HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.3 Energy and ecosystems

Mark scheme

Version 1 · 9 October 2026

TOTAL MARKS	QUESTIONS
55	7

How to use this mark scheme

;	Separates marking points. Each semicolon marks the end of one creditable point, and each point is worth one mark.
;;	Two marks for this answer (used for calculations).
/	Alternative words or phrases that are credited for the same point.
OR	An alternative answer for the same mark.
( )	Words in brackets are not needed to gain the mark.
max	More marking points are listed than marks available. Award up to the number of marks shown.
Accept	An alternative answer that gains credit.
Reject	A wrong answer. It does not gain credit and cancels a correct point it contradicts.
Ignore	Neither credited nor penalised. Mark the rest of the answer.
ECF	Error carried forward: credit correct working that uses an earlier wrong answer.
AO	Assessment objective: AO1 knowledge and understanding; AO2 applying knowledge; AO3 analysing, interpreting and evaluating.

Where an answer is correct but not listed, credit it if it is biologically accurate and answers the question at the depth the marks require. Right + wrong = wrong: a contradiction cancels a correct point.

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Biomass and its measurement 3.5.3

Question	Marking guidance	Mark	Comments
01.1	Biomass can be measured as the mass of carbon per given area;	**1** (1 × AO1)	Biomass is measured as mass of carbon or dry mass of tissue per given area; its chemical energy store is estimated by calorimetry.

Question	Marking guidance	Mark	Comments
01.2	Any **two** from: polysaccharides; lipids; proteins; nucleic acids;	**1** (1 × AO1)	**Accept** named examples, eg starch / cellulose for polysaccharides; triglycerides / phospholipids for lipids; polypeptides / enzymes for proteins; DNA / RNA for nucleic acids Two named examples from the same group = 0 marks, eg starch and cellulose **Reject** sugars, eg glucose / sucrose **Ignore** carbohydrates unqualified

Question	Marking guidance	Mark	Comments
01.3	1. Dry mass = 7.18 (g) because the mass stayed constant (from 8 to 10 hours); 2. At 4 hours the sample still contained water (mass still falling, 7.85 g), so stopping then would overestimate the dry mass;	**2** (2 × AO3)	1. The mark needs 7.18 g **and** a reference to constant/unchanging mass 2. **Accept** so all the water is removed only when heated to constant mass 2. **Accept** weight for mass **Reject** references to burning the sample

Question	Marking guidance	Mark	Comments
01.4	1. (Oxygen supply) allows complete combustion, so all the chemical energy in the sample is released (as heat); 2. (Chamber in the water) heat from the burning sample passes directly into the water OR less heat is lost to the air/surroundings;	**2** (2 × AO3)	Each feature must be explained in terms of combustion or heat 1. **Ignore** 'oxygen is needed for burning' unqualified 2. **Accept** heat is conducted through the chamber wall into the water 2. **Reject** vacuum

Question	Marking guidance	Mark	Comments
01.5	Correct answer for 2 marks: 17.7 OR 17.74 OR 18 (°C);; Accept for 1 mark, an incorrect answer with one error: shows 177 (ignore position of the decimal point and any further digits), ie kJ/J conversion error **OR** 35.5 (mass of sample not used) OR 71.0 (divided by 0.50 instead of multiplied) **OR** 74.2 (4.18 not used) OR 2129 (volume of water not used)	**2** (2 × AO2)	Working: 17.8 × 0.50 = 8.9 kJ = 8900 J; 120 × 4.18 = 501.6 J per °C; 8900 ÷ 501.6 = 17.74 °C

Question	Marking guidance	Mark	Comments
01.6	1. Some heat was lost to the surroundings (eg through the lid/jacket); 2. Some heat was absorbed by the calorimeter/chamber/thermometer/stirrer (and not by the water); 3. Incomplete combustion OR not all of the sample burned; 4. Highest temperature reached was not recorded OR the water was not stirred (before reading the temperature);	**2 max** (2 × AO3)	**Accept** the student's *Miscanthus* had a lower energy content than the published sample (eg different variety/growing conditions) **Ignore** 'sample not dried' (Table 1 shows it was dried to constant mass) **Ignore** 'human error' or 'inaccurate thermometer/balance' unqualified

Primary production and productivity 3.5.3

Question	Marking guidance	Mark	Comments
02.1	1. GPP is the (total) chemical energy store in plant biomass (in a given area or volume); 2. NPP is the chemical energy store (in plant biomass) after respiratory losses (to the environment) are taken into account OR NPP = GPP − R;	**2** (2 × AO1)	2. **Accept** 'is' for =; accept RL for R; accept respiration for respiratory losses **Accept** GPP and NPP in answers **Reject** references to consumers/animals having NPP

Question	Marking guidance	Mark	Comments
02.2	1. Growth (of the plants); 2. Reproduction (of the plants); 3. (Eaten by) herbivores/primary consumers OR passed to the next trophic level; 4. (Dead material used by) decomposers;	**2 max** (2 × AO1)	3. **Accept** a named herbivore, eg rabbits / cattle **Reject** respiration (respiratory losses are not part of NPP) **Ignore** 'stored' unqualified

