



ATAR course examination, 2020

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

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 2020: 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.

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.

1. Which of the following describes the expected sequence of climatic impacts produced by a major stratovolcano eruption?
 - (a) a period of increased rainfall due to water vapour being added to the atmosphere during the eruption, followed by localised flooding
 - (b) initial atmospheric cooling due to ash circulating in the stratosphere, followed by longer-term warming due to the release of gases such as carbon dioxide (CO₂) and methane
 - (c) a period of cooling due to thunderstorms induced by the eruption, followed by global warming due to circulation of hot volcanic ash in the upper atmosphere
 - (d) local warming due to ash circulating above the volcano, followed by an extended period of drought due to changed weather patterns

2. In which of the following geological settings would you be likely to find a nickel sulfide ore body?
 - (a) a 2500 million-year-old sedimentary basin
 - (b) a folded Mesozoic metamorphic terrane
 - (c) an ancient ultramafic lava flow
 - (d) a pegmatite dyke

3. If an earthquake occurred somewhere in inland Western Australia, which of the following observations could **not** help scientists to identify its location?
 - (a) the time taken for seismic waves to reach measurement stations across the State
 - (b) reports of shaking felt by observers on social media applications such as Twitter
 - (c) offsets measured in fence lines and other infrastructure
 - (d) observations of unusual animal movements on farms

4. Which of the following technologies could **best** improve the effectiveness of a photovoltaic solar panel array as a source of base load power?
 - (a) installation of large-scale batteries to store collected energy
 - (b) an improved panel design capable of collecting energy more efficiently
 - (c) construction of a coal-fired power station nearby
 - (d) the introduction of daylight saving

See next page

5. Which of the following could be used to provide a geological record of climate change?
- (a) recording of atmospheric carbon dioxide levels at the Mauna Loa Observatory
 - (b) satellite mapping of seasonal sea ice coverage of the Arctic Ocean
 - (c) collection and identification of pollen and plant spores present in ancient lake sediments
 - (d) computer modelling of the tectonic movement of continents

Questions 6 and 7 relate to the graph below, which shows gold production at the Rio de la Lagrimas mine from its opening in 1986 to its closure in 2010.



6. The graph shows that
- (a) gold production at the mine did not fall below 2000 ounces until 2007.
 - (b) annual gold production at the mine never exceeded 10 000 ounces.
 - (c) peak gold production at the mine occurred before 2000.
 - (d) the mine needed to produce more than 3000 ounces of gold per year to remain profitable.
7. Which of the following provides the **most** likely explanation for the progressive increase in annual gold production observed between 1992 and 1998?
- (a) The gold was being deposited at a faster rate than it was being extracted.
 - (b) The gold mine became more profitable.
 - (c) Active exploration at the mine site identified new sources of ore.
 - (d) Driverless trucks began to be used at the mine in 1992.

8. When mining operations cease, rehabilitation processes can include
- (i) filling the pit with waste material.
 - (ii) fencing exposed areas of pit wall.
 - (iii) allowing water to inflow and fill the pit naturally.
 - (iv) replanting the area with native plants from a seed bank collected prior to mining.

A plan for the environmental rehabilitation of an open-cut mine site should include

- (a) i and iii
 - (b) i and iv
 - (c) i, ii and iv
 - (d) i, ii, iii and iv
9. Which of the following methods of electricity generation would have the **least** ecological impact?
- (a) solar panels installed on home roofs
 - (b) wood-fired thermal electricity generation
 - (c) a nuclear power plant
 - (d) a hydro-electric plant that dams a river to produce electricity
10. Within Australia, which of the following changes to typical weather patterns is unlikely to be associated with an El Niño event?
- (a) increased rainfall
 - (b) increased frost risk
 - (c) decreased alpine snow depths
 - (d) reduced number of tropical cyclones

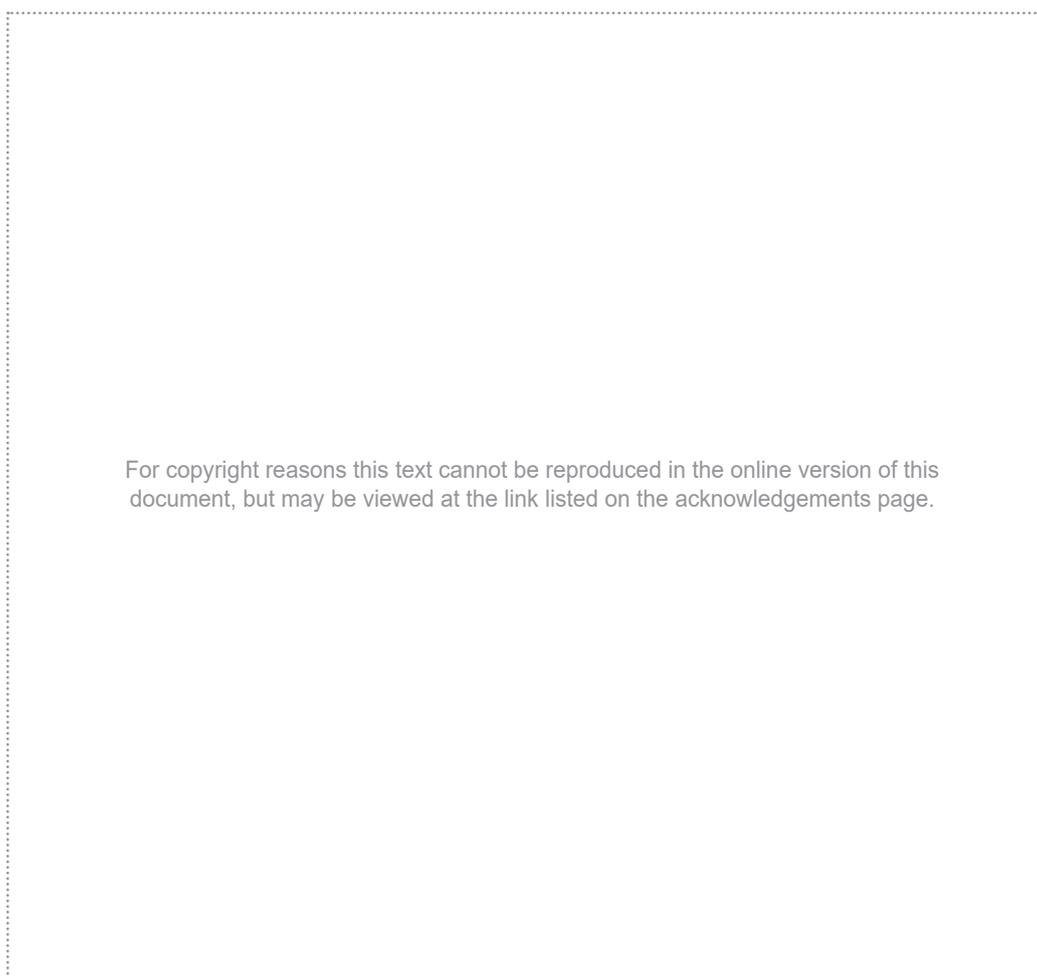
11. Gases present in the Earth's atmosphere include

- (i) carbon dioxide.
- (ii) nitrogen.
- (iii) methane.
- (iv) ozone.

