2025/4715
Web version of 2024/77290

Government of **Western Australia**
School Curriculum and Standards Authority

ATAR course examination, 2024

Question/Answer booklet

EARTH AND ENVIRONMENTAL SCIENCE

Please place your student identification label in this box

WA student number: In figures | | | | | | | | |

In words _____

_____

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
				Total	100

Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2024: 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.

See next page

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. During normal El Niño-Southern Oscillation (ENSO) conditions, which of the following occurs?

   (a) consistent westerly (trade) winds across the equatorial Pacific Ocean
   (b) upwelling of nutrient-poor water around the west coast of South America
   (c) cooler than normal surface water around the east coast of Indonesia and Australia
   (d) development of low-pressure systems near the east coast of Australia, resulting in tropical cyclones

2. An environmental scientist studying the impact of open-cut mining on a group of marsupials recorded their population numbers over ten years. The **best** way to represent this information graphically would be a

   (a) line graph.
   (b) bar graph.
   (c) pie chart.
   (d) histogram.

3. A rock has been described by a geologist as a foliated rock made up of dark green and black crystals exhibiting distinct cleavage. The rock type is **most** likely to be

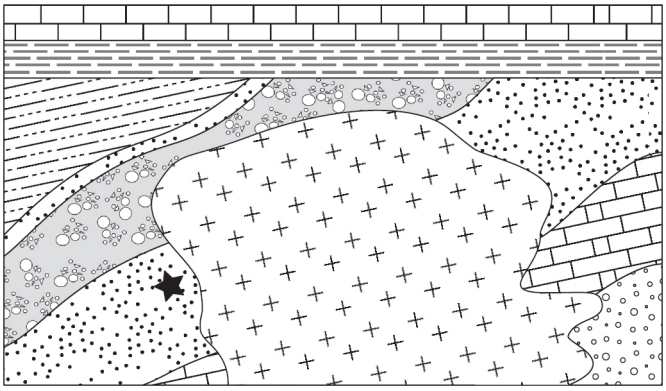
   (a) gneiss.
   (b) amphibolite.
   (c) marble.
   (d) slate.

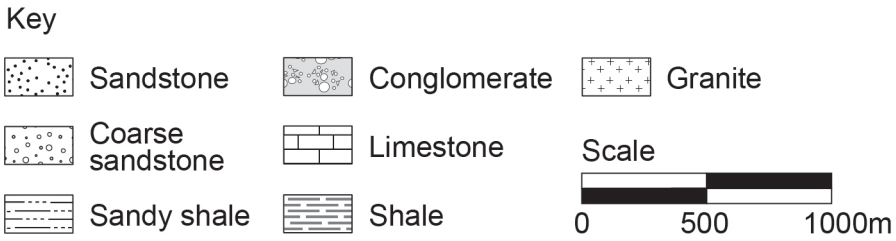
4. At least eight ice ages have occurred at regular intervals over the past million years. The principal cause of these periodic ice ages is **most** likely

   (a) variations in the sun's output.
   (b) the combustion of fossil fuels.
   (c) cyclic variations of the Earth's orbit around the sun.
   (d) variations in greenhouse gas concentration in the Earth's atmosphere.

See next page

Questions 5 and 6 relate to the geological cross-section shown below.





5. The intrusion of the granite shown is **most** likely to have produced which of the following types of metamorphism at the location ★?

(a) compressional
(b) contact
(c) regional
(d) retrograde

6. The rock type formed by metamorphism at location ★ would **most** likely be

(a) granite.
(b) marble.
(c) quartzite.
(d) slate.

7. Analysis of pollen from the fossil record provides a record of past

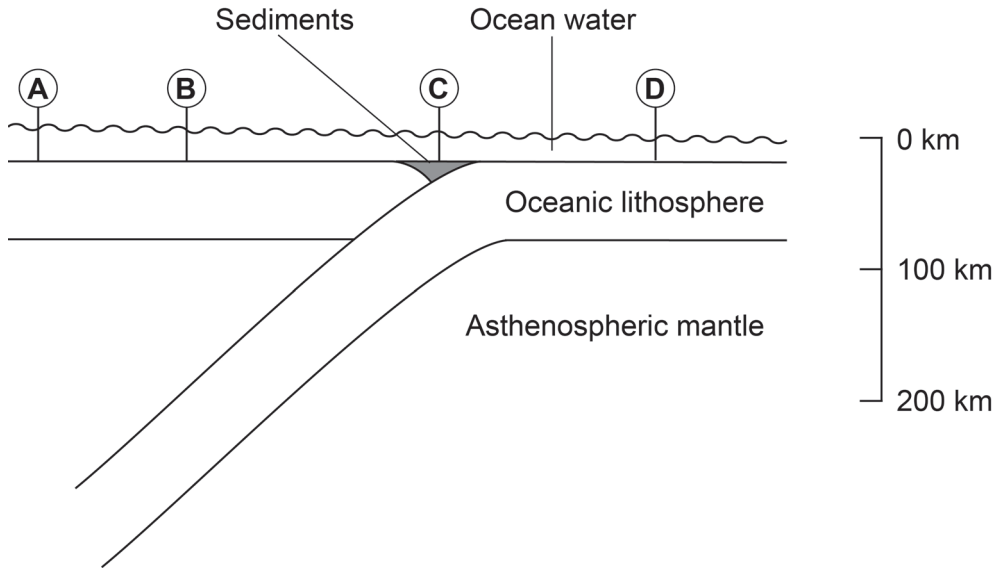
(a) atmospheric chemistry, including greenhouse gas concentration.
(b) bushfire frequency.
(c) rainfall patterns.
(d) distribution of vegetation in a particular area.

