HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.6.3 Skeletal muscles

Mark scheme

Version 1 · 14 October 2026

TOTAL MARKS	QUESTIONS
68	10

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.

Antagonistic pairs and the structure of skeletal muscle 3.6.3

Question	Marking guidance	Mark	Comments
01.1	Each muscle fibre contains many myofibrils;	**1** (1 × AO1)	Muscle fibres are multinucleate; myofibrils lie inside fibres; the sarcolemma surrounds each fibre

Question	Marking guidance	Mark	Comments
01.2	1. Hamstrings contract; 2. Quadriceps relax(es);	**2** (2 × AO2)	If the muscles are not named, eg 'one contracts and the other relaxes', award 1 mark **Reject** 'constrict' for contract Shorten/lengthen alone do not gain credit; contract/relax is required If both muscles are said to contract (or both to relax), award 1 mark only

Question	Marking guidance	Mark	Comments
01.3	1. Muscles can only pull (when they contract) OR muscles cannot push/cannot actively lengthen; 2. So a second/antagonistic muscle is needed to move the bone back/reverse the movement OR to stretch/lengthen the relaxed muscle; 3. The skeleton is incompressible, so the force of contraction moves the bone (at a joint) instead of compressing/deforming it OR bones act as levers;	**2 max** (2 × AO1)	**Reject** 'muscles expand' or 'muscles push' **Ignore** 'to work together' unqualified

Question	Marking guidance	Mark	Comments
02.1	1. (In **X**) actin and myosin (filaments) overlap OR both actin and myosin are present; 2. The I band contains only actin; 3. The H zone contains only myosin;	**2 max** (2 × AO1)	1. **Accept** 'X is denser/contains more protein (because both filaments are present)' Filaments must be named as actin and myosin; ignore thin/thick alone **Reject** actin and myosin swapped **Ignore** references to the A band **Ignore** descriptions of sliding/contraction

Question	Marking guidance	Mark	Comments
02.2	Length of A band / µm: 1.6 Length of H zone / µm: 0;	**1** (1 × AO2)	The A band is the length of the myosin filaments (1.6 µm) and does not change; H zone = 2.0 − (2 × 1.0) = 0

Question	Marking guidance	Mark	Comments
02.3	Correct answer for 2 marks: 1.5×10^4;; Accept for 1 mark: 15 000 (not in standard form) OR 36 000 (µm) ÷ 2.4 OR 1.5×10^n where n is not 4 (correct digits, conversion error)	**2** (2 × AO2)	

Question	Marking guidance	Mark	Comments
02.4	Correct answer for 2 marks: 12.5 (%);; Accept for 1 mark: (2.4 − 2.1) ÷ 2.4 OR 3.15 (cm, length after contraction) OR 87.5 (%)	**2** (2 × AO2)	**Accept** 13 (%) for 2 marks

Question	Marking guidance	Mark	Comments
03.1	Correct answer for 2 marks: 2.4 (µm);; Accept for 1 mark: 2.5 (µm per division) OR 60 (µm, length of 25 sarcomeres)	**2** (2 × AO2)	**Accept** 2.40 **Reject** 0.96 (divisions not converted) for 2 marks

Question	Marking guidance	Mark	Comments
03.2	One sarcomere is only about one division long, so measuring many reduces the (percentage) uncertainty/error OR gives a more accurate/precise (mean) value;	**1** (1 × AO3)	**Accept** 'a single sarcomere is too small to measure accurately with the graticule' **Ignore** 'to make it reliable/fair' unqualified

Question	Marking guidance	Mark	Comments
03.3	1. An optical microscope has a low/limited resolution (because of the wavelength of light); 2. The filaments are too thin/too close together to be distinguished as separate (structures); 3. The bands are wider than the limit of resolution (so they can be seen);	**2 max** (2 × AO2)	1. **Accept** a correct figure for the resolution of an optical microscope, eg about 0.2 µm; not required **Reject** magnification is too low as the only explanation **Ignore** references to staining

