VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
Year

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER | | | | | | | | | Letter |

ENVIRONMENTAL SCIENCE

Written examination

Day Date
Reading time: *. to *.** (15 minutes)**
Writing time: *. to *.** (2 hours)**

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	8	8	90
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied
- Question and answer book of 34 pages
- Answer sheet for multiple-choice questions

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

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

March 2022

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

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.

Question 1

Deforestation is a major threat to biodiversity.

One consequence of deforestation is

A. increased soil erosion.

B. increased rate of nutrient cycling.

C. decreased levels of greenhouse gases in the atmosphere.

D. increased availability of remnant vegetation for native animals.

Question 2

Which of the following lists the categories of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species in order from highest risk of extinction to lowest risk of extinction?

A. endangered, near threatened, vulnerable, extinct in the wild, extinct

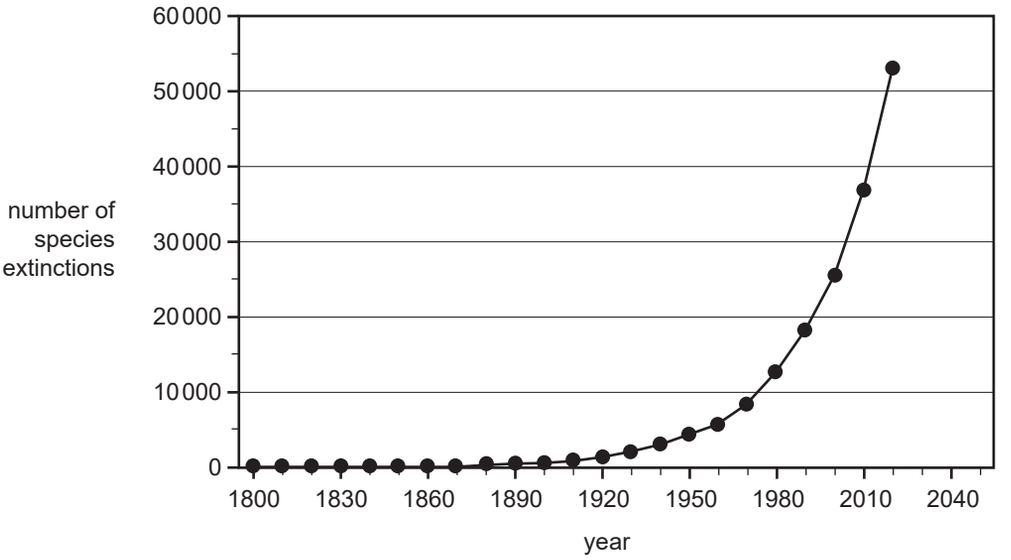
B. extinct, endangered, critically endangered, vulnerable, near threatened

C. extinct, extinct in the wild, critically endangered, endangered, vulnerable

D. extinct, extinct in the wild, endangered, critically endangered, vulnerable

Question 3

The graph below displays the number of species extinctions between 1800 and 2020.



Source: adapted from Center for Biological Diversity,
<www.biologicaldiversity.org/programs/population_and_sustainability/extinction/>,
and JM Scott, 'Threats to biological diversity: global, continental, local' in
'Shifting baselines & new meridians', University of Colorado, summer 2008, conference proceedings

Which one of the following gives the approximate percentage increase in species extinctions during the period 1950–2020?

A. 13%

B. 95%

C. 198%

D. 1250%

Question 4

Cultural burning is a traditional practice used by Aboriginal and Torres Strait Islander peoples to restore balance to ecosystems and reduce fuel load, preventing large-scale bushfires. It involves deliberately setting small 'cool' fires.

Cultural burning is an example of

A. erosion control.

B. species diversity measurement.

C. responsible land management.

D. population size control for pest species.

Question 5

Many native Australian marsupial species are classified as critically endangered, with small population sizes in the wild.

One of the risks associated with a small population size is

A. low ecosystem diversity.

B. more frequent interbreeding.

C. increased resistance to disease.

D. higher rates of genetic disease due to inbreeding.

Question 6

Humans receive a range of benefits from properly functioning ecosystems.

Which of the following lists the four main categories of ecosystem services?

A. biological, ecological, economic, geological

B. cultural, provisioning, regulating, supporting

C. economic, regulating, social, supporting

D. biological, cultural, economic, geological

Question 7

Which one of the following is an example of biomagnification?

A. the development of cancer in a person because they ingested a toxic pesticide

B. the rate of intake of mercury in one shellfish exceeding the rate of removal

C. a high concentration of microplastics in a secondary consumer in an ocean habitat

D. the failure of an organism to reproduce successfully because they consumed a pollutant

Question 8

Which one of the following results in a medium-term change to biodiversity?