8. Oceanic thermohaline circulation contributes to global climate by

(a) transporting cold waters away from polar regions.
(b) cooling surface waters in equatorial regions.
(c) increasing the reflection of solar radiation from sea ice.
(d) reducing or reversing trade winds in the equatorial Pacific.

See next page

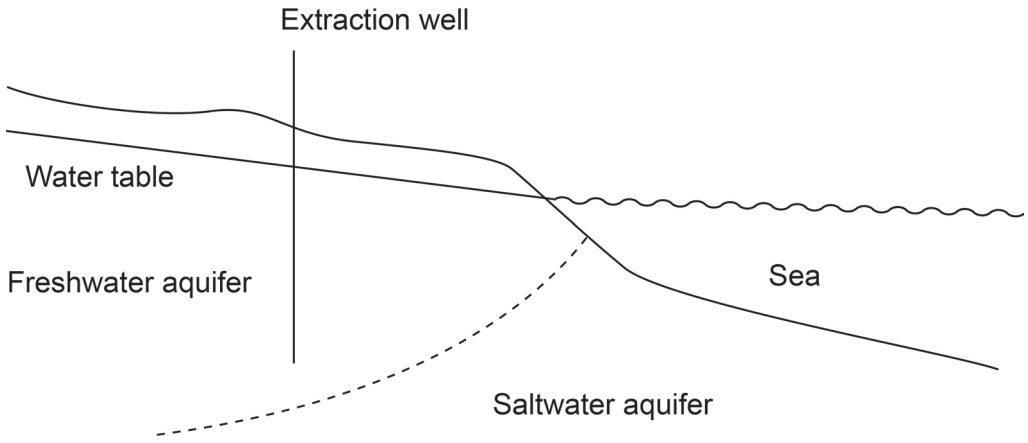
9. The diagram below illustrates a convergent boundary between two oceanic plates, where one plate is being subducted beneath the other.



At which of the locations indicated would it be **most** likely for undersea volcanism to occur?

(a) A
(b) B
(c) C
(d) D

10. The diagram below shows a coastal aquifer open to the sea. A well has been drilled at the location shown to extract water for irrigation.

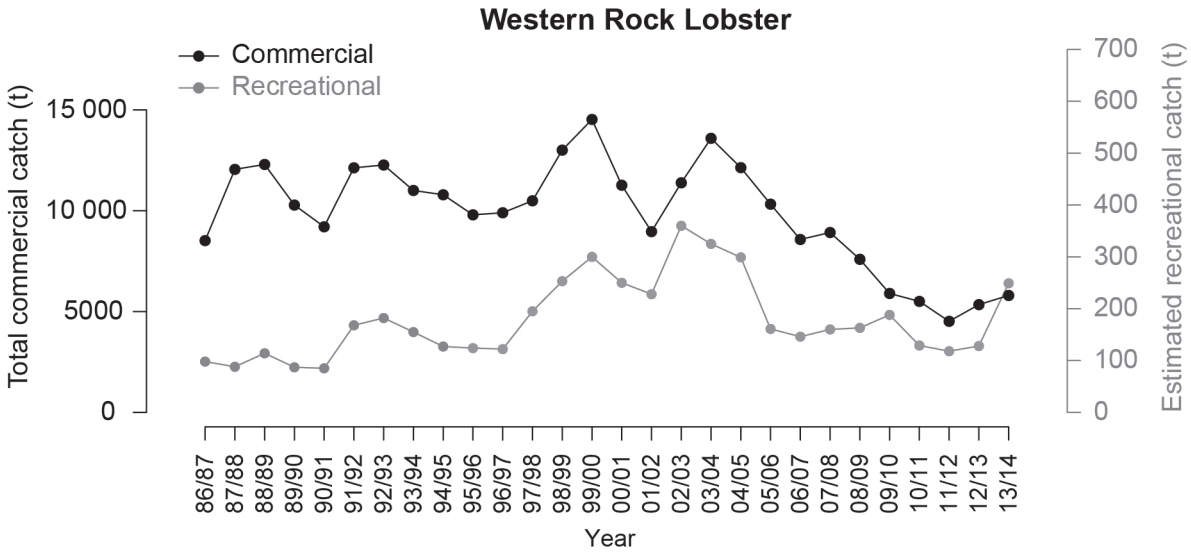


What is the **most** likely negative consequence if water is over-extracted from this well?

