HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.4 Nutrient cycles

Mark scheme

Version 2 · 15 October 2026

TOTAL MARKS	QUESTIONS
59	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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Microorganisms and the nitrogen cycle 3.5.4

Question	Marking guidance	Mark	Comments
01.1	Ammonium ions are oxidised to nitrite ions and then to nitrate ions by nitrifying bacteria;	**1** (1 × AO1)	Nitrification is the oxidation of ammonium to nitrite and then nitrate, by nitrifying bacteria.

Question	Marking guidance	Mark	Comments
01.2	1. (P) Ammonification; 2. (S) Denitrification;	**2** (2 × AO1)	1. **Ignore** decomposition / putrefaction / saprobiotic nutrition unqualified 1. **Reject** nitrification 2. **Reject** nitrification / nitrogen fixation Mark each label independently

Question	Marking guidance	Mark	Comments
01.3	1. Secrete enzymes (onto the dead leaves) OR extracellular digestion; 2. (Enzymes) hydrolyse protein into amino acids; 3. Absorb the soluble products (of digestion), eg amino acids; 4. Convert (the nitrogen in) amino acids/proteins into ammonium ions/ammonia OR ammonification;	**3 max** (3 × AO1)	**Accept** saprophytes / saprotrophs for saprobionts throughout 1. **Reject** ingest / engulf (the leaves) 2. **Accept** digest / break down for hydrolyse 2. **Reject** peptides/amino acids produced by condensation 4. **Accept** NH_4^+ / NH_3 **Ignore** nitrification and nitrogen fixation

Question	Marking guidance	Mark	Comments
02.1	Correct answer for 2 marks: 72.5 (%);; Accept for 1 mark: a decrease of 29 (mg kg^{-1}) **OR** correct method using the student's readings from the graph	**2** (2 × AO2)	Plotted values: 40 (day 0) and 11 (day 10) **Accept** 72 or 73 for 2 marks **Accept** readings within ±1 mg kg^{-1}, giving answers in the range 69 to 76 (%), for 2 marks **Reject** 27.5 (day 10 as a percentage of day 0) = 0 marks

Question	Marking guidance	Mark	Comments
02.2	1. Nitrate fell by 36 mg kg^{-1} but ammonium rose by only 18 mg kg^{-1} OR the fall in nitrate is (about) twice the rise in ammonium, so at least half of the nitrogen lost from nitrate did not become ammonium; 2. Waterlogged soil has little oxygen/is anaerobic, so denitrifying bacteria convert/reduce nitrate to nitrogen gas, which is lost from the soil to the air (denitrification); 3. Some nitrate is absorbed by the grass roots (to make amino acids/proteins) OR is leached/washed out of the soil by the flood water; 4. The ammonium comes from dead organic matter, by saprobionts/ammonification; 5. Nitrifying bacteria need oxygen, so the ammonium is not oxidised to nitrite and nitrate (and accumulates);	**4 max** (4 × AO2)	**Max 3** if no data from Figure 2 are used 1. **Accept** readings within ±1 mg kg^{-1} 1. **Accept** a statement that this assumes little ammonium was removed (eg absorbed by roots) during the 20 days; never required 2. **Accept** NO_3^- reduced to N_2 2. **Reject** nitrate converted to ammonium/ammonia by denitrifying bacteria 2. Nitrate converted to nitrogen gas gains the mark without "lost to the air" 4. **Accept** saprophytes / saprotrophs 4. **Reject** saprobionts are anaerobic / convert nitrate to ammonium 5. Order must be nitrite then nitrate

Question	Marking guidance	Mark	Comments
02.3	1. More oxygen for nitrifying bacteria, so more nitrification; 2. (So more) ammonium is oxidised/converted to nitrite and then nitrate; 3. Less denitrification (because denitrifying bacteria are anaerobic); 4. More oxygen for (aerobic respiration by) saprobionts, so more decomposition/ammonification;	**2 max** (2 × AO2)	1. **Accept** nitrifying bacteria respire aerobically 2. Order must be nitrite then nitrate **Ignore** 'more oxygen' unless linked to a named type of bacteria or process

