



EARTH AND ENVIRONMENTAL SCIENCE

ATAR course examination 2022

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

Section Two: Short answer

55% (110 Marks)

Question 16

(13 marks)

- (a) State
- two**
- reasons why flood plain regions are used for urban development. (2 marks)

Description	Marks
For each of the two reasons (2 x 1 mark)	
States a suitable reason.	1
Total	2
Answers could include:	
<ul style="list-style-type: none"> • flood plain areas are generally flat lying • close to sources of reliable water • often rich agricultural land leading to high population density • dominated by soft sedimentary geology, with a lack of hard rock or boulders to remove during construction. 	
Accept other relevant answers.	

- (b) Explain how occasional floods on flood plains improve their suitability for agriculture. (3 marks)

Description	Marks
episodic floodwaters carry nutrient-rich sediment	1
flooding can distribute this sediment over a large area	1
the nutrients in this sediment replenish nutrients lost through farming	1
Total	3
Sample answer:	
<p>Flooding maintains the agricultural viability of flood plains because floodwaters usually carry a high sediment load rich in material with high organic content. When deposited over the flood plain by receding floodwaters, this organic material can replace nutrients lost from the soil from previous farming activities. When flooding occurs, it often occurs over a large area and therefore nutrient replacement occurs over this entire area, maintain higher growing capacity.</p>	
Accept other relevant answers.	

Question 16 (continued)

- (c) Describe **two** social or environmental benefits for communities that choose **not** to allow development on local flood plain areas. (4 marks)

Description	Marks
For each of the two benefits (2 x 2 marks)	
Identifies a benefit for communities that choose not to allow development.	1
States how that feature can benefit the community.	1
Total	4
Answers could include: <ul style="list-style-type: none"> • reduce risk of flooding to the community – floodwater can spread out across the natural flood plain, creating a lower velocity flood, reducing the impact on human health • supports maintenance of natural ecosystems. Natural vegetation cover of flood plains prevents soil erosion, which can assist water quality • provides recreational areas close to the water. Flood plain areas can be used for recreation activities • will attract wildlife • allows for great water table infiltration. Flood plain areas can act as areas of natural aquifer recharge. 	
Accept other relevant answers.	

- (d) Describe how **two** human activities can prevent the natural rejuvenation of flood plain environments. (4 marks)

Description	Marks
For each of the two human activities (2 x 2 marks)	
Identifies a human activity that can prevent rejuvenation.	1
Provides reasoning as to how the activity prevents rejuvenation.	1
Total	4
Answers could include: <ul style="list-style-type: none"> • by constructing dams on a river. The construction of dams on a river system alters the river’s natural (episodic) flow. By controlling how much water flows down a river, human management can prevent flooding and stop any resulting rejuvenation • by drawing significant volumes of water from a river. Human activities [could be specified as any of urbanisation, agriculture, forestry, mining or similar] can prevent flooding • human-induced climate change is altering rainfall patterns. This can impact the amount of water in river systems, typically making episodic flooding less common but more severe • flood mitigation strategies, e.g. levees. • Urban development prevents or discourages native fauna from living in the area. 	
Accept other relevant answers.	

Question 17

(14 marks)

- (a) While preparing an area for grazing, a farmer in a remote area of Western Australia exposed a horizon of potentially valuable sulfide minerals under a thick layer of silica-cemented sediments. Explain how an electromagnetic survey could be used to define the location and extent of the sulfide mineralisation. (3 marks)

Description	Marks
States how the extent of a sulfide layer can be defined	1
Outlines the process of an electromagnetic survey.	1
Identifies how an electromagnetic survey distinguishes sediments from sulfide materials.	1
Total	3
Sample answer:	
An electromagnetic survey measures the electrical conductivity of the subsurface. This is achieved by measuring the responses of the ground to the propagation of electromagnetic fields. The subsurface conductivity contrast between the sediments and the sulfide deposit will identify the extents of any potential deposit.	
Accept other relevant answers.	

- (b) Other than electromagnetic surveys, describe a different geophysical exploration method that could be used for identifying prospective areas for each of the following:

- (i) mineral resource. (2 marks)

Description	Marks
Identifies a (different) suitable geophysical exploration method for a mineral resource.	1
States how the nominated method is used to identify prospective areas.	1
Total	2
Answers could include:	
<ul style="list-style-type: none"> gravity survey – detects the differences in local gravitational pull resulting from presence of materials with different densities within the Earth. This technique is useful in structural geological mapping, gold, oil, and gas exploration magnetic survey – measures local differences in magnetic field resulting from geological materials with varying magnetic susceptibilities. Many target ore minerals have a high magnetic susceptibility (e.g. iron ore) or can be associated with local changes in magnetic susceptibility. 	
Accept other relevant answers.	

Question 17 (continued)

- (ii) non-renewable energy resource. (2 marks)

Description	Marks
Identifies a (different) suitable geophysical exploration method for a non-renewable energy resource.	1
States how the nominated method is used to identify prospective areas.	1
Total	2
Answers could include:	
<ul style="list-style-type: none">seismic survey – the arrival time of soundwaves produced by explosion, impact, or similar energy release and traveling through the Earth is recorded across a region. Because sound travels at different speeds through different types of rock, varying arrival times can be used to interpret the nature of the underlying geology, providing insight into geological structures and different lithologies that can help predict where concentrations of hydrocarbons may have accumulated.	
Accept other relevant answers.	

- (c) Explain why exploration companies commonly use additional non-geophysical methods to confirm the presence of mineralisation identified by geophysical surveying. (3 marks)

Description	Marks
Providing evidence of potential economic viability of a particular mineral discovery.	1
Geophysical methods provide only an indirect interpretation.	1
Physical sampling or other direct observation is needed to define the nature and grade of mineralisation at a scale relevant to actual mineral discovery.	1
Total	3
Sample answer:	
Geophysical exploration techniques provide large scale information, whereas non-geophysical techniques can provide information on a finer resolution relevant to meaningful discovery and sampling. Only physical sampling and geochemical assaying can provide information defining the grade and distribution of mineralisation. Economic viability of mineralisation cannot be established unless grade and distribution are systematically assessed.	
Accept other relevant answers.	

