AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.5.4 NUTRIENT CYCLES

SCORE	PERCENTAGE
/375	%

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Q1.

(a) 1. (µg because) very little ammonia (in soil);

2. (µg because) avoids use of (lots of) decimal places (in their results) / avoids the use of powers of 10 / avoids the use of standard form;

Accept makes numbers more manageable

Accept makes easier to plot graph

3. (g^{-1}) to allow comparisons (between samples);

2 max

(b) Answer between 4.5 and 4.6 µg g^{-1} day^{-1};;

Award 1 mark for correct number but wrong / no units

Ignore plus or minus signs

*Accept 'per gram' **AND / OR** 'per day'*

2

(c) 1. pH 4.3 / B has fastest rate of breakdown (of ammonia);

2. A + B / mixture at pH 6.9 slowest / slower (than A or B);

Not just ref. to A and then B on their own

3. Suggests (community / bacteria at) pH 4.3 / B doesn't work (well) at pH 6.9 / pH of mixture;

Accept converse that only (community / bacteria at) pH 6.9 / A is working in the mixture

3

(d) (Species **S** because) no mark

1. Species **S** change of 990,000 (per gram of soil);

Award MP1 and 2 OR MP3 and 4

Accept standard forms 9.9×10^5 and 9.9×10^3 for either

Accept for 1 mark for 100 times greater in correct context with no other calculations shown

2. Species **T** change of 9,900 (per gram of soil);

Accept standard forms 9.9×10^5 and 9.9×10^3 for either

OR

(Species **T** because) no mark

3. Species **S** has 99% change;

4. Species **T** has 9900% change;

2

(e) 1. They didn't count bacteria / cells / population(s);

Ignore ref. to other factors / other named factors affecting growth

2. Copies / number of mRNA related to amount of enzyme / amoA produced / translated;

3. Don't know how much mRNA / amoA produced by each cell;
Accept some bacteria produce more mRNA / amoA than others

4. Don't know if amoA (mRNA / enzyme) is linked to cell division / growth (of population);
Amount of amoA does not show cell division / growth
Reject references to mitosis / meiosis

4

(f) 1. Suitable method;
eg in boiling water / steam / autoclave / wash in disinfectant / wash in alcohol
Ignore heat unqualified
Ignore flaming of bottle
Accept radiation

2. (Reason) to remove / kill other bacteria / organisms that might break down ammonia;
Ignore ref to removing bacteria that 'affect the result'
Accept other bacteria producing amoA
Accept other bacteria compete with / kill bacteria that produce amoA
Ignore contamination unqualified

2

[15]

Q2.

(a) Used to produce named phosphate compound in cells;
e.g. ATP / ADP / phospholipids / DNA / RNA / RuBP / TP /GP etc.

1

(b) Example of a carbon-containing biological compound e.g. carbohydrate / amino acid / vitamin;
Accept: sugars / organic (compounds).
Ignore: products of photosynthesis.
Ignore: starch.

1

(c) 1. Represents dry mass / mass of carbon;
2. Represents gross production minus respiratory losses;
2. Accept: NPP = GPP −R.
2. Accept: Chemical energy minus respiratory losses.
1 and 2. Chemical energy store minus respiratory losses = 2 marks.

2

(d) 1. For the control an increase in phosphate increases (plant) growth;
2. For *Entrophospora* an increase in phosphate reduces (plant) growth;
3. *Scutellospora* reduces (plant) growth (compared to control);
4. *Entrophospora* and *Glomus* increases (plant) growth (compared to

control);
5. No SD / statistical test to determine significance;
6. Only 20 weeks of growth;
7. Underground / root growth not known;

5. Accept: no error bars.

7. Accept: only shows shoot growth.

4 max

(e) 1. Answer in range 0.07 to 0.09 = **2 marks**;
2. Answer in range 9.97 to 12.2
OR
Shows division by 140 or 20 × 7 = 1 mark;

2

[10]

Q3.

(a) Two suitable examples;
Examples
1. amino acid / protein / polypeptide / peptide;
2. nucleic acid / nucleotide / base;
3. DNA;
4. RNA;
5. ATP / ADP;
6. NAD / NADP (reduced or not);
7. Cyclic AMP / cAMP;
8. Chlorophyll;

List rule applies

Reject for either point nitrates / nitrites / ammonia / ammonium / urea

4. Accept pre-mRNA / mRNA / rRNA / tRNA

2 max

(b) Correct answer in the range 90 to 133.2 scores 2 marks;
1 mark for answers where yield calculated correctly for 1970 **OR** 2005;
(1970 in range) 170.8 to 176.4
OR
(2005 in range) 266.4 to 304.0;

Accept positive or negative values

2

(c) 1. Using more but getting less response over time;
2. The graph shows correlation but doesn't prove changes in yield due to fertiliser / but there could be other factors;
3. Becomes less cost effective with time;

Idea of over time is important

1. accept fertiliser becomes less effective over time

1. Accept use of figures from graph

1. Accept the idea of less grain / crop over time

2. Ignore whether correlation is positive or negative

2 max

[6]

Q4.

(a) 1. (Required to) make ATP / glucose phosphate, so less respiration / less energy for growth;

2. (Required to) make nucleotides, so less DNA / mRNA / tRNA for cell division / production of protein (for growth);

3. (Required to) make RuBP / NADP, so less CO_2 fixed / reduced into sugar;

4. (Required to) make phospholipids for membranes;

2 max

(b) 1. Hydrolyse;

Accept digest

2. murein / glycoprotein (in cell wall);

2

(c) 1. Bind to receptor (on target plant);

2. Acts as / leads to production of a transcription factor;

3. (Which) binds to promoter
OR
stimulates transcription of genes
OR
production of mRNA (for defensive enzymes);

3

(d) 1. Direct plant-to-plant transmission;

2. (So) localised response
OR
faster response
OR
no dilution of signal protein;

2

(e) 0.278;

Accept 1 mark for 1001.7 or

$$\frac{x - 450}{450} \times 100$$

= 122.6

2

(f) Should not use:

1. Fertilisers prevent development of mycorrhizae;

2. Mycorrhizae help plants to defend themselves (causing an increase in crop yield);

3. Mycorrhizae help plants to take up nitrates / phosphates (causing an increase in crop yield);

Should use:

4. Fertilisers containing phosphate and nitrate increase gross primary production so increase yield;

5. Most soil is poor in phosphate so without fertiliser (tomato) plant might not get enough phosphate;

4 max

[15]

Q5.

(a) 1. To kill any fungus / bacteria on surface of seeds or in soil;
2. So only the added fungus has any effect.

2

(b) So that only nitrate or ammonia / type of fertiliser affects growth.

1

(c) 1. So that effects of nitrate or ammonium alone could be seen;
2. So that effects of fungus can be seen.

2

(d) 1. Weigh samples at intervals during drying;
2. To see if weighings became constant (by 3 days).

2

(e) With live fungus – showing effects of the fungus:
1. Fungus increases growth of roots and shoots in both;
2. Produces greater growth with nitrate.

With heat-treated fungus – showing effects of fertiliser:

3. Similar dry masses for roots and shoots;
4. (Probably) no significant difference because SDs overlap.

4

(f) 1. Dry mass measures / determines increase in biological / organic material;
2. Water content varies.

2

(g) 1. Fungus with nitrate-containing fertiliser gave largest shoot: root ratio;
2. And largest dry mass of shoot;
3. 6.09:1 compared with ammonium-containing fertiliser 4.18:1

2 max

[15]

Q6.

(a) 1. Respiration/metabolism/ammonification;
2. (Releases/produces) heat;

Reject: 'produces energy'.

2

(b) 1. SD is spread of data around the mean;

Accept: variation around the mean.

*Accept: range is difference between highest and lowest values/extremes **or** range includes anomalies/outliers.*

2. (SD) reduces effect of anomalies/ outliers;

Reject: (SD) removes anomalies/outliers.

3. (SD) can be used to determine if (difference in results is) significant/not significant/due to chance /not due to chance;

Ignore: reliability/accuracy/validity.

2 max

(c) 1. Distributes heat / prevents 'hot' spots;
2. Distributes microorganisms;
3. More enzyme-substrate complexes;
4. Increases rate of decomposition;

Accept: increases nitrification/ammonification or 'breaks down waste faster'.

5. Aeration/provides oxygen;

2 max

(d) 1. Microorganisms change the abiotic conditions/temperature/organic waste /provide nutrients;

Must refer to microorganisms or bacteria/named bacteria causing the change.

Ignore: change the environment.

2. Less hostile conditions;
3. Decline in Cocci **and** increase in rods;

Accept: 'decrease in cocci, others are going up'.

Accept: decrease in cocci and increase in either rod type or increase in both types.

4. Gram positive outcompete / better competitors;

Accept: rods outcompete (cocci) / better competitors.

3 max

[9]

Q7.

(a) 1. Excites electrons / electrons removed (from chlorophyll);

Accept: higher energy level as 'excites'.

2. Electrons move along carriers/electron transfer chain releasing energy;

Accept: movement of H^+/protons across membrane releases energy.

Reject: 'produces energy' for either mark but not for both.

3. Energy used to join ADP and Pi to form ATP;

Reject: 'produces energy' for either mark but not for both.

Accept: energy used for phosphorylation of ADP to ATP

Do not accept P as Pi but accept phosphate.

4. Photolysis of water produces protons, electrons and oxygen;
5. NADP reduced by electrons / electrons and protons / hydrogen;

Accept: NADP to NADPH (or equivalent) by addition of electrons/hydrogen.

Do not accept NADP reduced by protons on its own.

5

(b) 1. Protein/amino acids/DNA into ammonium compounds / ammonia;

Accept: any named nitrogen containing compound e.g. urea.

2. By saprobionts;

Accept: saprophytes.

3. Ammonium/ammonia into nitrite;
4. Nitrite into nitrate;
5. By nitrifying bacteria/microorganisms;

Reject: nitrifying bacteria in root nodules.

1, 3 and 4. Accept: marks for conversion even if incorrect type of bacteria named as being involved.

2 and 5. Reject: marks for type of bacteria if linked to incorrect process e.g. nitrite converted to nitrate by saprobionts.

3 and 4. Accept: for one mark ammonia/ammonium into nitrate if neither mark point 3 or 4 awarded.

