Helicate

HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.3 Energy and ecosystems

Topic question bank

Version 1 · 9 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
7	55	No time limit	/ 55

Contents

Subtopic	Questions	Marks
Biomass and its measurement Specification 3.5.3	01	10
Primary production and productivity Specification 3.5.3	02–03	14
Energy transfer and secondary production Specification 3.5.3	04–05	16
Farming practices and production Specification 3.5.3	06–07	15
Total		**55**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA A-level Biology (7402), specification section 3.5.3. Not affiliated with or endorsed by AQA.

Do not write outside the box

Biomass and its measurement 3.5.3

Miscanthus is a tall grass grown as a fuel crop. The dried stems are burned in power stations to generate electricity.

0 1 . 1 Which statement about biomass is correct?
Tick (✓) one box.

[1 mark]

Biomass can be measured as the mass of carbon per given area. ☐

Biomass can be measured as the volume of plant tissue produced in one day. ☐

Colorimetry is used to estimate how much chemical energy is stored in dry biomass. ☐

The volume of oxygen a plant releases shows how much chemical energy is stored in its dry biomass. ☐

0 1 . 2 Most of the sugars that *Miscanthus* synthesises are used as respiratory substrates.
Name **two** other groups of biological molecules that *Miscanthus* makes from these sugars and that form part of its biomass.

[1 mark]

1 .....

2 .....

Question 1 continues on the next page

Do not write outside the box

A student placed a sample of fresh *Miscanthus* stems in an oven at 80 °C. She removed the sample every 2 hours, weighed it and returned it to the oven. Table 1 shows her results.

Table 1

Total time heated / hours	0	2	4	6	8	10
Mass of sample / g	25.40	11.62	7.85	7.21	7.18	7.18

0 1 . 3 Her partner said that they could have stopped after 4 hours, because by then the mass was changing only slowly.
Use Table 1 to give the dry mass of the sample, and explain why the student was right to continue heating after 4 hours.

[2 marks]

Question 1 continues on the next page

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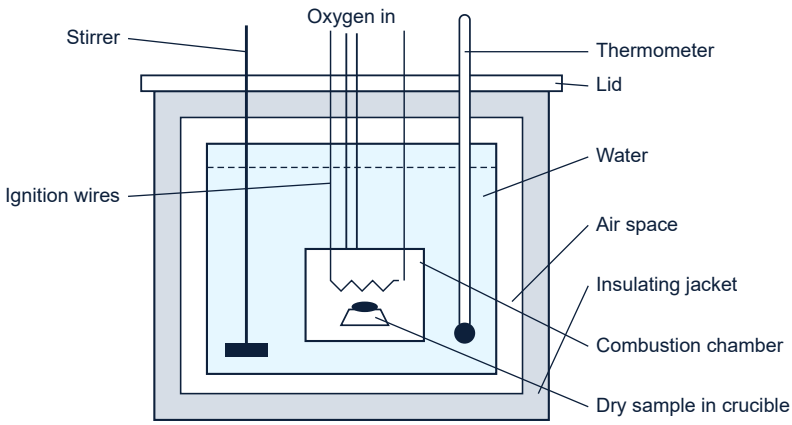
The student then used the calorimeter shown in Figure 1 to burn 0.50 g of the dried *Miscanthus*. The calorimeter contained 120 cm^3 of water.

Figure 1



0 1 . 4 Figure 1 shows that oxygen is supplied to the combustion chamber, and that the combustion chamber is surrounded by the water.
Explain how each of these features helps the rise in temperature of the water to reflect all of the chemical energy in the sample.

[2 marks]

Oxygen supply .....

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Chamber surrounded by water .....

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Question 1 continues on the next page

Do not write outside the box

A published value for the chemical energy store in dry *Miscanthus* is 17.8 kJ g^{-1}.
Each 1 cm^3 of water needs 4.18 J of heat energy for a 1 °C rise in temperature.

0 1 . 5 Calculate the rise in temperature of the water that the student should expect if all the chemical energy in the sample is transferred to the water.

[2 marks]

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Answer ..... **°C**

0 1 . 6 The temperature of the water rose by 14.6 °C.
Suggest **two** reasons why this rise was smaller than the rise expected from the published value.