A. bushfire

B. volcanic eruption

C. tectonic plate movement

D. El Niño-Southern Oscillation

Question 9

Particulate matter from car exhaust can coat and damage tree foliage. Forests that border major highways can be particularly affected. Zero-emission vehicles, including hydrogen fuel cell cars and electric cars, are considered to be a solution to air pollution.

This type of solution is an example of

A. biocentrism.

B. ecocentrism.

C. technocentrism.

D. anthropocentrism.

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Question 10

Which of the following describes the three dimensions of sustainable development?

A. ecological, economic, sociocultural

B. developmental, sustainable, environmental

C. technocentric, sustainably sourced, economic

D. environmental, developmental, socially acceptable

Question 11

Responsible environmental decision-making considers the interconnections and tensions between factors that influence environmental management. Consider the following statement:

'Blue Mountains locals and Aboriginal traditional owners in New South Wales are fighting a proposed mine expansion, which they say will threaten habitat and cultural sites that survived the 2020 Black Summer bushfires.'

Source: *The Feed*, 2021, episode 8, 'Lithgow Mine', SBS On Demand, <www.sbs.com.au/ondemand/video/1884807747632/the-feed-lithgow-mine>

Which factor is highlighted in the statement for decision-makers to consider?

A. regulatory frameworks

B. diverse stakeholder values

C. application of new technologies

D. current and historical scientific data

Use the following information to answer Questions 12–14.

A group of VCE Environmental Science students is planning a practical field investigation of a pollution reduction project in their local area.

Question 12

As part of the planning for the investigation, the students are required to include a scientific assessment of the likelihood of risks occurring (probability) and the potential severity of the risk outcomes (impact). This will be used to determine the overall severity of the risks associated with the field investigation.

This type of assessment is called

A. a qualitative risk analysis.

B. a quantitative risk analysis.

C. an ecological footprint analysis.

D. a cost-benefit analysis.

*Use the following **additional** information to answer Questions 13 and 14.*

The field investigation for the pollution reduction project involves observation of the remediation of a former gasworks site that is to be redeveloped into a school and residential complex. To ensure that the site is safe and clean for redevelopment, the Environment Protection Authority (EPA) issued a clean-up notice. The aims of the remediation are to ensure that the soil and the groundwater are of acceptable quality and suitable for the redevelopment, and that the risks of residual soil vapour are mitigated and managed.

Question 13

The role of the EPA in the management of the remediation project is to

A. ensure that the ecological integrity of the site is improved and to act as a regulatory authority.

B. represent current and future residents, thereby ensuring intragenerational and intergenerational equity.

C. represent local businesses to ensure that the user pays principle is employed.

D. ensure that the contaminated soil is transported to another site to maximise resource efficiency.

Question 14

Which three of Earth's four interrelated systems are targeted by the remediation project?

A. biosphere, atmosphere and hydrosphere

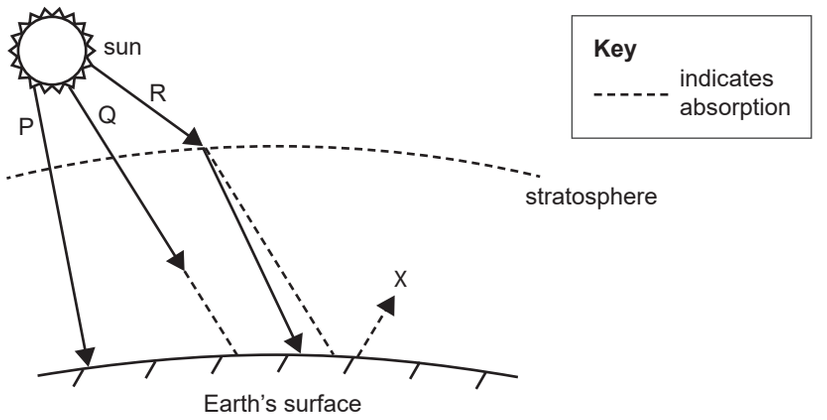
B. lithosphere, biosphere and hydrosphere

C. atmosphere, biosphere and lithosphere

D. hydrosphere, atmosphere and lithosphere

Use the following information to answer Questions 15 and 16.

The diagram below shows radiation entering Earth's atmosphere.



Question 15

Ultraviolet, infrared and visible light are forms of radiation emitted from the sun. These forms of radiation are partially or fully absorbed or not absorbed at all in Earth's atmosphere.

Which of the following correctly identifies the forms of radiation at positions P, Q and R in the diagram above?

