HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.2 Respiration

Mark scheme

Version 2 · 15 October 2026

TOTAL MARKS	QUESTIONS
65	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.

Glycolysis and anaerobic respiration 3.5.2

Question	Marking guidance	Mark	Comments
01.1	Glucose is phosphorylated using ATP;	**1** (1 × AO1)	Glycolysis is in the cytoplasm; triose phosphate is oxidised; glycolysis is the first stage of both aerobic and anaerobic respiration

Question	Marking guidance	Mark	Comments
01.2	1. ATP is used to phosphorylate glucose (to glucose phosphate); 2. More ATP is produced (than used) when triose phosphate is oxidised to pyruvate;	**2** (2 × AO1)	2. **Accept** a correct description of net gain, eg 2 used and 4 produced (per glucose), only if linked to the oxidation of triose phosphate; numbers are not required 1. **Reject** substrate-level or oxidative phosphorylation for the phosphorylation of glucose 2. **Accept** removal of hydrogen from triose phosphate for oxidation; reject triose phosphate 'converted/broken down' to pyruvate without oxidation **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once.

Question	Marking guidance	Mark	Comments
01.3	1. Reduced NAD is not oxidised OR (oxidised) NAD is not regenerated (because converting pyruvate to ethanol uses reduced NAD); 2. NAD is needed (to accept hydrogen) for the oxidation of triose phosphate (to pyruvate); 3. So glycolysis stops OR no (net) ATP is produced (by glycolysis); 4. No oxygen, so no other way of producing ATP / no oxidative phosphorylation, so no ATP for growth/cell division/protein synthesis;	**3 max** (1 × AO1) (2 × AO2)	**Accept** NADH / $NADH_2$ / $NADH + H^+$ for reduced NAD. Reject NADP / reduced NADP / NADPH **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once. **Reject** 'no energy produced'; accept 'no energy released' for point 3 **Ignore** pyruvate builds up unqualified

Question	Marking guidance	Mark	Comments
02.1	Correct answer for 2 marks: 7.5;; Accept for 1 mark: 0.125 (mmol dm^{-3} min^{-1}) OR (11.5 − 1.5) ÷ 80	**2** (2 × AO2)	**Accept** answers from 7.2 to 7.8 from readings within ±0.2 of 1.5 and 11.5 **Accept** a gradient from any two points on the straight section

Question	Marking guidance	Mark	Comments
02.2	1. Oxygen was present, so the yeast respired aerobically; 2. Oxygen is the final electron acceptor (in the electron transfer chain), so reduced NAD is oxidised / NAD is regenerated without producing ethanol; 3. Pyruvate enters the mitochondria/link reaction (instead of being converted to ethanol);	**2 max** (2 × AO2)	**Accept** NADH / $NADH_2$ / NADH + H^+ for reduced NAD. Reject NADP / reduced NADP / NADPH **Reject** 'yeast does not respire anaerobically because it has enough energy'

Question	Marking guidance	Mark	Comments
02.3	1. Anaerobic respiration produces less ATP per glucose (than aerobic respiration); 2. Without oxygen (as final electron acceptor) the electron transfer chain/oxidative phosphorylation/Krebs cycle stops, so only glycolysis produces ATP; 3. So more glucose must be respired (per unit time) to produce enough ATP / the same amount of ATP;	**3** (3 × AO2)	Correct ATP numbers per glucose may be credited for point 1 if compared, but are not required **Reject** energy is produced/made/created (once only) **Reject** 'anaerobic respiration produces no ATP'

Question	Marking guidance	Mark	Comments
02.4	The oxygen concentration was very low, so some yeast cells/parts of the suspension had no/too little oxygen (and respired anaerobically) OR there was too little oxygen to oxidise all the reduced NAD;	**1** (1 × AO3)	**Accept** oxygen not evenly spread through the suspension **Ignore** 'anomaly' or 'error' unqualified

