

OCR A-LEVEL BIOLOGY B • H422

BIOLOGY



EXAM QUESTION PACK

4.1.2 METABOLISM AND EXERCISE

SCORE

/188

PERCENTAGE

%

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1(a) Regular training programmes can improve aerobic fitness and affect skeletal muscle.

Discuss the benefits of improved aerobic fitness and the factors that should be taken into account when designing a regular training programme.

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- (b) Fig. 5, on the Insert, shows a photomicrograph of human skeletal muscle tissue as seen using a light microscope.

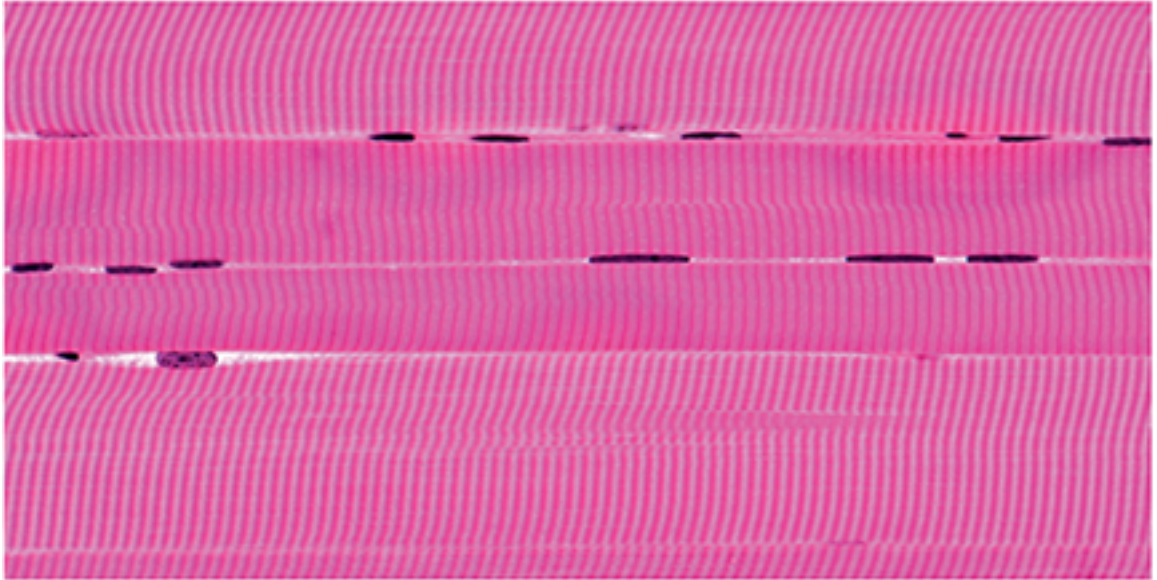


Fig. 5

Using the space below, draw a **labelled** diagram of the tissue shown in Fig. 5 and annotate **two** of the parts you have labelled.



[4]

2(a) Haemoglobin and myoglobin are respiratory pigments.

Complete the table below by placing a tick (✓) in the appropriate boxes to identify which pigment matches each description.

Description	Haemoglobin	Myoglobin
Can bind with four oxygen molecules		
Has higher affinity for oxygen		
Located inside skeletal muscle		

[2]

- (b) Portable haemoglobinometers can be used by patients at home to measure the haemoglobin concentration in their blood.

A haemoglobinometer works as follows:

- The patient drinks a litre of water to ensure they are well-hydrated.
- A small sample of blood is taken by a finger prick technique.
- The blood is put into a container and mixed with a chemical that releases haemoglobin from the red blood cells.
- The container is put into the haemoglobinometer to measure the colour intensity of the solution.
- The results are displayed on the screen of the haemoglobinometer.

- (i) State **one** advantage to the patient of using a portable haemoglobinometer.

----- [1]

- (ii) Suggest **one** reason for measuring haemoglobin concentration in the blood.

----- [1]

- (iii) The patient drinks a litre of water before the test to ensure that they are well-hydrated.

Suggest how hydration levels could affect the validity of the results.

----- [1]

3(a) VO_2 max is an indicator of cardiovascular fitness and a predictor of mortality risk.

(i) Describe what is meant by the term VO_2 max.

----- [1]

(ii) VO_2 max can be estimated from measurements of heart rate.

Suggest **one** advantage of **estimating** VO_2 max over taking a direct measurement.

----- [1]

(b) * A study published in 2004 demonstrated that VO_2 max can be estimated from an individual's maximum heart rate (HR_{max}) and resting heart rate (HR_{rest}), as follows:

$$\text{VO}_2 \text{ max} = 15 \times (\text{HR}_{\text{max}} \div \text{HR}_{\text{rest}})$$

Outline a method to investigate the effect of a fitness training programme on estimated VO_2 max in a group of school students.

Blank lined paper for writing.

- (c) Some athletes train at high altitude prior to participation in a sporting event. High altitude is defined as an elevation greater than 2000 m above sea level.

At high altitude, atmospheric air pressure is lower than at sea level, but the proportion of oxygen in the air remains the same.