Which of these are significant greenhouse gases?

- (a) i and iv
- (b) i, iii and iv
- (c) ii, iii and iv
- (d) i, ii, iii and iv

12. Identify the rock type that fits the following description: a medium-grained rock displaying a roughly parallel sheet-like fabric and consisting mostly of muscovite, biotite, quartz and feldspar.
- (a) marble
 - (b) schist
 - (c) gneiss
 - (d) phyllite
13. Gas extracted from ice cores has been used to measure variations in the concentration of CO₂ in the atmosphere over time. As shown on the graph below, from the year 0 BCE to the start of the industrial revolution in the middle of the eighteenth century, CO₂ levels increased by less than 1%.



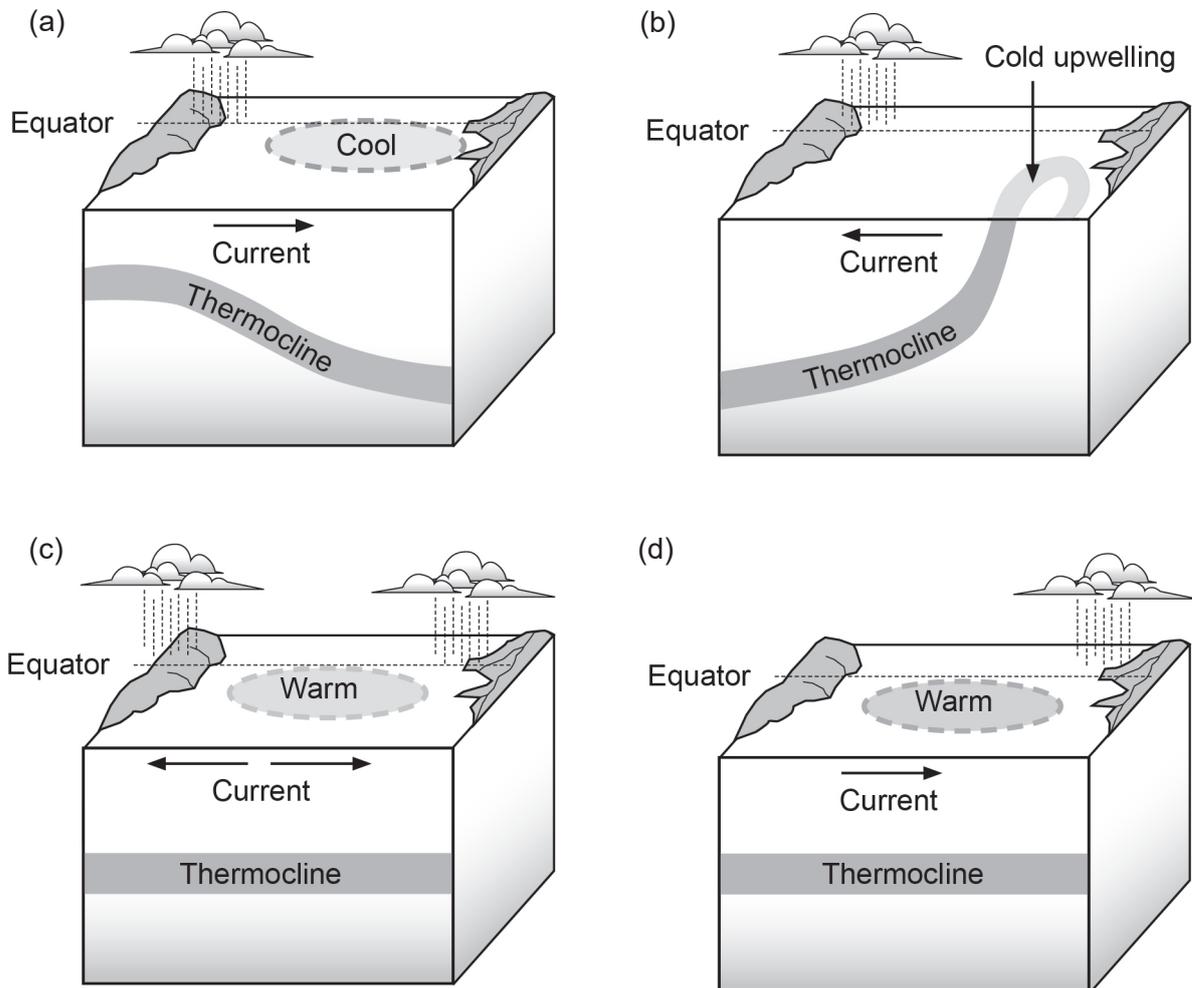
Between about 1750 and 2000, CO₂ levels increased by approximately

- (a) 15%.
- (b) 25%.
- (c) 40%.
- (d) 70%.

14. The geological record reflects global climate change over time. Study of this record may help scientists to understand the causes and potential consequences of change to climate systems. Which of the following is a cause of climate change predating the human era?

- (a) historical isotope records from drill core
- (b) an enhanced greenhouse effect
- (c) emissions from the burning of fossil fuels
- (d) the obliquity of the Earth's orbit around the Sun

15. Identify the diagram that illustrates correctly the conditions in the Pacific Ocean during an El Niño event.



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.

Question 16

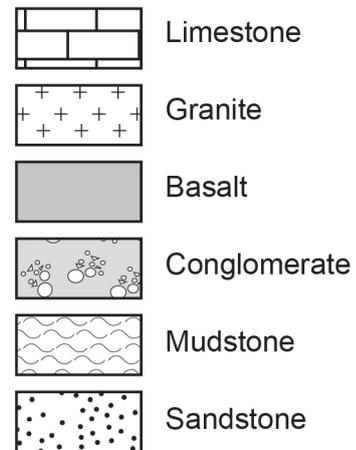
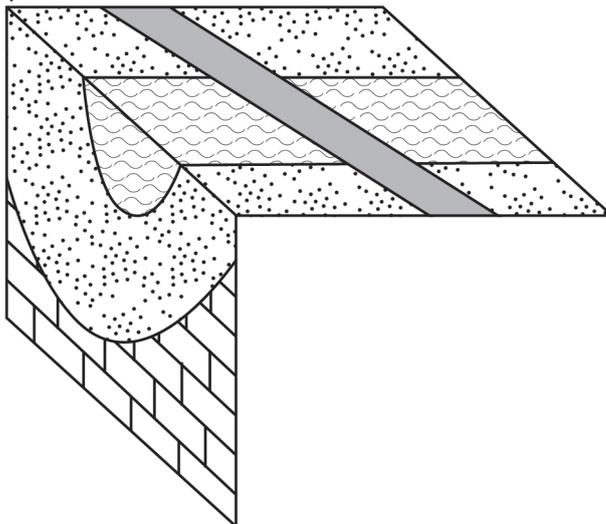
(11 marks)

After completing a program of fieldwork, a geologist has begun to prepare three block diagrams illustrating the relationships she has identified within her field area. Each of the diagrams has one face left blank.

