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Write your **student number** in the boxes above.

Letter

Environmental Science

Question and Answer Book

VCE Examination – Friday 15 November 2024

- Reading time is **15 minutes**: 3.00 pm to 3.15 pm
- Writing time is **2 hours**: 3.15 pm to 5.15 pm

Approved materials

- One scientific calculator

Materials supplied

- Question and Answer Book of 40 pages
- Multiple-Choice Answer Sheet

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents	pages
Section A (30 questions, 30 marks) _____	2–13
Section B (8 questions, 90 marks) _____	14–37

Section A – Multiple-choice questions

Instructions

- Answer **all** questions in pencil on your Multiple-Choice Answer Sheet.
 - Choose the response that is **correct** or that **best answers** the question.
 - A correct answer scores 1; an incorrect answer scores 0.
 - Marks will **not** be deducted for incorrect answers.
 - No marks will be given if more than one answer is completed for any question.
 - Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
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Question 1

What can be inferred from the discovery of similar fossil species across different geographic regions?

- A. Identical ecosystems exist worldwide.
- B. There is a lack of variation in species.
- C. Simultaneous extinction events have occurred worldwide.
- D. Rapid diversification has occurred, with subsequent migration of species.

Question 2

Carbon sequestration is an example of a

- A. cultural service.
- B. provisioning service.
- C. regulating service.
- D. supporting service.

Question 3

Why is genetic diversity important for species survival?

- A. High genetic diversity always results in larger population sizes and more individuals.
- B. A diverse gene pool supports species survival in fragmented or changed habitats.
- C. Genetic diversity eliminates the chance of mutations occurring in the population.
- D. High genetic diversity decreases the chances of interbreeding within a population.

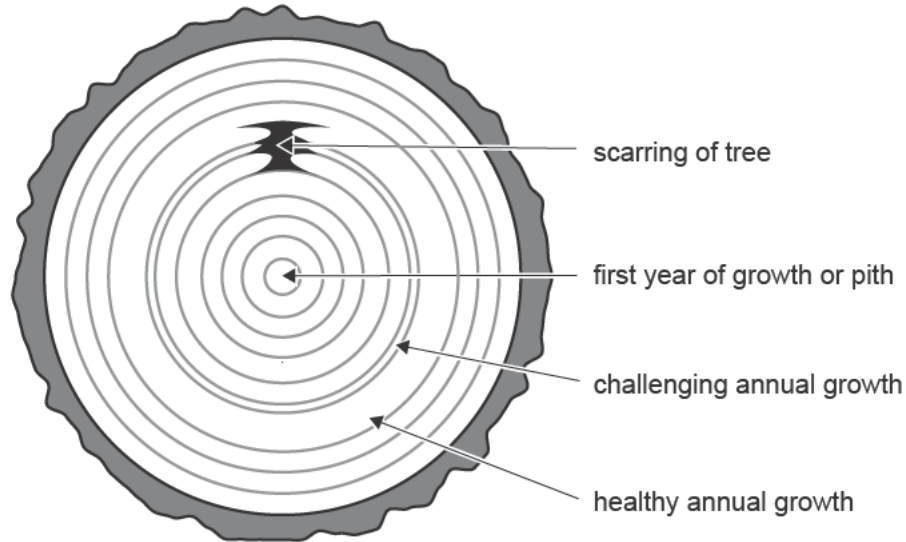
Question 4

Which of the following is a likely long-term effect due to repeated El Niño events?

- A. increased genetic diversity of all species
- B. unchanged ecosystem diversity since species are prevented from moving
- C. some species become more vulnerable to extinction while others adapt or migrate
- D. invasive species are completely eradicated, allowing endemic species to thrive

Use the following information to answer Questions 5 and 6.

Scientists can utilise annual tree ring growth for measuring past and present changes in the atmosphere. Annual growth rings are the circular rings found in the trunk of a tree. Each ring signifies one year of growth with two distinct growing seasons.



Question 5

What do the tree rings show in terms of climate variability in a regional area?

- A. tree scarring due to fire
- B. the age of a mature or ancient tree
- C. atmospheric concentrations of carbon dioxide and methane
- D. if a tree has experienced warm and wet years, or cold and dry conditions

Question 6

The method described above can be applied to investigate local climate change many thousands of years ago.

This would be an example of

- A. analysis of long-term atmospheric and ocean temperatures.
- B. data gathering from ice-core sampling.
- C. estimating atmospheric gas levels.
- D. utilising palaeoclimate records.

Question 7

Not all gases in the atmosphere act as greenhouse gases, and some greenhouse gases have a greater warming potential than others.

The contribution a gas makes to the greenhouse effect depends on the capacity of the gas to

- A. absorb heat energy, the length of time it persists in the lithosphere, and its concentration in the atmosphere.
- B. absorb kinetic energy, the length of time it persists in the atmosphere, and its concentration in the atmosphere.
- C. absorb heat energy, the length of time it persists in the atmosphere, and its concentration in the atmosphere.
- D. absorb heat energy, the length of time it persists in the atmosphere, and its pre-industrial concentration.

Question 8

Many regular events in plant and animal life cycles, such as migration and breeding, are influenced by climate. An example of this type of relationship can be seen between bees and flowering plants. Changes in climate can disrupt this relationship, limiting the ability of bees to obtain food and decreasing fertilisation of plants.

This relationship is an example of

- A. an increase in range of exotic species.
- B. phenological changes for plant–pollinator interactions.
- C. changes in length of plant-growing seasons and animal-breeding cycles.
- D. reduction in agricultural production due to warmer and drier conditions.

Use the following information to answer Questions 9–11.