(a) the well becoming dry
(b) saltwater intrusion into the well
(c) well blow-out
(d) pump failure

See next page

The graphs below show the total commercial catch and the estimated recreational catch over a period of time.



11. Given the data in the graphs above, which of the following statements is true?

    (a) The ten lowest commercial rock lobster catches were all recorded after 2002/2003.
    (b) Every year, both recreational and commercial rock lobster catch decreased.
    (c) Commercial catch is larger than recreational catch in every year shown.
    (d) Recreational rock lobster catch has never fallen more than three years in a row.

12. How can monitoring the catch rate of rock lobsters assist with sustainable practices? Monitoring

    (a) provides evidence of the changing health of the lobster population.
    (b) ensures the government receives adequate royalties from fishermen.
    (c) prevents recreational fishers taking more than their allowed catch.
    (d) helps the government monitor the location of predators such as sea lions that may affect rock lobster populations.

13. Which of the following gases is **least** likely to be released by a volcanic eruption on Earth?

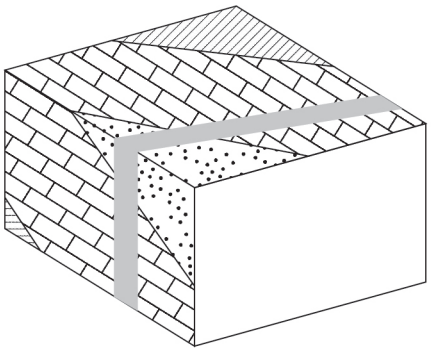
    (a) sulfur dioxide (SO_2)
    (b) carbon monoxide (CO)
    (c) water (H_2O)
    (d) hydrogen (H_2)

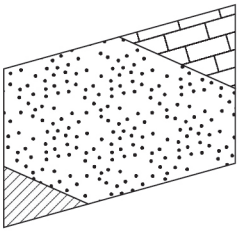
See next page

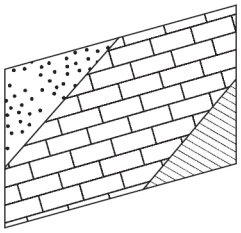
14. Which of the following **best** describes the main aim of an environmental assessment prior to commencing extraction of a non-renewable resource?

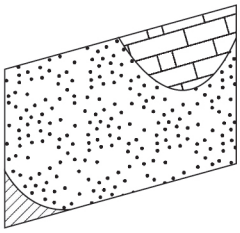
(a) guide government in establishing critical habitat protection areas
(b) prevent members of the public being concerned about a project
(c) compare the economic benefits of an activity against possible damaging effects of this activity on the environment
(d) assess whether an activity will have any adverse effects on the environment in which it occurs

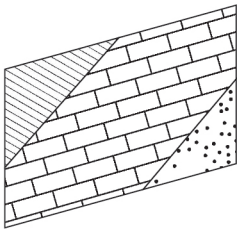
15. Assuming standard rules of stratigraphy are preserved, which is the **best** option to complete the geological block model provided?



(A) 

(B) 

(C) 

(D) 

(a) A
(b) B
(c) C
(d) D

End of Section One

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.

Question 16 **(11 marks)**

The diagram below shows the global distribution of locations where geothermal power plants are used to produce electricity.

(a) Using the information in the diagram above, describe how tectonic processes restrict the areas where geothermal energy can be economically harnessed. (3 marks)

See next page

(b) Outline **one** tectonic hazard associated with areas where geothermal energy can be produced on a large scale. (2 marks)

(c) Outline **two** environmental factors that should be considered before an investment in geothermal energy production is made. (4 marks)

One:

Two:

(d) Outline **one** political **or** economic reason why some countries or regions with significant resources of geothermal heat do not invest in geothermal energy production. (2 marks)

See next page

Question 17 **(12 marks)**

(a) Outline how the following attributes of an ore body may help determine how the mineral resource it contains may be extracted.

(i) Value of contained resource (2 marks)

(ii) Location of the ore body (2 marks)

As part of the work required to obtain permission to develop a mine in Western Australia, a survey of Indigenous heritage must be carried out across the area that may be disturbed by mining and related activities.