Question	Marking guidance	Mark	Comments
02.3	Correct answer for 2 marks: 51.8 (%);; Accept for 1 mark: NPP = 12 700 (kJ m^{-2} $year^{-1}$) **OR** 51.84 OR 52 (correct, but not to 3 significant figures)	**2** (2 × AO2)	Working: 24 500 − 11 800 = 12 700; 12 700 ÷ 24 500 × 100 = 51.84 **Reject** 48.2 (percentage lost in respiration) for 2 marks

Question	Marking guidance	Mark	Comments
02.4	1. Rainforest trees have a large mass of non-photosynthetic tissue (eg trunks/woody stems/roots) that respires but does not photosynthesise; 2. Higher (mean) temperature in the rainforest increases the rate of respiration (of plant tissue); 3. The maize crop is young/growing and mostly made of photosynthetic/leaf tissue, so less tissue respires without photosynthesising;	**2 max** (2 × AO2)	**Ignore** a restatement that R is a larger proportion of GPP in the rainforest (63% v 41%) unless a reason is given **Reject** 'more energy used in respiration' and energy 'produced/made' in respiration 1. **Accept** older/larger trees have more tissue that respires but does not photosynthesise **Accept** GPP and NPP in answers **Ignore** references to light intensity or photosynthesis rate unless linked to respiration

Question	Marking guidance	Mark	Comments
03.1	Correct answer for 2 marks: 2.8;; Accept for 1 mark: 84 (not divided by 30 days) OR 0.7 (not converted to 1 m^2) OR mean increase of 21 (g per quadrat) Unit (1 mark): g m^{-2} day^{-1};	**3** (3 × AO2)	Working: means 42.0 g and 63.0 g; increase 21.0 g per 0.25 m^2 = 84.0 g m^{-2}; ÷ 30 = 2.8 g m^{-2} day^{-1} Unit: accept g/m^2/day, g per m^2 per day, g day^{-1} m^{-2}; mark the unit independently of the value Unit: the unit must be mass per area per time; do not award the unit mark for g m^{-2} or g Unit: reject mass in the denominator, eg m^2 g^{-1}, or units that do not start with mass, eg m^{-2} day^{-1} g

Question	Marking guidance	Mark	Comments
03.2	1. Roots/below-ground growth were not included; 2. Some (new) growth was eaten by herbivores/primary consumers (eg insects) during the 30 days; 3. Some (dead) leaves were broken down by decomposers OR fell to the ground and were not collected; 4. Some biomass was used in reproduction, eg seeds were shed;	**2 max** (1 × AO1) (1 × AO3)	**Ignore** respiration, as NPP is measured after respiratory losses **Ignore** 'not all water removed' (this would overestimate)

Question	Marking guidance	Mark	Comments
03.3	(Dry mass of grass varies between quadrats, so) a mean is more representative of the meadow OR reduces the effect of an anomalous quadrat;	**1** (1 × AO3)	**Accept** 'to make the results more reliable' only if linked to calculating a mean or to variation in the meadow **Ignore** 'fair test'

Energy transfer and secondary production 3.5.3

Question	Marking guidance	Mark	Comments
04.1	1490 kJ;	**1** (1 × AO2)	$N = I - (F + R)$ = 16 500 − (5610 + 9400) = 1490 kJ

Question	Marking guidance	Mark	Comments
04.2	Correct answer for 2 marks: 23.6 OR 24 (%);; Accept for 1 mark: *N* = 505 (kJ) **OR** correct percentage from an incorrect *N*, eg 63.1 (*R* not subtracted) OR 60.5 (*F* not subtracted)	**2** (2 × AO2)	Working: 2140 − (790 + 845) = 505; 505 ÷ 2140 × 100 = 23.60 **Accept** 23.60 for 2 marks

Question	Marking guidance	Mark	Comments
04.3	1. A greater percentage of ingested energy is lost in respiration by the rabbit (57% compared with 39%) OR *R* is a larger proportion of *I* for the rabbit; 2. Rabbit maintains a constant body temperature (above that of its surroundings), so it has a higher rate of respiration; 3. (More) energy is lost (to the environment) as heat from respiration; 4. So less (chemical) energy is available for growth OR less energy is stored in (rabbit) biomass;	**3 max** (1 × AO1) (2 × AO2)	1. **Accept** correct use of figures, eg comparing 9 400 ÷ 16 500 with 845 ÷ 2 140 3. Heat must be linked to respiration **Reject** energy 'used' in respiration or energy 'produced/made' **Ignore** faeces and urine (a similar percentage for both, 34% and 37%)

Question	Marking guidance	Mark	Comments
04.4	1. Some (plant) food is not digested/absorbed, eg cellulose/cell walls; 2. Herbivores lack (their own) enzymes to digest/hydrolyse cellulose; 3. Excretion of (nitrogenous) waste, eg urea, which contains chemical energy, in urine;	**2 max** (2 × AO1)	1. **Accept** lignin for cellulose, but never require it 1. 'Lost in faeces' alone restates the question: no mark 2. **Accept** no cellulase 3. **Accept** uric acid for urea **Reject** faeces described as an excretory product **Ignore** 'waste' unqualified

