



ATAR course examination, 2017

Question/Answer booklet

EARTH AND ENVIRONMENTAL SCIENCE

Please place your student identification label in this box

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, non-programmable calculators approved for use in this 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	10	10	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 2017*. 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. 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 the use of planning/continuing your answer to a question have been 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. 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 one of the following lists is made up of renewable resources that provide provisioning services in the ecosystems of which they are a part?
 - (a) hydrocarbons, wind, sunlight
 - (b) food, water, timber
 - (c) carbon sequestration, oxygen, rainfall
 - (d) regulating services, nitrogen cycling, grass

2. Which one of the following could be used to provide a geological record of climate change?
 - (a) identifying changes in the distribution of fossil plant and animal species over time
 - (b) measuring the CO₂ content in air bubbles trapped in ice
 - (c) collecting and identifying pollen and plant spores present in a geological sample
 - (d) all of the above

3. Milankovitch cycles are used to model and predict patterns of climate change. What are these cycles?
 - (a) variations in the character of the Earth's orbit around the Sun
 - (b) variations in the output of solar radiation from the Sun
 - (c) changes in airflow in the lower atmosphere
 - (d) cyclical changes in the magnitude and direction of tectonic plate velocities

Questions 4–6 relate to a scenario that describes an investigation into the implications of a planned mine development.

4. As part of the planning for a new open-pit mine, an environmental risk assessment (ERA) is to be carried out. Which one of the following **best** describes the main aim of an ERA?
 - (a) to determine the least expensive way of protecting the environment
 - (b) to reduce the number of members of the public concerned about a project
 - (c) to compare the economic benefits of an activity against possible damaging effects of this activity on the environment
 - (d) to assess whether an activity will have any adverse effects on the environment in which it occurs

See next page

5. A leading scientist states that the open-pit development for the proposed mine, which is located within a wetlands system, must be ecologically sustainable. This means that the development
- (a) must be planned without compromising the environmental needs of future generations.
 - (b) must be planned in a way that takes the ecology of the area into account.
 - (c) must not affect the wetlands system in any way.
 - (d) cannot proceed.
6. Prior to the mine's development and over the three years following its completion, scientists monitored the bird life in the surrounding wetlands area by randomly sampling the population levels of different bird species. The results of this study are summarised in the table below.

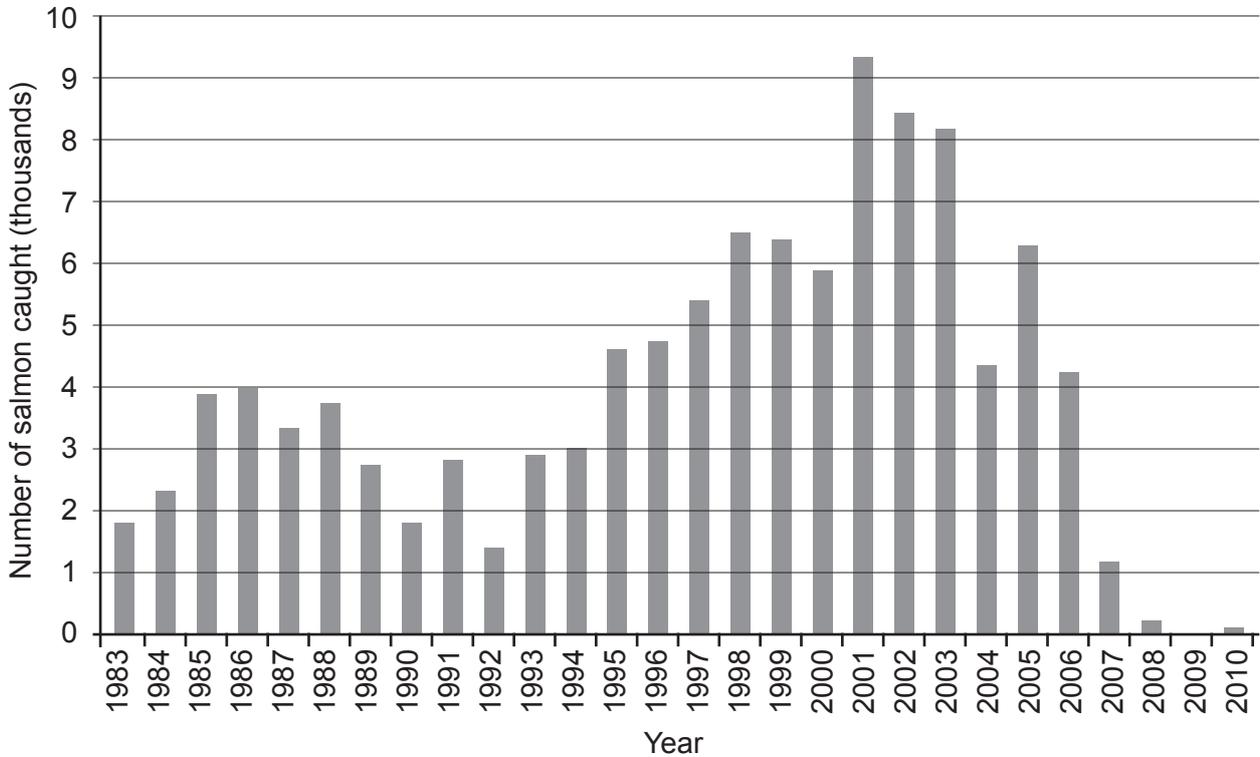
Species	Population level			
	Prior to mine	After 1 year	After 2 years	After 3 years
A	500	300	200	100
B	900	300	200	50
C	200	350	550	850

