



EARTH AND ENVIRONMENTAL SCIENCE

ATAR course examination 2023

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

Section Two: Short answer

55% (110 Marks)

Question 16

(13 marks)

- (a) Identify **two** geological factors that influence the texture or mineralogy of a metamorphic rock. (2 marks)

Description	Marks
Any two of (2 x 1 mark)	
<ul style="list-style-type: none"> • temperature • amount of pressure • orientation of pressure • amount of time available for metamorphism • level of deformation experienced by the rocks • mineral assemblage 	1–2
Total	2
Accept other relevant answers.	

- (b) Complete the following table by identifying the metamorphic rock or protolith as appropriate. (3 marks)

Description		Marks
Metamorphic rock	Protolith	1–3
Quartzite	Sandstone	
Marble	Limestone	
Amphibolite	Basalt (or dolerite)	
Total		3
Accept other relevant answers.		

Question 16 (continued)

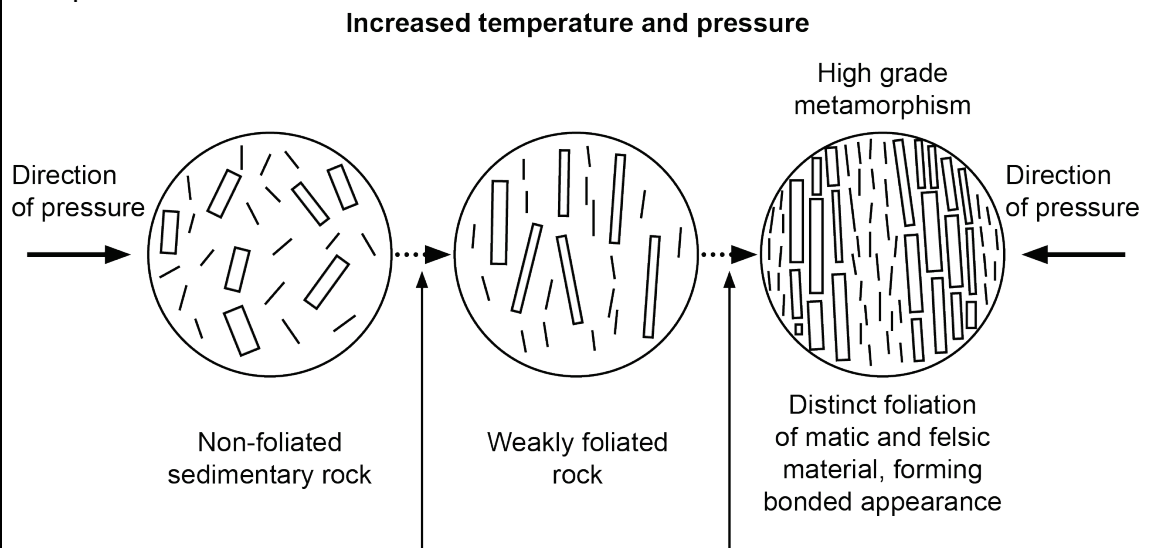
- (c) Outline **two** ways in which different metamorphic rock characteristics can be used to distinguish between slaty cleavage and schistosity. (4 marks)

Description	Marks
For each different metamorphic rock characteristic (2 x 2 marks)	
Outlines a feature characteristic of slaty cleavage or schistosity	1
Outlines how the feature differs in the second foliation type	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • grain size – slaty cleavage is expressed in fine grained rocks, whereas schistosity requires that crystals be visible to the naked eye (medium to coarse grained rocks) • mineral content – chlorite is the primary platy mineral present in rocks that display slaty cleavage, whereas rocks displaying schistosity will have platy minerals, such as biotite or muscovite • mineral layering – slaty cleavage develops in low-grade metamorphic rocks that are either homogenous or retain their primary layering inherited from a sedimentary protolith. Schistosity is commonly accompanied by complete recrystallisation of the rock, which can result in the development of distinct light (quartz and feldspar rich) and dark (mica and amphibole rich) layers • mineral alignment – slaty cleavage is not accompanied by visible alignment of minerals in a rock. Schistosity involves the visible alignment of elongate and/or platy minerals throughout the rock mass. 	
Accept other relevant answers.	

(d) With the aid of annotated diagrams, identify the key features of gneissic banding and describe how it forms. (4 marks)

Description	Marks
Labelled diagram supports description of gneissic banding	1
States gneissic banding requires increased temperature and pressure	1
Identifies that a gneissic band forms from the recrystallisation and migration of light and darker minerals	1
States gneissic banding/mineral alignment is perpendicular to the direction of pressure	1
Total	4

Sample answer



1. With increase in temperature and pressure, minerals are flattened, and begin aligning perpendicular to direction of stress.

2. Ongoing increased temperature and pressures result in mafic and felsic minerals forming distinct bands.

As temperature and pressure increase, easily recrystallised minerals, including feldspar and quartz regrow in distinct light coloured mineral layers. Meanwhile, less-mobile mafic minerals, such as biotite and amphibole left behind by the recrystallising felsic minerals become concentrated into dark layers, producing a distinct banded texture on a scale of 5–10 mm. The banding forms perpendicular to the direction of pressure.

Accept other relevant answers.

Question 17

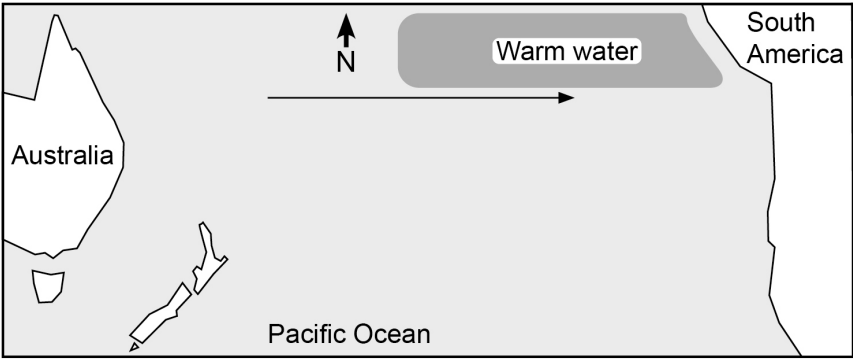
(11 marks)

(a) Answer the following questions relating to the diagram above.