The link reaction, the Krebs cycle and other respiratory substrates 3.5.2

Question	Marking guidance	Mark	Comments
03.1	Acetylcoenzyme A and reduced NAD;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
03.2	1. Acetylcoenzyme A combines/reacts with a four-carbon molecule; 2. Forming a six-carbon molecule **and** releasing coenzyme A; 3. (A series of) oxidation-reduction reactions; 4. Carbon dioxide is lost/released; 5. NAD is reduced OR reduced coenzymes/reduced NAD are produced (by removal of hydrogen); 6. ATP is produced by substrate-level phosphorylation; 7. The four-carbon molecule is regenerated (to combine with more acetylcoenzyme A);	**4 max** (4 × AO1)	**Accept** named intermediates, eg oxaloacetate and citrate, but they are not required 4. **Accept** decarboxylation 5. **Accept** reduced FAD; Accept NADH / $NADH_2$ / NADH + H^+ for reduced NAD. Reject NADP / reduced NADP / NADPH 6. **Reject** oxidative phosphorylation **Ignore** numbers of molecules unless incorrect **Reject** references to the Calvin cycle, RuBP or GP (once only)

Question	Marking guidance	Mark	Comments
03.3	1. Oxygen is the final electron acceptor (of the electron transfer chain); 2. Without oxygen, electrons stop passing along the electron transfer chain; 3. So reduced NAD/reduced coenzymes are not oxidised OR NAD is not regenerated; 4. The Krebs cycle needs (oxidised) NAD/coenzymes to accept hydrogen (in its oxidation reactions);	**3 max** (3 × AO1)	**Accept** 'oxygen is the terminal electron acceptor' or 'oxygen accepts electrons and protons to form water' for point 1 **Accept** NADH / $NADH_2$ / NADH + H^+ for reduced NAD. Reject NADP / reduced NADP / NADPH **Reject** 'the Krebs cycle is anaerobic'; ignore 'respiration becomes anaerobic' unqualified **Ignore** 'less ATP' unqualified

Question	Marking guidance	Mark	Comments
04.1	1. Glycolysis takes place in the cytoplasm OR mitochondria do not carry out glycolysis/do not have the enzymes for glycolysis; 2. So glucose is not converted to pyruvate/cannot be used in the link reaction or Krebs cycle (so no extra reduced coenzymes/electrons for the electron transfer chain) OR glucose does not enter mitochondria;	**2** (1 × AO1) (1 × AO2)	**Reject** glucose enters mitochondria / glucose is used in the Krebs cycle **Ignore** gluconeogenesis

Question	Marking guidance	Mark	Comments
04.2	Correct answer for 2 marks: 90.4 (%);; Accept for 1 mark: (52 − 5) ÷ 52 OR 47 ÷ 52	**2** (2 × AO2)	**Accept** 90 or 90.38 for 2 marks **Reject** 9.6 (5 ÷ 52): 0 marks

Question	Marking guidance	Mark	Comments
04.3	1. Pyruvate cannot enter the (mitochondrial) matrix (by active transport); 2. So no/less link reaction OR no/less acetylcoenzyme A for the Krebs cycle; 3. Fewer reduced coenzymes/less reduced NAD (produced); 4. Fewer electrons pass along the electron transfer chain, so less oxygen is needed/used as the final electron acceptor;	**3 max** (3 × AO2)	**Max 2** if no link to oxygen as the (final) electron acceptor **Accept** NADH / $NADH_2$ / $NADH + H^+$ for reduced NAD. Reject NADP / reduced NADP / NADPH **Reject** 'X stops oxygen entering the mitochondria'

Question	Marking guidance	Mark	Comments
04.4	1. Fatty acids (are broken down and) enter the Krebs cycle OR are converted to acetylcoenzyme A; 2. Producing reduced coenzymes/reduced NAD; 3. Electrons pass along the electron transfer chain to oxygen (the final electron acceptor);	**2 max** (2 × AO2)	**Max 1** unless point 3 is given 1. **Accept** 'fatty acids are used in the Krebs cycle' **Reject** fatty acids converted to glucose / enter glycolysis; ignore gluconeogenesis **Accept** NADH / $NADH_2$ / $NADH + H^+$ for reduced NAD. Reject NADP / reduced NADP / NADPH

Question	Marking guidance	Mark	Comments
04.5	To show the rate of oxygen uptake with no (added) respiratory substrate OR to show that the oxygen uptake in the other chambers is due to the substance added;	**1** (1 × AO3)	**Ignore** 'as a control' or 'for comparison' unqualified