- The percentage change in the total number of birds from the three species studied in the wetland area over the three-year period is closest to a
- (a) 40% decrease.
 - (b) 45% increase.
 - (c) 140% increase.
 - (d) 15% decrease.
7. The forces that cause tectonic plates to move away from one another are **mostly**
- (a) isolated in spots of intense tectonic activity called 'hot spots'.
 - (b) associated with lines of active volcanoes surrounding the Pacific Ocean known as the 'Ring of Fire'.
 - (c) experienced beneath ridges that extend for long distances across the ocean floor.
 - (d) generated by earthquakes located beneath high mountain ranges.
8. Ice cores can provide access to samples of the gases, pollen and other particles that were present in the atmosphere at different times in the past. Which one of the following methods is **most** likely to be able to determine the age of a sample collected from a core drilled from an ice sheet?
- (a) freshwater fossils preserved in the ice
 - (b) the presence of distinctive volcanic ash layers within the ice
 - (c) counting of the annual layers preserved in the ice
 - (d) measurement of the salt content in the water

9. Which one of the following is **least** likely to occur as a natural response to the enhanced greenhouse effect over the next several decades?
- (a) an increase in the flooding occurring on low-lying islands
 - (b) an increase in the frequency of record high temperatures
 - (c) a decrease in snow and ice cover on mountain ranges
 - (d) a decrease in the severity of tropical cyclones
10. The total area of land required to sustain the resource needs of a person or community is best described as their
- (a) biotic equivalent.
 - (b) ecological footprint.
 - (c) total carrying capacity.
 - (d) environmental impact.
11. A student exploring the geology of an area finds an exposure of well-bedded sandstone. Which one of the following lists of characteristics could she observe or measure in the field and record in her notebook?
- (a) the sorting and geochemistry of the sand and the original way up of the beds
 - (b) the isotopic age, grain size and fossil content of the sediments
 - (c) the strike and dip of the beds and the grain size and colour of the sediments
 - (d) the age and sorting of the sediments and the oxygen isotope ratio of any quartz grains present
12. Scientific measurements indicate that sea levels have risen steadily by 225 mm over the past 100 years. The **most** likely cause is
- (a) a rise in the temperature of seawater.
 - (b) the melting of sea ice over the north polar region.
 - (c) the formation of new mountain ridges due to seafloor spreading.
 - (d) an increase in the number and power of severe hurricanes.
13. Which of the following human activities contribute to the enhanced greenhouse effect?
- (i) deforestation
 - (ii) electric power generation
 - (iii) travel in jet aircraft
 - (iv) the use of solar water heating
- (a) i and ii only
 - (b) i, ii and iii only
 - (c) ii, iii and iv only
 - (d) i, ii, iii and iv

Questions 14 and 15 relate to the graph below, which shows the recreational fishing harvest of Chinook salmon from the Sacramento River in California between 1983 and 2010.

**Recreational catch of Chinook salmon from the Sacramento River
between 1983 and 2010**



14. Which one of the following statements is **true** for the data shown?
- (a) The recreational salmon catch did not fall below 2000 fish between 1990 and 2000.
 - (b) The peak recreational salmon catch over the period recorded occurred in 2001.
 - (c) The recreational salmon catch has never exceeded 8000 fish.
 - (d) The recreational salmon catch decreased every year between 2001 and 2007.
15. Californian fishery management authorities declared a ban on salmon harvesting from the Sacramento River in 2008. On the basis of data shown in this graph, which one of the following was the **most** likely reason for this ban?
- (a) to enable scientists to study the fishery in an undisturbed state
 - (b) to allow the fishery management authority to sell higher quotas to commercial fishermen
 - (c) to allow the salmon fishery to recover
 - (d) to trial new methods of more efficient fish harvesting on the river

End of Section One

See next page

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See next page

Section Two: Short answer

55% (110 Marks)

This section has **10** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for the use of planning/continuing your answer to a question have been 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

(10 marks)

Seismic activity produced by the build-up and release of tectonic stress is one of the characteristic features of plate boundaries. The map below shows the distribution and variation in depth of earthquakes associated with an active plate boundary.

- (a) On the basis of the information provided, on the map below:
- mark the boundary between the two plates
 - draw arrows to show the relative direction of movement of the two plates with respect to one another. (3 marks)



- (b) In the space below, draw a simplified cross-section along the line B–C, illustrating the type of plate boundary that this represents. Show and label clearly the major features associated with this type of boundary on your diagram. (4 marks)



- (c) Explain why earthquake depth varies systematically across this type of plate boundary. (3 marks)

Question 17

(12 marks)

Mount Kilauea is an active volcano located in the middle of the Pacific Plate in the Hawaiian Islands, while Mount Cotopaxi is an active volcano on the west coast of South America, along the subduction boundary between the Nazca Plate and the South American Plate.

- (a) Explain how the differing tectonic conditions experienced at their respective locations give rise to **two** differences between the composition **or** physical characteristics of magma erupted at Mount Kilauea and Mount Cotopaxi. (4 marks)

- (b) State **two** methods that can be used to monitor or predict eruptive activity in volcanically-active regions. (2 marks)

One: _____

Two: _____

- (c) Outline how each of your stated methods responds to volcanic activity. (2 marks)

One: _____

Two: _____

- (d) Describe **two** methods (other than observing and monitoring volcanic activity) that can be used to prevent damage to life and property from a volcanic hazard. (4 marks)

