NSW Education Standards Authority

2022 **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

Total marks: 100

Section I – 20 marks (pages 2–10)

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

Section II – 80 marks (pages 13–36)

- Attempt Questions 21–34
- 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 The frozen water part of the Earth's system is the

A. atmosphere.

B. cryosphere.

C. geosphere.

D. hydrosphere.

2 Which of the following could be a flow-on effect of climate change?

A. An increase in volcanic activity

B. A change in species distribution

C. Irresponsible land clearing practices

D. An alteration in the position of continents

3 Which of the following is the most sustainable waste management option for aluminium cans?

A. Compost

B. Incineration

C. Landfill

D. Recycling

4 Ecosystem damage in NSW due to coastal erosion and flash flooding is caused by

A. east coast lows.

B. the greenhouse effect.

C. volcanic aerosol emissions.

D. an increase in the explosivity of volcanic eruptions.

5 Which of the following defines the term *geo-engineering*?

A. Small-scale manipulation of global climate systems to reduce harmful variations in the Earth's climate

B. Large-scale manipulation of global climate systems to reduce harmful variations in the Earth's climate

C. Small-scale manipulation of local climate systems to reduce harmful variations in the Earth's climate

D. Large-scale manipulation of local climate systems to reduce harmful variations in the Earth's climate

6 Which fossil type is the most significant in developing the Geological Time Scale?

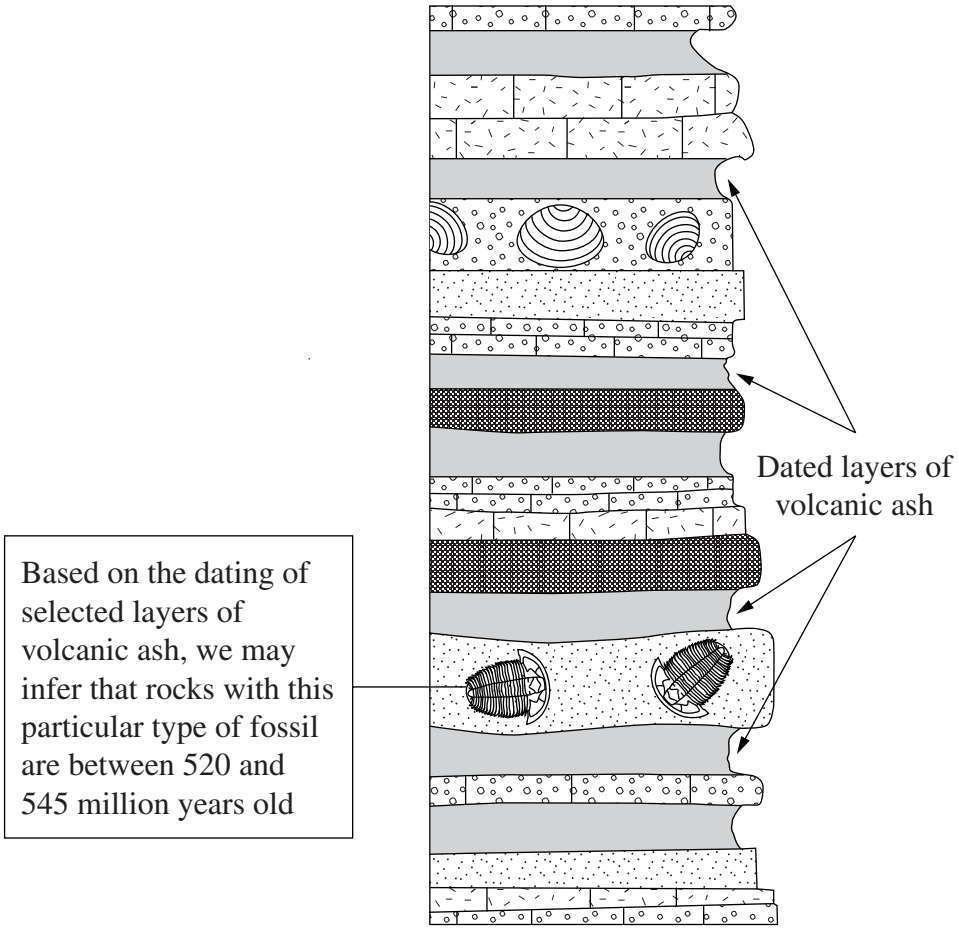
A. Index fossils

B. Trace fossils

C. Cast formations

D. Mould formations

7 Different techniques are combined to give us a more complete understanding of when rock strata were formed, as shown in the diagram.



Based on the diagram, which combination of techniques is the most effective at dating events of geological significance?

A. Absolute dating and relative dating

B. Superposition and uniformitarianism

C. Uniformitarianism and relative dating

D. Radiometric dating and absolute dating

8 The Pacific Plate subducts under Umnak Island near the edge of the North American Plate.

Which of the following identifies likely hazards on Umnak Island, based on its location?

