HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.1.8 Inorganic ions

Mark scheme

Version 2 · 10 October 2026

TOTAL MARKS	QUESTIONS
48	5

How to use this mark scheme

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

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

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Hydrogen ions and pH 3.1.8

Question	Marking guidance	Mark	Comments
01.1	Concentration of hydrogen ions: Higher pH: Lower;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
01.2	Correct answer for 2 marks: 10 (%);; Accept for 1 mark: 8 ÷ 80 **OR** 0.1 (not converted to a percentage) **OR** correct method using the student's readings from the graph	**2** (2 × AO2)	Plotted values: 8 at pH 7.2 and 80 at pH 4.8 **Accept** readings of 6–10 and 78–82, giving answers from 7.3 to 12.8 (%), for 2 marks

Question	Marking guidance	Mark	Comments
01.3	1. Cytoplasm has a lower concentration of hydrogen ions (than the lysosome); 2. (Change in hydrogen ion concentration) alters/breaks ionic bonds and/or hydrogen bonds in protease X, changing its tertiary structure; 3. Active site changes shape/is no longer complementary (to the protein), so fewer enzyme–substrate complexes form (and the rate is only 10% of the maximum); 4. Only a small amount of protease X is released OR it is diluted in the cytoplasm;	**3 max** (2 × AO1) (1 × AO2)	**Max 2** if hydrogen ions are not referred to 1. **Accept** converse, eg the lysosome has a higher concentration of H^+ 1. **Reject** 'higher pH means more hydrogen ions' 1. **Reject** 'hydrogen' alone for hydrogen ions 2. **Accept** (protease X) is denatured 3. **Accept** a correct comparison of rates from Figure 1, eg 8 compared with 80 **Accept** E-S complex / ES complex. E-S alone only if 'enzyme-substrate complex' is written elsewhere. Ignore ESC.

Question	Marking guidance	Mark	Comments
01.4	1. (Substance Z) reduces the concentration of hydrogen ions (in the phagosome), so the pH increases/rises (above 4.8); 2. Rate of reaction of protease X decreases as pH rises above 4.8, eg 80 at pH 4.8 compared with 26 at pH 6.4; 3. So fewer (bacterial) proteins are hydrolysed/the bacteria are not digested/destroyed;	**3** (2 × AO2) (1 × AO3)	1. **Accept** acidity decreases OR becomes less acidic 1. **Reject** pH decreases 2. **Accept** any correct pair of values from Figure 1 at or above pH 4.8 3. **Accept** bacterial enzymes/membrane proteins are not hydrolysed

Iron ions and haemoglobin 3.1.8

Question	Marking guidance	Mark	Comments
02.1	They are part of haemoglobin, and oxygen binds to them;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
02.2	1.1×10^9;	**1** (1 × AO2)	$2.8 \times 10^8 \times 4 = 1.12 \times 10^9$

Question	Marking guidance	Mark	Comments
02.3	Correct answer for 2 marks: 2.4×10^{-11} (g);; Accept for 1 mark: $96 \div 4.0 \times 10^{12}$ **OR** correct answer not in standard form, eg 0.000 000 000 024 OR 24×10^{-12}	**2** (2 × AO2)	**Ignore** 'per cell' after the unit **Reject** answers in pg or other units unless converted to g

Question	Marking guidance	Mark	Comments
02.4	1. (Supports:) group D has fewer red blood cells (4.0×10^{12} compared with 5.0×10^{12} per dm^3) OR 20% fewer red blood cells; 2. (Does not support:) each red blood cell in group D also contains less haemoglobin (2.4×10^{-11} g compared with 3.0×10^{-11} g) OR haemoglobin concentration is 36% lower but the number of red blood cells is only 20% lower;	**2** (2 × AO3)	**ECF** for the student's answer to 02.3 in point 2 2. **Accept** if fewer cells were the only cause, haemoglobin concentration in group D would be 120 g dm^{-3}, not 96