(b) State **one** benefit of these surveys for the:

(i) local Indigenous community. (1 mark)

(ii) mining company. (1 mark)

(c) State **two** ways a company could communicate with all members (Indigenous and non-Indigenous) of the local community near a planned mine site to support positive long-term relations. (2 marks)

One: _____

_____

Two: _____

_____

(d) Outline **two** environmental **or** economic factors, other than Indigenous heritage and community relations, that should be considered before a mining company commences operations. (4 marks)

One: _____

_____

_____

_____

Two: _____

_____

_____

_____

Question 18 **(12 marks)**

The data below shows the measured gold resources (in thousands of ounces) and annual gold extracted (in ounces) over eight years for a mine site recently listed for sale.

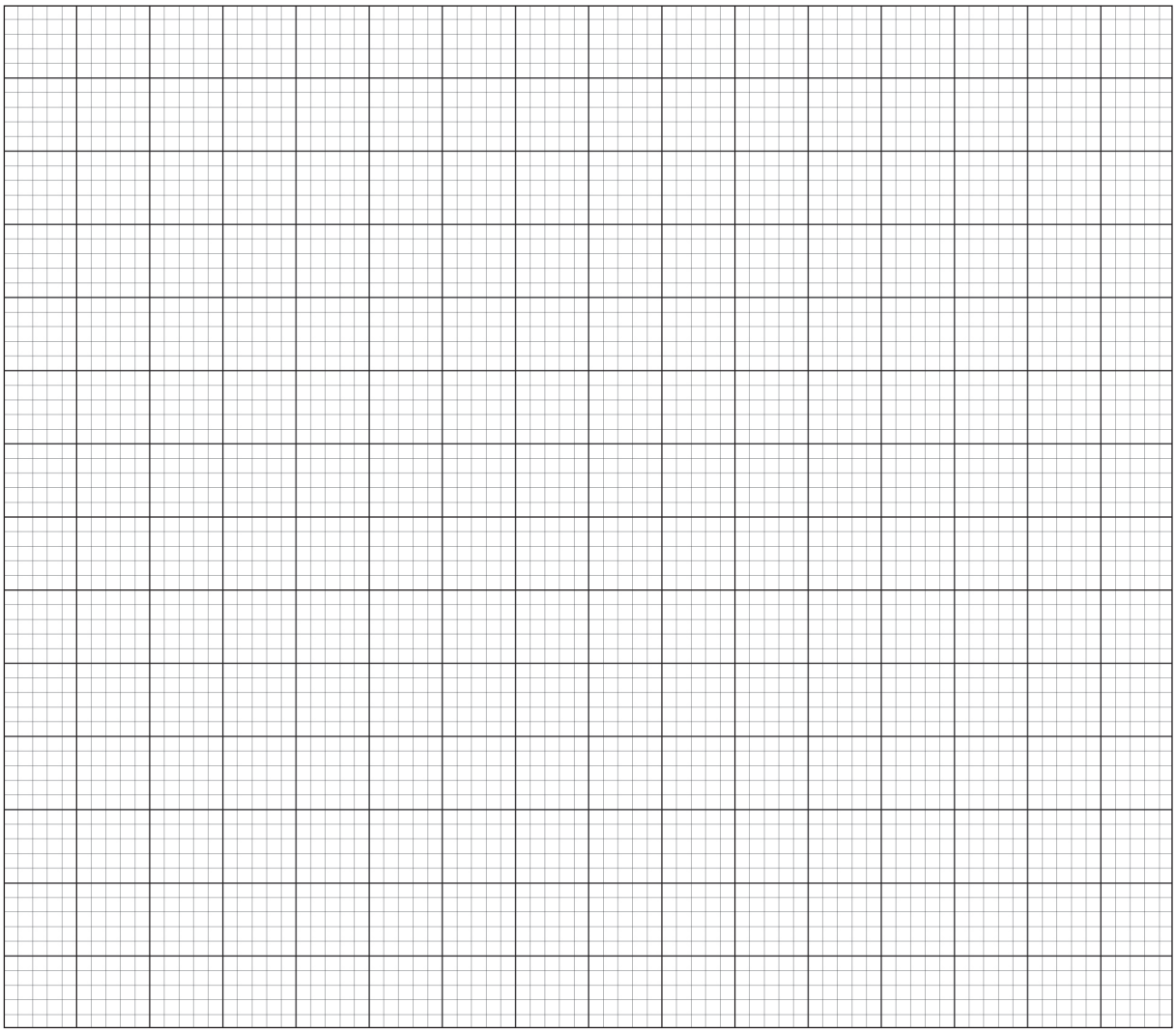
Year	Gold resources (1000s of ounces)	Gold extracted (ounces/year)
2015	500	50 000
2016	450	50 000
2017	400	50 000
2018	350	50 000
2019	520	50 000
2020	460	60 000
2021	400	60 000
2022	360	60 000

