossil fuels.
Timescale over which it occurs	Continuous over Earth's evolution.	

Question 24 (3 marks)

A family wishes to make changes to their 1970s home in order to minimise their contribution to the greenhouse effect. **3**

Annotate the diagram, justifying TWO design modifications that would achieve this goal.



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Question 25 (4 marks)

(a) Define the term *sustainability*. Include an example in your response. **2**

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(b) A student wants to investigate a sustainability initiative in their local community. **2**

Justify a strategy that is suitable for collecting information for this investigation.

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Question 26 (3 marks)

For a named resource, state whether the resource is renewable or non-renewable and recommend a strategy to improve the sustainable extraction and/or management of that resource. **3**

Resource: .....

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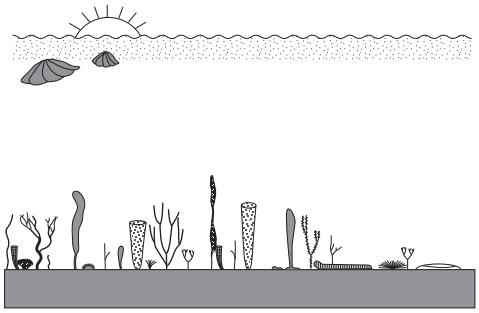
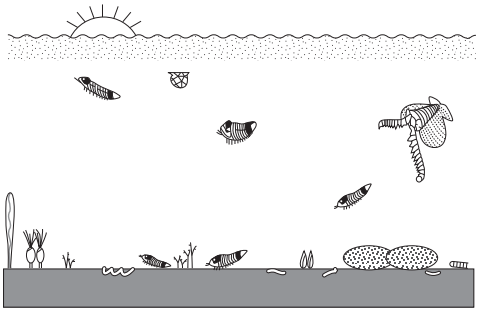
Question 27 (7 marks)

In 2004, the International Union of Geological Sciences approved the addition of the Ediacaran Period to the geological time scale. Many fossil sites were used as evidence to support the addition of this period. An overview of the characteristics of species from the Ediacaran and Cambrian periods found at two of these sites is provided in the table.

	Ediacaran organisms (fossils discovered in the Ediacaran Hills)		*Cambrian organisms* (fossils discovered in the Burgess Shale)	
				
	Characteristic	*Species found*	*Characteristic*	*Species found*
	Hard shells	0	Hard shells	72
	Soft bodied	42	Soft bodied	88
Movement	Attached	Yes	Attached	Yes
	Burrowing	Yes	Burrowing	Yes
	Swimming	Yes	Swimming	Yes
	Walking	No	Walking	Yes
Diet	Photosynthetic producers	Yes	Photosynthetic producers	Yes
	Filter feeders	Yes	Filter feeders	Yes
	Deposit feeders	Yes	Deposit feeders	Yes
	Scavengers	Yes	Scavengers	Yes
	Carnivores	No	Carnivores	Yes

With permission from the Palaeontological Society of Japan.

Question 27 continues on page 21

Question 27 (continued)

(a) Name ONE type of trace fossil likely to have been produced during either the Ediacaran or Cambrian Period. **1**

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(b) Describe the similarities and differences between the Ediacaran and Cambrian ecosystems. **3**

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(c) Explain how relative dating can be used to determine the age of organisms such as those described at the two fossil sites. **3**

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End of Question 27

Question 28 (4 marks)

Construct a flow chart that could be used to show people how to separate household wastes. In your flow chart, include strategies for the sustainable management of THREE different types of waste. **4**