Note: there are no marks for the role of nitrogen-fixing bacteria as the question refers to producing a source of nitrates from the remains of crops.

5

[10]

Q8.

(a) R.

1

(b) 1. Protein / amino acids broken down (to ammonium ions / ammonia);

Accept: nucleic acids / RNA / DNA / urea / any named nitrogen containing compound as an alternative to protein / amino acids

Accept: saprophytes / saprotrophs

2. By saprobionts / saprobiotic (microorganisms).

Neutral: decomposers

Reject: answers where incorrect type of bacteria given as saprobionts e.g. Nitrogen fixing bacteria

2

(c) 1. (Fertility increased as) more nitrate formed / less nitrate removed / broken down;

Accept: Nitrate remains

2. Less / no denitrification / process P is decreased / fewer denitrifying bacteria.

Accept: more nitrification / more nitrifying bacteria / process R is increased

2

(d) 1. Grow crops / plants with nitrogen-fixing (bacteria);

Accept: grow legumes / named example e.g. peas, beans, clover

Accept: <u>fallow</u> year

Accept: use different amounts of ions / nutrients

2. (Different crops use) different minerals / salts / nutrients / ions (from the soil);

3. (Different crops have) different pests / pathogens / diseases.

2 max

[7]

Q9.

(a) (i) 1. Amino acid / protein / enzyme / urea / nucleic acid / chlorophyll / DNA / RNA / / ATP / ADP / AMP / NAD / NADP;

2. DNA / RNA / nucleic acid / ATP / ADP / AMP / NADP / TP / GP / RuBP / phospholipids;

1. and 2. Accept any named equivalent examples e.g. nucleotides.

Neutral: ammonia / nitrite / nitrate / phosphate.

2

(ii) 1. Saprobiotic (microorganisms / bacteria) break down remains / dead material / protein / DNA into ammonia / ammonium;

Accept: saprobionts / saprophytes / saprotrophs

Neutral: decomposer

2. Ammonia / ammonium ions into nitrite and then into nitrate;

Allow correct chemical symbols.

Accept: correct answers which use incorrect bacteria e.g. nitrogen-fixing but then reject m.p. 3.

3. (By) Nitrifying bacteria / nitrification;

3

(b) 1. Nitrate / phosphate / named ion / nutrients for growth of / absorbed / used by plants / algae / producers;

2. More producers / consumers / food **so** more fish / fish reproduce more / fish grow more / fish move to area;

Must have idea of more plants related to some increase in fish.

2

[7]

Q10.

1. Carbon dioxide combines with ribulose bisphosphate / RuBP;

2. Produces two glycerate (3-)phosphate / GP;

Accept: any answer which indicates that 2 x as much GP produced from one RuBP.

3. GP reduced to triose phosphate / TP;

Must have idea of reduction. This may be conveyed by stating m.p. 4.

4. Using reduced NADP;

***Reject**: Any reference to reduced NAD for m.p.4 but allow reference to reduction for m.p. 3.*

5. Using energy from ATP;

Must be in context of GP to TP.

6. Triose phosphate converted to glucose / hexose / RuBP / ribulose bisphosphate / named organic substance;

[6]

Q11.

(a)

Part of ecosystem	**Mean rate of carbon dioxide production / $cm^3\ m^{-2}\ s^{-1}$**	**Percentage of total carbon dioxide production measured by the scientists**
Leaves of plants	0.032	25.0
Stems and roots of plants	0.051	**39.8**
Non-photosynthetic soil organisms	0.045	**35.2**

2 correct = 2 marks;;

Adding rates to get 0.128 = 1;

If rounded to 40 and 35 in table;

- *but working shows decimal points, then award 2 marks*
- *but no working shown, then 1 max*

2 max

(b) 1. Data only include (heterotrophic) soil organisms;

2. Doesn't include animals (above ground) / other (non-soil) organisms;

3. Doesn't take into account anaerobic respiration;

Award points in any combination

Accept for 1 mark idea that CO_2 for leaves doesn't take into account photosynthesis – not told in dark until part (d)

2 max

(c) **All three** of following = 2 marks;;

Two of them = 1 mark;

Volume of carbon dioxide given off

(From known) area / per m^2 / m^{-2}

In a known / set time

Ignore 'amount' / concentration of CO_2

Accept per second / per unit time

2

(d) 1. (In the light) photosynthesis / in the dark no photosynthesis;

2. (In light,) carbon dioxide (from respiration) being used / taken up (by photosynthesis);

2

(e) (i) (Rate of respiration)

Assume "it" means soil under trees

1. In soil under trees (always) higher;

Accept converse for soil not under trees

Accept 'in the shade' means under the trees

2. In soil under trees does not rise between 06.00 and 12.00 / in the middle of the day / peaks at 20:00-21.00 / in the evening;

3. In soil **not** under trees, peaks at about 14:00-15:00 / in middle of day;

2. and 3. No mm grid, so accept 'between 18.00 and 24.00' or 'between 12.00 and 18.00'

2 max

(ii) (Between 06.00 and 12.00, (No Mark))

Respiration higher in soil under tree, (No mark)

Do not mix and match mark points

No list rule

1. Tree roots carry out (a lot of) respiration;

2. More / there are roots under tree;

Accept converse for soil not under trees

OR

3. More food under trees;

4. So more active / greater mass of / more organisms (carrying out respiration);

Accept converse for soil not under trees

OR

Soil not under trees respiration increases (No mark)

5. Soil in sunlight gets warmer;

6. Enzymes (of respiration) work faster;

Accept converse for soil under trees

2 max

(f) (i) 1. Photosynthesis produces sugars;

2. Sugars moved to roots;

Do not penalise named sugars other than sucrose

3. (Sugars) are used / required for respiration;

2 max

(ii) Takes time to move sugars to roots;

Look for movement idea in (i) – can carry forward to (ii)

1

[15]

Q12.

(a) Push – legume

Pull – grass;

Both needed for mark

1

(b) 1. Set up tape measures on two sides of the plot / make grid of plot;

Allow 'Number each plant'. With this approach mp3 cannot be awarded.

2. Use random number table / calculator / generator;

Allow 'Select from a hat' idea.

3. To generate coordinates;

3

(c) 1. To prevent competition between the maize and the grass;

2. For light / nutrients / water;

OR

3. Idea of limits movement of pest (between grass and maize);

4. Only eating / damaging grass;

2 max

(d) 1. Nitrogen-fixing bacteria convert nitrogen (in the air) into ammonium compounds (in the soil) which are converted into nitrates / nitrification occurs;

Accept 'ammonia' for 'ammonium compounds'.

2. Maize uses nitrates (in soil) for amino acid / protein / ATP / nucleotide production;

2. Must be in the context of maize.
Ignore ionic formulae unless only these are given.

2

(e) 1. Reduced % damage to maize plants / increased maize grain yield;

2. Calculation to justify mp 1;

3. Standard deviation shows no overlap but need stats to show significance of this difference;

4. More profit / net income / greater income than additional cost (with push-pull);

5. $322 extra / 408% more / $401 v $79 profit;

Accept '$350 extra income compared to $28 extra spend'.

Mp5 gains credit for both mp4 and 5

3 max

[11]

Q13.

1. Growth of algae / surface plants / algal bloom blocks light;

2. Reduced / no photosynthesis so (submerged) plants die;

3. Saprobiotic (microorganisms / bacteria);

3. Accept: Saprobiont / saprophyte / saprotroph

3. Neutral: decomposer

4. Aerobically respire / use oxygen in respiration;

5. Less oxygen for fish to respire / aerobic organisms die;

[5]

Q14.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.

	are unrelated	Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	**Definition**
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process. When considering, for example, the importance of a process, the explanation must be at A-level standard. ‘Several’ here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic

	area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of the many different types of relationships and interactions between organisms**.

Topics

1.P	Pathogens and effects on host
2.T	Taxonomy
2.C	Classification and evolution.
2.I	Inheritance and evolution
2.Gc	Genetic code, universal
2.B	Behaviour
2.Ev	Populations and evolution, variation between individuals

	within a species
3.BP	Relationships within ecosystems − eg predator / prey
3.E	Energy transfer in ecosystems
3.N	Nutrient cycles, the organisms involved
3.S	Succession, biodiversity, species and individuals in a community
4.H	Human impacts on the environment and its effect on relationships between organisms − including farming
4.Gt	Gene technology and GMO and selective breeding
4.Ar	Antibiotic resistance

Examiners are free to select other letters if they wish

The emphasis in answers should be on the relationships and interactions between organisms not just the topics themselves

Breadth, one mark for use of an example from each of the following approaches − 3 max:

1. Pathogen and host

2. Evolution (related topics)

3. Ecological

4. Human intervention in relationships

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q15.

(a) (i) Nitrification / oxidation;

Accept 'nitrifying'

1

(ii) Denitrification;

Accept 'denitrifying'

1

(b) 1. (Nitrogen) to ammonia / NH_3 / ammonium;

1. Do not disqualify mark for any references to ammonia being converted to nitrite, nitrate etc

2. Produce protein / amino acids / named protein / DNA / RNA;

2. Do not disqualify mark for any references to protein being

formed from nitrogen, nitrite or nitrate

2

(c) 1. Soil has low(er) water potential / plant / roots have higher water potential;

1. Reference to water potential gradient is sufficient if correct direction of gradient or water movement is outlined

1. Accept WP or Ψ for water potential

2. Osmosis from plant / diffusion of water from plant;

2. Accept plant takes up less / not enough water by osmosis

2. Reference to movement of minerals by osmosis negates mark

2

[6]

Q16.

