



## ATAR course examination, 2023

### Question/Answer booklet

# EARTH AND ENVIRONMENTAL SCIENCE

Please place your student identification label in this box

WA student number: In figures

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In words

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### Time allowed for this paper

Reading time before commencing work: ten minutes

Working time: three hours

### Materials required/recommended for this paper

#### *To be provided by the supervisor*

This Question/Answer booklet

Multiple-choice answer sheet

Number of additional  
answer booklets used  
(if applicable):

#### *To be provided by the candidate*

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: protractor, drawing compass, mathomat, up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

### Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

## Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	15	15	20	15	15
Section Two Short answer	9	9	100	110	55
Section Three Extended answer	3	2	60	30	30
<b>Total</b>					100

## Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2023: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

3. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.
4. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.
5. The tear-out page is not to be handed in with your Question/Answer booklet.

**Section One: Multiple-choice****15% (15 Marks)**

This section has **15** questions. Answer **all** questions on the separate Multiple-choice answer sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

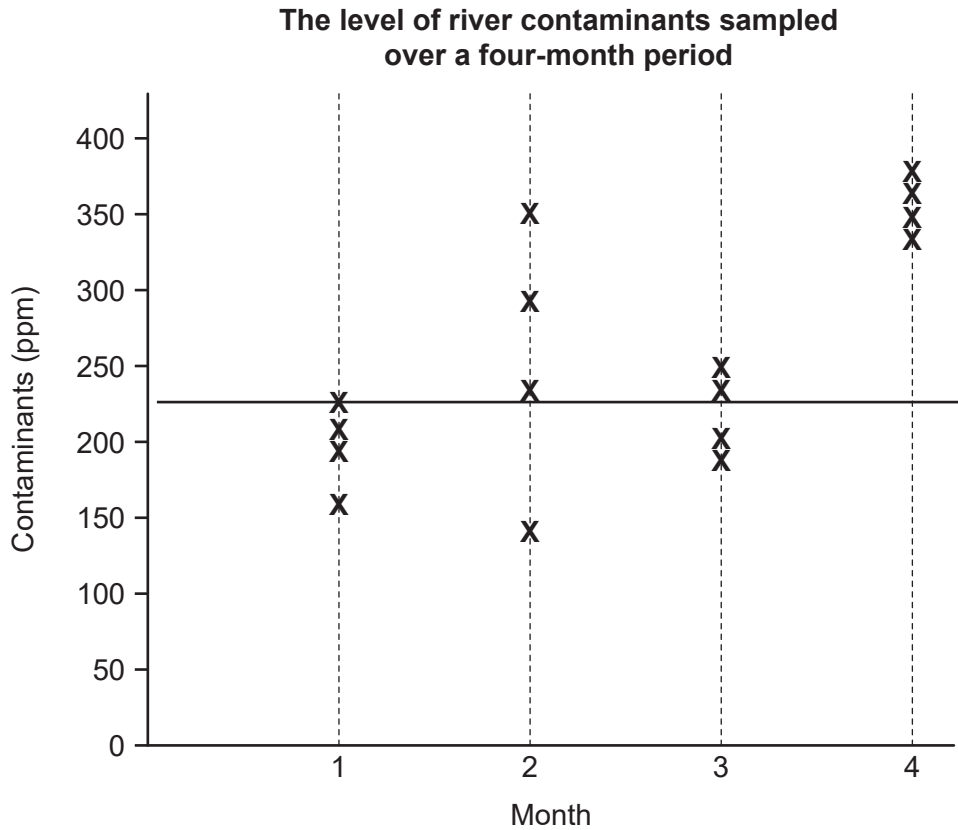
Suggested working time: 20 minutes.

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1. Ice cores extracted from ice sheets that have covered extensive land areas over a long period of time can provide a record of changing global climate through analysis of
  - (a) their thickness.
  - (b) the amount of nitrogen trapped therein.
  - (c) fossil microorganisms.
  - (d) the isotopic ratio of oxygen.
  
2. Which of the following **best** describes the plate tectonic super cycle? The
  - (a) uplift and erosion of mountain ranges.
  - (b) repeated formation and break up of continental landmasses.
  - (c) rise of mantle plumes driving major volcanic cycles.
  - (d) recycling of oceanic lithosphere at subduction zones.
  
3. Natural processes that increase methane ( $\text{CH}_4$ ) in the atmosphere include
  - (a) the anaerobic decomposition of vegetation in wetlands.
  - (b) waste disposal in landfill.
  - (c) fugitive gas released during oil and gas drilling.
  - (d) the widespread farming of rice.

Questions 4 and 5 relate to the information and graph below.

