AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
ENVIRONMENTAL SCIENCE

Paper 2

Wednesday 12 June 2019 Morning Time allowed: 3 hours

Materials
For this paper you may use:
- a calculator.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions 1 to 10 and **one** essay from question 11.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 120.
- All questions should be answered in continuous prose.
- You will be assessed on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

For Examiner's Use	
Question	Mark
1	
2	
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9	
10	
11	
TOTAL	

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

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0 1 **Table 1** lists the definitions of some ecological words and phrases.

Complete **Table 1** by matching a letter from the list below to each definition in the table.

A Habitat
B Taxon
C Ecological niche
D Population
E Community
F Ecosystem
G Biome

[5 marks]

Table 1

Definition	Letter
The relationships between organisms and their interactions with their physical environment.	
A large geographical area, with particular climatic features, where a characteristic, unique community of species lives.	
The number of individuals of one species in an area.	
The role of a species in a habitat, including how the species uses and changes the environment.	
All the members of all the species that live in an area.	

5

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0 2 An international rescue programme that bred Giant Pandas in zoos, with the aim of releasing them to the wild, has failed. Of the 400 animals born in zoos, only five animals have been released into the wild, two of which died within six months.

Outline methods that may be used to increase the survival of captive-bred animals that are released into the wild.

[5 marks]

Extra space

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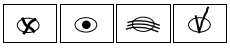
Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

0 3 Unmanned aerial vehicles (UAVs), such as drones, are used in agriculture to monitor crop productivity and manage fertiliser application. They can be fitted with optical sensors that measure the reflectance of crop canopies using the Normalised Difference Vegetation Index (NDVI).

Figure 1 shows a drone.

Figure 1

Nutrient-deficient crops reflect more red light (Red) and less near infrared radiation (NIR) than healthy crops.

The NDVI is a numerical indicator that compares the percentage of Red and NIR reflected from vegetation to give a number from –1 to +1, using the formula below.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

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Table 2 shows how NDVI values relate to crop health.

Table 2

DVI value	Health of crop
>0.66	Very healthy
0.33 to 0.66	Healthy
0 to 0.33	Unhealthy
–1 to 0	Dead

0 3 . 1 Assess the health of a potato crop reflecting 58% of NIR and 9% of Red.

Shade **one** box only.

[1 mark]

A Very healthy ⬭

B Healthy ⬭

C Unhealthy ⬭

D Dead ⬭

Question 3 continues on the next page

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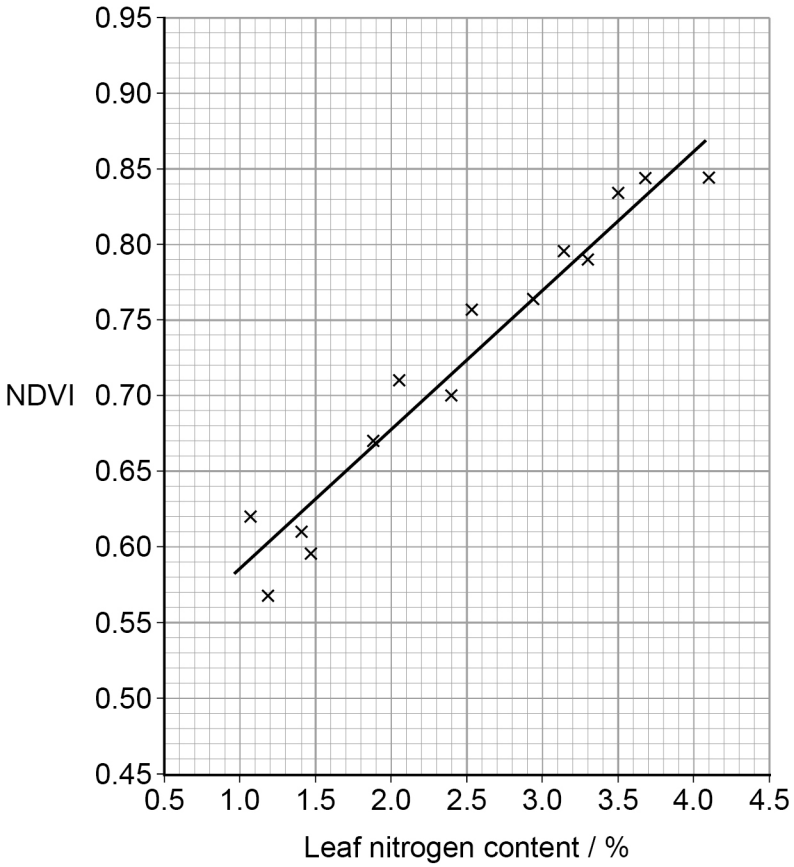
An agricultural scientist used a drone to collect data on crop reflectance in a wheat field. The data were used to calculate the NDVI for the crop in different areas of the field.