A. Earthquakes, tsunami, typhoons

B. Earthquakes, tsunami, ash eruptions, lahars

C. Extreme weather events, bushfires, droughts

D. Effusive lava flows, earthquakes, poisonous gas emissions

9 Direct measurements of greenhouse gases present in the atmosphere 400 000 years ago can be obtained from

A. tree rings.

B. fossilised pollen grains.

C. gas bubbles trapped in ice cores.

D. oxygen isotopes in ocean sediments.

Use the following information to answer Questions 10 – 12.

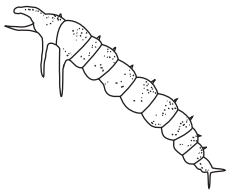
Aquatic macroinvertebrates are good biological indicators for water quality.

A group of students undertook a macroinvertebrate study over several weeks to investigate the water quality in the stream next to their school.

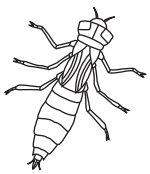
The students gathered data by randomly sampling macroinvertebrates which they classified using a key. These data were then multiplied by the sensitivity score shown below.

The higher the total weekly organisms score, the better the water quality. The study involved collecting data once a week for four weeks on the following species.

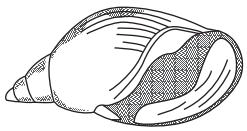
Caddisfly larva
Sensitive to pollution
Multiplier × 3



Dragonfly nymph
Moderately tolerant of pollution
Multiplier × 2



Pouch snail
Tolerant of pollution
Multiplier × 1



Organism	*Week*	*Count*	*Total score*	*Total weekly organisms score*
Caddisfly larva	1	1	3	34
Dragonfly nymph	1	10	20	
Pouch snail	1	11	11	
Caddisfly larva	2	2	6	37
Dragonfly nymph	2	12	24	
Pouch snail	2	7	7	
Caddisfly larva	3	0	0	
Dragonfly nymph	3	5	10	
Pouch snail	3	7	7	
Caddisfly larva	4	0	0	
Dragonfly nymph	4	9		
Pouch snail	4	9		

Complete the table to answer Questions 10 – 12.

10 During which week was water quality the best?

A. Week 1

B. Week 2

C. Week 3

D. Week 4

11 The accuracy of this data could be improved by

A. including a variety of microorganisms in the investigation.

B. extending the duration of the investigation by another four weeks.

C. repeating the experiment at three other streams, averaging the data and removing outliers.

D. reducing the chance of incorrect identification by cross-checking the classification of each organism with a qualified scientist.

12 The students were asked to graph water quality over time as part of their experimental report.

The best type of graph for this data is

A. a column graph because the data is continuous.

B. a pie chart because the data forms part of a whole count.

C. a line graph because the data is continuous and from the same location.

D. a line graph because the data can be grouped into discrete categories by location.

13 Which of the following has been most directly related to both the likely origin of organic molecules and the plate tectonic supercycle?

A. Black smokers

B. Panspermia

C. Stromatolites

D. Super-continents

14 Which of the following is evidence that climate change is being driven by anthropogenic causes?

A. Both CO_2 concentrations and global temperatures are increasing.

B. Changes in CO_2 concentrations and global temperatures are closely linked.

C. There is a cyclic variation in CO_2 concentrations and global temperatures over time.

D. There has been an anomalous increase in CO_2 concentrations and global temperatures in the past 200 years.

15 Which aspect(s) of earthquakes is best predicted using current technologies?

A. Timing

B. Location

C. Location and timing

D. Timing and intensity

16 The lease of a mining company extracting petroleum oil in the Carnarvon Basin off the coast of Western Australia expires in 2024. In line with current legislation, the company has planned the process of reclaiming the site.

Which row of the table correctly identifies the processes that should be undertaken as mining approaches completion?

	Stage 1	*Stage 2*	*Stage 3*	*Stage 4*
A.	Submit plans and risk assessments for approval	Decontaminate and contain wastewater	Backfill mining pit and contour land	Plant native vegetation in partnership with traditional landowners
B.	Request permission to cease mining	Remove the drill from the well	Trawl the ocean floor to clear debris	Treat and contain wastewater and tailings
C.	Submit plans and risk assessments for approval	Decontaminate and plug the oil well	Remove the platform and pipeline	Trawl the ocean floor to clear debris
D.	Request permission to cease mining	Remove the platform and pipeline	Create an artificial reef	Introduce new fish species to the reef

17 A dam was built on a river, 80 km upstream of a major city. The dam was built for the dual purpose of providing a safe and reliable water supply for the region and flood mitigation.

Which management strategy would be most effective in allowing the dam to serve its dual purpose?