- (d) Describe **two** non-geophysical exploration techniques that can be used to identify the presence of or location, and extent of mineralisation beneath the surface. (4 marks)

Description	Marks
For each of the two non-geophysical techniques (2 x 2 marks)	
Identifies a non-geophysical technique that can be used to define presence or location and extents of mineralisation beneath the surface.	1
Shows how the exploration technique is used to define presence or location and extents of mineralisation beneath the surface.	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • geological mapping – this exploration technique is used to gain a detailed understanding of the geology of the area. Geologists physically map the area to identify local changes or influences in the rock types of the area • stream sampling – sediment samples are collected from the main channel areas throughout the exploration area. Samples are analysed for trace amounts of ore minerals or other minerals associated with mineralisation • geochemical sampling – samples of rock or soil collected systematically from the surface • extracted from the subsurface via drilling, samples are used to map the zones of mineralisation or chemical alteration and then sent for assay. 	
Accept other relevant answers.	

Question 18

(16 marks)

- (a) State **one** human-related and **one** natural cause that could be responsible for the higher rates of native forest loss experienced after 1995. (2 marks)

Description	Marks
States a human-related cause of native forest loss.	1
States a natural cause of native forest loss.	1
Total	2
Answers could include: Human-related: <ul style="list-style-type: none"> • urban development or increased agriculture resulting in large areas of forest being cleared • illegally logged timber increasing native forest loss • political or economic pressures could have meant more area was allocated to native forest clearing • introduction of biological pests, such as Phytophthora dieback. Natural: <ul style="list-style-type: none"> • natural disaster such as forest fire or drought • climate change resulting in change to growing/germination conditions • increased local soil salinity. Accept other relevant answers.	

- (b) Identify **two** other trends apart from those stated above, that are apparent in the data shown. (2 marks)

Description	Marks
For each of the two trends (2 x 1 mark)	
Correctly identifies a trend.	1
Total	2
Answers could include: <ul style="list-style-type: none"> • commercial forest available increased between 1960 and 1975 • native forest loss decreased between 2005 and 2015 • commercial forest available decreased between 1995 and 2005. Accept other relevant answers.	

- (c) Describe **two** factors that can have an impact on the rate of renewal of a harvestable resource. (4 marks)

Description	Marks
For each of the two factors (2 x 2 marks)	
Identifies a factor that can impact rate of renewal of a harvestable resource.	1
States how the factor can impact the rate of renewal of a harvestable resource.	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> the growth rate of the harvestable resources determines the harvesting rate. Species with a slow growth rate need longer renewal time most harvestable resources need access to water and nutrients. The resources that have access to water and nutrients will be ready for harvesting prior to the resources that cannot access water and nutrients the changing climate results in changed growing conditions in certain regions, meaning resources that rely on climatic clues to enable germination are suitable to these changes. This ultimately will influence their rate of renewal soil degradation can result in slower growth rates, therefore reducing the rate of renewal episodic hazards such as fire or flood can destroy large areas of natural resources and stop or slow harvesting grazing animals can compress the soil and cause the destruction of soil surfaces, therefore reducing the rate of renewal. <p>Accept other relevant answers.</p>	

- (d) Outline the importance maintaining a sustainable ecosystem. (2 marks)

Description	Marks
Refers to the importance of having an ecosystem in the future.	1
Refers to the human dependence on ecosystem services.	1
Total	2
<p>Sample answer:</p> <p>Sustainable ecosystem management is critical in protecting ecosystem health. This ensures that the ecosystems and their resources they provide, are available for future generations.</p> <p>Accept other relevant answers.</p>	

Question 18 (continued)

- (e) Describe **three** initiatives that a government could introduce in the timber and forestry industry to help regulate native forest loss. (6 marks)

Description	Marks
For each of the three initiatives (3 x 2 marks)	
Outline a suitable initiative.	1
States how the initiative would help regulate native forest loss.	1
Total	6
Answers could include:	
<ul style="list-style-type: none">• modify criteria for approval of land clearing to make clearing permits harder to obtain, therefore slowing down the rate of native forest loss• annual and/or regional limits on land clearing and introduction of more rigorous limits to logging• mandate the preservation of specific species or biodiversity to prevent logging of certain locations or forest types• supporting research in biotechnology, such as the development of species of tree which grow faster in commercial plantation conditions, increasing growth rates, and subsequent harvesting rates, therefore reducing pressure to log native forest• alignment between federal and state logging policies, reducing the risk of uncertainty regarding rights and responsibilities of logging companies• increasing legal obligations on logging companies to utilise all parts to the trees logged. This reduces timber waste and in turn reduces requirement for native forest logging.	
Accept other relevant answers.	

Question 19

(12 marks)

Metamorphic rocks are rocks whose original mineralogy and/or texture have been changed by the effects of heat and pressure.

(a) Describe the processes of regional metamorphism **and** contact metamorphism.

(4 marks)

Description	Marks
Regional metamorphism	
Pressure and temperature are both significant factors in producing the changes in mineralogy and/or texture observed in regional metamorphic rocks.	1
Regional metamorphism is a process that occurs across continuous areas covering hundreds or even thousands of square kilometres.	1
Contact metamorphism	
Heat and peak temperature are the key controls on contact metamorphic change, with pressure having little or no influence.	1
Contact metamorphism is limited to a short distance (from metres to, rarely, several kilometres or more) from an igneous body or other source introducing large quantities of heat to a local area.	1
Total	4
<p>Sample answer:</p> <p>Regional metamorphism alters rocks for thousands of square kilometres and can occur due to pressures associated with burial by sediment or tectonic plate movement.</p> <p>Contact metamorphism occurs due to the intense heat associated with magmatic intrusions. Existing rocks exposed to this heat will begin to metamorphose. Contact metamorphism occurs on a scale of 10–100 km².</p>	

Question 19 (continued)

- (b) Complete the table below to create a classification key to distinguish between amphibolite, schist, and phyllite rock types. (6 marks)

Description		Marks
For each of the three metamorphic rock types (3 x 2 marks)		
Identifies a distinctive mineralogical component or assemblage of the rock.		1
Identifies a distinctive textural component that allows the rock to be distinguished from the others.		1
Total		6
Answers could include:		
Metamorphic rock type	Distinctive mineralogy	Textural features
Amphibolite	Amphibole, Hornblende, Plagioclase feldspar	Weakly to non-foliated Small flakes of black and white minerals in the rock often give it a salt-and-pepper appearance
Schist	Micas (biotite and muscovite), Talc, Garnet	Flat, large, and sheet-like intermediate sized grains aligned in a consistent preferred orientation
Phyllite	Mica (sericite, muscovite), Chlorite	Very fine grained (individual crystals not visible to the naked eye) Well-developed laminar (layered) texture often displaying crenulation.
Note: Mineralogical and textural features must distinguish the specified rock type from the others listed. Quartz is not a distinctive mineral. Type of micas and feldspars must be named.		