Leaves were collected from areas of the field that had different NDVI values. They were analysed for their nitrogen content.

Figure 2 shows the relationship between the NDVI and percentage leaf nitrogen.

Figure 2



0 3 . 2 Use the line of best fit in **Figure 2** to estimate the increase in the NDVI value produced by a 1.5% increase in leaf nitrogen content.

[1 mark]

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0 3 . 3 Describe how the sampling locations and timing may have been planned in an experiment that produced the results shown in **Figure 2**.

[4 marks]

0 3 . 4 Explain how the information provided by the use of drones can help to manage fertiliser application and reduce impacts on the environment.

[4 marks]

10

Turn over for the next question

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0 4 Coffee Leaf Rust (CLR) is fungal disease of coffee plants that can significantly reduce yields.

Coffee is a shade-tolerant plant that was, until recently, grown under the canopy of taller trees. Now, many farmers are growing coffee in direct sunlight in open fields to increase plant density and yields. However, CLR grows well in high temperatures so damage to the coffee crop has increased.

The White Halo Fungus is parasitic on CLR and reduces damage, but it only grows in shaded conditions.

Pesticides can be used to control CLR but non-target species may be killed.

Selective breeding of coffee plants to produce disease-resistant varieties is important but the breeding programmes introduce undesirable characteristics.

Creating windbreaks and destroying diseased plants can reduce the spread of CLR.

Table 3 shows data for coffee plantations in four areas.

Table 3

Plantation	**A**	**B**	**C**	**D**
Cultivation method	Shaded by taller trees	Shaded by taller trees	Direct sunlight	Direct sunlight
Area / ha	750	1000	900	850
Light levels / lux	560	560	1200	1200
Air temperature / °C	25.5	20.5	26.0	20.0
Soil temperature / °C	21.0	18.5	19.7	18.0
Humidity / % saturation	70	60	50	45
Relative wind velocity	Low	Low	High	High
Coffee harvest / t ha^{-1}	2.1	1.8	3.1	2.6
Reduction in harvest caused by CLR / %	15	12	30	24

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0 4 . 1 Calculate the increase in total harvest from Plantation **C** if the reduction in harvest caused by CLR could be reduced to 19%.

Show your working.

[2 marks]

Increase = _____

Question 4 continues on the next page

Scientists investigated how the growing conditions could be managed to minimise the yield reduction caused by CLR.