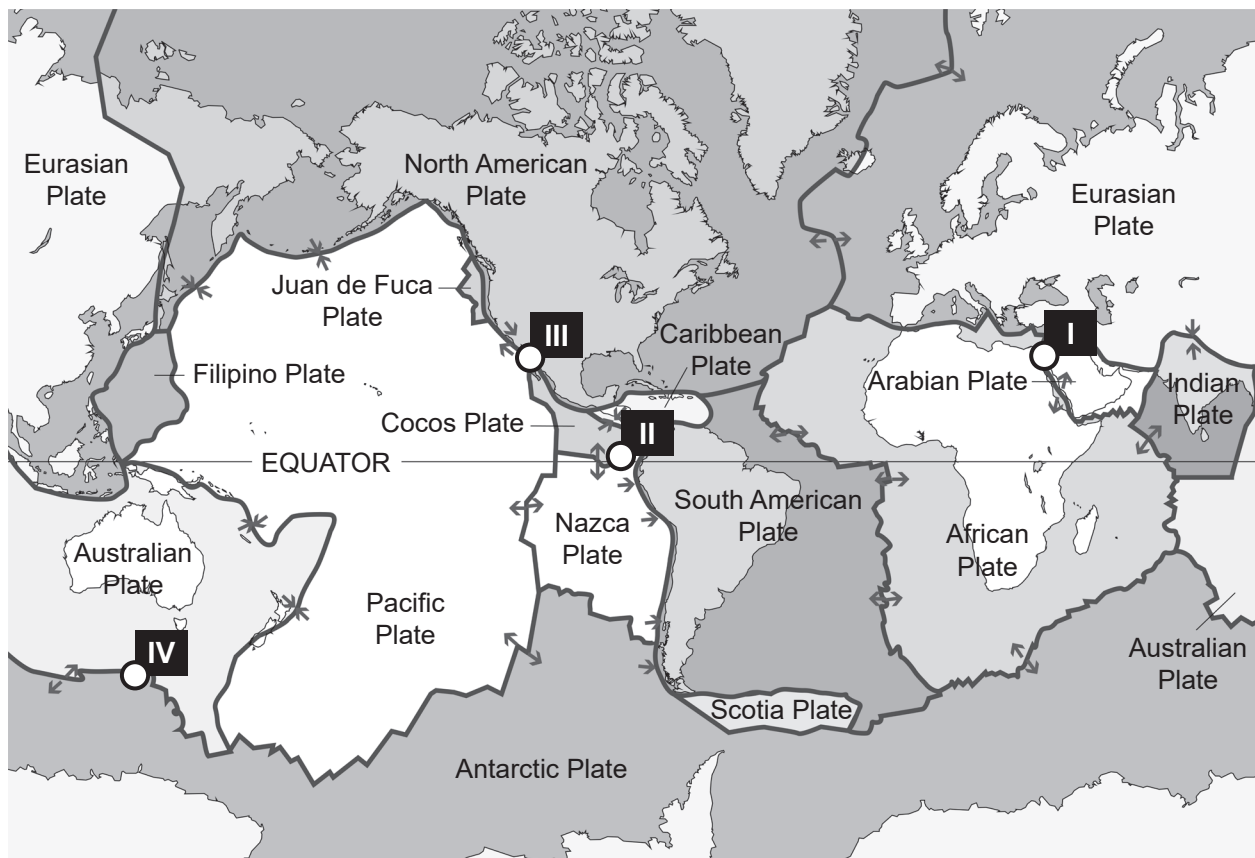
An environmental scientist collected water samples over a period of four months at one location to test for contaminants in the water. To account for inconsistencies in the analytical method, each sample was analysed four times. Historical records indicate the natural background level of contaminants at the site is 225 parts per million (ppm).



4. On the basis of the above data, during which month were analyses the most reliable?
- (a) 1
  - (b) 2
  - (c) 3
  - (d) 4
5. On the basis of the range of measurements in each sample period, which of the following statements is **best** supported by the data?
- (a) Contaminant levels remained consistent with historical background levels throughout the survey period.
  - (b) A chemical spill occurred between survey months 3 and 4.
  - (c) Contaminant levels may have increased each month during the survey.
  - (d) Contaminant levels were lowest during month 2.

6. Geosequestration of carbon involves
- (a) injecting carbon dioxide into sub-surface rock layers.
  - (b) depositing carbon dioxide into the ocean.
  - (c) restricting the accumulation of carbon dioxide in the biosphere.
  - (d) reducing carbon dioxide emissions by using renewables.
7. Upgrading banded iron formation into an economic iron ore deposit involves
- (a) prolonged anoxic burial.
  - (b) weathering in the near-surface environment.
  - (c) cyclical deposition of sedimentary layers.
  - (d) melting and gravitational settling.
8. Which of the following is **not** a recognised contribution to long-term climate change?
- (a) emissions of carbon dioxide from volcanoes
  - (b) variations in the Earth's orbit
  - (c) changes in the energy output from the sun
  - (d) level of carbon monoxide in the atmosphere

Use the map below to answer Questions 9 and 10.



9. Which of the following **best** describes the expected consequences of the tectonic processes occurring at 'I'?
- uplift of high mountains and frequent large earthquakes
  - shallow extensional earthquakes and intrusion of basalt dykes
  - large strike-slip earthquakes
  - subduction of oceanic lithosphere
10. Which of the labelled locations represents a transform boundary?
- I
  - II
  - III
  - IV
11. Which of the following **best** describes a valid experiment to measure the impact of sea surface temperature on sea ice melt?
- Measure seasonal temperature fluctuations for the area of interest.
  - Heat an area of sea ice to determine the temperature at which it begins to melt.
  - Measure the sea surface temperature and the area covered by sea ice each day.
  - Measure the amount of ice melt from the area of interest every hour.

12. Which of the following is **not** a possible benefit of managed aquifer recharge as a form of water management?
- (a) reduced evaporative water losses
  - (b) reduced risk of saltwater intrusion to the aquifer
  - (c) reduced water demand during summer
  - (d) preservation of cave ecosystems located within the aquifer
13. The term 'ecological footprint' can **best** be described as the
- (a) impact and sustainability of human activity on the environment.
  - (b) level of environmental degradation caused by human activity.
  - (c) area surrounding a site of human activity in which ecology is measurably disturbed.
  - (d) amount of biologically-productive land within an ecosystem.
14. Which of the following volcanic phenomena represents the greatest hazard?
- (a) pyroclastic flow
  - (b) basaltic lava flow
  - (c) rhyolite dome
  - (d) ash fall
15. The substantial nickel sulfide deposits found in Western Australia were predominantly formed by
- (a) weathering and supergene enrichment.
  - (b) immiscible liquid separation and gravitational settling.
  - (c) hydrothermal alteration.
  - (d) chemical reduction and precipitation.

**End of Section One**

**See next page**

**Section Two: Short answer**

**55% (110 Marks)**

This section has **nine** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 100 minutes.

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**Question 16**

**(13 marks)**

Metamorphic rocks are often identified on the basis of textural characteristics such as the presence or type of foliation that a rock displays.

