6.3 Organisms - Responses to their environment (A-Level Only) - Skeletal Muscles – Questions

Q1.

(a) Describe the roles of calcium ions and ATP in the contraction of a myofibril.

(Extra space) _____

(5)

(b) ATP is an energy source used in many cell processes. Give **two** ways in which ATP is a suitable energy source for cells to use.

1. _____

2. _____

(2)

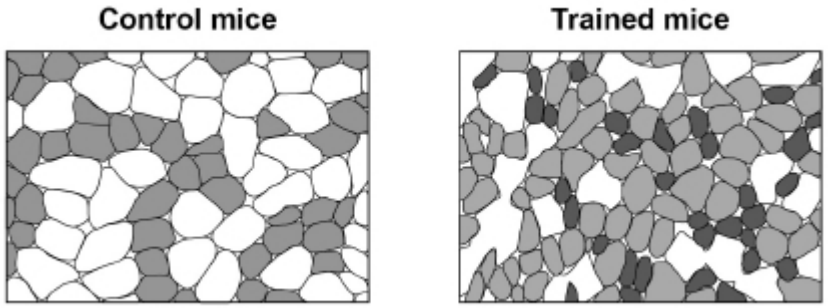
(Total 7 marks)

Q2.

Scientists investigated the effect of regular exercise on skeletal muscle fibres in mice. The scientists compared the muscle fibres of mice after six weeks of regular exercise (trained

mice) with those of mice that had not exercised (control mice). The scientists stained the muscle fibres from both sets of mice to show succinic acid dehydrogenase activity. The darker the stain the greater the succinic acid dehydrogenase activity.

The diagram below shows a typical set of results they obtained.



(a) Succinic acid dehydrogenase is an enzyme used in the Krebs cycle.

Suggest **one** reason for the difference in the staining between the muscle fibres of the control mice and the trained mice.

_____

_____

_____

(1)

(b) The scientists then compared the length of time that the control mice and the trained mice could carry out prolonged exercise. The trained mice were able to exercise for a longer time period than control mice.

Explain why.

_____

_____

_____

_____

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_____

(3)

(c) The scientists determined the mean diameter of muscle fibres in trained mice using an optical microscope to examine sections of muscle tissue. The circular area (πr^2) of one field of view was 1.25 mm^2. The diameter of this area was equal to the diameter of 15 muscle fibres.

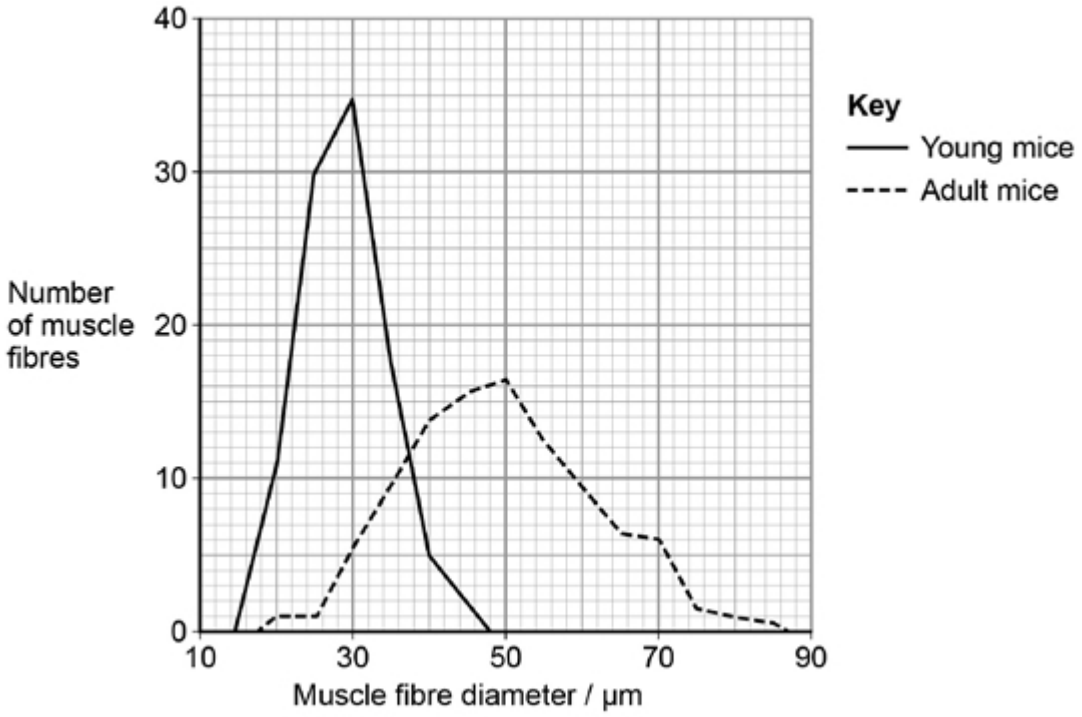
Using this information, calculate the mean diameter in μm (micrometres) of muscle fibres in this section of tissue.

Answer _____ μm

(2)

(d) The scientists also compared the diameter of samples of muscle fibres taken from young mice and adult mice.

Some of their results are shown in the graph.



Describe **two** differences between these samples of muscle fibres.

1. _____

_____

_____

2. _____

_____

_____

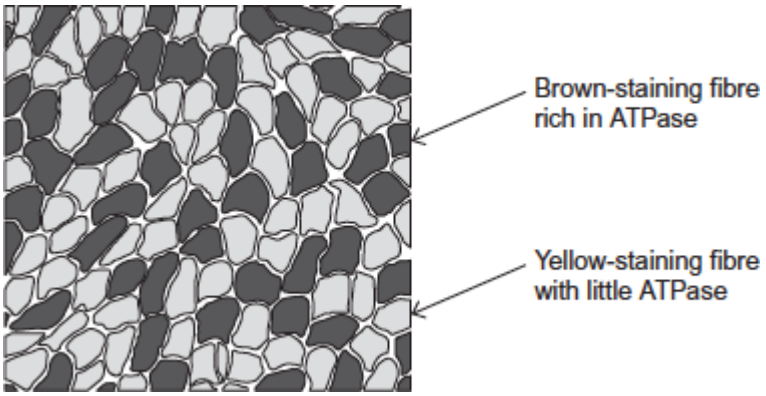
(2)

(Total 8 marks)

Q3.

Slow and fast skeletal muscles both contain slow and fast muscle fibres but in different proportions. The proportion can be determined by observing stained sections of muscle under a microscope. The stain used reacts with an ATPase enzyme. Muscle fibres containing a lot of this ATPase stain brown. Fibres containing little ATPase stain yellow.

The diagram shows stained muscle fibres in a section taken from a muscle.



(a) Both slow and fast muscle fibres contain ATPase.

Explain why.

_____

_____

_____

_____

(2)

(b) The tissue in the diagram came from muscle with a high proportion of brown-staining fibres. Was the tissue removed from slow or fast skeletal muscle?

Explain your answer.

_____

_____

_____

(1)

(c) The muscle tissue in the diagram had been stained for viewing with a microscope.

What is the evidence that it had been stained for viewing with an optical (light) microscope? Explain your answer.

_____

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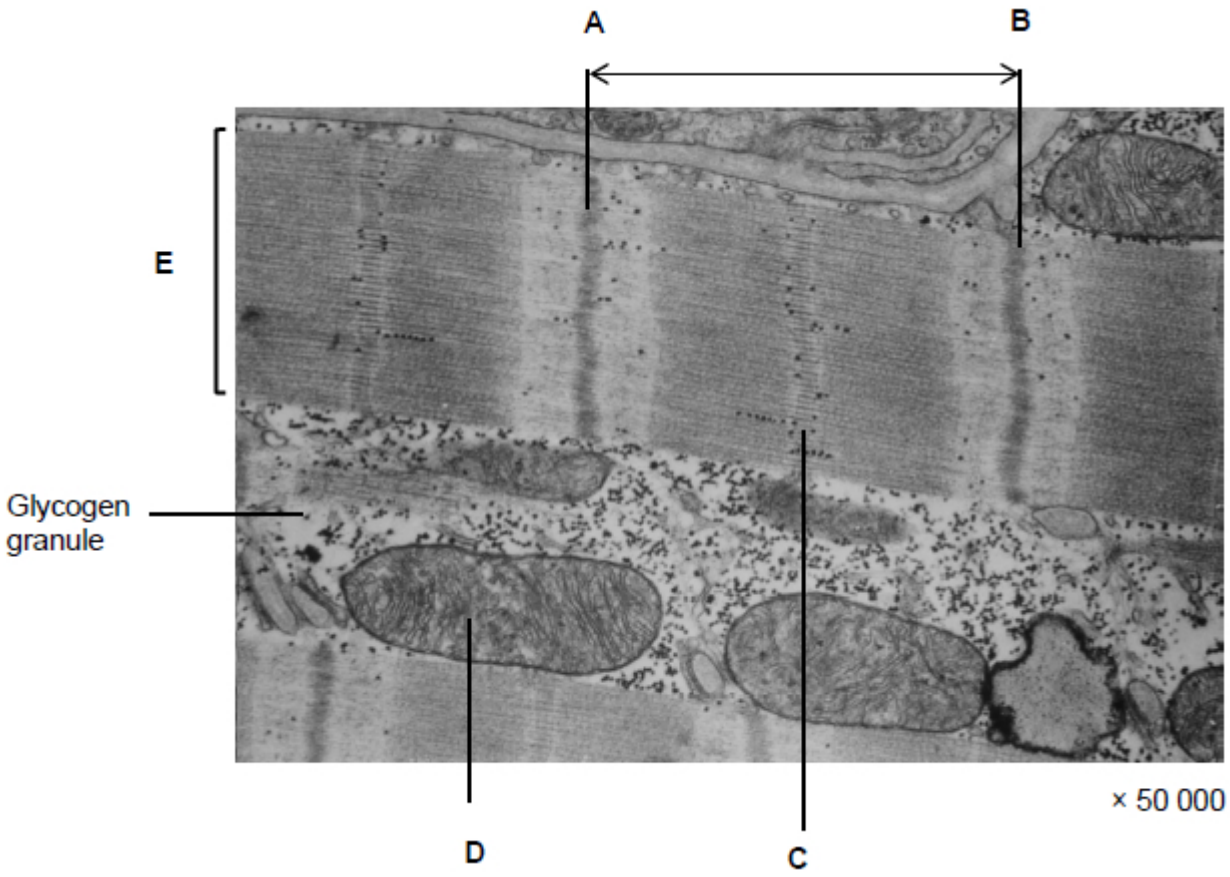
_____

(2)

(Total 5 marks)

Q4.

