

Questions

Q1.

Answer the questions with a cross in the boxes you think are correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint?

(1)

- A ligaments only
 B ligaments and tendons
 C tendons only
 D neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

Which of the rows in the table correctly describe the changes in this piece of tendon?

(1)

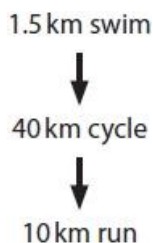
Row	Piece of tendon shows a change in its	The change is
1	genotype	an anatomical adaptation
2	genotype	a physiological adaptation
3	phenotype	an anatomical adaptation
4	phenotype	a physiological adaptation

- A row 1 only
 B row 3 only
 C rows 1 and 2
 D rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.



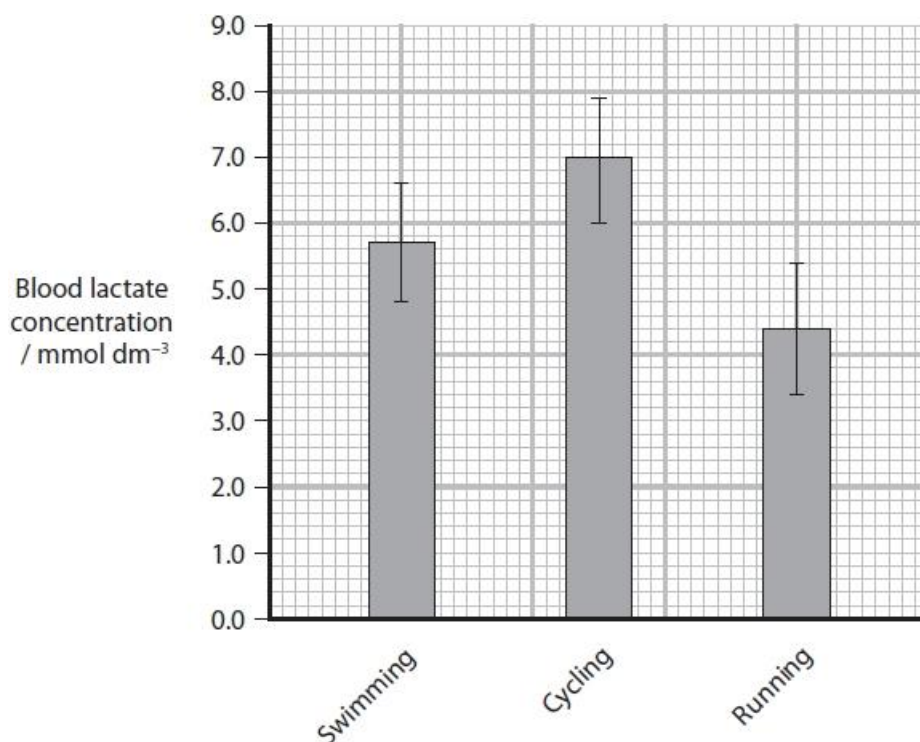
The modern triathlon involves three sports: swimming, cycling and running. An investigation was carried out to compare the level of demand on the body of these three sports during a triathlon. The investigation involved 12 athletes who were all males of the same age. Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.



The heart rate for each athlete was measured as they completed each sport. The mean heart rate for each sport was then calculated and is shown in the table.

Sport	Mean heart rate / bpm
Swimming	163
Cycling	165
Running	159

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated. The results are shown in the graph.

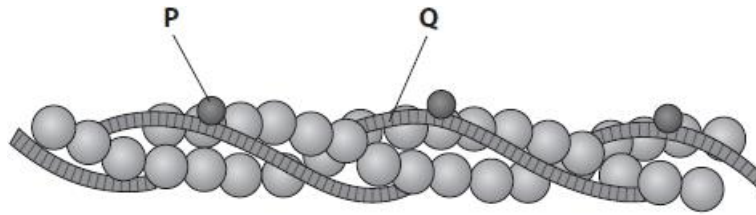


It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running. Evaluate the validity of this conclusion.

(6)
(Total for question = 8 marks)

Q3.

The diagram shows actin and other components (P and Q) of a thin filament in a myofibril.



(i) Describe the interaction between P and Q that allows muscle contraction.