- (a) Identify **two** geological factors that influence the texture or mineralogy of a metamorphic rock. (2 marks)

One: \_\_\_\_\_  
\_\_\_\_\_

Two: \_\_\_\_\_  
\_\_\_\_\_

- (b) Complete the following table by identifying the metamorphic rock or protolith as appropriate. (3 marks)

<b>Metamorphic rock</b>	<b>Protolith</b>
Quartzite	
	Limestone
Amphibolite	

- (c) Outline **two** ways in which different metamorphic rock characteristics can be used to distinguish between slaty cleavage and schistosity. (4 marks)

One: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Two: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



- (d) With the aid of annotated diagrams, identify the key features of gneissic banding and describe how it forms. (4 marks)

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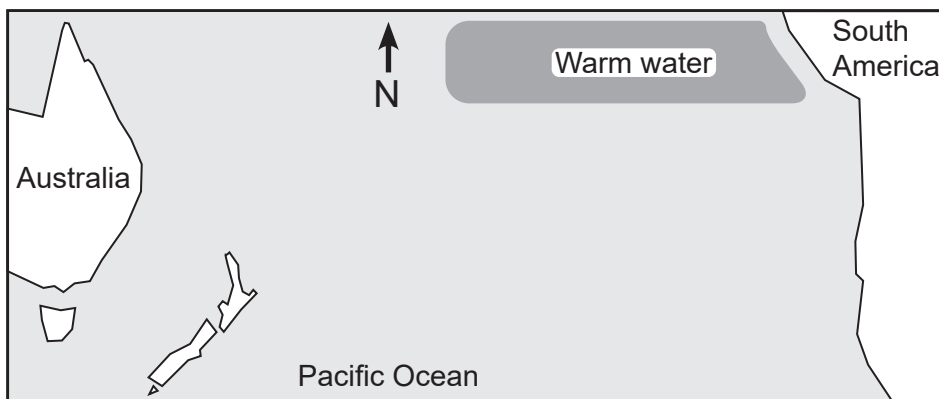
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**Question 17**

**(11 marks)**

The El Niño-Southern Oscillation (ENSO) is a periodic cycle of variations in weather conditions resulting from interactions between oceanic and atmospheric circulation across the Pacific. ENSO conditions have the potential to significantly impact communities surrounding the Pacific Ocean.



(a) Answer the following questions relating to the diagram above.

(i) Identify the ENSO state shown in the diagram as Neutral, El Niño or La Niña. (1 mark)

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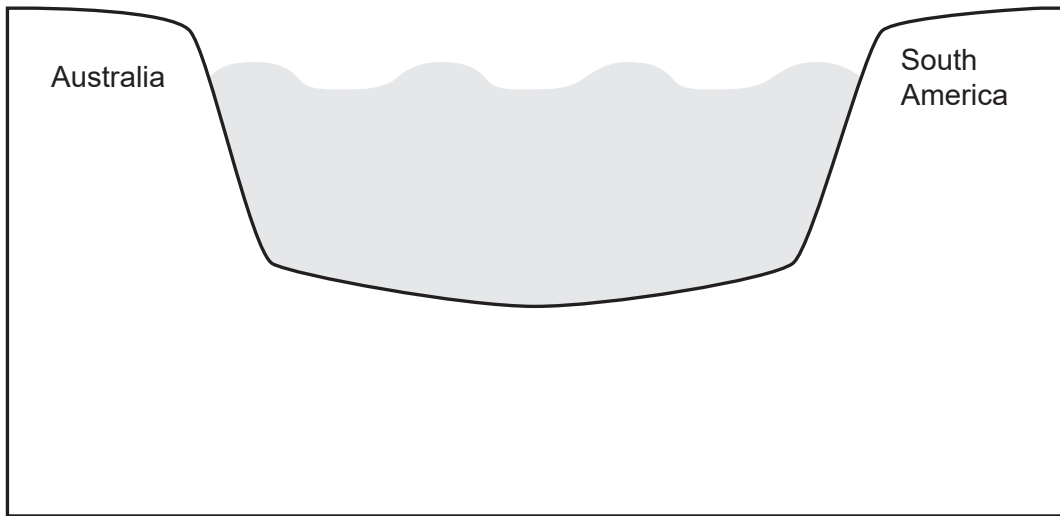
(ii) On the diagram above, clearly illustrate the predominant direction of Equatorial air flow that would be expected to accompany these conditions. (1 mark)

(iii) Name the weather feature whose relative strength or weakness generally instigates the change between El Niño and La Niña conditions. (1 mark)

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- (b) Complete the sketch of a cross-section below and label to show the surface ocean current, thermocline and location of warm and cool water expected under the ENSO conditions shown in the diagram on page 10. (4 marks)



- (c) Outline how ENSO conditions produce **two** weather patterns typically associated with a La Niña event in Eastern Australia. (4 marks)