(a) Calculate the following using the data above:

(i) total number of ounces extracted between 2015 and 2022. (1 mark)

(ii) ounces of gold added to the resources between 2018 and 2019. (2 marks)

(b) Using the grid provided, draw a line graph showing variation over the eight years of data provided for each of the measured gold resources and gold extracted. (6 marks)



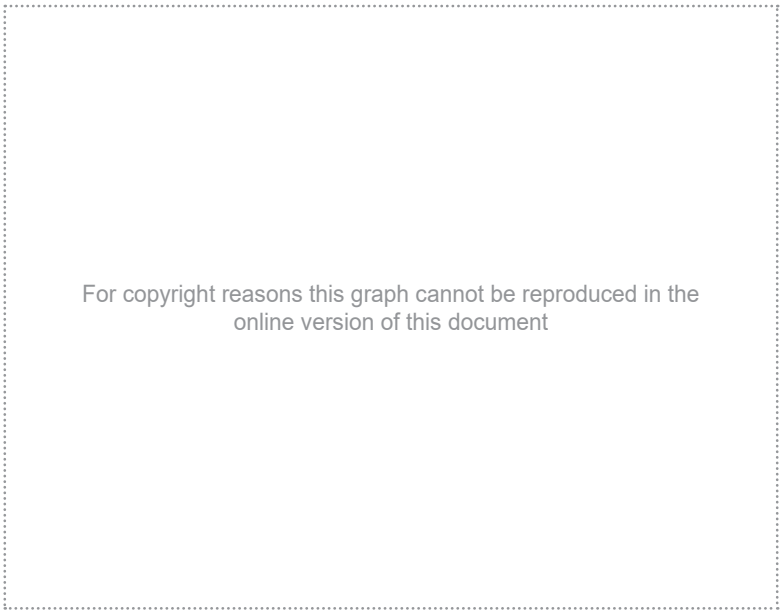
A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out this attempt and indicate that you have redrawn it on the spare grid.

(c) Explain how geological sampling could lead to an increase in the measured gold resources over time. (3 marks)

See next page

Question 19 **(13 marks)**

The graph below shows data extracted from analysis of Antarctic ice cores, plotting atmospheric CO_2 concentration (in parts per million by volume) and variation in the relative abundance of deuterium (a heavier isotope of hydrogen) in water over the past 165 000 years.



(a) On the basis of the graph shown above:

(i) state the relationship between the two data sets plotted. (1 mark)

_____

_____

(ii) identify **one** trend or pattern shown by the data over time. (1 mark)

_____

_____

See next page

(b) Explain how scientists would go about extracting and analysing material from ice cores to generate the data shown. (4 marks)

(c) Outline how a natural process could result in change over time in:

(i) atmospheric CO_2 concentration. (2 marks)

(ii) the ratio of heavy and light isotopes of hydrogen or oxygen in rain or snow. (2 marks)

(d) Explain why scientists might be interested in records of the natural fluctuation of atmospheric CO_2 over geological time. (3 marks)

See next page

Question 20 **(10 marks)**

(a) State **two** decisions that could be made to reduce water use associated with public infrastructure such as parks, sports fields and landscaped public spaces. (2 marks)

One: _____

_____

Two: _____

_____

(b) Outline **two** factors that affect the sustainability of an identified natural source of drinking water. (4 marks)

One: _____

_____

_____

_____

Two: _____

_____

_____

_____

(c) Explain how a specific technological solution can be applied to supplement the natural supply of drinking water for a city or town. (4 marks)

_____

_____

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_____

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_____

See next page

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See next page

Question 21 **(12 marks)**

(a) Describe **one** positive and **one** negative impact of volcanic eruptions for life on Earth. (4 marks)

Positive: _____

_____

_____

_____

Negative: _____

_____

_____

_____

(b) The nature of volcanic eruptions and the corresponding hazards they pose to local people vary in different tectonic settings. Use your knowledge of volcanic hazards to complete the following table: (4 marks)

Tectonic location	Volcano form	Typical volcanic rocks	Geohazards
Hot spot		Basalt, scoria, obsidian	Poisonous gases and lava flows
Rift	Caldera or fissure vent (Icelandic)	Basalt, scoria, obsidian	
Subduction boundary		Andesite, pumice, tuff	

See next page

(c) Describe **two** methods of monitoring volcanic activity to provide early warning of hazards to local populations. (4 marks)