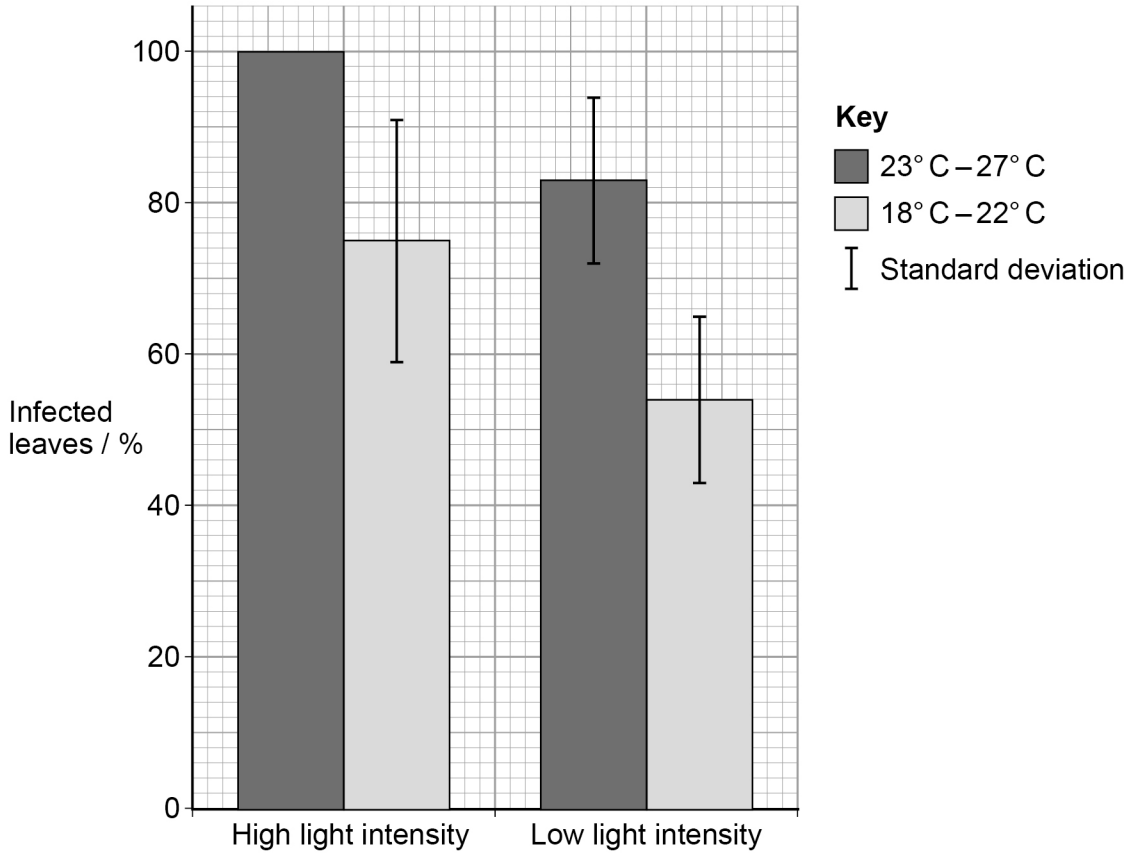
Coffee was grown in four trial plots with different environmental conditions:

High temperature	(23°C–27°C)	with high light intensity
High temperature	(23°C–27°C)	with low light intensity
Low temperature	(18°C–22°C)	with high light intensity
Low temperature	(18°C–22°C)	with low light intensity

The crops in each area were infected with CLR. After 50 days, 10 plants were randomly selected from each area and the number of infected leaves on each plant was counted.

Figure 3 shows the mean percentage (%) of leaves infected with CLR in each area.

Figure 3



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0 4 . 2 The standard deviation of the data collected in high temperature and high light intensity conditions was zero.

Explain what a standard deviation of zero shows about the data collected.

[1 mark]

0 4 . 3 Use the information provided and your own knowledge to explain why the four cultivation systems have different coffee harvests.

[3 marks]

0 4 . 4 Suggest the advantages and disadvantages of using genetic modification (GM) to protect coffee from CLR.

[4 marks]

10

Turn over for the next question

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0 5 **Table 4** shows the mean per capita ecological footprint of groups of countries with different levels of affluence.

Table 4

Country type	Mean per capita ecological footprint / Gha
Richest 15 countries 6% of global population	7.8
Other countries 94% of global population	3.3

0 5 . 1 Use the information in **Table 4** to calculate the mean per capita ecological footprint of the global population.

Show your working.

[2 marks]

_____ Gha

0 5 . 2 Describe the factors that affect the size of a country's per capita ecological footprint.

