Government of **Western Australia**
School Curriculum and Standards Authority

EARTH AND ENVIRONMENTAL SCIENCE

ATAR course examination 2020

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.

2020/65621

Section One: Multiple-choice **15% (15 Marks)**

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

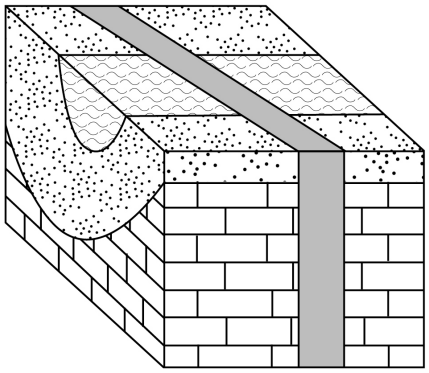
Section Two: Short answer **55% (110 Marks)**

Question 16 **(11 marks)**

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

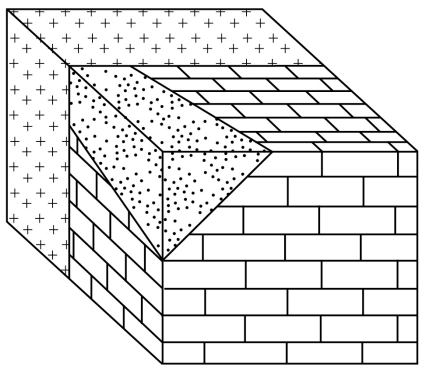
(i) (2 marks)

Description	Marks
Shows basalt shown as a vertical dyke cutting other units	1
Shows horizontal contact between sandstone and limestone	1
Total	**2**



(ii) (2 marks)

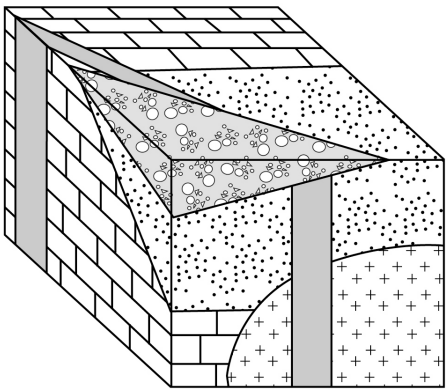
Description	Marks
Shows sandstone and limestone both cut by intrusive granite	1
Shows sandstone wedge getting thinner towards top of block face	1
Total	**2**



Question 16 (continued)

(iii) (2 marks)

Description	Marks
Shows basalt as a vertical dyke cutting other units	1
Shows sandstone in unconformable contact with overlying conglomerate	1
Total	**2**



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

Description	Marks
For each **two** correct relationships (1 mark)	
• conglomerate is the youngest • basalt is older than conglomerate • granite is older than basalt • mudstone is older than granite • sandstone is older than mudstone • limestone is the oldest	1–3
Total	**3**

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

Description	Marks
The older units experienced erosion	1
The conglomerate was deposited on the erosion surface	1
Total	**2**
Sample answer: The units older than the conglomerate were tilted by tectonic processes and eroded. Deposition then returned to the area, with the conglomerate laid down on the erosion surface.	

Question 17 **(12 marks)**

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

Description	Marks
For each of **two** processes (3 marks each)	
Explains how the identified natural process can affect global temperature on geological timescales and states the resulting change in global temperature	3
Describes how the identified natural process can affect global temperature on geological timescales	2
Identifies a natural process that can affect global temperature on geological timescales	1
Subtotal	**3**
Total	**6**

Answers could include:

Growth of ice sheets
- increased global albedo reflecting solar radiation back into space
- this results in decreased global temperatures

Flood basalt volcanism
- released CO_2 into the atmosphere can significantly increase the greenhouse effect
- this results in increased global temperatures

Tectonic movement of continental landmasses
- volcanic eruptions may occur, with the atmosphere having greater amounts of carbon dioxide and sulphur dioxide
- this results in increased global temperatures

Changed oceanic circulation patterns
- ocean currents help to distribute solar radiation around the globe, i.e. they move cold water from the poles to the equator and warm water from the equator to the poles.
- any change to these currents will result in more extreme global temperatures

Changes in orbital parameters of the Earth (Milankovitch cycles)
- changes to the Earth's orbit and position relative to the Sun affect natural warming and cooling affecting the length of seasons
- results in more extreme temperatures including ice ages

Meteor impacts
- production of ash and dust would block solar radiation
- this would cause a marked decrease in global temperatures.

Sample answers:

Growth of major ice sheets would increase global albedo, reflecting more solar radiation back into space instead of it being absorbed by the Earth. This would decrease global temperatures.

Flood basalt volcanism could release large amounts of CO_2 into the atmosphere over periods of 10s of thousands to 100s of thousands of years, leading to an intensification of greenhouse conditions and increased global temperatures.

Accept other relevant answers.

Note: To meet the qualification of operating on 'geological timescales' the stated process should be able to produce temperature effects lasting multiple decades at a minimum.

Question 17 (continued)

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

(4 marks)

Description	Marks
Explains how the identified record type can be used to show specific aspects of climate change over timescales outside the range of human history	4
Describes how the identified record type indicates climate change	3
Describes the features of the identified record type	2
Identifies a record type that can be used to show the occurrence of climate change over timescales outside the range of human history	1
Total	**4**

Answers could include:

Ice cores

- scientists drill deeply into ice sheets and extract a core showing layers of snow
- particles remaining in the ice cores provide information about past climates
- ice cores contain air bubbles showing different atmospheric gas concentrations at different times over thousands of years. They provide evidence of past global events, including volcanic eruptions

Dendrochronology

- tree rings grow at different rates in different conditions
- tree rings generally grow wider during warm and wet seasons, while times of drought see minimal growth
- show local climatic conditions such as temperature and rainfall for each year of life

Cave formations (speleothems)

- water drips into caves, leaving minerals behind as stalactites and stalagmites
- the layers/growth rings preserve climate information from the past
- they show periods of rainfall and temperature changes as the rate at which they form depends on climatic conditions

Fossil records

- traces of ancient organisms that lived previously are preserved
- show how animals and plants reacted to climate changes, both local and global
- shows what the climate was like and the organisms that lived at different times as plants and animals need specific temperatures and rainfall to survive.