- (a) Using the relationships shown and your knowledge of stratigraphy, complete diagrams (i), (ii) and (iii).

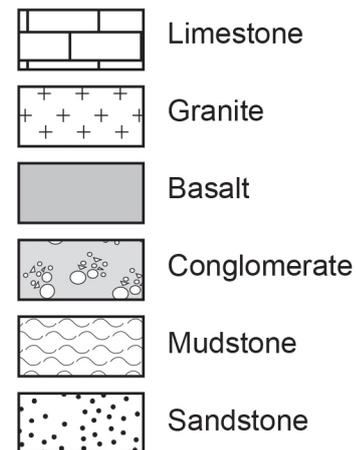
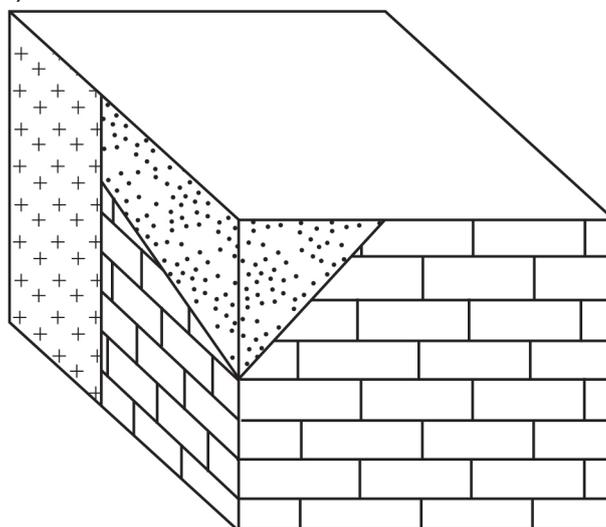
(i)

(2 marks)



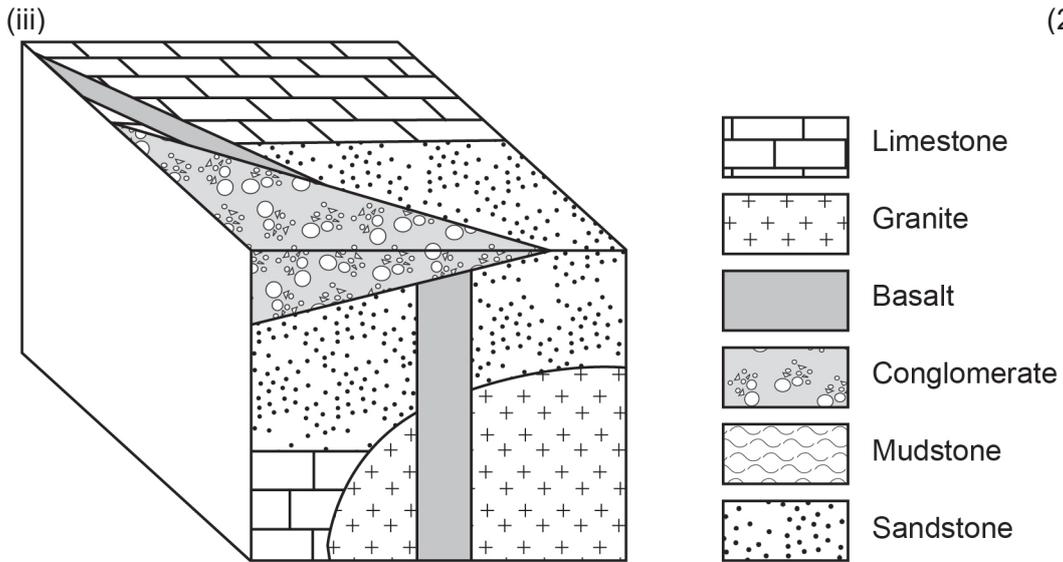
(ii)

(2 marks)



See next page

(2 marks)



(b) Using the relationships shown on the three block diagrams, place the stratigraphic units in order of age from youngest to oldest. (3 marks)

1. Youngest _____
2. _____
3. _____
4. _____
5. _____
6. Oldest _____

(c) The conglomerate has an unconformable relationship at its base. Describe the sequence of geological processes that produced this relationship. (2 marks)

Question 17

(12 marks)

Many rocks contain chemical and physical elements that vary in response to contemporary environmental conditions, locking in records that can be read by modern analysis to show how temperature and other aspects of climate have varied through geological time.

- (a) Explain how **two** different natural processes can affect global temperature on geological timescales. (6 marks)

One: _____

Two: _____

- (b) Identify and explain how a geological or prehistoric record can be used to show the occurrence of climate change over timescales outside the range of human history. (4 marks)

- (c) Describe **one** way in which warming or cooling of the Earth can alter the distribution of plant and animal species. (2 marks)

Question 18

(13 marks)

Western Australia's Archaean geology hosts a diverse range of non-renewable mineral resources that bring significant financial gain to the State, but the extraction and refining of these resources can also present a range of environmental challenges.

Ore deposits can be formed by a range of magmatic processes including gravitational settling, fractional crystallisation and immiscible liquid separation.

- (a) Explain how any **one** magmatic process can produce an ore body, using a diagram to aid your explanation. (5 marks)

Ore minerals can also be deposited by hydrothermal processes.

- (b) Identify a source of water that might be capable of producing an ore deposit. (1 mark)

- (c) Explain how water from the source identified in part (b) could produce an ore deposit. (3 marks)

- (d) Describe **one** major environmental impact caused by or associated with the mining of a specific ore resource. Outline a method of environmental protection that is or could reasonably be applied to reduce this impact. (4 marks)

Ore resource: _____

Environmental impact: _____

Environmental protection method: _____

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See next page

Question 19

(14 marks)

Farmers typically apply nitrogen-rich fertilisers to their land to replenish nitrogen lost through the production of crops. Once the fertiliser is applied, it may enter local waterways and tributaries, particularly after a rain event, leading to eutrophication.