[4 marks]

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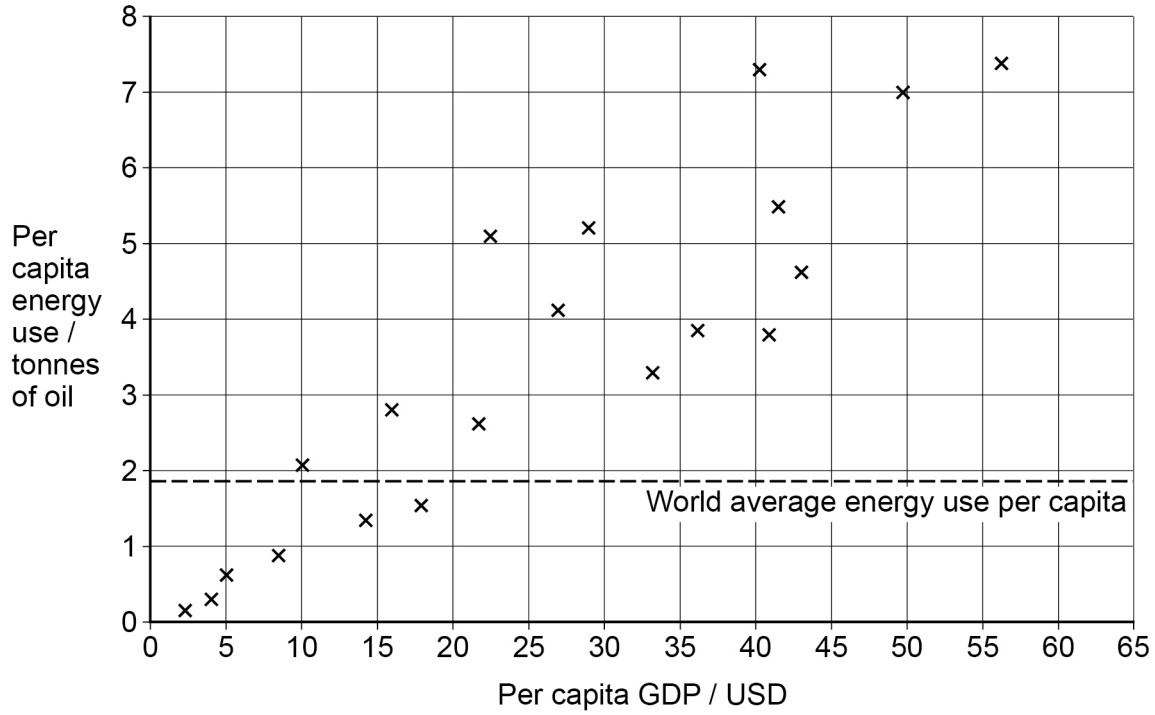
Figure 4 represents the energy consumption and the per capita Gross Domestic Product (GDP) of different countries.

Figure 4



0 5 . 3 Use information from **Figure 4** and your own knowledge to explain why an increase in per capita GDP often reduces the sustainability of lifestyles.

[4 marks]

10

Turn over ►

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0 6 **Figure 5** shows a Coypu, *Myocastor coypus*. Coypu are large, herbivorous, semi-aquatic rodents from South America that do not survive well in cold winters. Some Coypu have escaped from fur farms in the Swiss mountains. Some have survived and the Coypu is now considered an invasive species in Switzerland.

Figure 5

Introduced species may threaten biodiversity and have the greatest impact in isolated regions, for example, islands and mountainous areas.

0 6 . 1 Explain why the problems caused by introduced species are often greater in isolated regions.

[3 marks]

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Table 5 shows the number of days with temperatures below 0 °C and the number of introduced species surviving in mountainous regions of Switzerland.

Table 5

Year	Number of days with temperature below 0 °C	Number of introduced species surviving
1900	75	1
1910	80	1
1920	80	1
1930	75	1
1940	78	1
1950	75	2
1960	50	2
1970	36	3
1980	35	4
1990	33	6
2000	28	11
2010	15	18

0 6 . 2 Suggest why the change in number of days with temperatures below 0 °C may have affected the number of new species living in the mountains of Switzerland.

[1 mark]

0 6 . 3 Use information from **Table 5** to calculate the increase in the mean annual rate of change in the number of introduced species from 1990 to 2010 compared with 1940 to 1960.

[1 mark]

_____ species per year

Do not write outside the box

0 6 . 4 Use examples to describe the methods that may be used to reduce problems caused by introduced species.