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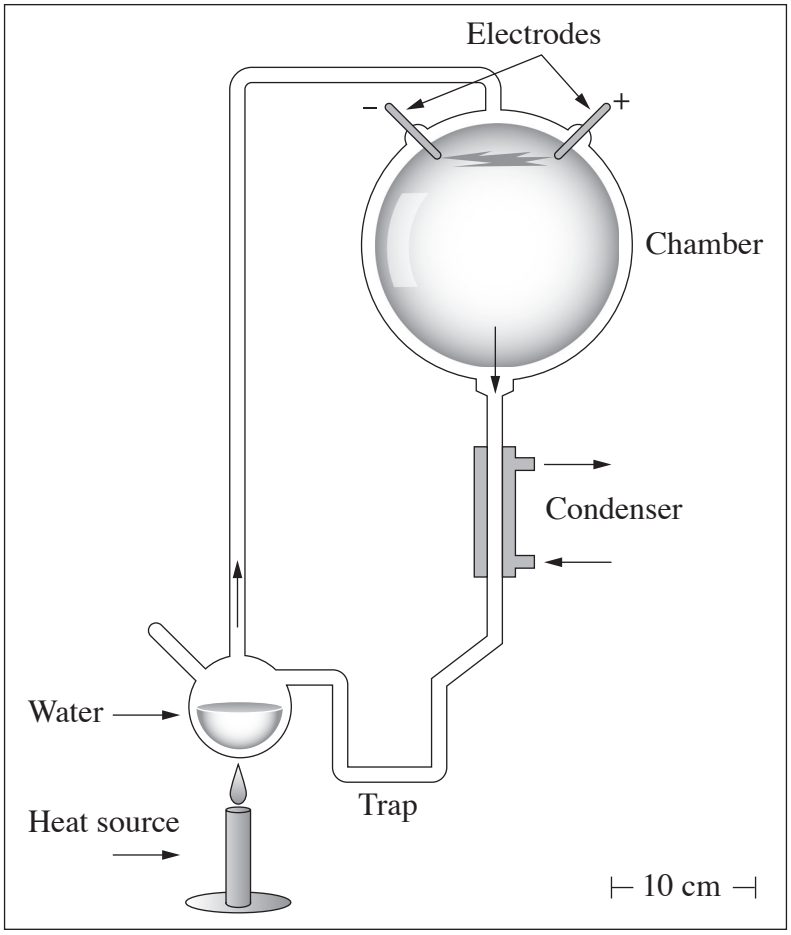
Question 29 (8 marks)

The diagram shows a model of the Urey–Miller experiment.



Courtesy of Ned Shaw

(a) Explain how the Urey–Miller experiment provides evidence for the origin of organic molecules in Earth's early environment. In your response, include reference to TWO of the labelled components shown in the diagram. **3**

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Question 29 continues on page 25

Question 29 (continued)

(b) For a scientific model to be useful, it should: **5**

- provide an explanation
- allow for predictions
- assist in solving problems.

Assess a model of the Plate Tectonic Supercycle (PTSC) using the given criteria.

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End of Question 29

Question 30 (5 marks)

A student investigated the effect of increasing levels of ocean acidity on the mass of oyster shells. Increased acidity is indicated by lower pH. The student used the following hypothesis:

Increasing ocean acidity levels lowers the mass of oyster shells.

The student was provided with the following equipment:

- 3 oyster shells
- 3 glass jars with airtight lids
- Seawater
- Hydrochloric acid dropper bottle
- Digital pH meter
- Digital scale.

(a) Identify the following variables in this experiment. **1**

Independent variable .....

Dependent variable .....

(b) The student obtained the following results. **2**

Complete the table by calculating the change in mass and percentage difference.

pH level	*Shell mass before* (g)	*Shell mass after* (g)	*Change in mass* (g)	*Percentage difference* (%)
8	32.1	32.5	+0.4	+1.2
6	25.0	23.9		
3	26.8	22.7		

(c) Justify a conclusion for this investigation. **2**

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Question 31 (7 marks)

Evaluate the involvement of traditional owners in the planning procedures for a mine, mining practices during operation, and restoration of damaged lands after mining operations cease. **7**

Your response should identify relevant criteria and refer to a case study and/or a specific example.