Oxidative phosphorylation 3.5.2

Question	Marking guidance	Mark	Comments
05.1	It accepts electrons at the end of the electron transfer chain;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
05.2	1. Reduced NAD/reduced coenzymes (from glycolysis, the link reaction and the Krebs cycle) provide hydrogen/electrons to the electron transfer chain; 2. Electrons pass along/down the electron transfer chain (in the inner mitochondrial membrane) in oxidation-reduction reactions; 3. Energy (released by the electrons) is used to move protons across the inner mitochondrial membrane (out of the matrix); 4. This creates a proton/electrochemical gradient across the inner membrane; 5. Protons diffuse back (into the matrix) through ATP synthase; 6. ATP synthase catalyses the production of ATP from ADP and (inorganic) phosphate; 7. Oxygen is the final electron acceptor OR oxygen combines with electrons and protons to form water;	**5 max** (5 × AO1)	**Accept** chemiosmosis/chemiosmotic theory described correctly for points 3–6; the term alone gains no mark **Accept** H^+ or hydrogen ions for protons; ignore 'hydrogen' unqualified 3. **Ignore** 'active transport' of protons (neither credit nor penalise); credit the point if the rest is correct 3. **Accept** 'into the intermembrane space'; not required 6. **Accept** P_i; reject phosphorus **Accept** NADH / $NADH_2$ / NADH + H^+ for reduced NAD. Reject NADP / reduced NADP / NADPH **Reject** energy is produced/made/created (once only)

Question	Marking guidance	Mark	Comments
06	1. **R**: oxygen is the final electron acceptor, so (almost) no oxygen is taken up (0.2 compared with 4.2); 2. **R**: electrons stop passing along the electron transfer chain, so protons are not moved across the inner membrane / no proton gradient; 3. **R**: so (almost) no ATP is made by ATP synthase/oxidative phosphorylation/chemiosmosis; 4. **R**: ATP is not zero (3.1) because glycolysis/anaerobic respiration still produces (a net gain of) ATP; 5. **R**: less heat is released because the Krebs cycle/electron transfer chain/aerobic respiration has (almost) stopped, so less energy is released; 6. **T**: electrons still pass along the electron transfer chain to oxygen, so oxygen uptake does not fall/increases (7.0 compared with 4.2); 7. **T**: protons diffuse back across the membrane without passing through ATP synthase, so the proton gradient is lost; 8. **T**: so less ATP is made (by ATP synthase/oxidative phosphorylation) even though oxygen is still used (2.8 compared with 8.0); 9. **T**: the energy (from electron transfer/the proton gradient) is released as heat instead (52 compared with 30);	**6 max** (4 × AO2) (2 × AO3)	**Max 4** if only **R** or only **T** is explained 6. **Accept** oxygen uptake increases because electron transfer is no longer held back by the proton gradient; not required Quoting or describing the data without an explanation gains no marks; data may support a point but are not required **Accept** H^+ or hydrogen ions for protons; ignore 'hydrogen' unqualified **Ignore** 'active transport' of protons 9. **Accept** 'produces heat'; reject 'produces heat energy' 4. **Accept** anaerobic respiration producing lactate; reject lactate and carbon dioxide **Reject** energy is produced/made/created (once only)

Required practical 9: rate of respiration of single-celled organisms 3.5.2 (RP9)

Question	Marking guidance	Mark	Comments
07.1	1. Boiling removes dissolved oxygen OR kills (other) microorganisms OR cooling stops the yeast being killed/its enzymes being denatured; 2. Stops oxygen (from the air) entering/dissolving in the suspension, so respiration is anaerobic;	**2** (2 × AO3)	1. Either idea from boiling, or the cooling idea, gains the mark 2. **Reject** 'stops carbon dioxide escaping'; ignore 'stops evaporation'

Question	Marking guidance	Mark	Comments
07.2	1. So the suspension (and gas) reached the temperature of the water bath; 2. So expansion of the gas as it warmed did not move the coloured liquid (during readings); 3. So any remaining oxygen was used up and the yeast respired (only) anaerobically; 4. So the yeast could acclimatise / the rate of respiration became steady;	**2 max** (2 × AO3)	**Ignore** 'to make it a fair test' unqualified **Accept** 'so the pressure inside stayed the same as the air outside' for point 2

Question	Marking guidance	Mark	Comments
07.3	Correct answer for 3 marks: 1.4×10^{-1} ($cm^3\ h^{-1}$);;; Accept for 2 marks: 0.14 / 0.145 / 1.45×10^{-1} (correct but not in the required form) **OR** 5.8×10^{-1} (diameter used as the radius, otherwise correct) Accept for 1 mark: $\pi \times 0.40^2 \times 48$ OR 24.1 mm^3 (in 10 minutes) OR 2.4×10^{-3} $cm^3\ min^{-1}$ OR 145 $mm^3\ h^{-1}$	**3** (3 × AO2)	Working: $\pi \times 0.40^2 \times 48 = 24.1$ mm^3 in 10 minutes; × 6 = 144.8 $mm^3\ h^{-1}$; ÷ 1000 = 0.1448 $cm^3\ h^{-1}$ **Accept** π as 3.14 or 3.142