[5 marks]

Extra space

10

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0 7 A buffer zone of trees was planted along the edge of a wetland to reduce storm water runoff from an urban area.

Figure 6 shows the wetland and buffer zone.

Figure 6

To investigate if this management strategy is affecting the vegetation in the wetland, a group of students decided to do an interrupted belt transect, taking samples at chosen intervals.

0 7 . 1 Explain why an interrupted belt transect is an appropriate method to choose.

[2 marks]

Question 7 continues on the next page

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Data on percentage plant cover were collected. The students did a preliminary study to find the optimum interval between sampling sites.

Table 6 shows the results of the preliminary study.

Table 6

Sample interval / m	Percentage of species cover in each quadrat along the transect															
	Quadrat number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	20	30	50	40	30	30	10	20	30	20	10	20	30	50	80	70
2	20		50		30		10		30		10		30		80	
4	20				30				30				30			
8	20								30							

0 7 . 2 Select the optimum sample interval for this study.

Shade **one** box only.

[1 mark]

A 1 m interval ⬭

B 2 m interval ⬭

C 4 m interval ⬭

D 8 m interval ⬭

0 7 . 3 Explain why this is the most appropriate interval between sampling sites.

[1 mark]

Do not write outside the box

0 7 . 4 Suggest how the buffer zone of trees may help to maintain diversity in the wetland.

[2 marks]

0 7 . 5 How may the conservation of wetlands benefit humans?

[4 marks]

Extra space

10

Turn over for the next question

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0 8 An ecologist investigated the relationship between percentage canopy cover in a temperate broadleaf woodland and the diversity of night-flying moths present in the woodland.

0 8 . 1 Outline **one** method that may have been used to capture the night-flying moths in this study.

[1 mark]

0 8 . 2 Outline **three** limitations of this technique for sampling moths.

[3 marks]

1

2

3

A Simpson's Index of Biodiversity was calculated for each site.

Table 7 shows the number of species recorded at four sampling sites.

Table 7

Number of species of moths recorded in each site			
Site A	**Site B**	**Site C**	**Site D**
7	6	12	4

0 8 . 3 What additional information is needed to calculate a Simpson's Index of Biodiversity for each site?

[1 mark]

5

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ANSWER IN THE SPACES PROVIDED

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0 9 **Figure 7** shows an area of heather moorland in Scotland.

Figure 7

Heather moorland is important for grazing sheep and as a wildlife habitat for many species that do not live in other habitats.

A group of students investigated the relationship between grazing pressure, the height of heather plants and the abundance of smaller wild plants.

Five study areas were chosen.

Four areas had different stocking densities of sheep and one was a fenced area where there was no grazing. The mean height of heather plants was predicted to be lowest in the area with the highest stocking density.

0 9 . 1 Suggest how the students could have planned the investigation to test this hypothesis.
[4 marks]

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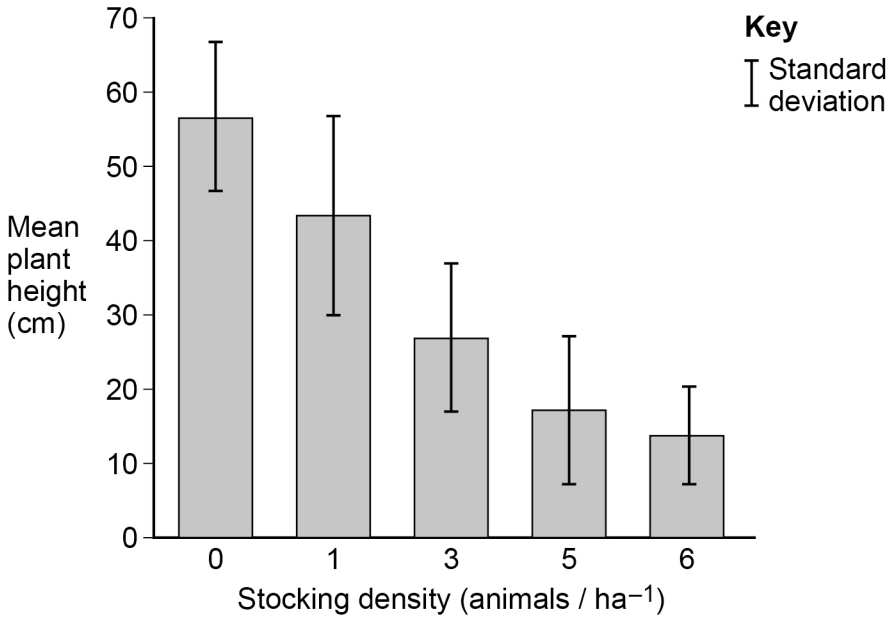
Figure 8 shows the students' results.

