HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.1.6 ATP

Mark scheme

Version 3 · 9 October 2026

TOTAL MARKS	QUESTIONS
51	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.

Structure of ATP 3.1.6

Question	Marking guidance	Mark	Comments
01.1	1. J: adenine; 2. K: ribose;	**2** (2 × AO1)	1. **Reject** adenosine 2. **Ignore** pentose (sugar) on its own 2. **Reject** deoxyribose

Question	Marking guidance	Mark	Comments
01.2	Z;	**1** (1 × AO2)	ADP keeps two phosphate groups, so the bond to the end phosphate group is hydrolysed.

Question	Marking guidance	Mark	Comments
01.3	1. (ATP contains) ribose, (DNA nucleotide contains) deoxyribose; 2. (ATP has) three phosphate groups, (DNA nucleotide has) one phosphate group;	**2** (2 × AO1)	Each point needs both parts of the comparison, or a clear comparative, eg 'ATP has two more phosphates' 1. **Ignore** pentose 2. **Reject** phosphorus or P for phosphate **Ignore** references to bases, as both contain adenine

Question	Marking guidance	Mark	Comments
01.4	Correct answer for 2 marks: 50;; Accept for 1 mark: 1200 (times per day) **OR** 60000 ÷ 50 ÷ 24, with one arithmetic error	**2** (2 × AO2)	60 kg = 60000 g; 60000 ÷ 50 = 1200 per day; 1200 ÷ 24 = 50 per hour **Reject** 0.05 (kilograms not converted to grams)

Hydrolysis of ATP, coupling and phosphorylation 3.1.6

Question	Marking guidance	Mark	Comments
02.1	Energy released by the hydrolysis of ATP is used in the energy-requiring formation of glutamine;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
02.2	1. Phosphorylation (of glutamate) makes it more reactive; 2. (So glutamyl phosphate) reacts (more easily) with ammonia OR lowers the activation energy for the reaction with ammonia;	**2** (1 × AO1) (1 × AO2)	1. **Accept** adding phosphate to glutamate makes it more reactive 1. **Reject** makes the cell more reactive 2. **Accept** less energy is needed for it to react with ammonia **Ignore** 'provides energy' unqualified

Question	Marking guidance	Mark	Comments
02.3	Correct answer for 2 marks: 47 (%);; Accept for 1 mark: 46.6 OR 46.56 (answer not to 2 significant figures) **OR** 14.2 ÷ 30.5 × 100 shown	**2** (2 × AO2)	**Reject** 53 (percentage not used to form glutamine)

Question	Marking guidance	Mark	Comments
03	1. Hydrolysis of ATP (to ADP) releases Pi/(inorganic) phosphate; 2. (Tube B) enzyme T transfers/adds phosphate from ATP to enzyme M OR enzyme M is phosphorylated/active only when both enzyme T **and** ATP are present (96); 3. (Tube A) ADP cannot supply the phosphate OR (Tube C) ATP cannot phosphorylate enzyme M without enzyme T (activity 4 and 5); 4. (Tube D) phosphate must attach to the (R group of the) amino acid that was replaced, so the altered enzyme M cannot be phosphorylated/activated (6); 5. (Negatively charged) phosphate forms (new) ionic bonds with/repels R groups, so the tertiary structure changes; 6. Active site changes shape so it becomes complementary to the substrate OR so enzyme–substrate complexes can form;	**5 max** (3 × AO1) (2 × AO2)	**Max 3** from points 1, 5 and 6 **Max 2** from points 2, 3 and 4 2. and 3. Do not credit the same statement for both points. A general statement that enzyme T and ATP are both needed gains point 2 only; point 3 needs a specific reference to tube A/ADP or to tube C/no enzyme T 1. **Accept** water used to break the bond to the last/terminal phosphate (group) 1. **Accept** (ATP →) ADP + Pi 1. **Accept** ATP hydrolase/ATPase (catalyses the hydrolysis) 1. **Reject** hydrolysis of a hydrogen bond 4. **Reject** phosphate binds to the active site of enzyme M 5. **Accept** hydrogen bonds for ionic bonds 6. **Reject** active site becomes the same shape as the substrate 6. **Accept** E-S complex / ES complex. E-S alone only if ‘enzyme-substrate complex’ is written elsewhere. Ignore ESC. **Reject** energy produced/made/created anywhere

