**Victorian Certificate of Education
2017**

Letter

STUDENT NUMBER

ENVIRONMENTAL SCIENCE
Written examination

Friday 17 November 2017

**Reading time: 3.00 pm to 3.15 pm (15 minutes)
Writing time: 3.15 pm to 5.15 pm (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	9	9	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 32 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.
- 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.

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.

Question 1

Which of the following conditions will most likely lead to the formation, over time, of an ecosystem with high species diversity?

A. small variation in climate throughout the year; few differences within internal habitats

B. little variation in climate over a long period of time; many differences within internal habitats

C. significant variation in climate throughout the year; few differences within internal habitats

D. significant variation in climate over a long period of time; many differences within internal habitats

Question 2

Over a period of time at the end of the Permian period, a very high proportion of species died out.

This period of time is associated with

A. a mass extinction.

B. the death of the dinosaurs.

C. an increase in species diversity.

D. the evolution of humans from the species that died out.

Use the following information to answer Questions 3–5.

The genus *Podarcis* is a group of 23 lizard species found throughout the Mediterranean Basin. High levels of diversity in body size, scale shape and colour patterns are found between lizard species living on the islands in the Mediterranean Sea and the surrounding countries.

Question 3

The 23 *Podarcis* lizard species are endemic to the Mediterranean Basin.

What does the term 'endemic' refer to?

A.   All of the species of *Podarcis* lizards have similar characteristics.

B.   All of the species of *Podarcis* lizards are found in similar types of habitats.

C.   The lizard species have all evolved from the same common ancestor lizard.

D.   Populations of the 23 *Podarcis* lizard species are only found on islands and countries located in the Mediterranean Basin.

Question 4

Scientists investigating a particular Mediterranean island for a species of *Podarcis* lizard decided to use an adequate number of randomly placed quadrats throughout the island to assess the range and diversity of these lizards by counting the burrows found in each quadrat.

Why did the scientists use randomly placed quadrats?

A.   Quadrats are easier to use than other methods when measuring lizard populations.

B.   Data collected in this way will minimise experimental bias and will be scientifically valid.

C.   They wanted to find interesting locations spread over the entire island where lizards hide from predators.

D.   Quadrats are the best way to measure species and population numbers over large areas, such as an entire island.

Question 5

The scientists also used small traps to catch lizards throughout the island in order to collect data using the mark-recapture method. They captured, marked and released 60 lizards on the first day that they set the traps. A week later they captured 38 lizards, of which 12 had been marked.

What is the best estimate of the population of lizards on the island?

A.   86

B.   110

C.   190

D.   456

Use the following information to answer Questions 6–8.

The waterlily *Eichhornia crassipes* bioaccumulates a large amount of mercury in leaf tissues without suffering damage. Scientists have suggested growing large numbers of waterlilies in lakes that are contaminated by mercury. However, some environmental scientists are concerned that introducing the waterlily to lakes where it is not a native species might harm the environment.

Question 6

Growing many waterlilies in mercury-contaminated lakes would primarily aim to achieve which of the following ecosystem services?

A. soil formation

B. nutrient recycling

C. water purification

D. carbon sequestration

Question 7

If the introduction of the waterlily occurs, what type of harm are the environmental scientists concerned about?

A. loss of pollinators of the waterlily

B. overexploitation of the waterlily by humans

C. genetic swamping of the waterlily by dispersal agents

D. reduced availability of natural resources for native species

Question 8

Waterlily populations that are grown for this purpose are often cloned from one individual and are genetically identical.

Such a population would

A. show similar morphological traits.

B. have a high level of genetic diversity.

C. show a large range of structural adaptations.

D. be likely to survive selection pressures due to low genetic diversity.

Question 9

It is thought that with the current trend of decline of the Tasmanian devil, the species will likely become extinct in the near future. While some individuals remain in the natural environment, a large proportion have been affected by a fatal disease.

Which one of the following conservation categories would best describe the situation of the Tasmanian devil?

A. extinct

B. endangered

C. extinct in the wild

D. conservation dependent

Use the following information to answer Questions 10 and 11.

The government of a large city believes that the city may soon have an inadequate supply of water. There is a mountain range to the north of the city and, on the other side of that, a large river flowing into a wetland. There is a small dam on this river, running a small hydro-electric plant for an adjoining town. The government proposes enlarging the dam and constructing a pipeline to bring water from the dam to the city. This will significantly reduce the flow below the dam.