Question	Marking guidance	Mark	Comments
04.5	1. Collect all the faeces (over the 10 days) and dry (in an oven) to constant mass; 2. Burn/combust a known mass of the dry faeces in a calorimeter; 3. Measure the temperature rise of a known volume of water and calculate energy per gram, then multiply by the total dry mass;	**2 max** (2 × AO3)	1. **Accept** heat and weigh until mass is constant 2. **Accept** calorimetry 2. **Reject** colorimeter

Question	Marking guidance	Mark	Comments
05.1	8.0 (%);	**1** (1 × AO2)	Working: 5.9 ÷ 74 × 100 = 7.97 **Accept** 7.97 OR 8

Question	Marking guidance	Mark	Comments
05.2	1. Less than 10% (of energy) is transferred at each step (9.9%, 8.5% and 8.0%); 2. Losses occur at each of three transfers, so only about 0.07% of NPP becomes *N* of the tertiary consumers; 3. Not all of the organisms (at one trophic level) are eaten OR some parts (eg bones/roots) are not eaten; 4. Some (ingested) food is not digested/absorbed and is lost in faeces; 5. Energy is lost in excretion/urine/urea; 6. Energy is lost (to the environment) as heat from respiration; 7. Dead organisms/remains are used by decomposers (not the next trophic level);	**5 max** (3 × AO1) (2 × AO2)	**Max 3** from points 3–7 1. **Accept** a correct efficiency for any one transfer 2. **Accept** 0.07% or 0.067% 6. Heat must be linked to respiration **Reject** energy 'used' in respiration or energy 'produced/made' **Do not credit** 'not digested' and 'faeces' as separate points

Farming practices and production 3.5.3

Question	Marking guidance	Mark	Comments
06.1	Correct answer for 2 marks: 35.5 OR 35 (%);; Accept for 1 mark: a difference of 2.2 (tonnes ha^{-1}) OR (8.4 − 6.2) ÷ 6.2 **OR** correct method using the student's readings from the graph	**2** (2 × AO2)	Plotted values: 6.2 (untreated) and 8.4 (both) **Accept** readings of 6.1–6.3 and 8.3–8.5, giving answers in the range 31 to 40 (%), for 2 marks **Reject** 135.5 (yield as a percentage of untreated) for 2 marks

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Question	Marking guidance	Mark	Comments
06.2	1. (Insecticide) fewer aphids/primary consumers feed on the wheat; 2. So less energy (from the wheat's NPP/biomass) is lost to non-human food chains OR the food web is simplified; 3. (Herbicide) fewer weeds compete with the wheat for light/water/mineral ions/carbon dioxide; 4. So the wheat photosynthesises more OR has a greater GPP/NPP; 5. More energy is stored in the wheat biomass/grain (available to humans);	**3 max** (2 × AO1) (1 × AO2)	**Max 2** if only one treatment is explained 2. **Accept** less energy transferred to (aphids in) other food chains **Accept** GPP and NPP in answers

Question	Marking guidance	Mark	Comments
06.3	1. (Supports) mean yield is higher with herbicide (7.4) than with insecticide (7.0) (tonnes ha^{-1}); 2. (Against) the difference is small (0.4 tonnes ha^{-1}); 3. (Against) the standard deviations/error bars overlap, so the difference may not be significant OR may be due to chance; 4. (Against) no statistical test was carried out; 5. (Against) only four plots per treatment OR only one field/one year/one variety of wheat, so the result may not apply generally; 6. (Against) the numbers of weeds and aphids were not measured OR the sprays may have had other effects on the wheat;	**4 max** (4 × AO3)	**Max 3** if no supporting point is given 3. **Accept** 'SDs overlap' **Ignore** 'repeat the experiment' unqualified

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Question	Marking guidance	Mark	Comments
07	1. Warmer surroundings (21 °C compared with 9 °C), so less heat is lost to the surroundings OR less energy is needed to maintain body temperature; 2. Small pens restrict movement, so less muscle contraction; 3. So less respiration OR reduced respiratory losses (*R*); 4. So less energy is lost (to the environment) as heat from respiration; 5. Food with less cellulose is more easily digested, so less energy is lost in faeces (*F*); 6. $N = I - (F + R)$, so a greater proportion of the energy in the food (*I*) becomes net production/is available for growth OR is stored in biomass; 7. Pigs reach slaughter mass sooner (160 compared with 190 days), so fewer days of respiratory losses (to maintain the body);	**6 max** (3 × AO1) (3 × AO2)	**Max 5** if no data from Table 5 are used 6. **Accept** as part of point 6: indoor pigs need 2.7 kg rather than 3.6 kg of food per kg gain, or gain 0.37 kg rather than 0.28 kg per kg of food, but only when linked to less energy lost (in *F* or *R*) 3. **Reject** energy 'used' in respiration or energy 'produced/made' 1. Heat loss must be linked to body temperature or respiration **Ignore** references to animal welfare, cost or disease

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