ENVIRONMENTAL SCIENCE

Written examination 1

Tuesday 8 June 2004

Reading time: 2.45 pm to 3.00 pm (15 minutes)
Writing time: 3.00 pm to 4.30 pm (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

<table>
<thead>
<tr>
<th>Section</th>
<th>Number of questions</th>
<th>Number of questions to be answered</th>
<th>Number of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>6</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total 90</td>
</tr>
</tbody>
</table>

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 17 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 electronic communication 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 is the best example of a vegetation sink?
A. a compost heap
B. a large body of water
C. a large plantation of sugar cane
D. a biomass-powered generating plant

Question 2
Which group contains only renewable energy sources?
A. solar, wind, coal
B. tidal, natural gas, wind
C. geothermal, hydroelectric, tidal
D. hydroelectric, uranium, natural gas

Question 3
Which group contains only fossil energy sources?
A. biomass, coal, oil
B. coal, oil, natural gas
C. geothermal, coal, oil
D. uranium, natural gas, coal

Question 4
Which of the following is an endothermic reaction?
A. melting ice
B. burning a candle
C. operating a petrol engine
D. condensing steam to liquid water

Question 5
Which of the following human activities does not contribute to the enhanced greenhouse effect?
A. deforestation
B. coal-burning power stations
C. use of ethanol from biomass
D. use of solar pool-heating systems
The following information relates to Questions 6–8.

A large natural gas field is located just outside the city of Browntown. The Browntown City Council wants to use the local natural gas supplies as the fuel source for the local public transport system. They have employed an engineer to evaluate the following two options.

**Option A**: Natural gas is used directly as the fuel for the city’s buses.

**Option B**: Natural gas is used to generate electricity to power an electric tramway system.

Under **Option A** (gas-fuelled buses), for every joule of energy put in by the natural gas, the bus produces 0.25 joules of work as motion.

**Question 6**
Most of the energy that is not converted to motion becomes
A. chemical energy.
B. potential energy.
C. a reusable energy source.
D. heat through exhaust gas and friction.

In **Option B** natural gas is used in a power station. A natural gas boiler provides steam to a turbine, which drives an electric generator. The electricity is then distributed through overhead wires to electric trams.

- The power station is 70% efficient.
- The distribution system is 90% efficient.
- The motors of the electric trams are 80% efficient.

**Question 7**
What is the best estimate of the overall efficiency of the electric tramway system described in **Option B**?
A. 240%
B. 75%
C. 50%
D. 24%

The engineer needs to evaluate the capital costs of the equipment mentioned below of each option. She obtains the following information.
- Each tram or bus costs $1 000 000.
- Either 20 buses or 20 trams will be required to provide the service.
- Under **Option B**, the cost of the power station, tracks and distribution system for the trams is $20 000 000.
- Each tram has a usable life of 40 years, and each bus 10 years.
- The electric power station, tracks and distribution system for the trams have a life of 40 years.

**Question 8**
Which statement describes the comparative costs of equipment for the two options over 40 years?
A. Option A (buses) is ten times that of Option B (trams).
B. Option A (buses) is twice that of Option B (trams).
C. Option A (buses) is the same as that of Option B (trams).
D. Option A (buses) is half that of Option B (trams).
Question 9
Emissions Trading allows countries or companies to buy and sell amounts of allowable emissions of greenhouse gases.
Which of the following is an example of Emissions Trading?
A. a power station emitting surplus heat as infrared radiation rather than ultraviolet
B. a city using electric-powered buses in place of diesel buses for public transport
C. a forest plantation company planting trees and selling credits to a power-generating company
D. a power-generating company using natural gas in place of oil to reduce greenhouse gas emissions

Question 10
Genetic diversity of a species is best described as
A. the rate of genetic drift.
B. the number of different species in an ecosystem.
C. genetic variation between different individuals of a species.
D. the relative population sizes of different species in an ecosystem.

Question 11
Species diversity in an ecosystem is best determined by measuring
A. the total number of individuals in an ecosystem.
B. the number of species and their relative population sizes.
C. the genetic differences within each of the species in the ecosystem.
D. the number of different habitats occupied by one particular species.

Question 12
What is endemism?
A. absence of genetic diversity in a species
B. restriction of a species to a particular location
C. dominance of one species in a particular location
D. unsuitability of an ecosystem for a particular species

Question 13
Genetic swamping is most likely to occur when
A. a species moves into a different ecosystem.
B. a number of previously isolated species come in contact.
C. geographic isolation of a population of a species leads to inbreeding.
D. a small, previously isolated population of a species comes in contact with a larger population.