Figure 8



0 9 . 2 Use information from **Figure 8** to state which stocking densities produced mean plant heights that were likely to be significantly different from the mean plant height in the ungrazed area.

[1 mark]

Question 9 continues on the next page

In a similar investigation, the students' t-test was used to assess whether there was a significant difference between two data sets.

Formula used to calculate a t-value:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

$\bar{x}_1$ = mean of first sample
$\bar{x}_2$ = mean of second sample
n_1 = size of first sample
n_2 = size of second sample
s_1 = standard deviation of first sample
s_2 = standard deviation of second sample

Table 8 shows data used in calculating a t-value.

Table 8

	Sample 1	**Sample 2**
Grazing pressure / sheep ha^{-1}	0	5
Sample size	11	11
$\bar{x}$ (Mean height) / cm	57.2	16.4
s (Standard deviation)	$s_1 = 21.64$	$s_2 = 1.32$
s^2 (Standard deviation^2)	$s_1^2 = 468.29$	$s_2^2 = 1.74$
$\frac{s_1^2}{n_1}$	42.57	n/a
$\frac{s_2^2}{n_2}$	n/a	0.158
Degrees of freedom (total number of samples -2)	20	

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0 9 . 3 Use the formula to calculate the t-value for this study.

Show your working.

[3 marks]

t value = _____

Question 9 continues on the next page

Table 9 shows the critical values for assessing the significance of t-values.

Table 9

Degrees of freedom (total number of samples -2)	**p-values**					
	0.20	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
	Critical values					
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725

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0 9 . 4 In a similar study, sample sizes of 14 and 12 produced a t-value of 2.950.

Use **Table 9** to find the lowest p-value that can be accepted for this similar study.

[1 mark]

p = _____

0 9 . 5 The null hypothesis for this study was that there was no significant difference between the means of each data set.

If the calculated t-value had been 1.235, state whether the null hypothesis should be accepted or rejected.

[1 mark]

_____

_____

0 9 . 6 The students extended the study by investigating the biodiversity of ground vegetation in each area. They found that the biodiversity was low in areas with the lowest and highest grazing pressure. Biodiversity was highest in areas with medium grazing pressure.

Suggest reasons for these results.

[5 marks]

_____

_____

_____

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_____

_____

15

Turn over for the next question

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1 0 Milkfish, *Chanos chanos*, are an important seafood in South East Asia and are raised in aquaculture lagoons in areas where mangroves have been cleared.