Sample answer:

The ratio of ^{16}O to ^{18}O in marine inorganic carbonate deposits varies with the growth and shrinking of ice sheets in response to changing climate over geological time. Expansion of ice sheets and glaciers in cooler conditions locks 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.

Accept other relevant answers.

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

Description	Marks
Outlines a warming or cooling phenomenon that could alter the distribution of plant and animal species on Earth	1
Describes the resulting change in the distribution of plant and animal species on Earth	1
Total	**2**

Answers could include:

- changing surface temperatures – the geographic range of temperature-sensitive animal species will change as they move to cooler locations. Plant species will no longer thrive in the altered conditions and will need to be planted closer to the poles
- rising ocean temperatures and sea levels – coastal plant species may disappear as sea levels rise and animal species relying on these plants as a food source may need to move inland. As ocean temperatures rise, the size and distribution of plankton and hence animal species e.g. whales which consume large amounts, will be altered
- altering rainfall patterns – distribution of species will alter as animals migrate to sources of water and only some plants will survive in drier conditions
- warmer ocean currents – animal and plant species will move to cooler waters where they are able to survive.

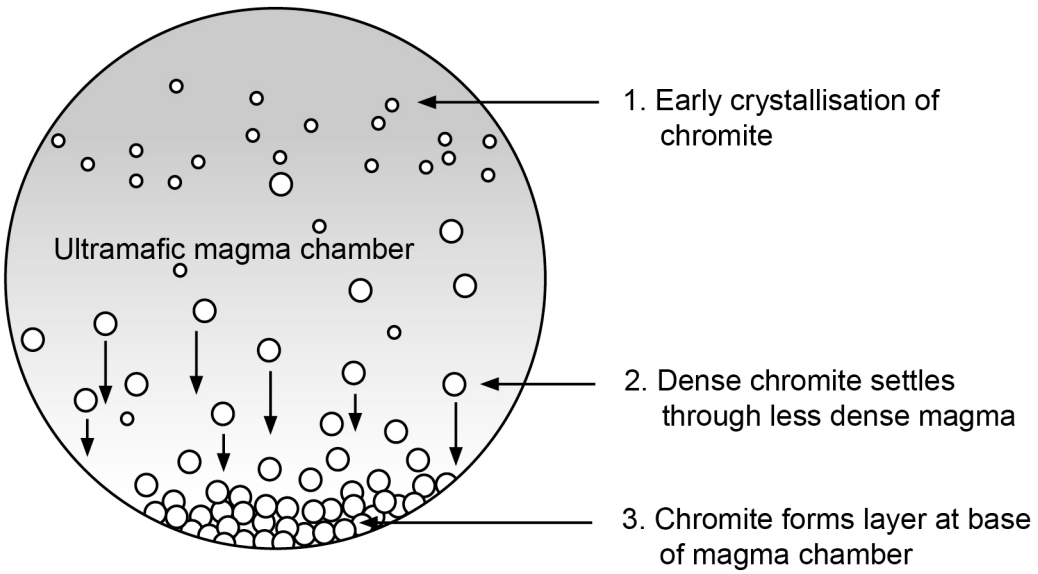
Accept other relevant answers.

Question 18 **(13 marks)**

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

Description	Marks
Ore-forming process	
Explains the process by which the chosen magmatic process can produce an ore body, including the resultant ore produced	3
Describes some features of the chosen magmatic process that enable it to form an ore body	2
Identifies an element of the chosen magmatic process	1
Subtotal	**3**
Diagram	
Diagram clearly shows the chosen ore-forming process and is labelled appropriately	2
Diagram shows some aspect of the chosen ore-forming process	1
Subtotal	**2**
Total	**5**

Answers could include:



Note: A diagram by itself might be acceptable for full marks if it adequately explains the chosen information.

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

Description	Marks
Identifies a source of water that might be capable of producing an ore deposit	1
Total	**1**
Answers could include: • meteoric water • deep ocean water • water released by metamorphic reactions • water released during crystallisation of an igneous body • groundwater.	
Accept other relevant answers.	

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

Description	Marks
Outlines deposition through precipitation (from changes in temperature and/or pressure of the fluid)	1
Describes the concentration process through chemical dissolution/chemical reactions	1
Identifies that the hydrothermal fluid moves the ore minerals in solution from their source and concentrates them to form an ore deposit	1
Total	**3**
Sample answer: As meteoric water moves from the surface deeper into the crust, it warms up and dissolves some of the mineral content out of the surrounding rocks. When that water cools down again, the dissolved minerals precipitate back out. If this happens rapidly and in a small volume of rock (for example, because the fluid rapidly flows up along a fault), the concentrated precipitation can form an ore deposit.	
Accept other relevant answers. Note: 'melting' and 'drying' are not adequate synonyms for dissolution and precipitation. Although not proscriptively defined, the terminology used must relate to aqueous chemical reactions.	

