2024 VCE Environmental Science external assessment report

General comments

The 2024 VCE Environmental Science examination provided students with the opportunity to use their knowledge and understanding of the core concepts from both Units 3 and 4. It was evident that most students were able to use the two hours available to apply their learning. Some students did not finish the paper in the allotted time. Time management is a skill that needs to be developed during revision and preparation for the exam, including making full use of the 15 minutes of reading time to start planning responses.

Student responses varied in their clarity and precision. Higher-scoring responses had clear, well-structured explanations and ideas that were supported, when required, with data or the correct use of key terms from the study design. Knowledge of all key terms, including those used in relation to data and measurement, was required throughout this exam. As well as being able to correctly define key terminology, higher-scoring students were able to use these terms in relation to the scenario being presented and in the context of the question being asked. Lower-scoring responses did not demonstrate an accurate understanding of the required term and/or did not apply it clearly to the example being discussed.

Important exam skills to practise include reading all the information provided, interpreting data in tables or graphs (including the axis, key and title), and directly answering each specific question. Students should not rewrite the question or pieces directly from the stem as their response. It was evident that some students had revised by using past exam papers, which is a key method in preparing well for any examination. However, it is important that students carefully read the actual exam question and all the information provided in the stem and directly respond to that question. Lower-scoring responses attempted to rewrite ideas from past exam questions, which did not apply to the questions or scenarios presented this year.

Students would benefit from practising writing responses to past exam questions where they make their key points clearly and do not contradict themselves. This would also help in understanding and responding to the different command terms used in exam questions, such as ‘state’, ‘explain’, ‘evaluate’ and ‘justify’.

As Environmental Science is a VCE science subject, students are expected to be able to apply basic mathematical skills to data. This can include calculating the percentage change in data, energy efficiency ratios, mark-recapture figures and Simpson’s Index of Diversity. It is important, as scientists, that students provide units of measurement in their answers (this is an important numeracy skill). For example, in Section B, Question 8, when discussing the use of wind turbines and patterns in the wind speed data, many students did not refer to metres per second or kilowatt hours in their responses.

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

The statistics in this report may be subject to rounding, resulting in a total of more or less than 100 per cent.