(a) 1. Fertilisers / minerals / named ion (added to soil);

Accept any named examples of natural fertilisers for mark point 1 e.g. manure, bone meal etc. Ignore named elements

2. Role of named nutrient or element e.g. nitrate / nitrogen for proteins / phosphate / phosphorus for ATP / DNA;

Accept fertilisers / minerals / named nutrient / element removes limiting factor for mark point 2

3. Selective breeding / genetic modification (of crops);

Accept idea of choosing particular variety of crop for mark point 5

4. Ploughing / aeration allows nitrification / decreases denitrification;

5. Benefit of crop rotation in terms of soil nutrients / fertility / pest reduction;

5

(b) 1. Protein / amino acids / DNA into ammonium compounds / ammonia;

Accept any named nitrogen containing compound e.g. urea for mark point 1

2. By saprobionts;

Accept saprophytes for mark point 2

3. Ammonium / ammonia into nitrite;

Accept marks for conversion i.e. mark points 1, 3, 4 and 6 even if incorrect type of bacteria named as being involved

4. Nitrite into nitrate;

However, reject marks for type of bacteria i.e. mark points 2, 5 and 7 if linked to incorrect process e.g. nitrite converted to nitrate by saprobionts

5. By nitrifying bacteria / microorganisms;

6. Nitrogen to ammonia / ammonium;

Award one mark for ammonia / ammonium into nitrate if

neither mark point 3 or 4 awarded

7. By nitrogen-fixing bacteria / microorganisms in soil;

Ignore reference to nitrogen-fixing bacteria in root nodules. If not specified, assume nitrogen-fixing bacteria are in the soil

5 max

[10]

Q17.

(a) Nitrification;

Accept nitrifying.

Do not accept nitrogen fixing.

1

(b) 1. Uptake (by roots) involves active transport;

Reject all references to bacteria

2. Requires ATP / aerobic respiration;

2

(c) (i) 1. Not enough time / fast flow washes bacteria away;

"Not enough time for bacteria to convert all the ammonia to nitrate" gains 2 marks

2. (Not all / less) ammonia converted to nitrate / less nitrification;

2

(ii) 1. Algal bloom / increase in algae blocks light / plants / algae die;

2. Decomposers / saprobionts / bacteria break down dead plant materials;

3. Bacteria / decomposers / saprobionts use up oxygen in respiration / increase BOD causing fish to die;

3. Accept alternatives such as microbes / saprophytes.

3

[8]

Q18.

(a) (i) 1. Gases / correct named gas not released;

2. Conditions (in digester) can be controlled;

3. Products / named product can be collected;

4. Open ponds associated with health risk / environmental damage / eutrophication;

Correct named gases include: methane, carbon dioxide, hydrogen sulphide, nitrogen oxides

1. Allow substance = product

4. Accept 'pond' in any context

2 max

(ii) 1. Respiration causes temperature increase / release of heat;

2. Enzymes would be denatured / microorganisms killed;

2

(b) (i) 1. Increase algae / algal bloom causes light to be blocked out;

2. Plants can't photosynthesise / plants and / or algae die;

3. Bacteria / saprobionts / EW feed off / breakdown dead organisms using up oxygen / bacteria respire / BOD rises;

3

(ii) 1. Acts as soil conditioner / improves drainage / aerates soil / increases organic content of soil;

2. Contains other elements / named element / wider range of elements;

3. Production of artificial fertiliser energy-consuming;

4. Less leaching / slow release (of nutrient);

Unspecified answers relate to natural fertiliser. Ignore references to cost / eutrophication

2. i.e. elements other than nitrogen, phosphorus and potassium

1 max

[8]

Q19.

(a) 1. Saprobionts / saprophytes;

2. Digest / break down proteins / DNA / nitrogen-containing substances;

3. Extracellular digestion / release of enzymes;

4. Ammonia / ammonium produced;

5. Ammonia converted to nitrite to nitrate / ammonia to nitrate;

6. Nitrifying (bacteria) / nitrification;

7. Oxidation;

Ignore all references to other parts of the nitrogen cycle

1. Accept saprotrophs. Allow this mark if saprobionts linked to fungi.

2. Ignore"nitrogen in plants"

Ignore enzymes excreted

6. Accept Nitrosomonas / Nitrobacter

5 max

(b) 1. Carbon dioxide combines with ribulose bisphosphate / RuBP;

2. Produces two molecules of glycerate (3-)phosphate / GP;

3. Reduced to triose phosphate / TP;

4. Using reduced NADP;

5. Using energy from ATP;

6. Triose phosphate converted to other organic substances / named organic substances / ribulose bisphosphate;

7. In light independent reaction / Calvin cycle;

3. Accept add hydrogen for reduced

4. Accept alternatives such as NADPH for reduced NADP / GALP for TP / ribulose biphosphate

6 max

[11]

Q20.

(a) Complementary to / fits / binds to <u>active site</u>;

Competitive / competes / 'prevents' enzyme-substrate complexes / 'prevents' urea attaching;

Max one mark if candidate suggests that active site / enzyme is damaged destroyed or useless.

Allow inhibitor 'prevents' or 'stops' urea / substrate attaching unless candidate clearly indicates this is permanent.

Ignore reference to inhibitor forming an enzyme / substrate complex.

2

(b) (i) Reduces loss of ammonia up to <u>day8 / 9</u>;

1

(ii) Increase in urease / temperature;

More enzyme-substrate complexes;

More bacteria;

2 max

(c) Less urea / ammonia lost (from soil) / less urea broken down;

Urea / ammonia converted to nitrite / nitrate;

Used to produce protein / amino acids / DNA / bases / nucleotides;

Reference to incorrect bacteria (e.g. denitrifying) producing nitrite / nitrate negates second marking point.

3

[8]

Q21.

(a) Ammonia / ammonium / NH_3 / NH_4^+;

1

(b) Will have similar shape / tertiary structure (as substrate) / complementary shape (to active site);

Neutral: same shape as substrate

Fit / bind with active site / forms enzyme-substrate complex;

Reject: same shape as active site

2

(c) (i) Provides ATP for the reaction / nitrogen fixation / reduction of nitrogen / formation of ammonia;

Accept: ATP or energy

Enzyme / nitrogenase produced quicker / <u>more</u> enzyme produced;

Ignore references to temperature

Uses / removes oxygen (so nitrogenase works);

Use of oxygen must be in the correct context

2 max

(ii) ATP used for / needed for nitrogen fixation / reduction of nitrogen / formation of ammonia / production of enzyme / nitrogenase;

Accept: ATP or energy

(So less ATP) available for growth / protein synthesis / production of new cells / production of biomass;

Accept: converse for those without fertiliser

2

[7]

Q22.

(a) 1. High concentration of carbon dioxide linked with night / darkness;

Accept: converse of low in day

2. No photosynthesis in dark / night / light required for photosynthesis / light-dependent reaction;

Ignore references to rate of photosynthesis in day / night
Accept day = light

3. (In dark) <u>plants</u> (and other organisms) respire;

Must be a reference to plants or <u>all</u> organisms

4. In light net uptake of carbon dioxide by plants / plants use more carbon dioxide than they produce / rate of photosynthesis greater than rate of respiration;

Do not allow converse for this point
Accept description of compensation point

5. Decrease in carbon dioxide concentration with height;

Accept: converse of increase closer to ground

6. At ground level fewer leaves / less photosynthesising tissue / more animals / less light;

5 max

(b) 1. Carbon dioxide combines with ribulose bisphosphate / RuBP;

2. To produce two molecules of glycerate 3-phosphate / GP;

3. Reduced to triose phosphate / TP;

4. Requires reduced NADP;

5. Energy from ATP;

This mark scheme is based on specification content. Accept alternate names such as NADPH

Credit relevant diagrams

Accept: description of 'reduced'

5

[10]

Q23.

(a) (i) dissolve (in soil water) / run-off / leaching; *reject nitrogen dissolving.*

1

(ii) insoluble / less soluble;
(molecules) require breaking down / slow release;

2

(b) increased growth / algal bloom;
blocks light; less photosynthesis;
plants die;
increase in decomposers / bacteria; *ignore growth of bacteria*
bacteria respire;
less oxygen;

4 max

[7]

Q24.

(a) (i) decomposers convert (nitrogen in organic compounds) into ammonia / ammonium; suitable example of "organic nitrogen" - protein / urea / amino acid etc. (e.g. linked to process); nitrifying bacteria / correctly named convert ammonium to nitrate; via nitrite;

3

(ii) convert nitrogen (gas) into ammonium / ammonia / amino acids;
add usable / available nitrogen to an ecosystem / eq.;

2

(b) (i) 1. numbers of dispersed bacteria increase as they <u>feed</u> on organic matter;

2. numbers of free-swimming protoctistans increase because number of bacteria increase;

3. dispersed bacteria decrease as amount of dispersed organic matter decreases / due to lack of food / as organic matter is converted to flocs / are preyed on by free-swimming protoctistans;

3

(ii) 1. (in a succession) organisms (enter an area and) change the environment / conditions creating new niches / habitats;

2. allows different species / different types of organisms to enter / be successful;

3. dispersed bacteria change dispersed organic matter to flocs;

4. presence of flocs allows crawling protoctistans to enter / to increase / to be successful;

4

[12]

Q25.

(a) (i) **P** = 3;
Q = acetylcoenzyme A;

2

(ii) 36 ATP, however derived = 2 marks
30 ATP, however derived = 1 mark

2

(iii) *Correct statement in the context of aerobic respiration or anaerobic respiration concerning*:
Oxygen as terminal hydrogen / electron acceptor allowing operation of electron transport chain / oxidative phosphorylation;
Fate of pyruvate;
Significance of ATP formed in glycolysis;

3

(b) (i) Thick walls exclude oxygen;
Produced by photosynthetic cells (of fern and *Anabaena*);
Contain no chlorophyll so do not photosynthesise;
Do not produce oxygen;
Oxygen would inhibit nitrogen fixation process;

max. 3

(ii) Decomposers / bacteria / fungi / saprobionts (in fields);

Convert protein / organic nitrogen (in cells of fern) into ammonium ions (*allow ammonia*);
Ammonium ions (ammonia) converted to nitrite, then converted to nitrate;

Allow 1 mark for NH_3 / $NH_4^+ \rightarrow NO_3^-$
By nitrifying bacteria / correctly named;
Nitrate used to form protein / amino acids in rice;

5

[15]

Q26.

(a) Fertilisers / detergents / slurry / manure / sewage / faeces;

1

(b) (31 – 5) / 31 x 100% / single error in otherwise correct method;
83.87 / 83.9 / 84%;

2

(c) Have continuous data for phosphate but not for biomass;
Effect of named factor explained;

2

(d) 1. Increased phosphate causes increase in plant growth / algal bloom;
2. Plants (cover surface and) block out light so plants (under surface) die;

3. Increase in (aerobic) bacteria / decomposers (which break down plants);
4. Bacteria / decomposers use up oxygen / reduce oxygen conc. in water;
5. In respiration;
6. Plants unable to photosynthesise so less oxygen produced;

max 6

[11]

Q27.