Question 10

Scientists are unsure if the wetland fed by the river contains any endangered species. Environmentalists have argued for maintaining an adequate water flow into the wetland.

Which process should be applied based on this information?

A.   bioremediation

B.   the user pays principle

C.   the precautionary principle

D.   efficiency of resource usage

Question 11

During the construction phase of the dam and pipeline, the principle of 'ecological sustainability' requires that

A.   the cost of the project be minimised.

B.   the environment of the construction sites be restored.

C.   there is no disturbance to the environment during construction.

D.   no residents or businesses be required to relocate away from the site.

Question 12

Which one of the following statements explains the difference between 'sustainability' and 'ecological sustainability'?

A.   'Sustainability' only applies to environmental concerns.

B.   'Ecological sustainability' is a broader term than 'sustainability'.

C.   'Sustainability' adds the concepts of economic needs and social needs to 'ecological sustainability'.

D.   'Sustainability' only refers to current needs; 'ecological sustainability' implies intergenerational equity.

Question 13

The natural processes that create fossil fuels typically occur over

A.   hundreds of years.

B.   thousands of years.

C.   millions of years.

D.   billions of years.

Question 14

Fossil fuels are created by

A.   combustion in engines.

B.   the decomposition of buried, dead organisms.

C.   the reactions of waste products in oil refineries.

D.   radioactive processes deep in Earth's crust.

Question 15

What does the term 'peak oil' refer to?

A.   the fuel with the highest octane level

B.   the maximum rate of consumption of oil

C.   the type of fuel used when household energy demands are greatest

D.   the year in which the maximum rate of extraction of oil is reached

Question 16

Which one of the following is not a renewable energy source?

A.   solar

B.   biomass

C.   natural gas

D.   geothermal

Question 17

Which of the following gives the sequence of energy forms in a thermal-electricity-generation station powered by natural gas?

A.   chemical, heat, kinetic, electrical

B.   kinetic, chemical, heat, electrical

C.   gravitational potential, kinetic, heat, electrical

D.   chemical, gravitational potential, kinetic, electrical

Question 18

One factor influencing the efficiency of coal-fired power stations is the moisture content of the coal. Higher levels of moisture in the coal lower heat output when the coal undergoes combustion and also produce greater carbon dioxide emissions per unit of electrical energy generated.

How could the efficiency of coal-fired power stations be improved?

A.   by using a coal source with a lower initial water content

B.   by trapping the carbon dioxide released when the coal is burnt and storing it underground

C.   by changing the fuel source from black coal to brown coal with a higher moisture content

D.   by replacing coal-fired power stations with renewable energy forms such as wind and solar

Question 19

Which one of the following is a greenhouse gas?

A.   carbon

B.   oxygen

C.   methane

D.   nitrogen

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Question 20

The contributions of a greenhouse gas to climate change depend on

A. whether the greenhouse gas comes from fossil fuels.

B. the number of carbon atoms in the greenhouse gas molecules.

C. the atmospheric concentration of the greenhouse gas before industrialisation.

D. how long the greenhouse gas persists in the atmosphere and its ability to absorb infra-red radiation.

Question 21

The albedo effect, when applied to Earth, is a measure of

A. greenhouse gas emissions.

B. the rise in global temperature.

C. the percentage of ice at Earth's surface.

D. how much of the sun's energy is reflected into space.

Question 22

Which of the following approaches do scientists use as the main method of projecting how Earth's climate will change in the future?

A. assumptions about the continuation of current climate trends

B. simulations by computer-based climate models

C. ice core and tree ring records

D. daily weather forecasts

Question 23

During 2015, Melbourne's weather was cooler and wetter than the previous year.

This difference is an example of

A. weather forecast errors.

B. natural variability of climate.

C. the first law of thermodynamics.

D. changes in atmospheric composition.

Question 24

Which of the following is one of the Milankovitch cycles that affect natural variability in climate?

A. changes in Earth's tilt

B. transitions between seasons

C. variations in the sun's energy

D. fluctuations in atmospheric composition

Question 25

Which one of the following is an example of carbon sequestration?