- (i) Identify the ENSO state shown in the diagram as Neutral, El Niño, or La Niña. (1 mark)

Description	Marks
El Niño	1
Total	1

- (ii) On the diagram above, clearly illustrate the predominant direction of Equatorial air flow that would be expected to accompany these conditions. (1 mark)

Description	Marks
arrow showing lateral east/west flow (demonstrating weakened or reversed Trade Winds) 	1
Total	1

- (iii) Name the weather feature whose relative strength or weakness generally instigates the change between El Niño and La Niña conditions. (1 mark)

Description	Marks
the Trade Winds	1
Total	1

- (b) Complete the sketch of a cross-section below and label to show the surface ocean current, thermocline and location of warm and cool water expected under the ENSO conditions shown in the diagram on page 10. (4 marks)

Description	Marks
Diagram clearly shows:	
warm water located near South America	1
direction of current towards warm water	1
thermocline drawn to prevent cold water upwelling along South America	1
cold water located below thermocline/warm water above	1
Total	4
Sample answer	
Note: horizontal thermocline can be accepted.	

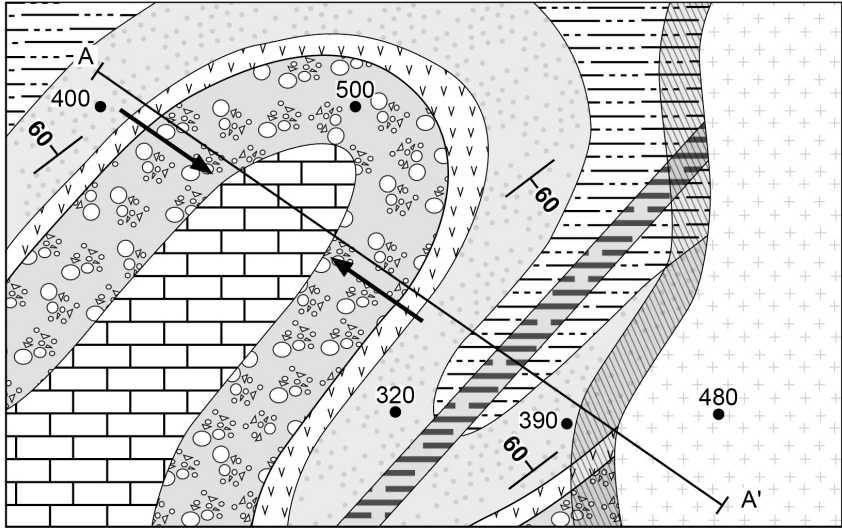
- (c) Outline how ENSO conditions produce **two** weather patterns typically associated with a La Niña event in Eastern Australia. (4 marks)

Description	Marks
For each weather pattern described (2 x 2 marks)	
Identifies a weather condition experienced in Eastern Australia during La Niña conditions	1
Outlines how ENSO causes the specified weather condition	1
Total	4
Answers could include:	
<ul style="list-style-type: none"> increased rainfall – warmer Pacific Ocean temperatures off the east coast of Australia result in higher rates of evaporation, increasing rainfall in Eastern Australia lower than average maximum daytime temperatures – this is due to the increase in cloud cover and rainfall increased frequency of tropical cyclones – warmer ocean temperatures off the east coast of Australia means greater evaporation, increasing the likelihood of cyclones forming. 	
Accept other relevant answers.	

Question 18

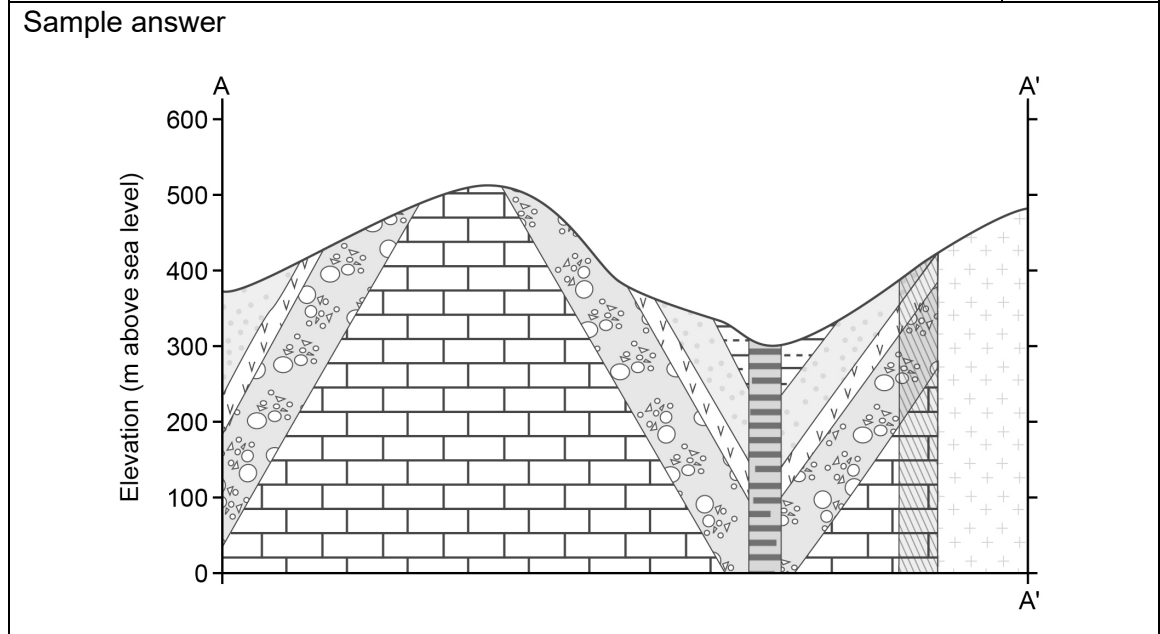
(12 marks)

- (a) Draw a set of arrows on the map to represent the direction of stress that caused the folding shown on the map. (1 mark)

Description	Marks
<p>Arrows drawn parallel to the cross-section line and pointing inwards</p> 	1
Total	1

- (b) Produce a cross-section along the line A–A¹ on the section line provided below. (5 marks)

Description	Marks
lithology contacts transferred accurately to section line	1
dip of contacts drawn accurately at 60 degrees	1
both anticline and syncline shown	1
dolerite shown as vertical dyke crossing other units	1
conglomerate projected correctly east of the dyke	1
Total	5



- (c) Name the oldest rock unit in this cross-section. (1 mark)

Description	Marks
limestone	1
Total	1

- (d) Field notes recorded by a geologist exploring this region state that fossils of freshwater fish have been found in the sandstone and basalt units. Outline why this statement is incorrect. (2 marks)

Description	Marks
Identifies that fossils could not be found in basalt	1
States any one of: <ul style="list-style-type: none"> • basalt is an igneous rock • any organic material entrained in a basalt magma would be destroyed due to the extreme heat. 	1
Total	2
Sample answer:	
This statement is incorrect because fossils are not found in basalt. Igneous rocks are formed through the solidification of molten magma, which is at temperature ranges that will destroy any organic material caught up in them.	
Accept other relevant answers.	