A. Maintain its water levels as close to full as possible

B. Demolish the dam and replace it with a smaller dam further upstream

C. Release water from the dam as necessary to prevent its water levels from approaching full

D. Continuously release sufficient amounts of water from the dam to ensure environmental flows

18 Why is it important to develop strategies to adapt to rising global temperatures as well as strategies to mitigate their effects?

A. Adaptation strategies are easier to implement.

B. People are more willing to adopt adaptation strategies.

C. Adaptation strategies are more cost effective than mitigation strategies.

D. Mitigation strategies will take decades to affect rising global temperatures.

19 Climate variations which occur across tens of thousands of years are most likely driven by

A. changes in solar output.

B. massive volcanic eruptions.

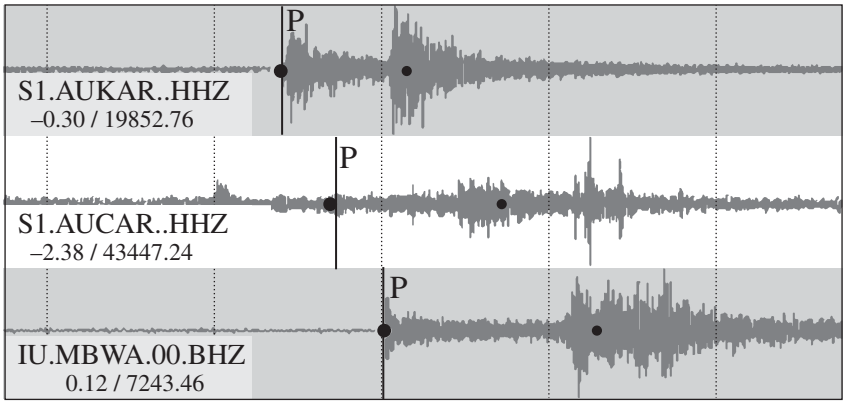
C. the plate tectonic supercycle.

D. variations in the Earth's orbit.

20 Earthquakes produce seismic waves which shake the lithosphere. Geoscience Australia has a network of seismometers which detect the shaking caused by seismic waves. Seismometer output is in the form of a seismogram, which is a graph with time on the horizontal axis and lithospheric shaking on the vertical axis.

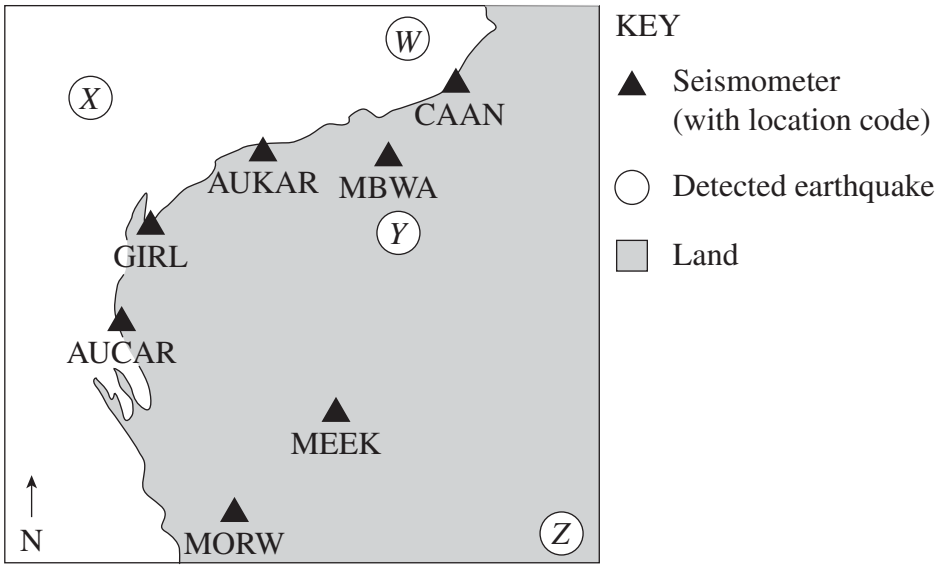
The distance between a seismometer and an earthquake can be determined by the arrival time of seismic waves: seismic waves reach nearby seismometers first and distant seismometers later.

Examine the seismograms below. Each seismogram has the same horizontal (time) axis.



Based on seismograms by Geoscience Australia

Scale map



Which earthquake is represented by the seismograms?

A. *W*

B. *X*

C. *Y*

D. *Z*

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2022 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Earth and Environmental Science

Section II Answer Booklet

80 marks
Attempt Questions 21–34
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 (3 marks)

Compare *eras* and *periods* in the Geological Time Scale. Your response should include TWO similarities or differences with reference to examples. **3**

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Question 22 (4 marks)

Blue carbon ecosystems such as saltmarshes, mangroves and seagrass forests can store 10 times more carbon in their soil than temperate forests, and 50 times more than rainforests. Most of the carbon in blue carbon ecosystems is stored in the soils rather than in the plants. **4**

Assess the role of blue carbon ecosystems in reducing the rate of global warming.