- (c) Explain why some metamorphic rocks consist of only a single mineral and others consist of multiple minerals. (2 marks)

Description	Marks
Identifies mineralogy of metamorphic rock is determined by parental rock.	1
Identifies that a mineral can only form from what is available.	1
Total	2
Sample answer:	
Metamorphic rocks are derived from other rocks, and therefore the mineralogy of a metamorphic rock is determined by its parent rock. If a parent rock has only one type of chemical building block present (such as silica in a quartz sandstone) then the metamorphic equivalent can only be composed of that same mineralogy.	
Accept other relevant answers.	

Question 20

(16 marks)

Once a new mineral deposit is identified, economic viability is a key consideration in whether or not a mine will be developed to extract the mineral resource. An exploration company has discovered several small but potentially valuable gold deposits at the site marked with a star on the map below. The site is approximately 500 km NE of the nearest small rural town of Wiluna, and 1300 km NE of Perth.

- (a) Identify **two** geographic and **two** social factors that could affect the economic viability of these deposits. (4 marks)

Description	Marks
For each of the two geographic factors (2 x 1 mark)	
Identifies a relevant geographic factor relating to the economic viability of the proposed mine site.	1
Subtotal	2
For each of the two social factors (2 x 1 mark)	
Identifies a relevant social factor relating to the economic viability of the proposed mine site.	1
Subtotal	2
Total	4
<p>Answers could include:</p> <p>Geographic factors:</p> <ul style="list-style-type: none"> • distance from nearest port • access to main roads • distance from electric infrastructure • distance from water infrastructure. • climatic conditions <p>Social factors:</p> <ul style="list-style-type: none"> • distance from population centres means no local workers • distance from population centres may mean few objections for noise, dust, or light pollution • may require negotiation with local traditional owners. <p>Accept other relevant answers.</p>	

- (b) The characteristics of two separate deposits from this site are identified below. Complete the table by identifying the method of extraction most suited to each deposit. (2 marks)

Description	Marks						
For each of the two methods (2 x 1 mark)							
Identifies the most suitable method of extraction	1						
Total	2						
<p>Answers could include:</p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Deposit characteristics</th> <th>Most suitable method of extraction</th> </tr> </thead> <tbody> <tr> <td>Evenly and widely distributed low-grade ore from a depth of 20 m below the surface</td> <td>Open cut</td> </tr> <tr> <td>High-grade ore concentrated in a narrow band of veins located 150 m below the surface</td> <td>Underground</td> </tr> </tbody> </table>		Deposit characteristics	Most suitable method of extraction	Evenly and widely distributed low-grade ore from a depth of 20 m below the surface	Open cut	High-grade ore concentrated in a narrow band of veins located 150 m below the surface	Underground
Deposit characteristics	Most suitable method of extraction						
Evenly and widely distributed low-grade ore from a depth of 20 m below the surface	Open cut						
High-grade ore concentrated in a narrow band of veins located 150 m below the surface	Underground						

Question 20 (continued)

- (c) The map below shows that geophysical responses indicate the likely presence of valuable mineralisation extending across parts of the habitat of an endangered marsupial, and across an area identified as having significant cultural importance to local native title holders.
- (i) Describe **two** ways in which a potential mine developer could respond to the presence of the endangered marsupial, and the likely impact of these measures on the economic viability of mine development. (4 marks)

Description	Marks
For each of the two ways (2 x 2 marks)	
States an appropriate response to presence of marsupial.	1
Identifies the likely impact of this proposed response on the economic viability of mine development.	1
Total	4
Answers could include:	
<ul style="list-style-type: none">• conduct a study of potential mine impact on the marsupial population• fence mine area and trap and relocate marsupials in affected area to another location• could decide to excise the areas of marsupial habitat from the possible mine development.	
Note: Impact on viability must be appropriate for the specific response. Most active measures would represent an additional cost on mine development. Some measures could also reduce the area able to be mined, and some may make mine development un-viable.	
Sample answer:	
The company could undertake a study of the marsupial population and their habitat in order to establish how much development of the mine would affect their natural range. This would impose an additional cost on mine development, and may make the mine less profitable. The company could also seek expert guidance with regards to the potential of relocating the marsupials to another location (either temporarily or permanently) and/or excluding them from the mine site. If it is not feasible to relocate the marsupials, this may make the mine uneconomic.	
Accept other relevant answers.	

- (ii) Describe **two** implications that the identified area of cultural importance could have for mine approval. (4 marks)

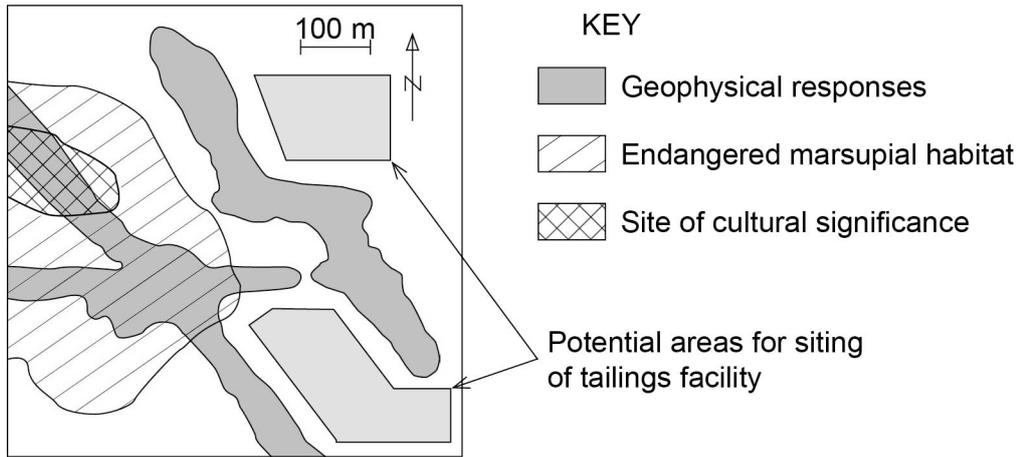
Description	Marks
For each of the two implications (2 x 2 marks)	
Identifies the implication for mine approval.	1
State how the implication identified affects mine approval.	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • consultation with local Aboriginal groups will be needed • community groups might not agree therefore halting mine approval • permission to mine in the area would be required from government agencies • the area mined might need to be altered to allow the protection of the culturally important area. <p>Sample answer:</p> <p>To obtain mine approval the company will have to consult with local Aboriginal groups, destruction of a heritage site could have impacts on both the cultural identity of the area and on the company itself. Appropriate consultation with local community groups might lead to mining in the area being approved with appropriate restrictions, alterations or caveats that benefit the local community while maintaining the structural and environmental attributes of the area.</p> <p>Accept other relevant answers.</p>	

Question 20 (continued)

(d) If the mineral deposit was to be developed, a local site would need to be identified for the permanent disposal of waste rock and mine tailings.