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that are found in coal, crude oil and petrol. They are released during combustion, after which they can be absorbed by sea water in the ocean. Animal studies indicate that high concentrations of PAHs can be carcinogenic and can prevent reproduction. PAHs have been found to concentrate in coral tissue.

Most reef-building corals contain photosynthetic algae cells, called zooxanthellae, that live in their tissues. The coral provides the zooxanthellae with a protected environment and the compounds they need for photosynthesis. In return, the zooxanthellae produce oxygen and help the coral to remove wastes. It is thought that PAHs can be transferred through a food chain to zooxanthellae and eventually deposited in the coral bodies.

Question 9

The type of relationship between the coral and the zooxanthellae is

- A. symbiotic.
- B. host–parasite.
- C. predator–prey.
- D. biocentric.

Question 10

What term describes the transfer of PAHs through the food chain from the zooxanthellae to the coral?

- A. trophic levels
- B. bioaccumulation
- C. biomagnification
- D. pesticide targeting

Question 11

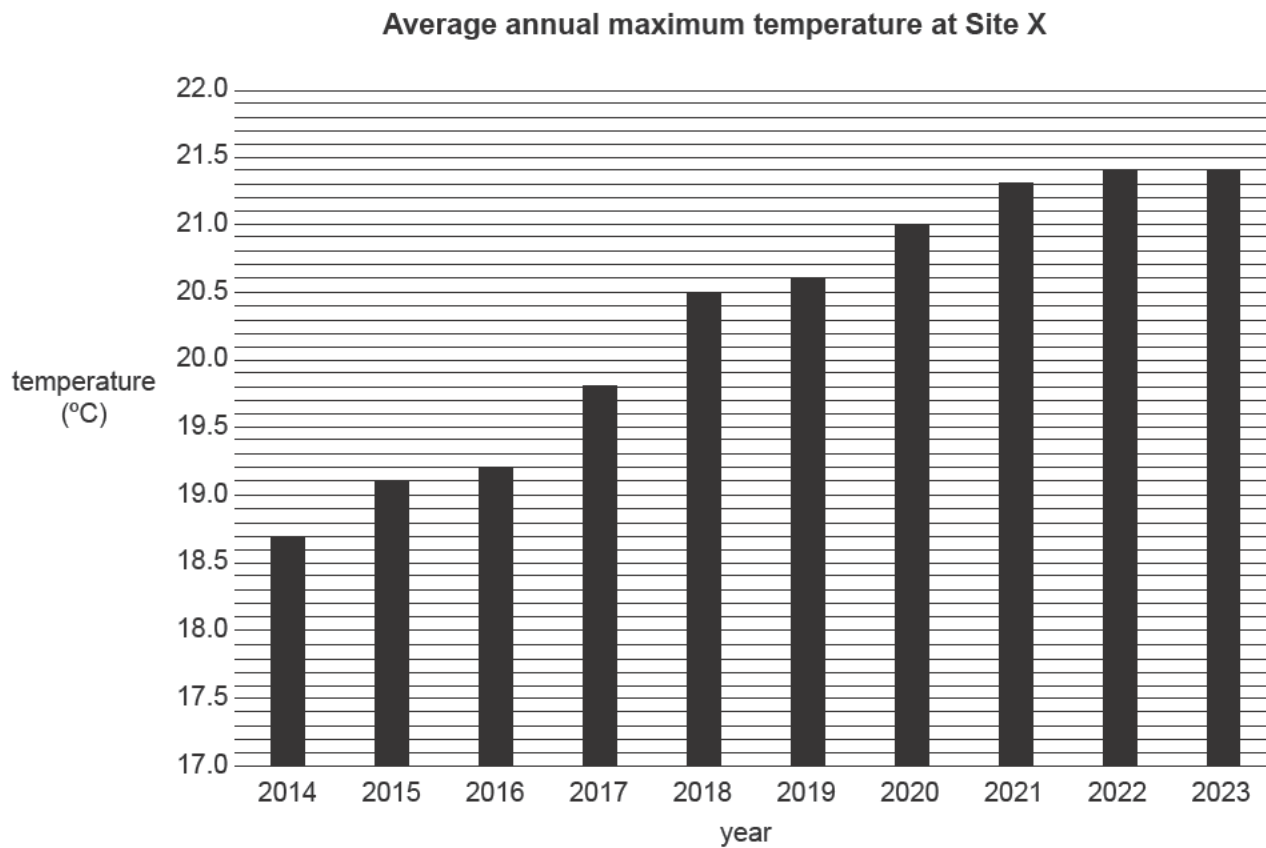
Some PAHs can impact negatively on human health. Australia has workplace exposure standards based on *Workplace exposure standards for airborne contaminants* (2024). Medical testing may be necessary if the results of air monitoring indicate frequent or potentially high exposure to a PAH.

The ongoing airborne monitoring for PAH levels is an example of

- A. a regulatory framework that informs environmental management strategies.
- B. use and interpretation of historical and current scientific data.
- C. understanding diverse stakeholder values.
- D. the application of new technologies.

Use the following information to answer Questions 12 and 13.

The graph below shows annual average maximum temperature measurements taken at Site X in the Southern Hemisphere between 2014 and 2023.



Question 12

What is the average annual maximum temperature at Site X between 2014 and 2023?