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Please turn over

Question 23 (4 marks)

Discuss the sustainability of ONE named waste management option. **4**

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Question 24 (5 marks)

Mt Vesuvius is a volcano that erupted in 79 CE, destroying the towns of Pompeii and Herculaneum. The modern city of Naples is near Mt Vesuvius. Technology is now used to monitor the volcano, as shown.

(a) Name a type of monitoring technology shown in the image. **1**

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(b) Explain how technology can be used to prevent a volcanic hazard from causing a disaster. **4**

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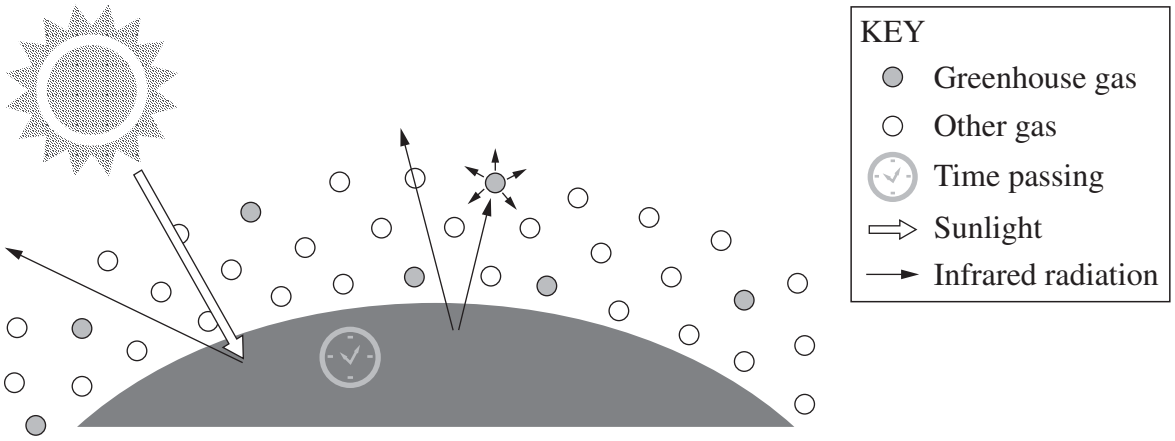
Question 25 (6 marks)

The simplified model shows the basic components of the greenhouse effect.



(a) Use this model to explain the natural greenhouse effect. **3**

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(b) Redraw the model in the space below to show the enhanced greenhouse effect caused by human activities. **3**

Question 26 (4 marks)

Draw and annotate a flow chart to demonstrate the effect of the plate tectonic supercycle on climate OR evolution. **4**

Question 27 (6 marks)

The following source contains information from an item published in ABC News online on 22 September 2021.

Mansfield magnitude-5.9 earthquake shakes Melbourne, regional Victoria, southern NSW, Sydney, Canberra, Adelaide and Launceston

Geoscience Australia said the first earthquake was detected in the Alpine National Park south-east of Mansfield and north of Rawson around 9:15 am and was 10 kilometres deep.

The quake is one of the largest earthquakes in eastern Australia since European settlement.

Part of a Chapel Street building crumbled during the earthquake.

* This image is not the same image as used in the examination due to copyright reasons.
Reproduced by permission from the Australian Associated Press.

There were 100 requests for assistance, around 55 of them in metropolitan Melbourne, and most of the minor structural damage was to chimneys and facades.

A spokesperson said it was fortunate the epicentre was in a less populated regional area. 'If that had occurred in one of the more urban and populated areas, we could be seeing quite a different result.'

Question 27 continues on page 21

Question 27 (continued)

(a) Explain why high magnitude earthquakes such as the 2021 Mansfield earthquake are rare on mainland Australia. **2**

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(b) Assess the effects of earthquakes such as the 2021 Mansfield earthquake on both the biosphere and the built environment. **4**

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End of Question 27

Question 28 (7 marks)

An ecological footprint is the impact a person has on the environment, expressed as the amount of land required to sustain their use of natural resources.

Cassie partially completed the Personal Ecological Footprint Calculator below.

(a) Complete the table. **3**

- Calculate the subtotals by adding scores
- Calculate total score by adding subtotals
- Then calculate Cassie's ecological footprint in square metres