Section A – Multiple-choice questions

The table below indicates the percentage of students who chose each option. Grey shading and bold text indicate the correct answer.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Question | Correct answer | % A | % B | % C | % D | Comments |
| **1** | D | 12 | 10 | 19 | **59** | The correct response is option D. The stem states ‘discovery of similar fossil species across different geographical regions’ and this is due to the process of rapid diversification, where organisms rapidly increase in numbers from a common ancestor as ecosystems change and organisms adapt to these changes. Changes due to factors such as continental drift and plate tectonics contribute to ecosystems and organisms evolving. Widespread distribution of species also occurs through parallel evolution and animal migration. Option A is incorrect because identical ecosystems do not exist worldwide. There may be similarities between ecosystems in different parts of the world, but they cannot be identical, so it is an incorrect explanation. It is the similarity of ecosystems in different parts of the world that resulted in the evolution of organisms to fill a particular niche and gave them similar physical characteristics (that have eventually created similarities in fossil species). |
| **2** | C | 0 | 8 | **74** | 17 | Carbon sequestration is classified as a regulating service (option C). As stated in the study design (on page 32), regulating services to be studied include those involved in climate control and as such, a key factor in managing greenhouse gases is carbon storage. While supporting services allow the Earth to sustain basic life forms, option D would not be regarded as correct because on its own carbon sequestration is not one of those key major processes that maintain whole ecosystems (such as the specific nutrient cycles, the water cycle or photosynthesis). |
| **3** | B | 3 | **70** | 5 | 21 |  |
| **4** | C | 3 | 4 | **91** | 2 |  |
| **5** | D | 5 | 8 | 26 | **62** | The patterns of wide or narrow rings record the year-to-year fluctuations in the growth of a tree. In addition to the age of the tree, these patterns indicate a weather history at the location where the tree grew. Therefore, ring widths can be used to estimate past temperatures and precipitation over the lifetime of the tree (option D). This is due to climate variability and is not directly related to atmospheric concentrations of carbon dioxide and methane (option C) at a regional level. |
| **6** | D | 14 | 6 | 20 | **60** | The method described in the stem is measuring the changes in annual tree ring growth to investigate local climate change. This is an example of using the palaeoclimate records (option D). Other methods can be used to estimate atmospheric gas levels (such as the analysis of carbon isotopes in tree rings) but this is not the method described. |
| **7** | C | 8 | 3 | **83** | 5 |  |
| **8** | B | 1 | **61** | 30 | 8 | An understanding of the term ‘phenological’ was required to give the correct answer of option B. Phenological refers to the study of how seasonal and climate variations impact the timing of periodic events in the life cycles of plants and animals, such as the relationship described in the question stem between the plants and bees. Some students incorrectly chose option C because the relationship described was focused on the role bees have in the pollination of plants, rather than the length of plant-growing seasons and animal-breeding cycles. |
| **9** | A | **83** | 7 | 1 | 9 |  |
| **10** | C | 4 | 34 | **61** | 2 | Confusion between the two terms ‘bioaccumulation’ and ‘biomagnification’ caused many students to incorrectly choose option B rather than option C. The transfer of PAHs from the zooxanthellae to the coral through the food chain is regarded as biomagnification. Bioaccumulation is the build-up in an organism of absorbed chemicals over time, whereas biomagnification is the increase in concentration of these chemicals in each organism up the food chain. |
| **11** | B | 70 | **12** | 3 | 15 | The correct response is option B because the ‘ongoing airborne monitoring’ is part of a process to collect data related to the medical testing of workers due to possible exposure to PAHs. Using this ongoing (i.e. historical and current) scientific data would feed into the understanding of the impacts on human health. The ongoing monitoring is not part of the exposure standards set in the Workplace exposure (2024) document, which is the legal framework (i.e. option A). It is not an application of a new technology (option D) because airborne monitoring for various harmful chemicals is not a new scientific method. |
| **12** | A | **74** | 10 | 4 | 12 |  |
| **13** | A | **29** | 64 | 2 | 5 | The confusion over this question stems from a common misconception that data from a single site can be used as evidence to conclude that global warming is or is not occurring. A single site cannot be regarded as giving enough evidence on its own to lead to this conclusion, and this is why climate scientists draw on evidence and data from a wide range of sources in their modelling and analysis. Therefore, option A was the correct response. |
| **14** | C | 32 | 5 | **54** | 8 | Reading this type of graph (known as a stacked area chart) requires students to compare the shaded areas between each line to determine the relative contribution of each variable – in this case different renewable energy sources. Students should be familiar with a variety of different data presentation formats used by scientists and how to analyse this type of information. The slope of the line from 2020 onwards actually indicates that solar energy has increased at a faster rate than hydro energy (which is why option A is incorrect). The graph shows that hydro energy has remained relatively constant (option C). |
| **15** | B | 9 | **49** | 34 | 8 | Reading the shaded areas from the graph for 2021, the contributions for each energy form were around 43% for solar, 34% for wind and 23% for hydro energy. Some students seemed to confuse the correct response for wind (option B) with the incorrect response of solar (option C). |
| **16** | C | 13 | 25 | **58** | 4 | Students were asked to identify an option that would indicate they understood the difference between base and peak load energy. As mentioned in the discussion of Section B Question 6c, this is not always well understood by students. Base load is the minimum amount of electricity needed to meet the continuous demand for power over a 24-hour period (option C), while peak load refers to the maximum amount of electricity required from the grid during periods of high demand. It is not the constant amount of electricity that can be generated (option B), because this varies according to demand. |
| **17** | C | 2 | 8 | **85** | 4 |  |
| **18** | D | 5 | 28 | 12 | **54** | From the four listed ideas, students were asked to identify one option that demonstrated increasing the energy efficiency of heating devices. Energy efficiency can be increased by limiting the number of energy conversions (which means less energy is lost with each conversion). This would result in an oil heater that uses two conversions being more efficient than a fan heater that requires four conversions (option D). Many students incorrectly chose option B, but this would not improve efficiency; it would only reduce the total amount of energy being used. |
| **19** | D | 7 | 4 | 20 | **69** | The change to the heating and cooling technology described for the manufacturing industry demonstrates an increase in the efficiency of resource use (option D). The improved technology would save energy resources and reduce environmental impacts. The focus of these changes is not on fairness and justice across communities and within the present generation (option C), which many students incorrectly chose. |
| **20** | A | **72** | 9 | 9 | 10 |  |
| **21** | B | 13 | **69** | 6 | 11 | ‘Biomass’ is defined as a renewable and non-fossil energy source (option B). Students chose a variety of incorrect responses from the other three options, which indicates a lack of understanding of these terms and how they relate to different energy sources. |
| **22** | D | 3 | 5 | 2 | **90** |  |
| **23** | B | 3 | **60** | 26 | 10 | Because the results were only collected once in August and the recorded reading was significantly above any of the other totals for phosphorus measured in the creek, it is likely the result of a personal error (option B) rather than a systematic error, which a number of students gave as their answer. Personal errors often result from misreading the measurement device (often due to not repeating the collection of data) whereas systematic errors can result from measuring instruments that are incorrectly calibrated. In this case, the October results were back in range, which would indicate that the instrument was calibrated correctly (no mention was made of a recalibration of the instrument). |
| **24** | A | **86** | 6 | 2 | 6 |  |
| **25** | D | 2 | 19 | 47 | **33** |  |
| **26** | A | **63** | 3 | 20 | 15 | The water quality data was collected at the stream site each month, which would be an example of fieldwork (option A). Many students incorrectly chose qualitative sampling (option C). The data collected was quantitative (numbers-based) rather than qualitative. |
| **27** | B | 1 | **95** | 1 | 3 |  |
| **28** | B | 3 | **74** | 19 | 3 |  |
| **29** | D | 2 | 4 | 5 | **89** |  |
| **30** | B | 2 | **91** | 6 | 1 |  |