Question	Marking guidance	Mark	Comments
03.1	1. (Bacteria) convert nitrogen (gas) into ammonia/ammonium (ions) OR nitrogen fixation produces ammonia/ammonium; 2. Plant uses the ammonium/nitrogen to make amino acids/protein/DNA/RNA/ATP/chlorophyll (for growth); 3. No other source of nitrogen in the solution, so nitrogen would otherwise limit growth;	**2 max** (2 × AO1)	1. 'Fix nitrogen' alone is not enough: the product must be given 1. **Reject** nitrogen converted to nitrate (by nitrogen-fixing bacteria) 1. **Accept** N_2 into NH_3/NH_4^+ 2. **Accept** any named nitrogen-containing organic molecule **Ignore** 'the bacteria obtain carbohydrates/sugars from the plant (mutualism)': correct but not required

Question	Marking guidance	Mark	Comments
03.2	4.4 (times);	**1** (1 × AO2)	Working: 1.86 ÷ 0.42 = 4.43 **Accept** 4.43 **Reject** 4 (too few significant figures) **Reject** 443% or 343% for the mark

Question	Marking guidance	Mark	Comments
03.3	1. (Supports) mean dry mass with bacteria (1.86 g) is similar to that with nitrate (2.04 g) OR both are much greater than with neither (0.42 g); 2. (Supports) the standard deviations (of B and C) overlap, so the difference is not significant OR is (likely) due to chance; 3. (Against) the mean is (slightly) lower with bacteria than with nitrate (by 0.18 g); 4. (Against) no statistical test was carried out; 5. (Against) only 8 plants per treatment OR only one concentration of nitrate OR grown in sand in pots, not in soil in a field; 6. (Against) only 8 weeks, and the bacteria take time to form nodules/fix nitrogen, so a longer study might give a different result;	**3 max** (3 × AO3)	**Max 2** if only supporting or only against points are given 1. 'Both much greater than A' gains credit only if B and C are also said to be similar 2. **Accept** 'SDs overlap' **Reject** 'results are significant/not significant' with no comparison **Ignore** 'repeat the experiment' unqualified 6. **Ignore** 'the experiment was too short' unless linked to the time needed for nodules to form or nitrogen fixation to start

Question	Marking guidance	Mark	Comments
03.4	1. Nitrogen/nitrate was no longer the limiting factor (in C) OR another factor, eg light/carbon dioxide/temperature/another mineral ion, limited growth; 2. The bacteria use carbohydrates/sugars from the plant (so less is available for the plant's growth); 3. Less nitrogen fixation (or fewer nodules form) when nitrate is available;	**2 max** (2 × AO3)	1. **Accept** named limiting factor 2. **Accept** organic compounds / respiratory substrate for carbohydrates **Ignore** a restatement that the difference (0.06 g) is small or not significant: the stem gives this **Ignore** 'too much nitrate' unqualified

The phosphorus cycle and mycorrhizae 3.5.4

Question	Marking guidance	Mark	Comments
04.1	Correct answer for 2 marks: 93.3 OR 93 (%);; Accept for 1 mark: 11.2 (kg ha^{-1} $year^{-1}$) returned by saprobionts **OR** 58.3 (dead grass only)	**2** (2 × AO2)	Working: 7.0 + 4.2 = 11.2; 11.2 ÷ 12.0 × 100 = 93.33 **Accept** 93.33 for 2 marks

Question	Marking guidance	Mark	Comments
04.2	1. Phosphorus in the sheep that are sold (0.8) is removed from the field/is not returned to the soil; 2. Phosphate is lost from the soil by leaching (0.3); 3. Weathering adds only 0.4, which is less than the losses (1.1) OR the soil receives 11.6 but loses 12.3;	**2 max** (2 × AO2)	**Ignore** references to fertiliser **Reject** 'the grass uses up the phosphate' unless linked to removal in sold sheep

Question	Marking guidance	Mark	Comments
04.3	Correct answer for 2 marks: 17.5 (kg);; Accept for 1 mark: net loss of 0.7 (kg ha^{-1} $year^{-1}$) **OR** correct multiplication by 25 of an incorrect net loss (ECF)	**2** (2 × AO2)	Working: (12.0 + 0.3) − (0.4 + 11.2) = 0.7; 0.7 × 25 = 17.5 **Accept** 0.8 + 0.3 − 0.4 = 0.7 as the net loss **Accept** ECF from an incorrect value for the phosphorus returned by saprobionts (11.2) or an incorrect net loss