(i) On the map on page 16, mark an X to identify a suitable location for such disposal. (1 mark)

Description	Marks
Identifies a suitable location (within the shaded regions).	1
Total	1



(ii) State a reason justifying your decision to locate the waste facility at your chosen location. (1 mark)

Description	Marks
States a reasonable justification for the chosen location.	1
Total	1
Answers could include: <ul style="list-style-type: none"> • proximity to all potential mineralisation means less transportation • not located on a possible extraction site • not located in the habitat of the endangered marsupial • not located in the area of cultural significance. Accept other relevant answers.	

Question 21

(14 marks)

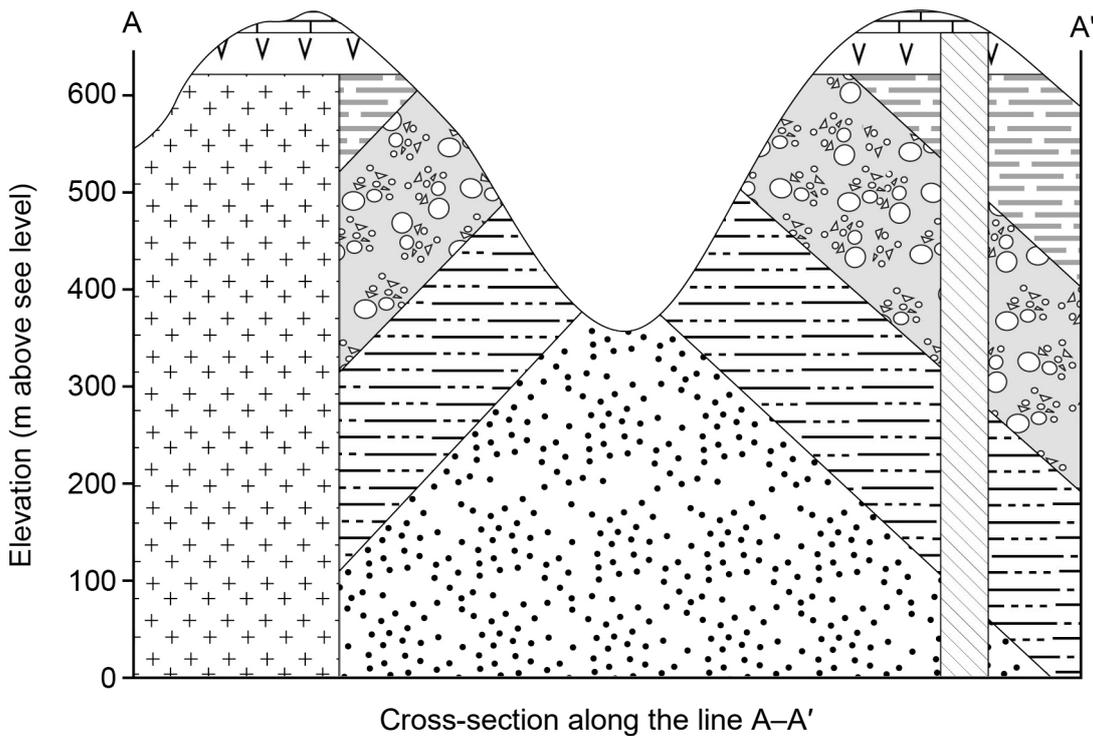
The map below represents the known distribution of rocks across a region being investigated by geologists.

- (a) Identify the oldest lithology in the mapped area. (1 mark)

Description	Marks
sandstone	1
Total	1
Note: Mark can be awarded for a lithology other than sandstone where the answer provided is consistent with an incorrectly drawn cross-section in part (a).	

- (b) Produce a cross-section along the line A–A' on the section provided below showing interpreted geology projected to sea level (0m elevation). (6 marks)

Description	Marks
appropriate topography	1
contacts shown in appropriate positions	1
basalt and limestone units flat lying	1
unconformable relationship between basalt and underlying units (granite, shale, sandstone, siltstone)	1
anticlinal fold structure shown	1
dolerite shown as a vertical dyke at an appropriate point	1
Total	6



Question 21 (continued)

- (c) The granite, dolerite and basalt all reflect different styles of igneous activity. On the basis of the relationships shown in the map, state how the basalt may have been emplaced in this area, and name **one** piece of evidence you would look for in the field to test your suggestion. (2 marks)

Description	Marks
States a relevant emplacement mechanism.	1
States a potential field evidence appropriate for the emplacement mechanism chosen.	1
Total	2
Answers could include: Emplacement mechanism <ul style="list-style-type: none"> • emplaced as a flow on the exposed surface • emplaced as a flat sill near to the surface • fed by the dolerite dike cutting across the region. Evidence <ul style="list-style-type: none"> • if the basalt is a surface lava flow, look for evidence of a baked soil beneath it • if the basalt is a surface lava flow, look for evidence of surface erosion on the underlying rocks. • if the basalt was fed by the dolerite, look for continuity of the two bodies where they meet. Accept other relevant answers.	

- (d) An area of metamorphic change is present in rocks adjacent to the granite. Identify **two** textural or mineralogical differences you might expect to see in this metamorphosed rock compared to its protolith in the area. (2 marks)

Description	Marks
For each of the two textural or mineralogical differences (2 x 1 mark)	
Identifies a relevant textural or mineralogical difference.	1
Total	2
Answers could include: <ul style="list-style-type: none"> • increase in grainsize • interlocking crystals • mineralogical change. Accept other relevant answers.	

- (e) On the map on page 18, draw in the direction of water flow of the stream. (1 mark)

Description	Marks
Draws arrow pointing in a SW direction.	1
Total	1

- (f) Some historical stream sampling data is available from the sampling site points marked as X, Y and Z on the map on page 18. Results from these points are shown below.