(a) **P** – denitrification;
Q – Nitrogen fixation;

2

(b) Ammonia formed by decay / decomposition / putrefying / ammonifying / by action of decomposers / saprobionts;
On nitrogenous waste / urea *or* nitrogenous compounds (e.g. proteins, amino acids, DNA, ATP);

2

(c) Oxygen added / hydrogen removed;
Ignore references to electron loss

1

[5]

Q28.

(a) (i) mass produced increases then levels off at 17.1 kg m^{-2} / concentrations above 40 kg ha^{-1};

1

(ii) replaces nutrients removed;
fertiliser provides nitrate needed for protein / amino acid production; as more fertiliser added, there is more growth / protein / amino acid / yield;

2

(iii) plants already have enough <u>nitrate</u> / <u>nitrate</u> no longer limiting;
another <u>named</u> factor / element is limiting growth;

2

(b) because cattle excreted / produced faeces / droppings / cowpats / manure; in field B crop used elements / minerals / nitrates / nutrients last year;

2

[7]

Q29.

(a) No - very little increase / no increase in yield of grass when *Rhizobium* added / no difference between C and D;

1

(b) Yes: increased yield with nitrates;

Correct reference to result in graph **C** c.f. graph **A /** use of correct numbers (from C + A)
e.g. greater yield of soyabean in C than in A /
greater yield of soyabean with nitrate than without <u>if no *Rhizobium;*</u>

2

(c) Forms mutualistic / symbiotic union with soyabean / forms root nodules / mutual benefits (/ described);
makes ammonia / ammonium; (Nitrates – CANCEL)
Helps produce organic-N / amino acids / protein;

max 3

[6]

Q30.

(a) (i) nitrogen-fixing;

(ii) nitrifying;
(names neutral, name only no mark)

2

(b) (i) growing legumes / named legume;
ploughed in / allowed to decompose / nitrogen-fixing (bacteria in nodules);

OR

allow cattle / named species / (farm) animals (to graze);
add dung / urine;

OR

spread / add manure / slurry;
decomposed to release nitrates / ammonia / nitrites;

2

(ii) bare soil / fallow in winter / hedge removal; leaching (of nitrates) / soil erosion;

OR

uptake of nitrates / ammonium compounds by crop;
harvesting crop / named crop which would be harvested;

OR

(farm) animals eat plants
(in field); (then) animals removed;

2

[6]

Q31.

(a) breakdown of organic matter / sewage by enzymes from bacteria;
nitrates / ammonia used by algae to make amino acids / proteins;
algae photosynthesise;
bacterial respiration uses O_2 / produces CO_2 for algae;
(respiration) allows for reproduction / growth of bacteria;

4

(b) sufficient light penetration for photosynthesis (of algae);
warm leads to faster enzyme activity;

faster bacterial respiration / decomposition;
faster photosynthesis;
increased growth / reproduction of bacteria / algae;

4

[8]

Q32.

(a) less nitrate taken up;
less amino acid / protein synthesis;

OR

parts of plant higher in protein die;
higher proportion of cellulose / non-protein components in diet;

2

(b) (wildebeest) selective feeders / only some species / parts of plant eaten;
choose to eat species / part of plant with high protein content;

2

(c) named protein;
consequences of lack of protein related to failure to escape from predators;

examples:

myosin / actin;
(skeletal) muscles weak / less muscular tissue so slower movement;

OR

relevant named enzyme;
why deficiency of enzyme increases chance of being caught;

OR

haemoglobin;
insufficient oxygen for muscle contraction;

2

[6]

Q33.

(a) contain nitrogen-fixing bacteria in roots / nodules (so don't need fertiliser);
nitrogen containing compounds added to the soil
<u>when plant dies / after harvest of crop;</u>

2

(b) low(er) / more negative water potential in soil (than in the plant);
prevents roots from taking up water (from the soil) / plants still lose water by transpiration; plants lose water to soil by <u>osmosis</u>;

2

Q34.

(a) prevents disease / pest organisms from reaching crop plants / prevents herbicides from reaching hedgerow / enables machinery to manoeuvre without damaging crop / hedgerow;

1

(b) some weeds provide habitats / niche for (beneficial) insects / animals:
allow (insect) pest predators to survive;
conserve (common) weed plants;
weeds are producers in food chains / food source;

2 max

(c) decomposers / saprophyte / bacteria / fungi / micro organisms (organisms) excrete / produce nitrogenous waste / e.g.; bacteria convert to nitrate / nitrifying bacteria;
(increased) nitrates(in soil) taken up / used by plants;
release of phosphate / potassium;
organisms respire and produce carbon dioxide which is used by plants in photosynthesis;

4

[7]

Q35.

(a) more proteins / amino acids / more DNA / nucleotides / nucleotide derivative;
increased cell division / number of cells formed;

2

(b) reduced light / shading;
less photosynthesis;

2

(c) 1 bacteria / fungi feed on dead matter saprobiotically;
2 respiration uses up oxygen;
3 converts proteins to amino acids;
4 then to ammonium compounds;
5 nitrifying bacteria convert ammonium compounds;
6 via nitrates;

6

(d) lower species diversity / number of species;
species tolerant to low oxygen thrive / species requiring high oxygen die out;

2

[12]

Q36.

(a) (i) ammonia / ammonium ions / compound;

1

(ii) glucose;

1

(b) final acceptor for hydrogen:
to form water;

2

(c) glycolysis can continue;
NAD can accept more hydrogen;

2

(d) secondary / tertiary structure;

produces particular shape of active site;
or
(shape of) active site;
complementary to shape of substrate;

2

(e) sodium ions / non-competitive inhibitor binds to enzyme
at a site other than active site;
resulting in change of shape of active site / no longer complementary;
substrate can no longer bind with the enzyme / enzyme-substrate
complexes no longer formed;

3

[11]

Q37.

(i) excessive use of fertilisers;
run-off / leaching;

2 max

(ii) 1. growth of algae / plants stimulated / increased;
2. death of algae / plants;
3. more bacteria / decomposers / decomposition;
4. respiration;
5. decomposers / bacteria remove oxygen;
6. animals die (because of lack of oxygen);

5 max

[7]

Q38.

(a) very long / deep roots, to reach water deep in the soil / nitrogen-fixing bacteria, to provide a source of nitrogen for growth in poor soil;

1

interspecific;

1

(b) (mesquite) proteins / amino acids (ploughed) into soil / nodules ploughed in
and (decomposers) bacteria / fungi feed on these;
excrete ammonia;
nitrifying bacteria convert these to nitrites / nitrates;
absorbed by roots of grasses and increase their growth;
accept increases recycling of other ions / phosphate / potassium;

3

(c) control organism a parasite / predator;
specific to pest;
population varies with population of pest;
controls size of pest population but does not kill all;
keeps pest population low enough to prevent significant (economic) damage;

3 max

[8]

Q39.

(a) proteins / amino acids broken down;
deamination / ammonification / release of ammonium compounds;

conversion to nitrates;
by nitrifying bacteria / named bacterium;
nitrates absorbed into roots;

5

(b) fewer nitrates in the soil for the next crop / plants grow less well because of lack of nitrates;
requiring application of more fertiliser / economic reason for using less fertiliser / valid environmental reason explained e.g. nitrates leaching into water / eutrophication / explanation / health related e.g drinking water;

2

(c) production of phospholipids;
in cell membranes;
synthesis of ATP;
production of DNA;
production of RNA;
production of NADP;

4 max

[11]

Q40.

(a) (i) presence of grass causes less nutrients / minerals / nitrates / ammonium ions to be leached;
(do not allow references to less nitrogen)

1

(ii) clover contains nitrogen-fixing bacteria;
(do not allow references to nitrifying bacteria)

decomposition (of ploughed clover) introduces nitrates / ammonium ions into soil;

2

(b) (i) minimal effect / no significant effect on yield / small increase up to 25 kg ha^{-1};
increase in protein content of grain with all fertiliser applications;

2

(ii) (37 ÷ 44 =) 0.84 : 1.0
(allow 0.8 : 1);

1

[6]

Q41.

run off / leaching of nutrients / nitrates;
leads to increased growth of algae / plants;
competition for light / effect of competition;
death of algae / plants;
increases food supply / increases microorganisms / decomposers;
respiration (of microorganisms) uses up oxygen / increases BOD;
fish / animals die due to lack of oxygen;

[5]

Q1.

On reflection, in question (a), it would have been better not to try and 'help' students by splitting the answer space into µg and g^{-1} and just let them answer as they saw fit. In any event, the question discriminated well. Some 22% obtained both marks, 44% one mark and 31% failed to score. All three marking points appeared with roughly equal frequency. Quite a few students seemed to miss the point entirely, writing about µg being used because ammonia is a small molecule.

Question (b) proved much more difficult than expected. Many students appeared to have difficulty extracting data from the graph, often apparently mis-reading the scale. 20% of students obtained both marks. Another 13% obtained one mark because they calculated the correct number but made a mistake with the units. The commonest error was to use a solidus to represent 'per'; so, /day instead of day^{-1}. For many years, AQA has followed the convention of using a solidus to separate units from the name of whatever is being presented. In this case, that would mean, "Difference in rate / µg g^{-1} day^{-1}". The question did discriminate reasonably well.

Question (c) proved too challenging for most students. They were asked to identify evidence that supported the idea of different communities of bacteria in soils A and B. This would suggest that the bacteria (bacterial populations) in each soil would be those adapted to a certain soil pH. Many misinterpreted the graph at the start and thought that ammonia was being made; thus thinking A+B gave the fastest rate. Others focused almost entirely on how much ammonia was left at the end of 20 days and/or described the lines on the graph. Some 29% did note that the mixture of A and B had the slowest rate of breakdown of ammonia and obtained one mark. Another 15% obtained a further mark by deducing that it must be bacteria from soil B that weren't working well at pH 6.9; or that only bacteria from soil A were working. Only 3% obtained all three marks by linking their deductions to bacteria from soil B having the fastest rate of ammonia breakdown in their own soil condition (pH 4.3).