	P	Q	R
A.	ultraviolet	infrared	visible light
B.	infrared	ultraviolet	visible light
C.	visible light	infrared	ultraviolet
D.	infrared	visible light	ultraviolet

Question 16

The natural greenhouse effect, labelled 'X' in the diagram above, is primarily caused by

A. the absorption of re-emitted infrared radiation.

B. heat energy created by the surface of Earth.

C. the absorption of infrared energy by Earth.

D. the absorption of re-emitted visible light.

Question 17

The difference between the natural and enhanced greenhouse effects is

A. due to the different types of gases being released into the atmosphere.

B. caused by energy being trapped in the atmosphere due to gases like water vapour and carbon dioxide (CO_2).

C. related to increasing amounts of various greenhouse gases being released into the atmosphere due to human activities.

D. caused by the rapidly increasing temperatures globally due to higher ocean temperatures and a decrease in the albedo effect.

Use the following information to answer Questions 18 and 19.

There has been a significant amount of research into the process of capturing CO_2 from power stations and industry, and then injecting this CO_2 deep into the ocean. The research and modelling suggest that injected CO_2 will be isolated from the atmosphere for several hundred years. To encourage the widescale use of this process, the next step is to secure the agreement of a large number of countries. It is hoped that current global and regional treaties and the internationally agreed laws of the sea could be used to reach an agreement.

Question 18

Which one of the following correctly describes the process of capturing CO_2 and injecting it deep into the ocean?

A. ocean acidification

B. carbon sequestration

C. increasing the albedo effect

D. part of the enhanced greenhouse effect

Question 19

The decision-making process that takes into account the potential international legal arguments around the injection of CO_2 deep into the ocean shows the

A. influence of the Intergovernmental Panel on Climate Change (IPCC).

B. inclusion of a limited range of stakeholder values and priorities in the process.

C. development of a regulatory framework that will guide environmental management strategies.

D. problems that could arise due to incomplete understanding of the impacts of climate change when modelling.

Question 20

A variety of different fruiting trees, such as apples and pears, require cold winter temperatures over a period of time for flowers to develop and for fruit to grow. Predicted climate change in some regions of Australia indicates that average winter temperatures are likely to increase by more than 1 °C by 2030.

Which one of the following is a likely impact of this predicted increase in average winter temperatures for fruitgrowers in these warming regions?

A. no change to their current crop of apples and pears

B. a decrease in the size of apples and pears grown and a decrease in the amount of fruit

C. a need to change to different species that will still produce fruit in warmer winter temperatures

D. a change in the length of the growing season, with apples and pears ripening slightly earlier due to warmer temperatures

Use the following information to answer Questions 21 and 22.

Portland cement is commonly used to build concrete structures. More than 95% of the cement used globally is Portland cement. A crucial step in making Portland cement involves limestone ($CaCO_3$) being heated to very high temperatures in a cement kiln to produce lime (CaO). This step releases CO_2.

Question 21

An option to reduce greenhouse gas emissions during the production of Portland cement would be to

A. not heat the limestone to very high temperatures.

B. increase the strength of concrete by adding extra Portland cement to the mix.

C. replace a portion of the Portland cement used with non-lime-based cement products.

D. generate the very high temperatures required in the cement kiln with natural gas instead of coal.

Question 22

A group of researchers conducted an experiment to find out whether the production of Portland cement emitted more CO_2 than the production of non-Portland cement.

The dependent variable in the group's experiment was the

A. amount of cement produced.

B. heat transferred into the cement kiln.

C. use of Portland cement or non-Portland cement.

D. volume of CO_2 released per tonne of cement.

Question 23

Why is biomass considered a renewable energy source?

A. The use of biomass speeds up the carbon cycle.

B. The combustion of biomass does not result in carbon emissions.

C. The growth of biomass removes carbon dioxide from the atmosphere.

D. Biomass can be regrown at an equal or greater rate than it is consumed.

Question 24

Which one of the following examples demonstrates the effects of the second law of thermodynamics on an energy source?

A. the intermittent nature of solar energy

B. excess heat emanating from a nuclear power plant

C. converting organic matter to fossil fuels over millions of years

D. using a battery to store useable energy from a renewable source

Question 25

Which one of the following is an example of a biofuel?

A. a solid fuel that has no carbon emissions

B. liquid transport fuel obtained from biomass

C. diesel obtained from natural oil deposits in the ocean

D. petrol obtained from the breakdown of organic matter over millions of years

Question 26

After peak oil is reached, some energy sources will become more costly to consumers.

One such energy source is

A. coal.

B. nuclear power.

C. petroleum.

D. hydroelectric power.

Use the following information to answer Questions 27–30.

An experiment was designed to test the ability of different agricultural pesticides to target only pest insect species and not native insect species. 100 pest and 100 native insects, all of different species, were placed in each of four different containers. Each container was treated with 5 mL of a pesticide or distilled water. The insects were then counted at the end of the treatment period. The results are shown in the table below.