[2 marks]

1 .....

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2 .....

.....

10

Turn over for the next question

Do not write outside the box

Primary production and productivity 3.5.3

Scientists estimated the gross primary production (GPP) and the respiratory losses (R) of the plants in three ecosystems. Table 2 shows their estimates.

Table 2

Ecosystem	GPP / kJ m^{-2} $year^{-1}$	R / kJ m^{-2} $year^{-1}$
Tropical rainforest	98 000	62 000
Temperate grassland	24 500	11 800
Maize crop	52 000	21 300

0 2 . 1 Explain the difference between gross primary production and net primary production.

[2 marks]

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0 2 . 2 Give **two** ways in which the net primary production of the temperate grassland may be used.

[2 marks]

1 .....

2 .....

Question 2 continues on the next page

Do not write outside the box

0 2 . 3 Calculate the percentage of the GPP of the temperate grassland that becomes net primary production.
Give your answer to **three** significant figures.

[2 marks]

Answer ..... **%**

0 2 . 4 A smaller percentage of GPP becomes net primary production in the tropical rainforest than in the maize crop.
Suggest an explanation for this difference.

[2 marks]

8

Turn over for the next question

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A student estimated the net primary productivity of the grass in a meadow. On day 0, she cut all the grass above soil level in five 0.25 m^2 quadrats. She dried each sample to constant mass and weighed it. On day 30, she repeated this using five different quadrats in the same meadow.

Table 3 shows her results.

Table 3

Quadrat	Dry mass of grass in quadrat / g	
	Day 0	Day 30
1	42.1	61.5
2	38.6	66.2
3	45.3	58.9
4	40.2	64.7
5	43.8	63.7

0 3 . 1 Use Table 3 to calculate the mean rate of increase in the dry mass of the grass, per square metre of the meadow per day.
Give the unit for your answer.

[3 marks]

Answer .....

Unit .....

Question 3 continues on the next page

Do not write outside the box

0 3 . 2 The student's teacher said that her result underestimates the net primary productivity of the grass.
Suggest **two** reasons why.

[2 marks]

1 .....

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2 .....

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0 3 . 3 Suggest why the student cut grass from five quadrats on each day rather than from one.

[1 mark]

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6

Turn over for the next question

Do not write outside the box

Energy transfer and secondary production 3.5.3

Scientists fed a young rabbit and a group of 50 locusts on clover leaves for 10 days. Both were kept at 20 °C. Rabbits keep a constant body temperature. The body temperature of a locust changes with the temperature of its surroundings.

The scientists measured the chemical energy in the food each herbivore ingested, and the chemical energy each lost to the environment. Table 4 shows their results.

Table 4

Chemical energy over 10 days / kJ	Rabbit	Locusts
In ingested food, *I*	16 500	2140
Lost in faeces and urine, *F*	5610	790
Respiratory losses, *R*	9400	845

0 4 . 1 What was the net production, *N*, of the rabbit during the 10 days?
Tick (✓) one box.

[1 mark]

1490 kJ ☐

7100 kJ ☐

10 890 kJ ☐

20 290 kJ ☐

Question 4 continues on the next page

Do not write outside the box

0 4 . 2 Calculate the percentage of the chemical energy in the food ingested by the locusts that became net production.

[2 marks]

Answer ..... **%**

0 4 . 3 The net production of the rabbit was 9.0% of the chemical energy in its ingested food.
Use Table 4 to explain why this percentage is lower for the rabbit than for the locusts.

[3 marks]

0 4 . 4 A large percentage of the chemical energy in the food ingested by both herbivores is lost in faeces and urine.
Suggest why.

[2 marks]

Question 4 continues on the next page

Do not write outside the box

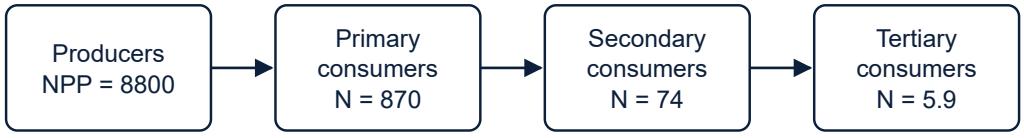
0 4 . 5 Suggest how the scientists could have found the chemical energy in the rabbit's faeces.