One: _____

_____

_____

_____

Two: _____

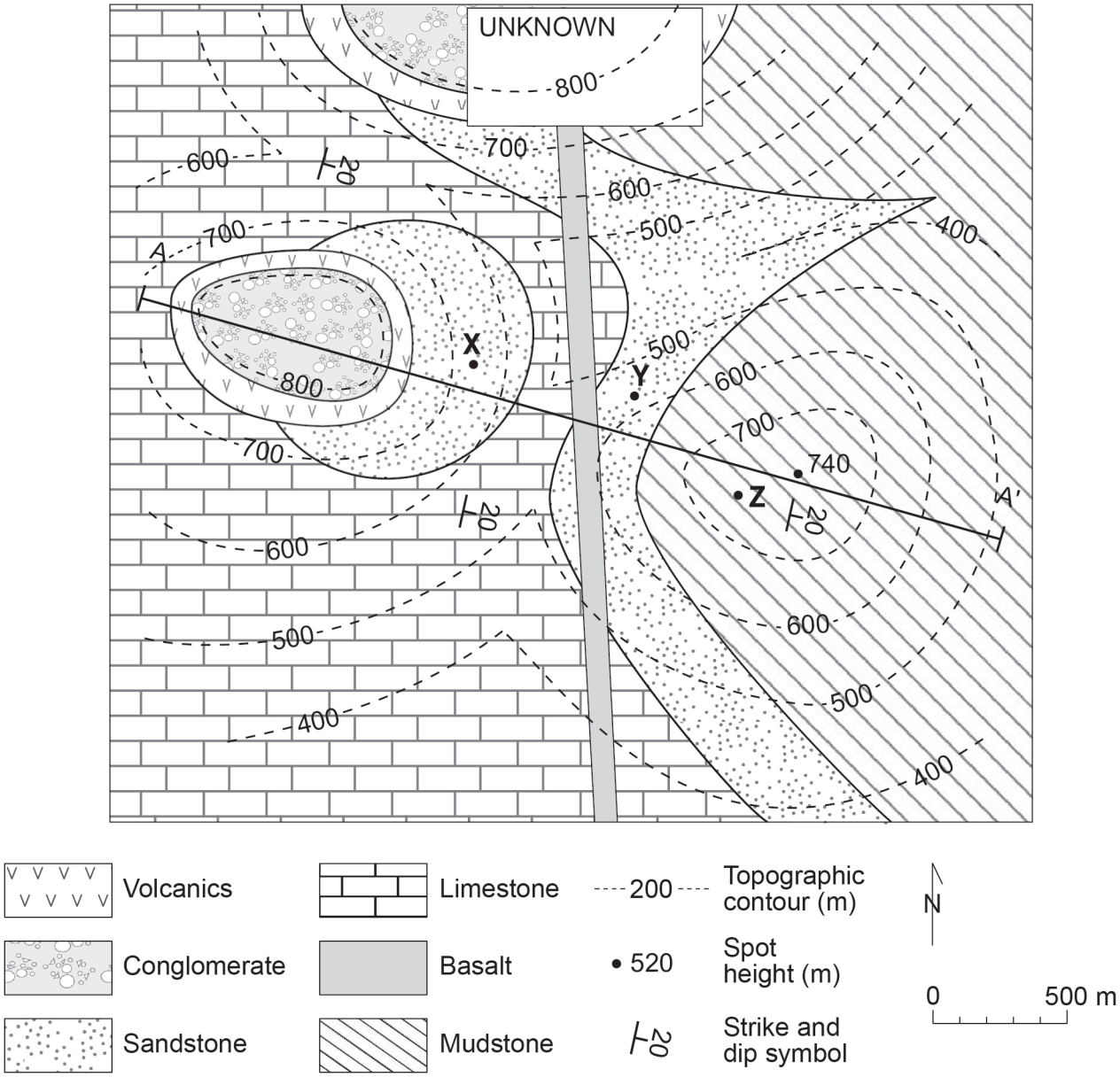
_____

_____

_____

Question 22 **(14 marks)**

A field geologist is mapping the geology of a region. Their current understanding is shown below.



(a) The boundaries of the basalt unit with all other lithologies are seen to continue straight across the landscape. State what this observation indicates about the style of intrusion of the basalt body. (1 mark)

(b) The geologist visits the point marked as Z at the peak of a hill in the area. Name the lithology they would expect to find at point Z. (1 mark)

See next page

(c) Construct a cross-section along the line A–A' in the box provided, interpreting geology below the surface down to sea level. Note: to assist you in transcribing strata locations, you may remove page 45 by tearing along the perforations. (6 marks)

A spare section line 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 section line.

(d) Shallow drillholes are drilled at points X and Y to test the subsurface geology. Both holes start in sandstone and intersect limestone some distance below the surface. Identify which hole would encounter the deeper contact between the two lithologies. (1 mark)

(e) The geologist is not sure whether the volcanics originated as a lava flow onto the surface or as an intrusive sill.