The image below shows a transmission electron micrograph of a longitudinal section of skeletal muscle.



(a) Name structures **C**, **D** and **E**.

C _____

D _____

E _____

(3)

(b) Give the name of the structure shown between points **A** and **B**.

_____

(1)

(c) Calculate the actual distance between points **A** and **B**. Give your answer in micrometres (μm).

Answer = _____ μm

(1)

(d) The image shows glycogen granules present in skeletal muscle.

Explain their role in skeletal muscle.

(2)

(e) During vigorous exercise, the pH of skeletal muscle tissue falls. This fall in pH leads to a reduction in the ability of calcium ions to stimulate muscle contraction.

Suggest how.

(3)

(Total 10 marks)

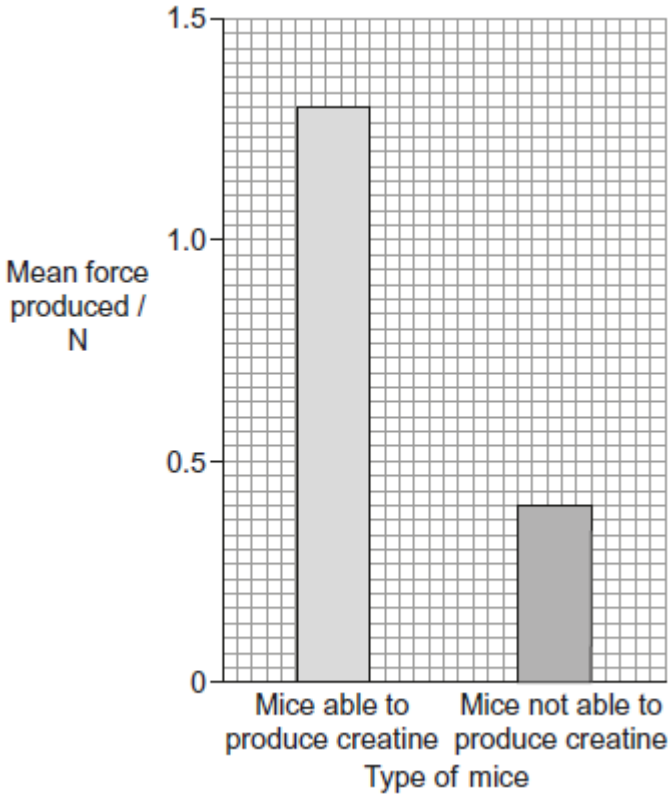
Q5.

(a) What is the role of ATP in myofibril contraction?

(2)

(b) Scientists investigated the effect of not being able to produce creatine on the force produced by muscle. They used mice with a mutation that made them not able to produce creatine.
The force produced when these mice gripped with their paws was compared with the force produced by normal mice that were able to produce creatine.

The graph shows the scientists' results.



(i) What was the percentage fall in the mean force produced by mice not able to produce creatine, compared with the normal mice? Show your working.

Answer _____ %

(2)

(ii) Suggest an explanation for these results.

_____

_____

_____

_____

(2)

(c) The mice that were not able to produce creatine were homozygous for a recessive allele of a gene. Mice that are heterozygous for this allele are able to produce forces similar to those of normal mice that are homozygous for the dominant allele of the same gene.

Explain why the heterozygous mice can produce forces similar to those of normal

mice.

_____

_____

_____

_____

(2)

(Total 8 marks)

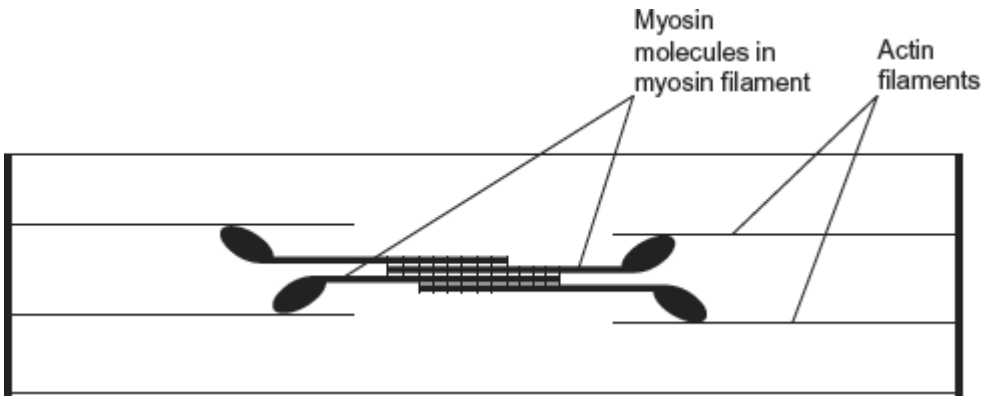
Q6.

(a) A sarcomere is made up of different molecules.
Complete the table by naming the molecule that carries out the function described.

Function	Name
Attaches to Z line at the end of the sarcomere	
Breaks down ATP	
Covers binding site on actin in relaxed myofibril	

(3)

(b) The diagram shows the arrangement of actin and myosin in a sarcomere.



One form of muscle disease is caused by a mutated allele of a gene. This leads to production of myosin molecules that are unable to bind to other myosin molecules.

If myosin molecules are unable to bind to other myosin molecules, this prevents muscle contraction.
Use the diagram and your knowledge of how muscles contract to suggest why.

_____

_____

_____

_____

_____

_____

[Extra space] _____

_____

_____

(3)
(Total 6 marks)

Q7.

Researchers investigated whether the blood supply to slow and fast muscle fibres in a muscle changes with age. They used diaphragms taken from hamsters (*Mesocricetus auratus*). The diaphragm is in constant use for breathing. They took diaphragms from groups of young, adult and old hamsters.

They removed the diaphragm from each animal and took a sample of muscle tissue.They examined it under an optical (light) microscope. For each sample they selected several fields of view at random. In each field of view, they then counted the number of capillaries associated with each type of muscle fibre.

This allowed the researchers to calculate the mean number of capillaries for each type of muscle fibre, for each age group.

The table below shows the researchers' results which include standard deviation (SD).

Hamster age group	**Number of hamsters in group**	**Mean number of capillaries associated with each type of muscle fibre**	
		Slow fibres (± SD)	**Fast fibres (± SD)**
Young	9	3.4 (±0.8)	4.0 (±0.8)
Adult	10	4.7 (±0.2)	6.3 (±0.4)
Old	8	4.6 (±0.9)	6.8 (±0.6)

(a) Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

(4)

(b) The researchers examined the muscle of an animal in the **old** age group. They found one field of view containing only slow muscle fibres. They counted 69 capillaries in this field of view.

(i) Use a calculation to estimate how many slow muscle fibres were visible in this field of view. Show your working.

Number of slow muscle fibres = _____

(2)

(ii) The actual number of slow muscle fibres in the field of view was **not** the same as the number you calculated in question (i).

Give **one** reason why.

_____

_____

_____

(1)

(c) A student read the report of the researchers' investigation. She thought that the investigation was unethical but that a conclusion could still be made.

(i) Suggest why she thought the investigation was unethical.

_____

_____

_____

(1)

(ii) She concluded that age had a significant effect on the mean number of capillaries per fibre.

Evaluate this conclusion.

_____

(4)

(Total 12 marks)

Q8.

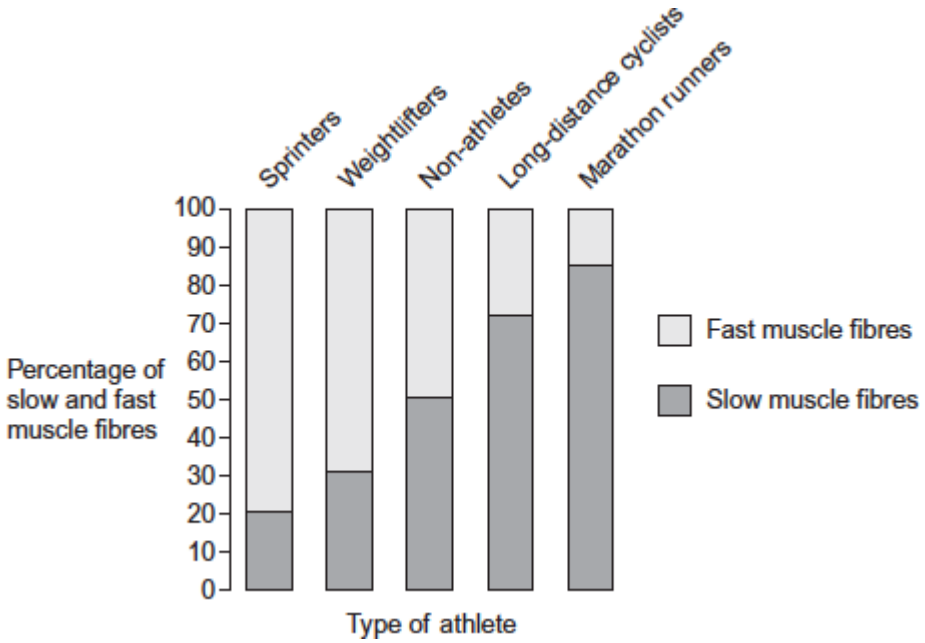
It is believed that each person is born with a certain percentage of slow and fast muscle fibres in their skeletal muscles. Most people have about 50% slow fibres and 50% fast fibres.

