



EARTH AND ENVIRONMENTAL SCIENCE

ATAR course examination 2018

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	a
2	c
3	a
4	a
5	d
6	b
7	c
8	d
9	b
10	b
11	c
12	d
13	c
14	d
15	b

Section Two: Short answer

55% (110 Marks)

Question 16

(10 marks)

- (a) Describe how renewable resources (such as fisheries) differ from non-renewable resources. (2 marks)

Description	Marks
Detailed and accurate description of how renewable resources differ from non-renewable resources	2
Basic and largely appropriate description relating at least one correct fact. May contain some misconceptions	1
Total	2
<p>Example:</p> <p>Renewable resources are those that are typically replenished at timescales of years to decades and with careful management are potentially sustainable. Non-renewable resources form over geological timescales and are therefore not sustainable and will eventually run out.</p>	

- (b) Outline **two** factors that influence the rate at which these resources can be sustainably used. (2 marks)

Description	Marks
For each of two factors (2 x 1)	
Outlines a factor that influences the rate at which these resources can be sustainably used	1–2
Total	2
<p>Factors could include:</p> <ul style="list-style-type: none"> • rate of consumption • rate of replenishment. <p>Example:</p> <p>The abundance of a resource and how quickly the resource is replaced by growth and reproduction influence the rate by which a resource can be sustainably used. The rate of usage must not exceed the rate of replenishment in order for the resource to be used sustainably.</p>	

Question 16 (continued)

- (c) Describe **three** management practices that have been (or could be) implemented to ensure the sustainability of Western Australia's fishing industry. (6 marks)

Description	Marks
For each of three relevant management practices indicated (3 x 2)	
Detailed and accurate description	2
Basic and largely appropriate description relating at least one correct fact. May contain some misconceptions	1
Subtotal	2
Total	6
Relevant management practices could include (but are not limited to):	
<ul style="list-style-type: none">• minimum and/or maximum fish sizes• maximum catch sizes• closed seasons• returning females in roe to the sea• establishing marine parks• restricting the number of commercial licences• ensuring the methods used produce minimal physical damage to the resource and to its environment.	
Example:	
There have been a number of management practices implemented into Western Australian fisheries restricting when, where and how fish can be caught. This has included minimum and maximum sizes for many species, the aim of minimum sizes being to allow fish to grow and spawn at least once with maximum size limits designed to protect the very important large breeding females. A second practice has been the implementation of closed seasons for some fish species, restricting fishing during the important spawning season. A third practice has been bag limit restriction of catch number, particularly for more sensitive species. The overall aim of all three of these is to develop a sustainable fishing industry in Western Australia.	

Question 17

(12 marks)

- (a) Describe how plate tectonic processes cause tsunamis on the shores of adjacent land masses. (4 marks)

Description	Marks
Each of up to four correct points describing how plate tectonic processes influence the origin, propagation or amplitude of tsunamis	1–4
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> vertical fault movement uplift of water waves propagate increase of wave height toward shore. <p>Example:</p> <p>Tsunamis often form when a large earthquake causes vertical movement along a fault on the seafloor. This vertical movement pushes a large volume of water upward, which then moves outward forming tsunami waves. The waves are small when in deep water but increase in height as the waves approach the shallow water of the shore.</p> <p>Note: tsunamis can also arise through a range of other plate tectonic mechanisms, including volcanic eruption or earthquake-triggered slope collapse.</p> <p>Accept other relevant answers.</p>	

- (b) Explain how **two** different types of scientific data could be used to produce a hazard map showing those regions most at risk of tsunamis. (4 marks)

Description	Marks
For each of two relevant types of scientific data (2 x 2)	
Accurate explanation of how the data could be applied to the production of a hazard map for tsunamis	2
Elementary statement of how data could contribute to hazard assessment	1
Subtotal	2
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> earthquake epicentre locations volcanic eruption locations historical tsunami locations plate movement data plate boundary locations. <p>Example:</p> <p>Historic earthquake epicentre and volcanic eruption locations are examples of two types of data that could assist the identification of potential tsunami risk areas. Plotting of these two types of data would produce a map that would help identify the position of active plate boundaries, as these two phenomena are commonly associated with these boundaries. This map could therefore be used to identify areas at greater risk of tsunami.</p> <p>Accept other relevant answers.</p>	

Question 17 (continued)

- (c) Describe **two** strategies that have been (or could be) implemented to reduce the potential effects of tsunamis on coastal populations. (4 marks)

Description	Marks
For each of two strategies (2 x 2)	
Detailed and accurate description	2
Basic and largely appropriate description relating at least one correct fact. May contain some misconceptions	1
Subtotal	2
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • sea walls • early warning systems • education about evacuation procedures • practice of evacuation procedures • communication systems. <p>Example:</p> <p>Two strategies that have been used to reduce the potential effects of tsunamis to humans include the production of tsunami walls, and the implementation of a tsunami early warning system. The walls are designed to physically stop the movement of waves or divert the waves into areas where they would cause the least damage. An early warning system usually includes sirens, radio/television warnings, or text messages to mobile phones. The aim of these warning systems is to give people time to move to areas of higher ground.</p> <p>Accept other relevant answers.</p>	

Question 18

(10 marks)

- (a) The first student wrote the following descriptions of **three** different metamorphic rocks she recognised in the field. For each description, provide an appropriate rock name and list a protolith (original unmetamorphosed rock) that could have been metamorphosed to produce the suggested rock type. (6 marks)

Description		Marks
For each of the three descriptions – maximum 2 marks each (3 x 2)		
Correct rock name provided for each description		1
Appropriate protolith stated for each stated rock type		1
Note: if students have suggested an inappropriate rock name, they may still score a mark here by listing a protolith appropriate for their chosen rock name.		
Subtotal		2
Total		6
Example answer:		
Metamorphic rock description	Rock name	Protolith
A dark, coarse-grained rock consisting of layers of muscovite and biotite alternating with quartz and feldspar layers on a millimetre scale	Schist	Shale or basalt
A light-coloured, medium-grained rock, consisting of interlocking calcite crystals	Marble	Limestone
A dark, fine-grained foliated metamorphic rock containing abundant mica. The mica is too fine-grained to be visible to the naked eye, but gives a lustrous sheen on cleaved surfaces	Phyllite	Shale, mudstone, or claystone
Note: alternative answers are acceptable as long as they are consistent with the wording of the question.		
Accept other relevant answers.		

