HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.1 Photosynthesis

Mark scheme

Version 2 · 15 October 2026

TOTAL MARKS	QUESTIONS
64	8

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.

The light-dependent reaction 3.5.1

Question	Marking guidance	Mark	Comments
01.1	Oxygen, protons and electrons;	**1** (1 × AO1)	Photolysis splits water into protons (H^+), electrons and oxygen

Question	Marking guidance	Mark	Comments
01.2	1. Chlorophyll absorbs light (energy); 2. Photoionisation of chlorophyll OR (excited) electrons are released/lost from chlorophyll; 3. Electrons pass along/down the electron transfer chain (in the thylakoid/chloroplast membranes); 4. Energy (released by the electrons) is used to move protons across the (thylakoid/chloroplast) membrane (into the thylakoid); 5. Photolysis of water (also) produces protons (inside the thylakoid); 6. Protons pass back across the membrane through ATP synthase OR protons diffuse down a concentration/electrochemical gradient through ATP synthase; 7. ATP synthase catalyses the production of ATP from ADP and (inorganic) phosphate;	**5 max** (5 × AO1)	**Accept** chemiosmosis/chemiosmotic theory described correctly for points 4, 6 and 7, but the term alone gains no mark 2. **Reject** 'photolysis' for photoionisation 4. **Accept** protons are pumped; do not credit 'active transport' of protons by the electron transfer chain as point 4 5. **Reject** water is hydrolysed 6. **Accept** H^+ or hydrogen ions for protons; reject hydrogen atoms 7. **Accept** P_i for inorganic phosphate **Reject** energy is produced/made (once only)

Question	Marking guidance	Mark	Comments
02.1	Correct answer for 2 marks: 1×10^4;; Accept for 1 mark: $[H^+]$ of 1×10^{-4} **and** 1×10^{-8} (mol dm^{-3}) **OR** 10 000 (not in standard form)	**2** (2 × AO2)	**Accept** 1.0×10^4 or 10^4 **Reject** 4 (difference in pH) or 2 (pH 8 ÷ pH 4)

Question	Marking guidance	Mark	Comments
02.2	1. In **A**, the concentration of protons is higher inside the thylakoids than outside OR there is a proton/pH gradient across the (thylakoid) membrane; 2. Protons diffuse out (of the thylakoids) through ATP synthase; 3. (Flow of protons through) ATP synthase catalyses the joining of ADP and phosphate / production of ATP; 4. In **B**, the pH is the same inside and outside, so there is no proton gradient/no (net) movement of protons through ATP synthase;	**3 max** (3 × AO2)	**Max 2** if treatment **B** is not explained (point 4) 1. **Accept** H^+ or hydrogen ions; accept electrochemical gradient 2. **Reject** protons are actively transported through ATP synthase **Ignore** references to light, chlorophyll or electrons: the thylakoids were in the dark

Question	Marking guidance	Mark	Comments
02.3	1. **D**: protons leak across the membrane (without passing through ATP synthase), so the proton gradient is lost and little or no ATP is made, showing a proton gradient is needed; 2. **E**: protons cannot pass through ATP synthase, so little or no ATP is made even though there is a proton gradient, showing protons must flow through ATP synthase;	**2** (2 × AO3)	Each point needs the treatment linked to its explanation **Accept** H^+ or hydrogen ions for protons **Ignore** ATP synthase is denatured for **E**

The light-independent reaction 3.5.1

Question	Marking guidance	Mark	Comments
03.1	Reduced NADP;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
03.2	Substrates: Carbon dioxide and RuBP Product: Two molecules of GP;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
03.3	1. Reduced NADP reduces GP to triose phosphate OR reduced NADP provides hydrogen/electrons to reduce GP (to triose phosphate); 2. (Hydrolysis of) ATP provides energy for GP to be converted/reduced to triose phosphate; 3. Without them, (less/no) triose phosphate is made, so RuBP is not regenerated (and CO_2 cannot be fixed);	**3** (3 × AO1)	**Accept** NADPH / $NADPH_2$ / NADPH + H / NADP + H for reduced NADP. Reject reduced NAD / NADH. Reject NADP (unreduced) alone 1. **Reject** reduced NADP oxidises GP OR triose phosphate is oxidised 2. **Accept** ATP provides energy to regenerate RuBP (from triose phosphate) for point 2 2. **Ignore** ATP provides phosphate; reject ATP makes/produces energy If GP is named, the name must be correct; reject eg glucose 3-phosphate (once only) **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once.