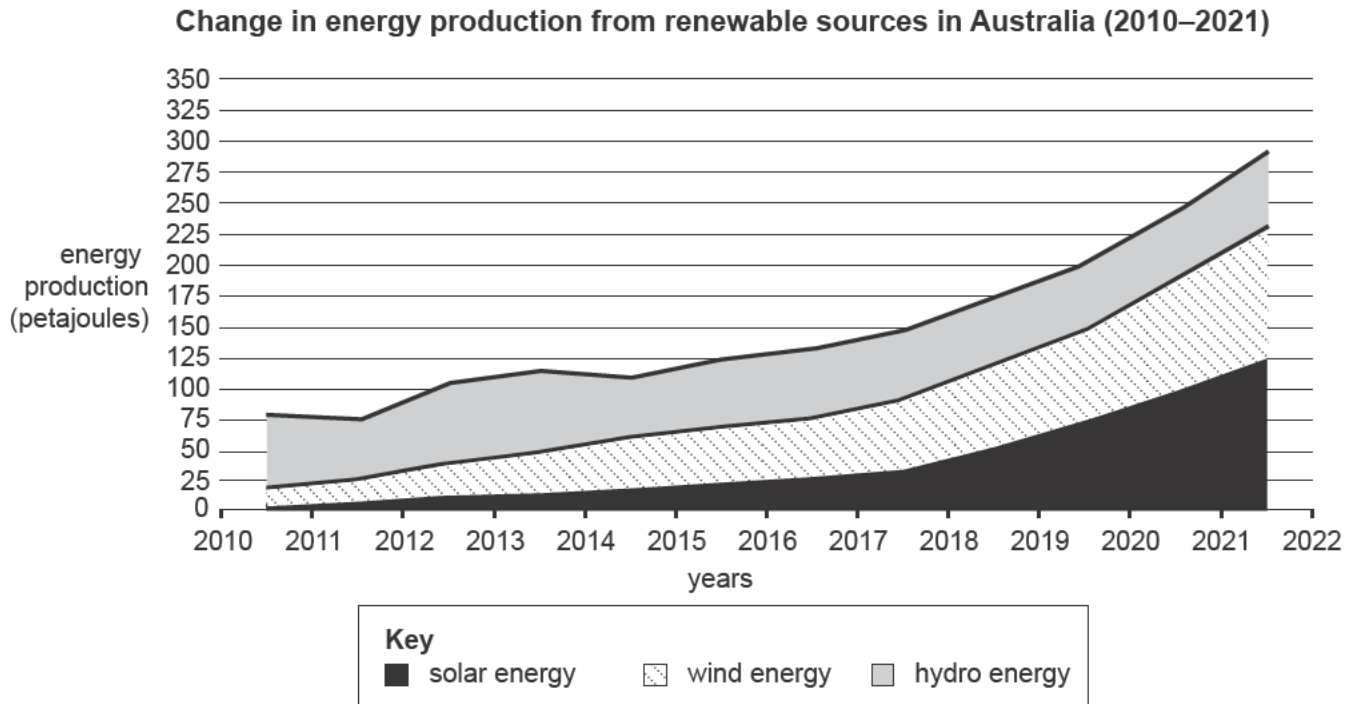
- A. 20.3
- B. 20.8
- C. 21.0
- D. 21.4

Question 13

What conclusion about global warming can be drawn from data shown in the graph?

- A. Data obtained solely from Site X does not provide evidence of global warming.
- B. Global warming is occurring at Site X.
- C. Global warming is not occurring at Site X.
- D. Shorter-term data from Site X is needed to provide evidence that global warming is occurring.

Use the following information to answer Questions 14 and 15.



Source: Adapted from Australian Bureau of Statistics, Energy Account, Australia 2021–22 financial year <www.abs.gov.au>

Question 14

Which of the following statements regarding Australia's renewable energy sources is correct?

- A. Solar energy has increased at a slower rate than hydro energy since 2020.
- B. Solar energy has contributed to more than half of Australia's renewable energy sources over the time period represented in the graph.
- C. Hydroelectricity provides a relatively constant contribution over the time period represented in the graph.
- D. Wind energy's contribution increased because of higher wind speeds in coastal locations over the time period represented in the graph.

Question 15

The contribution of wind to Australia's renewable energy in 2021 is closest to

- A. 29%
- B. 34%
- C. 43%
- D. 79%

Question 16

Energy requirements from the electricity grid fluctuate depending on the demand for power.

Which of the following best describes base load energy?

- A. the point in time where energy demand is the lowest
- B. the constant amount of electricity that can be generated
- C. the minimum amount of electricity required in a 24-hour period
- D. the source of electricity that provides the greatest supply to the grid

Question 17

The first law of thermodynamics states that

- A. in a closed system, total energy will always increase.
- B. matter is neither created nor destroyed, only changed into another form.
- C. energy cannot be created or destroyed, rather it is converted into another form.
- D. the more energy conversions a process involves, the more energy is lost from the system.

Question 18

Which of the following options demonstrates increasing the energy efficiency of heating devices in the home?

- A. Reducing the thermostat temperature of all heaters in the home.
- B. Turning off all heaters at night and during the day when residents are at work.
- C. Switching from a smaller heater that has lower capacity to a larger heater that can heat more space.
- D. Switching from an electronic fan heater that uses four energy conversions to an oil heater that uses two energy conversions.

Use the following information to answer Questions 19 and 20.

A meatworks factory has recently modified its heating and cooling system to be more energy efficient and reduce its environmental impacts. Solar panels are used to power heat pumps, and excess heat from refrigeration units is used to heat water for cleaning and packaging. If applied across the manufacturing industry, this technology would cost \$50 million, increase local jobs and could save 255 000 tonnes of CO₂ from being produced annually.

Question 19

This is an example of which sustainability principle in action?

- A. user-pays principle
- B. precautionary principle
- C. intragenerational equity
- D. efficiency of resource use

Question 20

Which of the following best explains how the factory is using circular economy thinking?