Stream sample analysis			
Metal	Sample content (weight %)		
	X	Y	Z
Copper (Cu)	<0.001	<0.001	<0.001
Lead (Pb)	<0.001	<0.001	<0.001
Gold (Au)	<0.001	0.48	0.46
Silver (Ag)	<0.001	0.09	0.10

- (i) Identify a possible source rock for the high levels of gold observed in some of the samples analysed. (1 mark)

Description	Marks
dolerite	1
Total	1

- (ii) State a reason justifying the source rock chosen. (1 mark)

Description	Marks
States an appropriate justification.	1
Total	1
Answers could include: <ul style="list-style-type: none"> • stream is devoid of gold at X, ruling out conglomerate and shale as gold sources • Y has evidence of gold (stream passes through dolerite) • Z has evidence of gold and passes through dolerite. Accept other relevant answers.	

Question 22

(11 marks)

The koala has been classified as a vulnerable species by the Australian Government since 2012. The results of research begun in 2008, tracking the estimated national koala population are shown in the table below.

Year	2008	2010	2013	2014	2015	2016	2018	2019	2020
Estimated koala population ('000)	145	144	139	139	133	128	120	115	58

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

Description	Marks
appropriate title – including both variables	1
axes appropriate – year on horizontal, koala population on vertical	1
units appropriate – time in years, population in '000s	1
appropriate choice of scale for both axes	1
accurate plotting of data and connecting line	1
Total	5

Sample graph:

Estimated koala population 2008–2020

Year	Estimated koala population ('000)
2008	145
2010	144
2013	139
2014	139
2015	133
2016	128
2018	120
2019	115
2020	58

- (b) State a long-term trend identified in the data. (1 mark)

Description	Marks
gradual decline in koala population	1
Total	1

- (c) The dramatic change reported in the estimated koala population between 2019 and 2020 was initially dismissed by foreign biologists as an error. Using Australian environmental factors, describe how this fall in numbers could be caused. (2 marks)

Description	Marks
Establishes that Australian wildlife is vulnerable to natural hazards than can produce dramatic population crashes.	1
States specific factor that could have caused fall in numbers.	1
Total	2
Answers could include: <ul style="list-style-type: none"> • severe bushfires in 2020 killing large numbers of koalas • severe drought conditions leading to large numbers of animal deaths • habitat loss. Accept other relevant answers.	

- (d) Assuming that the 2019 and 2020 figures are accurate, outline an implication of this dramatic decrease in population for the vulnerability of koalas in the wild. (1 mark)

Description	Marks
Recognises that reduced population size makes the koalas more vulnerable.	1
Total	1
Answers could include: <ul style="list-style-type: none"> • smaller populations have less genetic diversity, making them more vulnerable • smaller numbers could decrease pressure on their habitat, decreasing vulnerability. Accept other relevant answers.	

- (e) Identify **two** methods of protecting koalas in the wild that could be used to decrease their vulnerability. (2 marks)

Description	Marks
For each of two specified methods (2x1 mark)	
Identifies method of protecting koalas.	1
Total	1
Answers could include: <ul style="list-style-type: none"> • trapping koalas in environmentally degraded areas and relocating to more favourable areas • protection of koala habitat • increased surveillance and removal of potential predators in koala habitat. Accept other relevant answers.	

Question 23

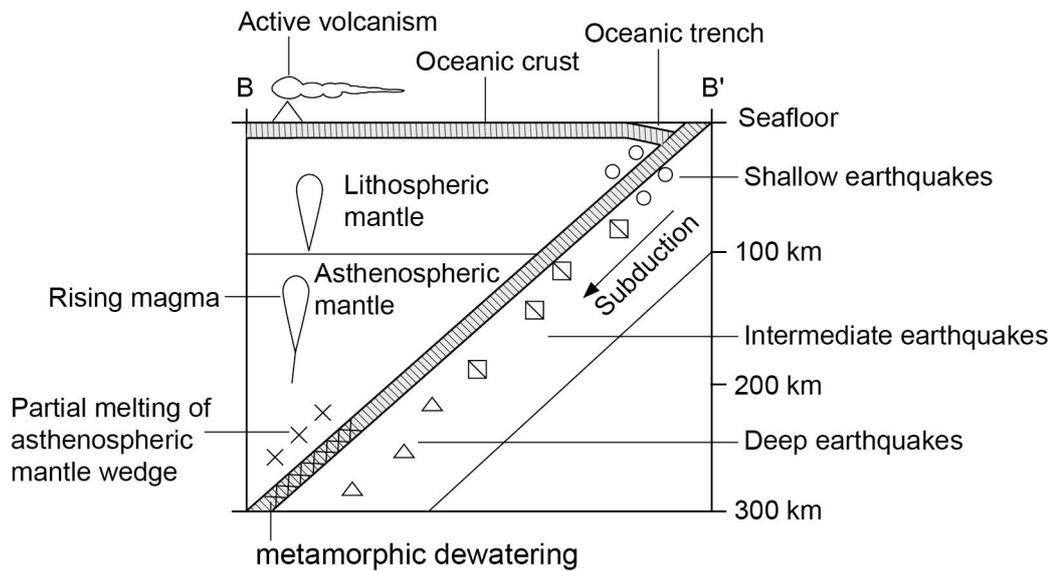
(14 marks)

The map below shows a group of islands (X, Y, and Z) and the distribution of earthquakes and volcanic activity around an active tectonic plate boundary. The boundary itself is not shown.

- (a) Draw a labelled sketch cross-section along the line B–B' showing the nature of the tectonic plate boundary. Show the approximate location and orientation of your section line on the map. Your section should also include any additional geological or structural features you would expect to be present. (5 marks)

Description	Marks
Shows clear representation of subduction conditions appropriate to the data presented.	1
Any four appropriate features:	
<ul style="list-style-type: none"> • oceanic slab subducting beneath other oceanic plate, with appropriate labels. • presence of an oceanic trench • subduction correctly dipping towards B • partial melting of mantle wedge above subducting slab deeper than ~ 200 km (appropriate scale shown) • active volcanism in appropriate location • metamorphism of down-going slab, releasing water. 	1–4
Total	5

Example diagram:



- (b) To reduce the vulnerability of the military base on Island X to natural hazards, the Government has decided to move it from its current location to the site labelled 'A' in the north of the island. State the primary hazard the base would be exposed to at its current location, and describe how moving the base to site 'A' would reduce risk from this hazard. (3 marks)

Description	Marks
Recognises the northern location A is less exposed to natural hazards	1
Identifies tsunami as primary hazard.	1
Identifies shallow undersea earthquakes as the primary cause of tsunamis in this setting.	1
Total	3
Accept other relevant answers.	