Personal Ecological Footprint Calculator

Water use	*Score*	*Energy*	*Score*
My shower on a typical day is: ☐ 1–3 minutes long (50) ☐ 4–9 minutes long (70) ☑ more than 10 minutes OR bath (90)	90	To attend school, I travel by: ☐ car (200) ☑ public transport (40) ☐ bike or walking etc (5)	
I flush the toilet: ☑ using the full flush (40) ☐ using the half flush (20)	40	I turn off the laptop/computer when not in use: ☐ yes (100) ☑ no (200)	
When I brush my teeth, I: ☐ let the water run (40) ☑ turn the tap off (10)	10	In summer I often use a/an: ☐ fan (20) ☑ air conditioner (200)	
When washing the dishes, I: ☐ hand wash (50) ☑ use a dishwasher (30)	30	Our home has solar panels: ☐ yes (subtract 100) ☑ no (50)	
SUBTOTAL	170	SUBTOTAL	
Food	*Score*	*Waste*	*Score*
My diet contains: ☑ meat or fish (150) ☐ vegetarian (80)		All of my weekly garbage could fit into a: ☑ snap lock bag (20) ☐ shopping bag (60) ☐ large garbage bag (200)	
I compost my food scraps: ☐ yes (subtract 20) ☑ sometimes (20) ☐ never (60)		I recycle all of my paper, cans and glass: ☑ yes (subtract 20) ☐ sometimes (50) ☐ never (100)	
On a typical day I throw out: ☐ a small portion of my food (100) ☑ about half of my food (200)		I avoid disposable/single use items: ☑ yes (subtract 20) ☐ most of the time (50) ☐ never (100)	
SUBTOTAL		SUBTOTAL	
TOTAL SCORE			

Ecological Footprint Calculation

Total score × 100 = ... m^2

Question 28 continues on page 23

Question 28 (continued)

(b) Justify a strategy for reducing Cassie's ecological footprint in terms of improving her management of at least one of Earth's resources. **4**

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End of Question 28

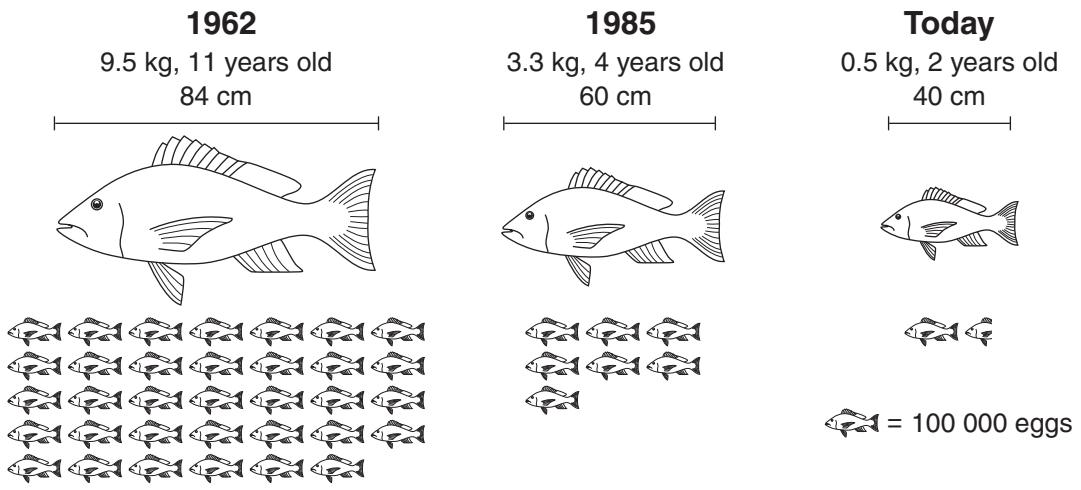
Please turn over

Question 29 (5 marks)

This diagram shows data on the reproduction rate of red snapper since 1962.

TIME TO REPRODUCE

Although red snapper can live up to 54 years, today too few are older than 10 years. Older fish are the best breeders. Since the 1960s, the average weight, age, size and reproductive capacity of snapper have diminished.



Kind permission granted by Pew Charitable Trust

(a) Recommend ONE improvement to the representation of data in this diagram. **2**

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Question 29 continues on page 25

Question 29 (continued)

(b) Account for the trends in this data. **3**

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End of Question 29

Please turn over

Question 30 (6 marks)

The graphs show variations in global temperature since 1440 CE, measured using a variety of techniques, and oxygen isotopic records from Namibia in south-west Africa since 1690 CE.

This material cannot be displayed due to copyright issues.

https://researchfeatures.com/stalagmite-reveals-climate-changes-clues-in-northeast-namibia-africa/

Question 30 continues on page 27

Question 30 (continued)

(a) Describe the trends observed in the temperature anomaly and the relative change in ^{18}O. **3**

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(b) Propose an explanation for the apparent lack of consistency between the temperature and isotopic data presented. **3**