- (e) Two annotated field sketches of rock samples from the mapped area are shown below.

- (i) Identify which of these samples was more likely taken from the alteration zone shown on the map on page 12. (1 mark)

Description	Marks
Sample B	1
Total	1

- (ii) Justify your choice in part (e)(i). (2 marks)

Description	Marks
Identifies that metamorphic processes alter rock textures	1
Provides valid example of metamorphic texture in sample B	1
Total	2
Cited features could include: <ul style="list-style-type: none"> • interlocking grains • crystalline texture • absence of pore spaces. 	
Sample answer:	
Metamorphic alteration zones experience high temperatures resulting in the recrystallisation or regrowth of minerals. Sample B clearly displays an interlocking crystal texture, which implies this sample has come from the alteration zone.	
Accept other relevant answers.	

Question 19

(11 marks)

- (a) Identify the location that experienced the greatest decrease in gecko numbers over the period studied. (1 mark)

Description	Marks
Location 2	1
Total	1

- (b) Calculate the percentage decrease (to the nearest whole number) in gecko numbers between 2012 and 2022:

- (i) at Location 3. (1 mark)

Description	Marks
States the percentage decrease is 78%	1
Total	1
Sample answer: decrease in population at location 3 = $245 - 55 = 190$ percentage decrease = $190/245 \times 100 = 78\%$.	

- (ii) in the entire gecko population. (1 mark)

Description	Marks
States the percentage decrease is 66%	1
Total	1
Sample answer: decrease in population = $(280+340+245) - (95+145+55) = 570$ percentage decrease = $570/(280+340+245) \times 100 = 66\%$.	

- (c) Propose an experimental design that could be used to investigate this claim. (4 marks)

Description	Marks
Included in the proposal any four of the following (4 x 1 marks)	
<ul style="list-style-type: none"> states appropriate hypothesis observing the consequences of stopping pesticide use maintaining control areas where conditions are unchanged how observations would be made how the investigation result would support or disprove claim 	1–4
Total	4
Sample answer	
<p>Insecticides are used to remove or reduce insects, such as mosquitoes, and this could be reducing gecko numbers by removing their food source. The testable question for an investigation could be: Will stopping insecticide use around mine site building increase the gecko population?</p> <p>To provide a control for the investigation, one of the three locations would need to continue to use insecticides to ensure no other factors were influencing any possible change in the gecko population.</p> <p>If after a suitable period of testing, the gecko population has increased at locations where insecticide use stopped and continued to decline at the location still using insecticides, the environmental groups claim would be supported.</p>	
Accept other relevant answers.	

- (d) Outline **two** measures, other than eliminating insecticide use, that could be implemented around the mine site to assist the population of geckos to increase. (4 marks)

Description	Marks
For each of the measures (2 x 2 marks)	
Outlines practice that could assist growth of gecko population	1
Outlines how practice would increase gecko population	1
Total	4
Answers could include:	
<ul style="list-style-type: none"> provide additional habitats, such as hollow logs and large rocks placed further away from camp buildings. Increasing habitat space may encourage breeding to increase population numbers ensure walkways around mine site buildings are clearly marked and lit at night. This will reduce the likelihood of people stepping on them while moving between camp buildings, helping to maintain population numbers removal of feral pests that may hunt the geckos, therefore reducing the number geckos killed creation of nature corridors that allow the gecko population to move between roadways. This will lower the number of geckos killed around the mine site. 	
Accept other relevant answers.	

Question 20

(12 marks)

(a) List **two** greenhouse gases.

(2 marks)

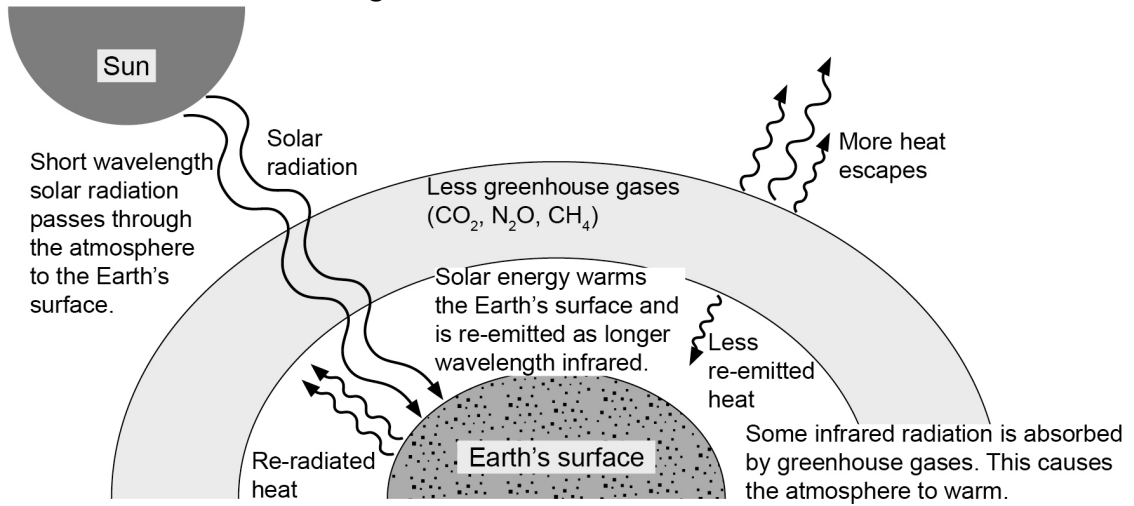
Description	Marks
For each greenhouse gas (2 x 1 mark)	
Lists a greenhouse gas	1
Total	2
Answers may include: <ul style="list-style-type: none"> • methane • carbon dioxide • water vapour • nitrous oxide • hydrofluorocarbons • ozone. Accept other relevant answers.	