- (b) When the two students met in the field, the second student claimed to have found metamorphic gneiss in the area, but the first student was not convinced by the description he provided. Write a description of the metamorphic texture and mineralogy of a typical gneiss. (2 marks)

Description	Marks
Answer provides an appropriate description of gneissic texture including coarse grain size and foliation/banding	1
Answer provides an appropriate description of the mineralogy of a typical gneiss	1
Note – mineral family names (feldspar, mica) are acceptable.	
Total	2
Example:	
<ul style="list-style-type: none"> coarse grained rock with alternating darker and lighter coloured bands (1 mark) lighter bands consist of felsic minerals, such as feldspar and quartz. Darker bands consist of mafic minerals, such as biotite, pyroxene and amphibole (1 mark) 	

Question 18 (continued)

- (c) List **two** features that could be used to distinguish gneiss from lower-grade metamorphic rocks in the field. (2 marks)

Description	Marks
For each of up to two distinguishing features of a gneiss	1-2
Total	2
Examples could include: <ul style="list-style-type: none">• gneiss has a coarser grain size• gneiss may contain minerals indicating a higher metamorphic grade (e.g. garnet)• gneiss is segregated into discrete alternating bands of felsic and mafic minerals• gneiss will not contain recognisable fossils.	

Question 19

(10 marks)

For any **one** of the metallic mineral resources mentioned above:

- (a) Describe how geological processes can lead to the formation of your chosen resource, using specific examples drawn from **one** or more named, real deposits where appropriate. (4 marks)

Description	Marks
Detailed and accurate description establishing clear geological process pathway leading to the development of the chosen, named deposit	4
Detailed description showing substantial geological insight. May include minor misconceptions and/or incomplete linkage to the chosen, named deposit	3
Description including multiple correct facts and making some attempt to integrate them into a formation pathway. May include errors and/or incomplete linkage to the chosen deposit type	2
Statement containing at least one correct fact, but with one or more misconceptions and/or fails to establish specific relationship to the chosen deposit type	1
Total	4
Example: <div style="border: 1px dashed gray; padding: 10px; text-align: center; margin: 10px auto; width: fit-content;"> For copyright reasons this text cannot be reproduced in the online version of this document. </div>	

- (b) Explain how tectonic setting controls where the type of deposit referred to in part (a) forms. (2 marks)

Description	Marks
Explanation displaying clear understanding of tectonic influence on deposit location	2
Statement containing at least one correct fact relating to tectonic influence. May contain minor misconceptions	1
Total	2
Example: The metamorphic processes described above are usually part of large-scale regional metamorphism that occurs during periods of compression along active continental margins, typically at subduction zones where rocks are being accreted. This setting provides the temperature and pressure required, and also a source of moist rocks required for the dehydration.	

Question 19 (continued)

- (c) Describe **one** example of how the extraction of your chosen resource can affect the abiotic components of the surrounding ecosystem, and **one** example of how its extraction can affect the biotic components of the surrounding ecosystem. (4 marks)

Description	Marks
For one example of abiotic (1 x 2)	
Detailed description displaying clear understanding of the impact of mining activity on the abiotic element of the ecosystem	2
Elementary description containing at least one correct fact. May contain minor misconceptions	1
Subtotal	2
For one example of biotic (1 x 2)	
Detailed description displaying clear understanding of the impact of mining activity on the biotic element of the ecosystem	2
Elementary description containing at least one correct fact. May contain minor misconceptions	1
Subtotal	2
Total	4
<p>Example:</p> <p>Water quality is an abiotic factor of the environment that can be negatively affected by the extraction of resources such as gold. There are a number of potential risks, such as seepage from tailings dams entering groundwater and run-off from machinery and processing plants polluting river systems.</p> <p>Gold mining can also affect biotic factors of the environment. One example is the interruption of animal migration due to the construction of mines, processing plants and roads. These structures can prevent the usual movement of animal species, possibly preventing them getting to important breeding areas.</p> <p>Accept other relevant answers.</p>	

Question 20

(12 marks)

- (a) Describe or show in a labelled diagram how geothermal energy can be harnessed to produce electricity. (2 marks)

Description	Marks
Description/diagram demonstrates understanding of how geothermal energy can be harnessed through detailed description or diagram	2
Statement/diagram demonstrating basic understanding of how geothermal energy can be harnessed. May contain minor misconceptions	1
Total	2
<p>Example:</p> <p>Energy is captured by injection of water into a subterranean heat source. The steam produced is used to drive turbines to generate electricity.</p>	

- (b) Name **two** advantages and **two** disadvantages of geothermal energy as a source of electricity by comparison with fossil fuels. (4 marks)

Description	Marks
Any two of the following advantages	
<ul style="list-style-type: none"> • renewable • lower emissions • needs no external fuel • continuous operation 	1–2
Subtotal	2
Any two of the following disadvantages	
<ul style="list-style-type: none"> • may cause ground subsidence • can induce or increase seismic activity • costly to establish • may disturb natural aquifer systems 	1–2
Subtotal	2
Total	4
Accept other relevant answers.	

Question 20 (continued)

- (c) Explain how tectonic processes produce thermal conditions that allow the economic production of geothermal electricity. (3 marks)

Description	Marks
Detailed explanation with multiple correct points AND relates tectonic setting to the economics of the project	3
Detailed description with multiple correct points	2
Elementary or vague description. May include minor misconceptions	1
Total	3
<p>Example:</p> <p>Tectonic setting is critical to the viability of geothermal energy fields. All high temperature geothermal resources suitable for electricity production are associated with tectonic regions with high volcanism. Active tectonic areas provide heat energy through the movement of magma and hydrothermal fluids. This movement of heat energy is located at shallow depths and therefore the cost of infrastructure associated to capture the energy is lower than for geothermal fields located further away from active tectonic areas.</p>	

- (d) Identify **one** tectonic hazard that might be associated with areas in which geothermal electricity can be produced on a large scale. (1 mark)