One: _____

Two: _____

Question 18

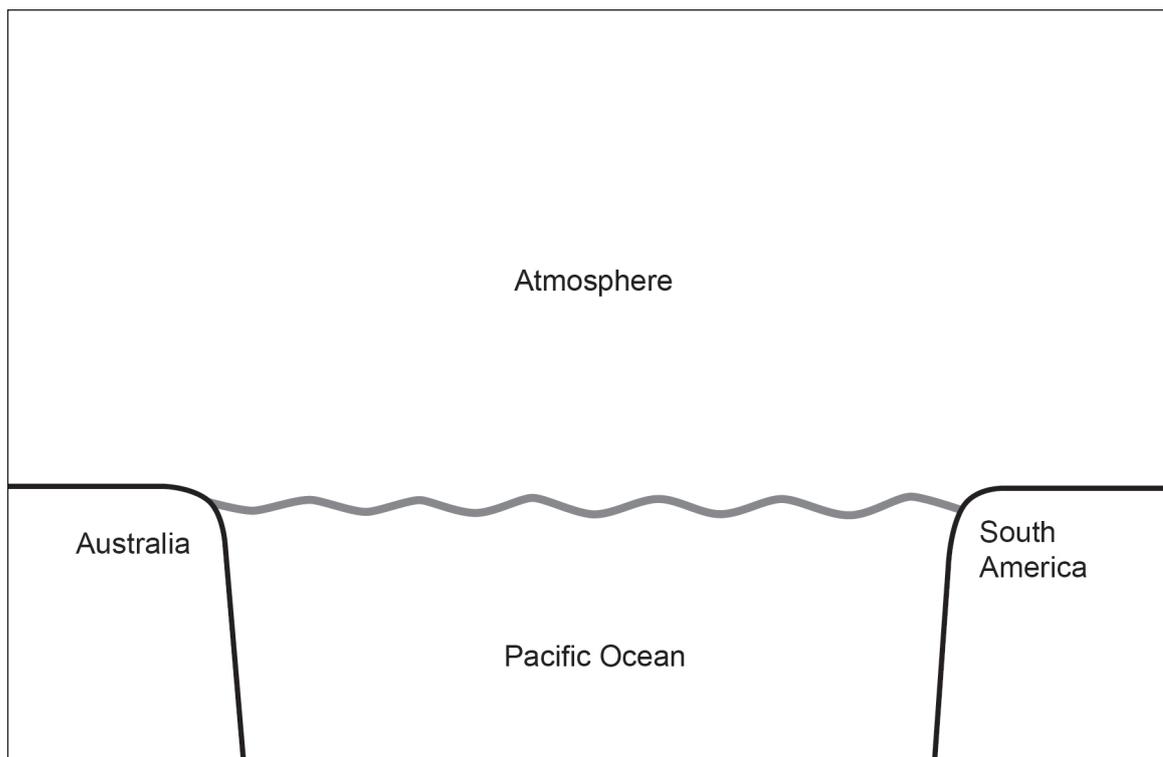
(11 marks)

Ocean currents play a key role in the global heat budget of the Earth, redistributing energy and mass over great distances.

(a) Complete the following diagram to show the **typical** circulation of water and air in the Pacific Ocean. Label your diagram to show:

- direction of surface currents
- general wind direction
- the areas of warmest water
- the location of upwelling deep ocean waters.

(4 marks)



(b) Describe the difference between the mechanisms that drive deep ocean currents and those that drive surface currents. (2 marks)

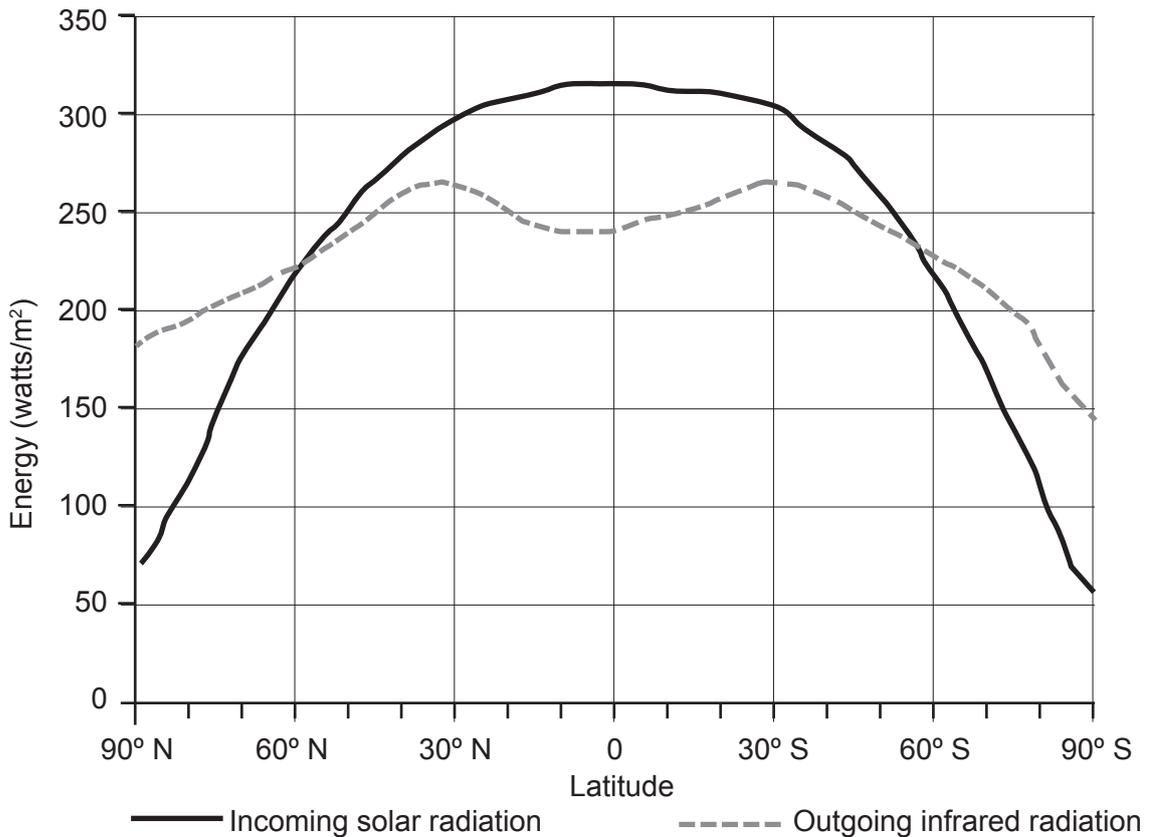
- (c) Name the **three** properties of the Earth's orbital motion that affect the distribution of solar radiation reaching any point on its surface. (3 marks)

One: _____

Two: _____

Three: _____

The diagram below shows the relative levels of thermal energy being received and emitted from the Earth at various latitudes.