(b) Draw detailed and labelled diagrams in the boxes provided below illustrating the natural greenhouse effect and the enhanced greenhouse effect. (6 marks)

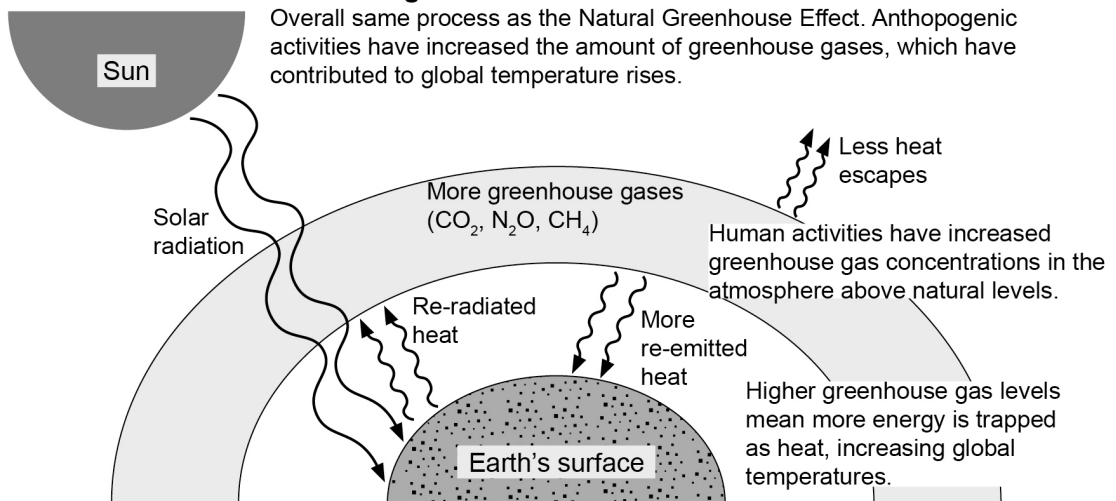
Description	Marks
Natural greenhouse effect:	
short wavelength solar radiation passes through the atmosphere to the Earth's surface	1
solar energy warms the Earth's surface and re-emitted as longer-wavelength infrared radiation	1
some infrared radiation is absorbed by greenhouse gases in the atmosphere, warming the atmosphere	1
Subtotal	3
Enhanced greenhouse effect:	
fundamental greenhouse process is the same as for the natural greenhouse effect	1
human activities increase greenhouse gas concentrations in the atmosphere above natural levels	1
higher greenhouse gas levels mean more energy is trapped as heat in the atmosphere, increasing global temperatures	1
Subtotal	3
Total	6
Accept other relevant answers.	

Sample answers:

Natural greenhouse effect



Enhanced greenhouse effect



Accept other relevant answers.

Question 20 (continued)

- (c) Using your understanding of the greenhouse effect, describe how increased frequency of bushfires could have an impact on global climate change. (2 marks)

Description	Marks
States a long-term impact	1
Outlines how this impact affects global climate change	1
Total	2
Impacts could include: <ul style="list-style-type: none"> • release of biological stores of carbon into the atmosphere as CO₂ from burning of vegetation, contributing to warming • reduced biological sequestration of carbon due to removal of vegetation • increased erosion releasing carbon stored in soils. Sample answer: An increase in bushfire frequency could increase the rate of global warming due to release of stored carbon to the atmosphere as CO ₂ , which is a greenhouse gas. Accept other relevant answers.	

- (d) State **one** positive and **one** negative effect bushfires can have on an ecosystem. (2 marks)

Description	Marks
States one relevant positive effect	1
States one relevant negative effect	1
Total	2
Answers could include: <p>Positive effect:</p> <ul style="list-style-type: none"> • germination of fire-dependent seeds • clear thick undergrowth • reduce competition for growth of seedlings • encourage new growth • create hollows in burnt trees and logs for animals to shelter in. <p>Negative effect:</p> <ul style="list-style-type: none"> • damage non-fire-resistant vegetation • reduce biodiversity by killing off flora and fauna • increase soil erosion by reducing ground cover or root systems • increase susceptibility of the environment to invasive species. Accept other relevant answers.	

Question 21

(14 marks)

- (a) State what is meant by both renewable and non-renewable energy resources. (2 marks)

Description	Marks
Renewable	
States that 'renewable' energy resources can be replenished on human timescales (decadal or shorter)	1
Subtotal	1
Non-renewable	
States that 'non-renewable' energy is replenished on geological timescales (millennial or longer)	1
Subtotal	1
Total	2
Accept other relevant answers.	

- (b) List
- two**
- examples of a renewable energy resource and
- two**
- examples of a non-renewable energy resource. (4 marks)

Description	Marks
For each example of a renewable energy resource (2 x 1 mark)	
Lists an example of a renewable energy resource	1
Subtotal	2
For each example of a non-renewable energy resource (2 x 1 mark)	
Lists an example of a non-renewable energy resource	1
Subtotal	2
Total	4
Answers could include:	
Renewable energy resources:	
<ul style="list-style-type: none"> • solar energy (the Sun) • wind energy • hydro power (dams/gravitational energy) • wave energy • tidal energy • geothermal energy • biomass. 	
Non-renewable energy resources:	
<ul style="list-style-type: none"> • nuclear energy • natural gas • oil • coal. 	
Accept other relevant answers.	