Question	Marking guidance	Mark	Comments
04.4	1. DNA; 2. RNA; 3. ATP/ADP; 4. Phospholipid; 5. RuBP; 6. GP; 7. Triose phosphate; 8. NADP;	**2 max** (2 × AO1)	Any **two** for 2 marks **Accept** any other named organic phosphorus-containing molecule, eg nucleotide mRNA/tRNA count as RNA, not as a separate point; ATP and ADP count as one point **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once **Reject** protein / amino acid / glucose **Ignore** 'phosphate' on its own

Question	Marking guidance	Mark	Comments
05.1	1. Mycorrhizae increase the uptake of (water and) inorganic ions/phosphate (by the roots); 2. (The fungal hyphae) increase the surface area for absorption OR extend further into the soil; 3. Phosphate is used to make DNA/RNA/ATP/phospholipids (for growth);	**2 max** (2 × AO1)	**Max 1** unless point 1 is given 2. **Accept** mycorrhizae act as an extension of the roots **Ignore** 'the fungus receives sugars/carbohydrates from the plant (mutualism)': correct but not required

Question	Marking guidance	Mark	Comments
05.2	3.2 (times);	**1** (1 × AO2)	Plotted values: 1.6 g and 0.5 g **Accept** answers in the range 3.1 to 3.3

Question	Marking guidance	Mark	Comments
05.3	1. (Supports) with the fungus, at low phosphate (0 to 100 mg kg^{-1}) the mean shoot mass is greater (than without the fungus); 2. (Supports) plants with the fungus given 50 mg kg^{-1} grew more (3.8 g) than plants without it given 100 mg kg^{-1} (3.1 g) OR with the fungus, 100 mg kg^{-1} gives as much growth as 200 mg kg^{-1} without it; 3. (Against) at high phosphate (200/400 mg kg^{-1}) there is little or no difference OR at 400 mg kg^{-1} plants without the fungus have a greater mass (4.7 g v 4.5 g); 4. (Against) no standard deviations/error bars OR no statistical test, so we do not know if the differences are significant; 5. (Against) plants were grown in pots (in sterilised soil), not in fields, so conditions differ from a farm; 6. (Against) field soil may already contain mycorrhizal fungi, so adding spores may give no extra benefit; 7. (Against) only leeks/one plant species OR only one species of fungus was tested; 8. (Against) only shoot dry mass was measured, not the yield of the crop OR the plants were not grown to harvest;	**5 max** (5 × AO3)	**Max 3** if only supporting or only against points are given **Max 4** if no data from Figure 4 are used 2. **Accept** any correct comparison showing the same or greater growth with less phosphate when the fungus is present 4. **Accept** 'SDs' **Ignore** cost unless linked to the data **Ignore** 'repeat the experiment' unqualified

Question	Marking guidance	Mark	Comments
05.4	1. The fungus obtains sugars/carbohydrates/organic substances from the plant, so less is available for the plant's growth; 2. Phosphate is no longer a limiting factor, so the fungus gives no benefit in return for the sugars it takes OR the cost to the plant outweighs the benefit; 3. The difference is small (0.2 g) and there are no standard deviations/statistical test, so it may be due to chance;	**2 max** (2 × AO3)	1. **Accept** the fungus uses the plant's respiratory substrate 2. Must be linked to a cost to the plant; 'phosphate is not limiting' alone does not explain a lower mass 2. **Ignore** 'too much phosphate' unqualified

Fertilisers, leaching and eutrophication 3.5.4

Question	Marking guidance	Mark	Comments
06.1	1. Nitrates/phosphates absorbed by the crop are removed when it is harvested, so they are not returned to the soil by decomposition/saprobionts; 2. Fertilisers replace the lost nitrates/phosphates (so they do not limit growth); 3. Nitrates are also lost by leaching, eg from bare soil after harvest;	**2 max** (2 × AO1)	1. **Accept** the crop does not die and decompose in the field **Ignore** 'crops use up the nutrients' unqualified

Question	Marking guidance	Mark	Comments
06.2	Much of the nitrogen in natural fertilisers is in organic compounds that saprobionts must break down before plants can absorb it;	**1** (1 × AO1)	Natural fertilisers (eg manure) contain organic matter that is decomposed by saprobionts; artificial fertilisers contain inorganic ions.