Container	Treatment	Percentage loss of native insects	Percentage loss of pest insects
1	Pesticide X	20	100
2	Pesticide Y	5	100
3	Pesticide Z	80	100
4	distilled water	5	5

Question 27

What is the purpose of Container 4?

A. acts as a control container

B. provides a safe container for the insects

C. ensures all variables are controlled, thereby increasing validity

D. can be used to measure the precision of the results from containers 1–3

Question 28

From the results of this experiment, it is reasonable to conclude that

A. Pesticide X gives the most reliable results.

B. Pesticide Y is the most successful at targeting pest species.

C. Pesticide Z is the most effective pest removal solution.

D. distilled water can be used to destroy a large percentage of pest insect species.

Question 29

Which one of the following could be a possible source of systematic error in this experiment?

A. Only 0.5 mL of pesticide was placed in Container 2.

B. Some insects escaped from Container 1 during counting.

C. Some insects were still alive in Container 4 but were counted as a loss.

D. All of the containers were contaminated with 0.5 mL of Pesticide X at the beginning of the experiment.

Question 30

Some random errors may have occurred during counting of the insects.

One way of reducing the effect of random errors is to

A. ensure results are close to the true value.

B. take repeated measurements and then calculate the average.

C. decrease the tolerance for uncertainty in a measuring instrument.

D. be careful not to make any personal errors during the experiment.

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (13 marks)

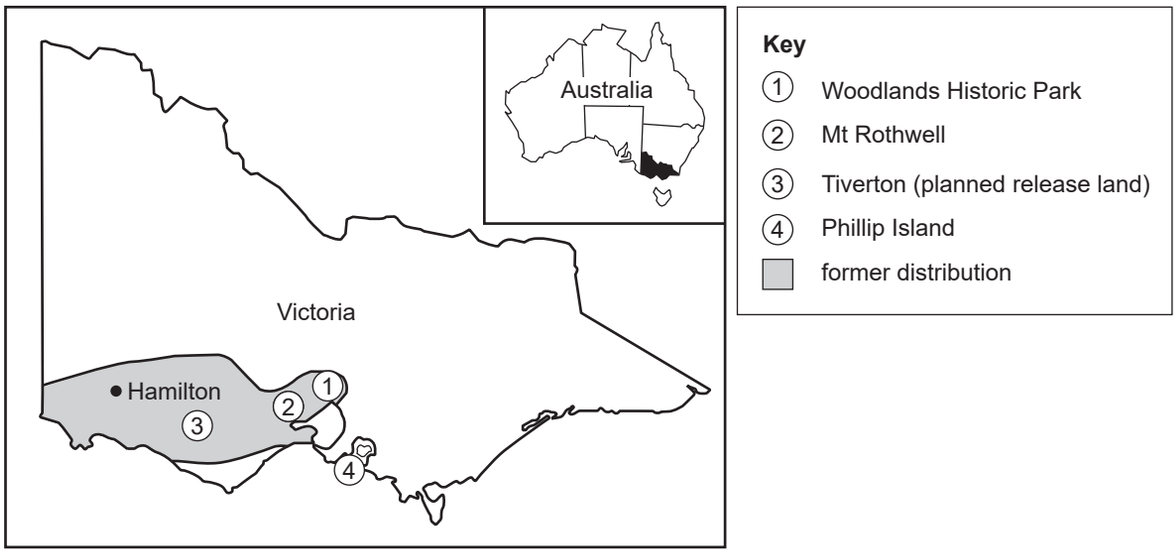
During September 2021, in an Australian first, Victoria's eastern barred bandicoot (*Perameles gunnii*) population bounced back from the brink of extinction.

Eastern barred bandicoot (*Perameles gunnii*)

Source: courtesy of Zoos Victoria

This nocturnal species was once common on the grassy plains of south-west Victoria, although its numbers were decimated and its habitat restricted to one area until only around 150 remained. These losses were mainly due to foxes, cats and loss of habitat from farming. Conservation groups and government agencies set up a recovery team in 1988 that implemented reintroduction programs at four fenced-in sites near Melbourne and south-west Victoria. These populations were protected by maremma sheepdogs under Zoos Victoria's Guardian Dog program.