A. emissions of methane from coal mines

B. combustion of diesel fuel in a car engine

C. sea water dissolving carbon dioxide from the air

D. absorption of infra-red radiation by greenhouse gases

Use the following information to answer Questions 26 and 27.

The graph below shows four different climate change projections for global temperature changes to the year 2100. The projections are based on different future greenhouse gas concentrations, from the highest projection (line R) to the lowest projection (line U).
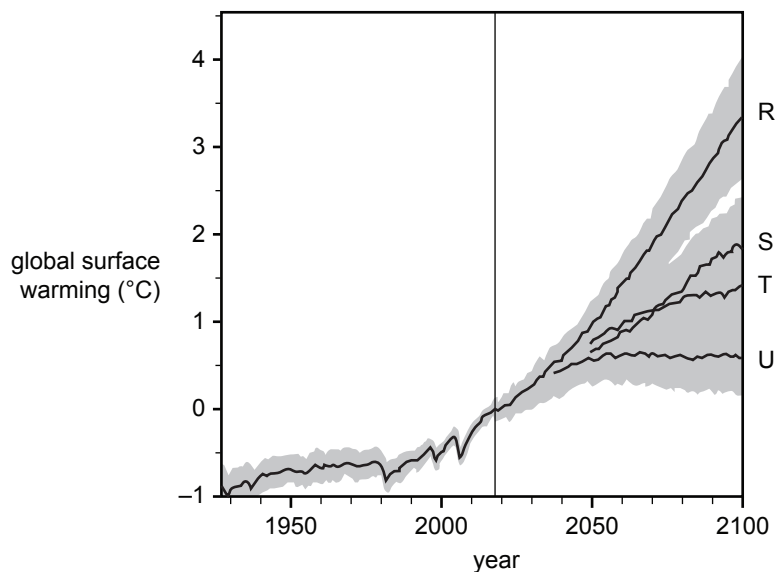
Source: Reto Knutti and Jan Sedláček, 'Robustness and uncertainties in the new CMIP5 climate model projections', *Nature Climate Change*, vol. 3, 2013

Question 26

The planet's average surface temperature is now approximately 15 °C.

If the world follows projection S, the average surface temperature in 2100 will be approximately

A. 15 °C

B. 16 °C

C. 17 °C

D. 18 °C

Question 27

Which feature of the graph shows the scientific uncertainty associated with each individual projection?

A. the future rise in temperature

B. the grey shading around each line

C. fluctuations in observed global surface temperature

D. the range of possible temperature changes, from U to R

Use the following information to answer Questions 28–30.

A class of students sets out to test the hypothesis that soil characteristics in a forest ecosystem change over time due to climate change. The class plans to take initial soil samples and return in six months' time to sample the same area.

The following initial readings were obtained from the same soil sampling grid by three different groups in the class.

Soil characteristic	Group 1	Group 2	Group 3
pH	5.5	5.0	4.7
potassium (mg per kg)	73	75	64
phosphorus (mg per kg)	30	33	28
total nitrogen (mg per kg)	25	24	23

Question 28

Which soil characteristic readings have the greatest precision in results between groups?

A.   pH
B.   potassium
C.   phosphorus
D.   total nitrogen

Question 29

Which one of the following should be a controlled variable in this experiment?

A.   soil composition
B.   climate change over time
C.   environmental temperature
D.   location of sampling grid

Question 30

The reliability of this experiment would be improved by

A.   having more groups taking measurements.
B.   monitoring for a significantly longer period.
C.   using a new pH meter every time a sample is tested.
D.   measuring carbon dioxide levels in the air above the soil.

END OF SECTION A
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SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

Question 1 (13 marks)

Microbats are a variety of species of bat that usually eat insects, are nocturnal and use tree hollows as nesting sites. They are small- to medium-sized bats with wingspans of up to 25 cm. There are 21 native species of microbats found throughout Victoria. Due to a lack of food over winter, most microbat species go into torpor (a mild form of hibernation) during the colder months. The bats mate in late spring and the pups (baby bats) are born in early summer.

Scientists studying the diversity of microbats at two sites in Victorian woodlands collected the following data. Simpson's Index of species diversity (D) was used by the scientists to quantify the microbat diversity of each of the woodland sites. The index (D) can be calculated as follows.