- (a) Define the term 'eutrophication'. (2 marks)

- (b) Describe the impact that eutrophication of a lake would have on light penetration through the water. (2 marks)

- (c) Identify **two** common physical signs that a body of water has been affected by eutrophication, other than its effect on light penetration. (2 marks)

One: _____

Two: _____

Question 19 (continued)

Table 1 shows the nutrient levels recorded in water samples taken from two different locations along the Swan River and Table 2 shows the aquatic condition classifications.

Table 1: Concentration of nutrients identified across two Swan River sites

Site	Concentration (mg per litre)		
	Nitrate	Ammonia	Reactive phosphorous
A	2.4	0.06	0.16
B	12.3	0.7	0.21

Table 2: Typical levels of selected water quality parameters for ecosystems classified as natural, moderately degraded and severely degraded

Aquatic condition	Concentration (mg per litre)			
	Nitrate	Ammonia	Reactive phosphorous	Biological oxygen demand
Natural	<3.0	<0.2	<0.1	<2.0
Moderately degraded	3.0–10	0.2–5.0	0.1–0.2	2.0–6.0
Severely degraded	>10	>5.0	>0.2	>6.0

Note: An ecosystem is classified on the basis of its most degraded measurement.

Use the information in both tables to answer the following parts of this question.

- (d) Classify the aquatic conditions of Sites A and B and state the nutrient measurement(s) that led to your classification. (4 marks)

Site A: _____

Site B: _____

- (e) List **two** characteristics of the aquatic plant life you would expect at Site B. (2 marks)

One: _____

Two: _____

- (f) Identify a remediation strategy that could reduce the effects of eutrophication in an affected water body and state the benefit of using this strategy. (2 marks)

Strategy: _____

Benefit: _____

Question 20

(14 marks)

The 2019 United Nations Climate Change Action summit delivered a vision for the global response required to address climate change for 2020 and beyond.

- (a) Using your understanding of human-produced greenhouse gases, explain **two** ways in which an increased demand for, and production of, food has contributed to increased methane concentrations in the atmosphere. (6 marks)

One: _____

Two: _____

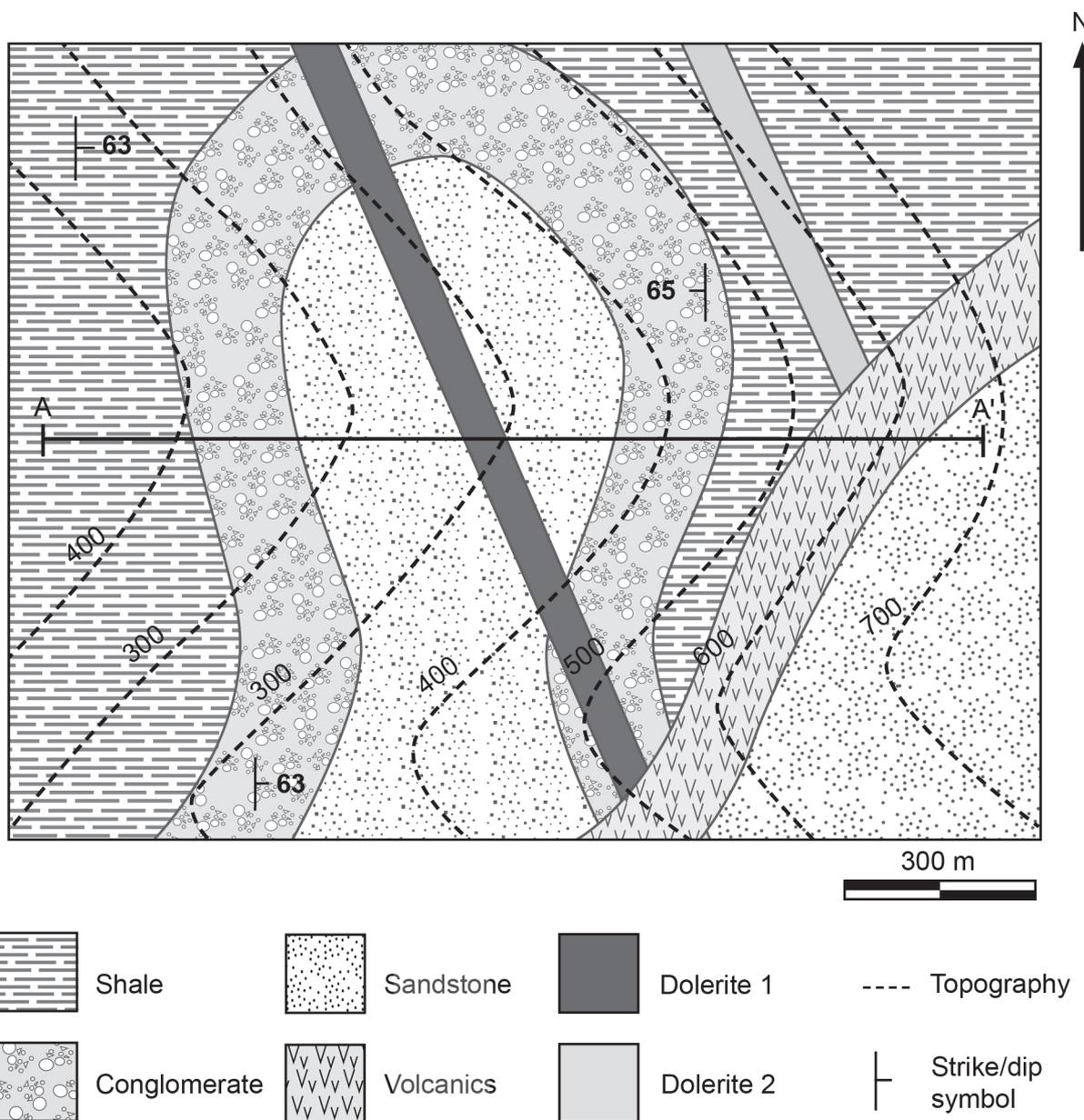
- (b) With the aid of a diagram, explain how increased greenhouse gases are contributing to climate change. (5 marks)

- (c) Identify and describe **one** way in which increasing global temperature is affecting the hydrosphere. (3 marks)

Question 21

(12 marks)

Use the map below to answer the following questions.



(a) Determine in degrees, the strike of Dolerite 1.

(1 mark)

- (b) Construct a cross-section of the region along the line A-A' on the section line provided below. Show the actual or inferred distribution of all lithologies cutting this section line down to sea level. Note: to assist you in transcribing data locations, you may remove page 45 by tearing along the perforations. (5 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.