Section B

Question 1a.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 47 | 27 | 16 | 9 | 0.9 |

One of the practical techniques used to assess species diversity, as listed in the study design, is the collection of data using grids, transects and quadrats. Higher-scoring responses clearly explained why grid sampling was used rather than transect sampling to measure insect diversity at the two sites. Examples of good responses:

Grid sampling is effective when sampling large areas and monitors changes in spatial variability over a site.

Transect sampling is better used to monitor changes across linear distance or along a line.

Examples of when transects would be used included:

measuring species change due to succession from the coast further inland or changes due to the increase (or decrease) in altitude

measuring changes related to differences in abiotic factors, such as temperature, soil pH or moisture, between different habitats or over a linear distance.

Clear reasoning showed that these students understood the difference between the two techniques (often because they had used these techniques in the field).

This was one of the questions that was not answered well by many students. In some of the incorrect responses, students:

did not understand that both transects and grids can be used to collect population data for both flora and fauna

tried to relate the use of grids and transects to the mobility (or lack of) of particular organisms

argued about transects collecting data that was more or less biased than grid sampling

argued that using grids was easier than using transects or provided better access to the site

tried to use points from a 2023 exam question about the edge effect and grid sampling.

Question 1b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 29 | 19 | 52 | 1.3 |

|  |  |  |
| --- | --- | --- |
| N = **89** |  | Σ [ni (ni – 1)] = **1260** |
| N(N – 1) = **7832** |

Therefore: Simpson’s Index of Diversity: 

D = 1 − 1260 / 7832

D = 1 − 0.161

D = 0.839

Most students were able to correctly complete the calculation using the figures from the table as shown above. Many students rounded up the diversity figure to 0.84, although this was not necessary. Some incomplete answers forgot to subtract 0.161 from 1 to get the final Simpson’s Index of Diversity figure.

Question 1c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 15 | 10 | 75 | 1.6 |

Having calculated a Simpson’s Index of Diversity (SID) figure in the previous question, better responses used this data to compare the diversity of the two areas. The urban park SID was 0.56 compared with the golf course SID of 0.84; therefore, this means that golf course has a higher diversity (0.28 higher) than the urban park.

Question 1d.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 19 | 43 | 38 | 1.2 |

Two reasons that suggested why ground-nesting bees might survive better on a golf course compared to an urban park were required. Correct ideas focused on the difference in native vegetation and human disturbance between the two areas and included:

Native vegetation on the golf course provides appropriate food sources for native bees whereas exotic plants do not.

Native vegetation on the golf course provides suitable nesting sites whereas exotic plants do not.

Pesticides that harm bees are used in urban parks as part of management whereas they are not used on golf courses.

Nests are disturbed by humans when leaf litter is cleared in urban parks but not when rough areas are left on golf courses.

Many lowerer-scoring responses simply gave general statements such as ‘humans kill bees in parks’ or ‘bees like native plants’ or repeated, word for word, information from the stem.

Question 1e.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 13 | 33 | 54 | 1.4 |

Most students were able to state two reasons why it is important to maintain insect populations in ecosystems. The ideas included:

their role in the process of pollination

their role as seed dispersal agents

their role as food sources for other species or as part of a food chain / food web

their role as detritivores and how they contribute to soil development.

Incorrect responses commented on the part bees play in the breakdown of leaf litter and waste (but bees are not detritivores).

Question 1f.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 21 | 49 | 29 | 1.1 |

Overall, this question was not well answered by many students. There was a lack of understanding of the term ‘validity’ and many of the lower-scoring responses jumbled the concepts of accuracy, reliability and validity. Correct responses acknowledged that validity relates to the ability of an experiment to test or measure what it set out to. Because the CO2 traps are less effective in trapping smaller insects, this would not show the diversity of all insects (the researchers would only trap larger insects) and would therefore not be a valid study. It originally set out to test the numbers of all insects and because of this limitation would be less valid.