Description	Marks
Appropriate tectonic hazard correctly identified	1
Total	1
<p>Answers could include:</p> <ul style="list-style-type: none"> • earthquakes • volcanic activity • tsunami <p>Example:</p> <p>Areas suitable for geothermal electricity production on a large scale are mostly located at plate boundaries or areas of high volcanism. The volcanism is required to produce the high geothermal gradients in the zone, however volcanic eruptions could destroy infrastructure.</p>	

- (e) Describe **one** appropriate measure to minimise the risk posed by the hazard chosen in part (d) to electricity production infrastructure. (2 marks)

Description	Marks
Appropriate method of management described with sufficient detail about how method will minimise impacts	2
Statement demonstrating basic understanding, but lacking relevant examples and/or incorporating some misconceptions	1
Total	2
<p>Example:</p> <p>Volcanic hazards may be managed by building infrastructure away from immediate magma source. This means that in the event of an eruption, the geothermal energy station is not in close proximity to areas of high risk.</p> <p>Other examples are possible, including buildings designed to withstand earthquakes.</p>	

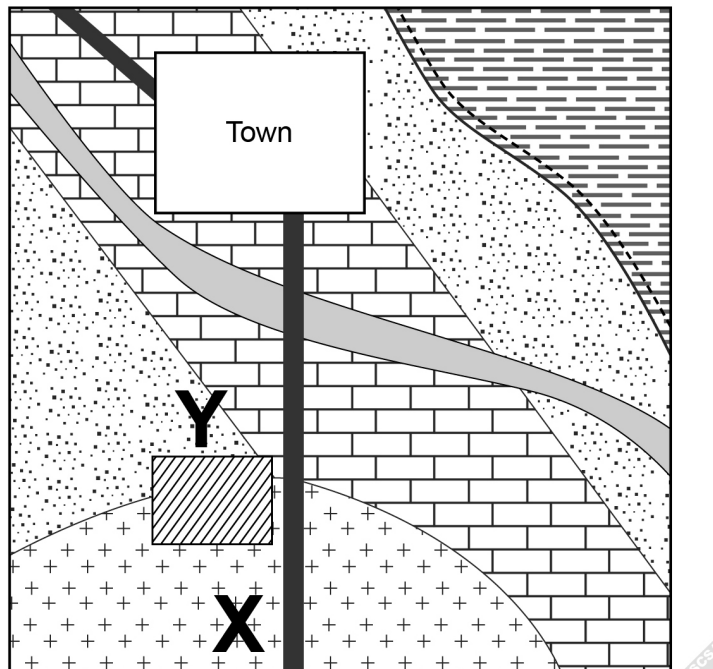
Question 21

(12 marks)

- (a) Mark on the map, using the letter 'X', where you would plan the location of a waste dump/tailings facility. (1 mark)

Description	Marks
X placed at a location equivalent to that indicated in the example below or X placed at an appropriate location consistent with appropriate arguments in part (b) of this question	1
Total	1

Example:



- (b) Explain the specific features of your chosen location that make it the most appropriate site for this facility. (2 marks)

Description	Marks
Explanation of specific features of chosen location	2
Statement of at least one feature of chosen location	1
Total	2

Factors relevant to the location of the facility could include:

- on the granite rocks for their low permeability
- on the shale for its low permeability
- as far as possible from the town site
- as far as possible from the river
- near the road for ease of transport of waste.

Example:

The shale is a non-permeable unit that is bound by a fault. This means that any contamination is restricted to this area and could not move to the porous units and possibly into the nearby river.

Accept other relevant answers.

Question 21 (continued)

- (c) Mark on the map, using the letter ‘Y’, where you would plan to locate a monitoring bore for your planned waste dump/tailings facility. (1 mark)

Description	Marks
Y placed at a location between the waste dump/tailings facility and the river or	1
Y placed at an appropriate location consistent with the reasoning provided in part (d) of this question	
Total	1

- (d) Explain the purpose of a monitoring bore for a waste dump/tailings facility. (2 marks)

Description	Marks
Explanation of purpose	2
Statement of purpose	1
Total	2
<p>Example:</p> <p>Bore hole monitoring of waste dump/tailings facilities is undertaken to watch for contamination leaking from the facility and potentially impacting on environmentally sensitive surrounding areas such as aquifers or rivers. In the event that contamination is identified in the bore hole sampling, necessary decontamination processes can be implemented and sites of contamination can be identified and rectified.</p> <p>Accept other relevant answers.</p>	

- (e) The proposed mine is expected to produce substantial noise and air pollution. Describe **two** methods that could be used to reduce the impact of either of these forms of pollution on the nearby town. (4 marks)

Description	Marks
For each of two impact reduction methods (2 x 2)	
Description of impact reduction method	2
Statement of impact reduction method	1
Subtotal	2
Total	4
<p>Appropriate methods could include:</p> <ul style="list-style-type: none"> • dust suppression • restricting blast times • roasting facilities placed a long way from town • thorough watering of stock piles and spoil heaps • creation of green belts. <p>Example:</p> <p>Greenbelts are zones of land located between the mine and township. These greenbelts generally include/support a large number of trees to help buffer the noise and air pollution created at the mine.</p> <p>Accept other relevant answers.</p>	

- (f) Describe **one** method that could be used to reduce the likelihood and/or severity of environmental impacts from the proposed mine on the aquatic ecosystem in the nearby river. (2 marks)

Description	Marks
Detailed description of method with multiple points of content	2
Statement of method	1
Total	2
Example:	
Many mining processes do not require potable water, therefore a method to reduce the impact of the mine on the nearby river could be to recycle mine water. Recycled water from the mining or processing could be stored and treated for secondary uses.	
Allow any reasonable justified response.	

Question 22

(12 marks)

- (a) Describe **two** ways that mining might affect the woylies living in this area. (4 marks)

Description	Marks
For each of two ways (2 x 2)	
Clear and informative description of potential affect of mining on woylies	2
Statement about affects making at least one relevant point	1
Subtotal	2
Total	4
Answers could include: <ul style="list-style-type: none"> • destruction of habitat • reduction of food sources • separation of population • physical harm • pollution of water supply • creation of noise. Example: Mining may directly reduce woylie numbers by causing fatalities during mine activity and reduce numbers by removing food and water resources previously relied upon. Accept other relevant answers.	