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

Note: $\sum$ refers to the 'sum of'

n_i means the total number of organisms of each individual species

N means the total number of organisms of all species

A higher index value indicates greater species diversity.

Bat species (at Site A)	n_i	$n_i - 1$	$n_i (n_i - 1)$
common bent-wing bat	11	$11 - 1 = 10$	$11 \times 10 = 110$
eastern horseshoe bat	7	$7 - 1 = 6$	$7 \times 6 = 42$
south-eastern long-eared bat	3	$3 - 1 = 2$	$3 \times 2 = 6$
little forest bat	18	$18 - 1 = 17$	$18 \times 17 = 306$
chocolate wattled bat	6	$6 - 1 = 5$	$6 \times 5 = 30$
southern forest bat	6	$6 - 1 = 5$	$6 \times 5 = 30$
N =	51		$\sum[n_i (n_i - 1)] = 524$
N (N – 1)	2550		

Therefore $D = 1 - \dfrac{\sum[n_i(n_i - 1)]}{N(N-1)}$

$D = 1 - \dfrac{524}{2550}$

$D = 0.795$

Simpson's Index (D) for Site A is 0.795

a.   Use the figures in the table below and the spaces provided to calculate Simpson's Index (D) for Site B.   3 marks

Bat species (at Site B)	n_i	$n_i - 1$	$n_i (n_i - 1)$
common bent-wing bat	26		
eastern horseshoe bat	5		
south-eastern long-eared bat	0		
little forest bat	21		
chocolate wattled bat	4		
southern forest bat	8		
N =			$\sum[n_i (n_i - 1)] =$
N (N − 1)			

Therefore $D = 1 - \dfrac{\sum[n_i(n_i - 1)]}{N(N-1)}$

$D = 1 - \dfrac{}{}$

Simpson's Index (D) for Site B is ☐ .

b.   Which of the two sites – A or B – has the higher species diversity? Justify your answer using the index figures you have calculated.   2 marks

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c. Population data about microbats from a third woodland site, Site C, was collected and used to calculate a Simpson's Index (D) of 0.336

Explain what this figure suggests about species diversity at Site C.   2 marks

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d. The south-eastern long-eared bat is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

What are the benefits of listing the south-eastern long-eared bat under this Act?   2 marks

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In order to measure the microbat population numbers at the three sites, scientists used harp traps to catch individual bats. The harp traps consisted of a 1.8 m × 1.8 m aluminium frame mounted on adjustable legs. Fishing line was strung within the frame, with a cotton catch bag at the bottom. Bats flew into the lines and slid down into the bag, from which they could not escape. Each animal was collected from the bag, measured, weighed and identified according to species, and then released. An example of a harp trap used to catch the bats is shown below.

Source: Four bank harp trap, image 19, Faunatech Austbat,
<www.faunatech.com.au/products/harptrap.html>

SECTION B – Question 1 – continued

The scientists followed a number of steps when using this trapping method. Harp traps were set along flight corridors through the woodland at various locations. The traps were set before sunset and left open overnight. Each trap was checked at least once during the night and then at dawn. Traps were not used during the period from late spring to early summer.

e.   There is an argument that animal species should not be trapped at all, even for scientific purposes.

   Explain how bioethical guidelines are being used to minimise the impact on the microbat species
   during this trapping process.   2 marks

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f.   The purpose of this study was to compare the populations at different sites. Scientists collecting bat population data at another site set up the traps a short distance from the main road on a flat piece of land because the location was easy to access.

   Describe the effect on experimental bias of this method of placing the harp traps.   2 marks

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Question 2 (9 marks)

Semon's leaf-nosed bat is an endangered species found in wet tropical rainforests on the Cape York Peninsula of Queensland. The bat is nocturnal, foraging at night around vegetation and along the ground for insects. It utilises old mining sites or natural caves for roosting during the day. The species is under threat mainly due to habitat destruction of roosting sites.

a. The bat consumes an introduced species, the coastal brown ant. The coastal brown ant competes with the endangered Australian native fritillary butterfly for suitable habitat.

Explain how extinction of the bat could affect the endangered fritillary butterfly species. 2 marks

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b. Describe **one** possible advantage and **one** possible disadvantage of each of the following management strategies for the bat population. 4 marks

• Captive breeding and reintroduction

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• Translocation of a small number of bats to a different area

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c. A key reason given for managing and protecting the bat population at this site is to give tourists visiting Cape York the opportunity to view these endangered animals in their natural habitat.