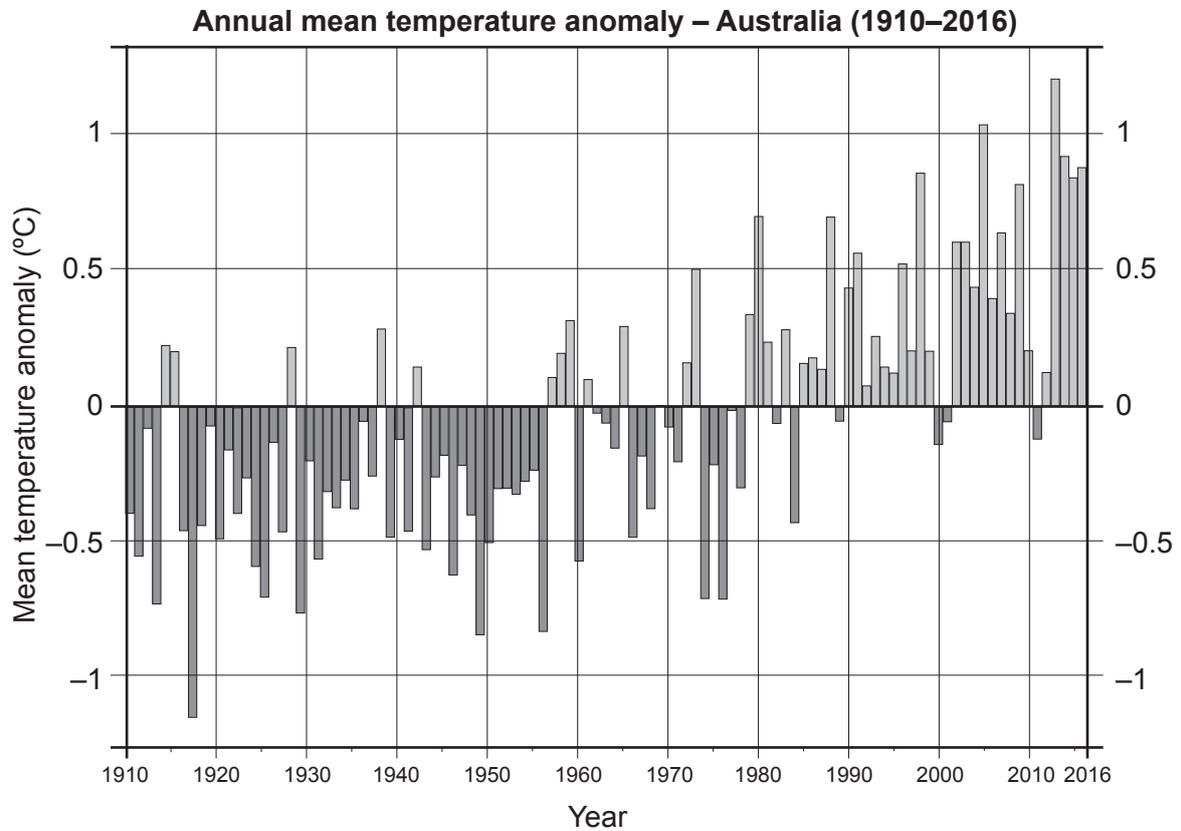


- (d) Using your knowledge of variations in solar radiation received and the transfer of heat by global circulation systems, explain why more heat is lost than received at latitudes higher than 60° N and 60° S of the Equator as shown in the graph above. (2 marks)

Question 19

(10 marks)

The graph below shows change in the mean annual temperature across Australia, expressed as variation (or anomaly) with respect to a 30-year average.



- (a) Describe **two** characteristics of the variation in temperature displayed between 1910 and 2016. (2 marks)

One: _____

Two: _____

- (b) Outline how human activities have caused **two** changes in the mix of gases in the Earth's lower atmosphere since 1910. (4 marks)

One: _____

Two: _____

- (c) Explain how **one** of these changes in atmospheric composition has influenced atmospheric temperature. (2 marks)

- (d) Describe **one** change in the hydrosphere that has resulted from change in atmospheric temperature over the past 100 years. (2 marks)

Question 20

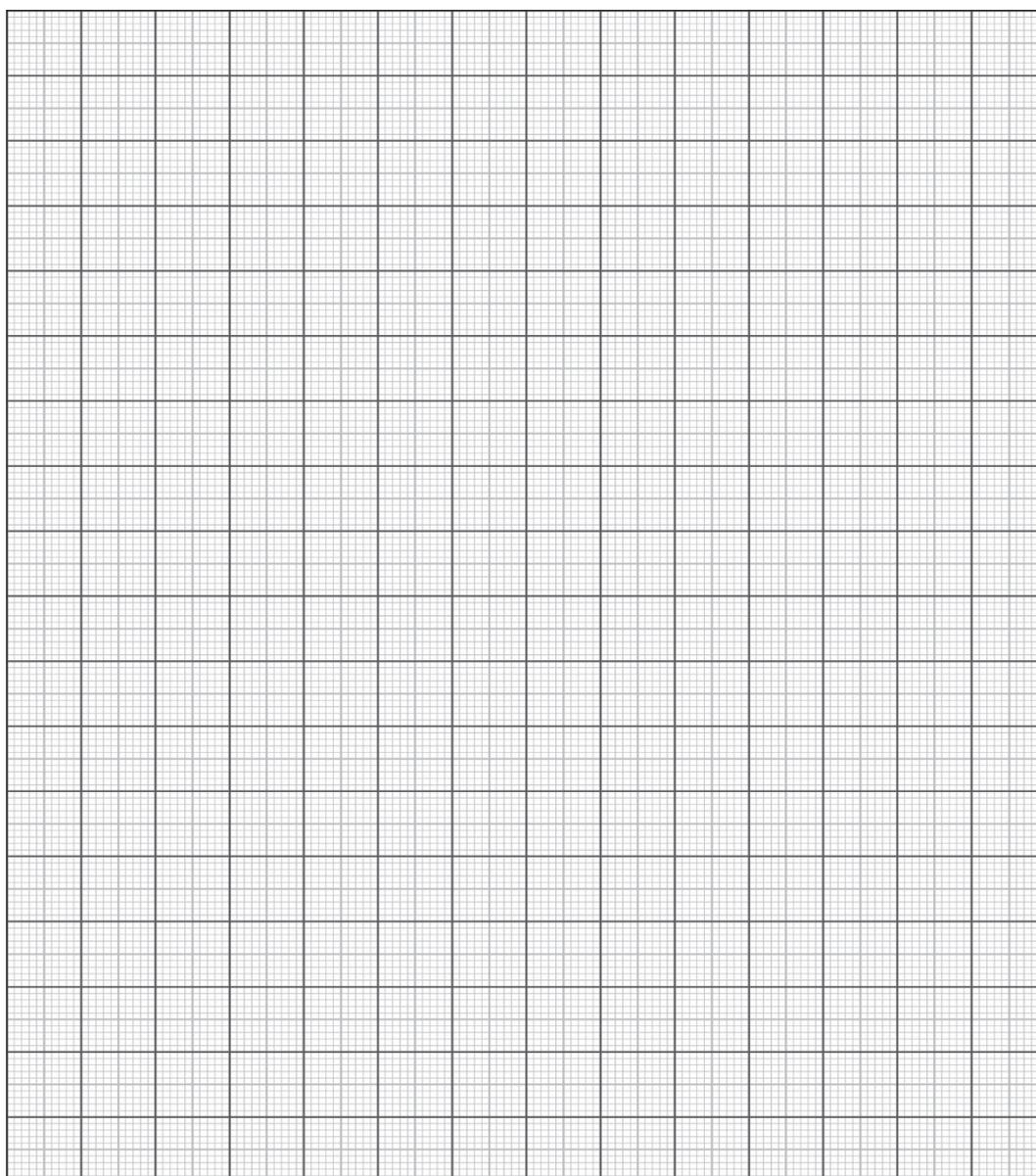
(12 marks)

