A-Level Biology

Energy and Ecosystems

Question Paper

Time available: 68 minutes
Marks available: 61 marks

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1. Freshwater marshes have one of the highest rates of gross primary production (*GPP*) and net primary production (*NPP*) of all ecosystems.

Carbon use efficiency (*CUE*) is the ratio of *NPP:GPP*. Freshwater marshes have a high *CUE*.

(a) Use your knowledge of *NPP* to explain why freshwater marshes have a high *CUE* **and** the advantage of this.

Do **not** refer to abiotic factors in your answer.

Explanation _____

Advantage _____

_____

(2)

(b) Freshwater marsh soils are normally waterlogged. This creates anaerobic conditions.

Use your knowledge of the nitrogen cycle to suggest why these soils contain relatively high concentrations of ammonium compounds and low concentrations of nitrite ions and nitrate ions.

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(2)

A student investigated the growth rate of a freshwater marsh plant.

The growth rate (*R*) of a plant can be determined using this equation.

$$R = \frac{(\ln W_2 - \ln W_1)}{t}$$

Where
ln = natural logarithm
t = duration of the investigation in days
W_1 = plant biomass at the start of the investigation
W_2 = plant biomass at the end of the investigation

The student used the equation above; however, she substituted height for biomass. This was because she did not want to destroy the plants to measure their biomass.

(c) State the assumption the student has made **and** suggest why this assumption might **not** be valid.

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(2)

(d) At the end of the investigation, the student noted the freshwater marsh plant had grown 268 mm in height, and now measured 387 mm. She calculated the rate of growth *(R)* to be 0.097 mm m^{-1} day^{-1}

Use this information and, **substituting height for biomass**, use the equation to calculate the duration of the student's investigation.

Give your answer to the nearest full day. Show your working.

_____ days

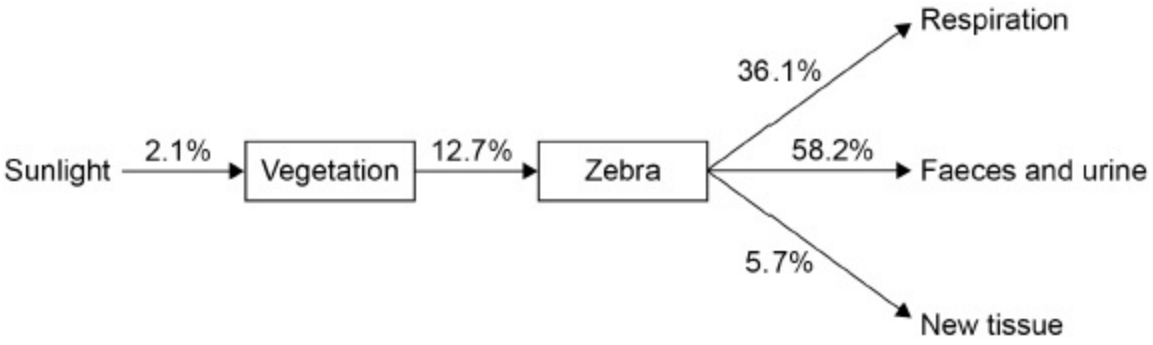
(2)

(Total 8 marks)

2. (a) Succession occurs in natural ecosystems. Describe and explain how succession occurs.

(4)

The diagram shows percentages of energy transferred from sunlight to a zebra in a grassland ecosystem.



(b) Use the diagram to calculate the percentage of sunlight energy that would be transferred into the faeces and urine of a zebra. Give your answer to 3 significant figures.

Answer = _____%

(1)

(c) In this ecosystem the net productivity of the vegetation is 24 525 kJ m^{-2} $year^{-1}$

Use this information and the diagram above to calculate the energy stored in new tissues of the zebra in kJ m^{-2} $year^{-1}$

Answer = _____ kJ m^{-2} $year^{-1}$

(2)

(Total 7 marks)

3. Biofuels are fuels which can be produced from plants. Scientists have developed a standard method called net life-cycle carbon dioxide production (NLP) to find the overall effect of producing and using particular biofuels on carbon dioxide production.