Question 21 (continued)

- (c) For each of the examples of a renewable energy resource identified in part (b), describe the process by which that energy could be captured and transported to be available for use at a major industrial site. (4 marks)

Description	Marks
For each of the two specified renewable resources (2 x 2 marks)	
States how the energy is collected from the renewable resource	1
Describes how the energy is transported to site for use	1
Total	4
<p>Answers could include:</p> <p>Collection processes:</p> <ul style="list-style-type: none"> • solar – sunlight is converted directly to electricity through photovoltaic cells or concentrated by mirrors and converted to heat energy to drive a turbine • hydropower – hydroelectric energy is collected by using the kinetic energy from water flowing from high elevation (usually, but not always created or enhanced by impoundment behind a dam) to low elevation to turn a turbine, generating electricity • wind – wind energy is captured through windmills which are rotated by wind, turning a turbine to generate electricity <p>Transport processes:</p> <ul style="list-style-type: none"> • transmission wires would be required to transmit energy from where it is captured to where it is used • energy could be converted into a transportable intermediate form (e.g. hydrogen) and physically transported to site • energy could be stored in batteries and transported to site. <p>Accept other relevant answers.</p>	

- (d) For each of the renewable energy resource examples identified in part (b), identify **one** advantage and **one** disadvantage the mining company might consider. (4 marks)

Description	Marks
For each of the specified renewable resources (2 x 2 marks)	
Specifies an advantage relative to diesel power generation	1
Specifies a disadvantage relative to diesel power generation	1
Total	4
<p>Answers could include:</p> <p>Solar advantages</p> <ul style="list-style-type: none"> likely to be plentifully available in remote areas may assist company in meeting carbon emission targets <p>Solar disadvantages</p> <ul style="list-style-type: none"> may require specialist expertise to repair and maintain production levels may vary and/or not align with load needs of the mine site <p>Wind advantages</p> <ul style="list-style-type: none"> may assist company in meeting carbon emission targets no ongoing fuel costs <p>Wind disadvantages</p> <ul style="list-style-type: none"> site-dependent – mine may be in a sheltered location production weather dependent and seasonal – levels may vary and/or not align with load needs of the mine site. <p>Accept other relevant answers.</p>	

Question 22

(14 marks)

- (a) Describe a mechanism by which tectonic processes can contribute to long-term climate change. (2 marks)

Description	Marks
Identifies a tectonic process which could contribute to long-term climate change	1
Describes how the identified tectonic process contributes to long-term climate change	1
Total	2
<p>Valid tectonic processes could include:</p> <ul style="list-style-type: none"> • increased volcanic emissions accompanying flood basalt volcanism and contribution • tectonic amalgamation of continental landmasses into a supercontinent • movement of continents opening or closing a seaway, disrupting a major ocean current • tectonic collision resulting in uplift of a mountain range. <p>Sample answer:</p> <p>Volcanic eruptions release a significant amount of gases including CO₂ into the atmosphere. During a flood basalt episode accompanying the rise of a mantle plume, the rate of volcanism and accompanying gas release can increase by orders of magnitude, leading to an elevated greenhouse effect and correspondingly increased temperatures.</p> <p>Accept other relevant answers.</p>	

- (b) Describe **one** physical or chemical impact that climate change can have on the ocean and how it is caused. (2 marks)

Description	Marks
States a viable potential impact of climate change on the oceans	1
Describes how this impact is caused by climate change	1
Total	2
<p>Viable impacts could include:</p> <ul style="list-style-type: none"> • acidification of ocean waters caused by enhanced reaction with CO₂ at high temperature • sea level rise caused by melting ice sheets or thermal expansion • changes to thermohaline circulation systems caused by increased surface water temperature. <p>Sample answer:</p> <p>Cold temperatures at high latitudes cool the surface of the ocean. This cooling makes the surface water more dense, which can lead to it sinking, drawing in water from adjacent areas to set up oceanic currents, such as the Gulf Stream in the Atlantic. As atmospheric temperatures increase, this cooling of ocean surface waters at high latitudes will decrease, reducing the intensity or even stopping the operation of these currents.</p> <p>Accept other relevant answers.</p>	

- (c) Use the data shown in the graph above to outline how the phytoplankton population may be affected by ocean surface temperature. (2 marks)

Description	Marks
as temperature increases, the chlorophyll concentration decreases	1
this indicates phytoplankton population declines as temperature increases	1
Total	2
Accept other relevant answers.	

- (d) Identify and describe **two** methods by which prehistoric records (records extending further back than recorded human history in a given location) can be used to provide evidence of climate change. (8 marks)

Description	Marks
For each prehistoric climate record (2 x 4 marks)	
Identifies a valid method of measuring prehistoric climate change	1
Outlines how the method is applied	1
Outlines how observations using this method can be related to climate change	1
Communicates how that record extends beyond the period of recorded human history	1
Total	8
Valid methods could include:	
<ul style="list-style-type: none"> • ice cores • dendrochronology • palaeontology (fossil records) • palynology. 	
Sample answer:	
Ice cores:	
<ul style="list-style-type: none"> • scientists drill deep into ice sheets and extract layered ice cores • each layer records an annual accumulation, allowing scientists to build a record of the time represented by the core • the isotopes of oxygen and hydrogen in each layer of ice represent a direct record of the contemporary snowfall that contributed to that layer • the isotope ratio of snowfall varies with global temperature and ice sheet growth, such that the isotope record of an ice core shows how global temperature has changed over time • layered ice core records from stable ice sheets can extend back tens of thousands of years, significantly further than recorded human history. 	
Accept other relevant answers.	

Question 23

(10 marks)

- (a) The table below shows turbidity measurements made over 10 years at two sites along a river where alluvial mining is occurring. Use the data to construct a line graph on the grid below showing the turbidity at these locations over the period recorded.

Put a line of best fit through the data and extrapolate out to 2025.

(6 marks)

Description	Marks
Data plotted accurately	1
Line graph	1
Appropriate title	1
Suitable and consistent scale	1
Axis labelled correctly and with units	1
Data for each location clearly identified	1
Total	6

Example graph

Year	Location 1 (NTU)	Location 2 (NTU)
2010	13	8
2012	11.5	7.8
2014	9	7.5
2016	8.5	6.5
2018	6.5	5.8
2020	4.5	5.5

Accept other relevant answers.

- (b) On the basis of your extrapolation, predict the turbidity in 2025 at both locations.

(2 marks)

Description	Marks
Location 1 projected turbidity in 2025 in the range 0 to 1.0	1
Location 2 projected turbidity in 2025 in the range 3.5 to 4.5	1
Total	2

- (c) The World Health Organization states that drinking water should have turbidity no higher than 5 NTU, and ideally below 1 NTU. On the basis of these categories, state whether the turbidity at each of the measured locations is expected to be unsatisfactory, satisfactory, or ideal for drinking water in 2025. (2 marks)

Description	Marks
Location 1 expected to have ideal turbidity levels	1
Location 2 expected to have satisfactory turbidity levels	1
Total	2
Accept other relevant answers if appropriate for their best fit line.	