Question	Marking guidance	Mark	Comments
03.4	1. Glucose/hexose; 2. Sucrose; 3. Starch; 4. Cellulose; 5. Lipids/fatty acids/glycerol; 6. Amino acids/proteins; 7. Nucleotides/nucleic acids/DNA/RNA;	**2 max** (2 × AO1)	**Ignore** sugar or carbohydrate unqualified **Reject** glycogen **Ignore** GP, RuBP or triose phosphate **Accept** other named organic substances, eg fructose

Question	Marking guidance	Mark	Comments
04.1	2 (: 1);	**1** (1 × AO2)	Increase in GP = 92 − 40 = 52; decrease in RuBP = 30 − 4 = 26 **Accept** answers from 1.8 to 2.2 from correct readings (GP 90–94; RuBP 3–5) **Reject** 0.5 (ratio inverted)

Question	Marking guidance	Mark	Comments
04.2	Each (molecule of) RuBP that reacts with carbon dioxide forms two (molecules of) GP;	**1** (1 × AO2)	**Accept** one RuBP is used to make two GP **Reject** two RuBP form one GP

Question	Marking guidance	Mark	Comments
04.3	1. Light off: no/less ATP **and** reduced NADP are produced (in the light-dependent reaction); 2. So GP is not reduced/converted to triose phosphate, so GP accumulates/increases; 3. Less triose phosphate is made, so (less) RuBP is regenerated; 4. RuBP still reacts with carbon dioxide/is still fixed (by rubisco), so RuBP is used up/decreases; 5. Prediction: GP concentration decreases **and** RuBP concentration increases; 6. Less carbon dioxide reacts with RuBP, so less GP is made and RuBP accumulates; 7. Light still on, so ATP and reduced NADP are still produced, so GP is still converted to triose phosphate and RuBP is still regenerated;	**6 max** (2 × AO1) (2 × AO2) (2 × AO3)	**Max 4** if no prediction is given (points 5–7) 1. Both ATP **and** reduced NADP are needed **Accept** NADPH / $NADPH_2$ / NADPH + H / NADP + H for reduced NADP. Reject reduced NAD / NADH. Reject NADP (unreduced) alone 1. **Accept** the light-dependent reaction stops; accept 'no' ATP and reduced NADP here, because the light was switched off **Do not accept** 'LDR' for light-dependent reaction 4. **Accept** rubisco is still active / carbon dioxide is still present 5. **Accept** the prediction in either order **Reject** references to the Krebs cycle **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once.

Limiting factors and agricultural practice 3.5.1

Question	Marking guidance	Mark	Comments
05.1	No photosynthesis (in the dark) but the algae still respire, using/taking up oxygen;	**1** (1 × AO2)	Both ideas are needed **Reject** algae respire only in the dark

Question	Marking guidance	Mark	Comments
05.2	7.5 (arbitrary units);	**1** (1 × AO2)	The line crosses zero net rate between the plotted points (5, -2) and (10, 2) **Accept** values from 7 to 8 **Reject** 5 (the compensation point at 20 °C)

Question	Marking guidance	Mark	Comments
05.3	1. Light intensity, because the rate still increases as light intensity increases OR raising the carbon dioxide concentration has no effect (both 20 °C lines are 4 μmol h^{-1}); 2. Carbon dioxide concentration, because the rate is higher at a high carbon dioxide concentration (28 compared with 14 μmol h^{-1}) OR increasing light intensity has no effect (rate stays at 14 μmol h^{-1}) but raising the carbon dioxide concentration increases the rate; 3. Temperature, because the rate is higher at 30 °C (36 μmol h^{-1}) than at 20 °C (28 μmol h^{-1}) OR because the rate does not increase with light intensity (from 60 to 80) but is higher at 30 °C;	**3** (1 × AO2) (2 × AO3)	Each mark needs the factor **and** correct evidence **Do not accept** 'amount of carbon dioxide' for carbon dioxide concentration, or 'amount of light' for light intensity 1. **Accept** the rate is the same at both carbon dioxide concentrations (at 20 °C) 3. **Reject** light intensity: the rate is level from 60 to 80 2 and 3. **Do not accept** 'the rate has levelled off' on its own as evidence: a plateau does not show which factor is limiting **Do not credit** water or humidity as a limiting factor; reject oxygen concentration; ignore pH or nutrients

