



EARTH AND ENVIRONMENTAL SCIENCE

ATAR course examination 2017

Marking Key

Marking keys are an explicit statement about what the examining panel expect of candidates when they respond to particular examination items. They help ensure a consistent interpretation of the criteria that guide the awarding of marks.

Section One: Multiple-choice

15% (15 Marks)

Question	Answer
1	B
2	D
3	A
4	D
5	A
6	A
7	C
8	C
9	D
10	B
11	C
12	A
13	B
14	B
15	C

Section Two: Short answer

55% (110 Marks)

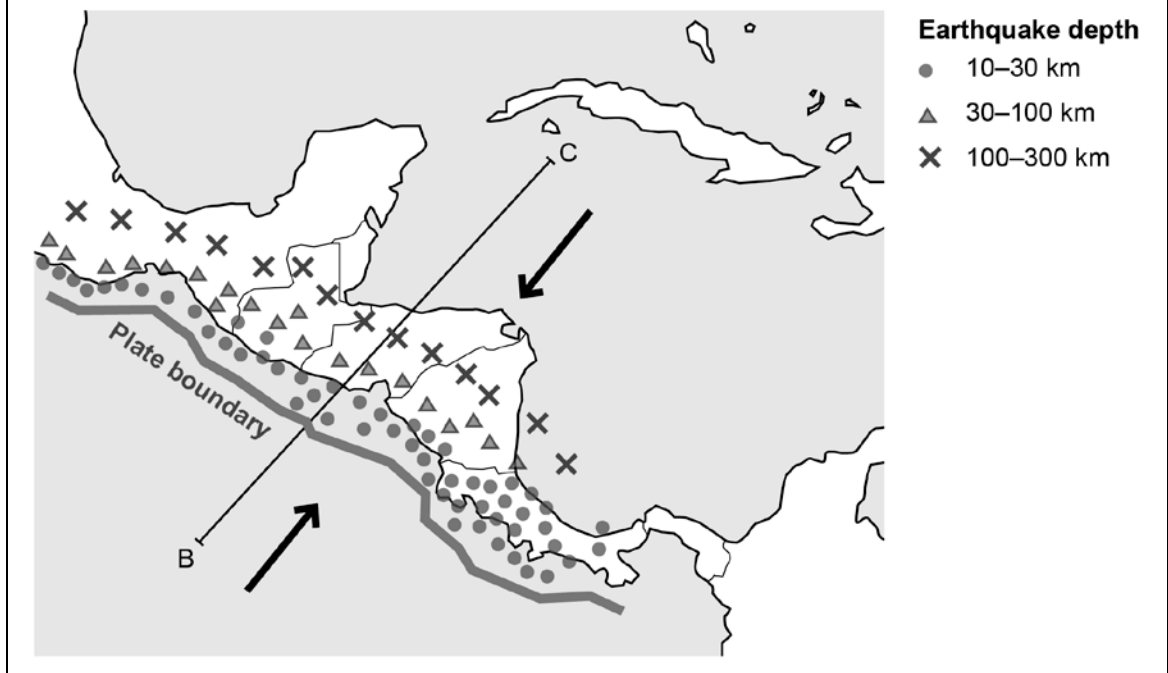
Question 16

(10 marks)

- (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)

Description	Marks
Plate boundary drawn to the south of the earthquake epicentres and following the coastline	1
One mark for each arrow correctly representing the relative movement of one of the two plates	1–2
Total	3

Example answer:

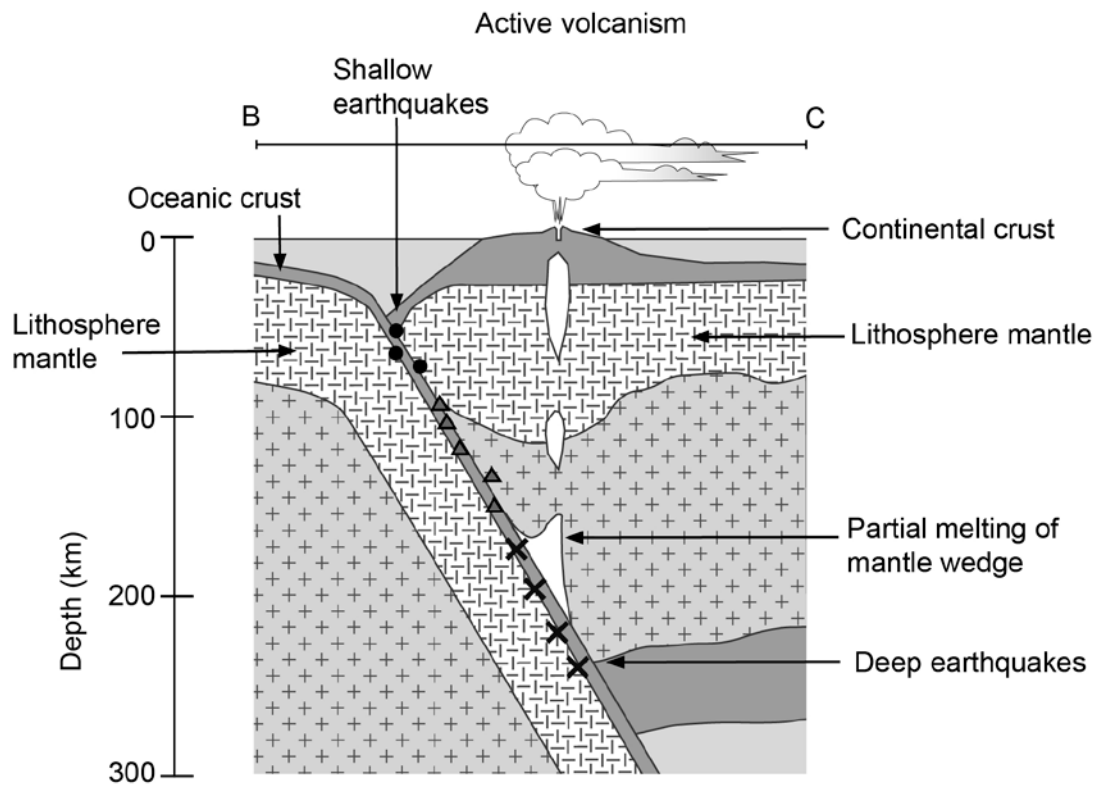


Question 16 (continued)

- (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)

Description	Marks
Clear representation of ocean-continent subduction conditions appropriate to the data presented	1
One mark for each specific appropriate feature included, up to a maximum of three. Features could include: Oceanic slab subducting beneath continental plate, presence of an oceanic trench, partial melting of the over-riding mantle wedge below c. 120 km, active volcanism	1-3
Total	4

Cross section example:



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

Description	Marks
Reference made to movement of plates and/or build-up of stress causing earthquakes	1
Recognition that the subducting plate is the host of deeper earthquakes, so that earthquakes move deeper as plate subducts	1
Good demonstrated understanding of plate movement and earthquake mechanisms and correct use of geological terminology	1
Total	3
<p>Example: Earthquakes are caused when the stresses built up in the plates by their movement with respect to one another become higher than their brittle strength. Earthquakes occur within the subducting plate as it moves down beneath the over-riding plate, resulting in a zone of earthquakes dipping down with the subducting plate to depths of 300 km or more</p>	

Question 17**(12 marks)**

- (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)

Description	Marks
One mark for each difference (maximum two marks) in physical or compositional characteristics of magma	1–2
Valid explanation of how this distinction arises from tectonic differences	1–2
Total	4
<p>Examples could include:</p> <ul style="list-style-type: none"> Hotspot magma (Kilauea) has a lower silica content than subduction zone magmas (Cotopaxi) This arises because hotspot magmas are derived from direct partial melt of the silica-poor mantle, while subduction zone magmas often evolve during their passage through the overlying crust <p>or</p> <ul style="list-style-type: none"> Hotspot magmas have a low volatile content, whereas subduction zone magmas are commonly volatile rich and explosive This arises because hotspot magmas are derived from dry partial melting of the mantle, whereas subduction zone melts incorporate water released during metamorphism of the subducting slab. 	

Question 17 (continued)

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

Description	Marks
One mark for each appropriate method stated	
Examples could include: <ul style="list-style-type: none"> • atmospheric monitoring of gases in the volcano crater • thermal imaging • seismic monitoring • installation and monitoring of tiltmeters • satellite imaging of eruptive plumes. 	1–2
Total	2

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

Description	Marks
One mark for each method appropriately explained	
Answers could include <ul style="list-style-type: none"> • Magma approaching the surface releases the volatiles dissolved within it. Change in the content of these volatile gases in the atmosphere around the volcano can thus reveal when fresh magma is approaching the surface and an eruption may be imminent • Magma carries up heat with it, so an increase in the temperature of a volcanic structure can indicate increased buildup of magma • Thermal imaging can also be used to monitor the distribution of active flows whose surfaces have cooled below red-hot • Movement of magma commonly requires the fracturing of host rock to open fluid pathways. This fracturing represents a small earthquake, so seismic monitoring can reveal when magma is moving within a volcano. 	1–2
Total	2

- (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)

Description	Marks
For each method	
Clear description of the basis and/or influence of the stated method on hazard prevention	2
Statement of a viable method relevant to prevention of volcanic hazard	1
Total	4
Answers could include: <ul style="list-style-type: none"> • education on volcanic hazards relevant to a particular area • public address systems to warn of imminent danger • development of emergency response plans. 	

Question 18

(11 marks)

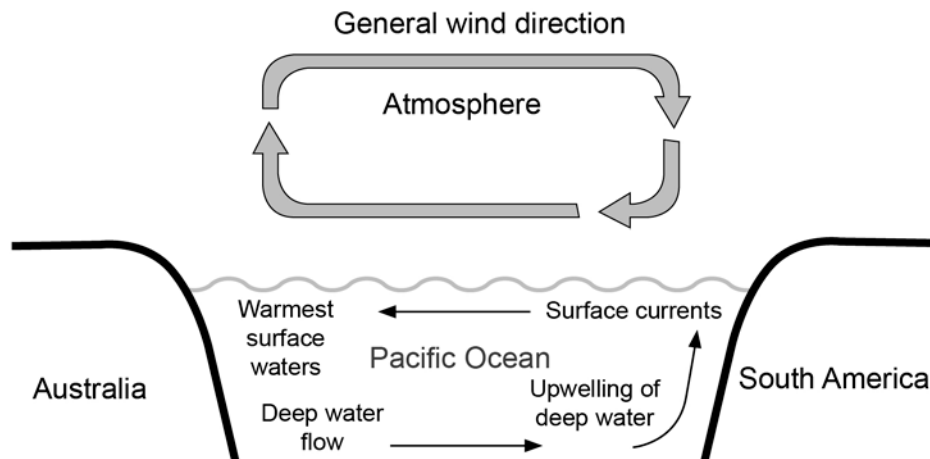
(a) Complete the following diagram to show the **typical** circulation of water and air in the Pacific Ocean. Label your diagram to show:

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

(4 marks)

Description	Marks
One mark for each relevant feature clearly shown and labelled on a diagram. Maximum four marks	
Relevant features could include: <ul style="list-style-type: none"> • westward flow of surface waters • eastward return flow of deep waters • upwelling of deep waters in the eastern Pacific • warmest surface waters in the western Pacific (to NE of Australia) • general westward flow of trade winds • elevation of the thermocline in the eastern Pacific. 	1-4
Total	4

Diagram example:



Question 18 (continued)

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

Description	Marks
Detailed answer integrating multiple factually correct points to demonstrate understanding of ocean circulation dynamics	2
Basic answer making at least one factually correct point	1
Total	2
Example answer: Deep ocean circulation is driven by differences in water density, which are caused primarily by variation in water temperature or salinity. Surface water circulation is driven primarily by the interaction of wind with the water's surface	

- (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)

Description	Marks
One mark for each of the following orbital parameters:	
• Eccentricity or shape of the Earth's orbit (The degree to which the elliptical orbital path varies from a circle)	1
• Obliquity or axial tilt (Deviation of the Earth's axis of rotation from perpendicular to the orbital plane)	1
• Precession or axial wobble (Change in the orientation of the Earth's axis of rotation over time)	1
Total	3

- (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)

Description	Marks
Explanation uses multiple factually correct points to demonstrate understanding of thermal energy distribution around the globe	2
Simple answer making at least one factually correct point	1
Total	2
Example answer: Although more thermal energy from the sun is received at low latitudes than higher latitudes, oceanic and atmospheric circulation redistribute heat towards the poles. This redistribution brings so much heat energy to high latitudes that in net terms, they actually radiate more thermal energy into space than they receive from the Sun – with the reverse true at low latitudes	

Question 19

(10 marks)

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

Description	Marks
One mark for each suitable characteristic described	
Characteristics could include: <ul style="list-style-type: none"> a trend towards increasing temperature over time from about 1985 onwards almost all temperatures are above the 30 year average before 1960 most temperatures are below the 30 year average coldest year recorded in this interval was 1917 warmest year recorded in this interval was 2013. 	1–2
Total	2

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

Description	Marks
Two marks for each change in atmospheric gases	
Identification of suitable anthropogenic change in gas concentrations	1–2
States the causes of this atmospheric change	1–2
Total	4
Answers could include: <ul style="list-style-type: none"> A rise in the concentration of CO₂ between 1910 and 2016, accelerating over the over the last 30 years or so Linked to the release of CO₂ through a variety of human economic activity including the burning of increasing volumes of fossil fuels, clearing forests, and burning vegetation A rapid rise in the volume of methane in the atmosphere Human activities which have caused an increase in atmospheric methane include increasing numbers of grazing animals which release methane, and allowing vegetation to rot as part of the crop growing cycle, especially in rice growing regions. 	

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

Description	Marks
Explanation uses multiple factual points to develop a valid answer	2
Simple valid answer making a single factual point	1
Total	2
Example answer for two marks: Carbon dioxide is a Greenhouse gas, allowing short wavelength solar radiation to reach the Earth's surface, but trapping long wavelength thermal energy emitted back into the atmosphere by the Earth. This trapped energy causes the atmosphere to warm.	

Question 19 (continued)

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

Description	Marks
Description uses multiple factual points to develop a valid answer	2
Simple valid answer making a single factual point	1
Total	1
Example answer for two marks: Less water is stored in the major ice sheets of Greenland and Antarctica due to glacial retreat, and thinning of the ice cover.	