Question (d) discriminated quite well and showed which students were able to use data presented in logarithmic form. The examiners allowed calculations of changes in numbers of copies of mRNA, or calculation of percentage changes. 42% of students obtained both marks. Some 7% of students obtained one mark for calculating one correct change. Some who failed to score used the 'power' numbers as simple numbers; so, for species S they said the fall was 2 and it was the same for species T. One mark was awarded if they gave an answer of 100 times with no further explanation.

Question (e) was the worst answered on the paper and 11% did not attempt it. This might indicate that more guidance should have been included in the stem of the question, or it should have been worth only three marks. All four marking points were seen but students often focused on one or two at great length. Since the command word was 'explain', there were only four marking points, for four marks. Few students noted that the population growth could not be determined using the method outlined because at no point were the bacteria counted. The method simply gives an indication of the amount of amoA enzyme produced. About 28% obtained one mark, usually for noting that the number of mRNA molecules produced might well vary from cell to cell. Some 8% obtained two marks, often for the previous point and suggesting that it is not known if there is a link between expression of *amoA* and population/cell growth/division.

Question (f) tested knowledge of aseptic technique and its use in the context used in the question. The examiners expected students to suggest methods for sterilising whole bottles before use. Many students wrote about flaming the necks of the bottles, ignoring

the inside (and outside). Others made vague references to 'heating the bottles', with no detail about how or to what sort of temperature. The mark scheme gave acceptable examples such as autoclaving, using boiling water and washing in alcohol. 36% of students obtained one mark, usually for suggesting a suitable method for sterilisation. The explanations of the reason for sterilising were usually very weak and did not link directly to this investigation. So, most explanations were restricted to statements about getting rid of contaminants or bacteria. The examiners were looking for ideas relating to the removal of bacteria that might compete with or kill the bacteria being studied, or removal of other bacteria that might produce amoA. Only 4% of students made these sorts of statements.

Q2.

(a) Over 80% of students obtained this mark, often for referring to the use of phosphate to produce ATP or DNA, although a variety of other correctly named compounds such as RNA, ADP, TP and NADP were mentioned. A common error was to refer to proteins.

(b) Almost 60% of students obtained this mark, usually for referring to carbohydrate or sugars. Incorrect responses often mentioned nutrients, water or oxygen.

(c) Very few students, slightly more than 5%, obtained both mark points for this question. Most students did not refer to biomass as representing the dry mass or mass of carbon in a plant. Alternatives such as the chemical energy store were also rarely credited. However, over 40% of students did provide a definition of net primary productivity in terms of gross productivity minus respiratory losses. This was often provided as an equation. Unfortunately, weaker responses also included loss due to faeces as part of this equation.

(d) This question produced a good spread of marks and some very extensive answers, often continued on additional pages. Over 90% of students obtained at least one mark and over 10% of students gained all four marks. The most common marking points credited related to directly comparing the effect of AMF or phosphate on plant growth, although a significant minority did refer to the lack of a statistical test. Generally, more marks were awarded for describing the effect of increased phosphate concentration on plant growth than the effect of AMF species on plant growth. References to only twenty weeks of growth, or to only shoot growth being considered, were infrequent. A number of students referred to the AMF as plant species and others confused the results between *Scutellospora fulgida* and *Entrophospora infrequens*, probably as a result of the similarity of the hatching on the graph for these two species.

(e) It was pleasing to note that over 50% of students demonstrated a good understanding of the $\log_e$ scale and obtained both marks for this question. Over 25% percent of students obtained a single mark, often by realising that the calculated $\log_e$ value had to be divided by 140 to determine the rate of shoot biomass production in grams per day.

Q3.

(a) Just over half of students scored both marks. Those who failed to score one or both marks usually gave one or two inorganic ions containing nitrogen as answers. It may be that the references to nitrates and nitrogen in the stem of the question caused some students to think about the nitrogen cycle, rather than biological molecules.

(b) About 30% of students calculated a difference within the accepted range (depending on where, exactly, they placed the points on the graph).

(c) This appeared to be an example of where students failed to appreciate the relevance of all the information in the stem of the question. Very many students appeared to interpret the data as what happens if crops are given different concentrations of fertiliser in experiments performed at the same time, rather than changes in response to fertiliser over time. This produced statements along the lines that “more fertiliser produces less crops”. It is worth noting that the data include the *fertiliser response ratio*. Historically, students have always tended to perform poorly on any question involving ratios.

Q6.

(a) This was well answered with 80% of students obtaining both marks and less than 5% scoring zero. The most common error was to suggest that ‘energy is produced’.

(b) Over 80% of students obtained at least one mark, often by stating that standard deviation shows the spread of values around the mean. Many also realised it was less affected by anomalous results and that SDs can be used to determine if differences in results were significant. Some answers included the idea of calculating the standard error from the standard deviation. Unfortunately some students defined standard deviation as the range of results around the mean. The descriptions of range were less clear, often only stating that the range involved the highest and the lowest values.

(c) Approximately a third of the students obtained both marks often by explaining that rotating the containers provided aeration and distributed heat. The idea of distributing microorganisms within the waste and increasing the rate of decomposition were also frequently credited. There were fewer references to more enzyme-substrate complexes being formed. A common misconception was that rotation ensured that all the waste would be equally exposed to sunlight. However, where this was described as equal exposure to heat from the sun, the idea of preventing hot spots was credited.

(d) This question proved to be a very effective discriminator. Most students obtained at least one mark. This was usually awarded for either referring to less hostile conditions or to the decrease in the population of cocci and increase in the population of rods as succession occurred. Although most students referred to a ‘change in the environment’, few described how the environment changed or related the change to the action of microorganisms. A third of students obtained all three marks often providing very detailed and extensive answers which were continued on additional paper. These answers clearly described the role of cocci in changing the abiotic conditions, making the environment less hostile so that rods could then out-compete the pioneer cocci.

Q7.

(a) Over 20% of students gained full marks on this question and almost 80% of students gained at least three marks. Most students displayed a very good understanding of the processes involved in the light-dependent reaction of photosynthesis. Failure to gain four or five marks on this question was often due to the omission of specific details. Although the vast majority of students described the passage of electrons down the electron transfer chain, a significant number failed to mention the release of energy. Similarly, the production of ATP was understood but the use of ADP and Pi in this process was sometimes omitted. Photolysis was described by the vast majority of students but a significant number omitted oxygen as a product. On a positive note, the reduction of NAD instead of NADP was seen less frequently than in previous years. However, a significant number of students referred to the reduction of NADP by protons on their own.

(b) This question caused very few problems for students. Almost 40% obtained maximum marks and almost 90% obtained at least three marks. Explanations that gained maximum marks were often clear and concise. A significant number of students omitted a named nitrogen-containing compound, e.g. DNA, when describing the formation of ammonia by saprobionts. A limited number of students referred to decomposers rather than saprobionts and occasionally nitrifying bacteria were thought to be in root nodules. However, most students showed an excellent understanding of the specific role of the different types of microorganisms. Some answers did include irrelevant information relating to the roles of nitrogen-fixing and denitrifying bacteria.

Q8.

(a) The vast majority of students correctly identified that process **R** involves nitrification.

(b) Most students gained one mark for mentioning saprobionts, although a minority simply referred to decomposers. Far fewer students gained the mark for referring to the breakdown of a named nitrogen-containing compound such as protein. Most students simply referred to dead organic matter or faeces. Other students limited their descriptions to extracellular digestion, nitrogen fixation or denitrification.

(c) The addition of oxygen to the soil as a result of ploughing and its effect in decreasing denitrification and / or increasing nitrification was well known, with many students also gaining the mark for increase in fertility related to the formation of more nitrate. However, there was also some confusion amongst weaker students concerning fertility, with some stating that more nitrates would decrease soil fertility or that the presence of nitrogen on its own in soil increases fertility. Occasionally, ploughing increasing oxygen availability was believed to increase denitrification and so reduce soil fertility or increase fertility by stimulating nitrogen-fixing bacteria.

(d) Only one in five students gained both marks; almost two thirds of students, however, gained one mark. These students often appreciated the idea that some pests will not be able to survive on different crops or outlined the advantages of growing legumes / plants with nitrogen-fixing bacteria. A significant minority of students stated that legumes contain nitrifying bacteria in their root nodules. The concept of different crops having different nutrient requirements was awarded less often. Many students mentioned crops dying and adding nutrients to the soil, not realising that these nutrients had been removed by the plants and were simply being replaced. Similarly students did not consider that crops are usually harvested thus taking nutrients from the soil.

Q9.

(a) (i) Over two thirds of students correctly identified two molecules containing nitrogen or phosphorus, most often DNA and ATP. The commonest answers were DNA, proteins and amino acids for a nitrogen-containing molecule and ATP and DNA for a phosphorus-containing molecule. Ammonia and nitrate were not accepted as biological molecules as they do not contain carbon. Fewer students could name a phosphorus-containing molecule, with lipids being a common incorrect response.

(ii) Although slightly more than 50% of students obtained all three marks, this question proved to be a fairly good discriminator. It was pleasing to note that fewer students than on previous papers were confusing nitrifying and nitrogen-fixing bacteria. Most students did appreciate that nitrification involved the conversion of ammonia to nitrate via nitrite. However, a significant number of students simply referred to ‘decomposers’ rather than providing any reference

to saprobionts or saprobiotic nutrition.

(b) Almost half the students failed to gain a mark in this question. Many of these students stated that the nutrients were used as a food source by fish. Students who did gain credit often did so by linking the increase in nitrates / nutrients to an increase in producers. Approximately half of these students then linked the increase in producers to some increase in the productivity of fish, usually increased growth or number.

Q10.

This question was well answered by most students, with over 75% of students obtaining four or more marks. The most commonly awarded marks were; carbon dioxide combining with RuBP, the formation of 2GP from this reaction, the reduction of GP to TP and the formation of a named compound, usually glucose or RuBP from TP. Approximately one in every four students specifically mentioned that ATP provides the energy for the reduction of GP to TP. A much higher percentage of students stated that reduced NADP is essential for the reduction of GP to TP. However, there was a significant minority of students who referred to reduced NAD rather than reduced NADP.

Q11.

(a) About three quarters of students obtained both marks for the calculation in this part. Some students only scored one mark because of incorrect rounding of numbers in their calculations or answers.