Is this argument based on anthropocentric or ecocentric values? Explain your answer, making the difference between the two terms clear.   3 marks

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Question 3 (13 marks)

A major city is served by a port located close to the city centre. The port is built on the edge of a large bay, which has both significant marine wildlife and recreational facilities. The port handles approximately 50 million tonnes of cargo each year and is accessed by a railway line. However, without major enlargement and redevelopment, the port will reach its capacity within 10 years. Without providing for more port capacity, the economy of the city will suffer substantially in the future.

A major fire in the port several years ago sent toxic smoke over parts of the adjoining city.

The shallow water of the bay currently prevents the largest container ships from entering the port.

The government is considering two options to enable more cargo to be handled by the port:

- Option 1 – Major enlargement of the current port

  This would include dredging of the bay to enable larger ships to enter. This would be substantially cheaper than any other option.

- Option 2 – Establishment of a new port approximately 100 km from the city

  This location is on another bay that is a major recreational centre for the local population and is on the edge of a national park. This bay would not require dredging. However, there is no rail access in the area. Supporters of this option argue that major roads could be built and trucks used to convey cargo to the city.

a.   Which of the two options – 1 or 2 – do you consider to be more ecologically sustainable? In justifying
your answer, use the sustainability principles of intergenerational equity, intragenerational equity, and
conservation of biodiversity and ecological integrity.   6 marks

b. Explain how the user pays principle could be applied to any plan for port redevelopment.

2 marks

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c. Describe **one** role that each of the following stakeholder groups could play in the decision-making process regarding the future development of a port.

2 marks

• Government agencies _____

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• Environmental interest groups _____

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d. Explain how the major fire that sent toxic smoke over parts of the city should influence risk management planning for the future port development.

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Question 4 (7 marks)

A coal-fired power station and its open-cut mine occupied an area of 20 hectares for over 30 years. It was developed in the middle of a large forest of radiata pine (a North American tree species). The radiata pine was introduced to this region over 70 years ago. Recently, the coal-fired power station was closed because of its age and because the coal deposit was almost exhausted. Geologists have found a natural gas reserve nearby.

a. State the mechanical and chemical processes that may be required to rehabilitate the power station and mine site. 2 marks

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b. The owners of the power station argue that the site should be replanted with radiata pine trees, as the company is required to rehabilitate the area to restore the original ecosystem and radiata pine was there before the mine began operation. Environmentalists argue that native eucalyptus trees should be planted instead.

Which of these two options is better for the biosphere? Justify your answer. 2 marks

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c. Scientists within the power company argue that the power station should be upgraded and converted from coal (its previous fuel source) to natural gas. Natural gas is mainly composed of methane. Leakage of natural gas during the drilling process and during transportation through pipelines releases methane into the atmosphere.
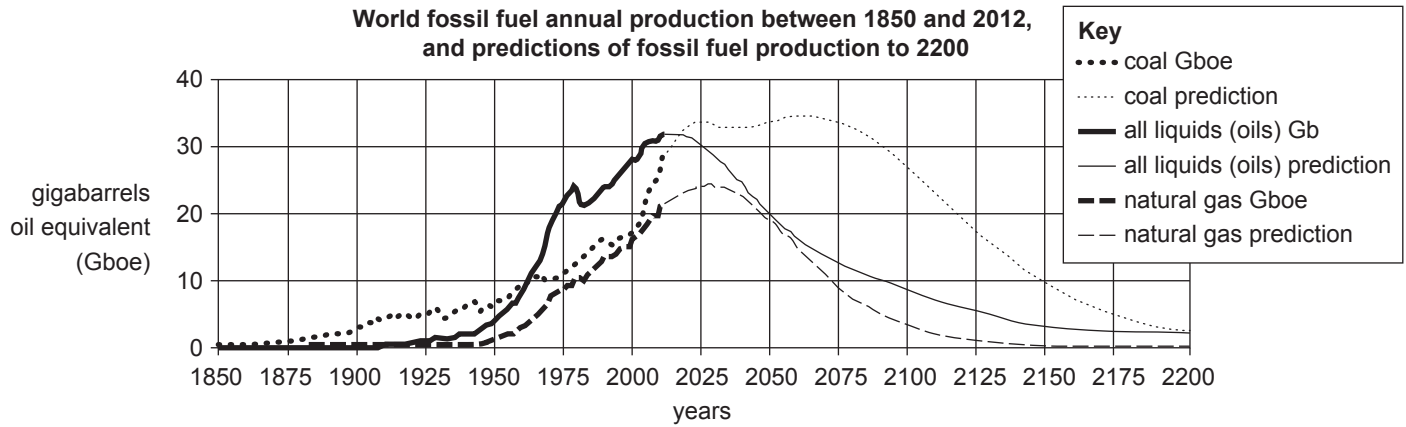
The combustion of coal generated large amounts of carbon dioxide. Methane has an estimated global warming potential that is 28 to 36 times higher than carbon dioxide.

