



ANSWER BOOK

Nutrient cycles: nitrogen, phosphorus and eutrophication

Ecology, populations and environmental change · Unit B20

AQA 3.5.4 · OCR A 6.3.1 · Edexcel A Topic 5 · CAIE 18.1

6 questions · 22 marks

NAVY EDITION

SECTION A · Short, 1 to 2 marks

- A1** **B1** Nitrosomonas oxidises ammonium to nitrite. **B1** Nitrobacter oxidises nitrite to nitrate. [2]
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SECTION B · Standard, 3 to 5 marks

- B1** **B1** nitrate ions are very soluble and are not held by the negatively charged clay and humus particles, so rain washes them down through the soil into the water, relieving the shortage of the nutrient that was limiting the algae. **B1** algae and cyanobacteria at the surface multiply rapidly to form an algal bloom, because they already had light, carbon dioxide and warmth and now have the nutrient too. **B1** the bloom forms a dense mat that blocks the light, so submerged rooted plants and deeper algae photosynthesise below the rate at which they respire, and die. **B1** those dead plants, and the bloom itself once it exhausts the nutrient and dies back, are a vast supply of dead organic matter on which saprobiotic bacteria feed, so the bacterial population grows enormously. **B1** those bacteria respire aerobically and take dissolved oxygen out of the water faster than it can dissolve back in from the air, so the dissolved oxygen concentration falls and fish and invertebrates needing well-oxygenated water suffocate. [5]
- B2** **B1** fixation starts with nitrogen gas from the atmosphere, whereas nitrification starts with ammonium already present in the soil, so only fixation brings nitrogen into the ecosystem. **B1** fixation reduces nitrogen gas to ammonia, which takes up a hydrogen ion to become ammonium, whereas nitrification oxidises ammonium to nitrite and then nitrite to nitrate. **B1** fixation is carried out by *Rhizobium* in the root nodules of legumes, by free-living soil bacteria such as *Azotobacter* and by cyanobacteria, whereas nitrification is carried out by *Nitrosomonas* and then *Nitrobacter*. **B1** nitrogenase is destroyed by oxygen, so fixation happens where oxygen is kept away and leghaemoglobin mops it up inside a nodule, whereas nitrification requires oxygen because both of its steps are oxidations. [4]
- B3** **B1** ploughing and draining keep air in the spaces between the soil particles, so oxygen is available. **B1** nitrification is carried out by *Nitrosomonas* and *Nitrobacter* and both of its steps are oxidations requiring oxygen, so ammonium is oxidised through nitrite to nitrate and nitrate accumulates. **B1** in a compacted or waterlogged soil the spaces are filled with water and oxygen is absent, so nitrification stops and no further nitrate is produced. **B1** denitrifying bacteria such as *Pseudomonas* then respire using nitrate as the final electron acceptor in place of oxygen, converting it to nitrogen gas that leaves the soil, so the nitrate already there is lost as well. [4]
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B4 **M1** there are two nitrogen atoms in NH_4NO_3 , so nitrogen is $2 \times 14 = 28$ of the [4]
relative formula mass of 80, which is $28 \div 80 = 0.35$, or 35 per cent by mass. **A1** nitrogen
applied = $200 \times 0.35 = 70$ kg per hectare, and over 25 hectares that is 1750 kg. **M1**
nitrogen carried by the stream = $5.6 \times 8.0 \times 10^7 = 4.48 \times 10^8$ mg, which is 448 kg. **A1** $448 \div$
 $1750 = 0.256$, so about 25.6 per cent of the nitrogen applied reached the stream.

B5 **B1** the algae are limited by whichever nutrient is in shortest supply, so [3]
removing phosphate leaves that shortage in place and the bloom cannot develop
even where other nutrients are plentiful. **B1** sewage effluent is a continuous point source
of phosphate, so treating it at the works removes the input rather than treating the
symptom, and one works serves a whole town. **B1** phosphate has no volatile form, so
there is no atmospheric route back to the land; the return from sea-bed sediment to
rock by uplift and weathering takes millions of years, so on any human timescale the
phosphate is lost.