Former distribution of eastern barred bandicoot and location of reintroduction sites



Source: adapted from R Cleave (author) and C Tulloch (illustrator), *Bouncing Back: An Eastern Barred Bandicoot Story*, CSIRO Publishing, Clayton South, 2018, <www.publish.csiro.au/book/7771>

Volunteers and research staff at the Mt Rothwell Conservation and Research Reserve are considering ways to establish new populations of the eastern barred bandicoot in other south-west Victorian areas.

a. Outline reasons why it is beneficial to establish new populations in different areas. 2 marks

b. A National Parks officer found a new population of the eastern barred bandicoot near Hamilton. It has been estimated that there is a population of 20 eastern barred bandicoots in this location. A volunteer at Mt Rothwell has proposed that six additional eastern barred bandicoots be reintroduced into the wild Hamilton population. The National Parks officer disagrees with the volunteer and suggests that 16–20 additional eastern barred bandicoots be reintroduced.

Evaluate the likelihood of success of these two suggestions. 3 marks

Conservation scientists are concerned about the diversity of food species at two new reintroduction sites – Site A and Site B. The scientists used quadrats to record plant species and live trapping to calculate invertebrate species. They collected the data in the table below from the two sites.

Simpson's Index of Diversity (SID) was calculated by the scientists in order to compare the diversity of food species at the two sites.

SID can be calculated using the following formula.

$$SID = 1 - \frac{\Sigma\left[n_i(n_i - 1)\right]}{N(N-1)}$$

Note: Σ refers to the 'sum of'

n_i represents the total number of organisms of each individual species

N represents the total number of organisms of all species

A higher index value indicates greater species diversity.

Food species observed at Site A	$\mathbf{n_i}$	$\mathbf{n_i - 1}$	$\mathbf{n_i(n_i - 1)}$
Invertebrate			
beetle grubs	5	5 – 1 = 4	5 (4) = 20
millipedes	11	11 – 1 = 10	11 (10) = 110
earthworms	12	12 – 1 = 11	12 (11) = 132
moths	25	25 – 1 = 24	25 (24) = 600
ants	135	135 – 1 = 134	135 (134) = 18 090
Plant			
onion grass bulbs	9	9 – 1 = 8	9 (8) = 72
kangaroo grass	10	10 – 1 = 9	10 (9) = 90
N =	**207**		$\mathbf{\Sigma\left[n_i(n_i - 1)\right] = 19\,114}$
N(N – 1) =	**42 642**		

Therefore $SID = 1 - \frac{\Sigma\left[n_i(n_i - 1)\right]}{N(N-1)}$

$SID = 1 - \frac{19\,114}{42\,642}$

SID = 1 – 0.4482

SID = 0.5518

SID for Site A is 0.55

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c. Use the figures in the table below and the spaces provided to calculate SID for Site B. 3 marks

Food species observed at Site B	$\mathbf{n_i}$	$\mathbf{n_i - 1}$	$\mathbf{n_i(n_i - 1)}$
Invertebrate			
beetle grubs	0	0	
millipedes	20	19	
earthworms	0	0	
moths	30	29	
ants	35	34	
Plant			
onion grass bulbs	15	14	
kangaroo grass	0	0	
N =			$\Sigma\left[\mathbf{n_i(n_i - 1)}\right] =$
N(N – 1) =			

Therefore $SID = 1 - \dfrac{\Sigma\left[n_i(n_i - 1)\right]}{N(N-1)}$

$SID = 1 - \dfrac{\qquad\qquad}{\qquad\qquad}$

$SID = 1 - \boxed{\qquad\qquad}$

$SID = \boxed{\qquad\qquad}$

d. Compare the species richness of Site A and Site B. 2 marks

e. Compare the species diversity of Site A and Site B. Referring to your response in **part c.**, suggest reasons for any differences between species richness and the species diversity calculations at the two sites. 3 marks

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Question 2 (12 marks)

On part of the Tonkin Highway in Western Australia is the state's first ever fully vegetated fauna bridge. There are already numerous fauna underpasses along this highway, but this 12 m wide vegetated fauna bridge provides a more natural route, encouraging all kinds of animals to safely cross the highway. The bridge is densely landscaped to mimic the natural environment of endemic animals, with trees, bushes, shrubs and ground cover native to the area. Natural barriers, such as heavy logs, have been placed at each entrance to discourage human access. The fauna bridge is closely monitored and maintained to ensure continued habitat connectivity for the long-term sustainability of local wildlife.

Vegetated fauna bridge – design

Source: 'Fauna overpass', ABC News, 29 June 2019, <www.abc.net.au/news/2019-06-29/fauna-overpass-1/11258280?nw=0>; image © Main Roads WA

a. A vegetated fauna bridge is referred to as a wildlife corridor and is an example of a biodiversity management strategy.

Provide **one** advantage and **one** disadvantage of using wildlife corridors to protect biodiversity. 2 marks

b. Value systems influence decision-making processes.