Question 24

(13 marks)

- (a) Explain how geological processes can lead to accumulation of your chosen resource to form an economic ore deposit. (4 marks)

Description	Marks
Identifies a metallic mineral resource, economic deposits of which can be formed by geological processes	1
Outlines one or more geological processes that can mobilise and transport the chosen resource	1
Outlines how the identified process(es) lead to concentration of the resource	1
Includes discussion of criteria for the definition of an economic ore deposit from non-economic mineralisation	1
Total	4
Valid mineral resources could include:	
<ul style="list-style-type: none"> • gold • iron ore • nickel sulphide • aluminium. 	
Sample answer:	
<p>Gold can be transported through the crust and concentrated by hydrothermal processes. Warm salty water, particularly when containing key solvent chemicals, such as complexes of sulfur or iodine can dissolve low levels of gold into solution. These fluids can be released in large volumes deep in the Earth when minerals dehydrate during metamorphism, or when large igneous intrusions crystallise, potentially generating huge volumes of gold-bearing hydrothermal fluid. These gold-bearing solutions, often containing additional elements, such as silicon and iron, migrate through fractures in the rocks towards cooler, lower pressure regions closer to the Earth's surface. These cooler lower pressure conditions result in the gold eventually becoming insoluble, leading to it precipitating out of solution. Silica also often crystallises with the gold leading to the formation of gold bearing quartz veins. As large volumes of fluid progressively cycle through the system over time, the locations along the fluid pathway at which gold comes out of solution can remain consistent, leading to large accumulations of gold to form an economic deposit.</p>	
Accept other relevant answers.	

- (b) Identify a geophysical method that could be useful for selecting areas in which to explore for your chosen mineral resource. (1 mark)

Description	Marks
Specifies a geophysical method capable of application to exploration for the chosen resource	1
Total	1
Possible geophysical methods could include:	
<ul style="list-style-type: none"> • aerial magnetic surveying • aerogravity surveying • electromagnetic surveying • seismic surveying. 	
Accept other relevant answers.	

- (c) Describe how the presence of your chosen resource and/or related changes in the surrounding rocks create a signal that can be detected by the geophysical method identified in part (b). (2 marks)

Description	Marks
Identifies a specific property or characteristic of the chosen resource and/or host rocks relevant to the specified geophysical method	1
Describes how accumulation of the specified resource creates a detectable signal	1
Total	2
<p>Possible properties could include:</p> <ul style="list-style-type: none"> • magnetic susceptibility (iron-bearing minerals) • density (iron-bearing minerals, sulfides) • electrical conductivity (sulfides) • electrical chargeability (distributed sulfides) • seismic reflection from structures (structurally-hosted minerals). <p>Sample answer:</p> <p>Iron-bearing minerals, such as hematite and magnetite are highly magnetic. When these minerals accumulate in high local concentrations – as in an iron ore deposit – the local magnetic field is typically much stronger than that over un-mineralised geology in the same area. These differences can be detected in magnetic surveys carried out to detect variations in the magnetic field across a region.</p> <p>Accept other relevant answers.</p>	

- (d) Outline the processes involved in conducting a geophysical survey using the method identified in part (b). (2 marks)

Description	Marks
Communicates equipment requirements relevant to the specified geophysical method	1
Describes the conduct of a viable geophysical survey using the chosen method	1
Total	2
<p>Sample answer:</p> <p>Early-stage magnetic surveying requires coverage of a wide region – typically hundreds to thousands of square kilometres. To cover this scale of survey, a magnetometer is mounted to a fixed-wing aircraft or helicopter and flown along a series of traverses back and forth across the region of interest to measure variations in the magnetic field across the terrain.</p> <p>Accept other relevant answers.</p>	

Question 24 (continued)

- (e) Assuming a potentially-valuable mineral has been found during exploration in the field, describe **two** types of analysis that could be undertaken to help determine whether it would be economic to develop a mine to extract that mineral. (4 marks)

Description	Marks
For each the two types of analysis (2 x 2 marks)	
Identifies a form of analysis relevant to the specified economic evaluation	1
Outlines how that analysis would support the required decision making	1
Total	4
Valid analyses could be anything contributing to understanding of mine economics, including, but not limited to:	
Geological:	
<ul style="list-style-type: none">• drilling to determine the scale and quality of mineralisation• geotechnical analysis to evaluate how a mine could be constructed.	
Environmental:	
<ul style="list-style-type: none">• assessments of flora and fauna to determine whether environmental permitting will be possible• analysis of local aquifers to assess availability of water for mine needs and/or identify environmental risk of mining.	
Economic:	
<ul style="list-style-type: none">• modelling of future commodity prices to evaluate profitability• analysis of infrastructure costs required to build and operate a mine.	
Sample answer:	
In order for mineralisation to be economic to mine, enough of the valuable mineral must be present to deliver returns in excess of the cost of developing and operating the mine infrastructure required to extract the mineral and transport it to market. To assess the scale of the deposit, a program of close drill sampling should be undertaken to evaluate the quantity of mineralisation present and its distribution and continuity across the site it has been shown to occur.	
Accept other relevant answers.	

Section Three: Extended answer

30% (30 Marks)

Question 25

(15 marks)

- (a) Explain **one** replenishment technique used to increase groundwater storage, and describe a benefit this technique provides compared to surface water storage in terms of water security. (4 marks)

Description	Marks
Identifies a groundwater replenishment technique	1
Communicates how the specified technique works to deliver water to an aquifer	1
Outlines how the action of the replenishment technique increases the level of stored potable water	1
Outlines a benefit of the specified technique compared to surface water storage	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • injection of recycled post-consumer waste water • infiltration • storage ponds. <p>Sample answer:</p> <p>Injection of post-consumer waste water:</p> <ul style="list-style-type: none"> • wastewater is processed to remove pathogens and make it safe for drinking, and then injected into a depleted aquifer • introduced water raises the level of water in the aquifer, while processing through the aquifer ensures a long lag time between waste processing and possible re-use, decreasing consumer resistance • is better than surface water storage in terms of not being affected by loss of water by evaporation. 	
Accept other relevant answers.	