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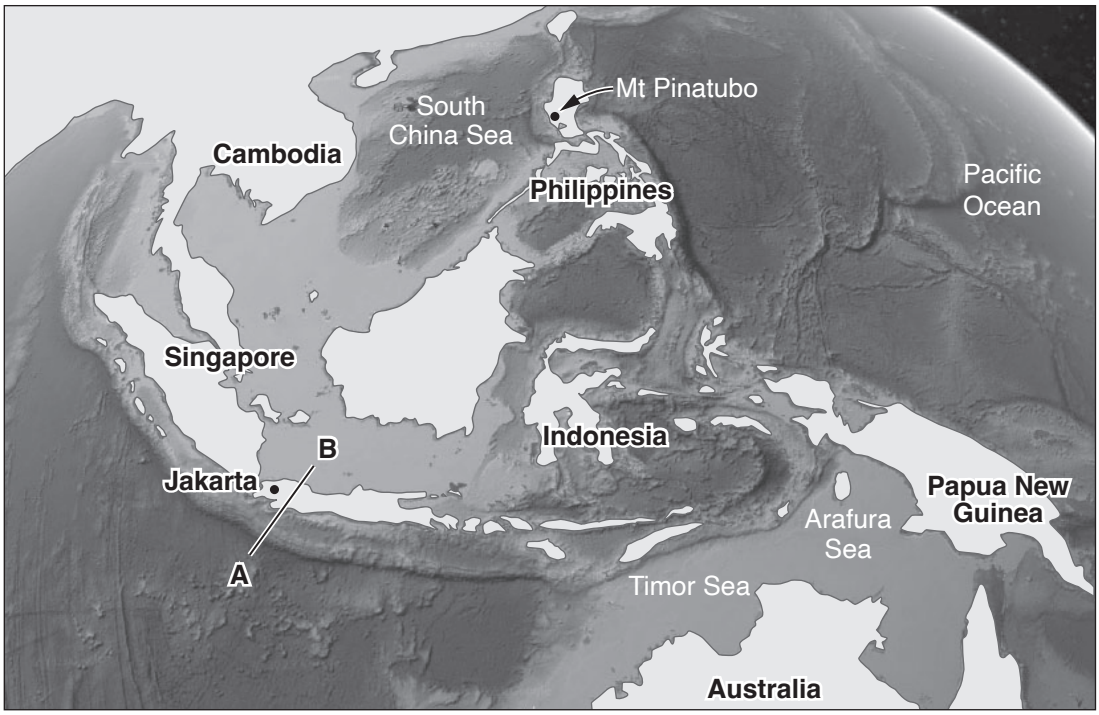
Question 32 (5 marks)

A satellite image of the region around Indonesia is shown. On 21 November 2022, an earthquake of magnitude 5.6 struck near Jakarta in the Indonesian volcanic island arc.



Open Source, with permission of the National Oceanic and Atmospheric Administration (NOAA)

(a) Draw a labelled cross-section of the plates along the line **A**–**B** showing key tectonic and topographical features. **3**

A **B**

Question 32 continues on page 29

Question 32 (continued)

(b) Describe a technology that could be used to understand a named characteristic of this earthquake. **2**

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End of Question 32

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Question 33 (10 marks)

On 15 June 1991, the second largest volcanic eruption of the twentieth century occurred at Mount Pinatubo, in the Philippines.

(a) Describe TWO hazards caused by this eruption. **3**

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(b) Assess the impact of this eruption on the natural environment surrounding the volcano. **3**

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(c) Account for the explosivity of this eruption. **4**

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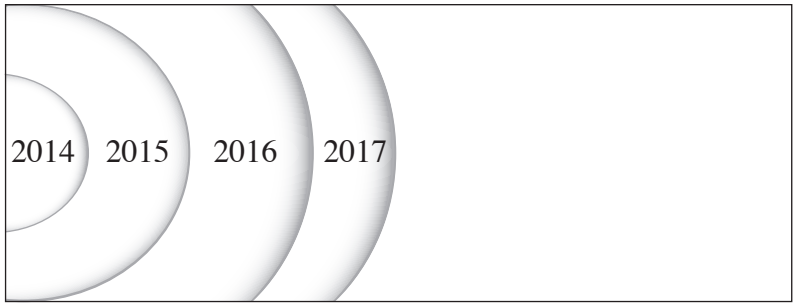
Question 34 (8 marks)

The annual rainfall for Isabella Plains, ACT, is provided in the following table.

Year	2014	2015	2016	2017	2018	2019	2020
Annual rainfall (mm)	683	721	863	629	403	350	902

(a) The following diagram outlines an incomplete cross-section of a tree trunk from the Isabella Plains area showing growth rings from 2014–2017. **2**

Using the rainfall data to predict the thickness of the rings, draw the next THREE growth rings for the tree.



Question 34 continues on page 33

Question 34 (continued)

(b) Discuss the use of dendrochronology AND changes in rock types as evidence for past variation in global temperatures. **6**

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End of Question 34

Question 35 (8 marks)

The Earth and Environmental Science course explores human activities and natural processes that explain the current state of Earth. **8**

Figure 1: A composite image of Earth during the day, showing the distribution of the continents, vegetation, water, deserts and ice.