(a) Petroleum is used as a comparison when evaluating NLPs of biofuels. Suggest **two** reasons why.

1. _____

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2. _____

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(2)

(b) Biofuels are produced by a variety of different companies. The scientists who developed the method of calculating NLPs are funded by the government's environmental agency. Suggest **two** advantages of this method being developed by these scientists.

1. _____

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2. _____

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(2)

Scientists compared the percentage change in carbon dioxide production if different biofuels replaced petroleum. Their results are shown in the table.

Biofuel	Percentage change in carbon dioxide production if this fuel replaced petroleum
Corn ethanol	–18
Soy-based biodiesel	+4
Switch-grass ethanol	–124
Sugar-cane ethanol	–26

(c) Producing and using biofuels from corn ethanol results in a negative percentage change in carbon dioxide production. Explain why.

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(2)

(d) Ethanol can be produced from cellulose. It is produced by anaerobic respiration of cellulose-based biomass by microorganisms. The cellulose is pre-treated by adding cellulose-digesting enzymes before it is used in anaerobic respiration. Suggest why pre-treatment is necessary.

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(3)

(e) Large areas of land have to be used to grow the plants to make biofuels. Ecologists have suggested that changes in land use could lead to a decrease in biodiversity.
Suggest how changes in land use could lead to a decrease in biodiversity.

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(2)

(Total 11 marks)

4. In some countries, pigs are reared in intensive units in which the temperature is controlled. Agricultural scientists investigated the effect of temperature on pig growth and on the efficiency with which the pigs converted food to biomass.

(a) (i) In the investigation, the scientists used pigs of the same breed, with similar genotypes.
Explain why.

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(2)

(ii) The pigs were allowed to eat as much food as they wanted.
How could this have decreased the reliability of any conclusions drawn from the investigation?

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(2)

The table shows the results of this investigation.

Temperature / °C	Mean growth rate / kg per day	Efficiency of conversion of food to biomass /%
0	0.54	19
10	0.80	42
20	0.85	48
30	0.45	37
35	0.31	37

(b) (i) Describe the effect of temperature on mean growth rate.

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(1)

(ii) A student concluded from these data that the mean growth rate of the pigs was fastest at 20 °C.
Do you agree with this conclusion? Explain your answer.

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(2)

(c) (i) Pigs can survive at temperatures above 35 °C. Use the data to suggest why scientists did **not** carry out any investigations at temperatures higher than 35 °C.

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(2)

(ii) The efficiency of conversion of food to biomass is lower at 0 °C than it is at 20 °C. Suggest an explanation for the lower efficiency.

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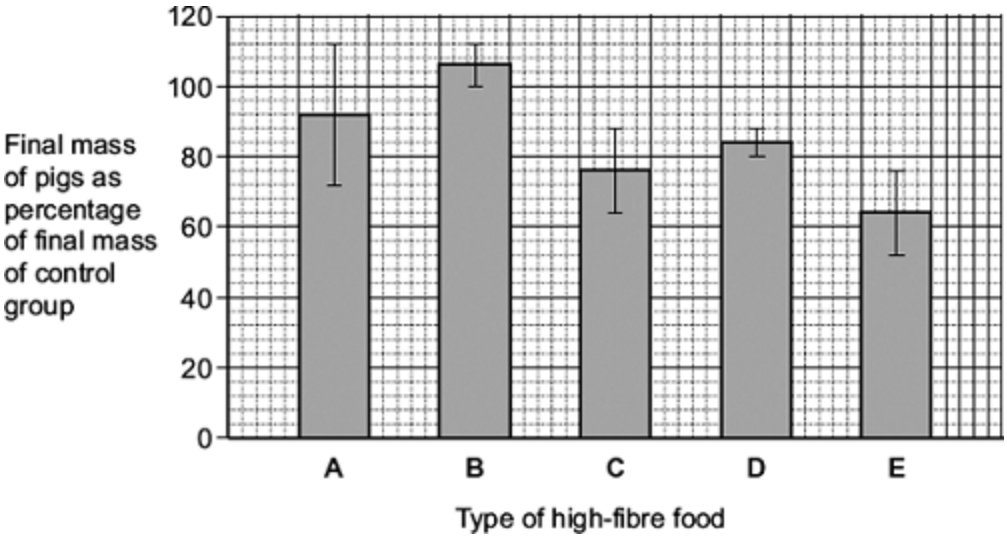
(2)

(d) Pigs require a mixture of fibre and protein in their food. The greater the ratio of fibre to protein, the less the food costs.