Question	Marking guidance	Mark	Comments
07.4	1. 18 (mm) (repeat 2); 2. 34 (mm);	**2** (1 × AO2) (1 × AO3)	2. **Reject** 28.7 (anomaly included) 2. **Accept** ECF for the mean of the other two values if a different value is identified as anomalous

Question	Marking guidance	Mark	Comments
07.5	1. Supports: the mean distance/rate is highest at 35 °C (48 mm compared with 34 mm at 45 °C and 20 mm at 25 °C); 2. Supports: the repeats at 35 °C (47–50 mm) do not overlap with those at any other temperature, so the difference is reliable; 3. Against: temperatures were 10 °C apart, so the optimum could be anywhere between 25 °C and 45 °C OR the optimum may be between 35 °C and 45 °C because the mean at 45 °C is higher than at 25 °C; 4. Against: only anaerobic respiration was measured, so the conclusion cannot be applied to aerobic respiration/respiration in general; 5. Against: carbon dioxide is less soluble/gas expands more at higher temperatures, so distance moved may not be a fair measure of the rate at different temperatures; 6. Against: only one strain of yeast/one glucose concentration/only 3 repeats/no statistical test;	**3 max** (3 × AO3)	**Max 2** if only supporting or only opposing points are given **Ignore** 'repeat the experiment' unqualified

Question	Marking guidance	Mark	Comments
07.6	1. Enzymes (in glycolysis/that convert pyruvate to ethanol) are denatured OR hydrogen bonds (in the tertiary structure) break, changing the shape of the active site; 2. Fewer enzyme-substrate complexes form; 3. So less glycolysis/less glucose is respired, so less carbon dioxide is released;	**2 max** (1 × AO1) (1 × AO2)	**Reject** enzymes are killed; reject the yeast cells are denatured **Accept** E-S complex / ES complex. E-S alone only if 'enzyme-substrate complex' is written elsewhere. Ignore ESC.

Question	Marking guidance	Mark	Comments
08.1	1. Dehydrogenase (enzymes) remove hydrogen from (respiratory) substrates/intermediates, eg triose phosphate (in glycolysis/the Krebs cycle); 2. The indicator accepts the hydrogen/electrons (instead of NAD) and is reduced;	**2** (1 × AO1) (1 × AO2)	1. **Accept** 'more glucose gives faster glycolysis, so more hydrogen is removed (per unit time)' for point 1; point 2 is still needed for 2 marks 2. **Reject** the indicator is oxidised **Accept** TP for triose phosphate only if 'triose phosphate' is written elsewhere in the answer. Penalise once. **Ignore** 'the indicator reacts with glucose'

Question	Marking guidance	Mark	Comments
08.2	Shaking would mix in oxygen/air, which would oxidise the indicator/turn it blue again (so the end point would be delayed/inaccurate);	**1** (1 × AO3)	**Accept** oxygen would accept the electrons/hydrogen instead of the indicator

Question	Marking guidance	Mark	Comments
08.3	To show that the colour change depends on (respiration of) glucose OR that yeast/the indicator alone does not cause the colour change (in this time);	**1** (1 × AO3)	**Ignore** 'as a control' or 'for comparison' unqualified

Question	Marking guidance	Mark	Comments
08.4	1. Supports: the mean times at 20 and 40 g dm^{-3} are similar (248 s and 231 s); 2. Supports: the standard deviations overlap (226–270 s and 206–256 s), so there is no significant difference / the difference is (likely) due to chance; 3. Against: only one concentration above 20 g dm^{-3} was tested, so the effect of other/higher concentrations is unknown; 4. Against: the mean time at 40 g dm^{-3} is (17 s) shorter, so there may be a small increase in activity; 5. Against: no statistical test was carried out OR the end point (colour disappearing) is subjective;	**3 max** (3 × AO3)	**Max 2** if only supporting or only opposing points are given **Accept** SD for standard deviation 2. **Accept** '(likely) due to chance' or 'not significant' **Reject** 'the results are significantly different'

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