Question 1g.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 18 | 32 | 50 | 1.3 |

Given the information provided on how insect diversity data was collected, to provide a complete response, students needed to clearly evaluate whether or not this study adhered to ethical guidelines and develop their reasoning. Higher-scoring responses focused on explaining that for research to be considered ethical, the collection of insects should minimise the harm and suffering of the organisms, the insects should not be killed, and scientists should only trap the minimal numbers needed. Based on this, some students presented reasoning that the study was ethical because the insects were released after they had recovered from the anaesthetic and were not killed, the anaesthetic did not stress the insects, and they were collected across the site using grid sampling so only minimal numbers were caught to give population figures. Other students argued that the research was not ethical because the trapping would cause some harm to the insects, they would suffer (or may even die) when being held in a trap, or that there was no evidence that minimal numbers were targeted during the research. Both approaches demonstrated an understanding of ethical principles in scientific fieldwork and research. Some students tried to use the term ‘non-maleficence’ in their response without making it clear what this principle meant in the context of this research.

Question 2a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 22 | 66 | 12 | 0.9 |

Information was provided about the behaviour and distribution of Australian sea lions, including a map showing their current and historical range. The map indicated that this species is endemic to the southern half of Australia, a fact that not many students recognised. The key idea that most students gave was that because there has been a significant reduction in the sea lions’ range (they no longer exist in Victorian and Tasmanian waters), this would contribute to their classification as endangered. Incorrect responses did not focus on the part of the question about ‘how the range of the sea lion … contributed to this classification’ and discussed general points about decreasing population size, over-hunting by Europeans or simply gave a definition of ‘endangered’.

Question 2b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 20 | 15 | 65 | 1.5 |

An understanding of the IUCN classification system meant that suitable responses recognised that management teams would be aiming to have the classification changed to ‘vulnerable’. Better student responses explained this by commenting that ‘vulnerable’ indicates an improvement in population numbers and therefore the sea lion numbers would have increased and would be at a lower risk of extinction. Incorrect responses tried to argue that having the classification changed to ‘critically endangered’ would be the management team’s aim because it would equate to greater protection for the species. It is a false argument to aim to let the population size decrease to a more critical stage (i.e. closer to extinction) and then begin to do something about trying to save the sea lion species.

Question 2c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 21 | 25 | 54 | 1.4 |

Most students understood the connection between small population numbers and a decrease in genetic diversity. Better responses then went on to explain that a lack of genetic diversity would mean the sea lion population is less likely to have a natural resistance to a new disease. With less resistance, more sea lions could die, thereby further reducing already small numbers.

Incorrect responses tried to use an explanation based on the idea that the sea lions, with a reduced range, would all be breeding in the one area and any new disease would quickly spread through the population. It should be understood from the information that there are still 66 breeding colonies that are found from the north of Perth in Western Australia through to the east of Adelaide in South Australia (a lengthy coastline of around 10 000 kilometres).

Question 2d.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 20 | 17 | 63 | 1.4 |

The question asked for students to circle one of the two listed threats to the sea lion population and then explain a management strategy to address this particular threat. In relation to the threat of ‘over-exploitation of prey’, better responses explained how placing restrictions on the harvest of fish and shellfish (especially on commercial fishing) would allow for an increase in the food supply. Students who circled ‘reduction in land-based habitat due to erosion’ identified strategies such as:

putting in place protected areas and preventing humans from entering these reserves, allowing for vegetation to recover

the restoration of habitat by employing methods to revegetate eroded areas and stabilise soil

the construction of sea walls or barriers to protect coastlines from wave erosion and allow dunes/shorelines to stabilise and plants to grow. This method would likely require ramps or steps of some description to allow sea lions access to the shore.

Translocation of sea lion colonies to an area with suitable habitat without erosion or with a more plentiful amount of prey (depending on which threat was circled) were other suitable management strategies. Incorrect responses discussed the use of captive breeding, which might increase population numbers but would not address either of the two given threats. Other lower-scoring responses misread the threat ‘over-exploitation of prey’ and wrote answers related to ‘by prey’. They incorrectly discussed issues about sea lion numbers declining because they were being eaten by predators as prey.

Question 2e.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 22 | 35 | 35 | 9 | 1.3 |

In general, part of this question was well answered by many students. They identified a variety of limitations related to the study of polyfluoroalkyl substances (PFAS) in sea lions. These included:

the focus of the study was PFAS levels in younger animals and not all ages of sea lions

the study only collected data from colonies in South Australia and did not include samples from Western Australia

data was collected from only 28 sea lion pups (i.e. a small sample size).

Many students failed to understand that the key limitation impacting on the scientists’ ability to draw a conclusion was that the study did not assess whether there was a link between PFAS levels and the pups’ deaths. It could not be concluded there was a cause-and-effect relationship between the levels and the deaths, and there could be other reasons for the deaths. Appropriate further testing would be required to draw a conclusion regarding the decline in sea lion numbers.

Question 2f.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 17 | 44 | 39 | 1.3 |

The sea lions should be protected in terms of ‘cultural services’ for the Wirangu people because the survival of the sea lion impacts on the non-material benefits the community receives from the species. Better responses identified factors related to:

the cultural significance the sea lions have for these important stakeholders

supporting the community’s sense of place and cultural identity

how the species provides spiritual enrichment and aesthetic experiences.