- A. The waste heat from the refrigeration units is being repurposed as an input.
- B. Using renewable energy decreases the cost of energy inputs for the factory.
- C. The use of waste heat makes the production of packaging more sustainable.
- D. An increase in local jobs leads to more money being spent in the local economy.

Question 21

Biomass, such as wood, can be used to provide energy for heating and cooking.

Which of the following explains how biomass would be categorised as an energy source?

	Renewability	Fuel source
A.	renewable	fossil
B.	renewable	non-fossil
C.	non-renewable	fossil
D.	non-renewable	non-fossil

Question 22

Electric vehicle (EV) fast-charging stations have been installed by a local council in the car parks at two railway stations. These EV chargers are supplied by 100% renewable power and will help the community to achieve net zero emissions by 2040, the target of the council's climate change response plan. The EV chargers provide between 15 and 20 minutes of free charging (around 40–50 km of driving range).

What is the council's aim in installing these charging stations?

- A. to increase the energy efficiency of electric vehicles
- B. to reduce the personal energy consumption of local residents
- C. to increase the council's income by charging for this renewable energy
- D. to contribute to a sustainable energy future that lowers greenhouse gas emissions

Use the following information to answer Questions 23–26.

A class of students worked with a WaterWatch group to record data related to their local stream. They usually measured the concentration of two nutrients, phosphorus and nitrogen, four times each month at the stream site and recorded the average in the table below.

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Total phosphorus (mg/L)	0.015	1.29	0.06	0.035	0.046	73.04	0.049	0.53
Total nitrogen (mg/L)	0.55	3.78	1.35	1.22	1.22	1.44	1.56	1.66

Nitrogen and phosphorus levels can vary naturally. However, a major human-induced source is run-off from agricultural land areas (due to fertilisers, organic wastes and animal feed being washed into water bodies). Levels of both nutrients increase when streamflow is higher.

Question 23

The students only measured the nutrient concentrations once in August.

The August results indicate that within the data set there was

- A. a true value.
- B. a personal error.
- C. a systematic error.
- D. an inconsistent level of nutrients.

Question 24

Based on the data, which month had a high rainfall event?

- A. April
- B. June
- C. July
- D. October

Question 25

The class of students and the WaterWatch group both used the same measuring equipment and followed the same standard techniques.

Why was this done?

- A. to reduce the accuracy of the data
- B. to monitor the validity of the experiment
- C. to increase the precision of the measurements
- D. to improve the reproducibility of the experiment

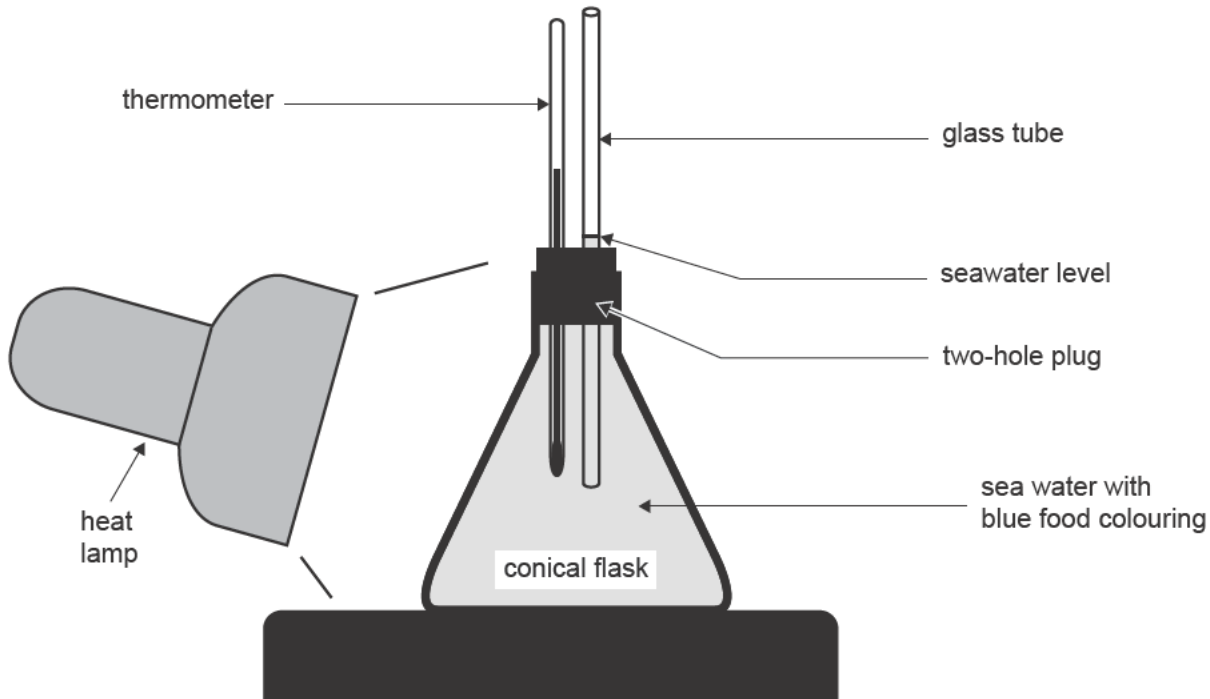
Question 26

The nutrient data was generated using

- A. fieldwork.
- B. modelling.
- C. qualitative sampling.
- D. a controlled experiment.

Use the following information to answer Questions 27 and 28.

