Earth & Environmental Science marking guide and response

External assessment 2023

Combination response (124 marks)

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

1. describe and explain the use of renewable and non-renewable resources and the cause and impact of Earth hazards and global climate change
2. apply understanding of use of renewable and non-renewable resources and the cause and impact of Earth hazards and global climate change
3. analyse evidence about the use of renewable and non-renewable resources and the cause and impact of Earth hazards and global climate change to identify trends, patterns, relationships, limitations or uncertainty
4. interpret evidence about use of renewable and non-renewable resources and the cause and impact of Earth hazards and global climate change to draw conclusions based on analysis.

Note: Objectives 5, 6 and 7 are not assessed in this instrument

Purpose

This document consists of a marking guide and a sample response.

The marking guide:

- provides a tool for calibrating external assessment markers to ensure reliability of results
- indicates the correlation, for each question, between mark allocation and qualities at each level of the mark range
- informs schools and students about how marks are matched to qualities in student responses.

The sample response:

- demonstrates the qualities of a high-level response
- has been annotated using the marking guide.

Mark allocation

Where a response does not meet any of the descriptors for a question or a criterion, a mark of '0' will be recorded.

Where no response to a question has been made, a mark of 'N' will be recorded.

Allow FT mark/s — refers to 'follow through', where an error in the prior section of working is used later in the response, a mark (or marks) for the rest of the response can still be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

Marking guide

Multiple choice

Question	Response
1	C
2	B
3	C
4	B
5	C
6	A
7	D
8	B
9	A
10	D
11	A
12	A
13	D
14	D
15	A
16	B
17	B
18	D
19	C
20	C

Paper 1: Short response

Q	Sample response	The response:
21a)	An ecological footprint is a measure of the biologically productive land or water needed to enable the production, transportation, processing and waste removal of resources consumed by humans. It is measured by area (global hectares).	• describes – an ecological footprint as a measure of biologically productive land or water **[1 mark]** – the unit as a unit of area **[1 mark]**
21b)	An example of a biological resource is eating meat (beef). When calculating the ecological footprint associated with eating meat, we take into consideration the area of agricultural land used for the cattle, the amount of land needed to offset cattle methane emissions, and other carbon emissions produced during the transportation of the cattle and meat after processing. The footprint calculation would also consider the amount of land required to offset emissions produced during the disposal of waste, such as carbon emissions from landfill caused by waste products.	• identifies – a valid biological resource **[1 mark]** – a factor when calculating ecological footprint **[1 mark]** – a second factor when calculating ecological footprint **[1 mark]** – a third factor when calculating ecological footprint **[1 mark]** – a fourth factor when calculating ecological footprint **[1 mark]**

Q	Sample response	The response:
22a)	1. Physical size reduction, e.g. crushing 2. Separation, e.g. by magnetic separation 3. Extraction/purification, e.g. smelting	• identifies physical size reduction process **[1 mark]** • identifies separation process **[1 mark]** • identifies extraction/purification process **[1 mark]**
22b)	Crushing is used as iron ore is a solid material extracted from the lithosphere. Crushing reduces the size and increases the surface area of the raw material so that iron can be extracted by the next step. Magnetic separation works with the magnetic property of iron and is used for minerals of iron such as magnetite. Smelting is used as iron is metallic and has a specific melting point, which permits its separation from impurities with different melting points.	• identifies properties of iron or iron ore supporting a physical size reduction process **[1 mark]** • explains a physical size reduction process **[1 mark]** • identifies properties of iron or iron ore supporting a separation process **[1 mark]** • explains a separation process **[1 mark]** • identifies properties of iron or iron ore supporting an extraction/purification process **[1 mark]** • explains an extraction/purification process **[1 mark]**