Question	Marking guidance	Mark	Comments
04.1	1. (ATP hydrolase) hydrolyses ATP to ADP + Pi; 2. Releases energy; 3. (Energy used to) change the shape of the carrier protein OR phosphate (from ATP) attaches to the carrier protein, changing its shape; 4. Potassium ions bind to (a binding site on) the carrier protein (outside the cell) and are released inside; 5. Moves potassium ions into the cell against their concentration gradient OR moves potassium ions into the cell by active transport; 6. Potassium ions are moved in as fast as/faster than they diffuse out;	**4 max** (2 × AO1) (2 × AO2)	1. **Accept** ATPase for ATP hydrolase 2. **Reject** energy produced/made/created 5. **Accept** from low to high concentration 5. **Do not credit** if the ions moved are sodium ions only **Ignore** references to glucose or anaerobic respiration

Question	Marking guidance	Mark	Comments
04.2	1. 1.6; 2. mmol dm^{-3} day^{-1};	**2** (2 × AO2)	1. Working: (12.4 − 1.2) ÷ 7 = 1.60 1. **Reject** 1.60 (not 2 s.f.) 2. **Accept** mmol dm^{-3} per day OR mmol dm^{-3} d^{-1} 2. **Accept** an equivalent unit with a correctly converted value, eg 0.067 mmol dm^{-3} h^{-1} 2. Mark the unit independently of the value

Question	Marking guidance	Mark	Comments
04.3	1. (Supports) from day 7, ATP concentration falls while potassium ion concentration keeps rising OR negative correlation after day 7; 2. (Supports) less ATP hydrolysed, so less energy for the carrier protein to move potassium ions back into the cells; 3. (Against) the largest rise in potassium ions is in the first 7 days (11.2 mmol dm^{-3}), when ATP did not fall/rose (4.4 to 4.6); 4. (Against) the low temperature/4 °C could reduce the activity of the ATP hydrolase/carrier protein, so fewer potassium ions are moved in even when ATP is available; 5. (Against) the rise in potassium ions slows down while ATP falls faster OR correlation does not show cause OR another factor could be responsible, eg damage to the membrane;	**3 max** (3 × AO3)	**Max 2** if only supporting points or only points against are given 3. **Accept** a comparison of the rates, eg over 11 mmol dm^{-3} in week 1 compared with about 4 mmol dm^{-3} in week 6 4. **Accept** less kinetic energy, so fewer enzyme–substrate complexes form **Ignore** 'only one sample/no repeats' unqualified

Resynthesis of ATP 3.1.6

Question	Marking guidance	Mark	Comments
05	1. Type of reaction: hydrolysis **and** condensation; 2. Enzyme: ATP hydrolase **and** ATP synthase; 3. Water: used **and** released;	**3** (3 × AO1)	Each row must be fully correct for the mark 1. **Accept** phosphorylation (of ADP) for condensation 1. **Reject** redox for condensation 2. **Accept** ATPase or hydrolayse for ATP hydrolase; accept synthayse for ATP synthase 2. **Reject** ATPase for ATP synthase 3. **Accept** 'water is a reactant' and 'water is a product'

Question	Marking guidance	Mark	Comments
06.1	1. No light, so no photosynthesis/light-dependent reaction, so no ATP resynthesised in photosynthesis; 2. Inhibitor stops respiration, so no/less ATP resynthesised in respiration; 3. ATP is still hydrolysed/used (for energy-requiring reactions), so the ATP content falls;	**2 max** (2 × AO2)	1 and 2. **Accept** no/less ATP synthase activity (for ATP resynthesis) as the consequence in either point 3. **Accept** ATP is still broken down by ATP hydrolase **Reject** energy produced/made/created

Question	Marking guidance	Mark	Comments
06.2	Correct answer for 2 marks: 19.6 OR 20 (%);; Accept for 1 mark: a difference of 18 OR (92 − 74) ÷ 92 **OR** correct method using the student's readings from the graph	**2** (2 × AO2)	Plotted values: 92 (light) and 74 (light + inhibitor) **Accept** readings of 91–93 and 73–75, giving answers in the range 17.6 to 21.5 (%) (18 to 22 to 2 significant figures), for 2 marks **Reject** a percentage increase

Question	Marking guidance	Mark	Comments
06.3	Leaf discs in buffer (solution) with the same volume of ethanol but no inhibitor;	**1** (1 × AO3)	**Accept** 'ethanol only' if same volume is implied **Ignore** 'in light and in dark' **Reject** a control with no ethanol and no inhibitor (these groups are already present)