- (i) VO_2 max is **immediately** decreased at high altitude. Suggest why.

[2]

- (ii) Air temperature changes at higher altitudes.

Suggest why air temperature can affect VO_2 max.

[1]

- (d) Excess post-exercise oxygen consumption (EPOC) is required for the regeneration of ATP and the replenishment of muscle glycogen stores.

Give **two** other reasons why excess oxygen is required after exercise.

1 -----

2 -----

[2]

- (e) The objective of training, particularly at high altitudes, is to increase the efficiency of oxygen delivery to muscle fibres.

The photomicrographs in Fig. 34, **a** and **b**, show sarcomeres in the relaxed and contracted state.



Fig. 34a

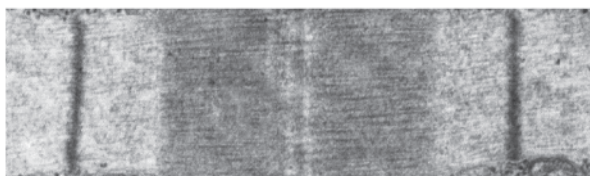


Fig. 34b

State which photomicrograph, **a** or **b**, shows a sarcomere in the relaxed state. Give **two** pieces of evidence to justify your answer.

photomicrograph

evidence 1 -----

evidence 2 -----

[2]

- (f) Table 34 shows some of the events of the sliding filament mechanism of muscle contraction. The events are lettered **A** to **E**.

A	ATP is hydrolysed to ADP and inorganic phosphate by the ATPase activity on the myosin head.
B	The myosin head binds to another myosin binding site on the actin filament.
C	ATP binds to the myosin head, causing the head to detach from the myosin binding site on the actin filament.
D	ADP and inorganic phosphate are released. The myosin head pushes the actin filament towards the centre of the sarcomere.
E	The angle of the myosin head changes into a new (cocked) position.

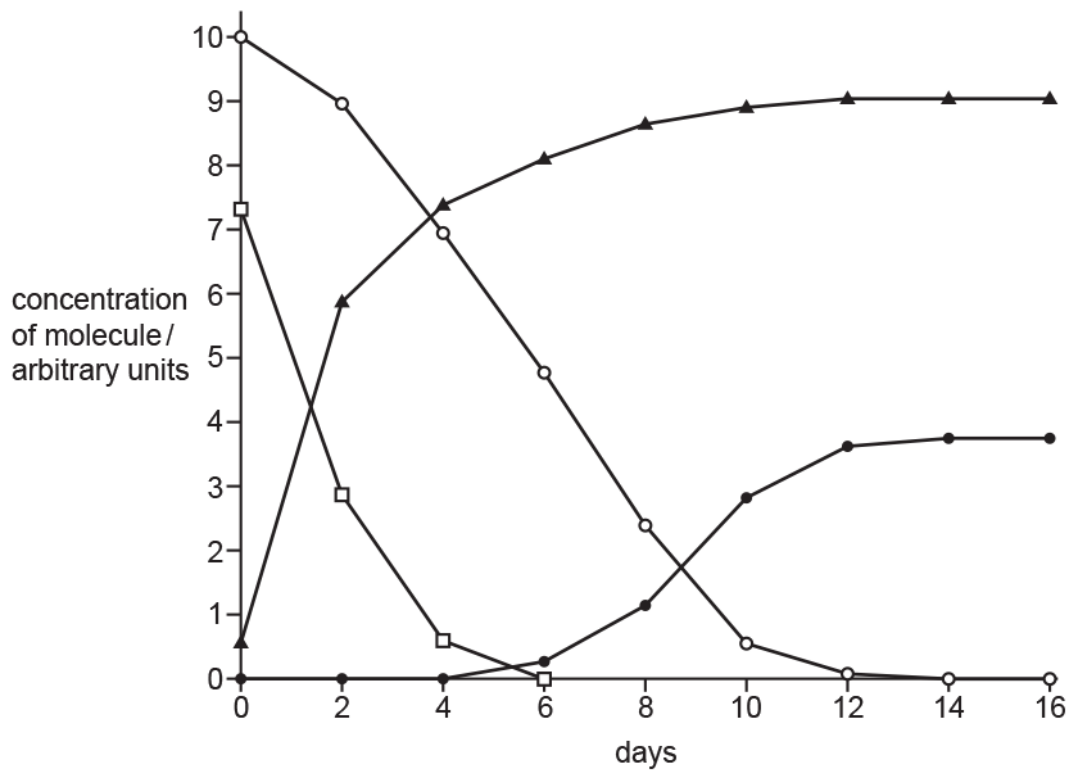
Table 34

Write the letters, **A** to **E**, in the correct order in the spaces below. The first space has been done for you.

.....**C**.....

[2]

- 4 The graph below shows the concentration of several molecules over time in the medium of a cell culture.



Key

- oxygen
- ▲ carbon dioxide
- glucose
- product X

Which of the following statements is/are correct?