Question	Marking guidance	Mark	Comments
05.4	1. Water absorbs heat (from the lamp), so the temperature (of the tubes) stays constant / temperature does not affect the rate; 2. The same number/quantity of algae can be put in each tube OR beads are easy to count/transfer;	**2** (2 × AO3)	1. **Ignore** 'to make it a fair test' unqualified 2. **Accept** the algae can be easily removed/reused, or do not settle/sink to the bottom

Question	Marking guidance	Mark	Comments
06.1	Correct answer for 2 marks: 20 (%);; Accept for 1 mark: (30.0 − 25.0) ÷ 25.0 OR 5.0 ÷ 25.0	**2** (2 × AO2)	**Reject** 16.7 (divided by 30.0): 0 marks

Question	Marking guidance	Mark	Comments
06.2	1. Carbon dioxide concentration was a limiting factor (at 400 parts per million); 2. More carbon dioxide reacts with RuBP / is fixed (by rubisco), so more GP and triose phosphate are made; 3. More (useful) organic substances, eg sugars/glucose/starch, are made for growth/fruit production;	**2 max** (2 × AO2)	1. **Accept** faster (rate of) photosynthesis/light-independent reaction **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once. **Ignore** more carbon dioxide unqualified

Question	Marking guidance	Mark	Comments
06.3	1. Supports: lighting alone (area 3) increased yield by 2.5 kg m^{-2}, worth £5.00, which is less than its cost of £7.50 (m^{-2}); 2. Against: with carbon dioxide enrichment, adding lighting (area 4 v area 2) increased yield by 5.0 kg m^{-2}, worth £10.00, which is more than the extra cost of £7.50; 3. Explanation: at 400 parts per million, carbon dioxide concentration limits the rate of photosynthesis, so extra light has little effect / once carbon dioxide is raised, light intensity becomes limiting; 4. Against: area 4 gives the greatest net gain, £10.40 m^{-2} compared with £7.90 for carbon dioxide enrichment alone; 5. Limitation: results are from only one season/one glasshouse/one variety, with no repeats/statistical test, OR prices/costs may change;	**4 max** (4 × AO3)	**Max 3** unless point 1 **and** point 2 or point 4 are given **Accept** calculations of profit or loss that use the correct figures, eg lighting alone gives a loss of £2.50 m^{-2} 2. **Accept** a gain of £2.50 m^{-2} **Ignore** temperature not controlled: the stem says it was the same in all areas

Required practical 7: chromatography of photosynthetic pigments 3.5.1 (RP7)

Question	Marking guidance	Mark	Comments
07.1	1. Pencil (graphite) does not dissolve in the solvent/move up the plate, but ink would separate/run and mix with the pigments; 2. Otherwise the pigments would dissolve into the solvent (in the beaker) instead of moving up the plate; 3. The distance moved by the solvent is needed to calculate R_f values (this is unknown if the solvent reaches the top);	**3** (3 × AO1)	1. **Accept** ink contains pigments/dyes that would be confused with the leaf pigments 2. **Accept** the pigments would wash off the origin 3. **Accept** so the pigments do not run off the end of the plate

Question	Marking guidance	Mark	Comments
07.2	1. R_f = 3.8 ÷ 9.0 = 0.42; 2. Chlorophyll b;	**2** (2 × AO2)	1. **Accept** 0.422 or 0.4 2. **Accept** ECF from an incorrect R_f value matched to the nearest value in the table 2. Chlorophyll b without working gains 1 mark only

Question	Marking guidance	Mark	Comments
07.3	1. The pigments have different solubilities in the solvent; 2. More soluble pigments are carried further (up the plate) by the solvent OR pigments with less attraction to the plate/stationary phase move further;	**2** (2 × AO1)	**Max 1** if 'solution' is used instead of 'solvent' 1. **Accept** pigments dissolve to different extents in the solvent / different affinities for the solvent / polarity / R_f values **Ignore** different sizes/masses of pigment molecules unqualified **Reject** pigments have different wavelengths; ignore stronger/more concentrated solvent