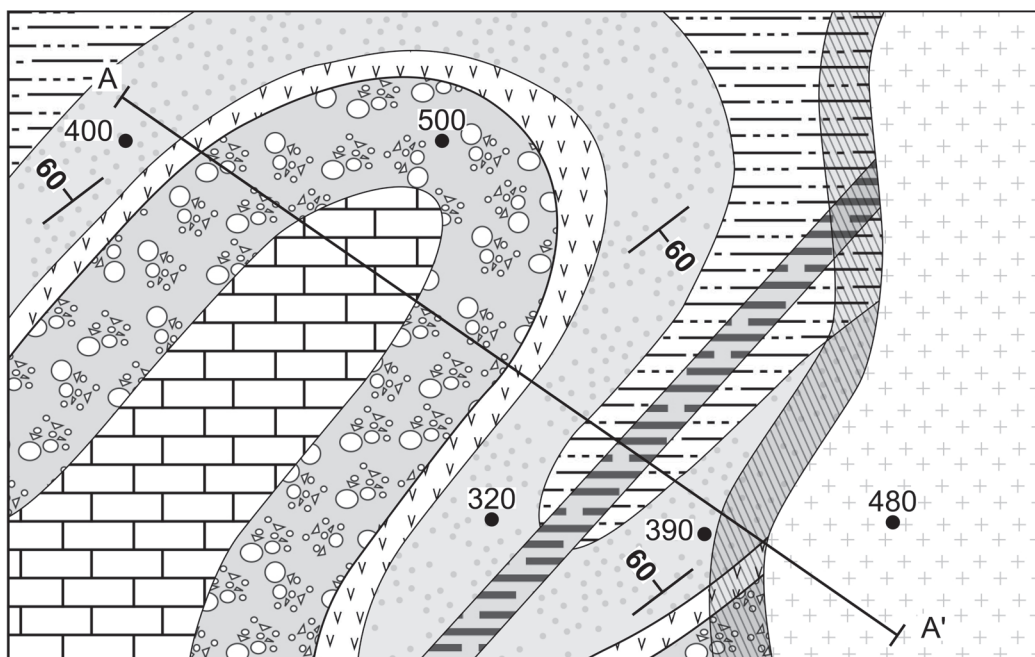
One: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Two: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Question 18

(12 marks)

Use the map below to answer the following questions.



Basalt



Alteration Zone



Conglomerate



60 Strike and dip symbol



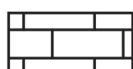
Dolerite

● 400 Spot height



Granite

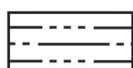
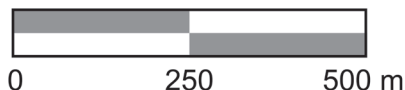
A A' Section line



Limestone



Sandstone

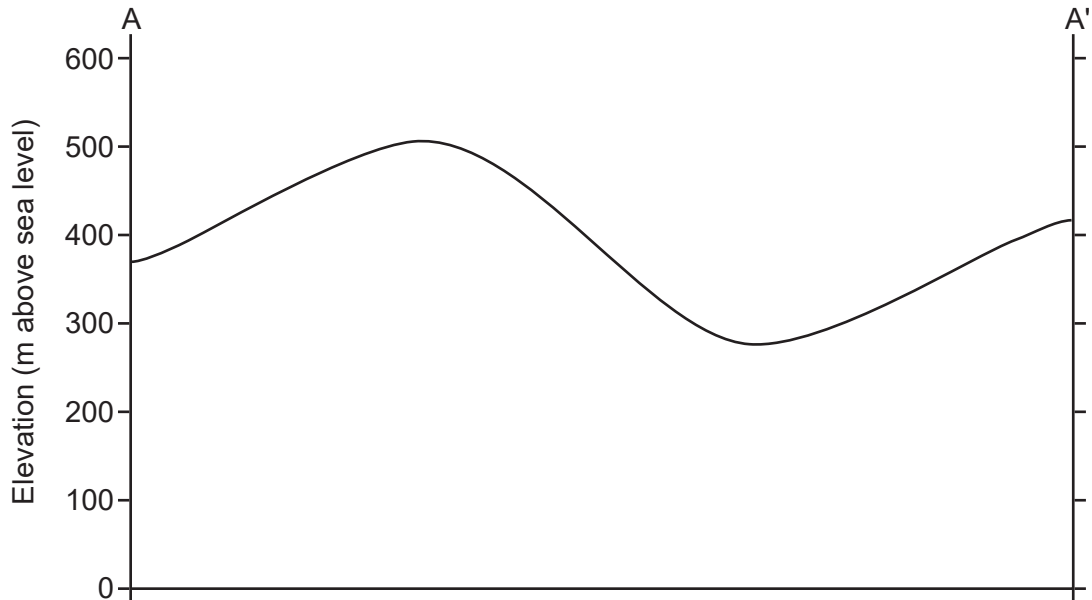


Siltstone

- (a) Draw a set of arrows on the map to represent the direction of stress that caused the folding shown on the map. (1 mark)

- (b) Produce a cross-section along the line A–A' on the section line provided below. (5 marks)

Note: to assist you in transcribing strata locations you may remove page 45 by tearing along the perforations.



A spare cross-section is provided at the end of this Question/Answer booklet. If you need to use it, cross out this attempt and indicate that you have redrawn it on the spare cross-section line.

- (c) Name the oldest rock unit in this cross-section. (1 mark)

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- (d) Field notes recorded by a geologist exploring this region state that fossils of freshwater fish have been found in the sandstone and basalt units. Outline why this statement is incorrect. (2 marks)

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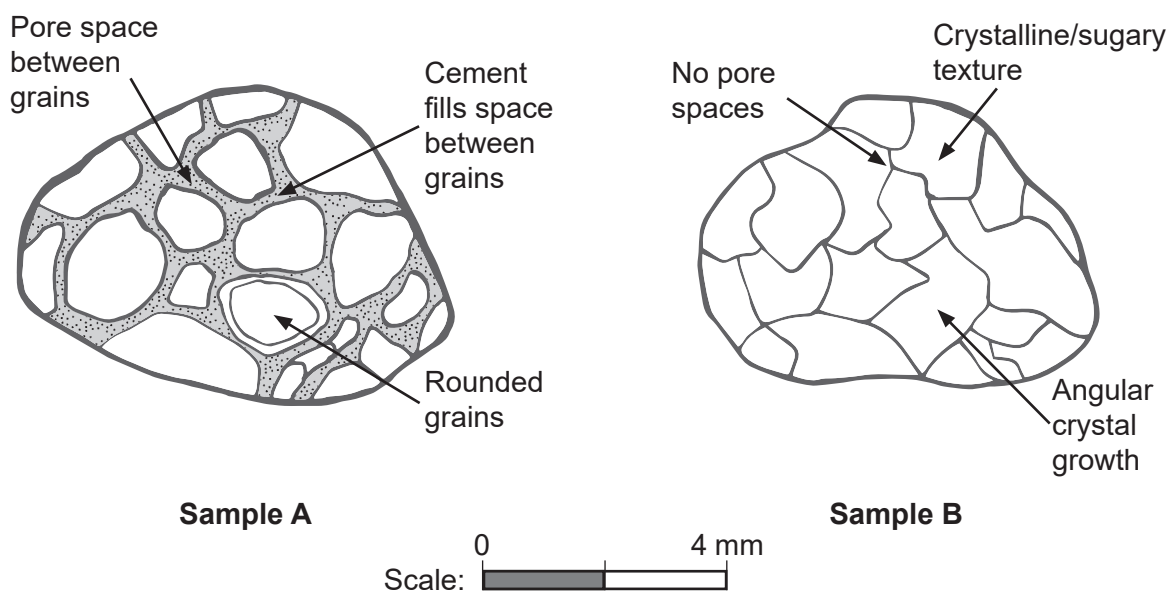
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**Question 18** (continued)