To investigate the impact of warming temperatures on seawater levels, a class of students conduct an experiment. They fill a conical flask with cold sea water, add blue food colouring and put a two-hole plug into the neck. In one of these plug holes they place a thermometer down into the water, and in the other a hollow glass tube. They mark the starting level of the sea water on the glass tube and then shine a heat lamp onto the flask. They measure the water level in the glass tube and the temperature change of the water every two minutes.



Question 27

The students predicted that, as the temperature increased, the sea water in the flask would expand, causing the level to rise up the tube.

What term would be given to this prediction?

- A. the aim
- B. the hypothesis
- C. the methodology
- D. the scientific theory

Question 28

The change in seawater level is a/an

- A. controlled variable.
- B. dependent variable.
- C. independent variable.
- D. uncontrolled variable.

Question 29

Before a swimming centre can open, it needs to evaluate the environmental health and water quality of its pool facilities and review the likelihood of problems with its filtration and treatment systems.

The centre must identify any potential issues and develop plans that could deal with any problems.

How would this evaluation be described?

- A. circular economy thinking
- B. stakeholder communication
- C. a cost-benefit analysis
- D. a qualitative risk analysis

Question 30

A small vegetable and flower garden has been established on council land with the aim of promoting sustainable development within the local community. It is free to join for any residents of the area, and benefits to residents include meeting a variety of new people, getting exercise, relaxing in the outdoor environment and enjoying the beauty of the plants they have helped to grow.

These benefits would be described as

- A. economic.
- B. sociocultural.
- C. environmental.
- D. responsible decision-making.

Do not write in this area.

Section B

Instructions

- Answer **all** questions in the spaces provided.
 - Write your responses in English.
 - Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
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Question 1 (15 marks)

A team of biodiversity researchers tested the hypothesis that urban golf courses encourage more native insect diversity than urban parks. They used grid sampling, setting up 25 insect CO₂ traps within each site. CO₂ traps anaesthetise the insects so they can be counted, after which the insects recover and are released.

Simpson's Index of Diversity (SID) was calculated by the researchers, to compare the native insect diversity of the two sites.

- a. The researchers used grid sampling in their study.

Explain why grid sampling was used, rather than transect sampling. Give one example of when transect sampling could be used in preference to grid sampling.

3 marks

Explanation _____

Example _____

- b. Use the figures in the table below and the space provided to calculate SID for the golf course.

2 marks

Native insect species observed at golf course	n_i	$n_i - 1$	$n_i (n_i - 1)$
Hymenoptera (bees)	25	$25 - 1 = 24$	$25(24) = 600$
Lepidoptera (butterflies)	11	$11 - 1 = 10$	$11(10) = 110$
Blattodea (cockroaches)	12	$12 - 1 = 11$	$12(11) = 132$
Diptera (flies)	11	$11 - 1 = 10$	$11(10) = 110$
Mantodea (mantids)	5	$5 - 1 = 4$	$5(4) = 20$
Hymenoptera (ants)	12	$12 - 1 = 11$	$12(11) = 132$
Hemiptera (bugs)	13	$13 - 1 = 12$	$13(12) = 156$

$N =$
$N(N - 1) =$

$\sum [n_i (n_i - 1)] =$

Therefore:

$$\text{Simpson's Index of Diversity: } D = 1 - \frac{\sum [n_i (n_i - 1)]}{N(N - 1)}$$

SID for the golf course is

--

- c. SID for insects within the urban park was calculated as 0.56.

Using these figures, compare the insect diversity of the urban park and the golf course, as indicated by the SID.

2 marks

- d. The researchers found that ground-nesting native bees are not found in much of the urban landscape because it is dominated by exotic flowering plants and is highly managed by humans. Golf courses, on the other hand, contain 'rough' areas that are dominated by native vegetation with minimal human intervention.

Using this information, suggest **two** reasons why ground-nesting native bees might survive on golf courses but not in urban parks.

2 marks

- e. Give **two** reasons why it is important to maintain insect populations in ecosystems.

2 marks

- f. One criticism of insect CO₂ traps as a method is that they are less effective at capturing smaller insects.

Explain how this limitation would have reduced the validity of this study.

2 marks

- g.** Evaluate whether the study adheres to ethical guidelines for undertaking scientific research.

2 marks

Do not write in this area.

Question 2 (13 marks)

Australian sea lions (*Neophoca cinerea*) are sea- and land-dwelling mammals and are only found around the western and southern coasts of Australia. They are carnivorous, consuming ocean fish and shellfish. They hunt in the ocean and breed on land. Sixty-six breeding colonies have been identified, with 28 in Western Australia and 38 in South Australia.



Source: Australian Fisheries Management Authority <www.afma.gov.au>

Sea lions were heavily hunted following European settlement, as part of commercial operations, especially in the 18th century. Large-scale hunting ceased in the 1920s.

Distribution of extant (surviving) Australian sea lion breeding colonies and extinct regional populations



Figure 1

Source: RA Campbell et al., 'Islands in the sea: extreme female natal site fidelity in the Australian sea lion, *Neophoca cinerea*', 2007 <www.researchgate.com>

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- a. The International Union for Conservation of Nature (IUCN) classifies the Australian sea lion as endangered.

Explain how the range of the sea lion (refer to Figure 1) would have contributed to this classification.

2 marks

- b. Would the management teams focused on the sea lion species be aiming to have the classification changed to 'vulnerable' or 'critically endangered'?

Explain your choice of classification.

2 marks

- c. Outline why the sea lions are at particular risk from a new infectious disease.

2 marks

Do not write in this area.

- d. In addition to hunting, the sea lions are under threat from over-exploitation of their prey, and from a reduction in their land-based habitat due to erosion.

Choose one of these threats and suggest a management strategy that will help to restore the range and/or population of the sea lions. Explain how this strategy will counter the specific threat you have chosen.