- (c) Island Y in the north of the region shown hosts two active volcanoes. Describe **two** different types of volcanic hazard you would expect this island to experience. (4 marks)

Description	Marks
For each of the two volcanic hazards (2 x 2 marks)	
Identifies volcanic hazard relevant to subduction zone (andesitic/composite) volcanism.	1
Specifies a characteristic of the identified hazard.	1
Total	4
Answers could include: <ul style="list-style-type: none"> • ash fall from explosive eruption • pyroclastic flows • volcanic gas • lahars from collapse of crater lake • landslides. 	
Accept other relevant answers.	

- (d) Explain why the hazards listed above would differ from those experienced on an active island volcano far in the interior of a tectonic plate, and removed from the influence of plate boundaries. (2 marks)

Description	Marks
Specifies a style of volcanism relevant to a plate interior.	1
Identifies a characteristic of plate interior volcanism that would cause hazards different to those of subduction zone volcanism.	1
Total	2
Answers could include: <ul style="list-style-type: none"> • basaltic volcanism at hot spot volcanoes is less viscous and therefore more likely to create a lava flow hazard • basaltic volcanism is less likely to be explosive, thus creating lower risk from airfall, pyroclastic flows etc. • the magma gas content differs meaning magma located in the interior of a tectonic plate contains less dissolved gas. 	
Accept other relevant answers.	

Section Three: Extended answer

30% (30 Marks)

Question 24

(15 marks)

Global climate has changed over geological time.

- (a) Explain how **two** types of evidence can demonstrate climate change outside human history. (6 marks)

Description	Marks
For each of two forms of evidence (2 x 3 marks)	
Identifies a type of evidence that can demonstrate climate change.	1
States the features of the identified evidence that can be used to demonstrate climate change.	1
States how the identified evidence can demonstrate climate change outside human history.	1
Total	6
<p>Answers could include:</p> <ul style="list-style-type: none"> • analysis of ice core • analysis of annual layers in lake sediments • analysis of fossil record showing changing faunal distributions <p>Sample answers:</p> <p>Ice sheets and glaciers grow from the accumulation of annual layers of snowfall compacting to ice. As long as the ice remains intact, these layers remain distinct, and taking a core sample through the ice sheet allows the individual layers to be identified and sampled, providing a record extending back thousands or even tens of thousands of years. Varying layer thickness provides a measure of the relative level of snowfall in a given year, and by analysing isotopic ratios of hydrogen and oxygen in the ice of different layers, scientists can build up a record of the global cryosphere over time, reflecting growth and decay of ice sheets during glacial and interglacial periods.</p> <p>Accept other relevant answers.</p>	

- (b) Describe how **two** natural processes have contributed to global climate change over geological timescales. (4 marks)

Description	Marks
For each of the two natural processes (2 x 2 marks)	
Identifies a natural process contributing to climate change over geological timescales.	1
Outlines how the stated process has contributed to global climate change over geological timescales.	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • albedo feedback from ice sheet growth • variations in orbital properties of Earth • continental rifting – increased volcanic outgassing • continental collision and mountain building. <p>Sample answer:</p> <p>Continental collision closes seaways, disrupting global oceanic currents, and causes the growth of major mountain systems, disrupting atmospheric currents. Because these currents are major mechanisms for the redistribution of heat around the globe, these disruptions lead to regional and global changes in climate.</p> <p>The fundamental driver of the heat energy circulating within the global climate system is the amount of solar radiation absorbed by the Earth's surface and re-radiated as heat. Ice sheets are highly reflective, and the growth of major ice sheets across large continental areas can significantly increase the proportion of solar radiation reflected from the Earth instead of absorbed and re-radiated, leading to overall global cooling.</p> <p>Accept other relevant answers.</p>	

Question 24 (continued)

- (c) Choose **one** of the following: the atmosphere, geosphere or hydrosphere, and outline how climate change has made an impact upon it. (2 marks)

Description	Marks
Outlines how climate change impacts the chosen element of the global system.	2
Identifies aspect of climate change affecting chosen element of the global system.	1
Total	2
Answers could include:	
Atmosphere	
<ul style="list-style-type: none">• increased ocean temperatures drive more powerful and frequent cyclones• increased evaporation from the oceans can increase rainfall.	
Geosphere	
<ul style="list-style-type: none">• local increases in amount and/or seasonality of rainfall can increase erosion rates• higher temperatures lead to higher rates of weathering in exposed rocks.	
Hydrosphere	
<ul style="list-style-type: none">• higher temperatures lead to retreat of glaciers and ice sheets• higher temperatures lead to changes in flow levels in rivers.	
Sample answer:	
Some major river systems such as the Indus in Pakistan are fed largely by the melt of glaciers and winter snow. Higher temperatures particularly in winter months – will drive glacier retreat and reduce snowfall, significantly decreasing flow levels in these melt-fed rivers.	

- (d) Using a relevant example, explain how climate change over time affects the distribution of plant or animal species. (3 marks)

Description	Marks
Explanation	
Explains the resulting change in the distribution of plant or animal species.	2
Identifies a warming or cooling phenomenon that can affect the distribution of plant or animal species.	1
Subtotal	2
Use of example	
Cites relevant examples of a plant or animal species that responds to climate change as specified.	1
Subtotal	1
Total	3
<p>Answers could include:</p> <ul style="list-style-type: none"> • changes geographic tolerance ranges of temperature-sensitive species • changed rainfall patterns alter natural vegetation distribution • climate stress on ecosystems makes them vulnerable to disruption by invasive species. <p>Sample answer:</p> <p>Many animal species have evolved physical and behavioural features specifically adapted to the climate conditions of their natural geographical range. Change in climate can leave these species maladapted to their surroundings, leading to significant stress and leaving them vulnerable to disruption and competition from invasive species better adapted to the new conditions. An example of this is polar bears, who are adapted to hunting seals on arctic sea ice. Decreased areas and duration of ice coverage during key feeding months are placing many polar bears under stress, leading to changes in their behaviour and increased interaction with humans as they search for alternative food sources.</p> <p>Accept other relevant answers.</p>	