Is the higher global warming potential of methane a valid argument against converting the power station from coal to natural gas? Explain your answer. 3 marks

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Question 5 (10 marks)

World fossil fuel annual production between 1850 and 2012, and predictions of fossil fuel production to 2200

Source: Jean Laherrere, 'World fossil fuels annual production and forecasts assuming no above ground constraint', *Update on Coal*, ASPO France, p. 12, 12 October 2012

Note: 'Production' refers to the amount of each fossil fuel mined and processed each year for use as an energy source.

a. Describe what is predicted to happen to coal production from 2012 to 2200.   2 marks

b. List **two** factors that could change the predicted production rates of these fossil fuels in the future.   2 marks

c. The predictions in this graph are based on scientific modelling.

What is the purpose of modelling data related to future fossil fuel production?   2 marks

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d. Does the graph indicate that we are using these fossil fuel energy resources in a sustainable manner? Explain your answer.   2 marks

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e. If these predictions for oil, coal and natural gas production are accurate, describe **one** impact on either society or our environment.   2 marks

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Question 6 (9 marks)

A small research station is located on the coast of Antarctica. Wind speeds in this region can reach over 250 km/h. Electricity is supplied by a diesel generator.

a. Indicate **two** disadvantages of using the diesel generator to provide electricity for the research station.   2 marks

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b. An engineer suggests replacing the diesel generator with a small nuclear reactor to generate electricity.

Describe the steps and energy conversions involved in generating electricity using nuclear energy as the source.   3 marks

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c. Another engineer suggests replacing the diesel generator with a number of wind turbines because there is a greater efficiency of energy conversions.

Explain what the term 'efficiency of energy conversions' refers to.   2 marks

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d. What difficulties could occur in using wind turbines as the major source of electrical energy for the research station?   2 marks

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Question 7 (7 marks)

a. Draw and label a simple diagram illustrating the natural greenhouse effect. Include the interaction of greenhouse gases in the atmosphere with different forms of radiation. 3 marks

b. Compare the impacts of the natural greenhouse effect and the enhanced greenhouse effect on Earth's biosphere. 2 marks

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c. Describe **one** method of carbon sequestration that could be used to reduce emissions from coal-fired power stations. 2 marks