(e) Two annotated field sketches of rock samples from the mapped area are shown below.



(i) Identify which of these samples was more likely taken from the alteration zone shown on the map on page 12. (1 mark)

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(ii) Justify your choice in part (e)(i). (2 marks)

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## Question 19

(11 marks)

Geckos are small lizards that commonly eat insects such as flies, mosquitoes, crickets and cockroaches. Many species of gecko are endemic to Western Australia (WA) (i.e. found nowhere else in the world).

As shown in the table below, the population of one endemic gecko species living in the area around an operating WA mine site has decreased over the past decade. This decrease has led to the species being listed as endangered.

**Table 1: Surveyed numbers of an endemic gecko species at three locations around an operating WA mine site, 2012–2022**

Year	Gecko Population		
	Location 1	Location 2	Location 3
2012	280	340	245
2013	270	300	250
2014	276	280	240
2015	245	285	195
2016	200	270	180
2017	220	240	175
2018	180	230	170
2019	170	200	150
2020	155	145	75
2021	90	135	70
2022	95	145	55

- (a) Identify the location that experienced the greatest decrease in gecko numbers over the period studied. (1 mark)

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- (b) Calculate the percentage decrease (to the nearest whole number) in gecko numbers between 2012 and 2022

- (i) at Location 3. (1 mark)

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- (ii) in the entire gecko population. (1 mark)

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Environmental groups have suggested that the use of insecticides around mine site buildings was responsible for the decreased gecko population.

- (c) Propose an experimental design that could be used to investigate this claim. (4 marks)

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- (d) Outline **two** measures, other than eliminating insecticide use, that could be implemented around the mine site to assist the population of geckos to increase. (4 marks)

One: \_\_\_\_\_

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Two: \_\_\_\_\_

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**Question 20**

**(12 marks)**

Increasing concentrations of greenhouse gases in the atmosphere have contributed to significant and ongoing warming of the planet over recent decades.

- (a) List **two** greenhouse gases. (2 marks)

One: \_\_\_\_\_

Two: \_\_\_\_\_

- (b) Draw detailed and labelled diagrams in the boxes provided below illustrating the natural greenhouse effect and the enhanced greenhouse effect. (6 marks)

**Natural greenhouse effect**

**Enhanced greenhouse effect**

Warming climate may have contributed to recent increases in the rate and intensity of bushfires in Australia and other fire-prone regions of the world.

- (c) Using your understanding of the greenhouse effect, describe how increased frequency of bushfires could have an impact on global climate change. (2 marks)

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- (d) State **one** positive and **one** negative effect bushfires can have on an ecosystem. (2 marks)

Positive: \_\_\_\_\_

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Negative: \_\_\_\_\_

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**Question 21**

**(14 marks)**

- (a) State what is meant by both renewable and non-renewable energy resources. (2 marks)

Renewable energy resource:

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Non-renewable energy resource:

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- (b) List **two** examples of a renewable energy resource and **two** examples of a non-renewable energy resource. (4 marks)

Renewable energy resource:

One: \_\_\_\_\_

Two: \_\_\_\_\_

Non-renewable energy resource:

One: \_\_\_\_\_

Two: \_\_\_\_\_

- (c) For each of the examples of a renewable energy resource identified in part (b), describe the process by which that energy could be captured and transported to be available for use at a major industrial site. (4 marks)

Resource one:

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Resource two:

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A mining company is considering the use of renewable energy as an alternative to diesel generators to power a remote mine site.

- (d) For each of the renewable energy resource examples identified in part (b), identify **one** advantage and **one** disadvantage the mining company might consider. (4 marks)

- (i) Resource one:

Advantage: \_\_\_\_\_

\_\_\_\_\_

Disadvantage: \_\_\_\_\_

\_\_\_\_\_

- (ii) Resource two:

Advantage: \_\_\_\_\_

\_\_\_\_\_

Disadvantage: \_\_\_\_\_

\_\_\_\_\_

Question 22

(14 marks)

- (a) Describe a mechanism by which tectonic processes can contribute to long-term climate change. (2 marks)

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- (b) Describe **one** physical or chemical impact that climate change can have on the ocean and how it is caused. (2 marks)