(2)

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(ii) The thick filament in a myofibril contains myosin. The myosin head contains the enzyme ATPase.

Explain the importance of the primary structure for the functioning of this enzyme.

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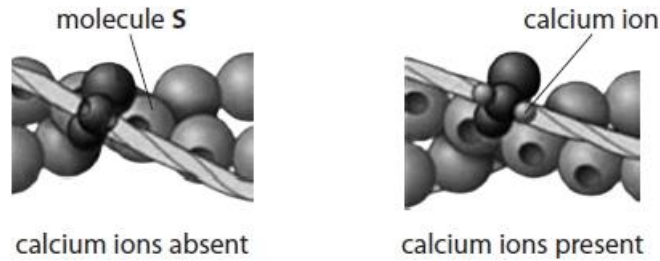
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(Total for question = 5 marks)

Q4.

Muscle cells contain myofibrils. The diagrams show the arrangement of some of the molecules present in a myofibril when calcium ions are absent and when they are present.



Describe how the concentration of calcium ions around the myofibrils is controlled.

(3)

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(Total for question = 3 marks)

Q5.

Calcium ions are required for muscle contraction.

Describe the role of calcium ions in the contraction of muscle fibres.

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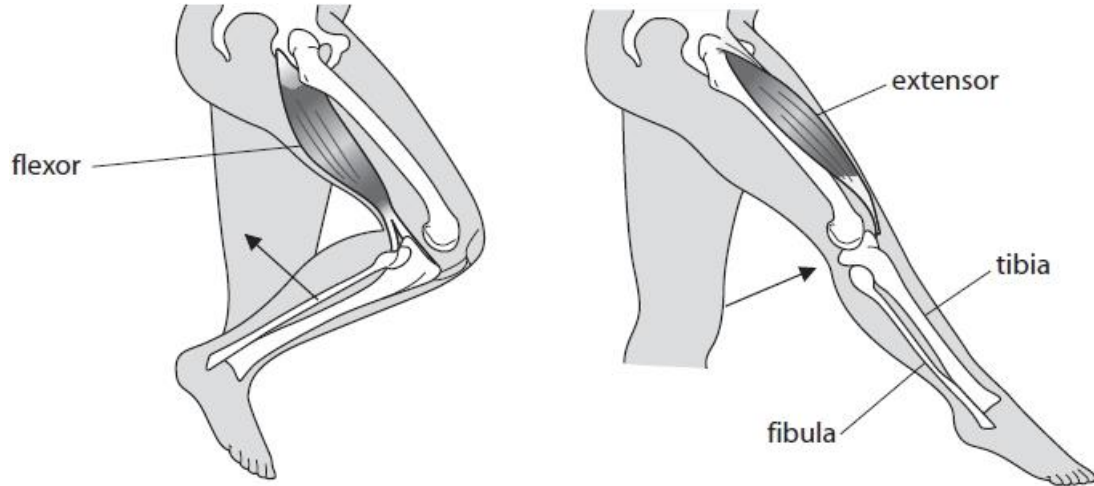
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(Total for question = 3 marks)

Q6.

Sepsis is a bacterial infection in the bloodstream. Sepsis can cause tissue death in limbs. This may require parts of a limb to be removed (amputation).

Extensor and flexor muscles are involved in the movement of the lower leg as shown in the diagrams.



(i) Explain how the extensor and flexor muscles bring about movement of the lower leg.

(2)

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(ii) Individuals who have had limbs amputated can use prostheses to compete in athletic events.

A transtibial amputation involves the removal of part of the lower leg below the knee. Extensor and flexor muscles are still attached to the parts of the lower leg bones (the tibia and fibula) that remain.

The photograph shows Paralympic athletes competing in the 100m final in London 2012. The three athletes shown have all had transtibial amputations.



www.sciencephoto.com

Deduce how athletes with transtibial amputations are able to move their prosthetic limbs during a race.

(1)

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(Total for question = 3 marks)

Q7.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Muscle fibres contain a number of proteins, including actin, myosin and collagen.

The myosin binding site is found on

(1)

- A actin
- B sarcoplasmic reticulum
- C tropomyosin
- D troponin

(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Moving a limb involves the interaction of muscles, tendons and ligaments.