A sports scientist wondered if these percentages could change over time depending on the type of sport in which a person was involved. He knew from previous investigations that:

- the number of mitochondria within a fibre can change
- the diameter of a fibre can change
- the number of muscle fibres in a skeletal muscle remains constant over time.

He determined the mean percentages of slow and fast fibres in skeletal muscles of different types of athletes.

His results are shown in the graph below in the form in which he presented them.



(a) (i) In which type of athlete would the sports scientist expect to find muscle fibres with the highest number of mitochondria?

_____

(1)

(ii) Explain the reason for your choice of athlete.

_____

_____

_____

_____

(2)

(b) The leg muscles of long-distance cyclists are usually larger than the leg muscles of non-athletes.

Suggest why.

_____

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_____

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_____

[Extra space] _____

_____

_____

(3)

(c) A reader of the sports scientist's results stated that 'the results show that regular weightlifting changes your proportion of slow and fast skeletal muscle fibres.'

Do you agree with this statement? Explain your answer.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q9.

(a) What is the role of phosphocreatine (PC) in providing energy during muscle contraction?

_____

_____

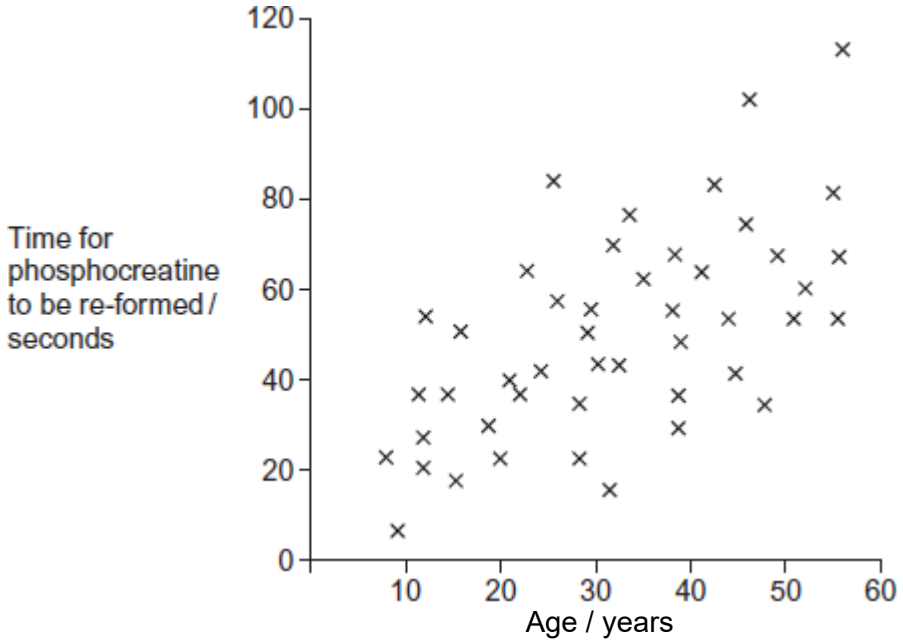
_____

_____

(2)

Scientists investigated the time for phosphocreatine (PC) to be re-formed in arm muscles after the same exercise in healthy people of different ages. The exercise involved brief, rapid contractions of arm muscles.

The figure below shows the scientists' results. Each cross is the result for one person.



(b) There is a lot of variation in the time taken for PC to be re-formed in people of a very similar age.

Suggest **one** reason for this variation.

_____

(1)

(c) Use your knowledge of fast muscle fibres to explain the data in the figure.

_____

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_____

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_____

(Extra space) _____

_____

_____

_____

(4)

(Total 7 marks)

Q10.

(a) Describe the part played by each of the following in myofibril contraction.

(i) Tropomyosin

(2)

(ii) Myosin

(2)

(b) The table shows features of fast and slow muscle fibres.

Feature	Fast muscle fibre	Slow muscle fibre
Type of respiration	Mainly anaerobic	Mainly aerobic
Glycogen	High concentration	Low concentration
Capillaries	Few	Many

Use information from the table to suggest and explain **one** advantage of:

(i) the high glycogen content of fast muscle fibres

(2)

(ii) the number of capillaries supplying slow muscle fibres.

(2)
(Total 8 marks)

Q11.

(a) Describe the role of each of the following in muscle contraction.

(i) Tropomyosin

(2)

(ii) ATP

(2)

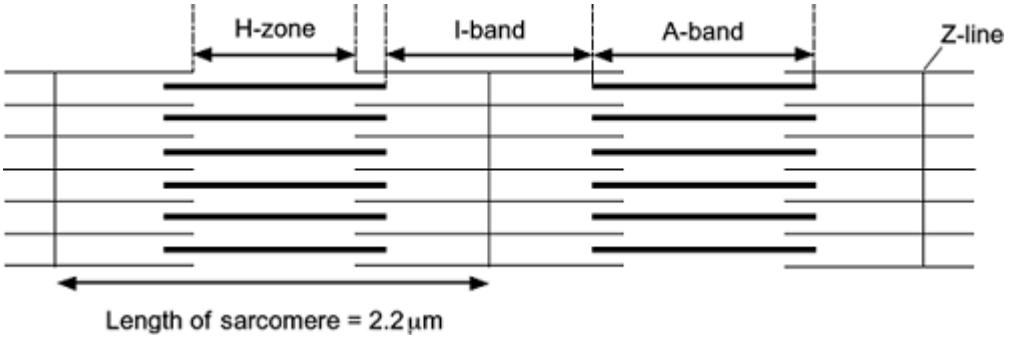
(b) Explain how muscles maintain posture.

(Extra space)

(3)
(Total 7 marks)

Q12.

The diagram shows two relaxed sarcomeres from skeletal muscle.



(a) When the sarcomeres contract, what happens to the length of

(i) the I-band

_____

(1)

(ii) the A-band?

_____

(1)

(b) The length of each sarcomere in the diagram is 2.2 μm. Use this information to calculate the magnification of the diagram. Show your working.

Magnification _____

(2)

(c) People who have McArdle's disease produce less ATP than healthy people. As a result, they are not able to maintain strong muscle contraction during exercise. Use your knowledge of the sliding filament theory to suggest why.

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_____

*(Extra space)*_____

_____

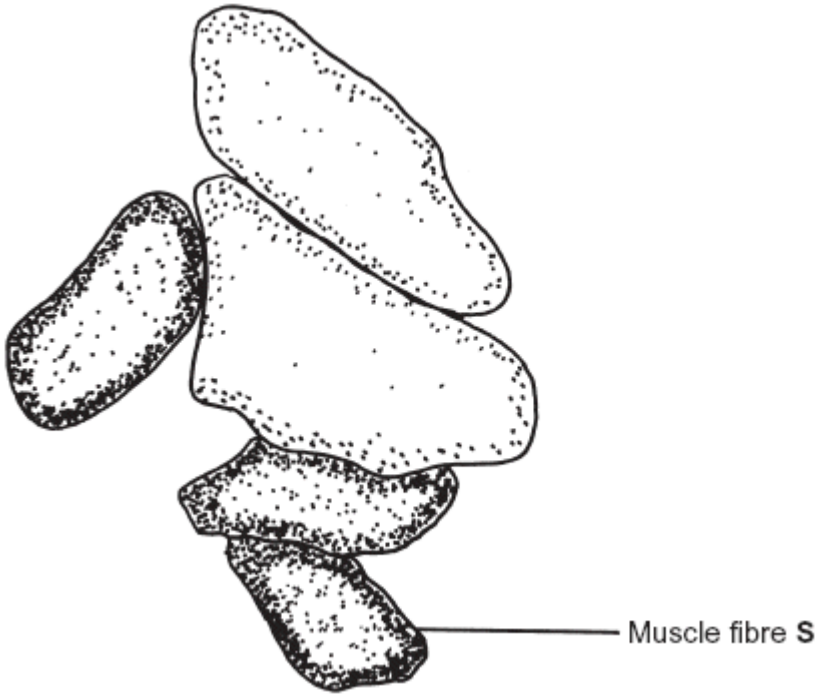
_____

(3)

(Total 7 marks)

Q13.

The drawing is a tracing of a cross-section through skeletal muscle tissue. This muscle contains fast muscle fibres and slow muscle fibres. The section has been stained to show the distribution of the enzyme succinate dehydrogenase. This enzyme is found in mitochondria.



(a) (i) Succinate dehydrogenase catalyses one of the reactions in the Krebs cycle. What is the evidence from the drawing that muscle fibre **S** is a slow muscle fibre? Explain your answer.

_____

_____

_____

_____

(2)

(ii) Use evidence from the diagram to describe the distribution of mitochondria inside the slow muscle fibres. Explain the importance of this distribution.

_____

_____

_____

_____

_____

_____

(3)

(b) (i) You could use an optical microscope and a slide of stained muscle tissue to find the diameter of one of the muscle fibres. Explain how.

_____

_____

_____

_____

(2)

(ii) A student found the mean diameter for the slow muscle fibres in a section. Give **two** precautions that she should have taken when sampling the fibres. Give a reason for each precaution.