Q	Sample response	The response:
23a)	i) Solar Average annual cost: $375 000 + ($2500 × 10) = $400 000 $400 000 ÷ 10 = $40 000/year Production: 125 kW × 12 h/day = 1500 kWh/day 1500 kWh/day × 365 day/year = 547 500 kWh/year Average energy cost: $40 000 ÷ 547 500 kWh = $0.0731/kWh or 7.31 c/kWh ii) Wind Average annual cost: $465 000 + ($3350 × 10) = $498 500 $498 500 ÷ 10 = $49 850 /year Production: 125 kW × 18.5 h/day = 2312.5 kWh/day 2312.5 kWh/day × 365 day/year = 844 062.5 kWh/year Average energy cost: $49 850 ÷ 844 062.5 kWh = $0.0591/kWh or 5.91 c/kWh	• for solar, determines – average annual cost **[1 mark]** – annual energy production **[1 mark]** – average energy cost **[1 mark]** • for wind, determines – average annual cost **[1 mark]** – annual energy production **[1 mark]** – average energy cost **[1 mark]**
23b)	Wind is the most cost effective, as it generates more energy for each dollar compared to solar.	• provides a valid conclusion **[1 mark]** • justifies the conclusion **[1 mark]**

Q	Sample response	The response:
23c)	Technological: Energy storage — need a way to store the energy produced, since wind and sun are not present 100% of the time. Environmental: Noise pollution — wind turbines produce greater noise pollution for local residents; therefore, if this is a problem, solar may be a better option. Geographical: Available land/area — where to place solar cells or wind turbines, as each have unique space requirements.	• identifies a technological factor **[1 mark]** • explains the technological factor **[1 mark]** • identifies an environmental factor **[1 mark]** • explains the environmental factor **[1 mark]** • identifies a geographical factor **[1 mark]** • explains the geographical factor **[1 mark]**
24a)	Rainfall in southern Australia has been below average since 1980, while it has been above average in northern Australia. In comparison, mosquitoes were once found across most of eastern Australia, but the population is now only found in north-east Australia. It seems likely that the change in rainfall patterns has affected mosquito distribution.	• draws a conclusion **[1 mark]** • discusses how the evidence – supports the conclusion **[1 mark]** – does not support the conclusion **[1 mark]**
24b)	If current rainfall trends continue, mosquitoes are most likely to stay in northern Australia and the distribution will not return to its 1980 southern extent.	• predicts a change in mosquito distribution **[1 mark]**

Paper 2: Short response

Q	Sample response	The response:
1a)	Water is renewed by rainfall in the water cycle. Similarly, groundwater is replenished by rainfall that infiltrates into the ground.	• explains that groundwater is recharged by rainfall **[1 mark]**
1b)	Recharge decreases from 1970 to 2023. This is due to the reduced frequency of recharge events (rainfall) over this time. This is demonstrated by the trendline for the first graph where recharge has been steadily reducing from 750 ML to approximately 300 ML.	• identifies that recharge decreases **[1 mark]** • provides a reason for the trend **[1 mark]** • provides evidence to support reason **[1 mark]**
1c)	Groundwater will no longer be sustainable because the demand for water will increase due to population increases (estimated to more than double by 2050), and water extraction for crops. At the same time, groundwater recharge will be reduced, from decreasing rainfall. Usage will exceed supply.	• makes a prediction **[1 mark]** • justifies with supporting evidence from the – population data **[1 mark]** – recharge data **[1 mark]**

Q	Sample response	The response:
2a)	Iceland is located on the plate boundary between the North American Plate and the Eurasian Plate. The plate boundary is divergent, meaning that the two plates are moving away from each other. As the two plates move apart, magma rises to the surface, forming new plates and volcanoes.	• identifies that Iceland is located on a plate boundary **[1 mark]** • explains – divergent plates are moving apart **[1 mark]** – volcanoes will form between the plates **[1 mark]**
2b)	While the eruption released ash clouds into the atmosphere, they were localised and did not spread around the globe. Therefore, they did not block worldwide solar radiation and change global temperatures, since it only affected northern Europe.	• explains – ash cloud was localised **[1 mark]** – solar radiation was not blocked **[1 mark]**
2c)	The ash clouds would have impacted local health outcomes by producing irritant particulates in the air, which lead to respiratory issues and irritation.	• identifies an effect **[1 mark]** • explains how the ash clouds would cause this effect **[1 mark]**
2d)	By introducing an early warning system for volcanoes in Reykjavík, people would be warned early to make it to high ground or safety to reduce loss of life. People would also be able to collect breathing apparatus to protect their airways.	• identifies a mitigation strategy **[1 mark]** • explains the strategy **[1 mark]**