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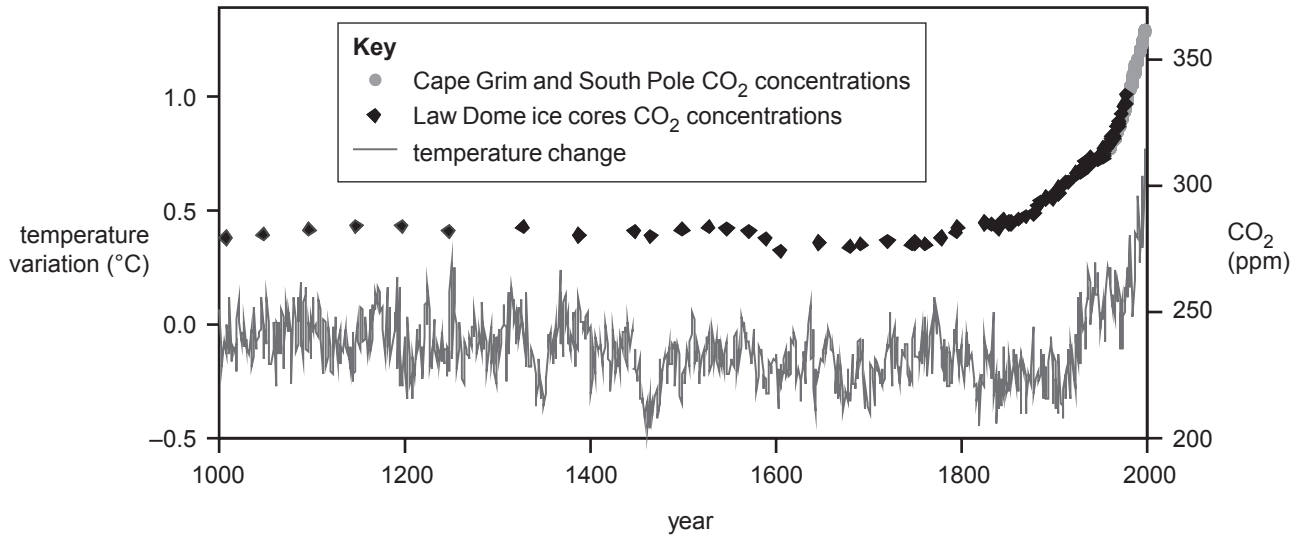**CONTINUES OVER PAGE**

Question 8 (10 marks)

The following graph shows variations in global atmospheric carbon dioxide concentrations and in global surface temperature from the year 1000 to the year 2000.

Variations in global atmospheric carbon dioxide concentrations and global surface temperature over the last 1000 years

Source: M Rebbeck, E Dwyer, M Bartetzko and A Williams,
A guide to climate change and adaptation in agriculture in South Australia, February 2007, p. 9;
© South Australian Research and Development Institute, Primary Industries and Resources SA and Rural Solutions SA

a. The graph includes global temperature measurements from a time when people did not have thermometers.

Explain **two** methods that scientists use today to estimate what global temperatures were hundreds of years ago.   4 marks

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b. Calculate the percentage change in atmospheric carbon dioxide concentrations from the year 1000 to the year 2000.   2 marks

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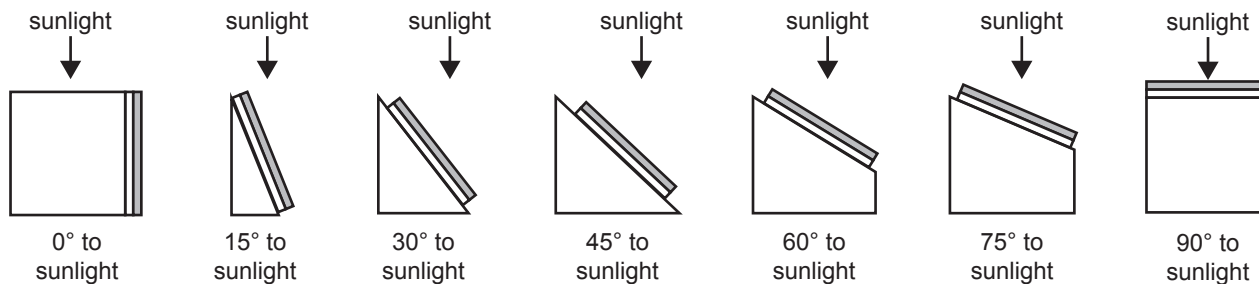**c.** State **two** reasons for the significant increase in atmospheric carbon dioxide concentrations over the past 200 years.   2 marks

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d. Explain the impact of global warming on sea levels.   2 marks

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**Question 9** (12 marks)

A group of students constructed a system to test if the angle at which a solar panel was placed towards the sun affected the amount of power (watts) that the solar panel was able to generate. The students hypothesised that the amount of power generated by the solar panel would decrease to zero watts as the angle reduced to zero degrees. They used the same type of solar panel on each of the seven mounts shown below. They measured the power generated for each angle.

sunlight	sunlight	sunlight	sunlight	sunlight	sunlight	sunlight
0° to sunlight	15° to sunlight	30° to sunlight	45° to sunlight	60° to sunlight	75° to sunlight	90° to sunlight

The power generated by each of the panels was recorded by the students and plotted on the graph below, except for the 45° panel, which was found to have an electronic fault.