1. _____

_____

2. _____

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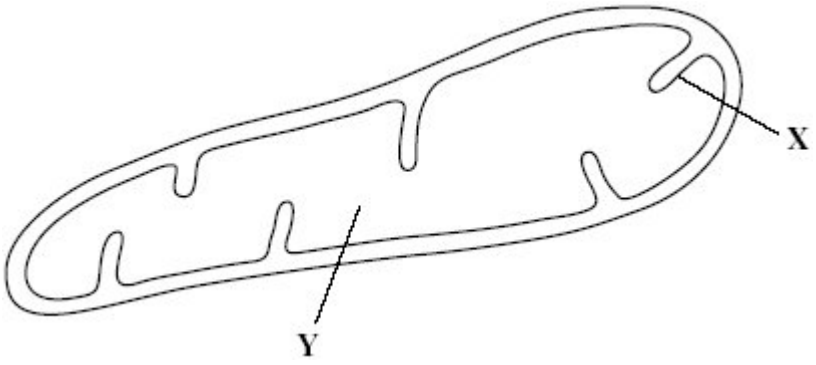
(2)

(Total 9 marks)

Q14.

The diagram shows a mitochondrion.



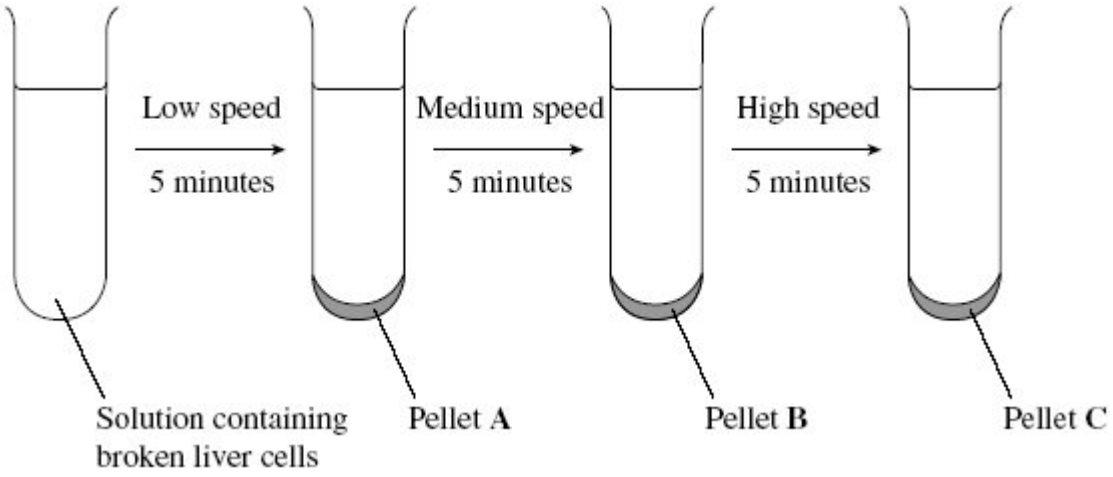
(a) Name the parts labelled **X** and **Y**.

(i) **X** _____

(ii) **Y** _____

(2)

Scientists isolated mitochondria from liver cells. They broke the cells open in an ice-cold, isotonic solution. They then used a centrifuge to separate the cell organelles. The diagram shows some of the steps in the process of centrifugation.



(b) Suggest which pellet, **A**, **B** or **C** contained the mitochondria.

(1)

(c) Explain why the solution used was

(i) ice-cold

(1)

(ii) isotonic.

(2)

(d) People with mitochondrial disease have mitochondria that do not function properly.

Some people with mitochondrial disease can only exercise for a short time. Explain why a person with mitochondrial disease can only exercise for a short time.

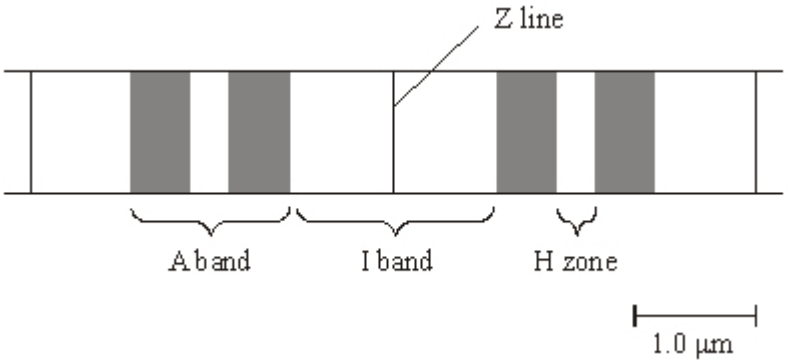
_____

(2)

(Total 8 marks)

Q15.

The diagram shows part of a myofibril from a relaxed muscle fibre.



(a) When the muscle fibre contracts, which of the A band, I band and H zone

(i) remain unchanged in length,

_____

(1)

(ii) decrease in length?

_____

(1)

(b) Explain what caused the decrease in length in part (a)(ii).

_____

_____

_____

_____

(2)

(c) The whole muscle fibre is 30 mm long when relaxed. Each sarcomere is 2.25 µm long when contracted. Use the scale given on the diagram to calculate the length of the contracted muscle fibre in millimetres.

Length of contracted fibre = _____ mm

(2)

(d) The table gives some properties of the two different types of muscle fibre found in skeletal muscle.

(i) Complete the table by writing the words 'high' or 'low' for the remaining three properties of each type of muscle fibre.

	Type of muscle fibre	
	Type 1	**Type 2**
Speed of contraction	high	low
Force generated	high	low
Activity of the enzymes of glycolysis	high	low
Number of mitochondria		
Activity of Krebs cycle enzymes		
Rate of fatigue		

(3)

(ii) The myosin-ATPase of **type 1** muscle fibres has a faster rate of reaction than that in **type 2** fibres. Use your knowledge of the mechanism of muscle contraction to explain how this will help **type 1** muscle fibres to contract faster than **type 2**.

(4)

(iii) The blood leaving an active muscle with a high percentage of **type 1** muscle fibres contained a higher concentration of lactate than that leaving a muscle with a high percentage of **type 2** muscle fibres. Explain why.

(2)

(Total 15 marks)

Q16.

The flow chart outlines an investigation to determine from where the calcium ions involved in muscle contraction are released.

Calcium ion transport proteins were isolated from human tissue.

↓

These proteins were injected into a rabbit.

↓

The rabbit formed antibodies to the proteins. These antibodies were collected and labelled with gold particles.

↓

Muscle tissue was treated with the labelled antibodies and examined with an electron microscope. High concentrations of gold particles were observed attached to the sarcoplasmic reticulum.

(a) Labelled antibodies and an electron microscope can be used to produce images locating proteins on the surface of organelles, but cannot be used to observe cross bridge cycling in muscle cells. Explain why.

(5)

(b) Describe the role of calcium ions and ATP in muscle contraction.

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 10 marks)

Q17.

Figure 1 shows part of a single myofibril from a skeletal muscle fibre as it appears under an optical microscope.

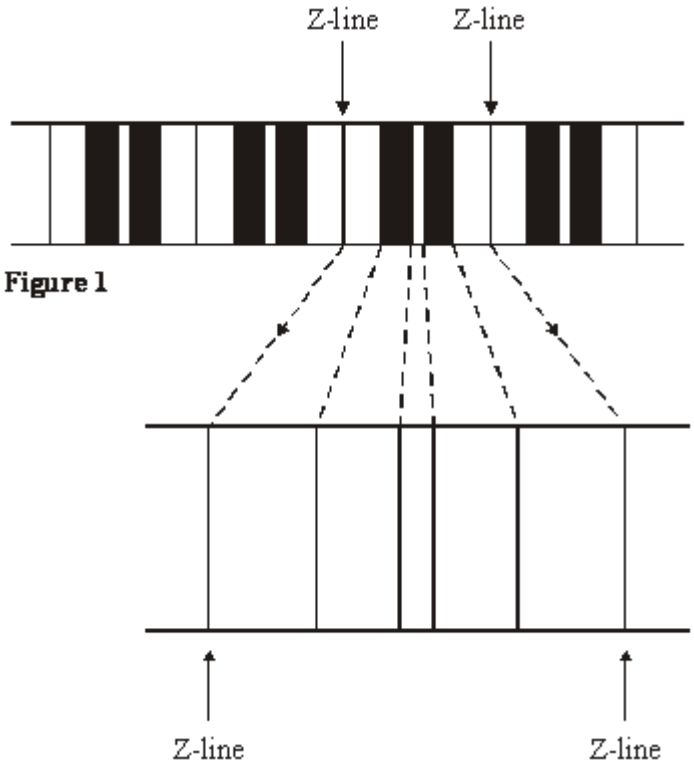


Figure 1

Figure 2

(a) (i) Complete **Figure 2** to show the arrangement of actin and myosin filaments in this part of the myofibril as they would appear under an electron microscope. Label the actin and myosin filaments.

(2)

(ii) Why are the details you have drawn in **Figure 2** visible under the electron microscope but not under the optical microscope?

_____

_____

(1)

(b) The myofibril in **Figure 1** is magnified × 8000. A muscle fibre is 40 μm in diameter. Calculate the number of myofibrils which would fit side by side across the diameter of the muscle fibre. Show your working.

Answer _____ myofibrils.

(2)

(Total 5 marks)

Q18.

Figure 1 shows part of a sarcomere.

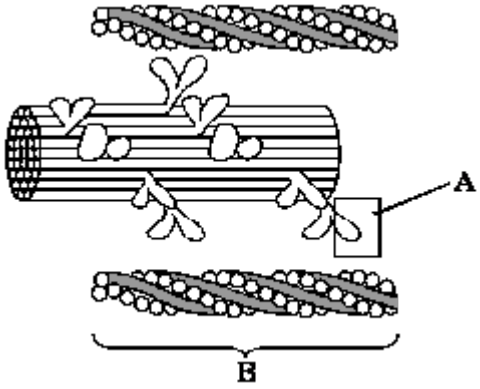


Figure 1

(a) (i) Name the main protein in structure **B**.