(b) This part proved far more challenging than intended. It was hoped that students would note that only (plants and) non-photosynthetic soil organisms are mentioned in the study and point out that there are lots of other organisms / animals that are not mentioned. The examiners accepted statements that carbon dioxide from leaves did not take into account effects of photosynthesis, because students were not told until (d) that measurements were taken in the dark. Quite a few students treated the leaves of plants and the stems and roots of plants as separate organisms, rather than different parts of the same organisms. Nearly three quarters of students failed to score any marks.

(c) To obtain two marks in this part, students had to identify three measurements: volume of carbon dioxide, from a given / known area, in a set time. If they identified two of these, they obtained one mark. A quarter of students obtained two marks and about half failed to score. There were many vague references to *amount* of carbon dioxide and *time* unqualified and many students missed out area altogether.

(d) This part was done well by many students and three quarters obtained both marks. They were able to state that there is no photosynthesis in the dark and photosynthesis would take up carbon dioxide. Some students were confused about whether it was photosynthesis or respiration that produces carbon dioxide, or uses it.

(e) (i) Most students noted that respiration in soil under trees is always higher in this part. Over a third went on to describe a difference in the peak times of respiration in soil under trees and soil not under trees. Although a 2 mm grid was not given on the graph, the examiners expected some attempt to describe time frames, rather than just *earlier* or *later*.

(ii) Correct answers to this part usually revolved around respiration in soil not under trees increasing because the soil gets warmer in sunshine and this leads to faster enzyme activity. Very few looked back to the table and noted

the high rate of respiration in roots of plants, of which there would be a lot under trees. Many students thought that photosynthesis by the trees would make more oxygen available in the soil under the trees. Others thought that photosynthesis by the soil not under the trees would increase during the day.

(f) As the final interpretive question on the final paper, this part was intended to be challenging and so it proved. Very few students appear to appreciate the relationship between photosynthesis and respiration in plants in terms of respiratory substrate. This was tested last year and proved challenging then. Students should appreciate that plants make their own respiratory substrates via photosynthesis. Those students who did score in this part did understand this. Given that many students treated leaves and roots of plants as separate organisms in (b), it was perhaps not surprising that very few students suggested it takes time for sugars to travel from leaves to roots. Some got 'close' by suggesting it took time for oxygen from photosynthesis to travel to the roots.

Q12.

(a) This question was intended as a gentle introduction to ensure the students had read and thought through the resource material and 95% of students gained this mark.

(b) This was a high-scoring question, with 65% of students gaining all three marks and 95% gaining two or more. Students who failed to obtain a third mark usually numbered each individual plant, rather than using a coordinate system, or missed out the first step of generating a grid.

(c) Students struggled to suggest why bare ground was left. If they thought about competition, they generally answered successfully and scored marking points 1 and 2. The idea of there being less movement of the pest between the maize and grass was rarely expressed clearly.

(d) Very poor understanding of the nitrogen cycle was frequently seen. Many students had the N-fixing bacteria providing 'the plant' with proteins, demonstrated poor understanding of nitrogen fixation and the use of nitrates by plants or failed to distinguish between the legume and the maize.

(e) Most students achieved marking point 1, for identifying a trend in the data. Fewer went on to use the data in a calculation to justify the trend they had reported. Many had the idea of an improved profit, although some expressed this very poorly, but few used the data to calculate the actual increase in profit in order to gain marking point 5. Virtually no students made reference to the standard deviations shown in the data.

Q13.

Not surprisingly this question produced a lot of good answers but still discriminated well despite forty percent of students scoring four or more marks out of the five available. Weaker responses lacked the appropriate level of scientific terminology, omitted essential details or confused ideas. Most students referred to an algal bloom and its effect on penetration of light. However, some students omitted any reference to photosynthesis, or related a reduced oxygen concentration solely to the activity of plants. Some students referred to fish dying due to lack of food with no reference to oxygen or respiration. The best responses were often clear and concise and read as the mark scheme. These answers referred to saprobiotic microorganisms rather than simply 'decomposers' and clearly related the death of fish to a decrease in oxygen for respiration.

Q14.

Large numbers of good and excellent essays were seen.

The vast majority of students appeared to understand that this is a synoptic exercise, where they have to draw on a wide range of examples to obtain a high mark. Some students only dealt with one or two topics but in great detail and depth. Unfortunately, this severely limited the mark they could obtain.

Essays with a narrow scope were more common with this question about relationships and interactions. Many of these just went on endlessly about food chains and webs. Attempts at extension material were common. However, the use of examples that any member of the public might use did not gain any extra credit; for example, vague accounts of the plight of polar bears as ice caps melt. Extension material has to be at least of A-level standard and accurately described using appropriate scientific terminology.

There are many different types of relationships and interactions between organisms.

There were some good accounts of the interactions between pathogen and host. These usually focused on the reaction of the immune system to a pathogen. Some looked more at how a pathogen may harm the host. This was a topic area where extension material was quite often included, usually relating to detailed accounts of the effects of a pathogen not named in the specification. Cholera was used as a specific example by many, together with varying amounts of detail on how it interacts with the host. Tuberculosis was quite often cited but relevant detail appeared to be rare.

Only the best essays tended to contain detailed and relevant accounts of taxonomy, classification and evolution. These included accounts of principles of phylogenetic classification, DNA hybridisation and immunological comparisons of proteins. These essays often contained good accounts of evolution of populations and speciation. Weaker essays often contained rambling accounts of competition and evolution of new species but used little or no correct terminology and often confused populations and species.

Behaviour was a very popular topic. There were good accounts of its importance during reproduction to identify individuals of the same species, in order to produce fertile offspring. Some accounts went on to explain its role in identifying individuals in breeding state, or even its role in promoting gamete production or release. There were a lot of vague descriptions of behaviour showing who was ready to mate, with no A-level content.

Many essays had very long and rambling accounts of relationships within ecosystems. Some consisted of little else. There were some very good accounts of the concepts of food chains and food webs and the inter-dependence of populations of different species within a community. These often went on to consider energy transfers within ecosystems, between different trophic levels. Weak accounts were at GCSE level or below, with references to plants making their own food, or energy, and this being passed on to all the animals. The predator-prey relationship was often described but infrequently with references to populations, inter and intra-specific competition or time lags.

Succession was another frequently seen topic. The best accounts wrote about pioneer species and communities, resultant changes in abiotic and biotic factors and the ensuing competition from other species that (may) out-compete the pioneers. They also wrote about communities and biodiversity changing over time until a climax community was established. Many accounts contained little or no scientific terminology or concepts.

Human impacts on the environment were as commonly written about as relationships within ecosystems. Unfortunately, many accounts were at or below GCSE standard and were often at the level of humans causing global warming which was bad for polar bears. There were good accounts that used, for example, deforestation as an example and

contained references to habitat destruction, loss of niches, loss of diversity and the reasons for this. Others wrote about farming and the simplification of food webs, loss of diversity, use of pesticides and selective breeding. Nutrient cycles were written about by most students. The specification rather limits what they can be expected to know about the carbon cycle but some failed to include any relevant detail. The nitrogen cycle was well done by some but there were common misconceptions about what happens in the root nodules of leguminous plants. Many thought that *Rhizobium* converts nitrogen to nitrates for the plants. There was also considerable confusion between nitrifying and denitrifying bacteria. Many students went on to write about eutrophication and it was pleasing to see many correct accounts of the process.

Gene technology in various forms was a popular topic. Most wrote about genetically engineering microorganisms to produce useful substances such as insulin. Others wrote about genetically engineered crop plants with herbicide resistance, or that produced an insecticidal protein. The quality of the accounts varied a great deal. Many who wrote about this also wrote about evolution of antibiotic resistance in bacteria. Good accounts included horizontal transmission of genes for resistance between species of bacteria, involving plasmids. Relatively few students made any mention of antibiotics as a selection pressure, or random mutations as the source of resistance.

Q15.

(a) (i) Almost ninety percent of students correctly identified process **P** as being nitrification.

(ii) Slightly fewer students correctly identified process **Q** as being denitrification.

(b) Very few students gained both marks in this question. The most common error was to suggest that nitrogen-fixing bacteria fix nitrogen to form nitrate rather than ammonia. Approximately half the students obtained one mark for indicating that the crop would be able to produce amino acids or proteins. Weaker answers simply stated that nitrogen was needed for better growth.

(c) Most students gained at least one mark by referring to a decrease in the water potential of the soil. Many students mentioned water loss from the plant but did not always refer to osmosis or diffusion to gain a second mark. Some students suggested that fertilisers would move into the plant by osmosis, or would alter the pH of the soil. Other students misinterpreted the context of the question and described the effects of eutrophication.

Q16.

(a) This question, as with part (b), proved to be a very effective discriminator. The vast range of farming practices which increase productivity of agricultural crops resulted in an extended mark scheme. The most commonly awarded marks were for fertilisers and the roles of named nutrients (usually nitrates for proteins), and for pesticides reducing crop damage. Many students also appreciated the role of herbicides in destroying weeds and removing competition. A significant number of students wrote at length about optimising light, temperature and carbon dioxide to maximise photosynthesis. Only one mark was available for this idea and it had to be in the context of using glasshouses. Selective breeding and the benefits of ploughing were also mentioned by a good proportion of students. Marks were awarded for correct references to crop rotation, irrigation and other similar farming practices not specifically outlined on the specification. However, many students failed to gain marks by correctly identifying a farming practice but then failing to explain clearly how it increased productivity.

(b) It was pleasing to note that, compared with previous years, a higher percentage of students obtained good marks on this topic. The most frequently awarded marks related to the action of nitrifying bacteria in the process of converting ammonium ions into nitrite and then into nitrate. However a significant number of students missed a mark by not clearly describing that the conversion of nitrite to nitrate is a separate process. There was some confusion relating to saprobiotic nutrition with relatively few students providing a named compound from which ammonia is formed. The action of nitrogen-fixing bacteria was outlined by better students although most simply referred to their presence in root nodules. There were inevitably some irrelevant descriptions of the role of denitrifying bacteria.

Q17.

(a) Nitrogen-fixing was the commonest wrong answer in this question. The majority of responses were correct.