Lower-scoring responses directly rewrote points from the stem, such as stating that the sea lions should be protected because ‘the Wirangu are the traditional custodians’ and ‘they are their spiritual totem’.

Question 3

This question is based on an environmental science case study, a proposal to mine a public reserve for tailings left behind after gold mining last century, with the aim of then restoring the site to a better state. This type of question aims to allow students to apply their knowledge and understanding of environmental management and sustainability principles (as outlined in Unit 3, Area of Study 2).

Question 3a.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | 4 | Average |
| % | 20 | 17 | 29 | 30 | 4 | 1.8 |

Better responses to this question clearly explained both of the required sustainability principles in the context of the proposal. ‘In context’ refers to not just providing a basic definition but explaining how it applies to the case study. In this scenario, ‘efficiency of resource use’ refers to extracting useful resources (i.e. gold, mercury, sand) from the tailings material that is otherwise regarded as waste, while trying to minimise the negative impacts on the creek valley. This type of explanation clearly demonstrates an understanding of the principle rather than just stating ‘It is the practice of using resources in a way that maximises output while minimising waste and not impacting negatively on the environment’. Similarly, the principle of ‘conservation of biodiversity and ecological integrity’ was well demonstrated when students wrote about how the proposal aimed to try to restore the previous ecosystems and improve on the current ecological state. Better responses acknowledged that the current environmental health was very poor (e.g. 59% exotic vegetation, 1–2 metres of tailings covering the original creek valley, toxic heavy metal tailings) and that a restoration plan would help to improve the ongoing ecological integrity of the public reserve.

Many students did not take note of the two command terms used in the question: ‘evaluate’ and ‘justify’. As part of preparing for any VCE examination, students should have a clear understanding of what different command terms mean and how each should be addressed. [Definitions of command terms](https://www.vcaa.vic.edu.au/assessment/vce-assessment/Pages/GlossaryofCommandTerms.aspx) are published on the VCAA website. Higher-scoring responses were able to justify that the proposal would meet the nominated sustainability principles because the restoration was based on the already highly disturbed and degraded state of the creek valley, the amount of weed species and issues around toxic heavy metals. Many students acknowledged that there would be some initial disturbance but over the five-year plan, the public reserve would eventually be in a much better ecological state and the community would benefit from resources that would otherwise be regarded as waste. The integrity of the site has been destroyed by previous mining activities; therefore, a plan to restore it and remove introduced species is an effort to positively address sustainability issues.

Question 3b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 20 | 14 | 66 | 1.5 |

Most students were able to identify that the extraction of gold prior to the 1920s did not demonstrate the principle of intergenerational equity. Responses with a suitable explanation that demonstrated their understanding of ‘intergenerational equity’ (i.e. fairness or justice between generations) included:

A damaged and altered environment, as well as harmful waste, was left behind by the early miners to be dealt with by the current generation.

The cost of environmental repair and restoration is being borne by the current generation rather than being absorbed by past generations.

Gold resources were extracted and depleted in the past, and therefore there are limited resources available for future generations.

Question 3c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 17 | 41 | 41 | 1.3 |

Most students were able to give at least one reason for an environmental effects statement (EES) helping to support responsible decision-making. Higher-sciring responses provided two points. Suitable responses included:

As part of the review and approval process, the EES would help identify any potential issues or risks.

It could be used to help develop strategies or management plans to address and minimise any possible impacts.

It can inform discussion by stakeholders who can then express viewpoints on the proposal to feed into the decision-making process.

It helps to make proponents more accountable for the plan.

Question 3d.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 46 | 33 | 18 | 3 | 0.8 |

Overall, this question was not well answered. Many responses gave an incorrect interpretation of the precautionary principle, confusing it with conducting a risk assessment or a cost-benefit analysis. Other lower-scoring responses stated that the principle required the proponents to be ‘cautious’ or just stop any negative environmental impacts. Higher-scoring students clearly understood that the precautionary principle refers to a lack of certainty around potential harmful environmental impacts (due to insufficient scientific information) and therefore means the proposal should not go ahead until more data is collected and potential impacts are determined. The question asked how the principle should be applied to any proposal to mine the tailings. In this case, there was a lack of evidence to establish the risk levels of extracting tailings and any potential impacts from this, and therefore more scientific research was required. Before the proposal could proceed, the mining company should be required to provide evidence that the environmental damage caused by removing material would be minimal and present plans for how the environment would be returned to its original state.