_____

(1)

(ii) Name the structure in box **A**.

_____

(1)

(b) (i) Describe how calcium ions cause the myofibril to start contracting.

_____

_____

_____

_____

(2)

(ii) Describe the events that occur within a myofibril which enable it to contract.

_____

_____

_____

_____

_____

_____

(3)

Slow and fast skeletal muscle fibres differ in a number of ways. Slow fibres get their ATP from aerobic respiration while anaerobic respiration provides fast fibres with their ATP. **Figure 2** shows a bundle of fast and slow fibres seen through an optical microscope. The fibres have been stained with a stain that binds to the enzymes which operate in the electron transport chain.

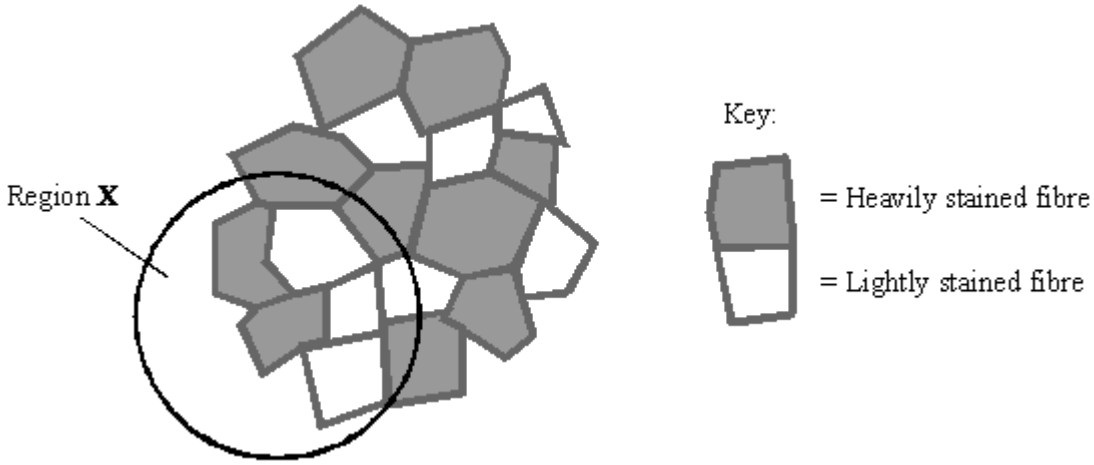


Figure 2

(c) (i) Describe how you could calculate the percentage of fast fibres in this bundle.

_____

_____

(1)

(ii) The figure calculated by the method in part (c)(i) may not be true for the muscle as a whole. Explain why.

_____

_____

(1)

(d) The fibres in **Figure 3** correspond to those in region **X** of **Figure 2**. They were stained with a substance that binds to enzymes involved in glycolysis. Shade

Figure 3 to show the appearance of the fibres. Use the shading shown in the key.

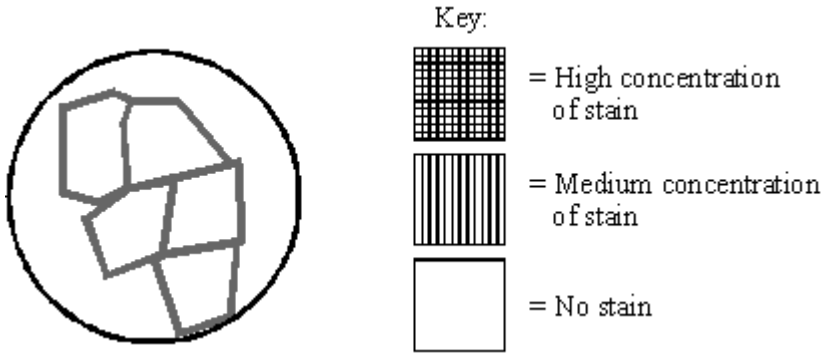


Figure 3

(2)

(e) Recent research has shown that the difference in fibre types is due in part to the presence of different forms of the protein myosin with different molecular shapes.

Explain how a new form of myosin with different properties could have been produced as a result of mutation.

_____

_____

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(4)

(Total 15 marks)

Q19.

(a) **Figure 1** shows part of a myofibril from skeletal muscle.

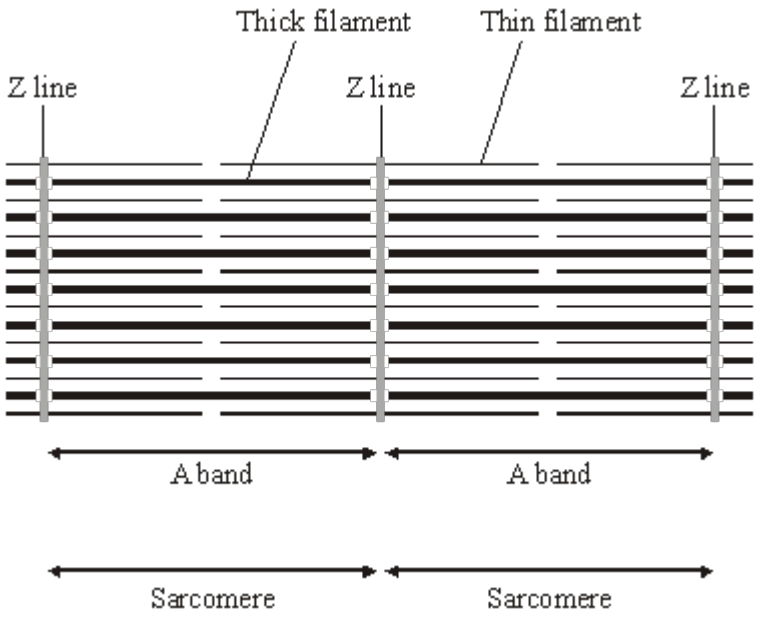


Figure 1

(i) Describe **two** features, visible in the diagram, which show that the myofibril is contracted.

1. _____

_____

2. _____

_____

(2)

(ii) Explain the role of calcium ions and ATP in bringing about contraction of a muscle fibre.

Calcium ions _____

_____

_____

ATP _____

_____

_____

(3)

(b) **Figure 2** shows the structure of a neuromuscular junction. The vesicles contain acetylcholine.

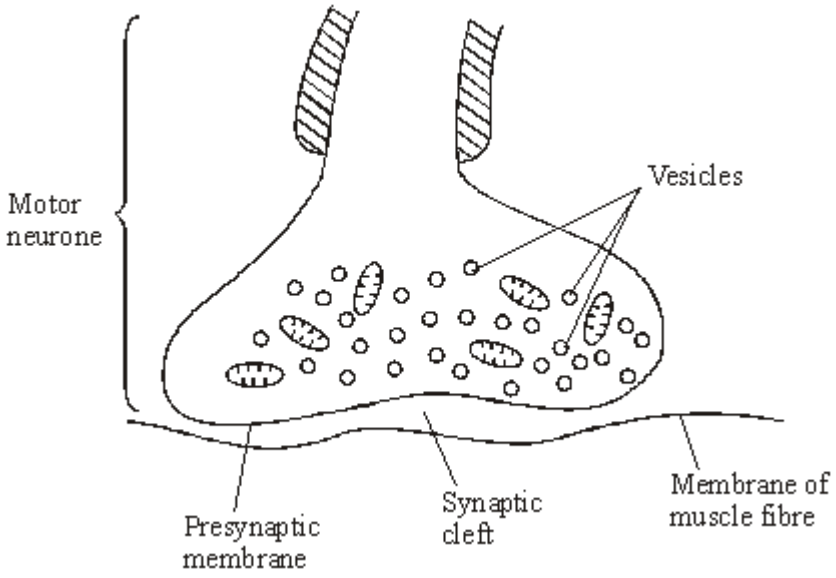


Figure 2

(i) An action potential is generated at the cell body of the motor neurone. Explain how this action potential passes along the motor neurone to the neuromuscular junction.

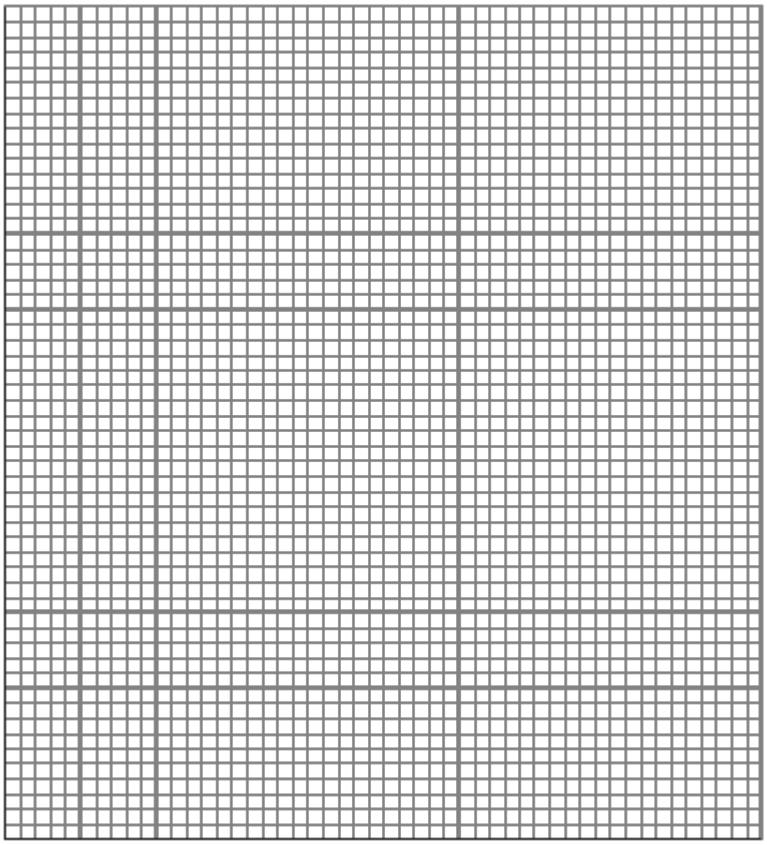
(3)

(ii) When the action potential arrives at the neuromuscular junction, it results in the secretion of acetylcholine into the synaptic cleft. Explain how.