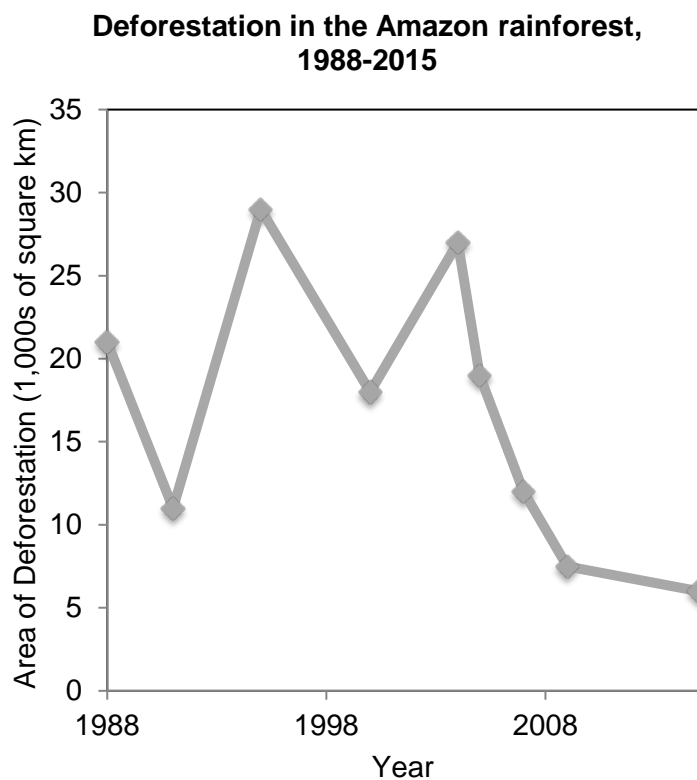
Question 20

(12 marks)

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

Description	Marks
Axes appropriately allocated and labelled – Year on the X axis, Area of deforestation on the Y axis	1
Appropriate title applied to the graph	1
Scale chosen appropriately to maximise use of the graph area	1
Accurate plotting of points	1
Accurate plotting of line graph between data points – not a trend line	1
Total	5

Example



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

Description	Marks
One mark for each valid trend identified in the data	
Relevant trends could include: <ul style="list-style-type: none"> • progressive decrease from 2004 onwards • high variability from 1988 to 2004 • reduction in rate of decrease from 2009 onwards. 	1–2
Total	2

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

Description	Marks
1995	1
Total	1

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

Description	Marks
One mark for each valid trend	
Valid trends could include: <ul style="list-style-type: none"> • population growth rate is progressively slowing over this interval • population is consistently growing over this interval • growth rate changes most rapidly in the earlier part of this interval between 1988 and 1995, with the rate of change slowing, particularly from 2004 onwards. 	1–2
Total	2

(e) Suggest a relationship that may exist between the data shown in Table B and those graphed on the previous page between 2004 and 2005. (2 marks)

Description	Marks
Detailed answer laying out a logical link between the two datasets, incorporating specific reference to figures and trends in the data and/or the incorporation of broader concepts	2
Elementary answer demonstrating an attempt to logically link the trends observed in the two datasets	1
Total	2
Two mark example answer: The decrease in population growth rate could result in reduced pressure for land from subsistence farming, and a corresponding fall in land cleared.	

Question 21

(11 marks)

- (a) Discuss how the excessive use of artificial fertiliser can affect the water quality and plant and animal life in nearby bodies of freshwater. (4 marks)

Description	Marks
Comprehensive answer linking multiple factual points into a coherent description	4
Answer making multiple correct factual points	3
Answer making multiple elementary factual points, including some incomplete understanding or error	2
Basic answer making at least one correct factual point	1
Total	4
Example answer: Excess nitrates in the fertiliser that are not absorbed on the farmland flow into water bodies with run-off. The nitrates enhance and speed up the growth of aquatic plants and algae. When these die, their decomposition lowers the oxygen content of the water, stressing aquatic animals and causing their migration or death.	

- (b) Identify **two** examples of how the process you described in part (a) affects human use of freshwater resources. (2 marks)

Description	Marks
One mark for each impact identified	
Impacts could include: <ul style="list-style-type: none"> • the decay of dead aquatic life acidifies the water, which can then present a human health hazard, irritating eyes and skin • the polluted and acidified water becomes unsuitable for drinking or cleaning purposes • the decaying aquatic plant and animal life causes unpleasant odours. 	1–2
Total	2

- (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)

Description	Marks
One mark for each relevant change	
Answers could include: <ul style="list-style-type: none"> • vegetation clearance removes the binding effect of vegetation on the land surface, allowing silt and mud to be washed into adjacent waterways, where it accumulates. • in more arid regions, salt which has accumulated on or near the surface can also be dissolved in the run-off water and cause salinity levels in freshwater streams to rise • more water flows into streams as it is not absorbed. 	1–2
Total	2

- (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)

Description	Marks
Comprehensive answer linking multiple factual points into a coherent description	3
More detailed answer making multiple factual points	2
Basic answer making at least one correct factual point	1
Total	3
Example answer: After sufficient precipitation falls, some surface water soaks through the soil and regolith. Gradually, this upper horizon becomes saturated and ground water moves downhill. Where the land surface drops below the level of the water table, water seeps out of the ground and forms a surface water body (lake or pond). The water level in this lake is controlled by the level in the aquifer which feeds it.	