- (b) As part of the company's application for a mining licence, you have been asked to prepare a policy for minimising the impact of mining on the woylie population. Describe the steps that you would recommend the company take at the following stages of the project:

- (i) before the start of mining (2 marks)

Description	Marks
Description of steps integrating multiple relevant points	2
Statement making at least one relevant point	1
Total	2
Answers could include: <ul style="list-style-type: none"> • impact study • fence mine area • trap and relocate. Example: The company should undertake a detailed study of the woylie population and their habitat in order to establish how much development of the deposit would affect their natural range. The company should also seek expert guidance with regards to the potential of relocating the woylies elsewhere (either temporarily or permanently) and/or excluding them from the mine site. Accept other relevant answers.	

- (ii) during mining (2 marks)

Description	Marks
Description of steps integrating multiple relevant points	2
Statement making at least one relevant point	1
Total	2
<p>Answers could include:</p> <ul style="list-style-type: none"> • monitor population • maintain fence lines • monitor environmental impact • preservation of topsoil. <p>Example:</p> <p>The company should make sure staff are trained in how to minimise the impacts of their operational activities on the woylies. If economically feasible, specialist environmental staff should be employed on the site to monitor the woylies and other animal and plant species to ensure operations are conducted in ways that minimise disruption to the fauna. Measures should also be taken to exclude the woylies from areas of risk by fencing off operational areas of the mine and tailings facilities.</p> <p>Accept other relevant answers.</p>	

- (iii) at the conclusion of mining (2 marks)

Description	Marks
Description of steps integrating multiple relevant points	2
Statement about steps making at least one relevant point	1
Total	2
<p>Answers could include:</p> <ul style="list-style-type: none"> • fence mine area • ensure area is safe • batter back angles • repopulation • rehabilitation • continue to monitor. <p>Example:</p> <p>Areas that may pose a risk to the woylies should be fenced off or covered in an impermeable layer. The woylies' habitat should be returned as far as possible to the state it was in prior to mining through planting of appropriate vegetation. Numbers and health of the woylie population should be monitored for several years following the closure of the mine to assist the company in demonstrating to the regulatory authorities that they have managed the sensitive population effectively.</p> <p>Accept other relevant answers.</p>	

(c) You have been asked to develop a list of talking points to help company executives prepare for negotiations with local communities.

(i) List **two** positive contributions you believe a mine might make to local communities. (1 mark)

Description	Marks
For any two relevant contributions listed, including, but not limited to: <ul style="list-style-type: none"> • jobs • economic growth • tourism • improvement of roads and/or transport links into the community • provision of training opportunities • company support of community schools and/or facilities. 	1
Total	1
Note: Candidates must provide two relevant points in order to receive one mark.	

(ii) List **two** objections you anticipate members of local communities may raise to the development. (1 mark)

Description	Marks
For any two relevant objections listed, including, but not limited to: <ul style="list-style-type: none"> • disruption of community way of life • loss of local aesthetic value • disruption to the local economy • noise pollution • dust pollution • environmental impacts arising from mining activities. 	1
Total	1
Note: Candidates must provide two relevant points in order to receive one mark.	

Question 23

(8 marks)

- (a) Identify a natural process that can affect the global climate on timescales of 10 years or longer and describe how this process affects the distribution and storage of solar energy in the atmosphere and/or hydrosphere. (3 marks)

Description	Marks
For the identification	
Identifies a natural process that can affect the global climate on timescales of 10 years or longer	1
For the description	
Description of natural process and how it affects distribution and storage	2
Outline of natural process and how it affects distribution and storage	1
Total	3
<p>Example:</p> <p>Sunspots are magnetic storms in the outer corona of the sun. These reduce the temperature of the sun's outer layer and the corresponding emission of solar radiation. The number of sunspots varies periodically on an approximately 11 year cycle and is thought to also have increased overall over the past 100 years. By altering the total solar radiation on Earth, sunspots affect the energy throughout the entire climatic system, with temperatures at all levels of the atmosphere rising when sunspot activity decreases, and falling when activity increases.</p> <p>Allow any other reasonable mechanism.</p>	

- (b) Name **two** consequences for the global climate arising from the thermal change you described in part (a). (2 marks)

Description	Marks
<p>For each of up to two relevant consequences. Depending on the answer given in part (a), these might include, but not be limited to:</p> <ul style="list-style-type: none"> • atmospheric temperatures rising/falling • change in the distribution of heat within the atmosphere • increased/decreased equatorial-polar temperature difference • altered wind patterns • altered patterns of precipitation • increased number and/or intensity of tropical storms • increase/decrease in polar sea ice and/or growth of ice sheets. 	1–2
Total	2