(3)

(c) Between the ages of 20 and 50, 10% of total muscle mass is lost. Between the ages of 50 and 80, a further 40% of the original total muscle mass is lost. Most of the muscle lost consists of fast fibres.

(i) Plot a graph on the grid below to show the percentage of muscle mass remaining between the ages of 20 and 80. Assume that the rate of muscle loss in each age range is constant.



(3)

(ii) Explain why explosive exercises, such as sprinting and weightlifting, will be more affected by this muscle loss than aerobic exercises, such as jogging.

_____

_____

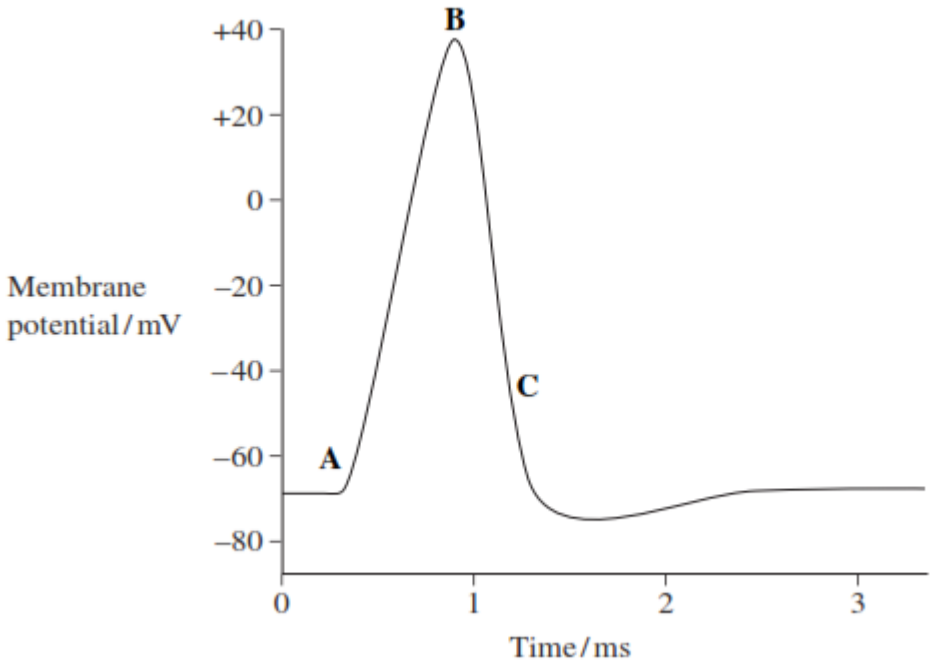
(1)

(Total 15 marks)

Q20.

Figure 1 shows changes in the membrane potential of a neurone during one action potential.

Figure 1



(a) What happens in the membrane to cause the change in membrane potential at time **B**?

_____

_____

_____

_____

(2)

(b) No further action potential can be produced between times **A** and **C**.

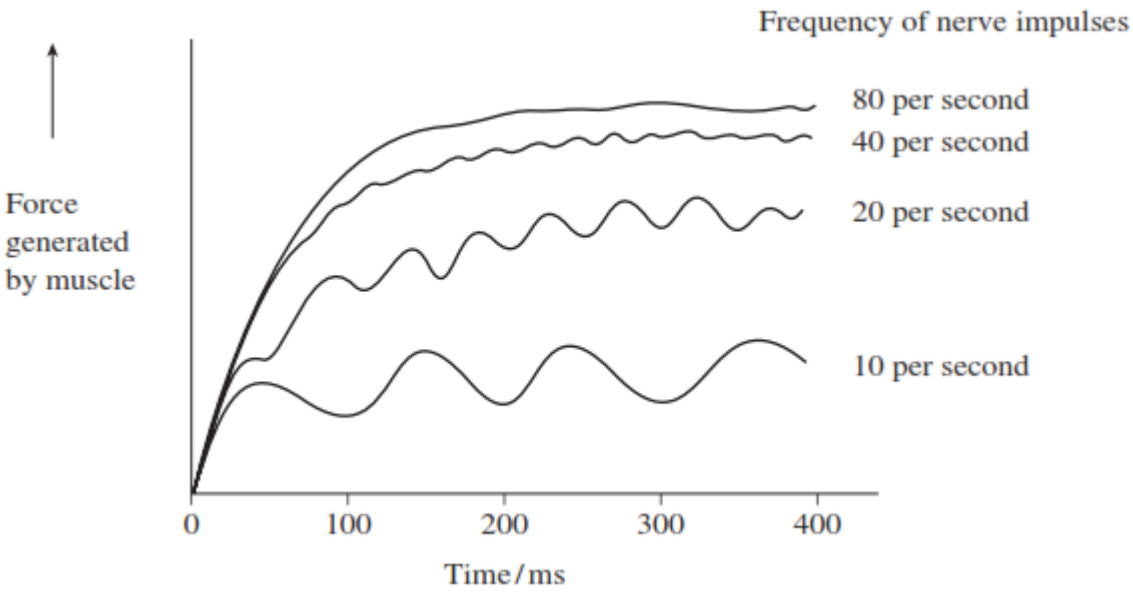
What is the name given to the period between times **A** and **C**?

_____

(1)

(c) **Figure 2** shows the force generated by a muscle when it was stimulated by different frequencies of nerve impulse.

Figure 2



A taser is a device used by the police to arrest violent suspects. It fires electrical impulses very similar to action potentials into a suspect. The frequency of the impulses is between 15 and 20 per second.

(i) Suggest the effect a taser has on a suspect's muscles.

_____

_____

_____

_____

(2)

(ii) Tasers with frequencies of between 40 and 80 per second are not used, because they are considered too dangerous. Suggest how they might be dangerous to a suspect.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q21.

(a) (i) What is meant by homeostasis?

_____

_____

(1)

(ii) Giving **one** example, explain why homeostasis is important in mammals.

_____

_____

_____

_____

(2)

(b) Cross-channel swimmers may suffer from muscle fatigue during which the contraction mechanism is disrupted. One factor thought to contribute to muscle fatigue is a decrease in the availability of calcium ions within muscle fibres. Explain how a decrease in the availability of calcium ions could disrupt the contraction mechanism in muscles.

_____

_____

_____

_____

_____

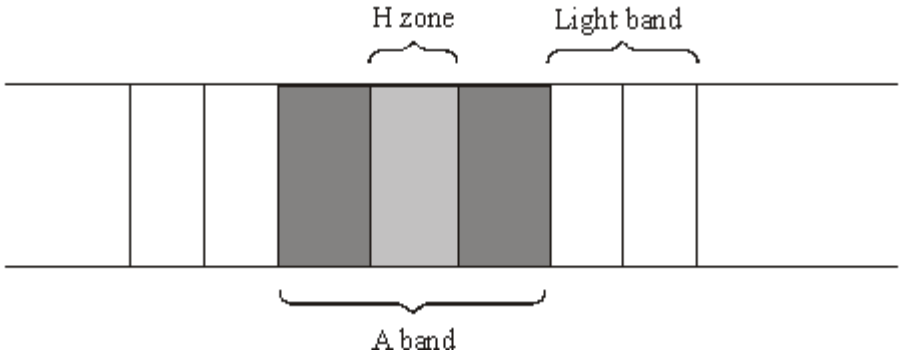
_____

(3)

(Total 6 marks)

Q22.

(a) The diagram shows the banding pattern observed in part of a relaxed muscle fibril.



(i) Describe what causes the different bands seen in the muscle fibril.

_____

_____

_____

_____

(2)

(ii) Describe how the banding pattern will be different when the muscle fibril is contracted.

_____

_____

_____

_____

(2)

(b) There is an increase in the activity of the enzyme ATPase during muscle contraction. An investigation into muscle contraction involved measuring the activity of ATPase in solutions containing ATP, myosin and different muscle components. The table shows the results.

Solution	Contents	ATPase activity / arbitrary units
A	ATP, myosin and actin	1.97
B	ATP, myosin, actin and tropomyosin	0.54
C	ATP, myosin, actin, tropomyosin and calcium ions	3.85

(i) Explain the importance of ATPase during muscle contraction.

_____

_____

_____

_____

(2)

(ii) Using your knowledge of muscle contraction, explain the difference in the results between

A and **B**;

_____

_____

_____

_____

(2)

B and **C**.