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	<i>Marble</i>
<i>Quartz sandstone</i>	Quartzite
Shale	<i>Slate or phyllite or schist or gneiss</i>
Granite	<i>Gneiss</i>

Description	Marks
One mark for each correct cell in the table	1–4
Total	4

- (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)

Description	Marks
One mark for each relevant lithological observation	
Relevant observations could include: <ul style="list-style-type: none"> • the presence of garnet crystals • the presence of coarse-grained crystals in a finer matrix (or porphyroblastic texture) • a pervasive penetrative rock fabric produced by alignment of planar minerals • the presence of mica grains visible to the naked eye • dominance of the rock by quartz and feldspar minerals. 	1–3
Total	3

Question 22 (continued)

- (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 to those of Lithology A. (3 marks)

Description	Marks
One mark for each relevant lithological observation	
Relevant observations could include: <ul style="list-style-type: none"> • the absence of garnet crystals • finer grain size than Lithology A • a pervasive cleavage throughout the rock • shiny fracture surfaces • the presence of mica grains too small to be seen with the naked eye (but possibly visible through a magnifying lens) • uniform dark colour. 	1–3
Total	3

- (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)

Description	Marks
Valid metamorphic name given	1
Valid mineral name given	1
Total	2
<p>Suitable names could include:</p> <ul style="list-style-type: none"> • Biotite schist • Greenschist • Phyllite • Slate <p>Suitable minerals could include:</p> <ul style="list-style-type: none"> • Biotite • Chlorite • Muscovite • Epidote • Actinolite (or the generic term amphibole) <p>The answers given should be consistent with the observations stated in part C above (e.g. a candidate could not state that no visible micas were present and then label the rock as a schist)</p> <p>Candidates are told the rock is metamorphic, so giving the name of an un-metamorphosed protolith is not acceptable.</p>	

Question 23

(11 marks)

- (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)

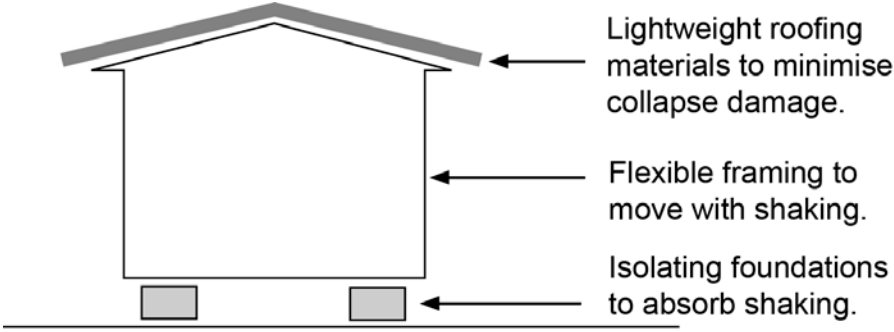
Description	Marks
Two marks for each valid linkage drawn between earthquake character or location and damage	
Valid points could include:	
• deeper earthquakes result in a wider distribution of seismic energy at the surface and correspondingly lower levels of damage than an equivalent-sized shallow quake	1–2
• the level of energy released by an earthquake is proportional to its duration – a longer quake will cause more damage	1–2
• earthquake damage decreases with distance away from the epicentre – so an earthquake close to a town or city will cause more damage than one in a distant wilderness area	1–2
• undersea earthquakes can cause tsunamis, which can cause large scale damage to infrastructure in coastal areas.	1–2
Total	4

- (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)

Description	Marks
Detailed answer linking multiple factual points and/or displaying complex understanding	2
Basic answer making at least one factually correct point	1
Total	2
<p>Example</p> <p>Unconsolidated sediments can undergo liquefaction during seismic shaking. This occurs when shaking increases the packing order in saturated sediments, which results in a reduction of the available pore space. The excess fluids dominate the strength of the sedimentary mass, which then behaves as a fluid, with buildings and infrastructure subsiding dramatically</p>	

Question 23 (continued)

- (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)

Description	Marks
Two marks for each method shown in a labelled diagram:	
Appropriate design method is shown and labelled, with sufficient additional information and/or labelling to illustrate how the method works to reduce risk	2
Appropriate design method is shown and labelled	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • isolating foundations • flexible framing • lightweight building materials – particularly roofing • deep and/or compacted foundations to reduce risk from liquefaction. <p>Example:</p> 	

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

Description	Marks
Outlines an economic factor or social factor relevant to the design features indicated in part (c)	1
Total	1
<p>Relevant social factors could include:</p> <ul style="list-style-type: none"> • lack of education could prevent understanding of earthquake implications and how building materials and engineering could reduce risk • traditional building practices could result in resistance to adoption of new methods • governments may make decisions on purely economic rather than social reasons and be resistant to spending money on reducing risk. <p>Relevant economic factors could include:</p> <ul style="list-style-type: none"> • individuals and governments in developing nations may lack the resources to implement advanced engineering solutions • the cost of building infrastructure that is resistant to the earthquakes likely to affect a particular region may be too high. 	

Question 24

(10 marks)

- (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)

Description	Marks
Two marks for each geological aspect	
Relevant aspect is stated and links to resource decision making are clearly established	2
Relevant aspect stated, but links to resource extraction decisions are absent or confused	1
Total	4
Relevant geological characteristics and reasoning could include: <ul style="list-style-type: none"> the minerals in which the desired element was incorporated, and how easy it would be to refine and process those to extract the resource. the volume of the mineral resource present. enough resource needs to be there to make it economic to build and operate a mine. the grade of the mineral resource. higher grades mean less material has to be mined to extract the same quantity of resource, meaning lower cost and higher profits the structural complexity of the ore body. If the ore body is disrupted by faults or has a complex form, it will be more difficult to plan and operate a mine to extract it. 	