Question 25 (continued)

- (b) Using a labelled flow chart, explain the processes occurring within a desalination plant. (5 marks)

Description	Marks
flow diagram illustrates coherent sequence of operations	1
Steps in the desalination process	
water is sourced from the sea or another saline source (saline aquifer, salt lake etc.)	1
treatment to remove bacteria and other pathogens e.g. chemical, UV light	1
fluid is forced through a nano-membrane to remove salts and impurities	1
drinking water is extracted for use and waste brine is discharged or removed for further processing	1
Total	5
<p>Sample answer:</p> <pre> graph LR A["water is sourced from the sea or another saline source (saline aquifer, salt lake etc.)"] --> B["fluid is forced through a nano-membrane to remove salts and impurities"] B --> C["treatment to remove bacteria and other pathogens e.g. chemical, UV light"] C --> D["drinking water is extracted for use and waste brine is discharged or removed for further processing"] </pre>	
Accept other relevant answers.	

- (c) Outline **one** environmental factor that should be considered when designing a desalination plant. (2 marks)

Description	Marks
Identifies an appropriate environmental factor	1
Outlines how/why desalination process gives rise to this factor	1
Total	2
<p>Environmental considerations could include:</p> <ul style="list-style-type: none"> possible environmental impacts if the hypersaline brine produced as a by-product is released the energy-intensive nature and consequent carbon footprint of the desalination process. <p>Sample answer: One environmental consideration is the hypersaline brine produced as a by-product of desalination. This could disrupt ecosystems if discharged into the environment, so care needs to be taken in planning where and how this will be disposed of.</p>	
Accept other relevant answers.	

(d) Describe **two** community initiatives that could support reduced water use. (4 marks)

Description	Marks
For each of the two community initiatives (2 x 2 marks)	
Identifies relevant community initiative	1
Outlines how the initiative promotes water conservation	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • promoting community wide domestic grey water recycling • recycling suburban grey water and/or stormwater to industry • direct surface water flows to recharge points • town planning must use water wise plants for community spaces • water use restrictions. <p>Sample answer:</p> <p>Significant volumes of grey water (non-potable, but biologically safe waste water) are created in homes through laundry, dishwashing and similar domestic processes. Community wide application of this water to domestic uses, such as gardening, displacing demand on potable water sources.</p>	
Accept other relevant answers.	

Question 26

(15 marks)

(a) Describe how tectonic processes influence the eruption style and magma composition of volcanoes formed in each of the settings specified below: (6 marks)

- convergent plate boundaries
- intra-plate hotspots.

Description	Marks
For each of the two settings (2 x 3 marks)	
Outlines eruption style characteristics	1
Identifies magma composition	1
Links eruption style and magma composition to plate tectonic location	1
Total	6
<p>Sample answer:</p> <p>Convergent plate boundaries The most common volcanic landform at convergent plate margins are stratovolcanoes. They are characterised by the classic cone shape volcano formed through alternating layers of lava and ash. Eruptions are explosive, often hurling volcanic material high into the atmosphere. These explosive eruptions are due to the magmas high viscosity and gas content (water vapour and carbon dioxide).</p> <p>The magma at convergent plate boundaries are intermediate to felsic (Andesitic to Rhyolitic) in composition with a high silica content. As the oceanic crust subducts below the continental crust at convergent plate boundaries, large amounts of water is released, causing the partial melting of the mantle. This magma, rich in water, rises to the surface creating the explosive eruptions.</p> <p>Intra-plate hotspots Intra-plate volcanoes, also known as hot spot volcanoes form broad domed, gentle sloping shield volcanoes. The eruptions at these locations are generally effusive because the magma has a low gas content and low viscosity.</p> <p>Magmas formed at intra-plate locations are basaltic lavas that are mafic in composition with a low silica content.</p> <p>Hot spot magmas are derived from super-heated mantle plumes that rise to the surface. The magma does not interact with additional water from subducting tectonic plates, resulting in a lower gas content.</p> <p>Accept other relevant answers.</p>	

- (b) State why it is important for communities near active volcanoes to have systems in place to provide early warning of possible eruption. (1 mark)

Description	Marks
States why it is important for a community to have an early warning system	1
Total	1
Sample answer:	
Early warning of a volcanic eruption is important to a community to enable the safe evacuation of all members of that community, in particular those who need help to relocate (such as those in hospitals). Livestock can also be relocated to prevent further economic hardship.	
Accept other relevant answers.	

- (c) Describe **two** techniques that are used to monitor volcanic activity. (4 marks)

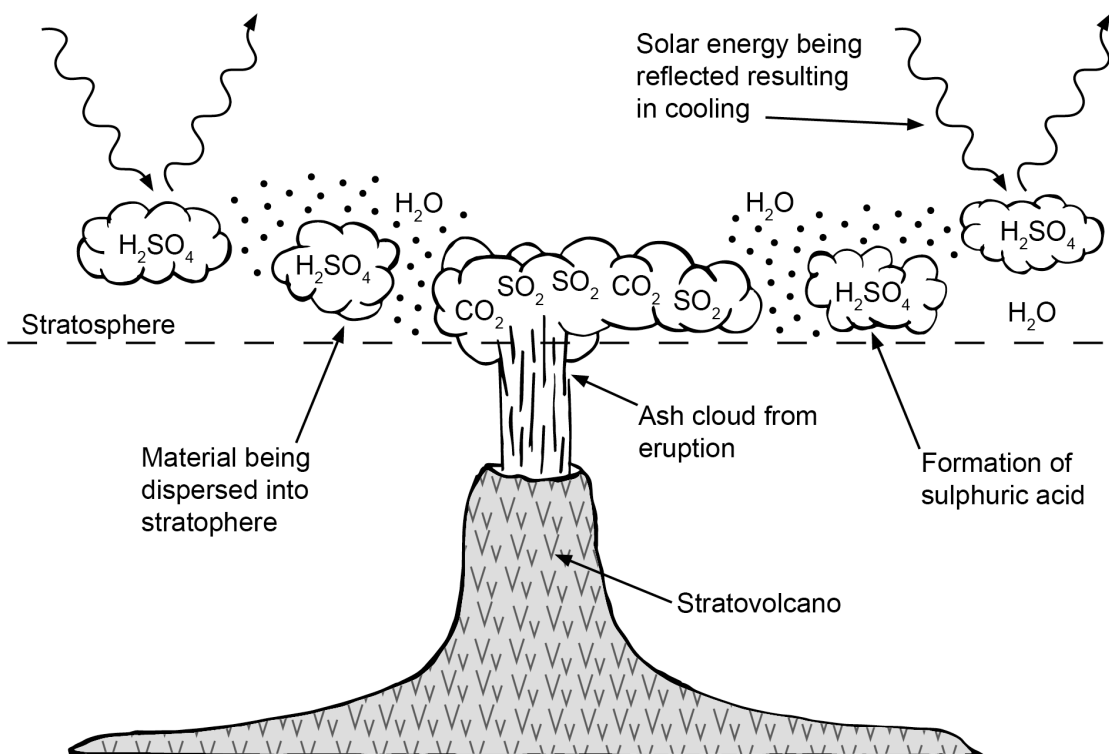
Description	Marks
For each relevant technique described (2 x 2 marks)	
Identifies technique used to monitor volcanic activity	1
Outlines how the technique indicates possible volcanic eruption	1
Total	4
Answers could include:	
<ul style="list-style-type: none"> • monitoring of gas volume and composition released. In the lead up to an eruption gas composition may change and volume released would increase • seismic monitoring of volcanic activity. Increased seismic activity may indicate magma is ascending through the volcanic chambers below, increasing the likelihood of an eruption • thermal imaging. This technique can detect an increased heat signature surrounding a volcanic structure, indicating a build-up of magma and possible eruption • monitoring ground deformation. Tilt meters are used to detect small changes in the shape of the volcanic landform. A change in the landform, suggests magma is moving below surface. 	
Accept other relevant answers.	