_____

_____

_____

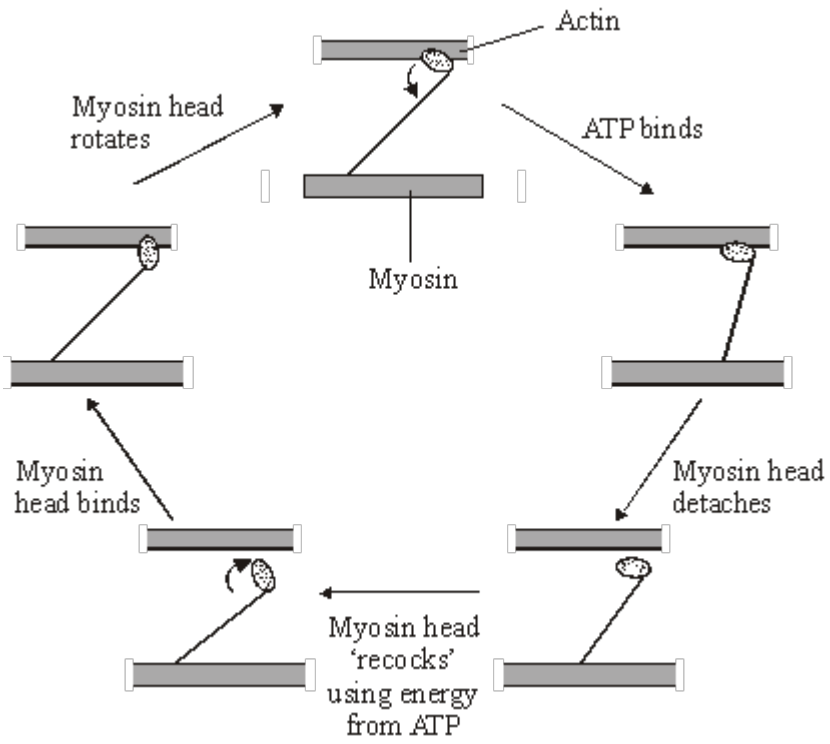
_____

(2)

(Total 10 marks)

Q23.

The diagram shows the stages in one cycle that results in movement of an actin filament in a muscle sarcomere.



(a) Describe how stimulation of a muscle by a nerve impulse starts the cycle shown in the diagram.

_____

_____

_____

_____

_____

_____

(3)

(b) Each cycle requires hydrolysis of one molecule of ATP and moves one actin filament 40 nm. During contraction of a muscle sarcomere, a single actin filament moves 0.6 µm. Calculate how many molecules of ATP are required to produce this movement.

Answer _____

(2)

(c) After death, cross bridges between actin and myosin remain firmly bound resulting in rigor mortis. Using information in the diagram, explain what causes the cross bridges to remain firmly bound.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q24.

Figure 1 shows a diagram of part of a muscle myofibril.

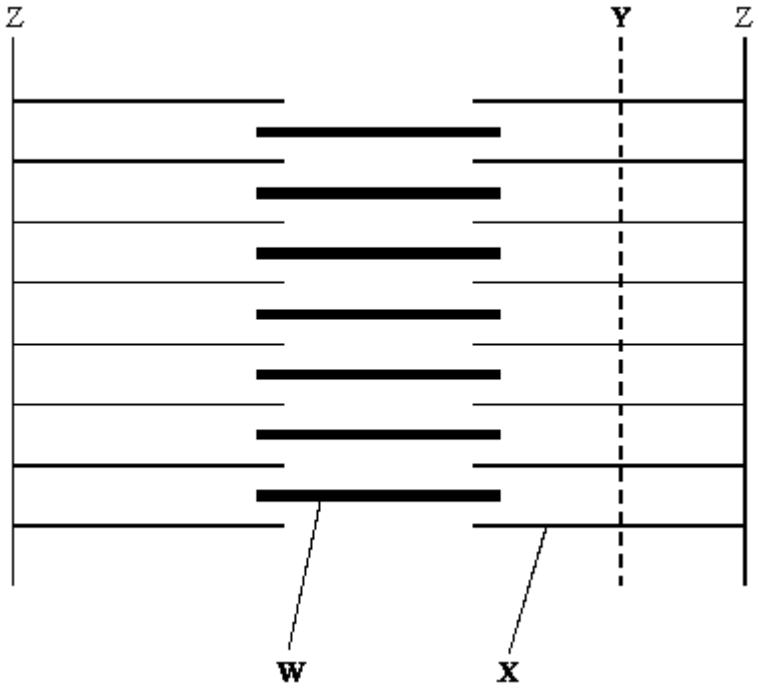


Figure 1

(a) Name the protein present in the filaments labelled **W** and **X**.

W _____

X _____

(1)

(b) **Figure 2** shows the cut ends of the protein filaments when the myofibril was cut at position **Y**. **Figure 3** shows the protein filaments when the myofibril was cut at the same distance from a Z line at a different stage of contraction.

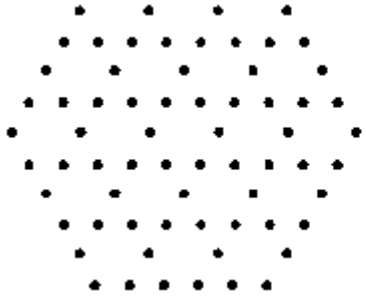


Figure 2

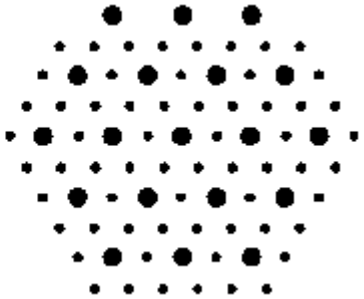


Figure 3

Explain why the pattern of protein filaments differs in **Figure 2** and **Figure 3**.

_____

_____

_____

_____

(2)

(c) Describe the role of calcium ions in the contraction of a sarcomere.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

Q25.

Surgeons sometimes use a drug called pancuronium to stop muscles contracting during an operation.

Pancuronium binds to acetylcholine receptors on muscle fibres.

(a) Suggest why pancuronium is able to bind to acetylcholine receptors.

(2)

(b) Pancuronium causes muscle paralysis. Explain how.

(Extra space)

(3)

(Total 5 marks)

Q26.

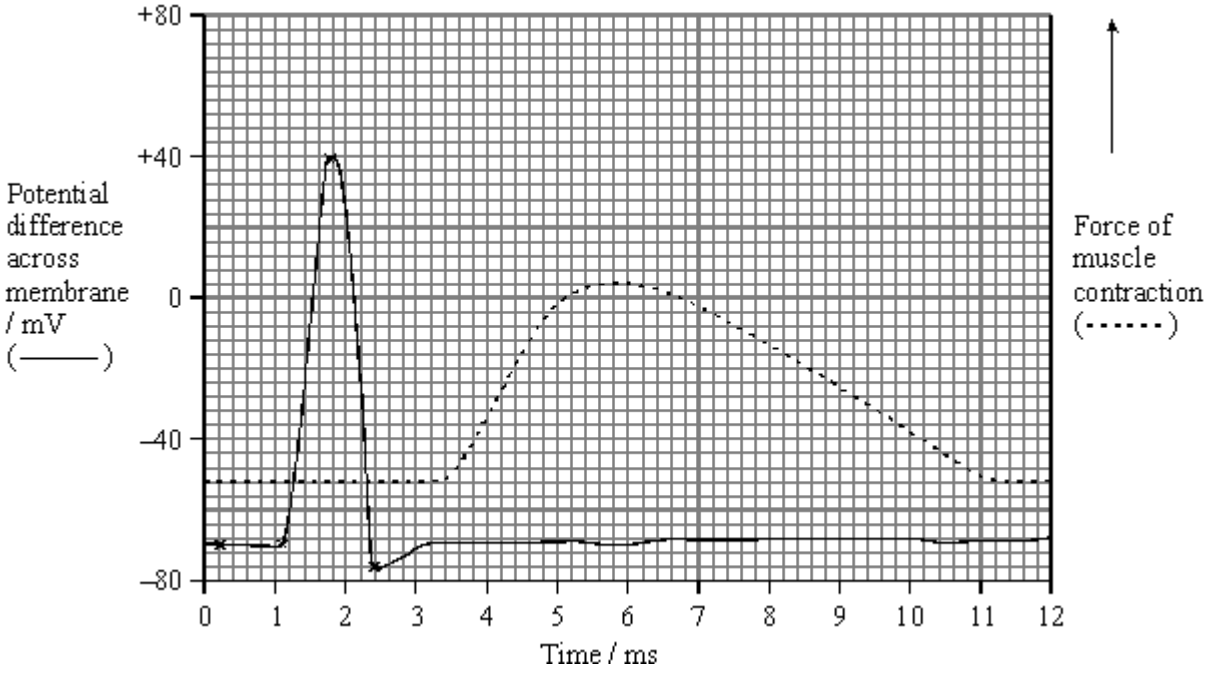
This question should be written in continuous prose, where appropriate.

(a) Explain how a resting potential is maintained in a neurone.

(4)

(b) In an investigation, an impulse was generated in a neurone using electrodes. During transmission along the neurone, an action potential was recorded at one point on the neurone. When the impulse reached the neuromuscular junction, it stimulated a muscle cell to contract. The force generated by the contraction was measured. The results are shown in the graph.

The distance between the point on the neurone where the action potential was measured and the neuromuscular junction was exactly 18 mm.



(i) Use the graph to estimate the time between the maximum depolarisation and the start of contraction by the muscle cell.

Time _____ ms

(1)

(ii) Use your answer to part (i) to calculate the speed of transmission along this neurone to the muscle cell. Give your answer in mm per second.

Show your working.

Speed _____ mm s^{-1}

(2)

(iii) Give **one** reason why the value calculated in part (ii) would be an underestimate of the speed of transmission of an impulse along a neurone.

_____

_____

(1)

Acetylcholine is the neurotransmitter at neuromuscular junctions.

(c) Describe how the release of acetylcholine into a neuromuscular junction causes the cell membrane of a muscle fibre to depolarise.

_____

_____

_____

_____

_____

_____

(3)

(d) Use your knowledge of the processes occurring at a neuromuscular junction to explain each of the following.

(i) The cobra is a very poisonous snake. The molecular structure of cobra toxin is similar to the molecular structure of acetylcholine. The toxin permanently prevents muscle contraction.

_____

_____

_____

_____

(2)

(ii) The insecticide DFP combines with the active site of the enzyme acetylcholinesterase. The muscles stay contracted until the insecticide is lost from the neuromuscular junction.