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

Description	Marks
Detailed answer integrating multiple factual points to present a coherent explanation	2
Basic answer with at least one factually correct point, but lacking detail and/or confused in some aspects	1
Total	2
Viable aspects could include: <ul style="list-style-type: none"> distance from market making transport costs too high to sell the resource economically presence of the mineral deposit in a national park or area of similar environmental sensitivity making it impractical to develop location of the mineral resource in a politically unstable country. 	

Question 24 (continued)

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

Description	Marks
Two marks for each valid cultural or environmental factor	
Detailed answer integrating multiple factual points to present a coherent explanation	2
Basic answer with at least one factually correct point, but lacking detail and/or confused in some aspects	1
Total	4
Valid factors could include: <ul style="list-style-type: none">• the presence of an endangered species on the site of the deposit, necessitating excessive developmental limitations or costs that might leave the project economically un-viable• location of the deposit in an area where government is prepared to offer development and/or employment subsidies that might make the project more economically attractive• the deposit being on a site of cultural significance, placing limits on the potential for development and/or imposing additional costs on development.	

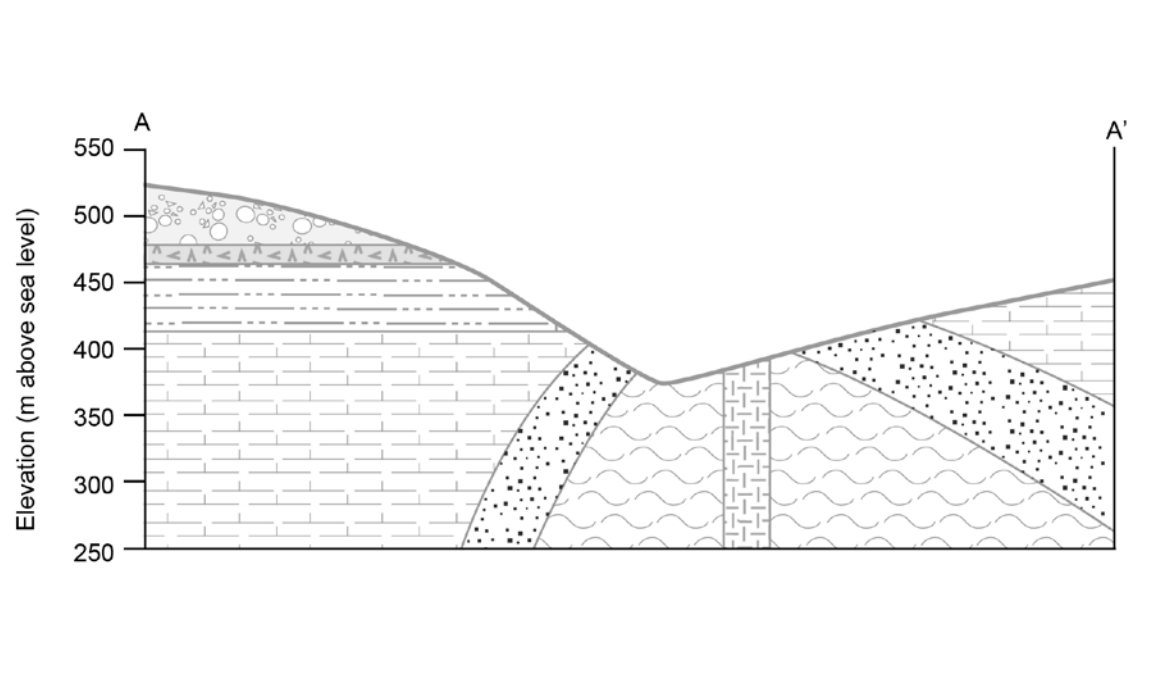
Question 25

(11 marks)

- (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)

Description	Marks
Topography plotted accurately	1
Lithological contacts transferred accurately to section line	1
Conglomerate, basalt, and siltstone shown as flat-lying units beneath NW hill	1
Fold constructed in lower units, with NW limb dipping more steeply than SE limb	1
Andesite shown as vertical dike	1
Total	5

Example



- (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)

Description	Marks
One mark for each lithology correctly listed in the appropriate position in this sequence	
The three lithologies are (1) basalt, (2) siltstone, and (3) limestone	1-3
Total	3

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

Description	Marks
The only acceptable answer is the mudstone unit	1
Total	1

- (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)

Description	Marks
One mark for each appropriate test	
Evidence to differentiate between these alternatives could include: <ul style="list-style-type: none"> • the presence of a baked soil horizon at the top of the overlying siltstone unit would indicate the basalt flowed across it • minor topography on the upper surface of the overlying siltstone filled in by basalt would indicate the siltstone was exposed at the surface and the basalt flowed across it • contact metamorphism on the lower surface of the overlying conglomerate unit would indicate the basalt was intruded into the rock sequence • xenoliths of conglomerate found within the basalt would indicate that the basalt intruded into the rock sequence. 	1–2
Total	2