Muscle contraction: actin, myosin, calcium ions and ATP 3.6.3

Question	Marking guidance	Mark	Comments
04.1	They cause tropomyosin to move, exposing binding sites on actin;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
04.2	1. Calcium ions cause tropomyosin to move (away from the binding sites); 2. Binding sites on actin are exposed/uncovered; 3. Myosin heads bind to actin, forming actinomyosin (cross-)bridges; 4. Myosin heads move/bend/pivot (the power stroke), pulling actin filaments inwards/towards the centre of the sarcomere; 5. ATP (binds to the myosin head and) causes it to detach from actin OR breaks the actinomyosin bridge; 6. Hydrolysis of ATP provides energy to return/recock the myosin head (to its original position); 7. Myosin heads bind to actin further along OR the cycle repeats; 8. The I band and H zone shorten (A band does not change) OR the Z lines move closer together;	**5 max** (5 × AO1)	**Accept** Ca^{2+} for calcium ions; accept 'calcium' alone because the question names calcium ions Myosin head must be named for the movement/binding points; accept myosin arm; reject 'myofibril' for myosin **Reject** 'active site' for the binding site on actin **Ignore** references to troponin (not required); the point is awarded for tropomyosin moving 4. **Accept** ADP/P_i released as the head moves; ignore 'sliding' alone 5. **Accept** 'ATP used to detach myosin and actin' 5. **Accept** 'ATP (used) to form/attach actinomyosin bridges'; not required 6. **Accept** ATP hydrolase/ATPase **Reject** calcium ions bind to actin/myosin binding sites

Question	Marking guidance	Mark	Comments
04.3	1. (Without ATP) myosin heads cannot detach from actin OR actinomyosin bridges cannot be broken; 2. Calcium ions cannot be actively transported back into the sarcoplasmic reticulum, so binding sites on actin stay exposed; 3. So actin and myosin stay joined and the filaments cannot slide apart (when the muscle is pulled);	**2 max** (1 × AO1) (1 × AO2)	**Max 1** if no reference to myosin heads/actinomyosin bridges/calcium ions 1. **Accept** 'ATP (used) to form/attach actinomyosin bridges'; not required **Accept** Ca^{2+} for calcium ions; accept 'calcium' alone because the question names calcium ions **Accept** endoplasmic reticulum for sarcoplasmic reticulum **Reject** 'active site' for the binding site on actin

Question	Marking guidance	Mark	Comments
05	1. Calcium ions (continuously) diffuse out of the sarcoplasmic reticulum into the sarcoplasm (through the open channels); 2. Calcium ion concentration stays high, so tropomyosin stays moved/binding sites on actin stay exposed; 3. Myosin heads keep binding to actin/actinomyosin bridges keep forming, so the muscle stays contracted/rigid; 4. Much ATP is hydrolysed (in the bridge cycle) to detach/recock myosin heads; 5. Much ATP is used to actively transport calcium ions back into the sarcoplasmic reticulum; 6. ATP is resynthesised by (more) aerobic respiration/oxidative phosphorylation, which uses more oxygen (as the final electron acceptor); 7. More carbon dioxide is produced in the link reaction/Krebs cycle; 8. Respiration/ATP hydrolysis releases heat, so body temperature rises;	**6 max** (3 × AO1) (3 × AO2)	**Max 4** if none of points 1–3 is given, or if none of points 6–8 is given 4. **Accept** 'ATP (used) to form/attach actinomyosin bridges'; not required **Accept** Ca^{2+} for calcium ions; accept 'calcium' alone because the question names calcium ions Myosin head must be named for the movement/binding points; accept myosin arm; reject 'myofibril' for myosin **Reject** 'active site' for the binding site on actin **Ignore** references to troponin (not required); the point is awarded for tropomyosin moving 6. **Accept** phosphocreatine is used up so more ATP must come from respiration 7. **Accept** decarboxylation; accept 'more (aerobic) respiration, so more carbon dioxide is produced' 8. **Accept** 'produces heat'; reject 'produces heat energy' **Reject** energy is produced/made/created (once only)

Question	Marking guidance	Mark	Comments
06.1	3.6 (µm);	**1** (1 × AO2)	(2 × 1.0) + 1.6

Question	Marking guidance	Mark	Comments
06.2	1. Less overlap of actin and myosin (filaments); 2. Fewer myosin heads can bind to actin OR fewer actinomyosin bridges form OR fewer binding sites on actin are available to myosin, so less (pulling) force on actin; 3. Force falls in proportion to the overlap OR force falls linearly because overlap decreases linearly; 4. At 3.6 μm there is no overlap, so no actinomyosin bridges and no force;	**3 max** (2 × AO2) (1 × AO3)	Describing the fall in force alone gains no marks **Max 2** if no reference to myosin heads/actinomyosin bridges/binding sites Myosin head must be named for the movement/binding points; accept myosin arm; reject 'myofibril' for myosin **Reject** 'active site' for the binding site on actin