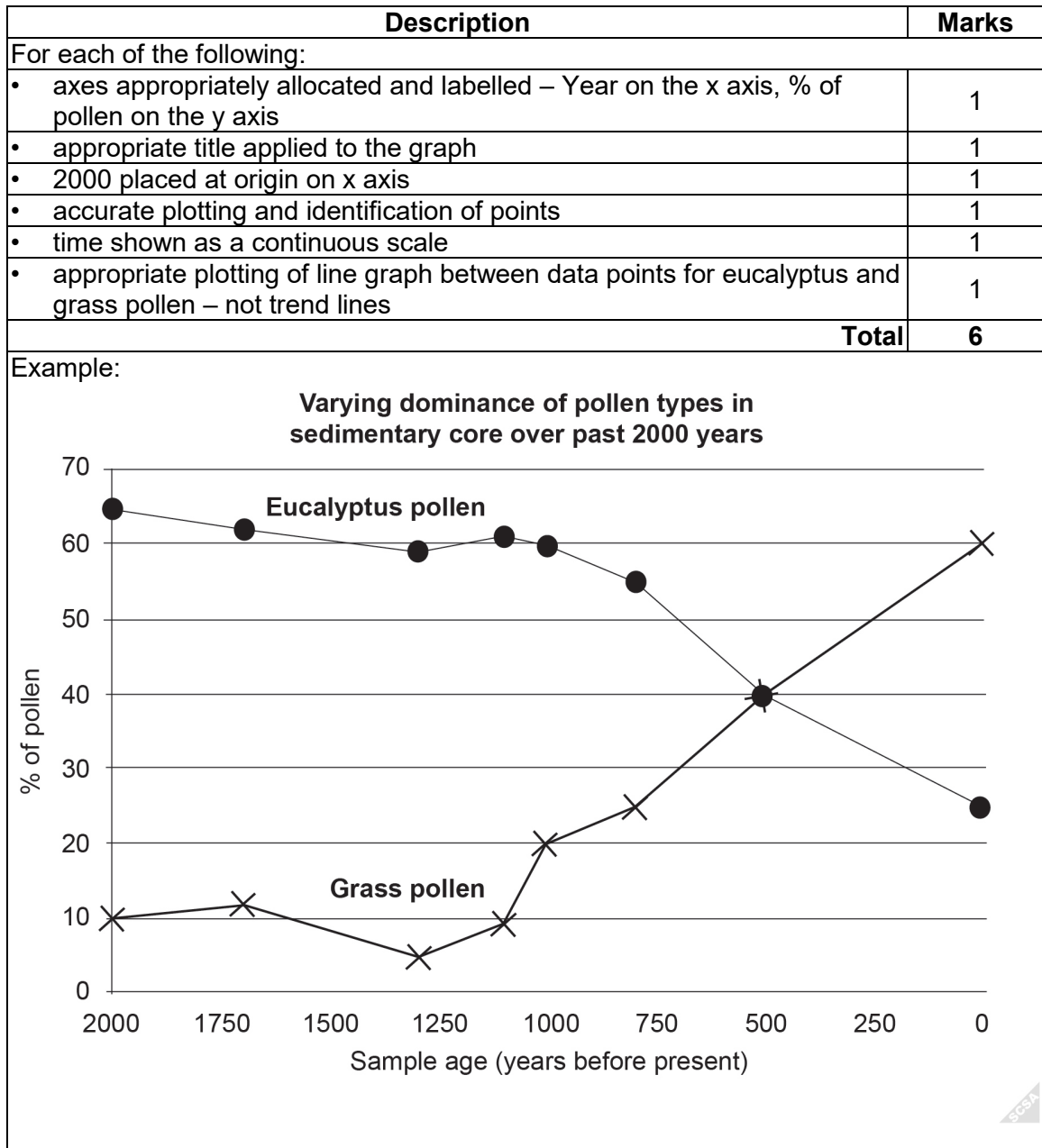
- (c) Provide a detailed description of how the climate changes you described in part (b) could be identified in records from time periods pre-dating human history. (3 marks)

Description	Marks
Detailed description integrating multiple relevant points to display clear understanding of how the climate changes described in part (b) could be identified in the pre-historical record	3
Description of pre-historical climate records with limited attempt to tie to climate changes indicated in part (b)	2
Statement about pre-historical climate records, poorly/not tied to the changes indicated in part (b)	1
Total	3
Example:	
Global cooling could be demonstrated by simultaneous widespread contraction and/or movement towards the equator of the ranges of flora and fauna preferring warm conditions, and corresponding expansion of the range of cold-tolerant species. Expansion of ice sheets and glaciers in cooler conditions would also lock up increased quantities of relatively ^{16}O -rich precipitation in the ice, producing a corresponding decrease in the ratio of ^{16}O to ^{18}O in ocean water which would be preserved in the oxygen isotope ratios of marine fossils and inorganic carbonate deposits formed.	
Allow any other reasonable and suitably justified record.	

Question 24

(13 marks)

- (a) On the grid provided, draw **one** graph separately plotting the change over time for eucalyptus pollen and for grass pollen. (6 marks)



- (b) Outline **two** long-term vegetation trends indicated by the data in the table. (2 marks)

Description	Marks
Two relevant vegetation trends outlined.	
• an increase in the dominance of grasses in the landscape	1
• a decrease in the dominance of eucalyptus in the landscape	1
Total	2

Alternatives may be possible, with the marker to evaluate suggested answers for their applicability.
 To satisfy the specification of 'long-term', cited trend should relate to behaviour encompassing at least 50% of the plotted time range (1000 years).

- (c) Name **one** natural process and **one** human activity that could account for the changing balance of vegetation types suggested in your answer to part (b). (2 marks)

Description	Marks
Natural process	
For a relevant natural process capable of producing the inferred change in vegetation dominance in the landscape over time, which include (but are not limited to): <ul style="list-style-type: none"> • natural climate change • reduction in rainfall • falling temperatures • increase in natural bushfire occurrence. 	1
Human activity	
For a relevant anthropogenic process capable of producing the inferred change in vegetation dominance in the landscape over time, which include (but are not limited to): <ul style="list-style-type: none"> • deliberate use of fire as an agricultural or hunting practice • deforestation • clearing of land for agriculture. 	1
Total	2

- (d) Identify **one** additional source of data (other than palynology) that could help scientists to identify which of your **two** suggestions in part (c) was the actual cause of the observed change in vegetation. (1 mark)

Description	Marks
Identification of any relevant source of constraint that could be applied to the period in question. Answers could include (but are not limited to): <ul style="list-style-type: none"> • archaeological records of human occupation of the area • dendrochronological (tree-ring) records of relative climate change across the relevant interval • fossil plant material preserved in the swamp. Relevance of the answer will be dependent on the candidate's answer to part (c) of the question above.	1
Total	1

- (e) Describe what the data source you chose in part (d) would show if the changes in vegetation were the result of a natural process. (2 marks)