Question 14
The conservation status of a species gets worse when it changes from
A. critical to vulnerable.
B. endangered to critical.
C. critical to endangered.
D. endangered to vulnerable.
**Question 15**
What is inbreeding?
A. breeding between different species
B. breeding attempts that are unsuccessful
C. breeding in very large populations of a species
D. breeding between individuals that are genetically related

**Question 16**
The main aim of a captive breeding program for an endangered species is to increase
A. species diversity.
B. ecosystem diversity.
C. the population to viable numbers.
D. the genetic diversity of the population.
A scientist is monitoring the population of a small animal in a habitat fragment surrounded by housing estates. The sampling is done annually, at the same time of the year. He samples by counting the number of the species observed over a six-hour period each night for a fortnight. From the sampling the population of the habitat is determined. The data collected is shown below.

**Question 17**
What is the best estimate of the percentage decrease in the population between 1995 and 2000?
A. 3%
B. 30%
C. 50%
D. 130%

**Question 18**
The minimum viable population for this species is considered to be 50 individuals. On current trends, when will the population reach this level?
A. 2003
B. 2007
C. 2010
D. 2017

**Question 19**
Which of the following is a likely cause of the population decrease?
A. inbreeding
B. endemism
C. biodiversity
D. genetic swamping
Question 20
Park managers remove some of these small animals from this habitat fragment and breed them in captivity. Their offspring will be released to another site that was previously occupied by the species. By reintroducing the small animals, what would the park managers hope to increase?

A. the demographic variation
B. the genetic drift of the small animals
C. the species diversity at the new site
D. the exotic competitors of the small animals
SECTION B – Short-answer questions

Instructions for Section B
Answer all questions in the spaces provided.

Question 1
a. Name one fossil energy source and one non-fossil energy source. Describe the emissions, if any, from these energy sources.

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

3 marks

b. Ultraviolet, visible and infrared radiation are absorbed differently in the atmosphere. Explain how this helps our understanding of the greenhouse effect. You may include a diagram in your response.

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

4 marks

SECTION B – Question 1 – continued
c. Explain how the fossil energy source that you have named in part a. contributes to the enhanced greenhouse effect, as its emissions interact with infrared, visible and ultraviolet radiation in the atmosphere.

3 marks

d. Outline one disadvantage of the use of the non-fossil energy source you have named in part a.

2 marks

e. Describe one impact of land use changes on the enhanced greenhouse effect.

2 marks

Total 14 marks
**Question 2**

An engineering company constructs pile drivers. This machine has a large mass that is lifted by a diesel motor. As the mass falls, it drives (pushes) the pile into the ground. Refer to the diagram below.

**a.** Describe three energy transformations that occur as the operation of the diesel motor raises the mass to its top position.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

3 marks

**b.** Refer to the pile driver to explain the difference between potential energy and kinetic energy.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4 marks
Each litre of diesel fuel can generate 37 800 kJ of energy. However, only 7 560 kJ of work is done by the pile driver for each litre of diesel fuel burnt in the engine.

c. Calculate the efficiency of energy conversion in the pile driver. Show working.

\[
\text{Efficiency} = \frac{\text{Work done}}{\text{Energy generated}} \times 100\%
\]

\[
\frac{7560 \text{ kJ}}{37800 \text{ kJ}} \times 100\% = 20\%
\]

2 marks

d. The first law of thermodynamics implies that energy is neither created nor destroyed. Explain how this law applies to the operation of the diesel engine in the pile driver.

The first law of thermodynamics states that the total energy of an isolated system remains constant. In the case of the diesel engine in the pile driver, energy is transferred in the form of work done by the pile driver, but the total energy remains constant because it is conserved as heat and work.

3 marks

The engineering company introduces a new motor powered by an engine that uses wood as a fuel rather than diesel. The company advertises that

‘Wood, as a renewable fuel, is more environmentally friendly than diesel’.

e. Describe the implications of this fuel choice for global warming.

Using wood as a fuel is more environmentally friendly because it is a renewable resource and does not contribute to the depletion of non-renewable resources like diesel. However, the carbon emissions from the burning of wood are greater than those from diesel, which can contribute to global warming.