2 marks

Circle one of the threats below:

over-exploitation of prey

reduction in land-based habitat due to erosion

Explanation of management strategy related to this threat:

- e. Another possible threat to the sea lions is polyfluoroalkyl substances (PFAS), persistent organic pollutants in the environment. PFAS have been reported to cause cancer and reproductive and developmental defects.

Between 2017 and 2020, scientists measured the concentrations of PFAS in liver samples from 28 young sea lion pups from colonies in South Australia. Scientists wished to investigate causes of the decline in sea lion numbers. Samples were taken from fresh carcasses at various sites and the scientists found high PFAS levels in all samples.

Identify the limitations of this investigation and explain how these limitations impacted on the scientists' ability to draw conclusions about what may be causing a decline in sea lion numbers.

3 marks

Do not write in this area.

- f. The Wirangu People, who are the traditional custodians of the Chain of Bays area in South Australia, hold the Australian sea lion in significant esteem as their spiritual totem.

Explain why it is important to protect the sea lion in terms of cultural services.

2 marks

- b. Does the extraction of gold in this region prior to the 1920s demonstrate the sustainability principle of 'intergenerational equity'? Explain.

2 marks

- c. How does the environmental effects statement (EES) help to support responsible decision-making?

2 marks

- d. Given that a detailed environmental assessment of the site has not been completed, explain how the 'precautionary principle' should be applied to any proposal to mine the tailings.

3 marks

- e. If the proposal were to go ahead, identify one beneficial impact on the lithosphere and one harmful impact on the hydrosphere that may occur.

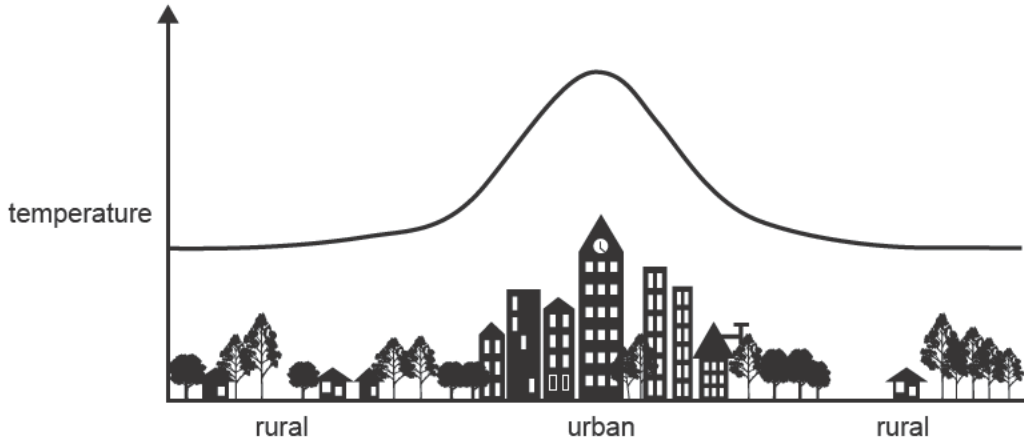
2 marks

Beneficial impact on lithosphere _____

Harmful impact on hydrosphere _____

Question 4 (11 marks)

The impact of rising temperatures and the increasing frequency of heatwaves is a growing challenge for urban areas. Rising temperatures particularly affect cities because of the 'urban heat island effect', in which urban areas are warmer than the surrounding rural land. This is a result of the presence of roads, pathways, buildings and dark roofs that absorb heat more than green (e.g. gardens and parks) and blue (e.g. rivers and lakes) surfaces. With the urban heat island effect, temperatures in our urban areas can be 1–7 °C higher than in surrounding areas.



Source: J Rocklov, 'Short-term Effects of Ambient Temperature on Daily Deaths and Hospital Admissions' <www.researchgate.com>

- a. Explain what is meant by the term 'albedo effect' and describe how it relates to the urban heat island effect.

3 marks

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- b. The Intergovernmental Panel on Climate Change (IPCC) estimates that, 'in urban areas, observed climate change has caused adverse impacts on human health, livelihoods and key infrastructure. Hot extremes have intensified in cities (high confidence)'.

The IPCC provided a rating of confidence as 'high confidence' for the above statement in 2023.

Explain what is meant by 'confidence rating' and what the rating is based on.

2 marks

- c. Increasingly, architects will include green roofs and green walls, also known as vertical gardens, in their designs. Green roofs and vertical gardens are buildings covered in plants.

Explain why this would be classified as an application of new technology to impact greenhouse gas levels.

3 marks

Do not write in this area.

- d. In 2018, the City of Melbourne adopted strategies for vertical and rooftop greening as part of its Green Our City Strategic Action Plan. The aim is to increase the number of high-quality green roofs and walls in the City of Melbourne as part of the city's future planning. These green roofs and walls can reduce the impact of the urban heat island effect by helping to cool the surrounding area.

Explain how the above strategy is an example of an adaptation option and not a mitigation option to manage climate change at a local level.

3 marks

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Examination continues on the next page.

Question 5 (8 marks)

According to the 2022 *Global Status Report for Buildings and Construction*, the building and construction sector contributes to approximately 34% of the global energy demand and 37% of global greenhouse gas emissions. Currently, the most common building material is concrete. Hempcrete is a plant-based material. While it cannot replace concrete for all building purposes, it does provide an option for some non-structural uses.

Hempcrete is made from hemp shiv (the woody inner portion of the plant stalk), lime and water, while concrete is made from cement, sand, gravel or stone, and water.