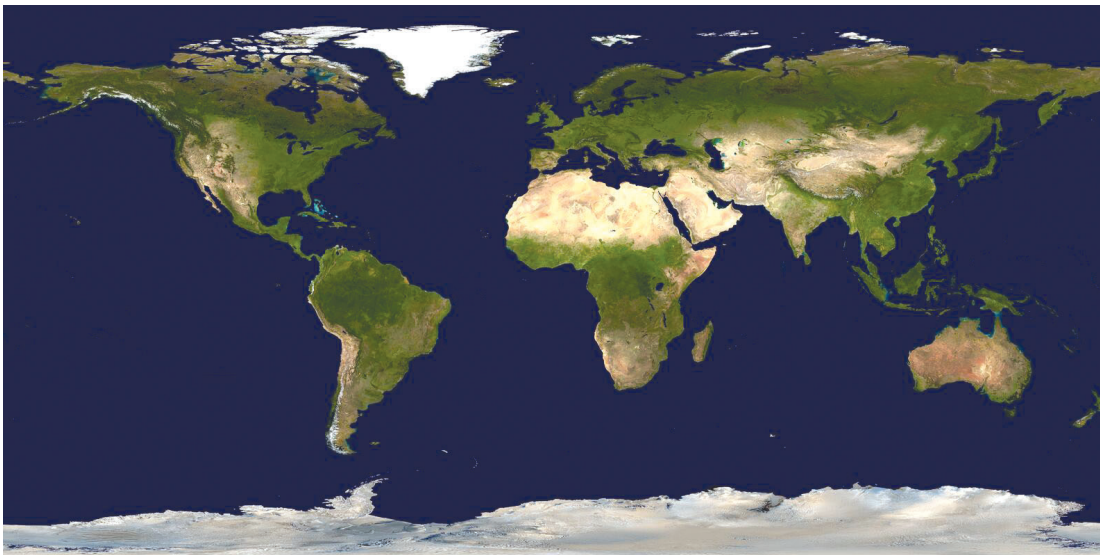
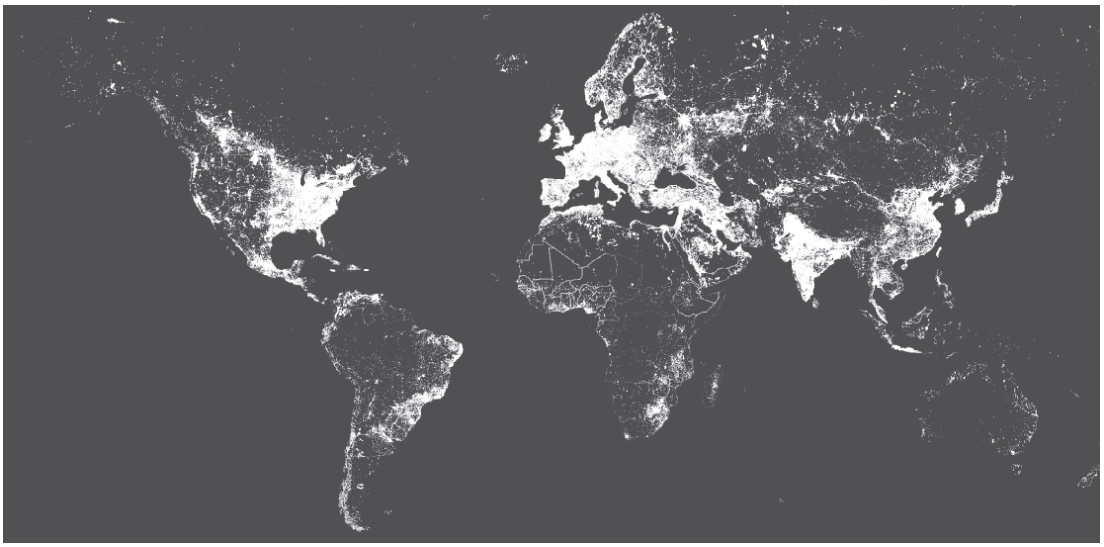


Figure 2: A modified composite image of Earth at night, which is lit by artificial light.