Question	Marking guidance	Mark	Comments
02.5	1. Iron ions are a component of haemoglobin, so less haemoglobin (is made) (96 compared with 150 g dm^{-3}); 2. Less oxygen binds/is loaded OR less oxyhaemoglobin forms, so the blood transports less oxygen; 3. Less oxygen supplied to (muscle) cells/tissues, so less (aerobic) respiration OR less ATP made;	**3** (1 × AO1) (2 × AO2)	1. **Reject** 'Hb' for haemoglobin; the full term is needed 2. **Accept** carries for transports; accept associates with for binds 3. **Reject** 'less energy produced/made'

Sodium ions and co-transport 3.1.8

Question	Marking guidance	Mark	Comments
03.1	Amino acids and glucose;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
03.2	To remove (radioactive) glucose from the outside/surface of the cells, so only glucose absorbed (into the cells) is measured;	**1** (1 × AO3)	**Accept** so glucose that has not been absorbed is not measured **Ignore** 'to wash the cells' unqualified

Question	Marking guidance	Mark	Comments
03.3	Correct answer for 2 marks: 2.4 (nmol min^{-1} mg^{-1});; Accept for 1 mark: 72 ÷ 30 OR correct change in glucose absorbed ÷ time for any two points on the line	**2** (2 × AO2)	Plotted line for solution A passes through 12 at 5 min, 24 at 10 min, 36 at 15 min, 48 at 20 min, 60 at 25 min, 72 at 30 min **Accept** answers from 2.3 to 2.5 for 2 marks

Question	Marking guidance	Mark	Comments
03.4	1. Keeps the water potential (of the solution) the same (as in solution A); 2. So the cells do not gain/lose water by osmosis OR so the cells do not swell/burst/shrink; 3. So the only difference is the absence of sodium ions OR so any difference in uptake is due to sodium ions;	**2 max** (2 × AO3)	1. **Accept** keeps the (total) concentration of ions/solutes the same **Ignore** 'fair test' unqualified

Question	Marking guidance	Mark	Comments
03.5	1. (In A,) sodium ions move into the cell down their concentration gradient (from the solution) OR sodium ions are moved out of the cell (by the carrier protein), maintaining a sodium ion concentration gradient into the cell; 2. Glucose moves in with sodium ions through the co-transporter (protein)/by co-transport; 3. (In B,) no sodium ions, so no sodium ion concentration gradient into the cell OR nothing to drive co-transport of glucose; 4. (In B, glucose only enters) by facilitated diffusion (down its concentration gradient), which is slower;	**3 max** (3 × AO2)	1. **Accept** (sodium ions enter) by facilitated diffusion/through the co-transporter 1. **Reject** sodium ions actively transported into the cell 2. **Accept** glucose moves in against its concentration gradient with sodium ions **Reject** 'sodium' once for sodium ions **Reject** glucose is actively transported (by the co-transporter) using ATP

Question	Marking guidance	Mark	Comments
03.6	1. For the first 5 minutes, uptake is similar to A (11 compared with 12) because a sodium ion concentration gradient is already present; 2. No ATP (hydrolysed), so the carrier protein no longer moves sodium ions out of the cells; 3. Sodium ions still enter the cells (with glucose), so the sodium ion concentration inside rises/the sodium ion concentration gradient decreases; 4. So less glucose is co-transported/uptake slows down after 5 minutes; 5. After 15 minutes, uptake rises at the same rate as B (0.2 nmol min^{-1} mg^{-1}), so glucose enters only by facilitated diffusion/no co-transport occurs; 6. Shows that ATP is needed only indirectly: glucose uptake depends on the sodium ion gradient, which ATP maintains;	**5 max** (3 × AO2) (2 × AO3)	2. **Accept** sodium ions are not actively transported/pumped out of the cells 2. **Reject** 'no energy produced/made' 3. **Accept** no sodium ion gradient is maintained 6. **Accept** glucose uptake continues for a short time without ATP production **Reject** 'sodium' once for sodium ions Description of the curve without explanation gains no marks

Phosphate ions in DNA and ATP 3.1.8

Question	Marking guidance	Mark	Comments
04.1	Phosphodiester (bond);	**1** (1 × AO1)	**Reject** ester bond alone **Reject** glycosidic/hydrogen/peptide bond