Question 18 (continued)

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

Description	Marks
Identifies a major environmental impact associated with the mining of a specified ore resource	1
Describes how the mining of the specified ore resource causes or is associated with the major environmental impact	1
Identifies a relevant environmental protection method	1
Describes how the protection method could be applied to reduce the environmental impact	1
Total	**4**

Answers could include:

Coal

- acid mine drainage – water from the mine is highly acidic and contains heavy metals. Rivers and habitats are polluted and water is often devoid of aquatic life. It reduces the quality of water supplies
- protection methods – placing a dry cover that does not erode over waste material, acting as a barrier to oxygen. Underwater storage can be used to contain heavy metals

Iron ore

- dewatering causing groundwater drawdown – affects irregular streams and ecosystems reliant on these
- protection methods – mines aim to maintain ecosystems with any excess water being released where it will not flood the area. Excess water can be used onsite, where it is used to limit dust from ore being transported

Bauxite

- clearing and fragmentation of vegetation and habitat – erosion of land and destruction of habitats occur during the mining process from leaching into water sources and bauxite dust
- protection methods – rehabilitating the mined areas assists by removing topsoil, collecting seeds and seedlings for use in rehabilitation the area. Reducing dust by placing covers over trucks and watering bauxite dust reduces the environmental impact

Gold

- mine pits posing dangers to animals and people – waste containing toxic levels of cyanide can escape confinement through mishandling on site and are hazardous to humans and animals. Cyanide can often be found in the water at mine sites
- protection methods – cyanide can be recycled in order to reduce the amount being used. Mines can convert the cyanide into cyanate, which is less harmful, before disposing of it. They can line their tailing ponds to prevent leaching.

Accept other relevant answers.

Question 19 **(14 marks)**

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

Description	Marks
Addition of excess nutrients to a water body	1
Causing disturbance to the natural aquatic ecosystem	1
Total	**2**
Sample answer: Eutrophication – the disturbance of a natural aquatic ecosystem by the addition of excess nutrients, typically through run-off or leaching of fertilisers applied in excess to farmland.	
Accept other relevant answers.	

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

Description	Marks
Specifies that an increased algal growth would occur	1
Identifies reduced light penetration	1
Total	**2**
Sample answer: The increased nutrient levels promote excessive algal growth, covering the surface of the water and reducing light penetration into the lake.	
Accept other relevant answers.	

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

Description	Marks
Identifies two common physical signs of eutrophication	1–2
Total	**2**
Answers could include: • fish struggling to obtain oxygen at the surface of the water • mass fish kills • odour • colour change to water • deterioration of water taste.	
Accept other relevant answers.	

Question 19 (continued)

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

Description	Marks
Site A	
Classifies aquatic condition as moderately degraded	1
Identifies reactive phosphate concentration of 0.16 mg/litre	1
Site B	
Classifies aquatic condition as severely degraded	1
Identifies reactive phosphate levels in excess of 0.2 mg/litre and/or nitrate levels in excess of 10 mg/litre	1
Total	**4**

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

Description	Marks
Any **two** characteristics (1 mark each)	
Answers could include: • elevated levels of aquatic weeds • elevated levels of algal growth • low-light species • dying plant life • abundant plant material on water surface • low diversity of aquatic plant types.	1–2
Total	**2**
Accept other relevant answers.	

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

Description	Marks
Identifies a remediation strategy that could reduce the effects of eutrophication in an affected water body	1
States the benefit of using the identified strategy	1
Total	**2**
Answers could include: • use of slow release fertilisers – reduces run-off • planting of vegetation buffers around wetland/waterways – absorbs excess nutrients • construction of sumps – captures run-off • dredging algae plant material – allows light penetration • oxygenation of water – allows biodiversity to re-establish • water mixing – enhances nutrient availability.	
Accept other relevant answers.	

Question 20 **(14 marks)**

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

Description	Marks
For each of **two** ways (3 marks each)	
Explains how production of food has contributed to increased methane concentrations in the atmosphere	3
Outlines how production of food is linked to methane release	2
Identifies a source of methane release linked to food production	1
Subtotal	**3**
Total	**6**

Examples could include:

- intensive meat production
- increased areas of land used for cattle production
- increased rice production
- increased food wastage and decomposition.

Sample answers:

An increase in the number of cows, sheep, pigs and chicken, produces more animal protein to meet the demands of increasing human population and/or increasing living standards around the world. Animals naturally produce methane when food breaks down in their stomachs and this is released into the atmosphere.

Dead organic matter created as a by-product of rice farming is left to rot in fields, and methane is released as this breaks down. Increased rice production to feed growing population in Asia has led to increased methane release.

Accept other relevant answers.

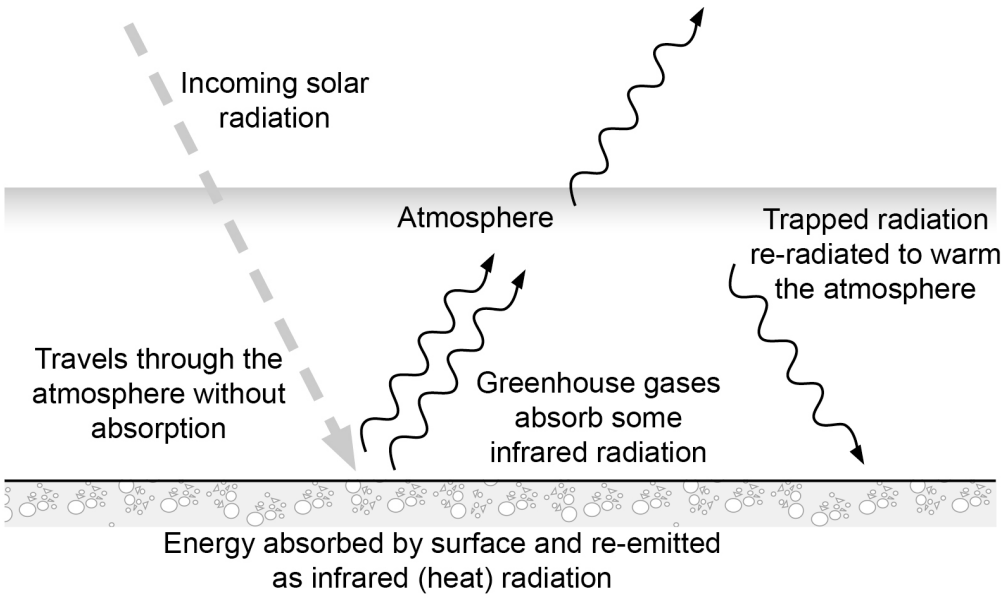
Question 20 (continued)