Question 3e.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 17 | 35 | 47 | 1.3 |

Most students were able to identify one beneficial and one harmful effect of the proposal. Beneficial impacts on the lithosphere included reshaping the creek valley to its original landscape or removing toxic heavy metal chemicals from the soil. The most commonly stated harmful impact on the hydrosphere was that harmful heavy metals could be released from the soil when disturbed and enter the creek waters via the run-off. Less successful responses made comments about harm or benefits on flora and fauna (rather than soil or water).

Question 4a.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 12 | 14 | 41 | 32 | 1.9 |

Students were asked to explain the meaning of the term ‘albedo effect’ and most responses explained the basic concept that it is a measure of how much solar radiation a surface reflects (or absorbs). Others stated that it is the fraction of solar energy reflected from Earth back into space measured on a scale from zero (absorbs all radiation) to 1 (reflects all radiation). Better responses went on to explain that this relates to the urban heat island effect because the darker-coloured surfaces found in cities absorb more radiation (or reflect less radiation) than lighter surfaces. Since urban environments have more dark surfaces (such as buildings, roads and carparks) compared with the surrounding rural areas, this leads to a greater localised warming, which is the urban heat island effect.

Question 4b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 30 | 39 | 32 | 1.0 |

This question required a correct understanding of what the Intergovernmental Panel on Climate Change (IPCC) confidence rating scale involves. Better responses stated that the confidence rating refers to ‘how plausible or likely or probable’ the projected range of climate change is for a given emission scenario. They then went on to explain that a particular confidence level is based on the evidence (which could be the type, amount or consistency of the data), the quality of the computer climate models or the degree of scientific agreement that the projection will produce. Many lower-scoring responses confused confidence with the idea of how ‘accurate or valid’ the projection was or simply stated ‘how confident the IPCC are of their prediction’.

Question 4c.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 19 | 29 | 34 | 18 | 1.5 |

Better answers responded to the question of why green roofs and vertical gardens would be classified as a new technology by explaining that this method is using previously unused or recently developed building methods and designs to have an impact (reduction) on atmospheric greenhouse gas levels. Less successful responses did not specifically indicate how greenhouse gas levels would be impacted but rather focused on the effect of this new technology on climate change in general. Better responses made it clear that the plants (in the vertical gardens and green roofs) would absorb carbon dioxide when photosynthesising and therefore could assist with carbon sequestration in a localised environment. This would reduce the levels of this key greenhouse gas (carbon dioxide) in the atmosphere.

Question 4d.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 23 | 24 | 30 | 24 | 1.6 |

Many students did not have a clear idea of the difference between mitigation and adaptation strategies used in an effort to manage climate change, and overall this question was not well answered. Better responses explained that mitigation strategies are focused on making the impacts of climate change less severe by reducing or preventing greenhouse gas emissions, and that adaptation strategies involve taking actions to prevent or manage the damage greenhouse gas emissions cause by adjusting to the effects of climate change. Most of these students then went on to explain that the strategy is an adaptation option because at a local level vertical gardens and rooftop greening is being used to help cool the surrounding area (i.e. adjusting to climate change effects) and is not directly aimed at reducing greenhouse gas emissions. Others successfully argued that it could be viewed as a mitigation option because more plantings in the urban environment reduce carbon dioxide levels because plants act as carbon sinks.

Question 5a.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 20 | 32 | 32 | 16 | 1.5 |

The main role carbon dioxide plays in the greenhouse effect is that it absorbs and re-emits infrared radiation in the atmosphere. Not all students made this point clear in their answers. Higher-scoring responses went on to identify that human activities have caused the enhanced greenhouse effect by adding increased levels of carbon dioxide and disrupting the carbon cycle. With more infrared radiation being trapped, there is an increased warming of the atmosphere (known as the enhanced greenhouse effect).

Question 5b.

|  |  |  |  |
| --- | --- | --- | --- |
| Mark | 0 | 1 | Average |
| % | 47 | 54 | 0.6 |

Two major greenhouse gases needed to be identified. Most students correctly stated methane and either nitrous oxide, ozone or chlorofluorocarbons (CFCs). Incorrect responses gave water vapour or carbon dioxide despite the question asking for greenhouse gases other than these two.

Question 5c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 17 | 55 | 28 | 1.1 |

The table provided space for students to write one environmental advantage and one disadvantage of using hempcrete rather than concrete in housing construction. Acceptable advantages included:

Hempcrete provides for carbon sequestration as the hemp plant grows.

Less greenhouse gases (or carbon dioxide) are emitted when hempcrete is used instead of concrete.

Hempcrete is a renewable and sustainable building resource.

Less mining for ingredients, including sand, gravel and stone, is required; therefore, the environment is less disrupted.

The environmental disadvantages given focused on the land clearing required to grow hemp crops and the resulting degradation or loss of natural habitat. Other disadvantages given were the impacts from the use of chemical fertilisers and pesticides or the use of farm machinery that results in fossil fuel combustion (and releases carbon dioxide). Lower-scoring responses gave economic or social advantages or disadvantages rather than environmental ones.