Muscles can contain fast twitch and slow twitch muscle fibres.

(i) Describe two structural differences between fast twitch muscle fibres and slow twitch muscle fibres.

(2)

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(ii) Muscles can be extensors or flexors.

Which of the following correctly describes the state of the muscles described?

(1)

	When the arm is bent at the elbow, the flexor muscle is	When the lower leg is straightened at the knee, the flexor muscle is
<input type="checkbox"/> A	contracted	contracted
<input type="checkbox"/> B	contracted	relaxed
<input type="checkbox"/> C	relaxed	contracted
<input type="checkbox"/> D	relaxed	relaxed

(Total for question = 3 marks)

Q9.

There are many reasons why humans may lose muscle mass.

Two known causes are hip replacement surgery and some genetically inherited conditions.

A muscle fibre is a specialised body cell.

Explain how the structure of a muscle fibre is related to its specialised function.

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(Total for question = 3 marks)

Q10.

When astronauts are in space, the force of gravity is less than when they are on a planet such as Earth or Mars.

Scientists need to investigate how varying gravity affects astronauts.



NASA/Science photo library

The scientists proposed a null hypothesis for the rate of breakdown of protein in the muscle cells of the two groups.

The data from this investigation showed that there was no significant difference at the 0.05 probability level.

(i) Explain what is meant by no significant difference at the 0.05 probability level for the rate of breakdown of protein.

(2)

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(ii) Some of the myosin in the muscle cells was broken down.

Describe how the tertiary structure of myosin is related to its function.

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(Total for question = 5 marks)

Q11.

Calcium ions are required for muscle contraction.

An investigation was carried out to study the effect of calcium ion concentration on muscle fibres.

Individual fibres, from one sample of muscle, were provided with different calcium ion concentrations. The force produced by each fibre was recorded and a mean force was calculated for each calcium ion concentration.

All other variables were kept constant.

(i) Give one advantage and one disadvantage of using muscle fibres from the same sample of muscle.

(2)

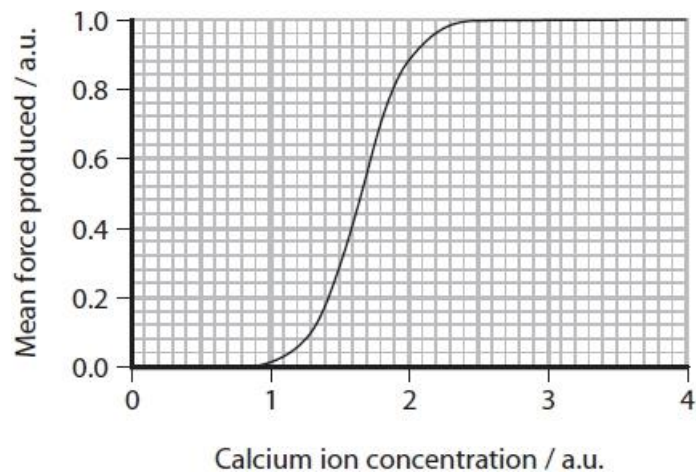
Advantage:

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Disadvantage:

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(ii) The results are shown in the graph.



Explain the effect of increasing calcium ion concentration on the mean force produced by muscle fibres.

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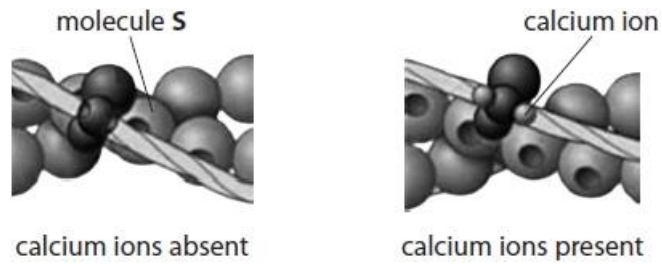
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(Total for question = 6 marks)

Q12.

Muscle cells contain myofibrils. The diagrams show the arrangement of some of the molecules present in a myofibril when calcium ions are absent and when they are present.



Which of the following is molecule **S**?