Table A represents the amount of deforestation occurring in the Amazon rainforest in selected years between 1988 and 2015.

Table A

Year	1988	1991	1995	2000	2004	2005	2007	2009	2015
Area of deforestation occurring in the Amazon rainforest (thousands of km ²)	21	11	29	18	27	19	12	7.5	6

(a) Using the grid provided, draw a line graph of the data shown in Table A. (5 marks)



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

- (b) Describe **two** trends in the amount of deforestation over time. (2 marks)

One: _____

Two: _____

- (c) Based on the information provided, in which year did the greatest amount of deforestation occur? (1 mark)

Table B represents the **annual** percentage increase in the population of Brazil in selected years between 1988 and 2015.

Table B

Year	1988	1991	1995	2000	2004	2005	2007	2009	2015
Rate of population increase (%)	1.8	1.6	1.5	1.5	1.3	1.2	1.0	0.9	0.8

- (d) State **two** trends in population growth shown by the figures in Table B. (2 marks)

One: _____

Two: _____

- (e) Suggest a relationship that may exist between the data shown in Table B and those graphed on the previous page between 2004 and 2015. (2 marks)

- (c) Give **two** changes that occur in freshwater streams and lakes when large amounts of natural vegetation covering their catchment areas are cleared. (2 marks)

One: _____

Two: _____

Many freshwater lakes obtain their water from aquifers that are close to the surface. The volume of water in these lakes increases and decreases as the levels of the aquifers change.

- (d) Describe the natural process by which water makes its way into near-surface aquifers and in turn increases the volume of water in lakes that they feed. (3 marks)

Question 22

(12 marks)

- (a) Complete the table below showing the relationship between metamorphic rock types and their protoliths. (4 marks)

Protolith	Metamorphic rock type
Limestone	
	Quartzite
Shale	
Granite	

- (b) During fieldwork, a student finds an outcrop of a metamorphic rock (Lithology A). After careful evaluation he describes this in his notebook as ‘a garnet-bearing quartzofeldspathic schist’. List **three** characteristics that he must have been able to observe about the nature of the rock to make this description. (3 marks)

One: _____

Two: _____

Three: _____

- (c) Another student exploring the geology of the same area comes across an outcrop of Lithology B which is a lower-grade metamorphic equivalent of Lithology A. Describe **three** characteristics she might observe in this rock type that would be different from those of Lithology A. (3 marks)

One: _____

Two: _____

Three: _____

- (d) On the basis of your suggested characteristics, give a valid name for Lithology B and indicate a distinctive mineral that you might expect to find in it. (2 marks)

Name: _____

Mineral: _____

Question 23

(11 marks)

The United States Geological Survey agency estimates that millions of earthquakes occur around the world every year. Many of these do no damage at all but others can be devastating to human infrastructure and life.