Question 5d.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 11 | 35 | 54 | 1.5 |

The graph clearly shows a large increase in carbon dioxide emissions from around 1945 onwards. The reasons for this were the rapid growth of the global population after World War II and the increased reliance on cement as a building material. Most students were able to identify the link between the growth in human population, which has resulted in increased levels of industrialisation and urbanisation, and the requirement for more cement to make the concrete used in infrastructure projects.

Question 6a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 9 | 34 | 56 | 1.5 |

Based on an understanding of the term ‘renewable’, better responses explained that because the Sun is the source of solar energy it cannot be depleted and will not run out. The idea that a renewable resource is derived from sources that are replenished at a higher rate than they are consumed was correctly used by many students. Incorrect responses discussed points about how solar panels operate or described how solar energy comes from a natural source (which is a true statement but does not make it renewable).

Question 6b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 12 | 23 | 65 | 1.5 |

Most students were able to identify a relevant stakeholder and describe the knowledge they bring to the issue of electrical energy supply and use. For example:

Energy companies have technical knowledge of how the electricity grid operates and its current limitations.

Home owners have knowledge of their own energy consumption requirements and patterns of usage, and can make adjustments to when appliances are used and what appliances they have.

Question 6c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 39 | 40 | 21 | 0.8 |

Many students did not focus on the last part of the question ‘could improve the reliability of the electricity grid’. Rather than focus on grid reliability, they discussed general points related to energy efficiency, including the energy lost through transmission lines (which relates to previous exam questions and not this specific question). An understanding of the extent to which different energy sources can supply current and projected base and peak load energy needs, what the difference between base and peak load is, and how the electricity grid supplies energy to consumers were not well demonstrated in general.

Higher-scoring responses responses discussed how remotely managing electricity resources and appliances through a virtual power plant (VPP) would reduce demand by remotely turning off appliances when they were not needed, which would reduce the peak load on the grid and mean less energy was wasted. Correct responses also discussed how controlling supply by remotely turning on power-generating resources would mean more electricity could enter into the grid (especially during peak times). By controlling ‘supply and/or demand’ the grid would experience a reduced risk of blackouts or power outages, leading to better control over the availability of energy and fewer malfunctions due to insufficient power.

Question 6d.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 24 | 35 | 41 | 1.2 |

Many students were able to explain that ‘intragenerational equity’ is the sharing and protection of environmental resources with equal access for the current generation. Improving the efficiency of the electricity grid would allow all members of the population to have access to reliable electricity supplies and mean that energy resources are shared equally throughout the current generation. Incorrect responses confused ‘intragenerational equity’ with ‘intergenerational equity’.

Question 7a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 36 | 4 | 60 | 1.3 |

Students were usually able to calculate the energy efficiency of the coal-fired power station using the figures provided and showed their working as follows.

19 000 / 52 500 = 0.3619

0.3619 × 100 = 36.19% (or 36.2%)

Question 7b.

|  |  |  |  |
| --- | --- | --- | --- |
| Mark | 0 | 1 | Average |
| % | 36 | 64 | 0.7 |

Most students correctly identified the form of energy found in coal as either potential or chemical. Some correctly gave both. Incorrect responses given included kinetic energy and heat energy.

Question 7c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 23 | 62 | 15 | 0.9 |

The range of responses given to this question indicated a wide variation in the depth of understanding of the carbon cycle and how the combustion of fossil fuels impacts on key processes in the cycle. The question asked about the impact of the combustion of coal on the carbon cycle; many students incorrectly focused on the impact on global warming. In better responses, students clearly understood that the combustion of coal releases carbon dioxide into the atmosphere. This then impacts on the carbon cycle by creating a greater level of carbon dioxide in the atmosphere, which cannot be returned to long-term sinks at the same rate. Coal takes millions of years to form and results in the long-term storage of carbon, but by mining and burning coal we are changing this equilibrium. Many lower-scoring responses simply stated that the cycle would be unbalanced or discussed how it would allow plants to photosynthesise more (without understanding the role that limiting factors play in photosynthesis).

Question 7d.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 15 | 20 | 65 | 1.5 |

Based on the information given, students were generally able to state one rehabilitation strategy that was mechanical and one that was biological (although lower-scoring responses confused the two).

Mechanical strategies included:

the movement of topsoil by machinery

the construction of physical erosion-control measures such as placing logs or rocks to limit run-off

the removal of old mining infrastructure such as mining equipment, roads and powerlines

building and placing nesting boxes in the area.

Biological strategies included:

the collection and spreading of native seeds

the direct planting of tube-stock to revegetate the site

the removal of weed species.