(1)

- A actin
- B myosin
- C tropomyosin
- D troponin

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	<p>The only correct answer is A - ligaments only</p> <p><i>B is not correct because the tendons do not join bones to bones in the elbow joint</i></p> <p><i>C is not correct because the tendons do not join bones to bones in the elbow joint</i></p> <p><i>D is not correct because the ligaments do join bones to bones in the elbow joint</i></p>	(1)
(ii)	<p>The only correct answer is D rows 3 and 4</p> <p><i>A is not correct because the tendons showing a change is not a change in genotype</i></p> <p><i>B is not correct because the tendons also show a physiological adaptation</i></p> <p><i>C is not correct because the tendons showing a change is not a change in genotype</i></p>	(1)
* (iii)	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant.</p> <p>Indicative content Valid because:</p> <ul style="list-style-type: none"> • {sufficient replicates / 12 individuals} used and a mean calculated • All same gender • Means of both heart rate and blood lactate agree with conclusion • Spread of data (standard deviation / error bars) between cycling and running does not overlap <p>Not valid because:</p> <ul style="list-style-type: none"> • Insufficient / only 12 individuals involved • Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced • The three disciplines are always done in the same order / different distances covered • Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming • As no time allowed to recover between sports, some of blood lactate shown for cycling could have been produced during swimming • Agree or not agree with conclusion 	(6)

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Considers one area only e.g. comparing mean data or spread of data only Conclusion based on only one set of data or only one sport considered e.g. cycling is most demanding
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers both a valid and an invalid aspect e.g. relevance of spread of data for lactate concentrations overlap in some cases or elements of the study Conclusion given that takes both valid and invalid aspects into account
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Considers both a range of valid and invalid aspects A conclusion based on a range of considered evidence

Q2.

Question number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following points: <ul style="list-style-type: none"> tropomyosin is moved (by troponin) (1) myosin binding sites (on actin) are exposed (1) 	ALLOW tropomyosin moves ALLOW actin-myosin binding site	(2)

Question number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to four of the following points:</p> <ul style="list-style-type: none"> • myosin heads can bind to binding sites (1) • (bound) myosin changes shape (1) • actin filaments { slide / pulled } over the myosin (1) • (therefore) { muscle fibres / myofibril / sarcomeres } shorten (1) • ATP hydrolysed / ADP and { inorganic phosphate / Pi } released (1) 	<p>ALLOW actin – myosin bridges form</p> <p>ALLOW description of head 'nodding' or 'dipping' forward</p> <p>ALLOW actin moves towards the M line</p> <p>ALLOW Ca²⁺ activates ATPase</p>	(4)

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • { P / troponin } changes shape (1) • causing { Q / tropomyosin } to move away from the myosin-binding sites (on actin) (1) 	<p>ALLOW P binds with calcium ions</p> <p>ALLOW Q is displaced away from myosin binding sites</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • (primary structure) determines interaction between { amino acids / R groups } (1) • (primary structure) determines { folding / tertiary structure } (1) • (therefore) affecting the shape of the active site (1) • (active site is) complementary to ATP (1) 	<p>e.g. bonds formed between R groups</p> <p>ALLOW 3D shape</p> <p>ALLOW ATP fits active site</p>	(3)

Q4.

Question number	Answer	Additional guidance	Mark
	<p>A description that makes reference to three of the following points:</p> <ul style="list-style-type: none"> calcium ions released from sarcoplasmic reticulum (1) in response to { nerve impulse / action potential / depolarisation } (at neuromuscular junction) (1) calcium channels open (to allow calcium ions to cross the membrane / enter the sarcoplasm) (1) calcium ions taken back up into the sarcoplasmic reticulum by active transport (1) 	<p>ALLOW Ca²⁺ for calcium ions</p> <p>ALLOW calcium ions moving through channel protein</p>	(3)