(i) State **one** form of geological evidence they may look for in the field to test these alternative hypotheses. (1 mark)

(ii) Describe how this evidence in part (d)(i) would distinguish between extrusive and intrusive origin for the volcanics. (2 marks)

Question 22 (continued)

The geologist has a hypothesis that the basalt and volcanics shown in the map on page 20 are actually parts of a single unit.

(f) Describe **or** draw a labelled sketch map illustrating the geological relationships that might be observed between these lithologies in the area marked as 'Unknown' if the geologist's hypothesis is correct. (2 marks)

or

See next page

Question 23 **(12 marks)**

(a) Name a non-renewable mineral or energy resource and state a geophysical or geochemical technique that could be used in early-stage exploration for your chosen resource in a new area. (1 mark)

Name of mineral/resource: _____

Exploration technique: _____

(b) State the rock property that your chosen exploration technique in part (a) is measuring and describe how this technique in part (a) would differentiate between areas where your chosen resource is present and areas where it is absent. (3 marks)

Physical rock property: _____

_____

Present/absent: _____

_____

_____

_____

(c) Explain how your chosen technique in part (a) would be applied in an exploration program **or** survey to test for the presence of the resource. (4 marks)

_____

_____

_____

_____

_____

_____

_____

_____

Question 23 (continued)

(d) If a potential resource was identified in the initial exploration, outline **two** further methods that could be applied to assess the scale or potential value of the resource. (4 marks)

One: _____

_____

_____

_____

Two: _____

_____

_____

_____

Question 24 **(14 marks)**

(a) Using an example, explain how a specific tectonic process can lead to metamorphism of pre-existing rocks. (3 marks)

(b) Describe **two** identifying characteristics for each of the following metamorphic rock types. (6 marks)

Phyllite

One:

Two:

Marble

One:

Two:

Gneiss

One:

Two:

See next page

Question 24 (continued)

(c) Explain why a metamorphosed basalt would be expected to contain a greater variety of minerals than a metamorphosed quartz sandstone at an equivalent metamorphic grade. (3 marks)

(d) Describe **one** way in which metamorphism could contribute to the development or enrichment of an economic mineral resource. (2 marks)

End of Section Two

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.

Suggested working time: 60 minutes.

Question 25 **(15 marks)**

(a) Explain how a specific geological process (one for each resource) can lead to the accumulation or formation of **one** non-renewable energy resource and **one** metallic mineral resource. (6 marks)

(b) Given the processes identified in part (a), compare the tectonic settings in which each of your chosen resources might develop. (5 marks)

(c) Following the initial accumulation of the resources specified in part (a), outline how subsequent geological processes might lead to the concentration or dispersal of each of your chosen resources. (4 marks)

Question 26 **(15 marks)**

(a) Identify **two** ways in which local changes in the hydrosphere could leave a physical record with the potential to be preserved over geological timescales. (2 marks)

(b) Describe how scientists could compile a record of change in the hydrosphere pre-dating human history using **one** of the physical records specified in part (a). (3 marks)

(c) Describe **two** ways in which climate change has altered the hydrosphere over the past 20 years. (4 marks)

(d) Explain the probable impact of future climate change on **two** renewable resources derived from the hydrosphere (including provisioning services, regulating services and supporting services). (6 marks)

or

Question 27 **(15 marks)**

You are working on plans to build a multi-storey apartment complex on a steep hillside overlooking the ocean. Your land runs from the top of a hill down to the beachfront and is currently densely forested. The area has a known history of significant earthquakes.

(a) Given the information provided, identify **three** hazards an earthquake could pose to people living in the proposed apartment complex. (3 marks)

(b) Describe **two** types of study that could help understand the magnitude and/or frequency of earthquake events the site may experience. (6 marks)

(c) Identify **two** measures that could be taken in the design, construction or operation of the planned apartment complex to mitigate seismic risk. (2 marks)

(d) Explain how each of the measures identified in part (c) would reduce hazards for occupants of the planned apartments. (4 marks)