Is the construction of a vegetated fauna bridge based on an anthropocentric value system or on a biocentric value system? Justify your response and ensure the difference between the two terms is clear. 3 marks

c. Explain why it is important to mimic the natural habitat of endemic species. 2 marks

d. Residents of areas neighbouring the vegetated site reported feeling a stronger sense of place since the installation of the bridge.

Explain the meaning of the term 'sense of place' and how it relates to the cultural service provided by the vegetated fauna bridge. 3 marks

e. An additional fauna underpass has been proposed for the highway. A local environmental group is concerned that the construction of this underpass will compromise a natural flowing creek. The group is particularly concerned because there is a lack of scientific review into the potential impacts on this waterbody.

Why is the local environmental group's concern an example of the precautionary principle? 2 marks

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Question 3 (10 marks)

Around the world, an estimated 1.3 billion people rely on livestock such as cattle and sheep for their livelihoods. There is a significant need to increase the productivity of livestock production to help lift people out of economic and food poverty.

[Ruminant] livestock unfortunately bring with them a gassy problem. Methane, primarily from [livestock] burps, is a greenhouse gas 28 times more powerful than carbon dioxide. Around 15 per cent of the world's entire total of greenhouse gas emissions come from livestock production, and in Australia the contribution of methane emissions from ruminant livestock is approaching 10 per cent of total greenhouse emissions.

…

Our scientists have collaborated with Meat & Livestock Australia and James Cook University to develop a cost-effective seaweed feed ingredient called FutureFeed, which uses a type of [*Asparagopsis*] seaweed, native to Australia, that significantly reduces livestock methane emissions and has potential to increase livestock productivity.

…

If just 10 per cent of global ruminant producers adopted FutureFeed as an ingredient to feed their livestock, it would have the same impact for our climate as removing 100 million cars from the world's roads, and potential increases in livestock productivity could create enough food to feed an additional 23 million people.

In December 2020 FutureFeed was awarded the Food Planet Prize for its benefits to the climate and environment, while also having the potential to improve profits and livelihoods by opening up a new global industry in seaweed farming.

Source: adapted from 'FutureFeed', Commonwealth Scientific and Industrial Research Organisation, <www.csiro.au/en/research/animals/livestock/futurefeed>;

a. Using a cost-benefit analysis of impacts on society, the economy and the environment, explain why the plan for *Asparagopsis* seaweed agriculture should be regarded as a sustainable development. 6 marks

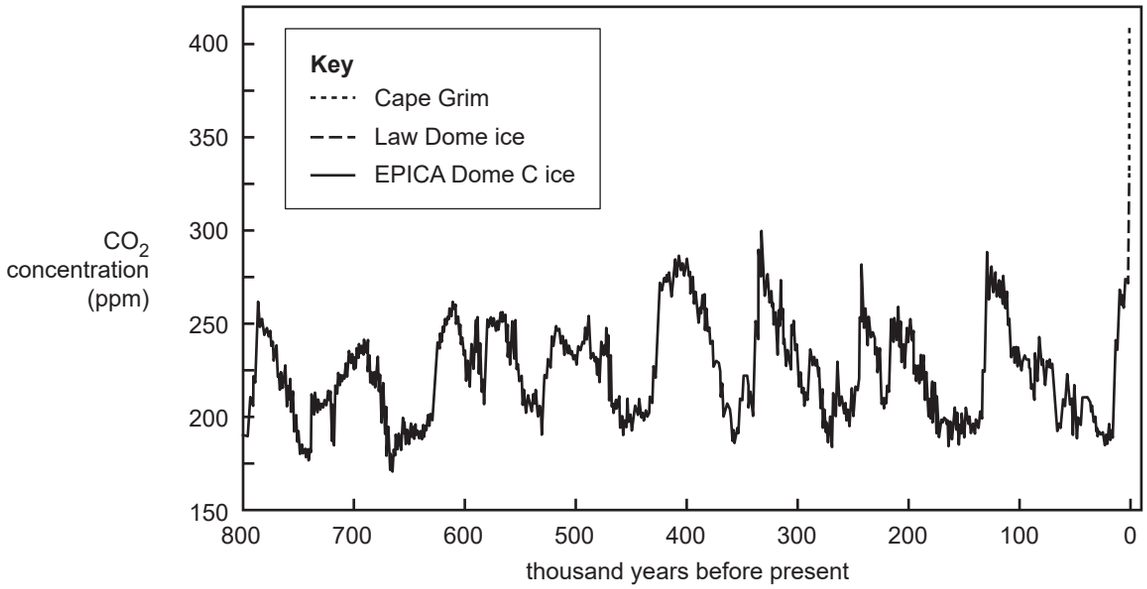
b. To what extent does the *Asparagopsis* seaweed agriculture project represent circular economy thinking? Justify your response and:

- explain the meaning of circular economy thinking
- give an example of how circular economy thinking might be developed and implemented further in the *Asparagopsis* seaweed agriculture project.