(b) This question was answered poorly because students did not think through the processes that were taking place in the reed bed. There were many incorrect responses referring to processes in the reeds that result in the formation of nitrates from ammonia / nitrite. Some then went on to gain one mark for active transport of these nitrates into the plant roots. Better students correctly linked the use of ATP from aerobic respiration in the active transport of nitrates, and wrote clearly and concisely. There was a surprising amount of confusion between diffusion and active transport, with active transport being said to be needed to diffuse nitrogen-containing substances from areas of high to low concentration. The oxygen was also thought to create a concentration gradient to allow the roots to take up the nitrogen-containing substances by diffusion.

(c) There were some very clear answers to part (i) from students who understood that too fast a flow would not allow time for the nitrification to occur, hence the decrease in concentration of nitrates. There was also not enough time for the saprophytes to decompose the sewage to release ammonium compounds. Some failed to mention the ammonia being converted. Other answers suggested that the soil would become waterlogged, preventing the action of the nitrifying bacteria, or that the reeds would take up more of the nitrates or that numbers of denitrifying bacteria would increase, converting the nitrate to nitrogen gas. A number thought that if the flow was too fast, the reeds would be unable to take up the nitrates, so they would end up in the lake. The fast flow was also thought to reduce the oxygen concentration in the water, thus preventing the action of the nitrifying bacteria. There was also confusion with leaching and eutrophication. There were only very occasional references to the bacteria being washed away by the fast flow. The fast flow was also said to maintain a steep diffusion gradient and increase uptake by the plant roots.

In part (ii), it was clear that many students had learnt this topic thoroughly and included all marking points. Weaker students could not explain the increase in decomposers breaking down the dead plants and using up the oxygen in the water in their respiration. The algae were often described as ‘feeding’ on the nitrates. A common incorrect reason for the death of the fish was a lack of food once the plants in the lake died. A minority of students had no understanding of the process of eutrophication and thought that dehydration and osmosis caused the fish to die or that high nitrate concentrations were toxic to both fish and algae. Increasing concentrations of carbon dioxide were also thought to be responsible for the death of the fish.

Q18.

(a) Apart from the few candidates in part (i) who discussed the recycling of „animal", this

question seemed to pose few problems. Where candidates interpreted 'open pond' as a natural pond containing wildlife and associated processing of waste with environmental damage, they were given credit. In part (ii), better candidates explained the effect of heat on enzymes and, thus, on microorganisms if it were not dissipated. Weaker candidates tended to do no more than repeat the stem of the question.

(b) In part (i), the effects of leaching of nitrates into watercourses were well known and many candidates gained full marks on this section. Part (ii) was answered less convincingly, with many candidates referring to the low cost or easy availability of animal waste, rather than identifying the high energy demands and carbon dioxide emissions associated with the production of artificial fertiliser.

Q19.

(a) The majority of answers were correct and concise but some candidates included extensive detail about nitrogen fixation, and denitrification that were not required by the question.

(b) A very large number of candidates appeared to have written all they knew about photosynthesis, rather than focus on the light independent reaction as required by the question. Generalising the reactions and writing too superficially, e.g., 'GP is converted to TP using ATP', was common but gained no marks, whereas 'GP is reduced to TP' would have gained one mark and 'GP is reduced to TP using energy from ATP and the reducing power from reduced NADP' would have gained three. Many diagrams and schemes for the light-independent reaction were included and, where these contained additional information, this was credited. However, many were inaccurate or only repeated what had already been written There were also a worrying number of these diagrams labelled as the Krebs cycle.

Q20.

(a) Most candidates obtained at least one mark often for referring to NBPT attaching to the active site. Better candidates referred to competitive inhibition or provided a suitable description to gain the second mark. Weaker candidates often referred to an active site on NBPT or described non-competitive inhibition.

(b) (i) Very few candidates stated that the inhibitor reduced the loss of ammonia up to day 8 or day 9. Most candidates gave very general descriptions of the effect of NBPT on the loss of ammonia from urea fertiliser or suggested it was lower for only 4-6 days.

(ii) This also proved problematic for candidates. Most candidates suggested that the increase in urea in the soil would lead to an increase in the loss of ammonia. However, this would not fully explain the increase from day 2 to day 4. Very few candidates gained both marks by suggesting that an increase in bacteria would lead to more urease being present. However, a number of candidates did gain one mark for referring to more enzyme-substrate complexes being formed.

(c) Most candidates gained at least one mark for indicating that less ammonia would be lost from the soil. Approximately two thirds of candidates gained a second mark by explaining this would be converted to nitrite/nitrate in the soil. Better candidates then described how this nitrogen source could be used to form proteins or nucleic acids.

Q21.

(a) Most candidates correctly identified ammonia as the product of nitrogen fixation.

(b) Candidates appreciated the idea of substances with a similar shape fitting the active site of an enzyme. Some, however, incorrectly identified the active site as part of a substrate structure.

(c) (i) Better candidates identified ATP as the product of aerobic respiration and went on to suggest, appropriately, that as Azotobacter removes oxygen during aerobic respiration, nitrogenase would have the required anaerobic conditions and catalyse the fixation of nitrogen. Less able candidates did not make full use of information provided in the question introduction and had limited success.

(ii) Processes involved in growth, such as protein synthesis or the production of new cells, require energy. If this energy is used in nitrogen fixation, less will be available for growth. Consequently, growth will be slower. Better candidates expressed this idea clearly.

Q22.

This question allowed candidates to demonstrate their knowledge but this did not mean that all were successful. All parts discriminated across the ability range.

(a) A significant proportion of candidates still gave the impression that they believed that respiration in plants only occurs at night. Others suggested that photosynthesis continues at night, but at a reduced rate. There were contradictions relating to the concentration of carbon dioxide in the canopy and at ground level. Few candidates considered the idea of the relative rates of photosynthesis and respiration in the light and the effect on the net uptake of carbon dioxide. There were, however, many complete and high scoring responses.

(b) Weaker candidates confused substances featuring in the light-independent reaction with those featuring in the Krebs cycle, and confused reduced NADP and reduced NAD. There were many good answers which identified that two molecules of glycerate-3-phosphate are formed and that this is reduced to triose phosphate using reduced NADP and energy from ATP.

Q23.

(a) In (i), most candidates understood the principles of run-off or leaching, although weaker candidates insisted on referring to ‘the nitrogen’ being leached.

In (ii), most candidates understood that organic fertilisers contain fewer soluble components. Fewer candidates realised that organic fertiliser takes time to break down.

(b) There were some very good accounts of eutrophication, with many candidates scoring maximum marks. Weaker candidates thought that nitrates poisoned the fish, or that nitrates stimulated respiration by plants, using up all the oxygen.

Q24.

(a) In this question, it was a relatively common failing for candidates to be unable to write about the relevant part of the nitrogen cycle without also trying to include other aspects. In (i), some candidates failed to distinguish between the roles of decomposers and nitrifying bacteria in their answers, phrasing their responses along the lines of “the decomposers and nitrifying bacteria convert the organic substances

into ammonia and then to nitrates". It was also disappointing to read the number of answers that included references to lightning and the Haber process. However, candidates who understood the nitrogen cycle well usually had little problem with this question. There was a general understanding in (ii) that nitrogen-fixing bacteria convert nitrogen gas into a form that is more readily available; however, there was also a widespread misconception that they convert the gas directly into nitrate ions.

(b) In (i), a disappointing number of candidates did not read the question carefully and described changes in the populations of both types of bacteria and both types of protoctistans, usually without really explaining the reasons for any of the changes. Good candidates recognised the predator-prey relationship between the dispersed bacteria and the free-swimming protoctistans in the way the numbers increased and then declined slightly out of phase with each other. In (ii), candidates who understood the process of succession were generally able to recognise the changes in the environment in the treatment tank that resulted in changes in the community inhabiting that environment. A common failing was not to make clear that it is the activities of the organisms that inhabit an area that change the environment and so make it suitable for colonisation by other species.

Q25.

(a) Too many candidates saw two empty boxes in the flowchart in (i) and either wrote the names of both substances in the boxes or the number of carbon atoms in each substance. This clearly is the result of not reading the question carefully. Those who did answer the question set, usually scored both marks. In part (ii) good candidates realised that all ATP is produced in mitochondria, except that produced in glycolysis. They therefore arrived at the correct answer of 36 ATP by deducting 2 from the net total yield of 38 ATP per molecule of glucose, or by deducting 4 from the total production of 40 ATP. Others did arrive at the correct answer by working out where each molecule of ATP was produced, but many attempting this method did so in a disorganised way and so made errors in calculation. In (iii) most candidates knew that, in the absence of oxygen, some of the reactions of respiration could not take place, but many were unable to describe the extent of anaerobic respiration. Well prepared candidates were able to state clearly that only glycolysis would take place and, therefore, the ATP production of the Krebs cycle and electron transport chain would be lost. They also often

(b) Despite being given specific information in part (i) concerning the features of the heterocysts (thick walls and the absence of chlorophyll), and the requirements of nitrogen fixation (anaerobic conditions) candidates too often invented other features and reasons other than maintaining anaerobic conditions for those features. Disappointingly few candidates confined themselves to answers based on excluding oxygen and not producing oxygen, which would inhibit the process of nitrogen fixation. There were some excellent answers to part (ii) from candidates who appreciated that nitrogen-containing compounds in the rice plants would be the starting point for the reactions of the nitrogen cycle, and duly described the roles of decomposition and nitrification accurately and logically. Some realised that the decomposers would produce carbon dioxide as a result of their respiration and that this could be used in photosynthesis by the leaves of the rice plants. However, too many just assumed that the ammonia produced by the heterocysts would be released into the soil, apparently unused by the fern and, in their answers, took this as the starting point for the nitrogen cycle. This clearly shows less appreciation of the situation as described.

Q26.

(a) Fertiliser was the most frequently seen answer but many attributed dying plants with

the ability to release significant volumes of phosphate.

(b) The calculation was well done by many and some credit was given even to those who chose the wrong denominator or misread the graph. Some used the wrong graph or calculated the 1995 level as the difference.

(c) It was good to see most candidates attempting this question, many appreciating that other factors might be involved. The second mark was only rarely given, usually for a comment on the validity of the information or for an explanation of the effect of the factor.

(d) Whilst many candidates were easily able to gain maximum credit here, a number performed badly and failed to recognise the idea of the question. References to phosphate killing fish directly or to plants giving out lethal levels of carbon dioxide were often seen. The main points missed were reference to *increased* phosphate and development of the lack of light aspect in reducing photosynthesis and thus oxygen output.