[2 marks]

10

Figure 2 shows the net primary production (NPP) of the producers (algae and pondweed) in a pond, and the net production (*N*) of the consumers at each trophic level. All values are in kJ m^{-2} $year^{-1}$.

Figure 2



0 5 . 1 The efficiency of energy transfer between two trophic levels can be calculated using this formula.

efficiency (%) = (*N* of higher level ÷ *N* of lower level) × 100

Calculate the efficiency of energy transfer from secondary consumers to tertiary consumers.

[1 mark]

Answer ..... **%**

Question 5 continues on the next page

Do not write outside the box

0 5 . 2 Use Figure 2 and your knowledge of energy transfer to explain why the net production of the tertiary consumers is much smaller than the NPP of the producers.

[5 marks]

6

Turn over for the next question

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Farming practices and production 3.5.3

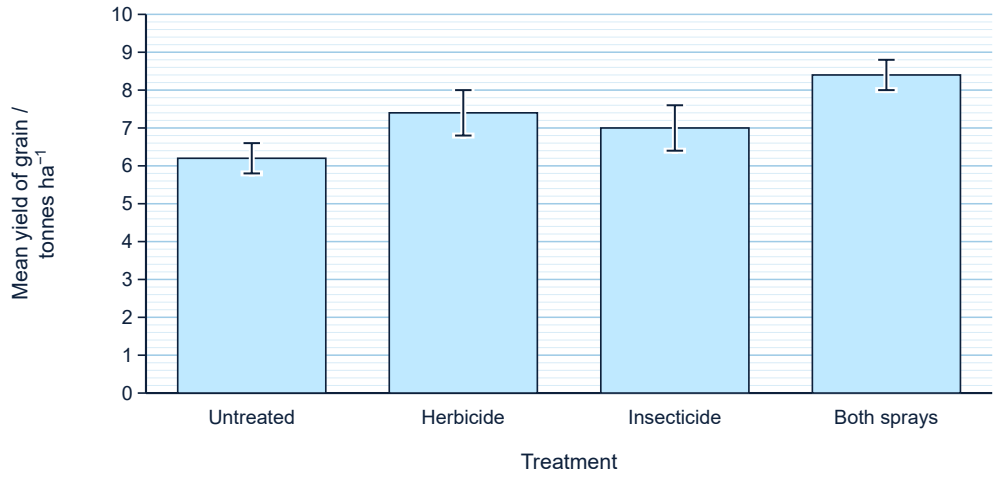
Aphids are insects that feed on the sap of wheat plants. Weeds are other plant species that grow among the wheat.

A farmer divided a field of wheat into 16 plots. She gave four plots each treatment:

- no spray (untreated)
- a herbicide, which kills weeds
- an insecticide, which kills aphids
- both the herbicide and the insecticide (both sprays).

She measured the mass of wheat grain harvested from each plot. Figure 3 shows her results. The error bars show ± 1 standard deviation.

Figure 3



0 6 . 1 Calculate the percentage increase in the mean yield of grain when both the herbicide and the insecticide were used, compared with untreated plots.

[2 marks]

Answer ..... **%**

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Use your knowledge of energy transfer to explain how spraying with the insecticide **and** spraying with the herbicide each increased the yield of wheat grain.

[3 marks]

0 6 . 3 The farmer concluded that killing weeds increases the yield of wheat more than killing aphids does.
Evaluate this conclusion.

[4 marks]

9

Turn over for the next question

Do not write outside the box

Pigs can be reared outdoors or indoors. Table 5 compares the two methods on one farm. The pigs were the same breed and were slaughtered when they reached the same body mass.

Table 5

	Outdoor rearing	Indoor rearing
Mean air temperature / °C	9	21
Space for each pig	Field, free to move around	Pen with 0.9 m^2 of floor
Food	Grass and cereal pellets	Cereal pellets with a low cellulose content
Mean mass of food eaten per 1 kg gain in body mass / kg	3.6	2.7
Mean age at slaughter / days	190	160

0 7 Use Table 5 and your knowledge of energy transfer to explain why indoor rearing produces more pig biomass from each kilogram of food.

[6 marks]

6

END OF QUESTIONS

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