Question 7e.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 25 | 30 | 37 | 8 | 1.3 |

Most students were able to understand that the rehabilitation of the coal mine displayed ecocentrism, but often failed to make the meaning of this term clear in their responses. Ecocentrism recognises the health of the ecosphere as being of central importance. Better responses focused on valuing all living and non-living things, including Earth’s ecosystems, natural processes and organisms, while de-emphasising the importance of humans. Common errors were made by simply stating that ecocentrism focuses on ‘protecting ecosystems’ or incorrectly discussing the importance of protecting living things (flora and fauna), which is a biocentric approach.

The other part of the question required students to explain how the rehabilitation of the mine site would display ecocentrism. This is achieved by addressing the damage to the area caused by humans, with the aim of restoring all environmental aspects and the integrity of the ecosystem as a whole. This included how the rehabilitation considered factors that affect the whole ecosystem by addressing multiple issues, such as soil quality, and provision of water and habitats for wildlife and native flora.

Question 8a

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 11 | 39 | 50 | 1.4 |

Most students were able to correctly list two aims of the students’ investigation. Suitable responses included:

recording wind speed measurements at the site

recording wind speed directions at the site

identifying if the winds are strong enough to generate electricity

comparing wind speeds at different heights (i.e. 10 and 20 metres)

identifying if there is enough wind for the farmer to rely on wind power

measuring wind speed variations over a 10-month period.

The most common errors were to state that the students were aiming to test the different-sized wind turbines or which turbine produces the most electrical energy. The students did not collect this wind turbine and energy output data.

Question 8b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 15 | 35 | 50 | 1.4 |

Students were required to use the wind speed data provided in the table to identify patterns in monthly average wind speeds. Suitable responses included:

Wind speeds were consistently higher at 20 metres (average of 5.5 metres per second) compared to 10 metres (average of 4.6 metres per second).

Wind speeds are slightly greater at both heights between August and November.

Wind speeds are slightly lower in the April–June period; for example, between 4.2 and 4.3 metres per second at 10 metres.

Winds are reasonably consistent across the 10-month period, with a range of only 0.8 metres per second at both heights.

Question 8c.

|  |  |  |  |
| --- | --- | --- | --- |
| Mark | 0 | 1 | Average |
| % | 52 | 48 | 0.5 |

To calculate how much energy the farm would require in a year, most students correctly multiplied the average number of kilowatt hours required per day (86 kW h) by 365 (days in a year). The correct answer is 31 390 kW h. Working out was not required. The most common error made was multiplying this answer, 31 390, by 24 (the number of hours in the day) to get 753 360 kilowatts.

Question 8d.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | 3 | Average |
| % | 50 | 24 | 24 | 2 | 0.8 |

Given the figure calculated in the previous question (31 390 kW h) and an accurate reading of the ‘Variation in wind turbine energy output with annual average wind speed’ graph, students should have noted that a single 20 kW turbine could create enough total energy (around 32 000–33 000 kW h) because the average wind speed was 5.5 metres per second at a height of 20 metres. The 5 kW and 10 kW turbines would not generate the total amount of energy required, and it would be unlikely that the farm owners would put multiple turbines across the site (due to cost and other factors).

Based on this data, wind could provide a suitable energy source but in justifying this many students did not acknowledge the limitation of wind turbines – they are an intermittent source of energy. Therefore, the farm would need some sort of storage system (i.e. batteries) or other energy option / backup system for when there was no wind or to supplement the total energy output.

Incorrect answers often used the highest figures from the graph that the wind turbines would produce, for example, a 20 kW turbine with an average annual wind speed of 8.5 metres per second would produce 80 000 kW h per year.

Question 8e.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 67 | 7 | 26 | 0.6 |

Many of the responses to this question demonstrated a lack of understanding of the scientific term ‘repeatability’ and how to apply it to this particular example. Higher-scoring responses noted that although there is a closeness of agreement between both the students’ and the bureau’s wind speed readings, it does not show repeatability because they have not been recorded under the same conditions of measurement. For example, they have different locations, different observers, different procedures and different anemometers.

Question 8f.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mark | 0 | 1 | 2 | Average |
| % | 16 | 19 | 65 | 1.5 |

Most students were able to state one environmentally based argument for and one against the use of wind turbines on the farm.

Arguments presented in favour of using wind turbines included:

Wind is a renewable and sustainable resource.

Using wind turbines reduces the use of fossil fuels and therefore environmental impacts related to mining them.

Using wind turbines reduces the use of fossil fuels and therefore greenhouse gas emissions / the rate of global warming.

Arguments given against using wind turbines included:

the potential injury or harm to birds and bats from flying into turbine blades

the noise and visual disturbance to locals from turbines

the wind is not constant or reliable so some form of backup energy will be required, which may involve burning a fossil fuel such as diesel

the impact of the construction of turbines on the local habitat, such as clearing vegetation

the extraction/processing of materials to create turbines involves mining, which leads to environmental disturbance and the production of greenhouse gases.