Question	Marking guidance	Mark	Comments
06.3	Correct answer for 2 marks: 20 (%);; Accept for 1 mark: 34 (kg ha^{-1} $year^{-1}$) lost because of the fertiliser **OR** 27.1 (no-fertiliser loss not subtracted)	**2** (2 × AO2)	Working: 46 − 12 = 34; 34 ÷ 170 × 100 = 20.0

Question	Marking guidance	Mark	Comments
06.4	1. Ammonium nitrate contains soluble ions, so a large amount of nitrate is in the soil water at once; 2. More nitrate than the crop roots can absorb, so the excess dissolves in rainwater and is washed out of the soil in the drainage water (leaching); 3. Nitrogen in manure is (mostly) in organic compounds, eg protein/urea, which must be decomposed by saprobionts/ammonified and nitrified first; 4. So nitrate is released slowly/gradually and is absorbed by the crop as it is released OR less nitrate is in the soil water at any one time to be leached;	**3 max** (1 × AO1) (2 × AO2)	**Max 2** if no data from Table 2 are used, eg 46 v 21 kg ha^{-1} $year^{-1}$ 2. A definition of leaching alone, not linked to the larger amount of nitrate from ammonium nitrate, gains no credit 3. **Accept** saprophytes / saprotrophs **Reject** 'manure contains no nitrate' **Ignore** eutrophication

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Question	Marking guidance	Mark	Comments
06.5	1. (For) less nitrate is leached with manure (21 v 46 kg ha^{-1} $year^{-1}$) OR 5.3% v 20% of added nitrogen lost, so less risk of eutrophication/pollution of rivers; 2. (Against) the yield of grain is lower with manure (6.4 v 8.2 tonnes ha^{-1}) OR ammonium nitrate gives about 28% more grain; 3. (Against) no standard deviations/statistical test OR only one year/one site/one variety, so the results may not apply to her fields; 4. (Against) only one rate of each fertiliser was tested OR a different rate/timing of ammonium nitrate might reduce leaching; 5. (For) manure recycles farm animal waste OR adds organic matter/other ions, eg phosphate, to the soil; 6. (For) organic nitrogen in manure continues to be released in later years, so a one-year trial may underestimate its effect on yield;	**3 max** (3 × AO3)	**Max 2** if only for or only against points are given 1. **Accept** less nitrate in drainage water **Ignore** cost unless linked to yield or to the data **Ignore** 'repeat the experiment' unqualified

Question	Marking guidance	Mark	Comments
07.1	1. Rain washes/leaches (soluble) nitrate from the fields into the stream/lake (nitrate rises from 2.1 to 9.4 mg dm^{-3} by May); 2. Nitrate is no longer limiting, so algae grow/reproduce rapidly OR algal bloom (chlorophyll rises from 4 to 96 µg dm^{-3}); 3. Algae (at the surface) block light (from reaching plants below); 4. Less/no photosynthesis by submerged plants, so they die; 5. Saprobionts decompose the dead plants/algae; 6. Saprobionts respire aerobically OR use oxygen in respiration (oxygen falls from 10.8 to 1.1 mg dm^{-3}); 7. Less oxygen for fish to respire (aerobically), so they die;	**6 max** (3 × AO1) (3 × AO2)	**Max 5** if no data from Table 3 are used 3. **Accept** surface plants for algae 5 and 6. **Accept** saprophytes / saprotrophs / saprobiotic bacteria; 'decomposers' or 'bacteria' alone are neutral 4. **Reject** plants die because of a lack of nitrate **Reject** nitrate/fertiliser/algae are toxic to fish **Ignore** warmer water holds less oxygen

Question	Marking guidance	Mark	Comments
07.2	1. Grass (roots) absorb nitrate from the water draining from the fields, before it reaches the stream; 2. No fertiliser can be spread or blown directly into the stream (from next to it); 3. Grass roots hold the soil/slow the run-off, so less soil carrying ions enters the stream OR more ions are absorbed; 4. Less (fertiliser/nitrate) reaches the lake, so less growth of algae/algal bloom;	**2 max** (2 × AO2)	1. **Accept** grass takes up nitrate leached from the fields 2. 'Fertiliser is not spread next to the stream' alone repeats the stem: no mark **Ignore** 'acts as a barrier' unqualified

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