Source: 'Opportunities & challenges of hempcrete as a building material for construction: An overview', *Materials Today: Proceedings* <sciencedirect.com>

- a. Describe the role of carbon dioxide in the enhanced greenhouse effect. 3 marks

- b. Apart from water vapour and carbon dioxide, state **two** other major greenhouse gases in Earth's atmosphere. 1 mark

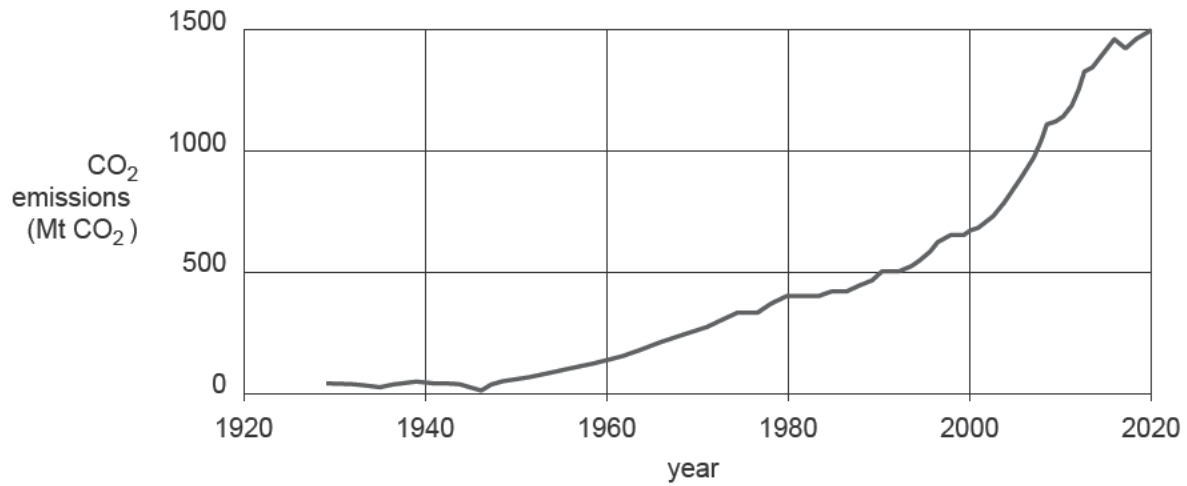
- c. Using the spaces in the table below, identify one environmental advantage and one environmental disadvantage of using hempcrete in housing construction compared to concrete. 2 marks

Environmental advantage	
Environmental disadvantage	

Do not write in this area.

- d. Cement production accounts for more than 7% of global carbon dioxide emissions. For every year, world production is around 1 m^3 of concrete per head of population, and each tonne of cement emits about 900 kg of CO_2 .

Global process emissions from cement production



Source: Adapted from RM Andrew, 'Global CO₂ Emissions from Cement Production, 1928–2018', Earth System Science Data, 2019 <essd.copernicus.org>

Explain **one** reason why carbon dioxide emissions from cement production have increased over the period shown in the graph above.

2 marks

Question 6 (8 marks)

As more homes install solar panels on their roofs, managing the distribution of electricity becomes a challenge. Currently, a project is investigating if using a virtual power plant (VPP) can help to regulate the energy produced and used by households.

The VPP does not generate its own electricity. However, it will remotely turn off household appliances, such as hot water heaters and pool pumps, when they are not required. It will also turn on electricity-generating resources, such as home solar panels, when more electricity is required. The aim is to reduce demand in peak periods and better manage overall supply and demand for electricity.

- a. Explain why solar power is categorised as a renewable energy source. 2 marks

- b. Identify **one** stakeholder relevant to the virtual power plant project and describe the knowledge they bring to the energy supply issue. 2 marks

- c. Suggest how remotely managing resources and appliances could improve the reliability of the electricity grid. 2 marks

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- d. Explain how improved efficiency of the electricity grid could contribute to intragenerational equity. Make the meaning of 'intragenerational equity' clear in your response.

2 marks

Question 7 (10 marks)

Coal accounts for approximately 53% of Australia's electricity generation.

- a. A coal-fired power station generated 19 000 megajoules of electrical energy from burning 52 500 megajoules of coal in one day.

Calculate the energy efficiency of this conversion. Show your working.

2 marks

- b. Identify the form of energy found in coal.

1 mark

- c. Describe the impact of the combustion of coal on the carbon cycle.

2 marks

Use the following information to answer parts d and e.

An open-cut coal mine was closed in 2012 and has since undergone rehabilitation.

The following measures were taken:

- Topsoil was spread across the area; physical erosion-control measures were implemented; tree hollows, woody debris and logs were incorporated into the landscape; and nesting boxes were installed.
- Native seeds were sown and more sensitive plants were transplanted as tube-stock trees.
- Revegetation with native flora was monitored and invasive weeds were removed to ensure the success of the rehabilitation process.

The main hole created by the mine was allowed to fill with rainwater and run-off. It will eventually flow into the nearby creek.

Recent monitoring of the site has found seven threatened species living in the area, including the powerful owl and squirrel glider.

- d. Using the information above, state one mechanical and one biological rehabilitation strategy used by the coal mine.