Question	Marking guidance	Mark	Comments
06.3	1. Between 2.0 and 2.2 μm, the gap between the ends of the actin filaments/the H zone is 0–0.2 μm, so it lies within the region with no myosin heads; 2. So all the myosin heads overlap actin/the number of myosin heads that can form actinomyosin bridges stays the same (at its maximum);	**2** (2 × AO3)	**Accept** 'actin filaments only lose overlap with the part of myosin that has no heads' for point 1

Question	Marking guidance	Mark	Comments
06.4	Actin filaments (from opposite ends) overlap each other/collide, interfering with bridge formation OR myosin filaments are pushed against the Z lines (so cannot shorten further);	**1** (1 × AO3)	**Accept** 'myosin filaments are the same length as the sarcomere' (1.6 μm) **Ignore** 'fewer actinomyosin bridges' without a reason

ATP and phosphocreatine 3.6.3

Question	Marking guidance	Mark	Comments
07.1	1. Phosphocreatine concentration fell rapidly/phosphocreatine was used (from 24 to 15 mmol per kg); 2. Phosphocreatine provides phosphate to/combines with ADP to (re)form ATP (as fast as ATP is used);	**2** (1 × AO1) (1 × AO2)	Phosphocreatine must be written in full; abbreviations are not accepted 2. **Reject** phosphocreatine 'provides energy' unless phosphate/ADP is also mentioned

Question	Marking guidance	Mark	Comments
07.2	1. 1.4; 2. mmol kg^{-1} s^{-1};	**2** (2 × AO2)	1. **Accept** 1.3–1.5 from readings within ±0.5 of 24 and 10 2. **Accept** mmol per kg per s / mmol kg^{-1} $second^{-1}$; the unit mark is independent of the value **Accept** 84 mmol kg^{-1} min^{-1} for 2 marks

Question	Marking guidance	Mark	Comments
07.3	1. Phosphocreatine was (mostly) used up: it fell to 10 mmol per kg after a 10-second sprint and to about 4.5 after a 30-second sprint (less than a fifth of the resting value) OR the store of phosphocreatine is limited; 2. So ATP must be made (mainly) by (anaerobic) respiration/glycolysis, which is slower; 3. ATP was used faster than it was regenerated, so the ATP concentration fell (from 6.0 to 4.4 mmol per kg), so fewer actinomyosin bridge cycles/less force;	**2 max** (2 × AO3)	Phosphocreatine must be written in full; abbreviations are not accepted **Accept** lactate builds up/pH falls as an additional idea; not required **Ignore** 'runs out of energy'

Question	Marking guidance	Mark	Comments
07.4	1. Creatine is phosphorylated/forms phosphocreatine using (phosphate from) ATP; 2. This ATP is made by aerobic respiration/oxidative phosphorylation, which needs oxygen (as the final electron acceptor);	**2** (1 × AO1) (1 × AO2)	Phosphocreatine must be written in full; abbreviations are not accepted 1. **Accept** 'ATP is used to re-form phosphocreatine' **Reject** 'oxygen combines with creatine'

Question	Marking guidance	Mark	Comments
08.1	1. To show that any effect is due to creatine (and not to taking a supplement/expecting an effect) OR to allow for the placebo effect; 2. To avoid bias in how they recorded/measured results OR so they could not (unconsciously) influence the volunteers' effort;	**2** (2 × AO3)	1. **Ignore** 'as a control' unqualified 2. **Ignore** 'to make it fair' unqualified

Question	Marking guidance	Mark	Comments
08.2	1. Supports: the creatine group had more (resting) phosphocreatine (29.0 v 24.0) and the standard deviations do not overlap, so this difference is significant/(probably) not due to chance; 2. Supports: more phosphocreatine means ATP can be regenerated (from ADP) faster/for longer during a sprint; 3. Supports: mean power output was higher in the creatine group (by 50 W/about 6%); 4. Against: the standard deviations for power overlap (750–890 W and 790–950 W), so there may be no significant difference/the difference may be due to chance; 5. Against: small sample (10 per group) OR no statistical test; 6. Against: power was not measured before the supplement, so the groups may have differed at the start; 7. Against: only one type of sprint/one duration of supplement/power is only one measure of performance;	**4 max** (4 × AO3)	**Max 3** if only supporting **or** only opposing points are given Phosphocreatine must be written in full; abbreviations are not accepted **Accept** SD for standard deviation 4. **Accept** '(likely) due to chance' or 'not significant' **Reject** 'the power results are significantly different'