- (c) Which is the oldest unit in this region? (1 mark)

- (d) Using your cross-section, determine how deep you would need to drill a vertical hole through the volcanics to intersect Dolerite 2. (1 mark)

Mineralisation has been located at the intersection of the Dolerite 2 dyke with the lower contact of the volcanics.

- (e) Describe **two** further exploration techniques that could assess the extent or grade of the deposit. (4 marks)

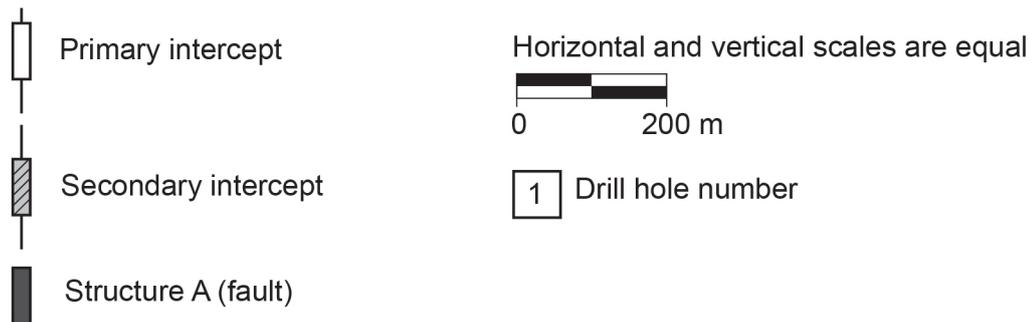
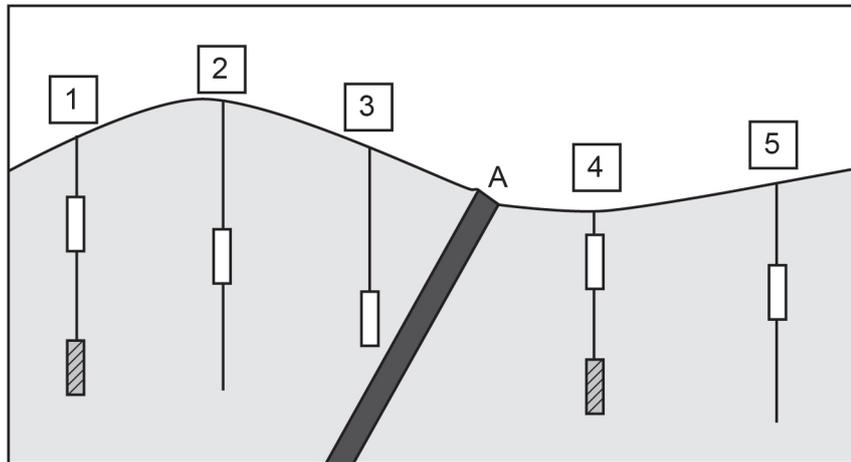
One: _____

Two: _____

Question 22

(13 marks)

A global mining company has identified a potential economic resource in a recent exploration drilling campaign. The significant mineralised intercepts have been marked on the cross-section shown below, as well as a number of secondary intercepts that may prove to be significant after further investigation.



- (a) On the diagram above, complete a geological interpretation of the ore deposit by modelling the upper and lower ore contacts for **both** the primary and secondary intercepts. (2 marks)
- (b) On the basis of the distribution of the inferred resource and the proximity to the surface of this deposit, describe the mining method that is best suited for the deposit. (2 marks)

- (c) Describe the impact of structure A on your deposit model and the corresponding plan for mining of the resource. (2 marks)

- (d) Using an identified exploration method, explain how the mining company could improve understanding of the extent and continuity of the secondary intercepts. (3 marks)

This new deposit is located close to an established township.

- (e) Describe **one** advantage and **one** disadvantage of this proximity. (4 marks)

Advantage: _____

Disadvantage: _____

Question 23

(11 marks)

Although not widely used in Australia, geothermal heat is used to supply warmth to homes and other buildings in many countries.

- (a) Describe the source of energy contained within a geothermal resource. (2 marks)

- (b) With the aid of a diagram, outline **one** method by which geothermal energy can be extracted from its source for use. (3 marks)

- (c) Identify any **three** factors, geographic, environmental and/or economic, that would be considered when evaluating the suitability of potential sites for geothermal energy production and state how they affect site selection. (6 marks)

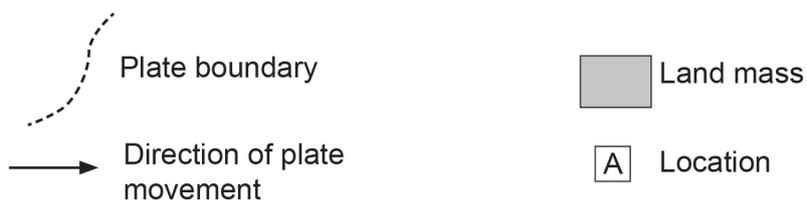
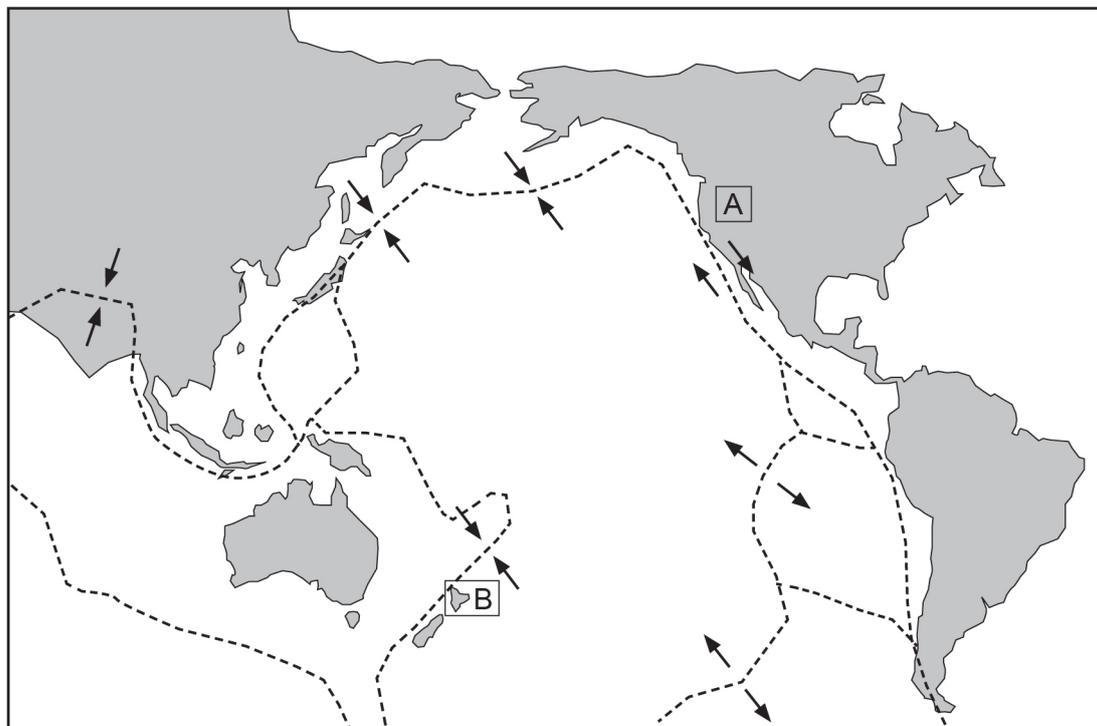
Factor	How site selection is affected
One:	
Two:	
Three:	

Question 24

(10 marks)

Tectonic plate movement plays a major part in both the occurrence and impact of natural geological hazards such as earthquakes, tsunamis and volcanic eruptions.