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

Description	Marks
Explanation	
Identifies that solar radiation is trapped by greenhouse gases	1
Identifies an increase in greenhouse gas leads to an increase in radiation trapped	1
States that an increase in global temperature results from trapped radiation	1
Subtotal	**3**
Diagram	
Diagram clearly shows how greenhouse gases are contributing to climate change and is labelled appropriately	2
Diagram shows some aspect of greenhouse effect	1
Subtotal	**2**
Total	**5**

Sample answer:
Greenhouse gases absorb infrared energy (heat) released from the Earth's surface and atmosphere. As the energy is absorbed it causes the lower atmosphere's temperature to rise. Some of the heat is transferred back to the Earth's surface. As the volume of greenhouse gases increases, the heating effect in the atmosphere also increases.

Sample diagram:



Accept other relevant answers.

Note: A diagram by itself might be acceptable for full marks if it adequately explains the chosen information.

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

Description	Marks
Identification	
Identifies a way in which increasing global temperature affects the hydrosphere	1
Subtotal	**1**
Description	
Detailed description of the process by which increasing global temperature affects the hydrosphere	2
Limited description of how the identified factor affects the hydrosphere	1
Subtotal	**2**
Total	**3**

Answers could include:

- retreat of glaciers and ice sheets
- reduced formation of winter ice
- decreased tropical storms
- increased acidification of the oceans.

Sample answer:
Increased ocean surface temperatures in tropical regions create more severe tropical cyclones/typhoons. Such storm systems take much of their energy from the warm water. Warmer oceans lead to more evaporation and more heat radiation, and thus to larger, more intense storms.

Accept other relevant answers.

Question 21 **(12 marks)**

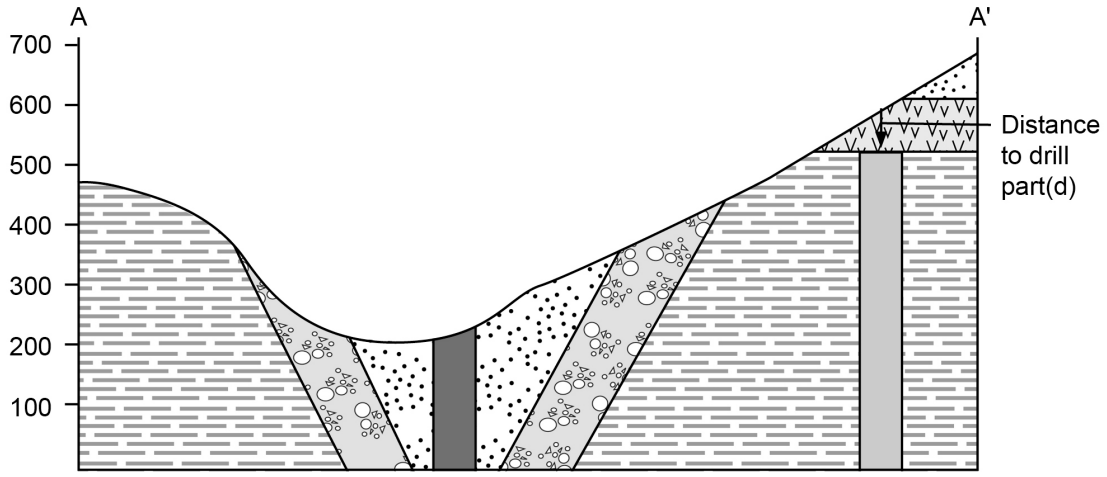
(a) Determine in degrees, the strike of Dolerite 1. (1 mark)

Description	Marks
Answer between 150 and 160 degrees **or** between 330 and 340 degrees	1
Total	**1**

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

Description	Marks
Accurate plotting of topography	1
Lithological contacts transferred accurately to section line	1
Syncline structure illustrated by units dipping inwards	1
Volcanics and upper sandstone shown as horizontal units	1
Contacts of lower sequence extrapolated beneath volcanics (Dolerite 2)	1
Total	**5**

Sample answer:



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

Description	Marks
shale	1
Total	**1**

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

Description	Marks
Answer between 75 m and 95 m	1
Total	**1**
Note: incorrect answers that match the projection of the cross-section in part (b) should be accepted.	

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

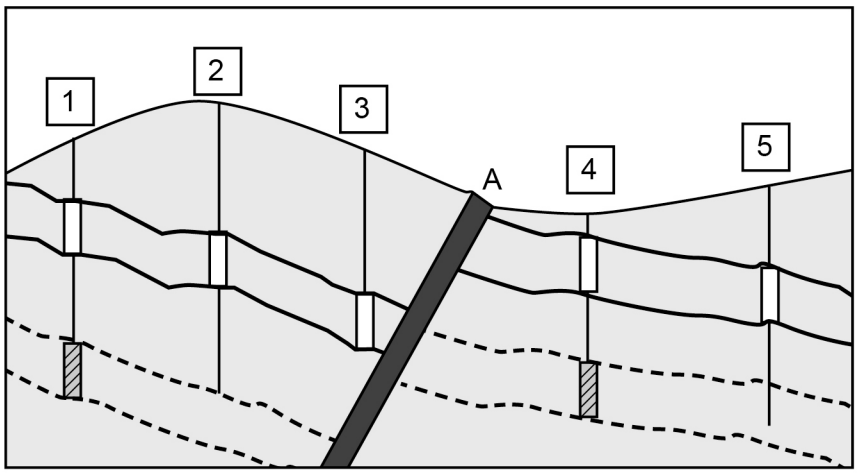
Description	Marks
For each of **two** exploration techniques (2 marks each)	
Identifies a further exploration technique that could assess the extent or grade of the deposit	1
Describes how this exploration technique could be used to assess the extent or grade of the deposit	1
Subtotal	**2**
Total	**4**
Answers could include: • drilling and geochemical sampling • soil sampling and drilling • geophysical techniques such as magnetic or gravity surveys. Sample answer: The extent and grade of the mineral deposit can be estimated through a diamond drill program. A geologist can define the deposit with geological mapping of the core data and create an estimate of the grade using the assay information from the geochemical data. Gravity surveys can then be overprinted onto the model to determine any structural controls of the mineralised zone.	
Accept other relevant answers.	