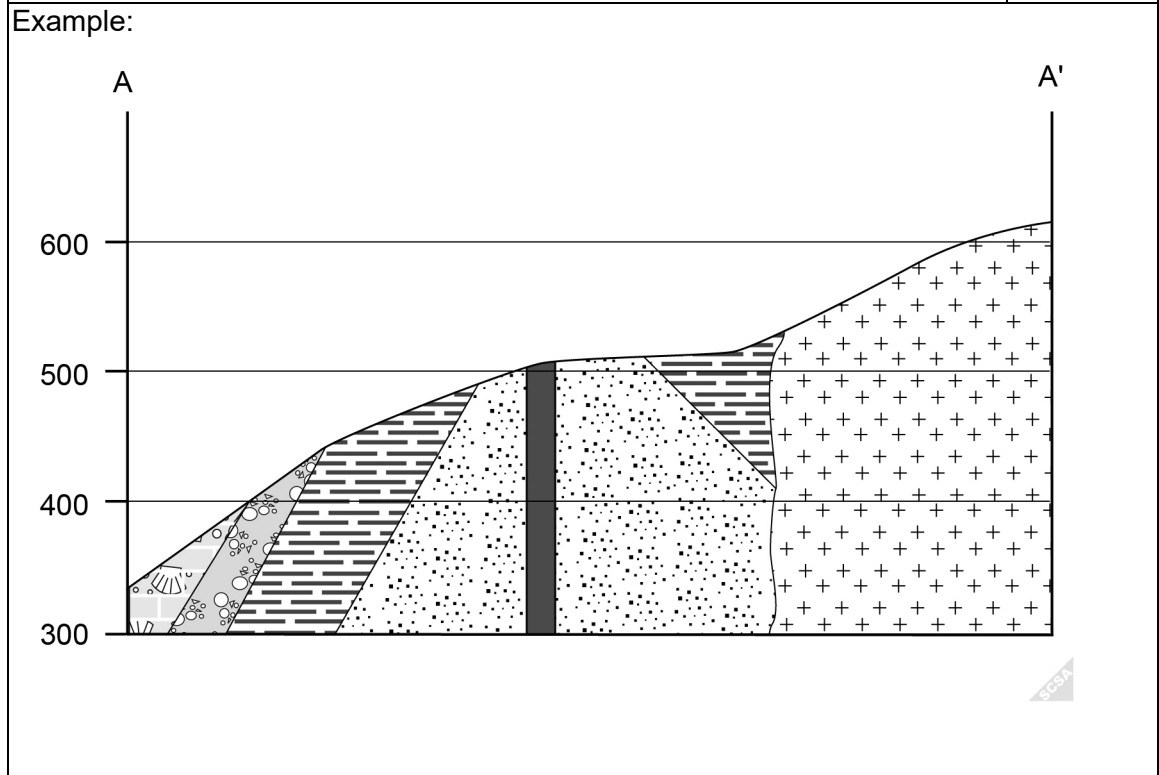
Description	Marks
Description clearly showing what the data source would show	2
Statement making at least one relevant point about what the data source would show	1
Total	2
Example: Records from multiple widely-dispersed sites around the surrounding region would show simultaneous decrease in eucalypt dominance.	

Question 25

(11 marks)

- (a) 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 and the surface topography. (6 marks)

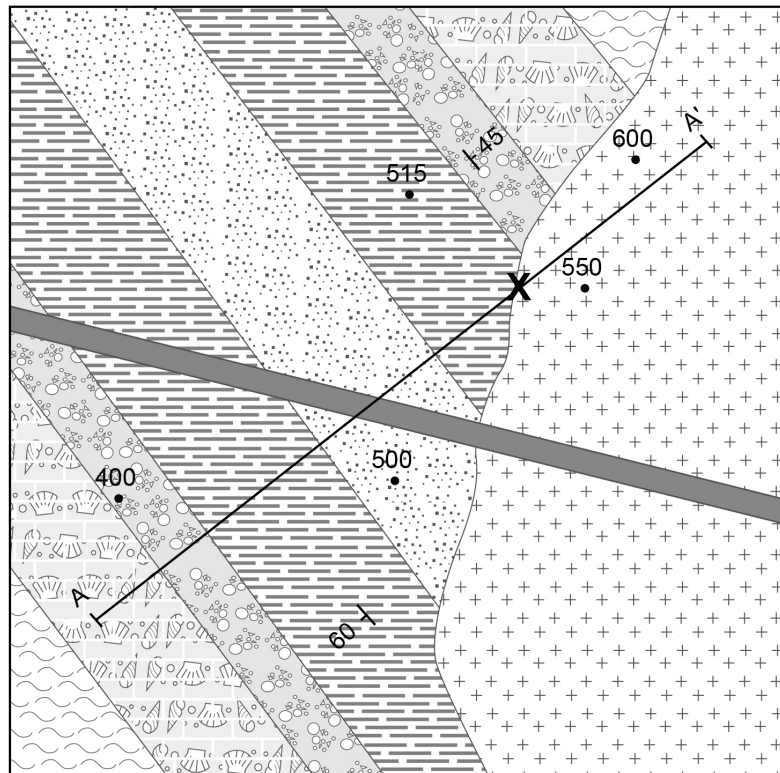
Description	Marks
For each of the following:	
• topography plotted appropriately and accurately	1
• lithological contacts transferred accurately to section line	1
• fold constructed correctly	1
• bedding plotted with asymmetrical fold limbs	1
• granite contact represented appropriately	1
• dyke shown in correct position and dipping vertically	1
Total	6



- (b) (i) Based on these geological characteristics, use your cross-section to identify a point below the surface at which similar mineralisation might occur. Mark an 'X' **on the map** on page 26 to show the location on the surface where you would drill a vertical hole to test your prediction. (1 mark)

Description	Marks
X placed at a point on the map vertically above where the student's cross section locates the intersection of the sandstone, shale and granite units or X placed at the point indicated in the example below	1
Total	1

Example:



- (ii) At what depth below the surface would your planned hole be expected to encounter the mineralised zone? (1 mark)

Description	Marks
A figure in the range 100–150 m or A figure consistent with the construction of the candidate's cross section	1
Total	1

Question 25 (continued)

- (c) (i) State an appropriate name for this type of metamorphism. (1 mark)

Description	Marks
Contact metamorphism	1
Total	1

- (ii) List **two** textural differences likely to be observed between this alteration zone and the surrounding sediments. (2 marks)

Description	Marks
For each of up to two relevant textural differences, which could include: <ul style="list-style-type: none">• increase in grain size• interlocking grains• spotted texture with large crystals overgrowing smaller matrix• destruction of fossils and fine rock texture.	1–2
Total	2

Section Three: Extended response

30% (30 Marks)

Question 26

(15 marks)

- (a) Describe **one** example of how human activities have changed the composition of the atmosphere (3 marks)

Description	Marks
Description clearly establishing how an identified human activity has changed the composition of the atmosphere, with effective use of details and/or supporting facts to illustrate understanding	3
Response identifies appropriate example and provides coherent description of how this has changed atmospheric composition, but with limited or no specific details or supporting arguments	2
Appropriate example identified, but description is vague and/or confused	1
Total	3
Example for burning fossil fuels: The burning of fossil fuels (coal, oil, and natural gas) releases the carbon previously locked away in those fuels into the atmosphere as CO ₂ . Up until the mid-19th century, the carbon dioxide released in this was soaked up by natural carbon sinks in forests and the oceans, but since the beginning of the Industrial Revolution around 1850, changes in land and resource use – in particular the massive increases in fossil fuel consumption to power our industrial societies and meet human transport needs - have substantially exceeded the capacity of natural sinks to absorb the CO ₂ produced. Accept other relevant answers.	