End of questions

Question number: _____

Question number: _____

Question number: _____

Question number: _____

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Question number: _____

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Question number: _____

Question number: _____

Question number: _____

Supplementary page

Question number: _____

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Supplementary page

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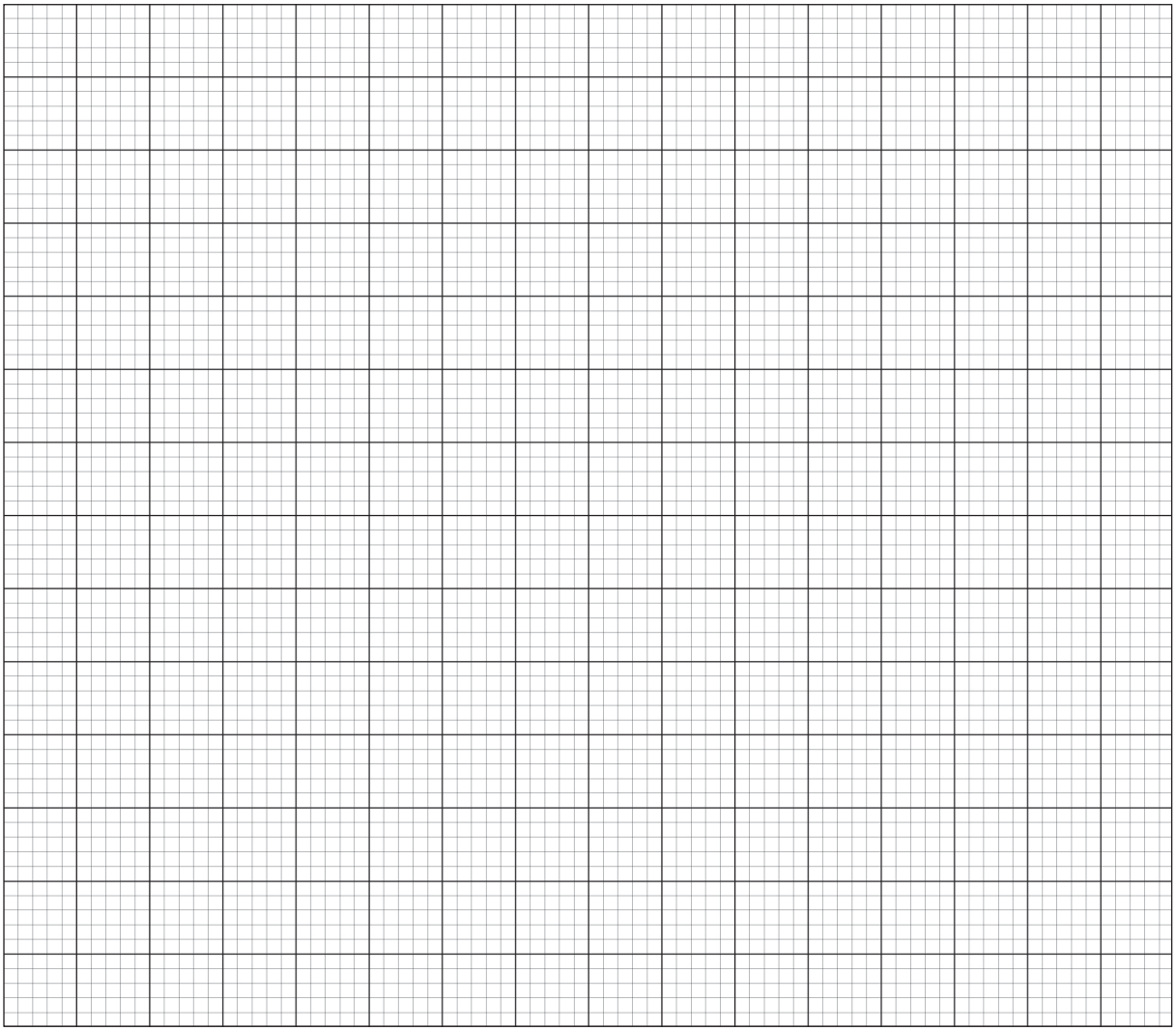
Question number: _____

Spare grid for Question 18(b)



You may tear along the perforations to use this page to transcribe strata locations for Question 22(c).

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 22(c).

This page is to be used for transcribing strata locations only

Spare section line for Question 22(c)

ACKNOWLEDGEMENTS

Question 11 Adapted from: Ryan, K. L., Trinnie, F., Jones, R., et al. (2016, February 16). Recreational Fisheries Data Requirements for Monitoring Catch Shares (Figure. 2) [Graph]. *Fisheries Management and Ecology, 23*(3–4). (p. 223). Retrieved April, 2024, from https://onlinelibrary.wiley.com/doi/10.1111/fme.12151

Question 16 Diagram adapted from:
Ghosh, D. (2023). Plate Tectonics [Diagram]. Retrieved April, 2024, from https://www.worldatlas.com/geography/plate-tectonics.html

Skimel. (2017). *Simplified Blank World Map Without Antartica (no borders)* [Map]. Retrieved November, 2024, from https://commons.wikimedia.org/wiki/File:Simplified_blank_world_map_without_Antartica_(no_borders).svg

Question 19 Barnola, J. M., Raynaud, D., Korotkevich, Y. S., et al. (1987, October 1). Vostok Ice Core Provides 160,000-year record of Atmospheric CO_2 (Fig. 2). *Nature* 329, 408–414 (p. 410). Retrieved April, 2024, from https://www.nature.com/articles/329408a0

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