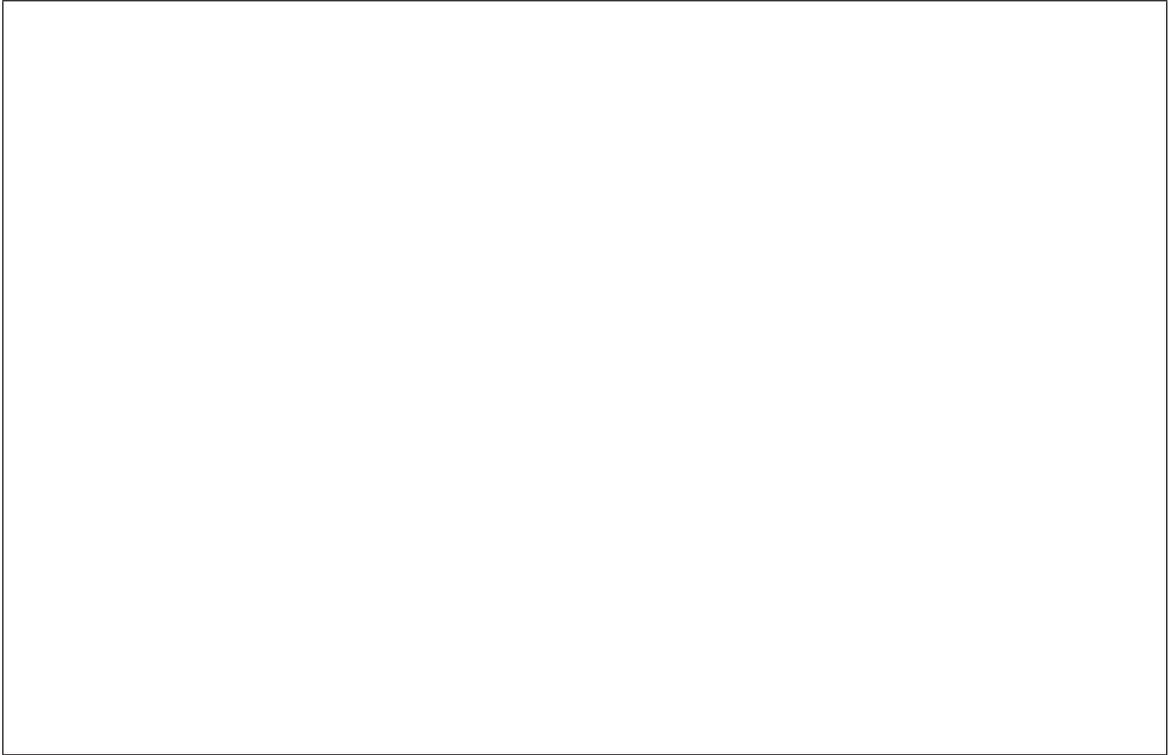
- (a) Describe how **two** different aspects of an earthquake's character, location **or** setting will influence the level of damage it causes to housing, roads or other kinds of infrastructure. (4 marks)

One: _____

Two: _____

- (b) Describe **one** way in which the nature of the near-surface geology can influence the impact of earthquake activity on a locality. (2 marks)

- (c) Draw and label a diagram to illustrate **two** ways in which housing can be designed to reduce the risk of earthquakes to the inhabitants. (4 marks)



- (d) Outline **one** economic **or** social factor that might prevent your design suggestions from being implemented in some parts of the world. (1 mark)

Question 24

(10 marks)

There are many examples around the world of certain factors preventing desirable mineral resources from being developed into mines.

- (a) Describe how **two** geological aspects of a mineral deposit would influence a judgement on whether it was viable to extract the resource. (4 marks)

One: _____

Two: _____

- (b) Explain **one** way in which the geographical location of a mineral deposit could influence its economic viability. (2 marks)

- (c) Describe how **two** cultural **or** environmental factors could affect the viability of extraction of a mineral resource. (4 marks)

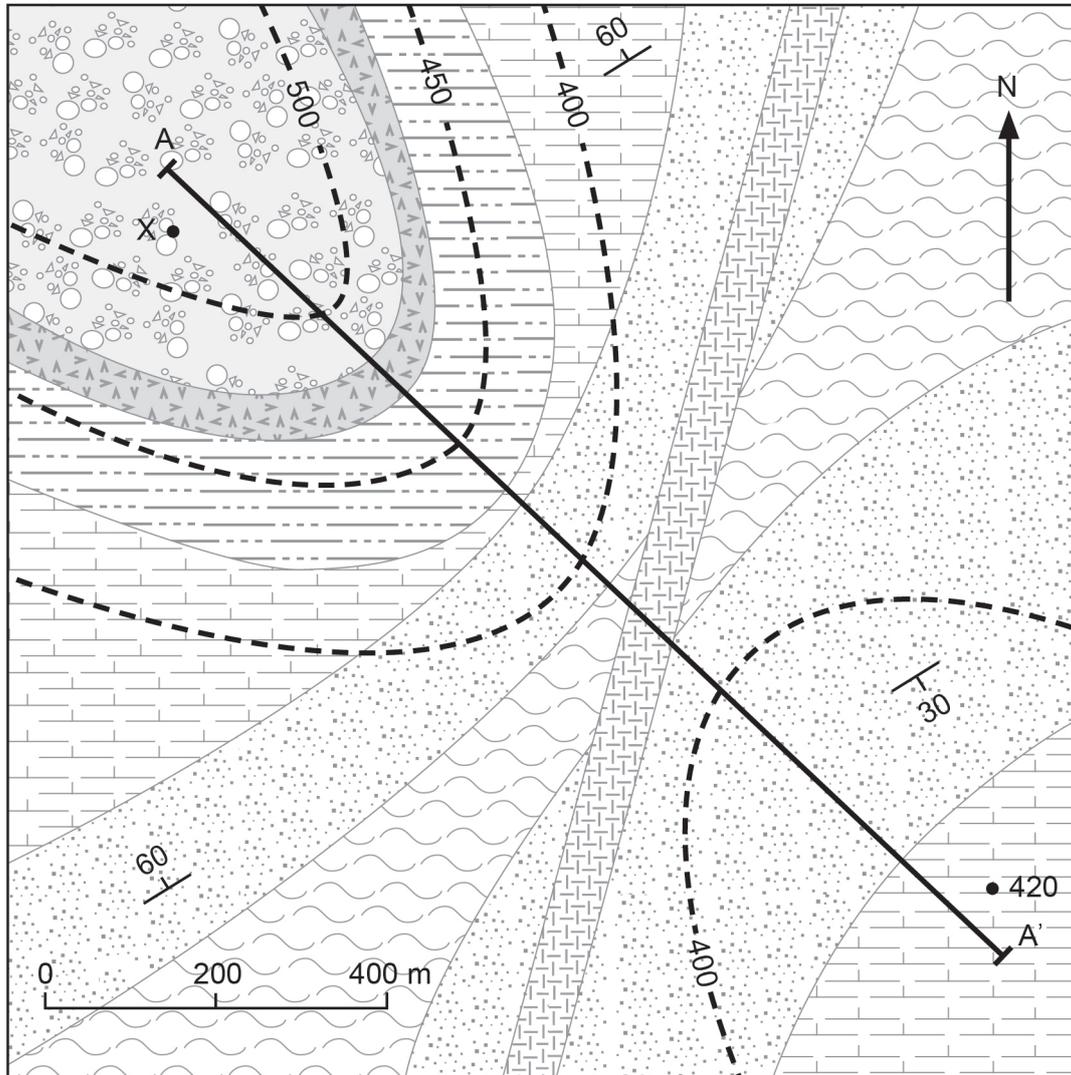
One: _____

Two: _____

Question 25

(11 marks)

The accompanying map displays the known geology of an area you are investigating. Use this map to answer the following parts of this question.