Question	Marking guidance	Mark	Comments
06.4	1. (Supports) in the light, the inhibitor reduced ATP content by only about 20% OR from 92 to 74; 2. (Supports) with the inhibitor, ATP content in the light (74) is much higher than in the dark (9), so this ATP comes from photosynthesis; 3. (Against) ATP content is the balance of resynthesis and hydrolysis OR ATP content does not show the rate of resynthesis; 4. (Against) inhibitor may not stop all respiration OR inhibitor may also affect photosynthesis; 5. (Against) when respiration is inhibited, photosynthesis may resynthesise more ATP than usual, so the result may underestimate respiration;	**3 max** (3 × AO3)	**Max 2** if only supporting points or only points against are given 1. **Accept** comparison with the dark, where the inhibitor reduced ATP by about 82% 1. **Accept** the standard deviation bars for light and light + inhibitor do not overlap, so the decrease is significant/(probably) not due to chance, but small, as part of point 1 3. **Accept** ATP made in photosynthesis may be used (in the chloroplast) in the light-independent reaction **Ignore** 'only one species/only 30 minutes' unqualified

Measuring ATP: an unfamiliar practical 3.1.6 (PS 1.2, 2.4)

Question	Marking guidance	Mark	Comments
07.1	1. So ATP (concentration) is the only limiting factor OR so the light released depends only on the ATP concentration; 2. If luciferase were not in excess, (at high ATP concentrations) all active sites would be occupied/saturated, so light would not increase in proportion to ATP concentration;	**2** (2 × AO2)	2. **Accept** if luciferin were not in excess, it would limit the rate at high ATP concentrations 2. **Accept** the calibration curve would level off/would not be a straight line **Ignore** 'to make it a fair test'

Question	Marking guidance	Mark	Comments
07.2	Correct answer for 3 marks: 1.0×10^{-6} (mol dm^{-3});;; Accept for 2 marks: 1000 (nmol dm^{-3}) OR 1.0×10^{3} (nmol dm^{-3}) **OR** 50×10^{-9} OR 5.0×10^{-8} (mol dm^{-3}) (dilution not taken into account) Accept for 1 mark: a reading of 50 (nmol dm^{-3}) from the graph	**3** (3 × AO2)	**Accept** graph readings of 49–51 nmol dm^{-3}, giving answers from 9.8×10^{-7} to 1.02×10^{-6} mol dm^{-3}, for 3 marks Multiplying by 19 instead of 20 (giving 9.5×10^{-7} mol dm^{-3}) = 2 marks **Accept** 1×10^{-6} for 3 marks

Question	Marking guidance	Mark	Comments
07.3	ATP hydrolase is denatured, so ATP is not hydrolysed (to ADP + Pi) before it is measured OR so the ATP concentration does not change before it is measured;	**1** (1 × AO2)	**Accept** ATP synthase is denatured, so no more ATP is resynthesised **Accept** ATPase for ATP hydrolase **Ignore** 'kills the yeast' unqualified

Question	Marking guidance	Mark	Comments
07.4	So the ATP concentration/light released is within the range of the calibration curve OR the undiluted extract (about 1000 nmol dm^{-3}) is above the highest standard (100 nmol dm^{-3});	**1** (1 × AO3)	**Accept** so that luciferase/luciferin is still in excess **Ignore** 'so it is easier to measure' unqualified

Question	Marking guidance	Mark	Comments
07.5	Temperature affects the rate of the luciferase reaction/light released, so the calibration curve is only valid at 25 °C OR so the only variable affecting the light released is ATP concentration;	**1** (1 × AO3)	**Accept** temperature affects (luciferase) enzyme activity/kinetic energy/number of enzyme–substrate complexes formed **Ignore** 'fair test' unqualified

Question	Marking guidance	Mark	Comments
08	1. Use at least five temperatures (eg 20–60 °C) in (thermostatically controlled) water baths; 2. Leave the ATP solution and the ATP hydrolase solution in the water bath (separately) to reach the temperature before mixing; 3. Same volume and concentration of ATP (solution) and ATP hydrolase, with buffer to keep the pH constant; 4. After a set time, remove a sample and stop the reaction by adding it to boiling water (to denature ATP hydrolase); 5. Cool (all samples to 25 °C), add excess luciferase and luciferin and measure the light with the luminometer; 6. Use the calibration curve to find the ATP concentration (diluting if above the range of the curve); 7. Calculate the rate as the decrease in ATP concentration ÷ time; 8. Repeat (at least three times) at each temperature and calculate a mean; 9. Control with boiled/denatured ATP hydrolase (at each temperature) to show that ATP is not broken down without active enzyme;	**6 max** (2 × AO1) (4 × AO3)	4. **Accept** any valid method of stopping the reaction that denatures ATP hydrolase 4. **Reject** placing on ice alone (does not stop the reaction) 5. **Accept** measuring all samples at the same temperature 7. **Accept** 1 ÷ time for a set decrease in ATP, or a comparison of the ATP remaining after the same time 9. **Accept** water/buffer in place of the ATP hydrolase **Ignore** 'room temperature' unless a way of keeping it constant is given

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