_____

_____

_____

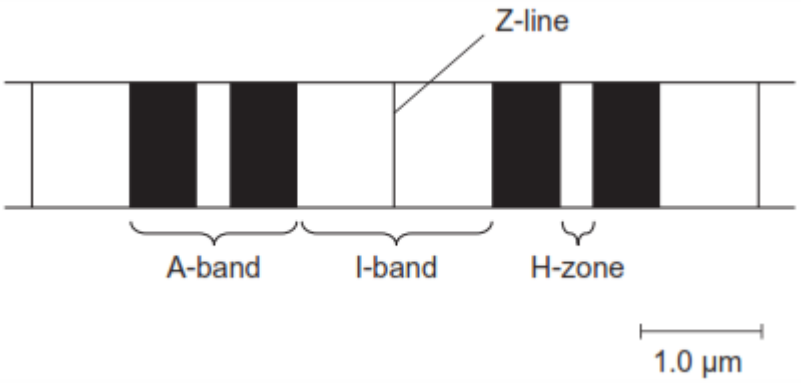
_____

(2)

(Total 15 marks)

Q27.

The diagram shows part of a relaxed myofibril.



(a) When the myofibril contracts, which of the A-band, I-band and H-zone will

(i) remain unchanged in length _____

(ii) decrease in length? _____

(2)

(b) The whole myofibril is 21 mm long when relaxed. Use information from the diagram, and the scale provided, to calculate the number of sarcomeres in the myofibril.

Show your working.

Number of sarcomeres = _____

(2)

(c) Calcium ions are involved in myofibril contraction.
Describe how.

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

_____

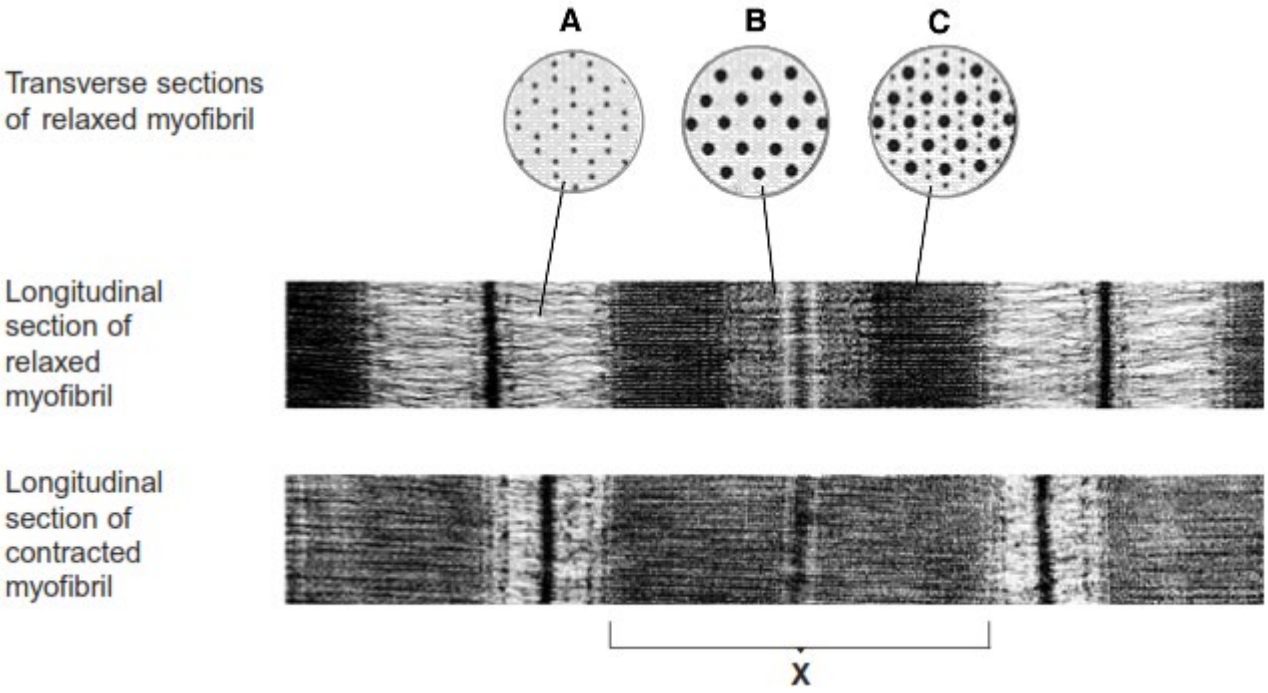
(3)

(Total 7 marks)

Q28.

Figure 1 shows sections through relaxed and contracted myofibrils of a skeletal muscle. The transverse sections are diagrams. The longitudinal sections are electron micrographs.

Figure 1



(a) (i) The electron micrographs are magnified 40 000 times.
Calculate the length of band **X** in micrometres.
Show your working.

Length of band **X** = _____ μm

(2)

(ii) Explain the difference in appearance between transverse sections **A** and **C** in **Figure 1**.

_____

_____

(1)

(b) Explain what leads to the differences in appearance between the relaxed myofibril and the contracted myofibril.

_____

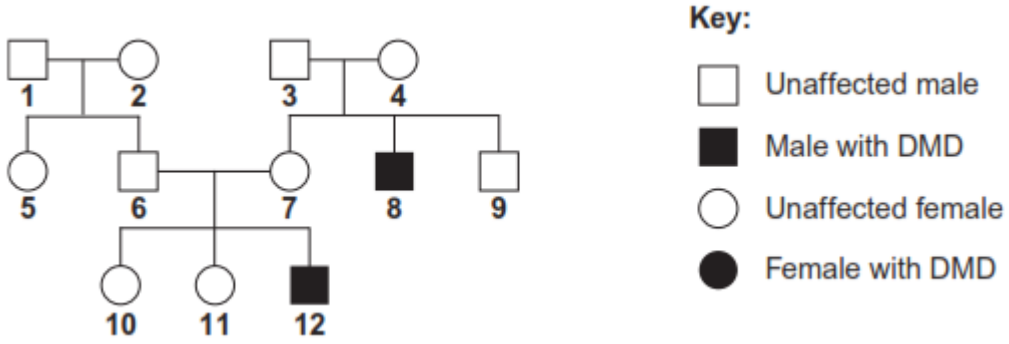
_____

(*Extra space*) _____

(4)

(c) Duchenne muscular dystrophy (DMD) is a condition caused by the recessive allele of a sex-linked gene. A couple have a son with DMD. They want to know the probability that they could produce another child with DMD. They consulted a genetic counsellor who produced a diagram showing the inheritance of DMD in this family.
This is shown in **Figure 2**.

Figure 2



The couple who sought genetic counselling are persons **6** and **7**.

(i) Give the evidence to show that DMD is caused by a recessive allele.

_____

_____

(1)

(ii) Give the numbers of **two** people in **Figure 2** who are definitely carriers of muscular dystrophy.

_____

(1)

(iii) Complete the genetic diagram to find the probability that the next child of

couple **6** and **7** will be a son with muscular dystrophy. Use the following symbols:

$\mathbf{X^D}$ = normal X chromosome
$\mathbf{X^d}$ = X chromosome carrying the allele for muscular dystrophy
Y = normal Y chromosome

	6	**7**
Parental phenotypes	Unaffected	Unaffected
Parental genotypes	_____	_____
Gametes	_____	_____

Offspring genotypes _____

Offspring phenotypes _____

Probability of having a son with DMD _____

(4)

(d) DMD is caused by a deletion mutation in the gene for a muscle protein called dystrophin. A deletion is where part of the DNA sequence of a gene is lost. People in different families may inherit mutations in different regions of this gene.

Scientists isolated the dystrophin gene from DNA samples taken from children **10**, **11** and **12**. They cut the gene into fragments using an enzyme. The scientists then used two DNA probes to identify the presence or absence of two of these fragments, called **F** and **G**. This allowed them to find the number of copies of each fragment in the DNA of a single cell from each child.

The table shows their results.

Child	**Number of copies of gene fragment per cell**	
	F	**G**
10 (unaffected girl)	2	1
11 (unaffected girl)	2	2
12 (boy with DMD)	1	0

(i) The number of copies of gene fragments **F** and **G** shows that person **12** has DMD.
Explain how.

(1)

(ii) The number of copies of gene fragments **F** and **G** shows that person **12** is male.
Explain how.

(2)

(iii) The genetic counsellor examined the scientists' results. He concluded that person **10** is a carrier of DMD but her sister, **11**, is not.

Describe and explain the evidence for this in the table.

(*Extra space*)

(3)

(e) Person **12** took part in a trial of a new technique to help people with DMD.

Doctors took muscle cells from person **12**'s father and grew them in tissue culture.

They suspended samples of the cultured cells in salt solution and injected them into a muscle in person **12**'s left leg. They injected an equal volume of salt solution into the corresponding muscle in his right leg. Person **12** was given drugs to suppress his immune system throughout the trial.

Four weeks later, the doctors removed a muscle sample from near the injection site in each leg. They treated these samples with fluorescent antibodies. These antibodies were specific for the polypeptide coded for by gene fragment **G** of the dystrophin gene.

The results are shown in the table.

Location and treatment	Percentage of muscle fibres labelled with antibody
Left leg - injected with cultured cells suspended in salt solution	6.8
Right leg - injected with salt solution	0.0

(i) Why was it necessary to treat person **12** with drugs to suppress his immune system?

_____

_____

(1)

(ii) Explain why salt solution was injected into one leg and cultured cells suspended in salt solution into the other.

_____

_____

_____

(1)

(iii) This technique is at an early stage in its development. The doctors suggested that further investigations need to be carried out to assess its usefulness for treating people with DMD.

Explain why they made this suggestion.

_____

_____

_____

_____

_____

_____

_____

_____

(*Extra space*) _____

_____

_____

_____

(4)

(Total 25 marks)