Q	Sample response	The response:
3a)	The northern basin is the most likely location for a drought, since most dams there are at less than 20% capacity.	• determines the northern basin **[1 mark]** • provides supporting evidence from the map **[1 mark]**
3b)	Dam distribution is highest near the coastal regions. This is because the largest population centres are located here. Also, these dams capture the eastern flow of rivers heading to the coast. Dams are less common in the interior of the Murray–Darling region because there are smaller populations in regional areas. However, there is a need for agricultural water, so inland dams are still required.	• explains dam distribution in coastal regions **[1 mark]** • provides an appropriate reason for dam distribution in coastal regions **[1 mark]** • explains dam distribution in inland regions **[1 mark]** • provides an appropriate reason for dam distribution in inland regions **[1 mark]**
3c)	Physical: Construct new dams. This would act as a water store for the future that can be accessed during times of drought. Increasing the frequency of smaller dams upstream from the main dams would increase water storage. Biological: Plant drought-resistant crops in areas with low dam frequency in the northern basin. These crops require less water than traditional crops and so reduce water use.	• identifies a physical strategy **[1 mark]** • explains this strategy **[1 mark]** • provides an appropriate reason for this strategy **[1 mark]** • identifies a biological strategy **[1 mark]** • explains this strategy **[1 mark]** • provides an appropriate reason for this strategy **[1 mark]**

Q	Sample response	The response:
3d)	Terrestrial ecosystem: Increased erosion — reduced water availability leads to reduced vegetation cover and less plant roots to stabilise soils. Aquatic ecosystem: Reduced water quality — reduced water levels and flow result in increased concentrations of nutrients and pollutants, increased sediment and reduced oxygen levels.	• identifies an impact on a terrestrial ecosystem **[1 mark]** • explains this impact **[1 mark]** • identifies an impact on an aquatic ecosystem **[1 mark]** • explains this impact **[1 mark]**

Q	Sample response	The response:
4a)	The last glaciation period ended 17 000 years ago.	• identifies the endpoint of the last glaciation period **[1 mark]**
4b)	There is an increase in herb pollen when temperature drops, e.g. 10 000–35 000 years ago, herb pollen increased from 0% up to around 50%, and again at 130 000 years ago when the temperature dropped –8 °C. There is an increase in small tree pollen when temperature decreases, e.g. 10 000–75 000 years ago when temperature decreased between –4 and –8 °C. In colder climate conditions (e.g. 10 000–70 000 years ago), glacial advances are likely to prevent tall trees from growing. In warmer conditions (e.g. 0–10 000 years ago), the percentage of tall tree pollen increases.	• identifies that cold temperatures correspond with – an increase in herb pollen percentage **[1 mark]** – an increase in small tree pollen percentage **[1 mark]** – a decrease in tall tree pollen percentage **[1 mark]** • provides – evidence for herbs percentage **[1 mark]** – evidence for small trees percentage **[1 mark]** – evidence for tall trees percentage **[1 mark]**
4c)	Pollen is produced in various types and in large amounts; therefore, it is likely to be found in the fossil record. Pollen is also persistent in the fossil record, since the stimulus indicates pollen grains are found up to 150 000 years ago.	• identifies an advantage of using pollen **[1 mark]** • provides evidence to support this advantage **[1 mark]**

Q	Sample response	The response:
5a)	Land clearing reduces the amount of natural carbon stores in forested areas. The reduction of forest trees reduces the amount of carbon uptake through photosynthesis and produces greenhouse emissions, by releasing stored CO_2 into the atmosphere. Increased particulate matter is also released into the atmosphere.	• describes how land clearing – increases particulate matter **[1 mark]** – increases atmospheric CO_2 **[1 mark]** by ▪ reducing photosynthesis **[1 mark]** ▪ releasing stored CO_2 **[1 mark]**
5b)	Methane emissions are above the amount that can naturally be removed from the atmosphere. There is an imbalance between sinks and emissions, causing an additional 10 Mt of atmospheric CH_4 per year. If the methane budget is unchanged, then the relative concentration of methane in the atmosphere will increase.	• identifies – that emissions exceed sinks **[1 mark]** – atmospheric methane levels will increase **[1 mark]** – 10 Mt increase in CH_4 per year **[1 mark]** • predicts a change in the composition of the atmosphere **[1 mark]**
5c)	Anthropogenic emission sources are greater than natural emission sources. This will result in increasing global temperatures, as methane has a stronger greenhouse effect per particle than carbon dioxide.	• identifies that – anthropogenic contributions are increasing atmospheric methane **[1 mark]** – methane is significant as a greenhouse gas **[1 mark]** • draws a conclusion about the effect of increased atmospheric methane **[1 mark]**