Consider the sketch map of tectonic plate interactions shown below.



(a) Identify **two** factors that influence plate movement. (2 marks)

One: _____

Two: _____

- (b) Complete the table below relating to potential hazards at Locations A and B. (4 marks)

	Location A	Location B
Natural hazard most likely to occur		Volcanic eruption
Type of plate boundary	Transform	
Mitigation technique that could be used to reduce risk to human life and infrastructure		

- (c) For each of Locations A and B, describe **one** way in which the hazard identified in the table above could affect the local environment. (4 marks)

Location A: _____

Location B: _____

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). For Question 25, write your answers in the spaces provided. For Question 26 or Question 27, write your answers on the lined pages 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)

Table A shows the population, in thousands, and the total fresh water use, in Western Australia (WA) in selected years from 1950 to 2010.

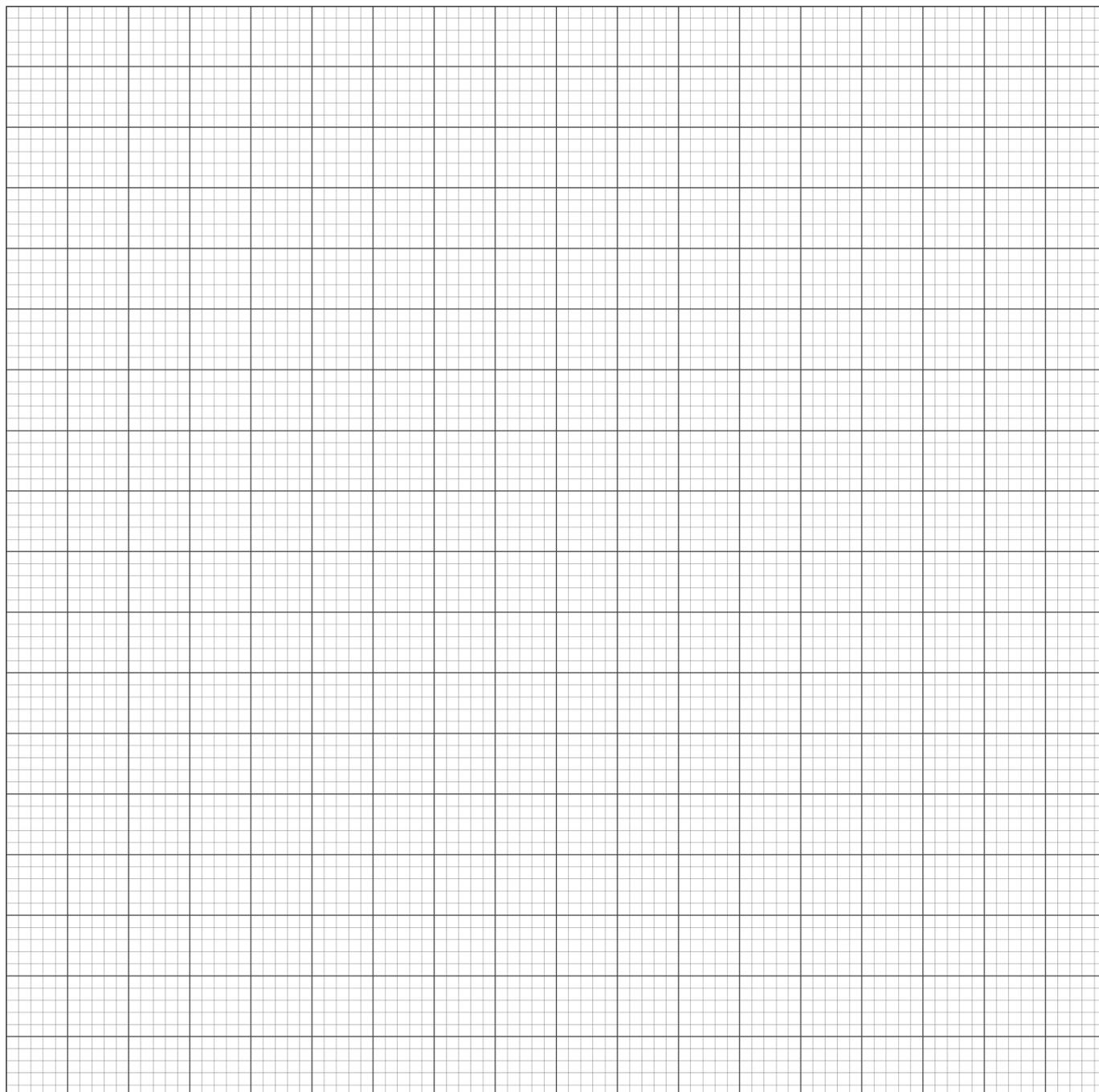
Table A

Year	1950	1960	1965	1970	1980	1990	2000	2010
Population of WA ('000)	602	700	750	1000	1280	1550	1880	2300
Total fresh water use in WA (Gigalitres, GL)	95	200	250	400	570	1150	1810	2420

(a) Using the grid provided on page 29, draw **one** line graph separately plotting population and total fresh water use over time. Extend your axis to the year 2030. (4 marks)

(b) State the relationship between changing total fresh water use and population in WA over the period recorded. Provide a probable reason for this relationship. (2 marks)

(c) Use your graph to predict the total fresh water use in WA for the year 2030, assuming the indicated trend continues. (1 mark)