Slow and fast skeletal muscle fibres and muscle fatigue 3.6.3

Question	Marking guidance	Mark	Comments
09.1	Number of mitochondria: Higher Concentration of myoglobin: Higher Number of capillaries: Higher;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
09.2	1. More capillaries, so a good blood supply brings (more) oxygen/glucose (and removes carbon dioxide); 2. More mitochondria, so more aerobic respiration, producing (more) ATP; 3. More myoglobin, which stores oxygen/releases oxygen to the mitochondria (when the oxygen concentration is low); 4. So ATP is supplied continuously/less anaerobic respiration, so the muscle fatigues slowly (keeps 85% of its force);	**4** (3 × AO2) (1 × AO3)	Each mark needs a feature linked to its function; quoting data alone gains no marks 4. **Accept** 'mainly slow fibres, which respire aerobically/fatigue slowly'; slow contraction (70 ms) alone gains no mark **Accept** 'release energy' for producing ATP; reject 'produce energy' **Accept** slow twitch for slow

Question	Marking guidance	Mark	Comments
09.3	1. Fast fibres contract more quickly/powerfully than slow fibres (for short periods); 2. Fast fibres mainly use anaerobic respiration (which does not depend on the oxygen supply); 3. So ATP is produced quickly; 4. Fast fibres have a large glycogen store, which is hydrolysed to glucose for respiration/glycolysis; 5. Fast fibres fatigue quickly, but this does not matter because a sprint is short;	**3 max** (2 × AO1) (1 × AO2)	**Accept** fast twitch for fast 2. **Ignore** 'fast fibres use phosphocreatine' (both fibre types do); accept 'fast fibres have a larger phosphocreatine store' as extra detail, not required **Reject** 'working anaerobically' for anaerobic respiration **Reject** energy is produced/made/created (once only) **Accept** 'release energy quickly' for point 3 Phosphocreatine must be written in full; abbreviations are not accepted **Reject** glucagon for glycogen; reject starch

Question	Marking guidance	Mark	Comments
10.1	1. The same clothes peg/pegs with the same spring strength; 2. The same hand/fingers used throughout by each volunteer; 3. The peg squeezed fully open each time; 4. The same position of the hand/arm (eg arm resting on the bench); 5. No exercise of the hand before the investigation OR the same time of day/room temperature;	**2 max** (2 × AO3)	**Ignore** age/sex/fitness of volunteers: each volunteer's results are compared over time, so these do not affect the trend **Ignore** 'same time' unqualified (the timing is given)

Question	Marking guidance	Mark	Comments
10.2	Correct answer for 2 marks: 39.1 (%);; Accept for 1 mark: (46 − 28) ÷ 46 OR 18 ÷ 46 OR 60.9 (%)	**2** (2 × AO2)	**Accept** 39 or 39.13 for 2 marks **Reject** 64.3 (divided by 28): 0 marks

Question	Marking guidance	Mark	Comments
10.3	1. Phosphocreatine (store) is used up, so ATP cannot be regenerated as quickly; 2. Not enough oxygen is supplied for aerobic respiration, so more anaerobic respiration, which produces less ATP per glucose; 3. Lactate builds up/pH falls, inhibiting enzymes/contraction; 4. Less ATP is available to break actinomyosin bridges/move myosin heads/pump calcium ions back into the sarcoplasmic reticulum, so contraction is slower;	**2 max** (1 × AO1) (1 × AO2)	Phosphocreatine must be written in full; abbreviations are not accepted **Reject** energy is produced/made/created (once only) **Reject** 'working anaerobically' for anaerobic respiration **Ignore** 'muscles get tired' unqualified

Question	Marking guidance	Mark	Comments
10.4	1. The decrease between intervals gets smaller (5 between the first two intervals, 2 between the last two), so the rate of decrease is not constant; 2. Extrapolating beyond the data/time tested is unreliable; 3. The number is likely to level off (because some ATP is still made by aerobic respiration) OR cannot fall below zero;	**2 max** (2 × AO3)	**Accept** a correct comparison of any two decreases for point 1 **Ignore** 'the prediction is wrong' without a reason

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