Question	Marking guidance	Mark	Comments
04.2	ATP 3; ADP 2; DNA nucleotide 1; Phospholipid 1; Triglyceride 0 All five correct for 2 marks;; Three or four correct for 1 mark	**2** (2 × AO1)	**Accept** words, eg 'three', 'none' **Accept** a dash for triglyceride only if 0 is clearly meant

Question	Marking guidance	Mark	Comments
05.1	Dead bacteria also make the culture cloudy/absorb light OR the colorimeter cannot distinguish living from dead bacteria;	**1** (1 × AO3)	**Accept** other material in the culture, eg cell debris, absorbs light

Question	Marking guidance	Mark	Comments
05.2	1. Polyphosphate is broken down/hydrolysed to release phosphate ions; 2. Phosphate (ions) used to make (named) phosphate-containing molecules, eg DNA/nucleotides/ATP/phospholipids, needed for (a few) divisions;	**2** (1 × AO1) (1 × AO2)	2. **Accept** used for DNA replication (before binary fission) 2. **Reject** 'phosphorus' as a component of DNA/ATP/phospholipid

Question	Marking guidance	Mark	Comments
05.3	1. Phosphate is a component of (DNA) nucleotides OR forms the sugar–phosphate backbone of DNA; 2. So at low phosphate concentrations fewer nucleotides/less DNA can be made, so less DNA replication; 3. DNA replication (of circular DNA/plasmids) is needed before binary fission, so fewer divisions/fewer new bacteria; 4. Phosphate is a component of ATP (and ADP); 5. Less ATP, so less energy released (by hydrolysis) for energy-requiring reactions, eg DNA replication/protein synthesis/active transport; 6. Less inorganic phosphate to phosphorylate other compounds, so they are less reactive; 7. Phosphate is a component of phospholipids, so less (cell-surface) membrane can be made for new cells; 8. Phosphate is a component of RNA, so less protein synthesis/fewer enzymes, eg DNA polymerase/ATP synthase; 9. From 0.0 to 1.0 mmol dm^{-3}, phosphate is the limiting factor, so more phosphate gives many more bacteria (3 to 690 × 10^6 cm^{-3}); 10. From 1.0 to 2.0 mmol dm^{-3}, the increase is smaller (270 × 10^6 compared with 687 × 10^6 cm^{-3}), because another factor, eg another nutrient/oxygen/space, begins to limit growth;	**6 max** (4 × AO1) (1 × AO2) (1 × AO3)	**Max 3** if the answer only lists phosphate-containing molecules without explaining how a lack of them reduces growth or division 1, 4, 7 and 8. **Reject** 'phosphorus' for phosphate as a component of DNA/ATP/phospholipid/RNA, once only **Accept** 'less phosphorus in the medium' when describing the supply of the nutrient 5. **Reject** 'less energy produced/made' 6. **Accept** Pi for inorganic phosphate 9 and 10. **Ignore** description of the data unless it is linked to phosphate or another factor limiting growth

Question	Marking guidance	Mark	Comments
05.4	1. (Supports:) the number of bacteria increases as phosphate concentration increases up to 2.0 mmol dm^{-3}, eg from 3×10^6 to 960×10^6 cm^{-3}; 2. (Supports:) phosphate is a component of DNA nucleotides, and DNA replication is needed before binary fission; 3. (Supports:) above 2.0 mmol dm^{-3} the number hardly changes (960 and 970×10^6 cm^{-3}), so phosphate limits growth only at low concentrations; 4. (Against:) DNA replication/DNA content was not measured, only the number of bacteria; 5. (Against:) phosphate is also needed for (named) other molecules, eg ATP/phospholipids/RNA, so lack of these could limit growth; 6. (Against:) only one culture at each concentration/no repeats OR no statistical test, so cannot tell whether the differences are significant;	**4 max** (1 × AO1) (3 × AO3)	**Max 3** if only points for, or only points against, the conclusion are given 2 and 5. **Reject** 'phosphorus' as a component of these molecules 6. **Ignore** 'more repeats needed' without a reason **Ignore** the colorimeter overestimating the number of living bacteria (credited in 05.1)

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