Question 22 **(13 marks)**

(a) On the diagram above, complete a geological interpretation of the ore deposit by modelling the upper and lower ore contacts for **both** the primary and secondary intercepts. (2 marks)

Description	Marks
Two lode structures drawn that match drill intercepts	1
Shows offset at structure A	1
Total	**2**

Sample answer:



Accept other relevant constructions.
Note: Horizontal lode structures should not be awarded marks.

(b) On the basis of the distribution of the inferred resource and the proximity to the surface of this deposit, describe the mining method that is best suited for the deposit. (2 marks)

Description	Marks
Identifies underground mining as the method best suited for the ore deposit	1
Provides adequate justification for the stated mining method	1
Total	**2**

Answers could include:

- depth exceeds 100 m for most of the modelled lode, meaning too much overburden would need to be removed for an open pit mine
- lode is concentrated in bands rather than disseminated through country rock, therefore minimise waste extraction.

Accept other relevant answers.

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

Description	Marks
States that structure A offsets or terminates the lode	1
Recognises that the mining sequence would require modification/change of level to accommodate structure A	1
Total	**2**

Answers could include:

- structure A (fault) has occurred after the formation of the economic lode material
- the mining plan will need to take this offset into account and the mine design will have to incorporate access to the material either side of the fault structure
- this could include access via a waste drive to the upper lode sequence to the right of the fault, otherwise two declines can be planned either side of the fault
- extraction of material within close proximity of the fault structure will require additional ground support of engineering intervention.

Accept other relevant answers.

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

Description	Marks
Identifies an appropriate exploration method	1
Describes how the identified exploration method could improve understanding of deposit extents (width and depth)	1
Describes how the identified exploration method could improve understanding of deposit continuity (breaks and seams)	1
Total	**3**

Answers could include:

- drilling
- geochemical sampling
- downhole survey.

Sample answer:
Further diamond drilling designed to extend deeper than the previous drilling to prove the extents of the secondary lode as modelled in the cross-section above. The intercept indicates the secondary lode dips to the right, yet the drilling does not extend past the intercept in drill hole 1, therefore holes 2 and 3 will need to be drilled deeper.

Accept other relevant answers.
Note: Geophysical methods should not generally be accepted as the upper lode would mask the extent of the lower lode.

Question 22 (continued)

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

Description	Marks
Identifies one advantage	1
Describes how the identified item acts as an advantage	1
Identifies one disadvantage	1
Describes how the identified item acts as a disadvantage	1
Total	**4**
Answers could include: Advantages • cost – lowered for the development of infrastructure such as access roads • availability of workers – lowers FIFO costs, lower social impact on workers Disadvantages • noise pollution – firing times and operations must consider impact on township • water use – miner will have to regulate and monitor water use and quality.	
Accept other relevant answers.	

Question 23 **(11 marks)**

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

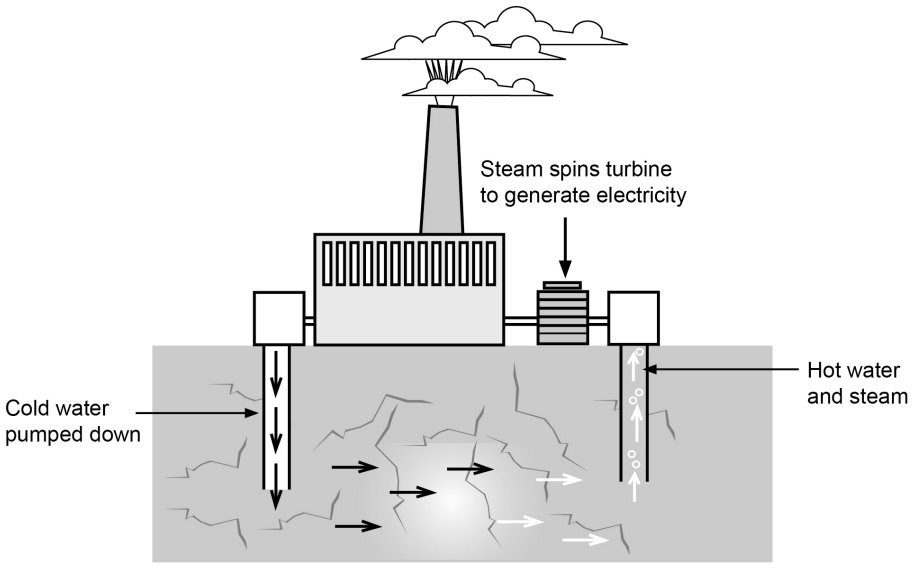
Description	Marks
States that energy is generated and stored within the Earth	1
States that energy is created from the breakdown of radioactive material or is a residual from the Earth's formation	1
Total	**2**
Sample answer: Geothermal energy comprises residual heat that generated in the formation of the planet Earth and heat is generated by the decay of radioactive isotopes.	

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

Description	Marks
Outline	
Outlines how heat can be extracted for use	1
Subtotal	**1**
Diagram	
Diagram clearly shows how heat is extracted from its source and is labelled appropriately	2
Diagram shows some aspect of heat extraction	1
Subtotal	**2**
Total	**3**

Answers could include:

- direct-use systems – heat from underground water is used to directly heat facilities such as swimming pools
- hot rocks or enhanced geothermal systems – heat is extracted by pumping cold water down into well, water is heated as it travels through fractures. Eventually it is extracted as hot water, which is used to create electricity using steam turbines
- hot sedimentary aquifers – aquifers are heated by nearby heat flow from the crust. Hot water can be extracted and converted into electricity using turbines.