Question 26 (continued)

- (d) With the aid of a diagram, explain how a large-scale volcanic eruption can disrupt global weather patterns. (4 marks)

Description	Marks
Effectively incorporates the use of a diagram to support explanation	1
Volcanic eruptions release large volumes of ash, gas and aerosol particles into the stratosphere	1
Sulfur dioxide combines with water vapour to form sulfuric acid	1
Sulfuric acid reflects solar energy lowering global temperatures	1
Total	4

Sample answer



Large-scale volcanic eruptions, such as those of a stratovolcano, release large amounts of ash, gases and aerosols high into the atmosphere. If these substances reach the stratosphere, they can be circulated around the globe. Once in the stratosphere, sulphur dioxide will react with water vapour to form sulphuric acid. When in the atmosphere sulfuric acid reflects incoming solar radiation out of the atmosphere, resulting in a lowering of global temperatures.

Accept other relevant answers.

Question 27

(15 marks)

- (a) Outline **two** factors that are expected to contribute to rising sea levels over the next decade. (4 marks)

Description	Marks
For each factor contributing to rising sea levels (2 x 2 marks)	
Identifies factor contributing to rising sea levels	1
Outlines how chosen factor contributes to rising sea levels	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • thermal expansion of water as oceans warm • melting of high latitude ice sheets (Greenland or Antarctica) • melting of glaciers <p>Sample answer:</p> <p>Water expands when heated. The projected warming of global temperatures over coming decades will result in increased temperature of ocean surface waters, causing them to expand. The increased volume of ocean water will result in rising sea levels.</p> <p>Accept other relevant answers.</p>	

- (b) Outline **two** negative impacts of rising sea levels on coastal infrastructure. (4 marks)

Description	Marks
For each negative impact on coastal infrastructure (2 x 2 marks)	
Identifies a negative impact of rising sea levels on coastal infrastructure	1
Outlines how rising sea levels produce the stated impact	1
Total	4
<p>Answers could include:</p> <ul style="list-style-type: none"> • salt water intrusion of coastal aquifers ruining coastal irrigation schemes • increased coastal erosion destroying roads, buildings or other infrastructure • sea levels exceeding the design limits of flood barriers • sea levels exceeding the operating limits of port facilities. <p>Sample answer:</p> <p>As sea levels rise coastal erosion levels are increased, with high tides and storm waves reaching above both natural and man-made barriers. Because many coastal cities have highly urbanised coastlines, this increased erosion can damage or destroy many houses and roads built close to the shoreline.</p> <p>Accept other relevant answers.</p>	

Question 27 (continued)

- (c) Rising sea levels may also increase the frequency of flooding along major rivers. Outline **two** possible benefits and **two** possible negative consequences of such flood events for local ecosystems. (4 marks)

Description	Marks
For each benefit of flooding (2 x 1 mark)	
Outline a possible benefit	1
Subtotal	2
For each negative consequences of flooding (2 x 1 mark)	
Outline a possible negative consequence	1
Subtotal	2
Total	4
Ecosystem benefits could include: <ul style="list-style-type: none"> • replenishment of soils by distributed silt • seed dispersal for plants evolved to depend on episodic floods • recharging of local aquifers • allows migration and mixing of fish populations in distributed flood plain water bodies (e.g. billabongs). Negative ecosystem consequences could include: <ul style="list-style-type: none"> • sediment build-up choking vegetation • displacement or elimination of endemic and/or endangered flora and fauna • introduction of invasive species to isolated water bodies. Accept other relevant answers.	

- (d) Describe a mitigation strategy that could reduce the impact of sea level rise or flooding for an affected community. State **one** environmental **or** social factor that the strategy is based on. (3 marks)

Description	Marks
Mitigation strategy cites a factor or initiative that could reduce the impact of sea level rise or flooding for an affected community	1
Outlines how the identified factor would reduce impact of sea level rise or flooding	1
States a relevant environmental or social factor relevant to consideration	1
Total	3
Relevant mitigation strategies could include: <ul style="list-style-type: none"> • construction of flood defences (e.g. sea walls, levees, flood barriers) • re-zoning to prevent development of at-risk coastal areas • movement of at-risk houses • planting/cultivation of vegetation to stabilise coastal land and protect against erosion (e.g. mangroves). Sample answer: Because rising sea levels will place coastal land at increased risk of erosion, planning regulations should prevent development and the building of houses close to the shoreline. This would reduce the quantity of roads, buildings and other infrastructure that may be destroyed by coastal erosion imposing related costs on members of the community. This would have the added benefit of preserving coastal ecosystems (e.g. dunes, mangroves, coastal lowland forests) that are commonly under pressure from development. Accept other relevant answers.	

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