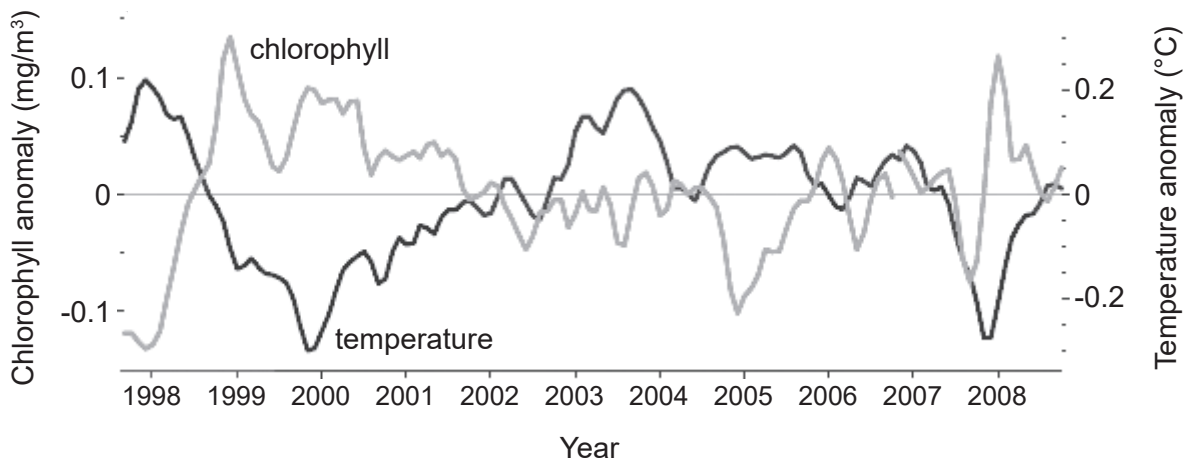
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The level of chlorophyll measured by satellite observations is used by scientists as an indicator of the abundance of phytoplankton (photosynthesising marine micro-organisms) in surface sea waters. The graph below shows how average global chlorophyll concentrations and ocean surface temperature changed between 1998 and 2008.



- (c) Use the data shown on the graph above to outline how the phytoplankton population may be affected by ocean surface temperature. (2 marks)

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- (d) Identify and describe **two** methods by which prehistoric records (records extending further back than recorded human history in a given location) can be used to provide evidence of climate change. (8 marks)

One: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Two: \_\_\_\_\_  
\_\_\_\_\_  
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\_\_\_\_\_

**Question 23**

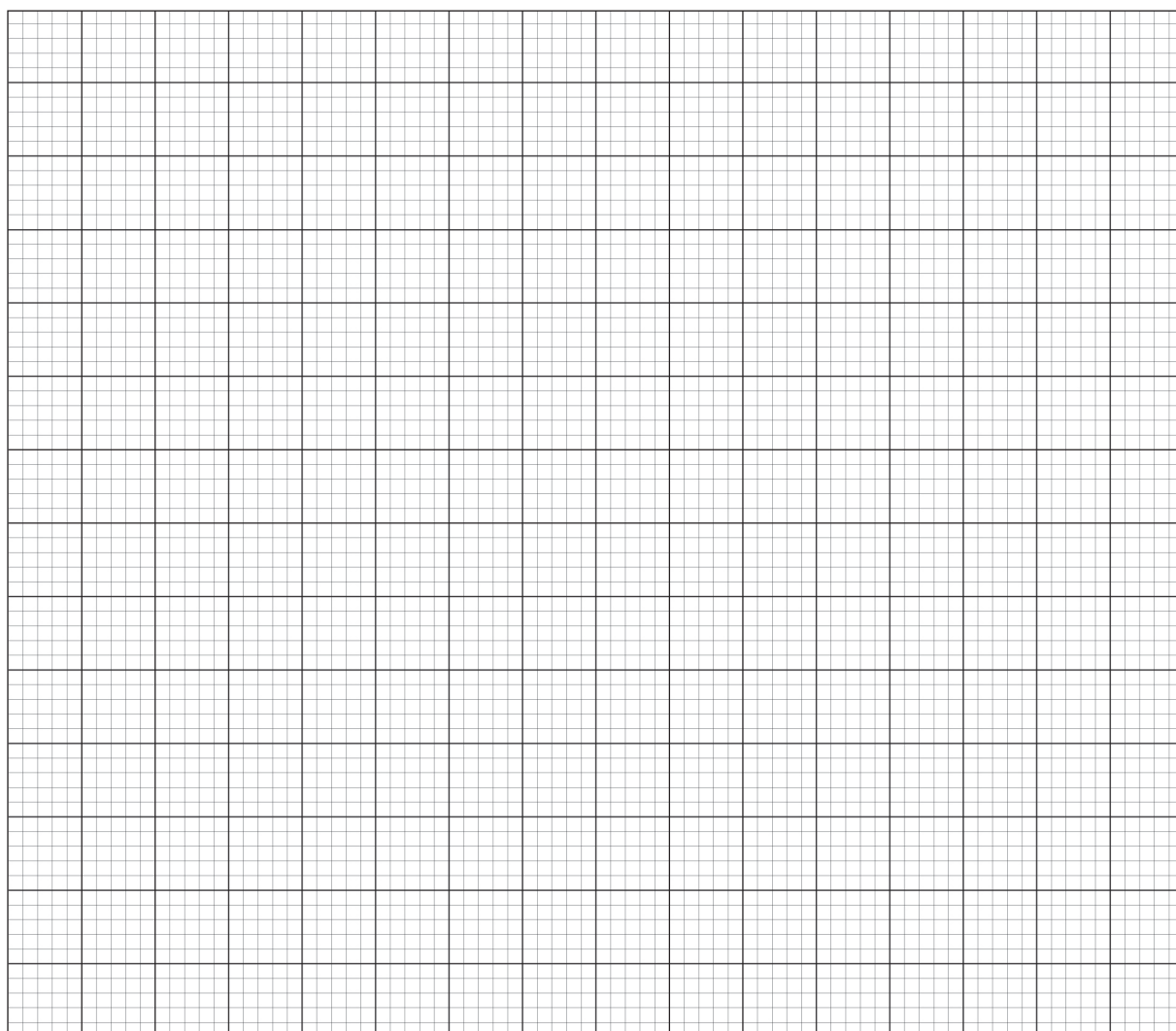
**(10 marks)**

Turbidity refers to the cloudiness of water due to sediment load, and is measured in nephelometric turbidity units (NTU).