Question 35 continues on page 35

Question 35 (continued)

Analyse both images using your knowledge and understanding of natural processes and human influences.

Your response should refer to both images and to concepts from at least TWO of the following modules: Earth's Processes, Hazards, Climate Science, Resource Management.

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Question 35 continues on page 36

Question 35 (continued)

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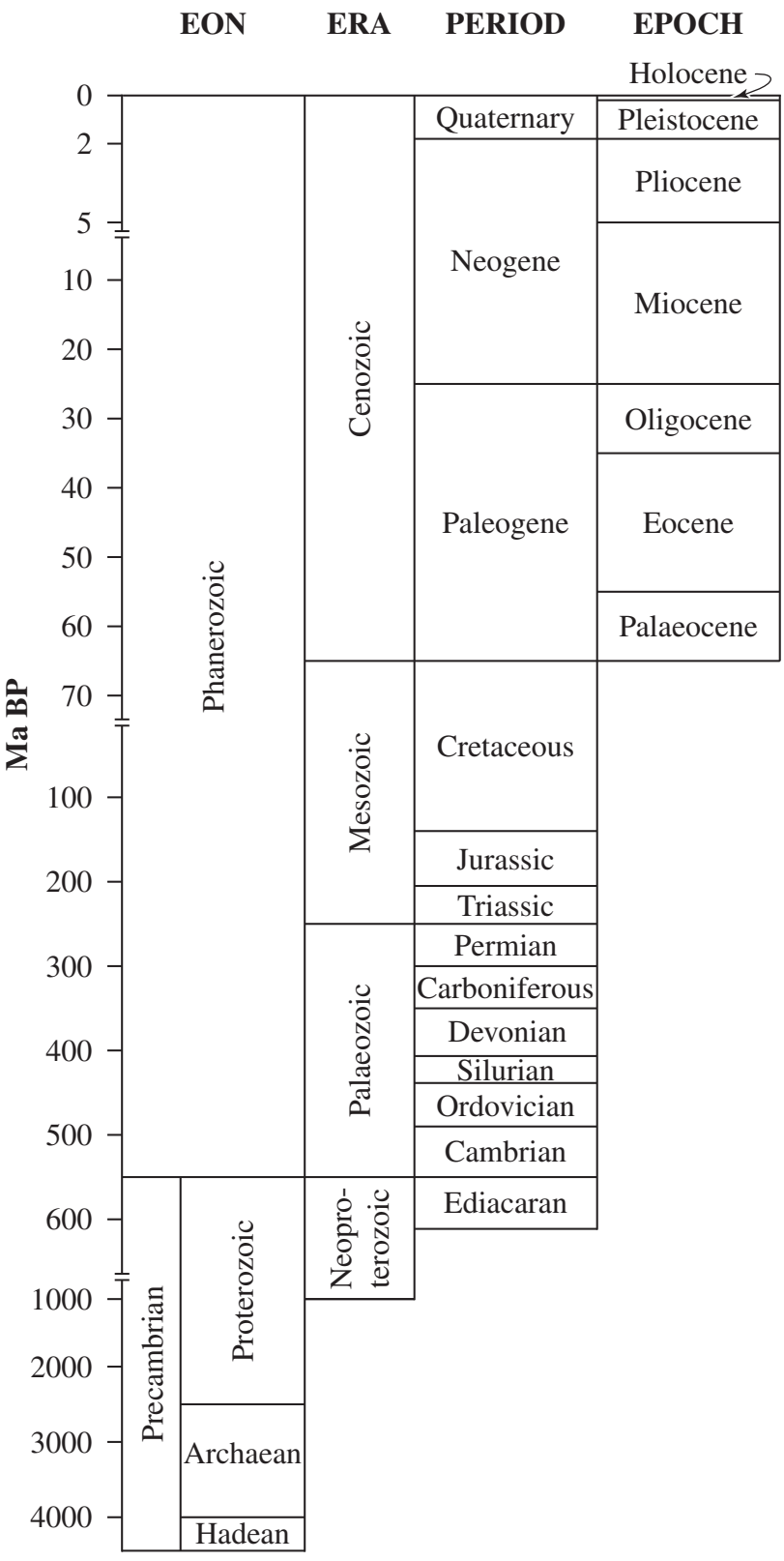
Earth and Environmental Science

Geological Time Scale



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