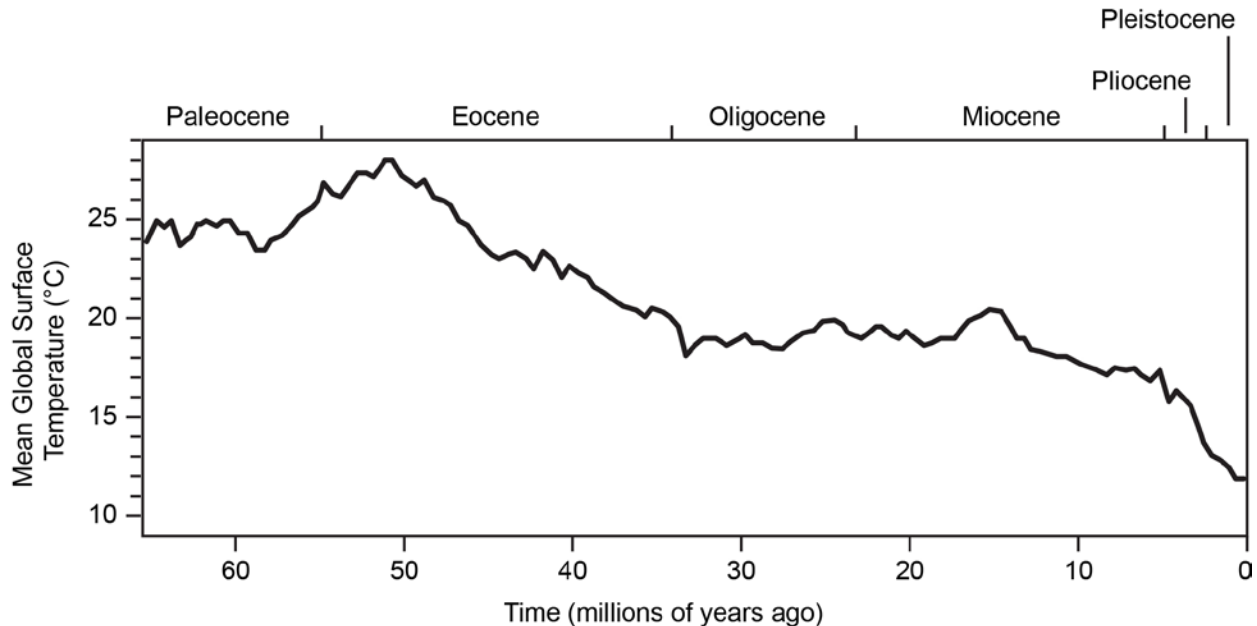
Section Three: Extended response

30% (30 Marks)

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)



Description	Marks
Answer identifies and accurately describes multiple trends in temperature covering both short and long-term behaviour	2
Answer identifies multiple trends in temperature, but fails to address both short and long term variation, or answer contains substantial points of confusion	1
Total	2
<p>Example answer: Temperature experiences variation up and down by approximately 1 degree C on short timescales of 2-3 million years, superimposed on a longer term trend of temperature increasing from the Paleocene to a peak of around 28 degrees C in the Early Eocene. Temperature then falls through the later Eocene, and stabilises at around 19 degrees C through the Oligocene and early Miocene, before falling further in the later Miocene and into Plio-Pleistocene time</p>	

Question 26 (continued)

- (b) Using your knowledge of how natural processes contribute to global climate change, explain **two** possible causes of this Cenozoic temperature variation. (4 marks)

Description	Marks
Two marks for each valid cause in temperature variation	
Answer clearly explains a viable mechanism for the key features of Cenozoic temperature variation and integrates facts and examples into a coherent answer	2
Answer identifies a mechanisms of global temperature change, but fails to link these to the Cenozoic temperature record, or answer contains misunderstandings	1
Total	4
Mechanisms of temperature change discussed could include: <ul style="list-style-type: none"> • trapping of carbon dioxide in carbonate rocks, methane hydrate, or other forms of stored carbon • secular variation in the output of energy from the sun • variation in the Earth’s orbital parameters (Milankovitch cycles) • variation in the level of volcanism. 	

- (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)

Description	Marks
Answer describes geological paleoclimate constraint in significant depth, specifically addresses the timescales of constraint, and illustrated the points made with appropriate supporting example(s) in a coherent discussion	5
Answer displays clear understanding of at least one paleoclimate method and makes mention of others in addressing the question, and includes relevant supporting example(s)	4
Answer makes multiple correct statements and provides at least one relevant example	3
Answer makes multiple correct and relevant points, but fails to address timescale and/or use appropriate example(s). May show some confusion.	2
Basic answer – makes at least one factually correct and relevant point, but may be incomplete and/or show confusion on some points	1
Total	5
Relevant points of discussion could include: <ul style="list-style-type: none"> • Geological materials preserve physical and isotopic evidence of the conditions prevailing at the time of their deposition • This provides a record of climate extending potentially as far into the past as we have geological materials preserved • Cave paintings and remains of prehistoric human settlements can indicate the flora, fauna, and climatic conditions prevailing locally • Many plant and animal species can tolerate only a limited range of climatic conditions, so changing fossil biota can illustrate varying climate • Some lithologies and landforms are associated with specific climatic conditions – for example tillites and various glacial landforms • The isotopic ratios of biologically mediated elements such as oxygen, hydrogen, carbon, and to some extent sulphur vary with environmental temperature, so these ratios in preserved fossil and geological materials can be used to derive a contemporary temperature record. 	