Question 26 (continued)

- (b) Discuss how the atmospheric change identified in part (a) can be demonstrated and why it is attributed to human impact rather than natural causes. Your answer should include the sources of scientific data relied upon and identify clearly any assumptions and limitations underpinning the arguments presented. (5 marks)

Description	Marks
Discussion synthesising multiple points into a consistent argument and incorporating appropriate examples and/or additional detail to demonstrate understanding of the subject	5
Discussion integrating multiple distinct and appropriate points, and clearly establishing both the attribution of the change to human impact and the scientific data sources involved	4
Explanation making multiple distinct and relevant points and attempting to address both the attribution of human impact and the scientific data sources involved	3
Description making at least one valid point. May lack discussion of either how the impact can be attributed to human activity or of the scientific data sources relied upon	2
Statement making at least one valid point. Lacking use of relevant examples or additional facts, and may include minor misconceptions	1
Total	5
<p>Example:</p> <p>The CO₂ content of the atmosphere rises and falls through natural processes on a range of timescales, but the increases in CO₂ experienced since the industrial revolution far exceed this natural variability.</p> <p>Direct measurement of pre-historical atmospheric composition is possible by analysing bubbles of atmospheric gas trapped in ice that has been held stable in ice sheets. Analysis of this record shows that CO₂ has naturally cycled between levels of around 180-300ppm in the atmosphere over the past 800 000 years, but levels have dramatically increased over the past c.200 years to in excess of 380 ppm, and are still rising.</p> <p>Long-term measurements of CO₂ begun in the mid-20th century by atmospheric scientist Charles Keeling provide direct evidence that this trend has been consistent throughout the late 20th and early 21st centuries.</p> <p>Volcanic activity also represents a significant natural source of CO₂ emissions that some people argue might drive increases to atmospheric concentrations, but such volcanic emissions are calculated as being only 1% as large as emissions from human activity in a typical year. Statistical analysis of historic and prehistoric eruptions also shows that there has been no departure from the background frequency or magnitude of volcanic activity that could provide a meaningful contribution to the measured increase in CO₂ levels in the atmosphere over the past few decades.</p> <p>Accept other relevant answers.</p>	

- (c) Explain how your chosen atmospheric change can affect the distribution of **two** plant **and/or** animal species. Use specific examples where possible to describe how these changes relate to the environmental sustainability of the human activity cited in part (a). (4 marks)

Description	Marks
Explanation synthesising multiple points into a consistent argument and incorporating appropriate examples, and including coherent and effective discussion of implications with respect to environmental sustainability	4
Explanation of multiple distinct and appropriate points and making use of appropriate examples to support or illustrate arguments. Some attempt made to discuss environmental sustainability	3
Description making multiple valid points, and with at least some use of appropriate supporting example(s)	2
Statement making at least one valid point. Lacking use of relevant examples or additional facts, and may include minor misconceptions	1
Total	4
<p>Example:</p> <p>The burning of fossil fuels has led to atmospheric changes which include increased temperatures and ocean acidification. These changes have affected the distribution of some plant and animal species and are not environmentally sustainable. For example, the habitat of polar bears is being decreased and the distribution of their food sources is changing, due to the melting of ice caps. The distribution of tropical fish is also changing in response to warming oceans. The continued burning of fossil fuels is unsustainable due to the environmental change it causes.</p>	
Accept other relevant answers.	

Question 26 (continued)

- (d) Discuss **one** strategy that has been (or could be) implemented by individuals **or** government to reduce **or** reverse the effects of this atmospheric change. Your answer may include reference to the role of social **or** economic factors in limiting the actions taken. (3 marks)

Description	Marks
Discussion incorporating multiple distinct and appropriate points and making use of appropriate examples to support or illustrate arguments.	3
Explanation making multiple valid points, and with at least some use of appropriate supporting example(s)	2
Statement making at least one valid point. Lacking use of relevant examples or additional facts, and may include minor misconceptions	1
Total	3
<p>Answers could include:</p> <ul style="list-style-type: none"> • using alternate fuels (e.g. renewables) • encouraging public transport use • encouraging carpooling/ride sharing • carbon sequestration • introducing a carbon tax or emissions trading scheme • international agreements <p>Example:</p> <p>One strategy to reduce or reverse the effects of global warming has been centred on international treaties such as the Kyoto Protocol, under which industrialised nations agree to binding limits on their gas emissions, and then seek to reduce emissions and/or increase the sequestration of CO₂ on a national level. Reduction in CO₂ emission can be achieved through reducing power demand or developing alternative electricity sources that do not release CO₂, such as wind power, geothermal energy, or other renewable energy sources. CO₂ levels in the atmosphere can also be reduced by sequestering carbon in a more stable form. This is currently achieved largely through the planting and growth forests and enhancement of soil carbon content, but experiments are underway to find alternative sequestration possibilities including enhanced oceanic sequestration by 'seeding' ocean waters with iron to produce algal blooms, and by capturing CO₂ from the atmosphere and injecting it into geological reservoirs.</p> <p>Accept other relevant answers.</p>	

Question 27

(15 marks)

- (a) With reference to its low population, explain Australia's use of water per person and the pressure on water resources. (4 marks)

Description	Marks
Explanation synthesising multiple points into a consistent explanation and incorporating appropriate examples and/or data extracted from the stimulus materials provided.	4
Explanation incorporating multiple distinct and appropriate points but lacking integration or cohesion. Makes use of appropriate examples to support or illustrate arguments	3
Description making at least one valid point, with appropriate supporting example(s)	2
Statement making at least one valid point. Lacking use of relevant examples or additional facts, and may include minor misconceptions	1
Total	4
Example:	
<p>Australia has more than double the per-capita fresh water consumption rate of any other nation, and 97% of that fresh water is used in farming. These figures, however, are coloured by the fact that Australia has a lower population than many other countries on the list, so that the impact of its agricultural sector is proportionately greater. Another relevant factor is the nature of Australia's hot, dry climate and unreliable rainfall which requires additional water for growing crops. A high standard of living and a widely dispersed population also help to explain Australia's high use of water per person. These factors increase the pressure on existing water sources both on the surface and underground, necessitating the use of alternative water sources such as desalination and groundwater replenishment.</p>	
Accept other relevant answers.	