Movement of water through hot rocks

Accept other relevant answers.

Note: A diagram by itself might be acceptable for full marks if it adequately explains the chosen information.

Question 23 (continued)

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

Description	Marks
For each of **three** factors (2 marks each)	
Identifies a valid factor that would be considered when evaluating the suitability of potential sites for geothermal energy production	1
States how the valid factor would affect site selection	1
Subtotal	**2**
Total	**6**

Answers could include:

Geographic

- proximity of potential power use – if ideal location is remote or removed from where the energy is required the facility may be deemed not viable
- local geothermal gradients – if area has a low geothermal gradient, depth to which wells need to be drilled may mean facility is uneconomic.

Environmental

- availability of water resource – geothermal power plants require abundant water. A site may not be given approval if water resources will be taken away from native environments or townships
- Impact on native flora and fauna – noise and land disturbance may impact local flora and fauna. The facility may be restricted to where it can be established due to endemic species.

Economic

- access to location – if geothermal resource is located in a remote area, then the cost of setup, transport of equipment and subsequent transport of electricity may outweigh profit of plant. Additionally, cost for staff including transport and accommodation add to overheads
- initial start-up costs – a geothermal resource has high set up cost, in particular the drilling of the wells.

Accept other relevant answers.

Question 24 **(10 marks)**

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

Description	Marks
Identifies up to two relevant factors	1–2
Total	**2**
Answers could include: • convection currents within the mantle • slab pull • ridge push.	
Accept other relevant answers.	

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

Description	Marks
Completes the table correctly with one relevant answer for each of up to four vacant cells	1–4
Total	**4**

	Location A	Location B
Natural hazard most likely to occur	**Earthquake**	Volcanic eruption
Type of plate boundary	Transform	**Convergent**
Mitigation technique that could be used to reduce risk to human life and infrastructure	**Improved construction methods including elements such as base isolation and braced frames**	**Seismic monitoring or tilt meters combined with warning system and/or evacuation plans**

Accept other relevant answers.

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

Description	Marks
For each of **two** natural hazards (2 marks each)	
Identifies an effect of the hazard	1
Describes how the hazard could affect the local environment	1
Subtotal	**2**
Total	**4**
Answers could include: Earthquake (location A) • ground shaking can cause landslides. This can destroy habitats of local organisms, leaving them displaced and at greater risk from predators • in built-up areas, ground shaking can cause gas mains to crack/leak, resulting in fires. These fires can create a hazardous environment, destroying buildings that survived the initial ground movement Volcanic eruption (location B) • destruction of local habitat from lava or lava flows. This will result in the flora and fauna of the local area to be destroyed • ash settles out from the eruption column. This could cause respiratory issues with local organisms who breathe in the material.	
Accept other relevant answers.	

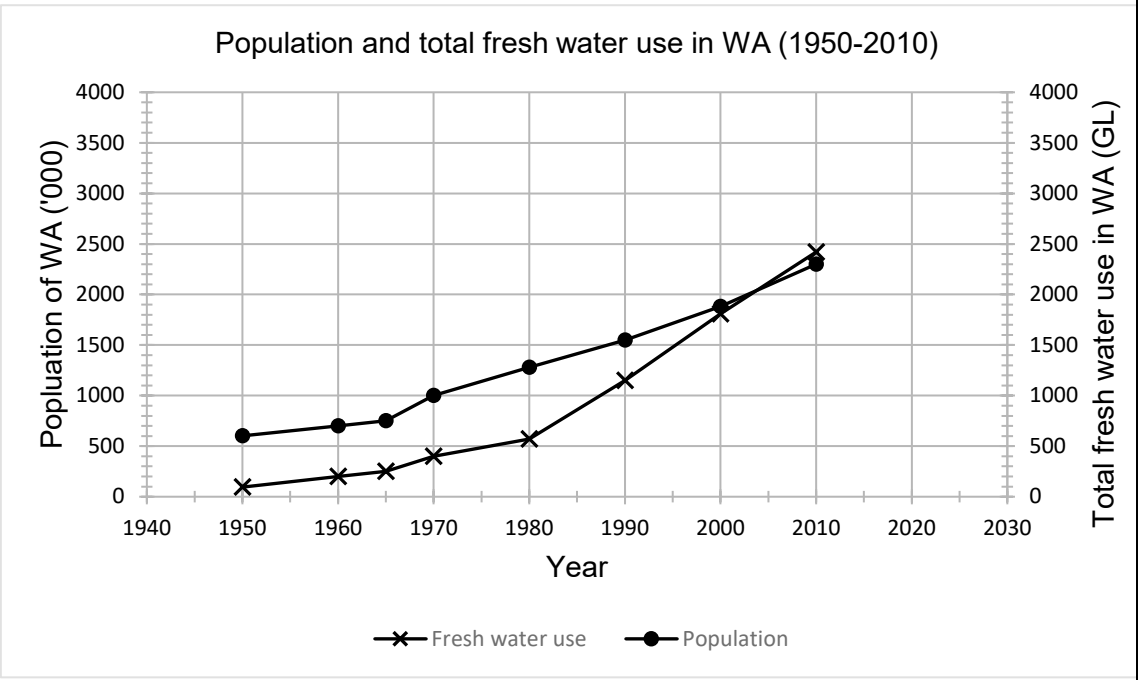
Section Three: Extended answer **30% (30 Marks)**

Question 25 **(15 marks)**

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

Description	Marks
Correct features of the graph: • horizontal axis labelled appropriately • includes an appropriate title.	1
Population figures plotted correctly and joined by straight lines	1
Water use figures plotted correctly and joined by straight lines	1
Vertical axes labelled appropriately to show scale for both population and water use, with clear legend	1
Total	**4**

Sample answer:



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

Description	Marks
States the relationship between the changing total fresh water use and population in Western Australia	1
Provides a probable reason for the stated relationship	1
Total	**2**

Answers could include:
Relationship
- as the population increases the total fresh water use increases
- total fresh water use increases faster than population after 1980
- fresh water use per person becomes higher after 1980

Probable reason
- changes in attitudes to water use after 1980 have seen greater use per person e.g. there has been an increase in water-intensive cultural features such as pools, sports fields and gardens.