Power generated versus angle of panel
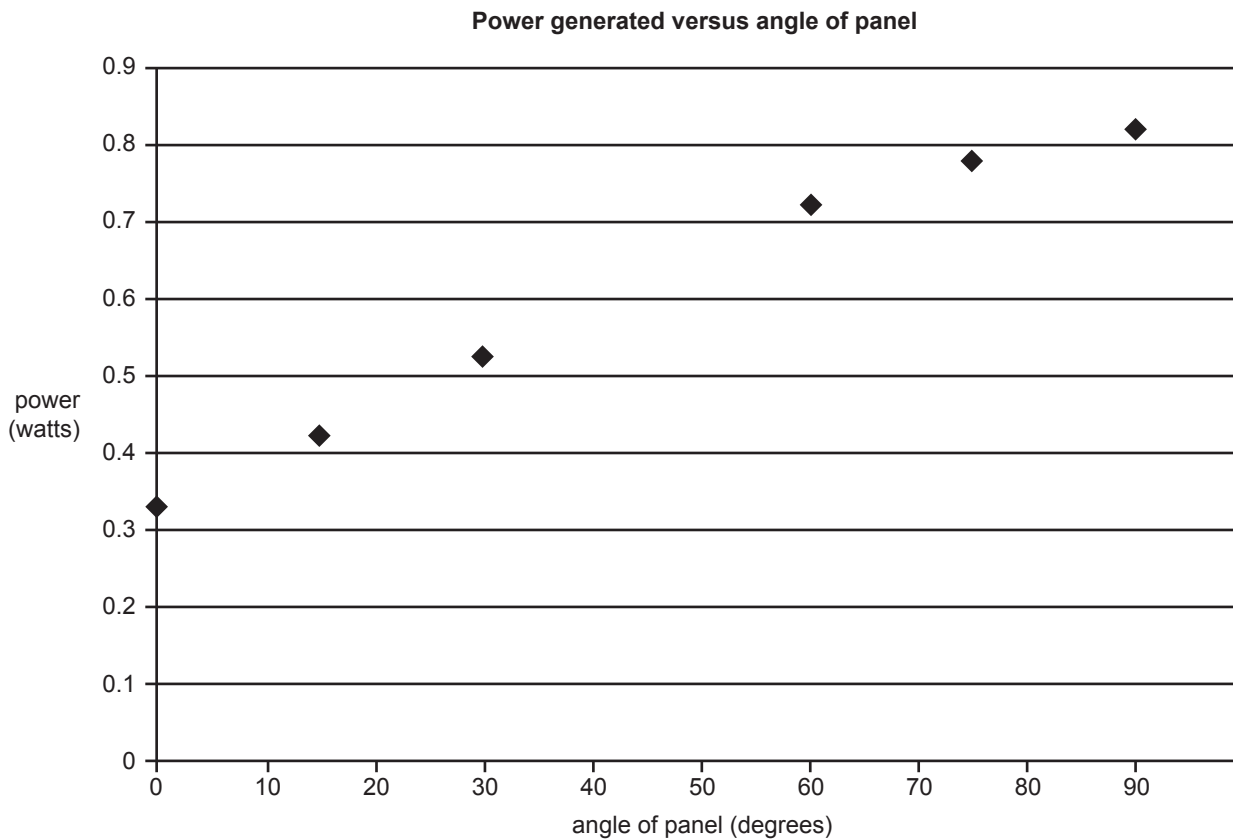
Source (diagram and graph): 'How different angles of incidence of solar rays impact the performance of a solar cell', All Science Fair Projects, <www.all-science-fair-projects.com/project1091_96_2.html>

a. State the independent variable used in this experiment.   1 mark

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b. Did the students collect qualitative or quantitative data? Explain your answer, making clear the difference between the two terms.   3 marks

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c.   **i.**   On the graph on page 30, draw a line of best fit.   1 mark

    ii.   Using this graph, estimate the power collected by the 45° panel.   1 mark

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d. What conclusion should the students make based on the data they collected relative to their hypothesis?   2 marks

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e. Explain **one** way that the experiment could be improved to make the data more reliable.   2 marks

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f. Describe **one** health and safety guideline that should have been followed when the students were conducting the experiment with the solar panels.

2 marks

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END OF QUESTION AND ANSWER BOOK