Question	Marking guidance	Mark	Comments
07.4	1. **S**: 2.0 (: 1); 2. **T**: 3.5 (: 1);	**2** (2 × AO2)	**S**: 1.40 ÷ 0.70; **T**: 1.33 ÷ 0.38 **Accept** 2 : 1 and 3.5 : 1; ratios not in the form *x* : 1 gain no credit If both ratios are inverted (b to a), award 1 mark

Question	Marking guidance	Mark	Comments
07.5	1. **S** has more chlorophyll b (0.70 compared with 0.38 mg per g) OR a lower ratio of chlorophyll a to chlorophyll b OR more total chlorophyll (2.10 compared with 1.71 mg per g); 2. So **S** absorbs more of the light/wavelengths available in shade OR absorbs a greater range of wavelengths; 3. More photoionisation of chlorophyll OR more ATP and reduced NADP produced (in the light-dependent reaction); 4. Faster rate of photosynthesis/light-independent reaction (in low light) OR more sugars/organic substances made for growth;	**3 max** (2 × AO2) (1 × AO3)	1. A comparison is needed; accept a relatively higher proportion of chlorophyll b **Accept** NADPH / $NADPH_2$ / NADPH + H / NADP + H for reduced NADP. Reject reduced NAD / NADH. Reject NADP (unreduced) alone 3. **Do not accept** 'LDR' for light-dependent reaction **Ignore** references to green light being reflected

Required practical 8: dehydrogenase activity in chloroplast extracts 3.5.1 (RP8)

Question	Marking guidance	Mark	Comments
08.1	1. Light causes photoionisation of chlorophyll OR light causes electrons to be released from chlorophyll; 2. Electrons (from the electron transfer chain) are accepted by/reduce the indicator (instead of NADP); 3. Photolysis of water provides (more) electrons/protons (that reduce the indicator);	**2 max** (2 × AO2)	2. **Accept** the indicator accepts hydrogen 2. **Accept** dehydrogenase (enzymes) transfer hydrogen/electrons to the indicator **Reject** the indicator is oxidised

Question	Marking guidance	Mark	Comments
08.2	1. Light intensity: 4 (times); 2. Rate: 1.52 (times);	**2** (2 × AO2)	1. $(20 \div 10)^2 = 4$ 2. 190 ÷ 125 = 1.52; accept 1.5 **Reject** 2 (distance ratio) for point 1; reject 0.66 (inverted) for point 2

Question	Marking guidance	Mark	Comments
08.3	1. Light intensity is no longer the (only) limiting factor at short distances; 2. Another factor limits the rate, eg the concentration of indicator/the amount of chlorophyll/the number of chloroplasts/the amount of dehydrogenase (enzyme)/temperature; 3. Evidence: the mean time changes little between 15 cm and 10 cm (140 s and 125 s) although light intensity increases 2.25 times;	**2 max** (1 × AO2) (1 × AO3)	2. **Accept** all the chlorophyll is being photoionised / the enzymes are working at their maximum rate **Ignore** heat from the lamp unless linked to a limiting temperature

Question	Marking guidance	Mark	Comments
08.4	1. **X**: shows that light is needed for the indicator to be reduced/change colour OR that the extract does not reduce the indicator in the dark; 2. **Y**: shows that the colour change needs (active) enzymes/dehydrogenase, because heating denatures them OR shows light alone does not reduce the indicator;	**2** (2 × AO3)	**Ignore** 'as a control' or 'for comparison' unqualified 2. **Accept** heating destroys the chloroplasts/thylakoid membranes

Question	Marking guidance	Mark	Comments
08.5	Use a colorimeter and record the time for the absorbance/transmission to reach that of the reference tube OR a set value;	**1** (1 × AO3)	**Accept** measure the absorbance at fixed time intervals and calculate the rate of change **Ignore** repeat the experiment / use more repeats **Ignore** use a white background/tile unqualified

Copyright © 2026 Helicate. All rights reserved.