Question 25

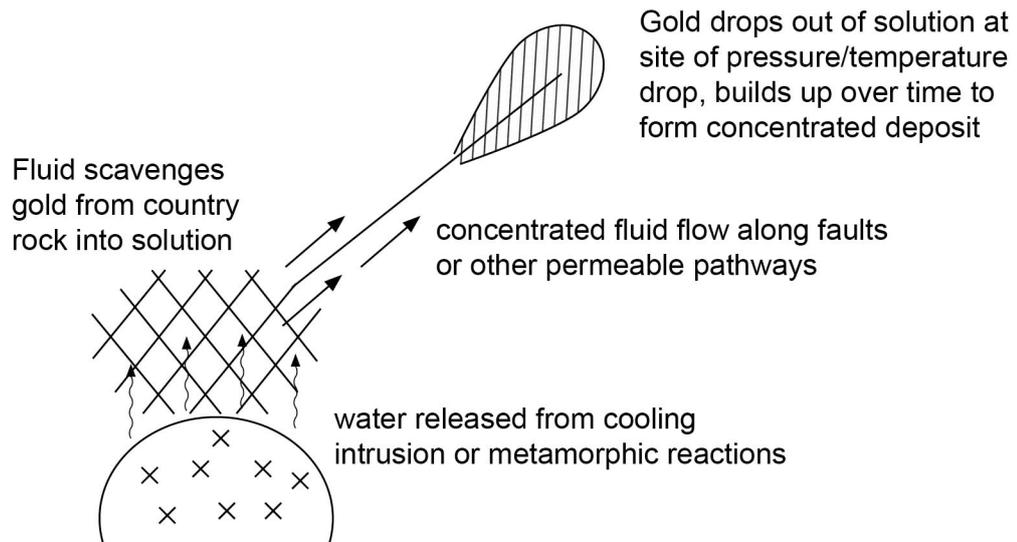
(15 marks)

For any one non-renewable mineral or non-renewable energy resource address the following question parts.

- (a) With the aid of a labelled diagram, describe how geological processes can lead to the formation of your chosen resource, using a specific example or examples drawn from real resource systems where appropriate. (7 marks)

Description	Marks
Specifies a non-renewable mineral or non-renewable energy resource formed by geological processes.	1
Subtotal	1
Diagram	
Diagram clearly shows the geological processes that can lead to the formation of the chosen resource.	2
Diagram shows some aspect of the formation of chosen resource.	1
Subtotal	2
Description	
Outlines a geological processes which can lead to the formation of the chosen resource.	1
Indicates features of the stated geological processes which lead to the formation of the chosen resource.	1
Links characteristic of the chosen resource system to the specified geological process.	1
Subtotal	3
Use of example(s)	
Cites a relevant real example(s) of a non-renewable mineral or non-renewable energy resource system.	1
Subtotal	1
Total	7
<p>Answers could include:</p> <p>Non-renewable mineral resources</p> <ul style="list-style-type: none"> • iron ore • nickel sulfide ore bodies • hydrothermal gold. <p>Non-renewable energy resources</p> <ul style="list-style-type: none"> • coal • petroleum. <p>Accept other relevant answers.</p>	

Example 1: Hydrothermal gold



Sample answer for hydrothermal gold:

Hot water containing dissolved sulphur, CO_2 or other chemical agents capable of complexing with gold, strips gold out of a large volume of source rocks containing gold at low concentrations. Flow of the gold-bearing fluids under gradients of pressure or temperature transports the gold. As the fluids cool or encounter different chemical or pressure conditions, the gold is released from solution and precipitates, along with vein minerals. As fluid continues to flow through the system over time, progressive build-up of gold at the precipitating location can lead to accumulation of gold to high concentrations.

Note: Descriptive points can be included in the diagram, and markers should assess and award marks on this basis where appropriate.

Examples for hydrothermal gold:

- Golden Mile in Kalgoorlie
- Telfer.

Accept other relevant answers.

Question 25 (continued)

Example 2: Petroleum systems

1. marine sedimentation

fine grained shale – potential hydrocarbon barrier

organic rich layer – potential hydrocarbon source

pile of sediments several km deep

2. sediments continue to build up – burying and heating source rock

gas

4. barrier rocks trap hydrocarbons

oil

3. organic material breaks down, releasing hydrocarbons

Sample answer for petroleum (oil or gas):

Change of sedimentary conditions leads to burial of organic rich sediments beneath fine grained sediments such as shale that hydrocarbons cannot flow through. Further burial of the organic rich sediments leads exposes them to increased temperatures, breaking down the organic material to release hydrocarbons. Region of hydrocarbon accumulation needs to stay buried and not disrupted by faulting, otherwise the hydrocarbons are able to escape.

Examples for hydrocarbons:

- oil and gas in the Canning Basin
- gas on the Northwest Shelf
- oil and gas in Bass Strait.

Accept other relevant answers.

- (b) On the basis of your answer to part (a), explain how their tectonic setting can influence the location of the kind of non-renewable resource described. (4 marks)

Description	Marks
Identifies a tectonic setting appropriate to formation of the mineral resource specified in part (a).	1
Correctly determines how the tectonic setting can influence the location of the chosen resource.	1
States some features of the tectonic setting that influences the location of the chosen resource.	1
States how the specified features contribute to the location of the chosen resource.	1
Total	4
<p>Answers could include:</p> <p>Resource</p> <ul style="list-style-type: none"> • petroleum – passive margin, or adjacent to continental subduction margin • hydrothermal gold – orogenic system or convergent plate margin • epithermal copper-gold – continental plate overriding a subducting slab • nickel sulphide – Archean rift settings. <p>Sample answer for petroleum resources: Passive continental margins accommodate long-term uninterrupted build-up of sediments. This both gives rise to laterally continuous sedimentary layers producing widespread reservoir and seal rocks, and results in the burial and heating of organic rich sediments to liberate hydrocarbons. The lack of structural disruption in passive settings is also important, making it less likely traps will be breached to release accumulated hydrocarbons.</p> <p>Sample answer for hydrothermal gold: Orogenic systems can deliver the release of metamorphic fluids able to transport gold, and create structural pathways (faults) and thermal gradients to drive fluid migration to concentrate gold. Intrusion of granites in orogenic systems can also release gold-bearing or gold-carrying fluids and drive their migration through establishing strong local thermal gradients.</p> <p>Accept other relevant answers.</p>	

Question 25 (continued)