Scientists took five large groups of pigs. They fed each group a different high-fibre food. Each of the foods contained fibre from different plant species, but they all had the same energy content. The scientists fed a control group of pigs a low-fibre food with the same energy content. After 10 days, the scientists compared the masses of the pigs fed on high-fibre food to those fed on low-fibre food.

The graph shows the results of the investigation. The bars represent ±2 standard errors of the mean.



A farmer saw these results and concluded that he should replace his pigs' usual food with food **B**.
Evaluate this conclusion.

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(4)

(Total 15 marks)

5. Residual food intake (RFI) is the difference between the amount of food an animal actually eats and its expected food intake based on its size and growth rate. Scientists have selectively bred cattle for low RFI.

(a) (i) Explain the advantage to farmers of having cattle with a low RFI.

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(2)

(ii) When RFI is calculated, low values are negative. Explain why they are negative.

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(1)

(b) Scientists have developed a standard procedure for comparing RFI in cattle. They control **two** factors. These are type of food and environmental temperature. Explain why each of these factors needs to be controlled.

Type of food

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Environmental temperature

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(4)

(c) Bacteria in the digestive systems of cattle break down food and produce methane. Scientists investigated the relationship between RFI and methane production. They measured the rate of methane production of 76 cattle over a fifteen-day period. Some of the results are shown in **Table 1**.

Table 1

	Low RFI	**High RFI**
Mean rate of methane production / g day^{-1}	142.3	190.2

Suggest a null hypothesis for this investigation.

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(1)

(d) Other scientists investigated the release of methane from rice fields. They investigated the effect of adding organic material (straw) and inorganic substances on the release of methane from rice fields. The results are shown in **Table 2**.

Table 2

Inorganic substance added to soil	**Total methane released over 30 days / μmol kg^{-1} soil**	
	Without straw	**With straw**
None	1179	25 492
Nitrate	63	764
Sulfate	19	144
Iron oxide	39	313
Manganese oxide	53	475

(i) Which treatment is most effective in reducing release of methane from rice fields?

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(1)

(ii) Research findings are not always of direct use to farmers. What else would rice farmers need to know before acting on the results of this investigation?

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(2)

(iii) Methane is produced by anaerobic microorganisms in the soil. The scientists found that rice fields that are not flooded do not produce large amounts of methane.

Suggest why.

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(2)

(Total 13 marks)

6. Two fields, **A** and **B**, were used to grow the same crop. The fields were divided into plots. Different masses of fertiliser containing sodium nitrate were applied to these plots. After six weeks, samples of crop plants from each plot were collected and their mass determined. The results are shown in the table.

Mass of fertiliser added/kg ha^{-1}	**Mass of crop/kg m^{-2}**	
	Field **A** - used for grazing cattle in previous year	Field **B** - used for same crop in previous year
0	14.5	6.4
10	16.7	9.8
20	17.4	12.9
30	17.5	16.2
40	17.5	17.1
50	17.5	17.1
60	17.5	17.1

(a) (i) Describe the pattern shown by the data for field **B**.

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(1)

(ii) Explain the change in the mass of crop produced from field **B** when the mass of fertiliser added increases from 0 to 20 kg ha^{-1}.

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(2)

(iii) Explain why the mass of crop produced stays the same in both fields when more than 40 kg of fertiliser is added.

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(2)

(b) In the previous year, field **A** had been used for grazing cattle. Field **B** had been used to grow the same crop as this year. When no fertiliser was added, the mass of crop from field **A** was higher than from field **B**. Explain this difference.

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(2)

(Total 7 marks)