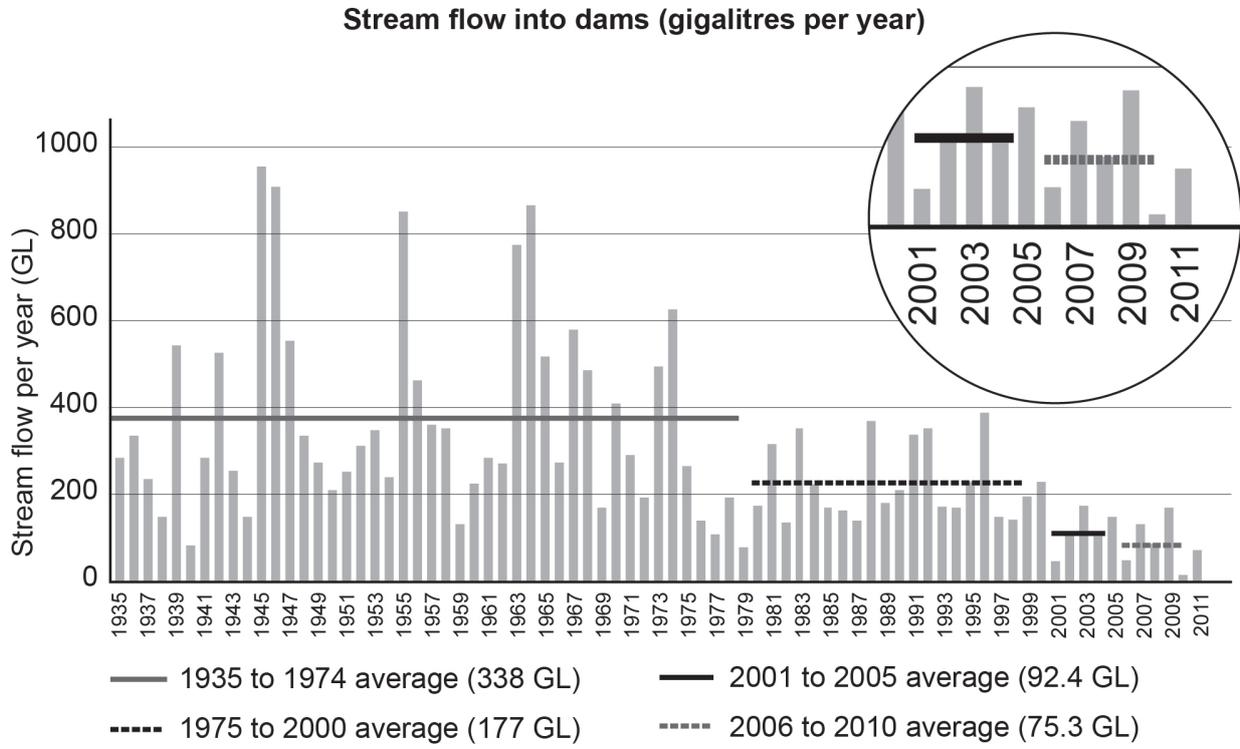


A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out this attempt and indicate that you have redrawn it on the spare grid.

See next page

Question 25 (continued)

The graph below shows variation in total stream flow into dams holding water for metropolitan Perth, where over 80% of WA's population live.



- (d) How should government respond to the trend in stream flow illustrated in the graph above, in light of the changing water demands shown in Table A? (2 marks)

Question 26

(15 marks)

The Australian bushfires in the summer of 2019–2020 burnt approximately 18.6 million hectares of farmland and natural habitat, and had a catastrophic impact on infrastructure and wildlife. Bushfires, however, are an intrinsic part of the Australian landscape and scientific studies have shown that they can produce beneficial impacts for some ecosystems.

- (a) Describe **two** climatic factors that might affect the frequency or severity of bushfires in Australia over the next 30 years. (4 marks)

- (b) Some Australian plant species have evolved to rely on bushfires for their long-term viability. Name an evolutionary adaptation and describe how it assists a plant's survival after fires. (3 marks)

- (c) Describe **two** ways in which bushfires might leave the local environment of affected areas vulnerable to further disturbance. (4 marks)

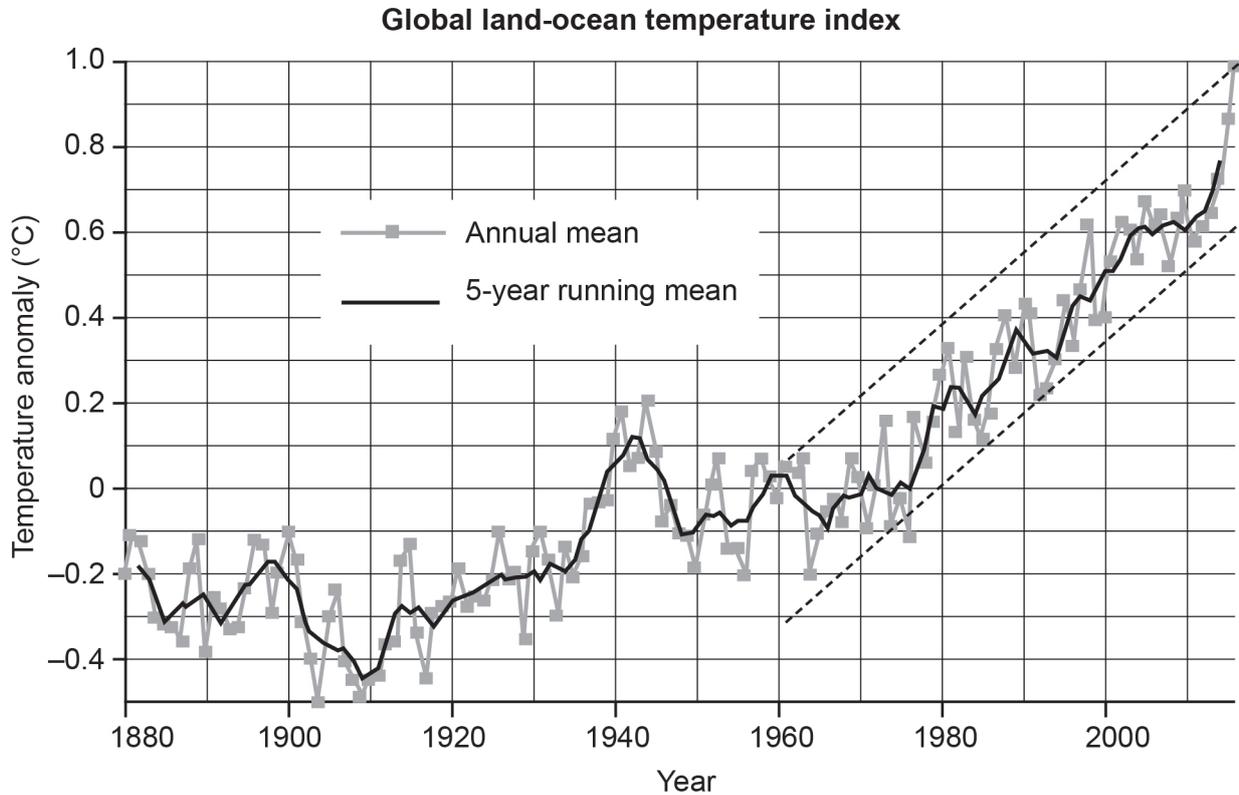
- (d) Although it may not be possible to entirely avoid them, the consequences of fire events on human society might be minimised by employing mitigation techniques. Describe **two** local or national strategies that could be used to reduce the risk to human life and infrastructure from bushfires. (4 marks)

or

Question 27

(15 marks)

Climate models assist in predicting future climate. The graph below shows the global land-ocean temperature index from 1880 to the present. This combines recordings from individual sites on both land and sea into a single value for a given year, presented in terms of relative change from an historic baseline (temperature anomaly).