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End of Question 30

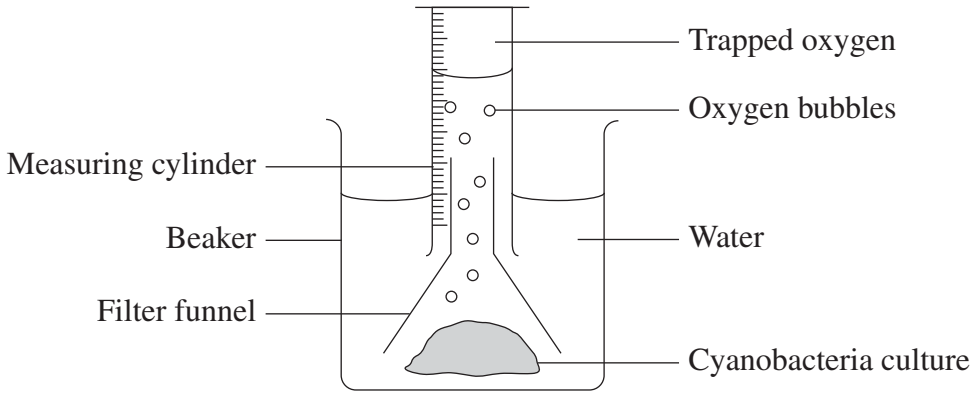
Question 31 (7 marks)

A student wanted to investigate the effect of photosynthesising cyanobacteria on the oxygenation of the atmosphere. The student developed the following hypothesis:

> *Increasing light levels enables photosynthesising cyanobacteria to produce greater quantities of oxygen.*

The student was provided with the following equipment:

- 10 g living cyanobacteria culture (can be separated)
- 10 light-proof cupboards
- 10 lamps with variable brightness
- 10 remote sensing light meters
- 10 sets of glassware and water as shown in the following diagram
- spatula
- laboratory balance/scales
- water.



Question 31 continues on page 29

Question 31 (continued)

Design a valid procedure to test the student's hypothesis. **7**

Your response should include a method for changing the independent variable, measurement of independent and dependent variables, management of controlled variables, use of a control and appropriate safe work practices.

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End of Question 31

Question 32 (9 marks)

The photos show some aspects of bushfires in Australia.

Bushfire in Australia

Extent of bushfire smoke over south-east Australia and the Tasman Sea

(a) Outline how land management practices in Australia could affect the magnitude of bushfires. **2**

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Question 32 continues on page 31

Question 32 (continued)

(b) Explain how a change in the biosphere can affect the Earth's atmosphere and climate. Refer to the images provided. **4**

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(c) Predict the effect a change in the biosphere can have on the sustainability of resources. **3**

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End of Question 32

Question 33 (7 marks)

Atmospheric low pressure systems can cause severe weather and flood hazards.

The following table shows Mean Sea Level Pressure (MSLP) recorded daily from 16–27 March 2021 at Shellharbour Airport on the NSW coast.

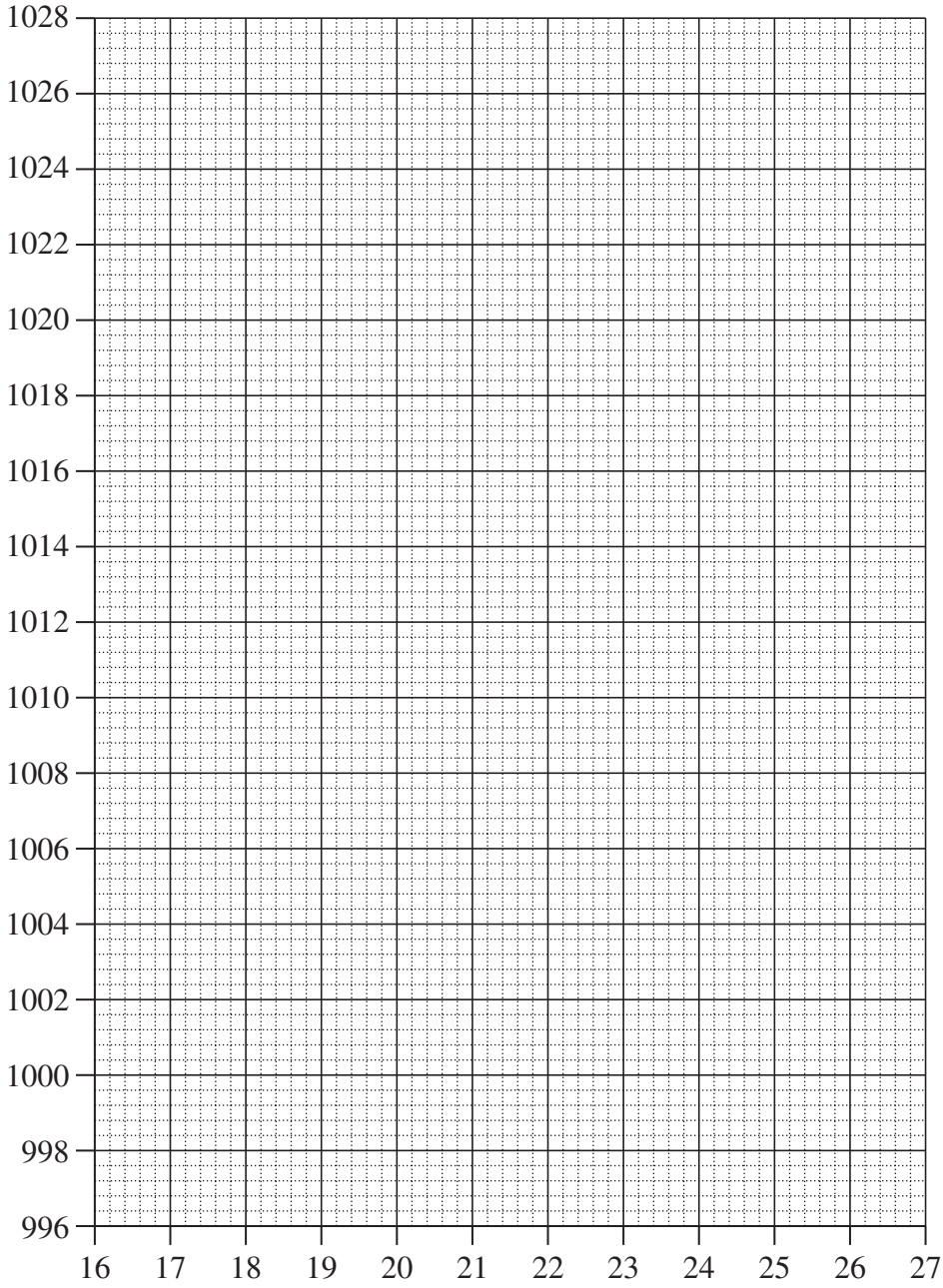
Date (March 2021)	*MSLP* (hPa)
16	1026.5
17	1026.6
18	1025.4
19	1027.2
20	1024.5
21	1025.7
22	1023.8
23	1009.5
24	997.4
25	1002.5
26	1014.0
27	1013.7