- Contour line
- 420 Spot height
- Geological contact
- 30 Strike and dip measurement
- All elevations given in metres
- Andesite
- Basalt
- Conglomerate
- Siltstone
- Limestone
- Quartz sandstone
- Mudstone

See next page

- (a) Produce 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 from an elevation of 250 m to an elevation of 550 m above sea level. Note: to assist you in transcribing strata locations, you may remove page 41 by tearing along the perforations. (5 marks)



- (b) Imagine that you were going to drill a 250 m deep hole at point X on the map. Your hole would start in the conglomerate unit. List in order, the next **three** lithologies you would encounter as you drilled deeper. (3 marks)

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

- (d) The geologist who produced this map was not sure whether the basalt encountered in the north-west of the region was an intrusive sill or an extrusive flow. Suggest **two** pieces of evidence you could look for to test which of these alternatives was true. (2 marks)

One: _____

Two: _____

End of Section Two

See next page

Section Three: Extended answer

30% (30 Marks)

This section contains **three (3)** questions. You must answer **two (2)** questions: the compulsory question (Question 26) and **one (1)** of the other questions (Question 27 **or** Question 28). Write your answers on the pages provided following Question 28.

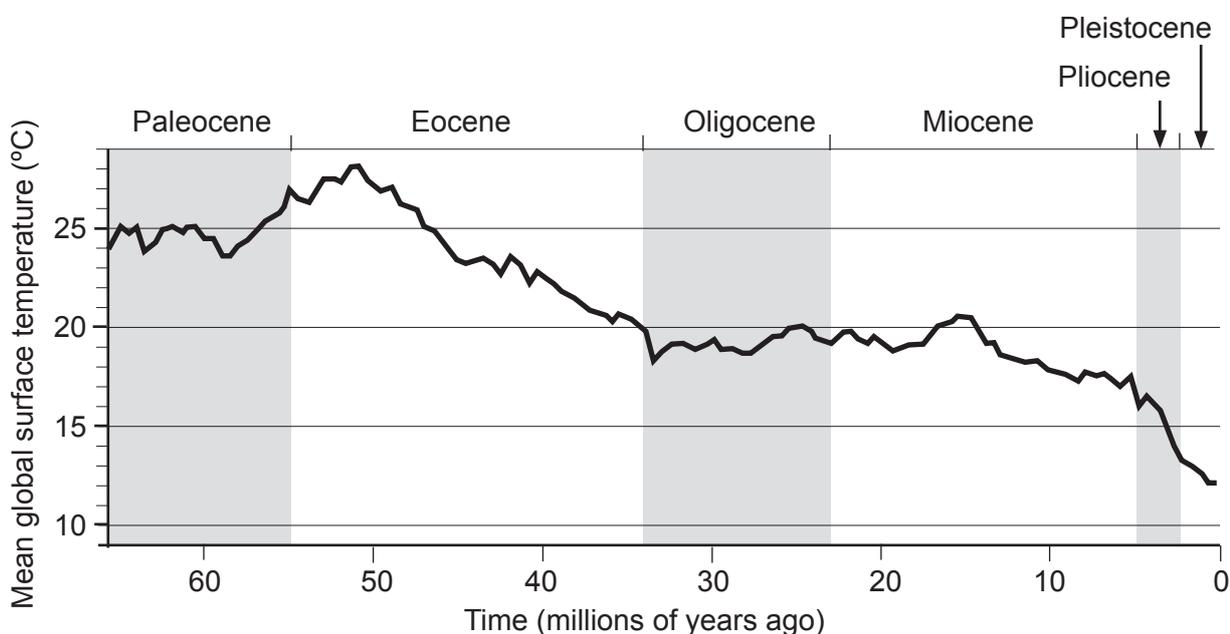
If you use a page for planning, indicate this clearly at the top of the page.

Suggested working time: 60 minutes.

Question 26 (compulsory)

(15 marks)

- (a) The graph below shows a compilation of global temperature estimates throughout the Cenozoic Era. Describe a short-term trend and a long-term trend in temperature apparent throughout this interval. (2 marks)



- (b) Using your knowledge of how natural processes contribute to global climate change, explain **two** possible causes of this Cenozoic temperature variation. (4 marks)
- (c) Using specific examples, discuss how geological and prehistoric records can be used to demonstrate the effects of climate change over time scales outside the range of human history. (5 marks)
- (d) Discuss how warming and cooling affect the hydrological system of the Earth and the related distribution of plant and animal species. (4 marks)

Question 27**(15 marks)**

Most people who live in a small island nation are very poor and live by catching fish, hunting and collecting resources in the forests and by growing food on tiny plots of land. Their government has ambitious plans to develop and exploit local resources in a short time scale to improve the living standards of the population.

You work for an organisation which provides advice on issues related to the impact of rapid development on local renewable resources. You have been approached by the government of the island to advise them on three proposals it has to develop their economy. For **each** proposal you are required to produce a short report:

- outlining **three** likely impacts of the proposal on the island's renewable resources
- describing **one** way that the government could place limits on the proposal to ensure the future of the renewable resources.

The three proposals are:

- (a) Replace the islanders' small fishing boats with modern boats using drag nets that can find and catch 1000% more fish each day. (5 marks)
- (b) Use open-cut techniques to mine the large coal reserves located below the crop-growing land to fuel a large coal-fired power station. (5 marks)
- (c) Clear all of the undisturbed forest using heavy equipment and then burn the vegetation to create space in which to grow one commercial crop. (5 marks)

or

Question 28**(15 marks)**

The extraction and refining of non-renewable mineral resources can bring significant financial gain, but also present a range of environmental challenges.