4 marks

Question 4 (8 marks)

Changes in atmospheric carbon dioxide (CO_2) concentration over the past 800 000 years



Source: adapted from 'Greenhouse gases', Commonwealth Scientific and Industrial Research Organisation, <www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/greenhouse-gases>; 'State of the Climate 2020' report, produced by Bureau of Meteorology and CSIRO;

The data used to produce this graph came from three sources. The measurements were taken from ice cores extracted at Law Dome and EPICA Dome C in Antarctica. Additionally, Cape Grim Baseline Air Pollution Station has been recording atmospheric carbon dioxide levels since 1976.

a. Using the graph above, describe what has happened to atmospheric CO_2 concentration over the last 800 000 years. 3 marks

b. Explain what contributed to the regular changes in the concentration of CO_2 in the atmosphere between 300 000 and 800 000 years ago. 2 marks

c. Explain what ice core sampling is and why scientists use this method to collect data related to atmospheric gas concentrations. 3 marks

Question 5 (7 marks)

The Intergovernmental Panel on Climate Change's (IPCC) 'Special Report on the Ocean and Cryosphere in a Changing Climate' states, 'Global mean sea level (GMSL) is rising (virtually certain) and accelerating (high confidence). The sum of glacier and ice sheet contributions is now the dominant source of GMSL rise (very high confidence)'.

Source: IPCC, 'Special report on the ocean and cryosphere in a changing climate', H-O Pörtner, DC Roberts, V Masson-Delmotte, P Zhai, M Tignor, E Poloczanska, K Mintenbeck, A Alegría, M Nicolai, A Okem, J Petzold, B Rama and NM Weyer (eds), 2019, p. 323, <www.ipcc.ch/srocc/>

a. Why do the IPCC scales not include a 100% probability confidence level for rising sea levels? 1 mark

b. A community recorded sea level measurements at several locations on the coastline of a small island over the last two years. The data showed that the average yearly sea level for this period had decreased by 4 mm around the island. Using this finding, the community's leadership group argued that the community has nothing to worry about in terms of rising sea levels.

Clearly present a scientific argument about the sea level measurement data and briefly discuss how this data compares to the opinions of the leadership group. 2 marks

c. Based on the IPCC's predictions that global mean sea levels are rising and at an accelerated rate, suggest **two** actions that low-lying coastal communities could take to deal with these increased risks. 2 marks

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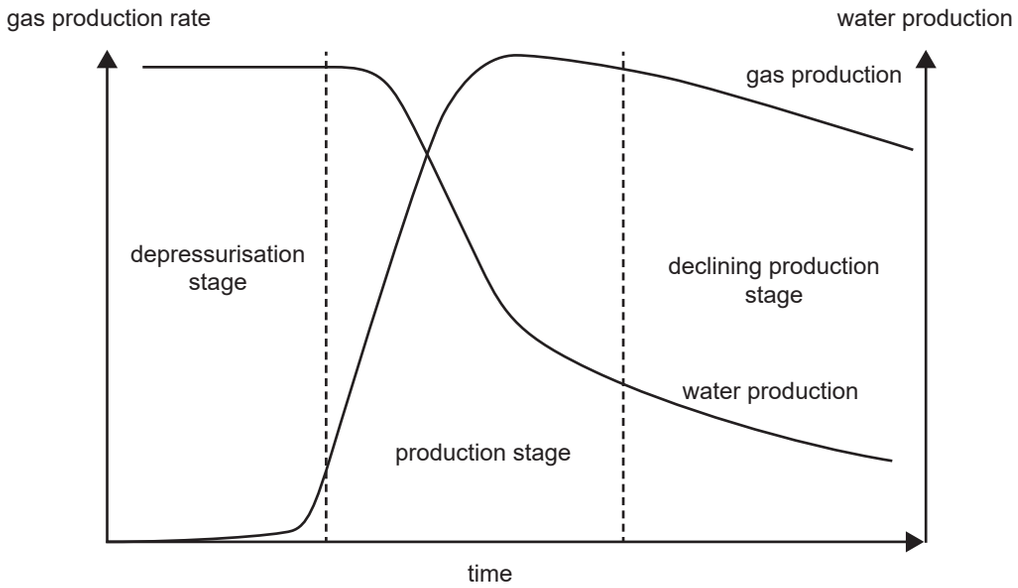
d. Apart from the melting of glaciers and ice sheets, explain another key factor contributing to global mean sea levels rising. 2 marks

Question 6 (8 marks)

The commercial production of coal seam gas in Australia is quite recent, commencing in 1996 in the Bowen Basin, Queensland. The gas is held in place underground by water under high pressure. Machines extract this water, causing the gas to rise to the surface through pipes, to be collected above ground. The graph below shows the relative amount of water and gas typically extracted in this process.