Question 33 continues on page 33

Question 33 (continued)

(a) Graph the data on the following grid. Label both axes, plot the data and provide a trend line. **3**

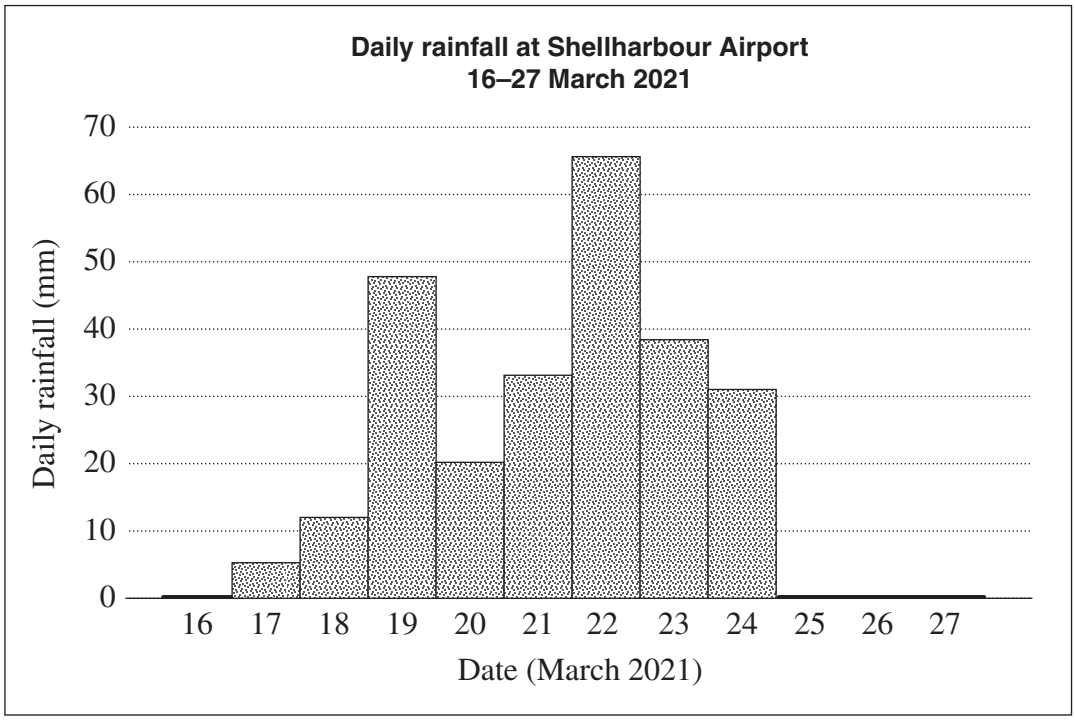
Shellharbour Airport – MSLP 16–27 March 2021



Question 33 continues on page 34

Question 33 (continued)

(b) The following chart shows rainfall recorded at Shellharbour Airport during the same time period. **4**



Assess the effectiveness of meteorological technology in predicting natural weather events. In your response, make reference to the pressure and rainfall data provided.