Accept other relevant answers.

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

Description	Marks
Answer in the range: 3500 GL to 3900 GL	1
Total	**1**

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

Description	Marks
Recognises declining stream inflow or increasing water use	1
Identifies a relevant government response	1
Total	**2**

Answers could include:
- current water usage cannot be maintained so policies for reducing water use should be implemented
- educating the public is needed so that attitudes to water use change
- greater public investment in water security may be required.

Accept other relevant answers.

Question 25 (continued)

(e) Identify **two** strategies that could be used to help WA meet its water needs over the next 10 years. For each strategy, outline how it addresses the balance of water supply and demand, and identify an accompanying challenge.

Description	Marks
For each of **two** strategies (3 marks each)	
Identifies an appropriate strategy	1
Outlines the expected impact of the strategy on the water supply	1
Outlines a challenge for the strategy	1
Subtotal	**3**
Total	**6**

Answers could include:
Strategy – encouraging moderation of domestic water use, limit daily use
Impact – water use would decrease on a per person basis
Challenge – changing people's attitudes to taking shorter showers, having more water-wise gardens or paved areas instead

Strategy – changing building regulations to require higher-density housing with less green space and lower per-capita water consumption
Impact – the water supply would remain at a higher level as less water would be used on parks and gardens
Challenge – changing people's attitudes towards block size and living in closer proximity to others

Strategy – investing in the development of more desalination plants
Impact – the fresh water available would remain at a higher level, with more fresh water available to consumers
Challenge – expensive to implement this and keep plants operational

Strategy – increasing levels of water treatment and re-use or recycling greywater and sewage
Impact – this increases the available drinking water and is a water-saving measure because used water returns to natural water sources
Challenge – changing people's attitudes to the re-use of water and using treated water.

Accept other relevant answers.

Question 26 **(15 marks)**

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

Description	Marks
For each of **two** factors (2 marks each)	
Identifies a climatic factor that might affect the frequency or severity of bushfires	1
Describes how the climatic factor might affect the frequency or severity of bushfires over the next 30 years in Australia	1
Subtotal	**2**
Total	**4**

Answers could include:

- reduced rainfall/drought/drying environment – results in dry fuel with low levels of moisture, so severity of fire will increase
- extreme high temperatures – high fuel temperatures will mean that fires will spread at a much faster rate
- strong wind systems – the wind fans fires and increases the spread. It can also change the direction and spread of the fire.

Sample answer:
The severity of a bushfire event can be influenced by stronger wind systems created by a changing climate. These strong winds act as an accelerant, driving the flames further ahead of the front, increasing the severity of the bushfire.

Accept other relevant answers.
Note: Reduced rainfall and drought should be considered synonymous and only accepted as a single climatic factor.

Question 26 (continued)

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

Description	Marks
Identification	
Identifies an adaptation that assists a plant's survival after fires	1
Subtotal	**1**
Description	
Detailed description of the mechanism that assists a plant's long-term viability after fires	2
Limited description of how the mechanism used by the plant ensures its survival after fires	1
Subtotal	**2**
Total	**3**

Answers could include:

- re-sprouters or lignotubers – seed buds are protected by soil or bark, so they are not damaged during fire – plants have evolved to release seeds after fires, ensuring long-term viability
- re-seeders – seed shells crack with intense heat allowing moisture to get to the seeds and ensuring rapid germination – this seed protection assists a plant's survival following fires
- plants have evolved to release seeds and flower after fires – seed germination requires heat and/or smoke from fires – ensures a plant's long-term survival.

Sample answer:
Many Australian plants have evolved to embrace bushfires. Some Australian plants are re-seeders, in which their seeds are encased in thick woody capsules that shield the seeds from the intense heat of the fire. The heat forces the capsules open, allowing the seeds to be released into the soil below. This burnt soil contains nutrients that had been previously locked up in biomass. This enriched soil enables rapid germination, and these species are able to colonise new open space.

Accept other relevant answers.

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

Description	Marks
For each of **two** ways (2 marks each)	
Identifies a way in which bushfires might leave the local environment vulnerable to further disturbance	1
Describes the potential effect on the local environment	1
Subtotal	**2**
Total	**4**

Answers could include:

- increased erosion due to removal of vegetation – heavy rainfall might wash away topsoil causing sedimentation of creeks and wetlands
- potential for feral animal invasion – fresh growth is not protected by other growth and is vulnerable to being eaten by feral animals
- landslides due to lost topsoil and vegetation – on hillsides, heavy rainfall soaks into the topsoil. Since there is no vegetation to hold onto the soil, the soil can slide down the hill
- potential for weed and grass invasion – weeds and invasive grasses grow well in disturbed areas, so can easily take over landscapes.

Sample answer:
During a bushfire event undergrowth is burnt and removed. The removal of small plants and grasses can result in topsoil becoming susceptible to erosion. If significant rain events occur while there is loose topsoil, this can get washed into the local waterways, in turn causing sedimentation of water body, creating a less than ideal environment for aquatic organisms.

Accept other relevant answers.