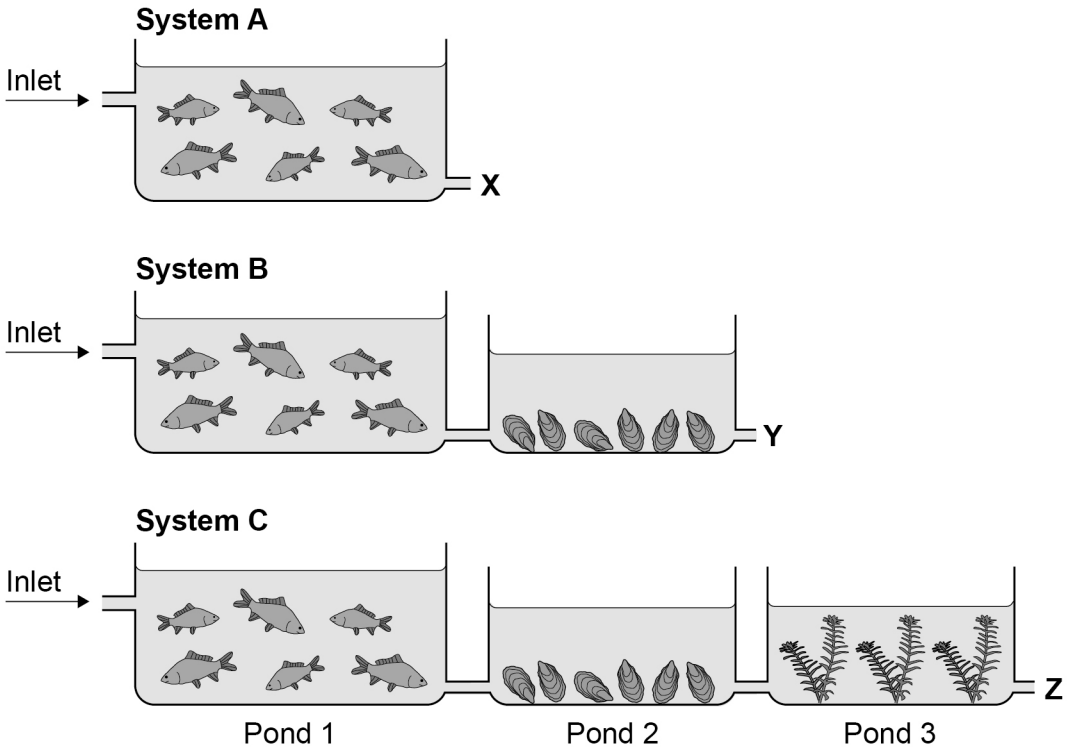
Integrated multi-trophic aquaculture (IMTA) is a polyculture system where species in different trophic levels are cultivated. The effects of an IMTA system on water quality were investigated.

Three aquaculture systems were set up as shown in **Figure 9**:

System A: Pond 1 with 300 Milkfish
System B: Pond 1 with 300 Milkfish, Pond 2 with 500 oysters
System C: Pond 1 with 300 Milkfish, Pond 2 with 500 oysters, Pond 3 with seaweed.

The waste water from outlets X, Y and Z is discharged into the sea.

Figure 9



Water samples were collected from the pond outlets **X**, **Y** and **Z**, shown in **Figure 9**. One water sample was collected each day from each outlet.

The water samples were analysed for nitrate concentration, dissolved oxygen concentration and turbidity.

The mean data of the 10 samples from each system are shown in **Table 10**.

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Table 10

Aquaculture system	Nitrate / mg l^{-1}	Dissolved oxygen / mg l^{-1}	Turbidity / arbitrary units
A	60	6.1	25
B	70	5.4	5
C	10	9.7	4

1 0 . 1 Use **Figure 9** and **Table 10** to explain the difference in the turbidity readings for the outlet water from aquaculture systems **A** and **B**.

[2 marks]

1 0 . 2 Use **Figure 9** and **Table 10** to explain the difference in the nitrate concentrations for the outlet water from aquaculture systems **A** and **C**.

[2 marks]

Question 10 continues on the next page

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1 0 . 3 Use **Figure 9** and **Table 10** to explain the differences in the dissolved oxygen concentrations for the outlet water from **all three** aquaculture systems.

[2 marks]

1 0 . 4 Discuss how changes in aquaculture systems, other than using IMTA, may reduce the environmental impacts of aquaculture.

[9 marks]

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Extra space

Turn over for the next question

15

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Write an essay on one of the following topics.

1 1 . 1 Discuss how changes in human activities may reduce threats to forests and allow them to be exploited sustainably.

[25 marks]

OR

1 1 . 2 Discuss how changes in human activities may reduce threats to marine fisheries and allow them to be exploited sustainably.

[25 marks]

Shade the lozenge below to indicate which optional question you have answered.

Question **1 1 . 1** ⬭ Question **1 1 . 2** ⬭

CORRECT METHOD ⬬ WRONG METHODS ⊘ ⦿ ≋ ∅

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25

END OF QUESTIONS