Source: Commonwealth of Australia, 'Coal seam gas extraction: modelling groundwater impacts', prepared by Coffey Geotechnics for the Department of the Environment, Commonwealth of Australia, 2014, p. 21; graph © Queensland Water Commission 2012

a. State the major chemical component of coal seam gas. 1 mark

b. State and explain the change in the gas production rate after the production stage in the graph above. 2 marks

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c. Outline how the extraction and use of coal seam gas results in changes in the carbon cycle. 3 marks

d. Scientists calculated the gas production rate. They produced a table of results to record their findings. The table included the volume of gas produced and one other measurement.

What is the other measurement required for the scientists to find the gas production rate? Explain your reasoning. 2 marks

Question 7 (15 marks)

Energy planners are working to provide a more sustainable mix of energy sources for a small city. At present, the city's energy needs are largely met by burning brown coal. Significant infrastructure is already present, including a coal mine that is close to a coal-fired power station. The coal-fired power station will soon be decommissioned and the site rehabilitated for use as a large wind farm.

a. In the table below, show the steps and energy conversions involved in producing electrical energy from wind. Using this information, compare the energy efficiency of a wind turbine to the energy efficiency of a coal-fired power station. Explain your reasoning. 5 marks

Energy source	coal-fired power station	wind turbine
Steps and energy conversions	coal (chemical energy) → boiler (thermal energy) → turbine (kinetic energy) → generator (electrical energy)	
Comparison of energy efficiency		
Reasoning		

DO NOT WRITE IN THIS AREA

b. Outline the requirements for accessing wind energy that would need to be present at the site. 2 marks

c. Identify and describe one mechanical and one biological process that would be involved in rehabilitating the site. 4 marks

Mechanical process

Description

Biological process

Description

d. Outline **one** limitation that the wind farm would have for supplying base load power to the town. 2 marks

e. Suggest a strategy, still based on renewable energy, to overcome the limitation outlined in **part d.** 2 marks

Question 8 (17 marks)

Carbon sinks absorb carbon from the atmosphere. Two VCE Environmental Science students performed an experiment to test the question: Are old growth or new regrowth forests better carbon sinks?

The students tested a particular species of woody tree. Each tree was approximately 13 years old. These trees have a mixture of leaves that range in age from 0 to 13 years. From each tree, a sample of 100 leaves had their ages identified and were tested using a carbon dioxide monitor to detect the rate of photosynthesis. The average leaf age for each leaf was then calculated. This data was converted to a percentage of the maximum measured rate of photosynthesis. The results are shown in the graph below.

The percentage of maximum rate of photosynthesis in leaves of different ages

Source: adapted from JL Hom and WC Oechel, 'The photosynthetic capacity, nutrient content, and nutrient use efficiency of different needle age-classes of black spruce (*Piceamariana*) found in interior Alaska', *Canadian Journal of Forest Research*, vol. 13(5), October 1983; cited in SG Pallardy, *Physiology of Woody Plants*, 3rd edition, Academic Press, 2008

a. Write a suitable hypothesis for this experiment. 2 marks

b. At what leaf age was the maximum rate of photosynthesis reached? 1 mark

c. Explain why the rate of photosynthesis can be used to measure the carbon uptake (sequestration) capacity of forests. 2 marks

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The aim of the experiment was to determine whether old growth or new regrowth forests have a greater uptake of carbon.

d. Is the experiment valid and does it address its aim? Explain your response, ensuring you define the term 'validity'. 3 marks

e. Outline additional steps that could be carried out to improve or extend the experiment. Include variables and a brief method. 3 marks

After the experiment, the students published their results and conclusions in their school's newsletter. A large agricultural company used the results and conclusions from the newsletter without the permission of the students. The company claimed that the results showed that old growth forests are not suitable to mitigate carbon emissions. The company then put forward a proposal to clear an old growth forest, making way for cattle-grazing pasture land.

f. Use an ecocentric viewpoint to explain the scientific arguments against the proposal to clear an old growth forest. Refer to intergenerational equity in your response. 4 marks

g. Give **two** reasons why the company's use of the students' results and conclusions was unethical. 2 marks

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END OF QUESTION AND ANSWER BOOK


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Answers to multiple-choice questions

Question	Answer
1	A
2	C
3	D
4	C
5	D
6	B
7	C
8	D
9	C
10	A
11	B
12	A
13	A
14	D
15	C

Question	Answer
16	A
17	C
18	B
19	C
20	C
21	C
22	D
23	D
24	B
25	B
26	C
27	A
28	B
29	D
30	B