- (a) The table below shows turbidity measurements made over 10 years at two sites along a river where alluvial mining is occurring. Use the data to construct a line graph on the grid below showing the turbidity at these locations over the period recorded. (6 marks)

Put a line of best fit through the data and extrapolate out to 2025.

Location	Mean measured turbidity (NTU)						
	2010	2012	2014	2016	2018	2020	2025
1	13.0	11.5	9.0	8.5	6.8	4.5	
2	8.0	7.8	7.6	6.5	5.8	5.5	



A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out this attempt and indicate that you have redrawn it on the spare grid.



- (b) On the basis of your extrapolation, predict the turbidity in 2025 at both locations. (2 marks)

Location 1: \_\_\_\_\_

\_\_\_\_\_

Location 2: \_\_\_\_\_

\_\_\_\_\_

- (c) The World Health Organization states that drinking water should have turbidity no higher than 5 NTU, and ideally below 1 NTU. On the basis of these categories, state whether the turbidity at each of the measured locations is expected to be unsatisfactory, satisfactory, or ideal for drinking water in 2025. (2 marks)

Location 1: \_\_\_\_\_

Location 2: \_\_\_\_\_

**Question 24**

**(13 marks)**

Choose **one** metallic mineral resource to answer Question 24.

Metallic mineral resource chosen: \_\_\_\_\_

- (a) Explain how geological processes can lead to accumulation of your chosen resource to form an economic ore deposit. (4 marks)

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- (b) Identify a geophysical method that could be useful for selecting areas in which to explore for your chosen mineral resource. (1 mark)

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- (c) Describe how the presence of your chosen resource and/or related changes in the surrounding rocks create a signal that can be detected by the geophysical method identified in part (b). (2 marks)

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- (d) Outline the processes involved in conducting a geophysical survey using the method identified in part (b). (2 marks)

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- (e) Assuming a potentially-valuable mineral has been found during exploration in the field, describe **two** types of analysis that could be undertaken to help determine whether it would be economic to develop a mine to extract that mineral. (4 marks)

One: \_\_\_\_\_

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Two: \_\_\_\_\_

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**End of Section Two**

**See next page**

**Section Three: Extended answer**

**30% (30 Marks)**

This section contains **three** questions. You must answer **two** questions: the compulsory question (Question 25) and **one** of the other questions (Question 26 **or** Question 27). Write your answers on the pages provided following Question 27.

If you use a page for planning, indicate this clearly at the top of the page.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

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**Question 25**

**(15 marks)**

As the population of Australia's major cities grows over the coming decades, urban water demand is projected to increase. With surface water sources already utilised to near their maximum capacity, this trend is placing increasing demands on communities to invest in alternative water sources and technologies in order to maintain water security.

- (a) Explain **one** replenishment technique used to increase groundwater storage, and describe a benefit this technique provides compared to surface water storage in terms of water security. (4 marks)

Desalination plants are used widely in Australia to improve water quality and increase freshwater security.

- (b) Using a labelled flow chart, explain the processes occurring within a desalination plant. (5 marks)
- (c) Outline **one** environmental factor that should be considered when designing a desalination plant. (2 marks)

As well as increased supply, water security can also be improved by the use of initiatives to reduce water consumption.

- (d) Describe **two** community initiatives that could support reduced water use. (4 marks)

**Question 26****(15 marks)**

- (a) Describe how tectonic processes influence the eruption style and magma composition of volcanoes formed in each of the settings specified below:
- convergent plate boundaries
  - intra-plate hotspots.
- (6 marks)
- (b) State why it is important for communities near active volcanoes to have systems in place to provide early warning of possible eruption. (1 mark)
- (c) Describe **two** techniques that are used to monitor volcanic activity. (4 marks)
- (d) With the aid of a diagram, explain how a large-scale volcanic eruption can disrupt global weather patterns. (4 marks)

**or**

**Question 27****(15 marks)**

Many coastal areas throughout the world are currently at risk from the effects of rising sea levels.

- (a) Outline **two** factors that are expected to contribute to rising sea levels over the next decade. (4 marks)
- (b) Outline **two** negative impacts of rising sea levels on coastal infrastructure. (4 marks)
- (c) Rising sea levels may also increase the frequency of flooding along major rivers. Outline **two** possible benefits and **two** possible negative consequences of such flood events for local ecosystems. (4 marks)
- (d) Describe a mitigation strategy that could reduce the impact of rising sea levels or flooding for an affected community. State **one** environmental **or** social factor that the strategy is based on. (3 marks)