- (a) Name **one** specific non-renewable mineral deposit and describe how that deposit was formed. (4 marks)
- (b) Describe **one** geophysical and **one** geochemical technique that might be used to search for resources such as the one you describe above and indicate how each technique would demonstrate the presence of the resource. (6 marks)
- (c) What are the environmental impacts of the **two** exploration techniques you specify in part (b)? (2 marks)
- (d) Give **one** major environmental issue caused by or associated with the mining of the deposit named in part (a) and outline a method of environmental protection that is (or could reasonably be) applied to reduce its impact. (3 marks)

End of questions

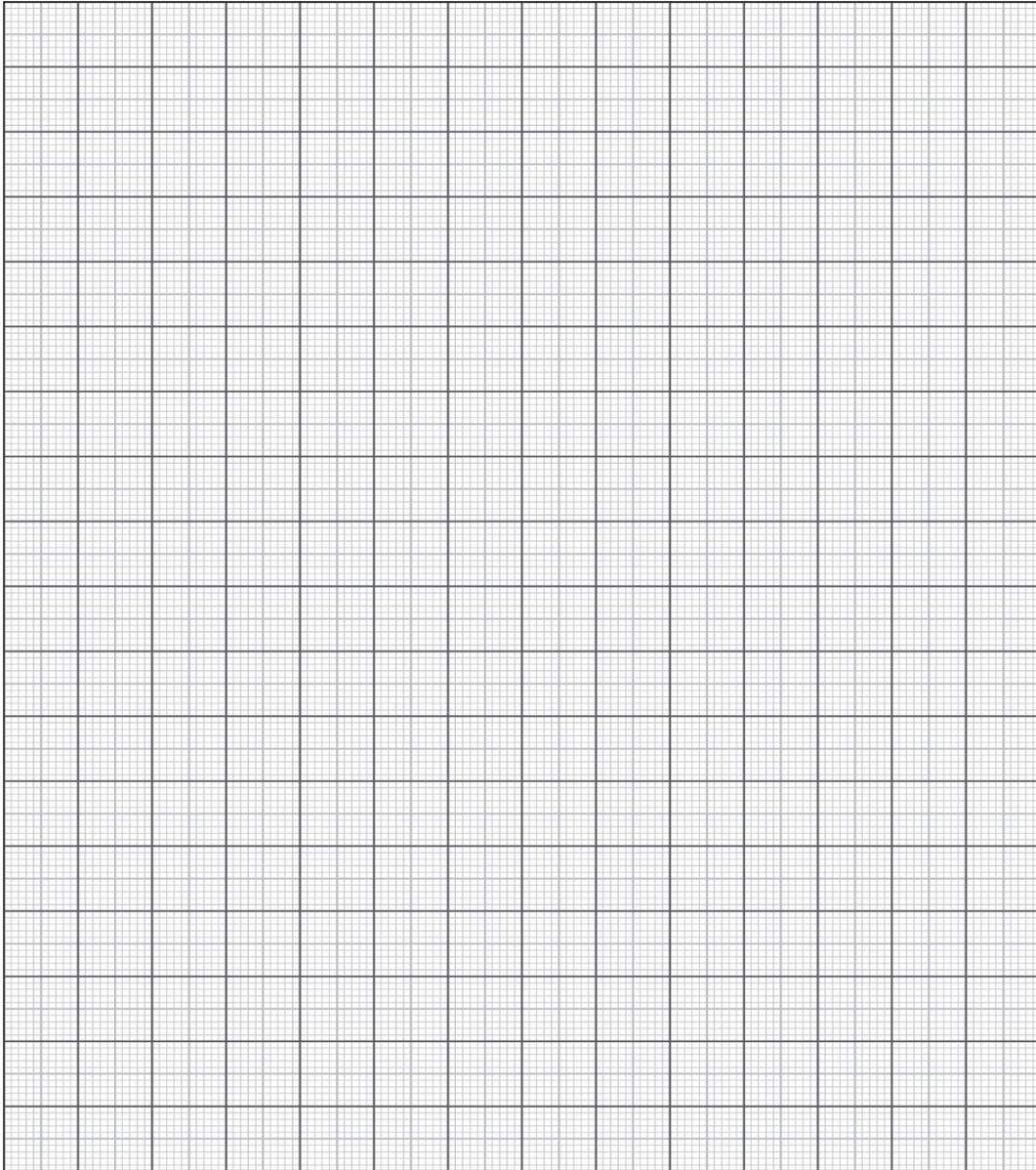
You may tear along the perforations to use this page (to transcribe strata locations for Question 25).

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 25).

This page is to be used for transcribing strata locations only

Spare grid



ACKNOWLEDGEMENTS

- Question 14 & 15** Data source: Winship, A. J., O'Farrell, M. R., & Mohr, M. S. (2012, February 28). *Management strategy evaluation for Sacramento River winter Chinook salmon*. Retrieved April, 2017, from www.pccouncil.org/wp-content/uploads/SRWC_MSE_2012_02_28.pdf
- Question 18(d)** Diagram adapted from: Pidwirny, M. (n.d.). *Fundamentals of physical geography* (2nd ed.) (Ch. 7, fig. 7j-1). Retrieved August, 2017, from <http://www.physicalgeography.net/fundamentals/7j.html>
- Question 19** Bureau of Meteorology. (2016). *Mean temperature anomalies averaged over Australia (as calculated from the 1961–1990 average)* [Graph]. Retrieved May, 2017, from www.bom.gov.au/climate/current/annual/aus/#tabs=Temperature
Used under Creative Commons Attribution 3.0 licence.
- Question 20(a–c)** **Table A & Table B**
Data source: Hansen, M. C., et al. (2013). High-resolution global maps of the 21st-century forest cover change. *Science*, 342, 850–853.
- Question 26** Data source: USGS Geo Data Portal. (n.d.). *Global temperature estimates throughout the Cenozoic Era*. Retrieved April, 2017, from <https://cida.usgs.gov/gdp/>

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