Paper 2: Extended response — Question 6

Q	Sample response	The response:
6a)	The highest percentage recovery for iron is 52% at a pH of 9.0. At that pH, the company would recover: 52% × 700 kg = 364 kg of iron At $0.17 per kilogram, the company would earn: 364 × $0.17 = $61.88 At pH 9, the company can recover 76% zinc from its ore. A 76% recovery rate on 150 kg of zinc is 76% × 150 kg = 114 kg of zinc At $2.76 per kilogram, the company would earn 114 × $2.76 = $314.64 The total financial value of the sample at pH 9 is $61.88 + $314.64 = $376.52	• identifies the optimal pH and iron recovery rate **[1 mark]** • determines the – amount of iron recoverable **[1 mark]** – potential earnings for iron **[1 mark]** • identifies – zinc as the other recoverable metal **[1 mark]** – the recovery rate for zinc **[1 mark]** • determines the – amount of zinc recoverable **[1 mark]** – potential earnings for zinc **[1 mark]** • determines the financial value of the sample **[1 mark]**
6b)	An alternative pH that would maximise value is 7.5. Copper recovery is 90% and lead recovery is 70%. Given that the price per kg of copper is triple the other metals, this should maximise profit. At pH 7.5, the recovery of copper would be: 90% x 50 kg = 45 kg of copper At $8.80 per kilogram, the company would earn: 45 x $8.80 = $396.00 At pH 7.5, the recovery of lead would be: 70% x 100 kg = 70 kg of lead At $1.90 a kilogram, the company would earn: 70 x $1.90 = $133 The total financial value of the sample at pH 7.5 is $396 + $133 = $529	• identifies an appropriate alternative pH **[1 mark]** – justifies with evidence from graph **[1 mark]** – justifies with evidence from table **[1 mark]** • determines the – amount of first metal recoverable **[1 mark]** – potential earnings for first metal **[1 mark]** • determines the – amount of second metal recoverable **[1 mark]** – potential earnings for second metal **[1 mark]** • determines the financial value of the sample for two recoverable metals **[1 mark]**

Question 6b): Table of expected responses

	pH										
	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	10
Iron(%)	42	30	15	10	12	20	32	40	48	52	50
Lead(%)	0	0	8	10	20	35	70	0	0	0	0
Zinc(%)	5	5	5	5	6	10	15	25	60	75	90
Copper(%)	64	75	85	92	95	95	90	80	0	0	0
Iron(kg)	294	210	105	70	84	140	224	280	336	364	350
Lead(kg)	0	0	8	10	20	35	70	0	0	0	0
Zinc(kg)	7.5	7.5	7.5	7.5	9	15	22.5	37.5	90	112.5	135
Copper(kg)	32	37.5	42.5	46	47.5	47.5	45	40	0	0	0
Iron($)	**49.98**	**35.70**	17.85	11.90	14.28	23.80	38.08	47.60	**57.12**	**61.88**	**59.50**
Lead($)	0	0	15.2	19	**38**	**66.50**	**133**	0	0	0	**0**
Zinc($)	20.70	20.70	**20.70**	**20.70**	24.84	41.40	62.10	**103.50**	**248.40**	**310.50**	**372.60**
Copper($)	**281.60**	**330**	**374**	**404.80**	**418**	**418**	**396**	**352.00**	0	0	0
Total($)	352.28	386.40	427.50	456.40	495.12	549.70	629.18	503.10	305.52	372.38	432.10
Total of two most financially viable (bolded)	331.58	365.70	394.70	425.50	456.00	484.50	529.00	455.50	305.52	372.38	432.10

Q	Sample response	The response:
6c)	The company should choose a pH of 7.5, as they would earn $529 for extracting only two metals, whereas using pH 9.0 they earn only $376.52. They make an additional $152.48 by using pH 7.5.	• draws a conclusion about pH **[1 mark]** • provides a justification **[1 mark]**