Q5.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> (calcium ions) {bind / attach} to the troponin (1) causing tropomyosin to be { displaced / shape altered } (1) exposing myosin binding sites (on actin) (1) 	<p>ALLOW changes shape of troponin</p> <p>ALLOW tropomyosin moved, 'shifted', 'pulled'</p> <p>ALLOW correct reference to the sliding filament hypothesis e.g. myosin head can bind to actin filament or actin-myosin cross bridges can form</p>	(3)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> tendons attach muscles to bones (flexor and extensor) muscles act as an antagonistic pair when the {extensor muscle contracts, it pulls on the tibia to extend the leg / flexor muscle contracts, it pulls on the fibula flexing the leg} 	<p>ALLOW marks for correctly annotated diagram</p> <p>ALLOW reference to a tendon attaching a named muscle to a named bone</p> <p>ALLOW quadriceps for extensor and hamstring for flexor</p>	(2)
Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> the muscles are still attached to (bones in) the lower leg and the prosthetic limb is attached to the lower leg (allowing movement) 	<p>ALLOW reference to tibia and/or fibula instead of lower leg.</p> <p>No marks if reference made to muscle attachment to prosthetic limb.</p>	(1)

Q7.

Question Number	Answer	Mark
	<p><i>The only correct answer is A - actin</i></p> <p><i>B is incorrect because the myosin binding site is not found on sarcoplasmic reticulum</i></p> <p><i>C is incorrect because the myosin binding site is not found on tropomyosin</i></p> <p><i>D is incorrect because the myosin binding site is not found on troponin</i></p>	(1)

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> fast twitch fibres have {no / few} mitochondria present / slow twitch fibres have many mitochondria (1) fast twitch fibres have {no / few} capillaries present / slow twitch fibres have many capillaries present (1) 		(2)

Question Number	Answer	Mark
(ii)	<p>The only correct answer is B – contracted and relaxed</p> <p><i>A is not correct because the flexor in the leg would be relaxed</i></p> <p><i>C is not correct because the flexor in the arm would not be relaxed and the flexor in the leg would not be contracted</i></p> <p><i>D is not correct because the flexor in the arm would not be relaxed</i></p>	(1)

Q9.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> { cell surface membrane / sarcolemma } contains voltage-gated channels to allow depolarisation (of muscle fibre) (1) many mitochondria for { (aerobic) respiration / to supply ATP } (1) presence of { myofibrils / actin and myosin } (1) (myofibrils) allow contraction (of muscle) (1) 	<p>ALLOW T tubules to allow depolarisation to be transferred to sarcoplasmic reticulum / sarcoplasmic reticulum { stores / releases } calcium ions</p> <p>ALLOW description of interaction of actin and myosin for contraction</p>	(3)

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> there is {more than a 5% likelihood / less than 95% likelihood} (1) therefore the rate of protein breakdown is the same {in space as it is on Earth / for groups 1 and 2} (1) the calculated value is less than the critical value (at $p=0.05$) (1) 	ALLOW: 'chance' for 'likelihood'	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> {part} folded into a specific shape with a globular head (1) that can bind to actin (1) {myosin} has a site that can bind with ATP (1) {part} straight to form a bundle with other myosin molecules (1) 	ALLOW R groups arranged to bind with ATP	(3)

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following:</p> <p><u>Advantage</u></p> <ul style="list-style-type: none"> controlled variable / increases validity (1) <p><u>Disadvantage</u></p> <ul style="list-style-type: none"> may not be representative / only one type of muscle tested (1) 	<p>ALLOW genetically the same / same age / same ratio of fast to slow twitch muscle fibres</p> <p>ALLOW same level of development / same level of exercise</p> <p>e.g. muscle might be damaged</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> no force produced at { low / less than 1.0 a.u. } calcium ion concentration (1) (as calcium ion concentration increases) force produced increases (1) (because more) { actin and myosin interact / myosin binding sites exposed } (1) there is no increase in force produced at { high / from 2.4 a.u. } calcium ion concentration (1) as all actin and myosin are { interacting / all myosin binding sites occupied } (1) 	<p>ALLOW there is a threshold concentration for calcium ion concentration</p> <p>ALLOW more tropomyosin displaced or more actin-myosin cross bridges formed</p> <p>ALLOW 2.5 a.u.</p> <p>ALLOW all troponin has Ca^{2+} bound to it , no troponin available or no more actin-myosin cross bridges can be formed</p>	(4)

Q12.

Question number	Answer	Mark
	<p>The only correct answer is A – actin</p> <p><i>B is not correct because myosin is not found in a thin myofilament</i></p> <p><i>C is not correct because tropomyosin is a fibrous protein</i></p> <p><i>D is not correct because troponin binds calcium ions as shown in the diagram</i></p>	(1)