Q27.

Once again, the nitrogen cycle proved a weak link in the understanding of a large number of candidates.

(a) More candidates were able to identify process **P** as denitrification than were able to identify process **Q** as nitrogen fixation. Nitrification was a common wrong answer, as was ammonification, since this refers to the conversion of nitrogen in organic compounds to ammonia.

(b) Many candidates misread the questions and did not realise that they had to account for the apparent discrepancy between the amount of ammonia converted to nitrates and the amount formed by nitrogen fixation. Good candidates knew that ammonia is also formed by the decomposition of proteins, amino acids, urea and other organic compounds in the detritus that contain nitrogen.

(c) Most candidates realised that hydrogen is lost and oxygen is gained in the conversion of ammonia to nitrate.

Q28.

(a) Many descriptions lacked precision through not supplying figures or giving only part of the pattern. Weak explanations failed to refer to the nitrate and its use in the plant. In the third part only a few realized that the nitrate would no longer be limiting and many offered no alternative limiting factors which might be operating. In this part, and elsewhere in the question, answers would have attained higher marks if the word ‘nutrient’ had been replaced by a more exact term.

(b) This section scored highly although a surprising number overlooked the output of the cattle and concentrated on the paucity of their input. The idea of a crop clearing a field of a particular mineral was seen in many scripts and removal on harvesting was well known.

Q29.

Many candidates found this to be quite a difficult question. Answers were frequently expressed with insufficient clarity and data were often used non-selectively.

(a) Most candidates realised that the data for the grass in graphs **C** and **D** showed no

significant difference. Weaker candidates imagined that some of the slight differences were of significance.

(b) For those who selected the appropriate graphs for comparison (i.e. **A** and **C**, with neither having *Rhizobium* added and only **C** having the nitrate), there was little difficulty in finding evidence for the effect of nitrate fertiliser on the soybeans. Less selective candidates produced very confused arguments.

(c) This section required candidates to both describe and explain the effect of *Rhizobium* on the growth of the soybeans. Many candidates did either one or the other. Explanations were frequently confused regarding the details of nitrogen fixation and answers often included nitrate production in addition to, or instead of, that of ammonium ions. A sizeable minority realised that a mutualistic relationship existed between the *Rhizobium* and the legume (or that, at least, the bacterium formed nodules on the plant's roots), and some went on to explain that the plant would gain organic nitrogen compounds such as amino acids or proteins as a result of the relationship.

In sections (b) and (c), a sizeable proportion of candidates appeared confused regarding what had been used in the experiment as a measure of plant growth – there were many references to the 'number of seeds' produced but, since this was plotted on the x-axis, it should have been realised that the number of seeds was a manipulated variable and not a result.

Q30.

This question produced the full range of marks, with some excellent answers and some with little knowledge of the nitrogen cycle and its importance to farming.

(a) Many candidates scored full marks, but there were also many who seemed to be naming any bacterium which was part of the nitrogen cycle.

(b) Only a minority of candidates scored full marks. There were many incomplete answers from candidates who just named a farming practice, and then gave no detail of the nitrogen compounds involved or how the farming practice would add or remove the nitrogen compounds. Many candidates did not seem aware of what constituted a farming practice, with many references to adding various types of bacteria or water-logging fields, or describing totally unrelated practices such as spraying pesticides. 'Growing legumes' and 'hedge removal' with associated explanations were the most common correct answers to (i) and (ii) respectively. Many candidates thought that the growing of any crop, and then ploughing it, would increase the nitrogen content.

Q31.

The question was generally well answered with the majority of candidates scoring more than half marks. However, only a minority of candidates scored full marks.

(a) The majority of candidates scored two marks for describing the importance of photosynthesis and respiration. Only a few candidates developed their answer fully to explain the role of enzymes in the breakdown of organic matter by bacteria, or explained how algae use nitrates and ammonia to form organic nitrogen compounds. Most just stated that they are needed for 'growth'. The weaker

candidates tended to describe the information given in the diagram rather than explain it.

(b) The majority of candidates linked the increased temperature to higher enzyme activity, but many of these failed to develop their answer further to discuss the effect of this on named metabolic processes. Many candidates just referred to enzymes working more efficiently or stated that the enzymes would be at their optimum. Many also stated that the shallow pond was to keep the bacteria and algae close together.

Q32.

(a) This was poorly answered as few candidates referred to the loss of high protein parts of the plants in dry conditions or the reduced uptake of nitrates. Most stated that, as the process of photosynthesis required water, there would be less energy or less carbohydrate for protein synthesis.

(b) Only a minority of candidates correctly explained the higher protein content in the food by selective eating of the high protein species/parts. Many stated that wildebeest had another source of protein, such as animals.

(c) There was a very wide variety of acceptable answers, although most candidates described the effect of a lack of actin or myosin. A significant number of candidates gave non-protein examples such as glucose, starch and acetylcoenzyme A or did not name a protein.

Q33.

(a) This was not well answered by many candidates. Most knew that legumes fixed nitrogen but references to roots, nodules or bacteria were often missing or incorrect. Very few discussed the advantage in a crop rotation, and just discussed the need for less fertiliser.

(b) This was either well answered or very poorly answered. If candidates made the link between fertiliser and water potential, they usually scored both marks but many candidates were unable to make this link.

Q34.

(a) This was well answered and most candidates were able to suggest a reason for leaving a strip of bare ground between the hedgerow and the conservation headland.

(b) This question was generally poorly answered with vague responses and poor terminology. Only the best candidates discussed ideas like habitats for pest predators. Weaker candidates refered to ‘homes for insects’, or stated increased diversity with no explanation.

(c) This was well answered by many, with candidates gaining three marks for a discussion of the nitrogen cycle. Few candidates discussed the carbon cycle, and

those that did were rather vague.

Q35.

(a) Most candidates scored at least one mark by referring to protein synthesis. Fewer candidates were able to give a second use of nitrate.

(b) The majority of candidates scored two marks for describing the shading of the submerged plants and the consequences of this on their photosynthesis.

(c) Many candidates scored high marks for explaining both the reduction in oxygen and the production of nitrates. Few, however, linked the saprobiotic digestion of the proteins in the dead organic matter to the production of ammonium compounds, and a significant number were confused as to which bacteria were involved in the process of nitrate production.

(d) Many candidates correctly described the lower species diversity, but only a minority appreciated the concept of tolerance, instead answering in terms of .aerobic species die. As in previous questions, poor expression was a problem, with many candidates referring to different animals' rather than species.

Q36.

(a) (i) Few candidates identified substance X as ammonium ions or ammonia. Nitrate was the most common incorrect answer.

(ii) Most candidates correctly identified substance Y as gluscose.

(b) Only the more able candidates successfully described the role of oxygen as the final hydrogen acceptor, producing water; many weaker candidates merely cited the equation for aerobic respiration. A surprising number of candidates responded incorrectly by discussing the role of oxygen in Krebs cycle or its use in lactic acid removal in muscles.

(c) This question was not well answered. Candidates failed to read the question and few realised that only glycolysis is operating during anaerobic respiration. The importance of NAD in allowing glycolysis to continue was missed and candidates concentrated instead on the production of ATP in the electron transfer chain.

(d) Most candidates recognised the active site as a feature of an enzyme that would contribute to its specificity; fewer scored the second mark explaining the significance of the active site by referring to its complementary shape.

(e) This was generally well answered, with most candidates aware of the action of non-competitive inhibitors.

Q37.

(i) Most candidates gained credit for the fact that the fertiliser had leached into the river, but only the more able explained that it is excess fertiliser that leaches in this way.

(ii) The vast majority of candidates scored highly by correctly recounting the standard sequence of events in eutrophication.

Q38.

(a) Almost all of the candidates cited the long roots of the plant.

(b) Almost every candidate correctly identified inter-specific competition.

(c) Most candidates thought that the nitrogen-fixing bacteria in the root nodules of the mesquite would remain active somehow after the plant was dead. There were few attempts to relate the increase in fertility to the decomposition of the plants.

Q39.

(a) This question produced a range of answers, with some clear and organised responses. A significant number, however, resorted to a strategy of writing everything they knew of the nitrogen cycle including a lengthy and irrelevant discussion of nitrogen fixation and the role of denitrifying bacteria, failing to take into account the information given. Some assumed the mustard contained root nodules and increased the nitrogen content of soil. A common omission was the lack of reference to the breakdown of proteins that leads to ammonium ions in the soil. Marks were also lost by candidates discussing ammonia or failing to explain the absorption of nitrate. Weaker answers confused the sequence of events completely.

(b) Most candidates gained one mark, usually either for recognising the eutrophication link, probably due to the association with leaching of nitrates, or for the effect on crop growth of a lack of nitrates. Few candidates gained two marks by providing a description of both or for suggesting the benefits to the farmer. There was a tendency to discuss in detail the effects of eutrophication.

(c) This question produced varied answers with candidates having problems with the synoptic element. Few were able to give a range of uses of phosphate necessary to gain full marks. Most gained one mark by providing ATP as one example but then described in detail its role. DNA and nucleic acids were also a relatively common answer but surprisingly few suggested phospholipids and cell membranes.

Q40.

(a) (i) Most candidates achieved this mark.

(ii) The presence of nitrogen-fixing bacteria in leguminous plants is well known, but the process by which the fixed nitrogen is made available to a future crop is not. Very few candidates referred to the role of decomposition in recycling nitrogen and many implied that the fixed nitrogen was automatically made available. Nitrifying bacteria were incorrectly given as having the ability to fix nitrogen and a surprising number of candidates believe clover is able to fix it.

(b) (i) The effect of increasing fertiliser application on the protein content of grain was usually described adequately, but only the most able candidates identified the small effect that fertiliser applications had on grain yield. Many candidates ignored the small increase in yield at low doses of fertiliser by stating that fertiliser had no effect on yield, without any indication that the yield increase might not be statistically significant.

(ii) This was well answered by the majority of candidates.

Q41.

This question demonstrated most students clearly understand the principles of eutrophication with high marks being gained for the first section. The remaining sections were less well answered.

Most students gained maximum marks with well-rehearsed answers. Some students gave slightly confused answers with inappropriate ordering of the stages but even these often achieved sufficient marks to score the maximum. A very few suggested bioaccumulation of fertiliser as a cause of the changes.