- (c) Describe **one** example of how 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 each of abiotic and biotic components (2 x 2 marks)	
Identifies a relevant aspect of the ecosystem that is affected by extraction of the chosen resource.	1
Shows how the relevant aspect of the ecosystem is affected by extraction of the specified resource.	1
Total	4
<p>Answers could include:</p> <p>Abiotic components</p> <ul style="list-style-type: none"> • water • temperature • pH • minerals. <p>Biotic components</p> <ul style="list-style-type: none"> • local plants • local animals • introduced pathogens. <p>Example answer for extraction of hydrothermal gold resources: Both open pit and underground mining to access hydrothermal gold resources typically require substantial de-watering of the ground, pumping out local groundwater to prevent mine workings from being flooded. This can both substantially deplete the local aquifer and depress the water table, resulting in the release of large volumes of water (in some cases with high salinity or dissolved chemical load) at the surface. Clearance of land and construction of earthworks for mine development result in the disruption and removal of endemic plant life. Removal of and modification of local soil horizons can make such disturbance slow or impossible to recover, particularly in fragile landscapes such as deserts and arid regions.</p> <p>Example answer for extraction of hydrocarbon resources: Hydrocarbons are typically extracted by drilling down to the reservoir in which they are accumulated and releasing or pumping them to the surface as fluid to be collected and processed. Hydrocarbon reservoirs are typically deeper than local aquifers, and the process of their drilling and extraction presents a risk of groundwater being contaminated by hydrocarbons and related chemicals, particularly in the event of unplanned release of hydrocarbons or drilling fluids, or if hydraulic fracturing of the reservoir is used in the extraction process. Installing and operating the drilling equipment and infrastructure to extract hydrocarbons requires construction of roads and clearance of significant areas of land. Endemic plant and animal species can be placed under stress through this clearance, both by direct disturbance and by the introduction of invasive species and pathogens.</p> <p>Accept other relevant answers.</p>	

Question 26

(15 marks)

Artificial oxygenation has been used since 2008 to increase low oxygen levels in the Swan River in Perth.

- (a) Explain how a human activity can deplete the oxygen levels in a river. (4 marks)

Description	Marks
Identifies a specific human activity that would cause oxygen to deplete (cause).	1
States how the identified human activity can alter river composition.	1
Outlines the process/es that this disturbance causes in a river system.	1
States how the mechanism above leads to oxygen depletion in the river.	1
Total	4
<p>Answers could include:</p> <p>Human activities</p> <ul style="list-style-type: none"> excessive fertiliser use for agriculture leading to fertiliser run-off into waterways release of raw sewage into waterway farming of animals leading to runoff of manure into waterways urban living resulting in discharge of detergents from household usage. <p>Explanation</p> <ul style="list-style-type: none"> introduction of nitrates and phosphates to waterway increased growth of surface algae leading to algae bloom death of bottom-dwelling plants leading to a decrease in oxygen being produced breakdown of decaying algae utilising oxygen death and decay of freshwater organisms leading to a decrease in oxygen. <p>Accept other relevant answers.</p>	

- (b) Explain a possible outcome for river ecosystems if oxygen levels depleted by human activity are not increased by artificial oxygenation or other management practices. (3 marks)

Description	Marks
Identify a possible outcome for the river ecosystem if oxygen levels are not increased.	1
Outlines some features of that possible outcome for the river ecosystem if oxygen levels are not increased.	1
Gives a consequence of depleted oxygen levels if oxygen levels are not increased.	1
Total	3
<p>Sample answer:</p> <p>Reduced oxygen levels increase stress on aquatic animals and at particularly low levels or with persistence over long periods may lead to die-off. This disrupts aquatic ecosystems, making them vulnerable to invasive species that may be more tolerant of low oxygen conditions, and could support excessive growth of aquatic plants and algae (if grazing organisms are absent or reduced in activity).</p> <p>Accept other relevant answers.</p>	

Question 26 (continued)

A hypothetical proposal has been made to develop a hydroelectric facility in the upper reaches of a major Western Australian river.

- (c) Describe **two** factors (atmospheric, hydrologic or social) that should be taken into consideration in evaluating such a proposal. (4 marks)

Description	Marks
For each of the two factors (2 x 2 marks)	
Identifies a relevant factor.	1
Outlines the consequence of this factor on a hydroelectric project.	1
Total	4
<p>Answers could include:</p> <p>Atmospheric</p> <ul style="list-style-type: none"> • whether evaporation from the surface of the impounded water would exceed the river flow rate filling the dam • whether the dam is strong enough to withstand predicted storm events • predicted impacts of climate change on rainfall and/or evaporation levels. <p>Hydrologic</p> <ul style="list-style-type: none"> • the interruption of natural water flow in the river below the dam • whether river flow levels above the dam are sufficient to fill it • impact of raised groundwater levels on local fauna. <p>Social</p> <ul style="list-style-type: none"> • recreational or amenity value placed on the area of land which would be flooded • potential significance of the river and/or the area to be flooded to local traditional owners • potential recreational or amenity value to be created by lake resulting from filling of the dam • potential use of captured water to irrigate farmland or support other valuable use. <p>Sample answer:</p> <p>Western Australia’s changing climate has meant a reduction in rainfall and an increase in hotter days. Because of this, large scale surface water storage is no longer viable as there simply isn’t the rainfall to fill a hydroelectric facility. Also the lack of rainfall would mean the power supply would be unreliable.</p> <p>Accept other relevant answers.</p>	

Demand for fresh water is expected to rise in Perth over the coming decades, and no additional surface water sources are available to meet this anticipated need.

- (d) Describe **two** alternative methods for increasing the availability of drinking-quality water. (4 marks)

Description	Marks
For each of the two alternative methods (2 x 2 marks)	
Identifies a relevant method.	1
Outlines how the identified method will increase the availability of drinking-quality water.	1
Total	4
<p>Answer could include:</p> <ul style="list-style-type: none"> • construction of a new or expansion of existing desalination plant • tapping of deeper, currently under-exploited groundwater aquifers • recharging of aquifers with treated waste water • direct re-use of treated waste water • construction of a pipeline to bring water in from the SW of the state. <p>Sample answer:</p> <p>Perth's desalination plants produced just under 100 gigalitres of water in 2020–2021 providing 48% of Perth's drinking water. Seawater is pumped into the plant and the salt and other particles removed through a process of filtration and reverse osmosis to produce fresh drinking water. Building an additional plant could deliver another 50 gigalitres of water to satisfy the city's growing needs. While desalination plants are expensive to build and maintain they have the ability to produce large amounts of fresh water to satisfy the growing needs of the city.</p> <p>Accept other relevant answers.</p>	

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