2 marks

	Rehabilitation strategy
Mechanical	
Biological	

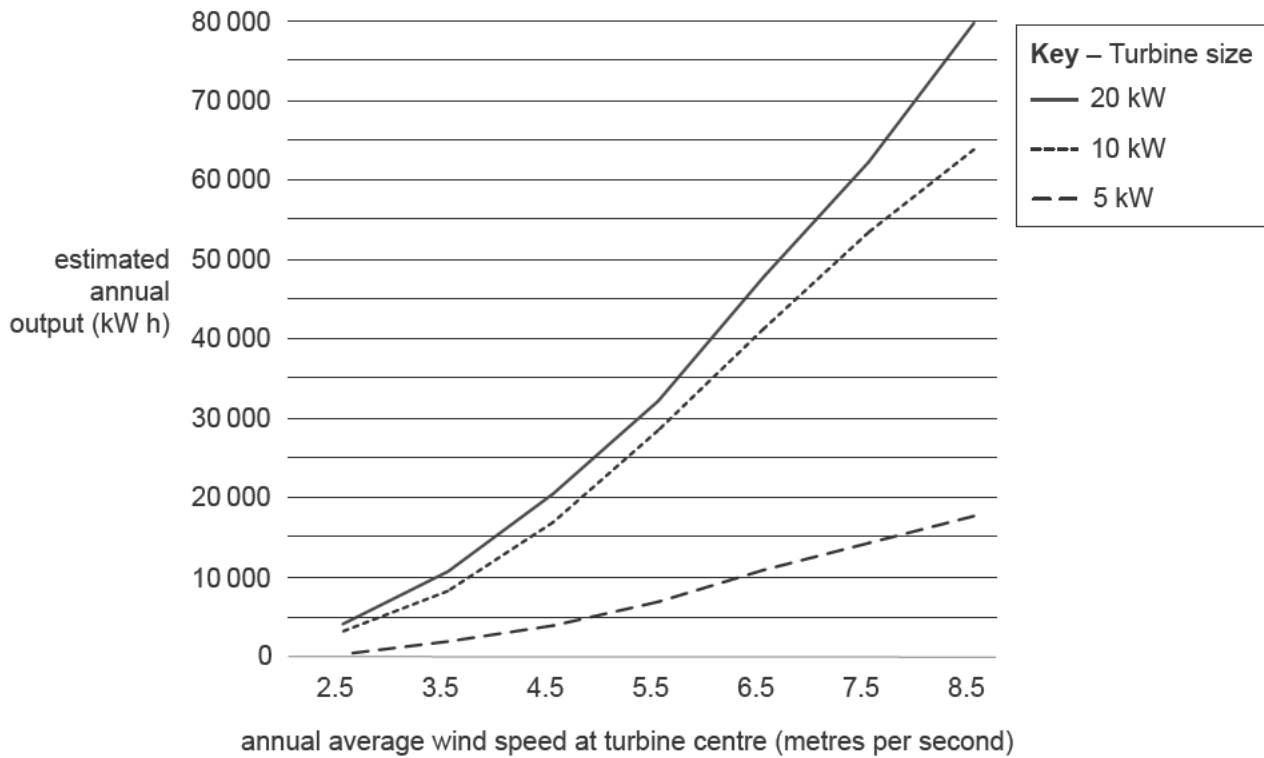
- e. Explain how the rehabilitation of the coal mine displays ecocentrism. Ensure that the meaning of the term 'ecocentrism' is clear in your response.

3 marks

Question 8 (12 marks)

An isolated farm near the coast needs an average of 86 kilowatt hours per day of electrical energy. It currently uses an old diesel generator. One option being considered to replace the generator is a wind turbine with blades like an aircraft propeller and a tail or vane to direct it into the wind. Small-scale wind turbines of 5, 10 and 20 kilowatts are options for use by the farm. The graph below shows the annual energy output of each turbine in relation to average wind speed.

Variation in wind turbine energy output with annual average wind speed



Source: Adapted from Ryse Energy, 2024, <www.ryse.energy>

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A group of students has been asked to collect wind speed data on the farm. The students oversee the installation of two anemometers on an existing tower (one at 10 metres above the ground and the other at 20 metres). An anemometer is an instrument that measures wind speed reading (metres per second) and direction. These anemometers are connected to a battery-powered data logger that records wind speed and direction every hour.

The students collected data for 10 months and calculated the average monthly wind speeds, as shown in the following table.

A wind speed and direction anemometer



Source: Bureau of Meteorology, 'Climate statistics for Australian locations', 2010
<www.bom.gov.au>

Monthly average wind speed recorded by students at farm (in metres per second)											
Height of anemometer	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	10-month average wind speed
10 metres	4.6	4.5	4.2	4.3	4.3	4.6	4.8	4.8	4.9	5.0	4.6 m/s
20 metres	5.4	5.3	5.2	5.2	5.1	5.5	5.8	5.9	5.8	5.9	5.5 m/s

- a. List **two** aims of the investigation being carried out by the students.

2 marks

Question 8 continues on the next page.

- b. Using the wind speed data collected by the students, identify patterns in monthly average wind speeds. 2 marks

- c. On average, how much electrical energy would the farm require in a year? 1 mark

- d. Based on the data collected by the students and the amount of energy that different-sized wind turbines can potentially generate (shown in the graph), would wind generation be a suitable source of energy in producing the average annual electricity requirements for the farm? Explain and justify your answer using data. 3 marks

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- e. A Bureau of Meteorology weather station 12 km along the coast constantly collects a variety of weather data, including wind speed and direction, using a different type of anemometer to that used by the students. Each year, wind data is recorded at this site every half hour at a height of 10 m. The highest wind speed recorded by the bureau during the students' investigation period was 18 m per second.

The data collected by the bureau produced very similar average wind speed readings during the same 10 months that the students recorded their data. Explain whether the closeness of the agreement between these results is demonstrating 'repeatability'.

2 marks

- f. A local environmental group might argue both for and against the use of wind turbines in this area.

State one example of an argument for and one example of an argument against using wind turbines from an environmental point of view.

2 marks

Argument for _____

Argument against _____

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