- (d) Discuss how warming and cooling affect the hydrological system of the Earth and the related distribution of plant and animal species. (4 marks)

Description	Marks
Effects on the hydrological system:	
Answer correctly identifies the consequences of warming and cooling to multiple aspects of the Earth's hydrological system	2
Answer correctly identifies at least one consequence of either warming or cooling to the Earth's hydrological system, but neglects the other	1
Answer mentions at least one relevant consequence to the distribution of plants	1
Answer mentions at least one relevant consequence to the distribution of animals	1
Total	4
Relevant points of discussion could include: <ul style="list-style-type: none"> • Cooling of climate can drive expansion of glaciers and polar ice sheets. This expansion of the cryosphere produces a commensurate fall in global sea level • Change in sea level alters the area of shallow marine and terrestrial habitat availability, with corresponding consequences to the distribution of relevant biota • Increase in temperature causes sea levels to rise due to a combination of factors including thermal expansion of the oceans and the melting of terrestrial ice sheets and glaciers • Rising temperatures increase the energy within the atmospheric system, with consequences including greater levels of evaporation and rainfall, greater intensity of atmospheric circulation, and increased numbers of storms • Changing temperatures (up or down) can shift global oceanic and atmospheric current systems away from their regular locations, producing dramatic shifts in relative habitability for existing biota. 	

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)

Description	Marks
Five marks for each proposal	
(A) Three likely impacts:	
One mark for each impact discussed	1–3
(B) Government response:	
Detailed answer combining multiple points and/or supporting arguments	2
Basic answer stating an appropriate response but lacking supporting arguments or integrated reasoning	1
Subtotal	5
Overall total	15
<p>Answers could include: Proposal One: Replace the islanders' small fishing boats with modern boats using drag nets that can find and catch 1000% more fish each day.</p> <p>Example answer: Modern fishing boats using drag nets could quickly reduce the fish stocks to a point where fish numbers rapidly decline and fishing would become unsustainable. This would create problems for the local fishermen who would find their catches rapidly declining. Drag nets also scrape along the ocean floor destroying reefs and scooping up many types of marine life. Other damage to the marine ecosystems could include plastic waste discharged into the ocean - some of which enters the marine food chain – and fuel spills. Government could reduce these impacts by declaring some coastal waters as marine parks where ecosystems can be kept intact and fish stocks can continue to breed undisturbed.</p>	

Proposal Two: Use open-cut techniques to mine the large coal reserves located below the crop-growing land to fuel a large coal-fired power station.

Example answer:

Open cut mining destroys farmland, which would reduce the supply of crops currently grown using local resources. A deep open cut mine could also adversely affect local groundwater quality. The transport of the coal from the mine site to the power station would require the development of substantial road or rail infrastructure that could further damage and degrade local land. The coal-fired power station would emit carbon dioxide into the atmosphere adding to the enhanced greenhouse effect and global warming. On a local scale, burning of poorer quality coal also releases sulphur compounds and other gases which can cause pollution that might adversely affect local health.

Government could reduce these impacts by planning for the smallest possible coal fired power station, and by introducing other renewable power sources alongside the thermal power station (e.g. solar or wind), and/or search for supplies of natural gas with which to generate power.

Proposal Three: Clear all the undisturbed forest using heavy equipment and then burn the vegetation to create space to grow one commercial crop.

Example answer:

Clearing the undisturbed forest would destroy entire habitats and ecosystems, resulting in the loss of biodiversity, as well as the destruction of local sources of food, fibres, medicines, and building materials. It would also hasten decline in the populations of local plants and animals. On a large scale, it could affect rainfall distribution, which in turn would affect farming practices. Burning cleared vegetation releases large quantities of smoke and ash particles into the atmosphere, along with carbon dioxide. Growing of a single crop (monoculture) would not provide an alternative source of basic materials for the local people, and would be vulnerable to the effects of plant disease or pests.

Government could reduce these impacts by systematically evaluating the condition of the local forests, and confining clearing to only the most degraded sections

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)

Description	Marks
Names a specific mineral deposit	1
Detailed description of the formation of the chosen mineral system and supporting facts to display clear understanding	3
Moderate answer making multiple factually correct points but failing to integrate and/or offer supporting arguments	2
Basic answer making one factually correct point	1
Total	4

- (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)

Description	Marks
For a geophysical technique relevant to the specific mineral resource stated in part A:	
• description demonstrating understanding of the application of this technique	1–2
• clear statement of the likely positive response of the technique	1
For a geochemical technique relevant to the specific mineral resource stated in part A:	
• description demonstrating understanding of the application of this technique	1–2
• clear statement of the likely positive response of the technique	1
Total	6

- (c) What are the environmental impacts of the **two** exploration techniques you specify in part (b)? (2 marks)

Description	Marks
Answer displays awareness of environmental impacts of the chosen exploration techniques	1–2
Total	2

- (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)

Description	Marks
States a valid environmental issue	1
Answer outlines how this issue is caused by mining of the relevant resource	1
Answer clearly outlines an appropriate protection method that could reduce its impact	1
Total	3

ACKNOWLEDGEMENTS

- Question 20** 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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*Published by the School Curriculum and Standards Authority of Western Australia
303 Sevenoaks Street
CANNINGTON WA 6107*