**End of questions**

























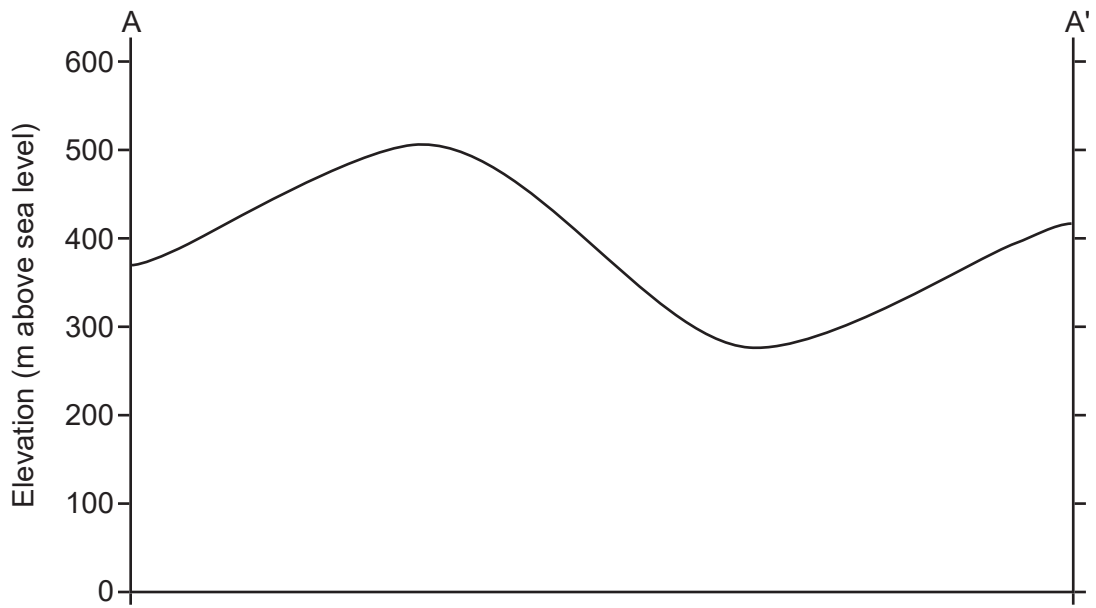








Spare section line for Question 18(b)



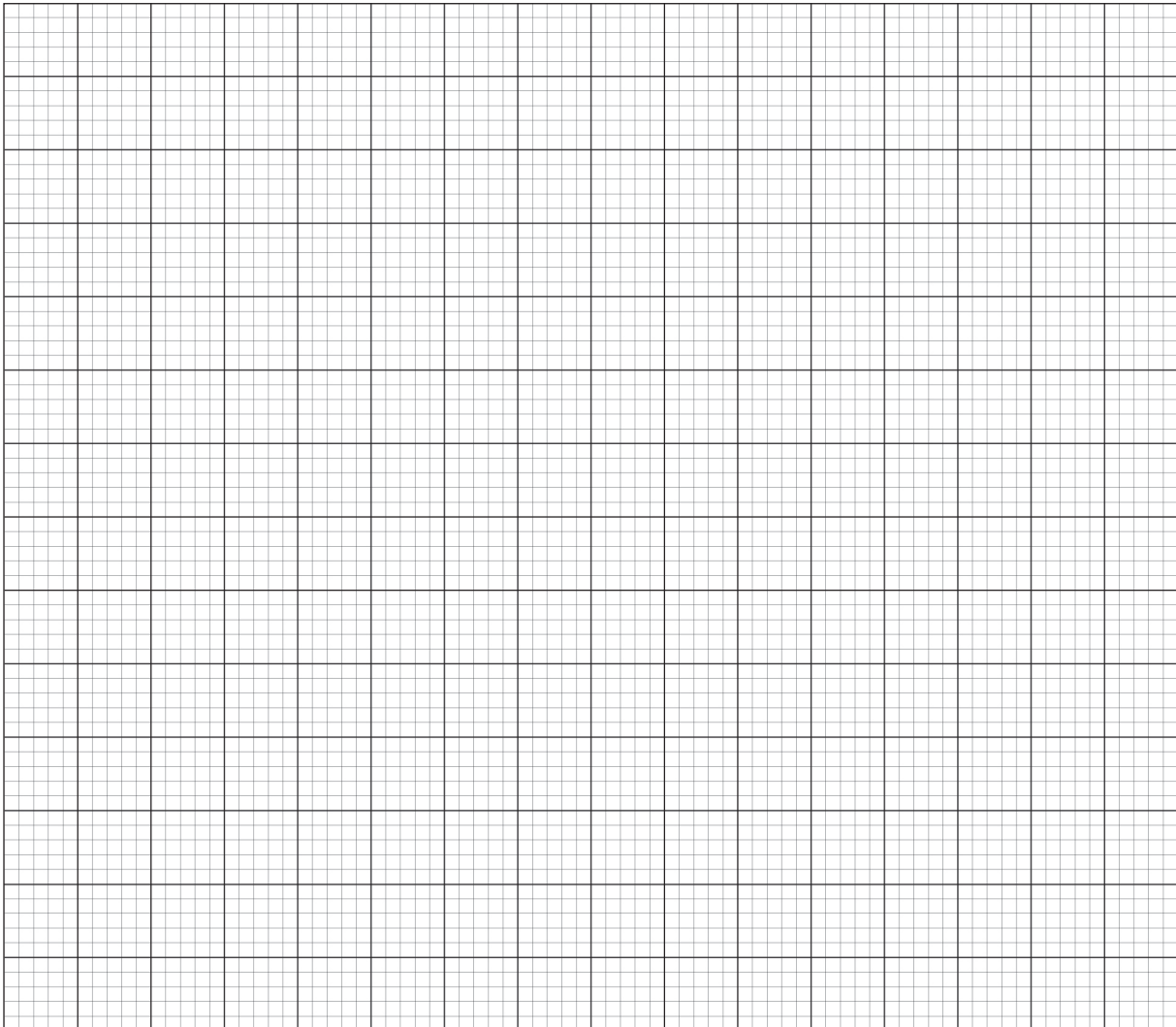
You may tear along the perforations to use this page to transcribe strata locations for Question 18(b).

**This page is to be used for transcribing strata locations only**

You may tear along the perforations to use this page to transcribe strata locations for Question 18(b).

**This page is to be used for transcribing strata locations only**

Spare grid for Question 23(a)



## ACKNOWLEDGEMENTS

- Questions 9–10** U.S. Geological Survey. (2021). *Plates tect2 en* [Map]. Retrieved May, 2023, from [https://commons.wikimedia.org/wiki/File:Plates\\_tect2\\_en.svg](https://commons.wikimedia.org/wiki/File:Plates_tect2_en.svg)
- Question 22(c)** Adapted from: Earth Observatory. (2010). *Long-term Changes in Phytoplankton* (Productivity graph). Retrieved May, 2023, from <https://earthobservatory.nasa.gov/features/Phytoplankton/page5.php>

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