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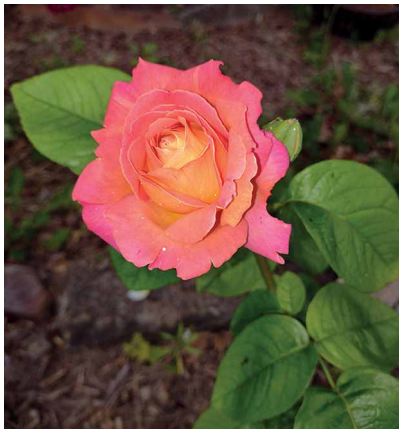
End of Question 33

Question 34 (7 marks)

Stromatolites



Modern plants

Modern animals

Analyse how the current biosphere originated and developed. In your answer, use specific examples such as those in the images provided. **7**

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End of paper

Section II extra writing space

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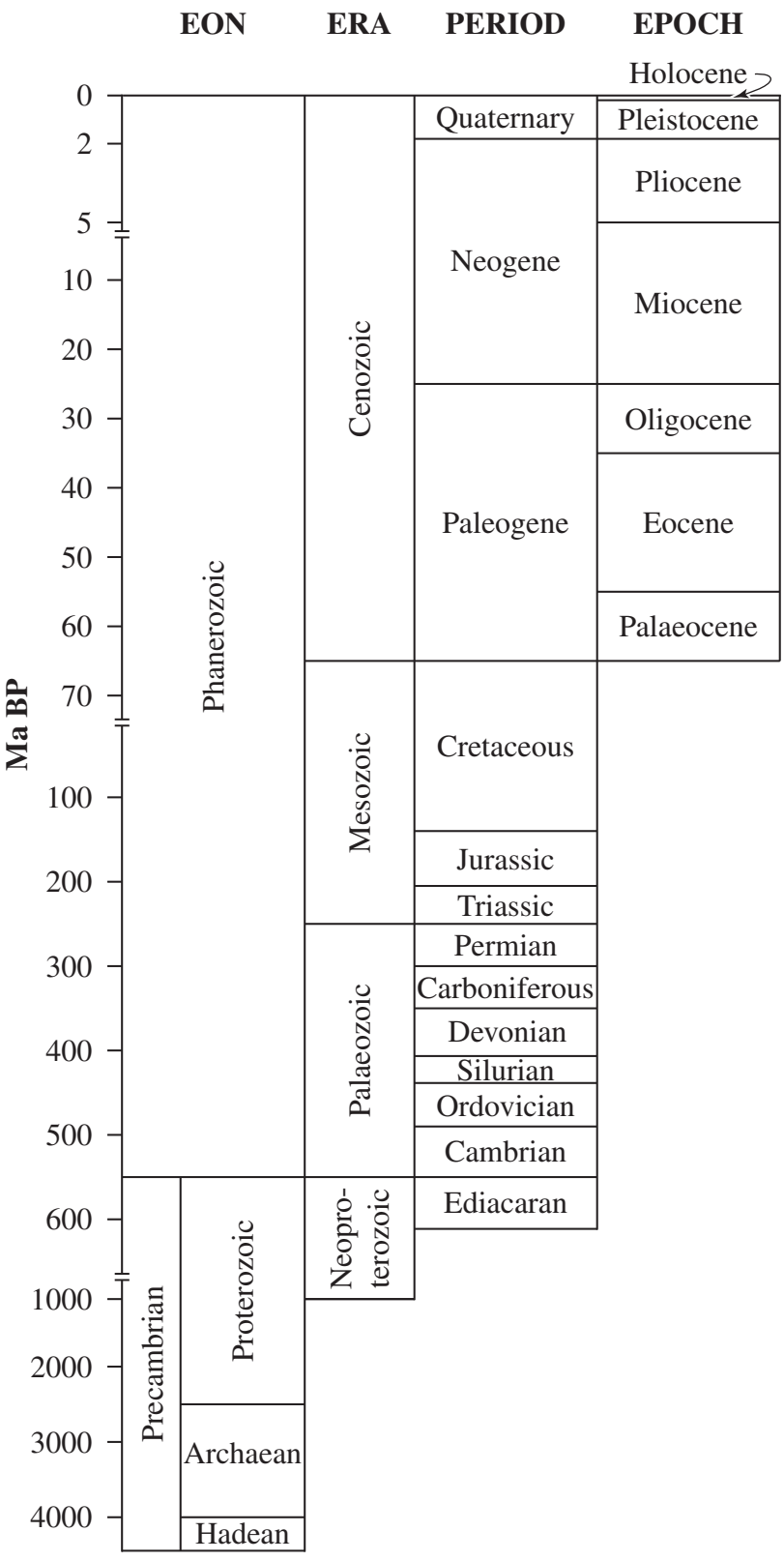
Earth and Environmental Science

Geological Time Scale



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