- (a) The temperature anomaly shown on the graph increases rapidly between 1960 and the present day. Describe a probable cause for this increase. (2 marks)
- (b) Identify **two** possible causes for the short-term (yearly) variability observed in global temperatures. (2 marks)
- (c) Describe how the climate change trend illustrated in the graph above might affect **two** physical or biological systems. (4 marks)
- (d) For **one** of the changes identified in part (c), describe and provide an example of the potential impact of this change on a human population and a possible strategy for mitigating this impact. (4 marks)
- (e) Explain how a specific technological, environmental, social or political approach could support meeting a global target of net zero greenhouse gas emissions by 2050. (3 marks)

End of questions

Spare section line



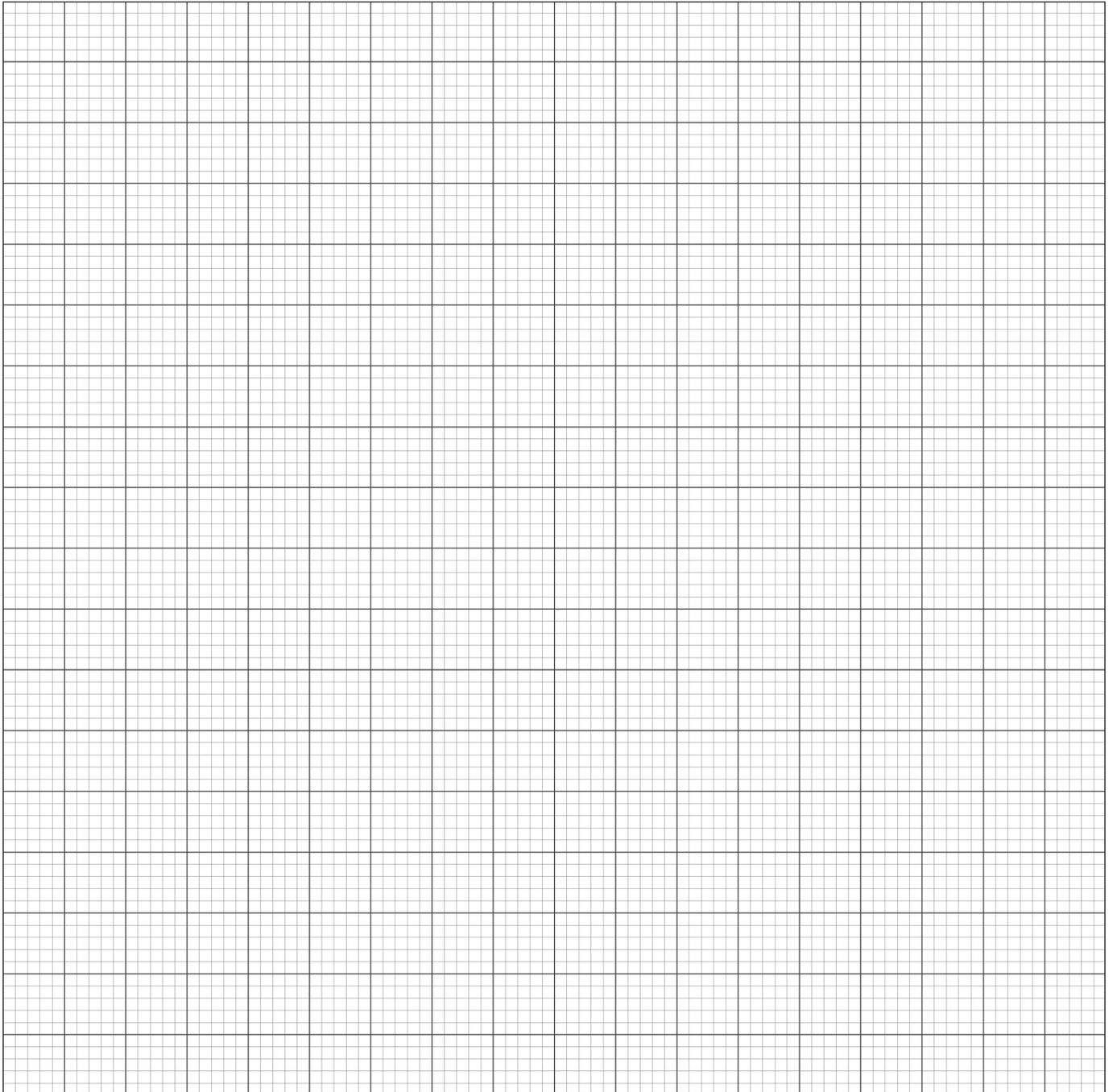
You may tear along the perforations to use this page (to transcribe strata locations for Question 21).

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 24).

This page is to be used for transcribing strata locations only

Spare grid



ACKNOWLEDGEMENTS

- Question 13** Adapted from: Intergovernmental Panel on Climate Change (IPCC). (2007). Concentrations of greenhouse gases from 0 to 2005 (FAQ 2.1, Fig. 1) [Graph]. *AR4 climate change 2007: The physical science basis* (p. 135). Retrieved June, 2020, from <https://www.ipcc.ch/report/ar4/wg1/changes-in-atmospheric-constituents-and-radiative-forcing/>
- Question 25** Adapted from: Water Corporation. (2011). Historical annual streamflows into Perth dams (Gigalitres per year) [Graph]. *Water forever: Whatever the weather* (p. 2). Retrieved June, 2020, from <https://www.watercorporation.com.au/-/media/WaterCorp/Documents/Our-Water/Sustainability-and-Innovation/Securing-Supply/Perth-10-year-water-supply-strategy.pdf>
- Question 27** Adapted from: Climate Council. (n.d.). *Global land ocean temperature index* [Graph]. Retrieved June, 2020, from <https://www.climatecouncil.org.au/resources/global-land-ocean-temperature-index/>

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