Question 26 (continued)

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

Description	Marks
For each of **two** strategies (2 marks each)	
Identifies a strategy that could be used to reduce the risk to human life and infrastructure	1
Describes how the mitigation strategy could be used to reduce the risk to human life and infrastructure	1
Subtotal	**2**
Total	**4**

Answers could include:

- removal of fuel load/undergrowth through prescribed burning – reducing the potential for fires and risk to humans, buildings and the environment
- creating fire breaks – slows the progress of fires, reducing threats to humans and infrastructure
- education programs – community education and awareness programs improve safety and reduce the risk to human life and buildings
- public response/evacuation plans – early evacuations minimise the risk to humans
- stricter building codes to limit building in fire-prone areas and/or require more fire-resistant structures
- greater resourcing of fire-fighting services and improvement of fire suppression capability – early responses reduce the risk to human life and infrastructure.

Sample answer:
The practice of prescribed burning works to reduce the risk and severity of bushfire hazards. These programs are implemented during the cooler seasons to burn the undergrowth of areas that are deemed to be a risk of significant fires. This practice reduces the fuel load available for a bushfire. Prescribed burning reduces the risk of a bushfire impacting human life and infrastructure.

Accept other relevant answers.

Question 27 **(15 marks)**

(a) The temperature anomaly shown on the graph increases rapidly between 1960 and the present day. Describe a probable cause for this increase. (2 marks)

Description	Marks
Identifies a probable cause	1
Links the cause to increasing greenhouse gas emissions	1
Total	**2**
Viable causes could include: • increased industrial output • increased commercial aviation • increased fossil fuel use. Sample answer: Rapid increase in fossil fuel use after 1960 resulted in an increase in greenhouse gas emissions into the atmosphere. Heat from the Sun and radiation from the Earth's surface are trapped by these gases and re-radiated back to Earth, causing a rise in the temperature.	
Accept other relevant answers.	

(b) Identify **two** possible causes for the short-term (yearly) variability observed in global temperatures. (2 marks)

Description	Marks
Identifies up to **two** possible causes for the short-term (yearly) variability observed in global temperatures	1–2
Total	**2**
Answers could include: • volcanic eruption • ENSO oscillation • changes in oceanic currents • global decrease in industrial activity.	
Accept other relevant answers.	

Question 27 (continued)

(c) Describe how the climate change trend illustrated in the graph above might affect **two** physical or biological systems. (4 marks)

Description	Marks
For each of **two** systems (2 marks each)	
Identifies an effect of the climate change trend on the physical or biological system	1
Describes how the climate change trend might affect the physical or biological system	1
Subtotal	**2**
Total	**4**
Answers could include: Possible impacts • reduction in the extent of glaciers and/or ice sheets • increased frequency and severity of tropical storms • reduction or cessation of the Gulf Stream Possible effects • movement of the range of tropical plant or animal species to higher latitudes • removal/destruction of the habitat of arctic animals • extinction of one or more species adapted to a high-latitude or polar climate • change in the latitude of agriculturally productive areas.	
Accept other relevant answers.	

(d) For **one** of the changes identified in part (c), describe and provide an example of the potential impact of this change on a human population and a possible strategy for mitigating this impact. (4 marks)

Description	Marks
Describes the potential impact of the change on a **human population**	1
Uses a relevant example	1
Identifies a relevant mitigation strategy	1
Describes how the chosen strategy mitigates impact	1
Total	**4**

Answers could include:

The extent of glaciers and/or ice sheets

- reduces fresh water availability for populations dependent on melt water e.g. Indus river
- by recycling waste water for use in households, agriculture and industry, the impact can be minimised e.g. re-use of household water in irrigation

Frequency and severity of tropical storms

- severe storms and cyclones are causing increased damage to infrastructure e.g. cyclone Yasi (2011) caused major damage in northern Queensland
- education programs will see homes better equipped to withstand storms e.g. homes built with metal roof beams and storm-proof windows in northern Australia reduce the amount of damage

Reduction or cessation of the Gulf Stream

- makes areas of northern Europe too cold for human habitation e.g. slowing down of the North Atlantic Drift sees warm waters not reaching northern Europe
- helping people prepare for the colder climates and higher sea levels will enable more to stay there. People will need to adapt e.g. projects are taking place to build houses in the north of Sweden that completely rely on solar energy, using surplus electricity stored during summer in winter

Movement of the range of tropical plant or animal species to higher latitudes

- impacting human populations e.g. introducing new pest species that affect human agriculture in higher latitudes
- those involved with agriculture will need to adapt. Farmers frequently already adapt to changing weather conditions, so this will become normal practice e.g. crops may need to be altered or sown at different times of the year

Extinction of one or more species adapted to a high-latitude or polar climate

- impacting human populations dependent on that species e.g. indigenous communities in Alaska depend on animals such as the bowhead whale. Their way is life is being threatened as these animals die out due to climate change
- the survival of all species within ecosystems are vital to humans as they are a part of food webs. The decline in the number of species further accelerates climate change, so species need to be protected or moved e.g. WWF has brought together people from polar climates to support research and conservation

Change in the latitude of agriculturally productive areas

- reducing the productivity and viability of existing farms e.g. the Kingaroy region of Queensland has significantly decreased their peanut production due to reduced summer rainfall
- educating farmers on changing land uses e.g. a variety of crops and livestock will keep farms viable. Productivity can be increased.

Accept other relevant answers.

Question 27 (continued)

(e) Explain how a specific technological, environmental, social or political approach could support meeting a global target of net zero greenhouse gas emissions by 2050.

(3 marks)

Description	Marks
Identifies an approach to reduce greenhouse gas emissions	1
Explains how this approach could reduce greenhouse gas emissions	1
Provides a relevant example	1
Total	**3**

Relevant approaches could include:

- government policies such as tax offsets for green energy use
- globally recognised carbon pricing or trading schemes
- development of alternatives to fossil fuel use, such as solar panels.

Sample answer:
An approach might include the use of carbon credits or offsets.
This is a regulatory system where companies are either compelled to or rewarded for undertaking actions to take CO_2 out of the atmosphere to offset the emissions from their regular activity. This can be done through measures including planting trees or allowing polluting companies to buy carbon 'credits' from more efficient companies.

Accept other relevant answers.

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