Question 27 (continued)

- (b) Describe in detail how cultural **and/or** water use policy changes could reduce the demand for water per person over the period. (5 marks)

Description	Marks
Detailed description synthesising multiple points and incorporating appropriate examples and data extracted from the stimulus materials provided	5
Description integrating multiple distinct and appropriate points, and making use of appropriate examples	4
Description making multiple distinct and relevant points but lacking integration or cohesion. Makes some use of appropriate examples	3
Outline making at least one valid point, with appropriate supporting example(s)	2
Statement making at least one valid point. Lacking use of relevant examples or additional facts, and may include minor misconceptions	1
Total	5
<p>Example:</p> <p>The projected near-50% growth in population to 35.9 million does not mean a corresponding 50% growth in water requirements, as the great majority of water use in the nation is used in agriculture, as noted above.</p> <p>Nevertheless, given per capita use is highest in the world, while Australia is the driest inhabited continent, any increased demand is problematic – as acknowledged in the response of the Prime Minister’s Engineering and Innovation Council.</p> <p>Demand-reduction strategies may require a substantial alteration in the cultural expectations of the population with regards to the availability and use of water, such as reducing the number of swimming pools and watered green spaces in the nation’s urban areas, or becoming more accustomed to native and drought-tolerant plant species of plants in gardens. As an alternative to shifting cultural attitudes to water use, such reductions in personal and social consumption could instead be driven by government policy, introducing regulations to limit water use for purposes such as cleaning cars and irrigating public green spaces.</p> <p>Accept other relevant answers.</p>	

- (c) Discuss **two** technological solutions that could increase the supply of fresh drinking water for Australia in the next 30 years. (6 marks)

Description	Marks
For each of two solutions discussed (2 x 3)	
Discussion identifying appropriate solution and describing the process involved and how it would contribute to an increased supply of fresh drinking water	3
Explanation identifying relevant solution with adequate justification provided for its selection	2
Statement identifying relevant solution, poor or absent attempt to justify its selection	1
Subtotal	3
Total	6
<p>Answers could include:</p> <ul style="list-style-type: none"> • recycled water • groundwater replenishment • covering water storages to reduce evaporation rates • piping water from other places <p>Example for desalination:</p> <p>The construction of new desalination plants may represent the most appropriate option for increasing the supply of fresh water to meet the needs of an increased population. Assuming the expanded population mirrors the concentration of population in the existing large cities, surrounding surface water resources and aquifers are largely heavily exploited already. As these cities are largely situated on or close to the coast, however, the available seawater represents a nearly limitless source if it can be tapped through the construction of desalination plants. Although offering a controllable source of additional water, however, such engineered solutions are expensive – both in themselves and in the additional demands they impose on electricity supplies that are themselves currently stretched in many areas of the country.</p>	
Accept other relevant answers.	

Question 28

(15 marks)

- (a) Choose **three** different mineral resources and for each, identify a specific geophysical or geochemical technique that would be appropriate to test for the presence of the chosen resource. A different exploration technique must be chosen for each of the three resources. (3 marks)

Description	Marks
For each of three different mineral resources	
Resource type clearly named and a geophysical or geochemical method that would be appropriate for the identification of this resource type identified	1
Subtotal	1
Total	3
Answers could include (but not limited to):	
<ul style="list-style-type: none"> • testing for detrital gold by a stream sediment-sampling program of the exploration lease • exploration for iron ore through aerial magnetic and/or gravity surveying • identification of manganese by geochemical analysis of surface soil samples • exploration for metallic (copper, nickel, lead, etc.) sulphide ores through induced polarisation surveying. 	
Markers may need to investigate the relevance of suggested exploration methods with which they are not familiar	

- (b) For each pairing of resource and exploration technique identified in part (a), explain the specific detail of how your selected technique would be applied in an exploration program targeting the chosen mineral resource. (6 marks)

Description	Marks
For each of three resource-technique pairings as specified in part (a) (3 x 2)	
Explanation displaying clear understanding of the chosen technique and its appropriate application to exploration for the indicated commodity	2
Description of the operation of the chosen technique displaying some knowledge of its relevance to the chosen resource	1
Subtotal	2
Total	6
Example for gold exploration by stream sediment-sampling:	
For preliminary exploration for gold by a stream sediment-sampling program of the exploration lease. To conduct this program, I would use aerial photography and topographic maps to identify the drainage in the area, then take regular samples (approximately 500m apart) along the drainage to analyse for gold. At each sample location, I would select a site where sediment appears to be concentrated, screen the sample to remove any large pebbles and send the remainder off for chemical assay.	

- (c) For each of the **three** exploration techniques described in part (b), explain how the presence of the targeted form of mineralisation would be identified in the results of the exploratory analysis. (6 marks)

Description	Marks
For each of three exploration techniques as specified in part (b) (3 x 2)	
Explanation integrating multiple points and demonstrating a high degree of understanding of the response of the chosen exploration technique	2
Description displaying some understanding of the response of the relevant exploration technique	1
Subtotal	2
Total	6
<p>Example continuing with stream sediment-sampling for gold:</p> <p>The typical positive response for a stream sediment-sampling program is the identification of stream branches that show anomalously high gold values. In an area containing a gold deposit that is being eroded, levels of gold in stream sediments typically increase in concentration upstream towards the source, and then fall back to background levels higher in the stream catchment than the deposit is exposed.</p>	

ACKNOWLEDGEMENTS

Question 19(a) Text under 'Example' adapted from: Birch, B. (n.d.). *Geology of gold*. Retrieved September, 2018, from <https://www.sbs.com.au/gold/story.php?storyid=128>

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