4 marks

Total 16 marks
Question 3
Compare one renewable and one nonrenewable source with respect to their usefulness for providing the energy needs of a small town. Your answer should address each of the following.
• relative energy efficiencies
• economic considerations over the life of the equipment
• environmental impacts
You must name the renewable and nonrenewable energy source you are comparing in the spaces provided below.

Renewable source ____________________________________________________________

Nonrenewable source ________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

6 marks
Total 6 marks
Question 4

A subspecies of an Australian bird is identified in a large wetland ecosystem in northeastern Victoria. The subspecies is found to be endemic to this area.

a. The fact that the subspecies is endemic to this area makes it more in need of protection. Explain why.

b. Explain the term Population Viability Analysis as it applies to this situation.

c. Outline two possible strategies for protecting the population, with particular reference to this subspecies in this location.

Total 9 marks
Question 5
A study is undertaken of a small national park. The park was previously situated next to extensive areas of native vegetation, but is now completely surrounded by housing estates.
A small native animal in the park is classified as ‘vulnerable’.

a. Explain the term vulnerable in terms of conservation categories.

2 marks

b. Identify and describe two possible threats to the survival of the population of this animal.

4 marks

c. Recommend two strategies for managing the population that respond positively to the threats described in part b. Explain how each would help.

4 marks

Total 10 marks
Question 6
In 1992 Australia signed the United Nations Convention on Biodiversity. One of the obligations of a national government under this convention is to monitor biodiversity, especially in threatened ecosystems.

A biologist, Gillian, is contracted by the government to assess the impact of recreational fishing on a lake system through which a major river flows.

She asks five local people to monitor the number of fish caught over a four-hour period on five successive days each year. They each record their total catches over the five-day period as follows.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albert</td>
<td>14</td>
<td>15</td>
<td>13</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Bert</td>
<td>13</td>
<td>16</td>
<td>18</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Cindy</td>
<td>16</td>
<td>13</td>
<td>15</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>David</td>
<td>17</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Calculate the average number of fish caught per person for 2001. Show your working.

b. With reference to the total catch per year, and variation between years, comment on the adequacy of Gillian’s sampling for assessing the impact of fishing.

2 marks

2 marks
Gillian also records the species of the catches. The data for 1998 and 2002 are shown below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>2002</td>
<td>5</td>
<td>10</td>
<td>40</td>
<td>20</td>
<td>75</td>
</tr>
</tbody>
</table>

Gillian uses Simpson’s Diversity index (D) to evaluate the biodiversity as required by the convention. Simpson’s index is a measure of biodiversity. Higher Simpson’s index indicates greater biodiversity. For the case of the four species above, Simpson’s index is given by the formula

\[
D = 1 - (p_1^2 + p_2^2 + p_3^2 + p_4^2)
\]

where \( p_1 = \frac{\text{number of individuals of species 1}}{\text{total number of individuals of all species}} \)

\( p_i = \frac{\text{number of individuals of this species}}{\text{total number of individuals of all species}} \)

\( p_i^2 = \frac{\text{number of individuals of this species}}{\text{total number of individuals of all species}} \)

\( D = 1 - \text{Total } p_i^2 \)

C. Complete the tables below to estimate Simpson’s index for the years 1998 and 2002. Show your working by filling in the columns.

**1998**

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of Individuals</th>
<th>( p ) = \frac{\text{number of individuals of this species}}{\text{total number of individuals of all species}}</th>
<th>( p^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murray cod</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver perch</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro carp</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td></td>
<td>Total ( p^2 = )</td>
</tr>
</tbody>
</table>

\( D = 1 - \text{Total } p^2 = \)

**2002**

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of Individuals</th>
<th>( p ) = \frac{\text{number of individuals of this species}}{\text{total number of individuals of all species}}</th>
<th>( p^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murray cod</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver perch</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro carp</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td></td>
<td>Total ( p^2 = )</td>
</tr>
</tbody>
</table>

\( D = 1 - \text{Total } p^2 = \)

4 marks
d. Albert, one of the fishermen, argues that since the number of fish caught has not changed over the five-year period 1998–2002, fishing should be allowed to continue. Gillian, the biologist, argues that there has been a change in biodiversity, as shown by Simpson’s index. Comment on these arguments. Your answer should include a reference to what the calculated Simpson’s indexes indicate.

3 marks

e. Outline two possible strategies that Gillian could suggest to the government to maintain the biodiversity of the lakes system.

4 marks
Total 15 marks

END OF QUESTION AND ANSWER BOOK