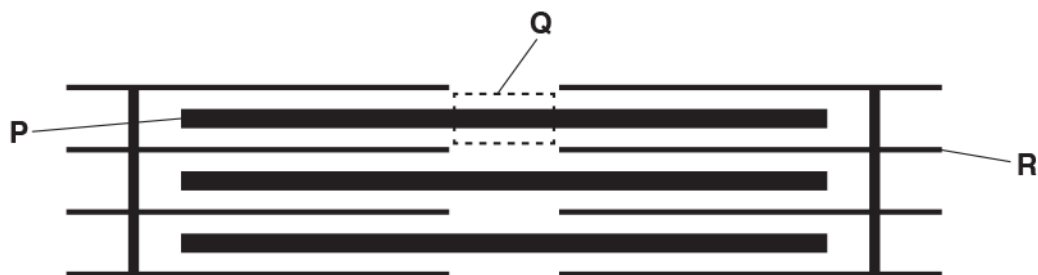
- 1 The culture comprises mammalian cells, **not** yeast cells.
 - 2 The graph shows evidence of aerobic and anaerobic respiration.
 - 3 Product X is generated in the cell cytoplasm.
- A** 1, 2 and 3 are correct
B only 1 and 2 are correct
C only 2 and 3 are correct
D only 1 is correct

Your answer

[1]

5 The diagram below represents the ultrastructure of a single sarcomere in skeletal muscle.

Three features of the sarcomere are labelled P, Q and R.



Here are three statements about the diagram:

- 1 During muscle contraction, R slides along P.
- 2 P is responsive to calcium ions.
- 3 Q is responsive to ATP molecules.

Which of the statements is/are correct?

- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

[1]

6 Which of the options, **A** to **D**, is the long-term effect of aerobic training on VO_2 max and excess post-exercise oxygen consumption (EPOC)?

A decreased VO_2 max and decreased EPOC

B decreased VO_2 max and increased EPOC

C increased VO_2 max and decreased EPOC

D increased VO_2 max and increased EPOC

Your answer

[1]

7 EPO can now be produced using recombinant DNA methods. The product is called rhEPO and has been used by athletes to enhance performance. This 'blood doping' has been banned since the early 1990s and anti-doping agencies have used a combination of blood and urine tests to detect the illicit use of rhEPO.

(i) Suggest how the use of rhEPO can be detected in a blood sample.

----- [2]

(ii) Suggest why it has been difficult to determine the illicit use of rhEPO in the past.

----- [2]

- 8 Patients with chronic anaemia have reduced levels of haemoglobin in their blood. When anaemia develops over a long period of time, the concentration of the compound 2,3-bisphosphoglycerate (2,3- BPG) in the blood increases.

Fig. 6 shows the oxygen dissociation curves of haemoglobin from two individuals, one suffering from chronic anaemia and the other a normal control.

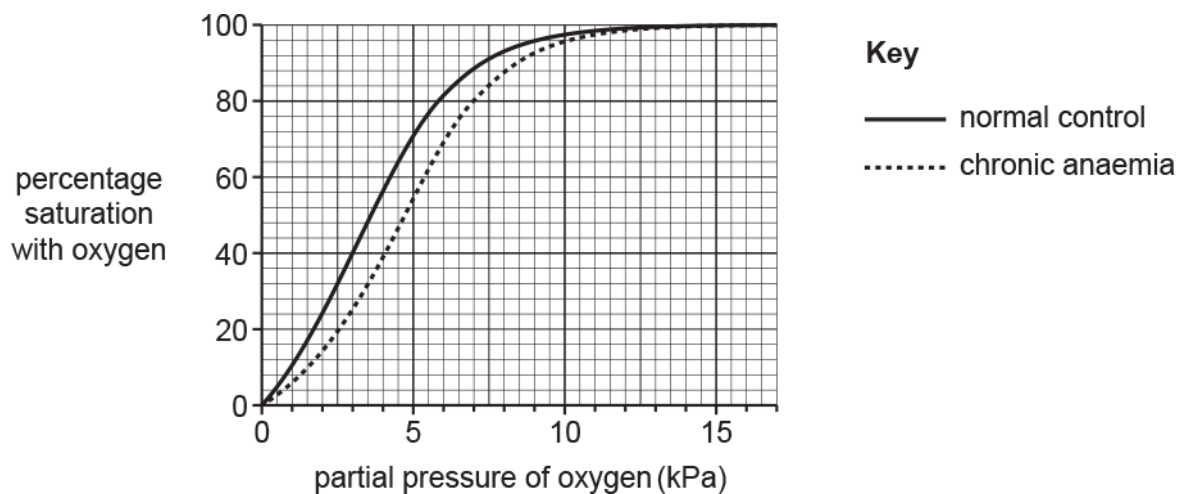


Fig. 6

- (i) P_{50} is the partial pressure of oxygen at which haemoglobin is 50% saturated.

Using Fig. 6, calculate the percentage increase in P_{50} in the anaemic patient compared with the normal control.

Show your working. Give your answer to **three** significant figures.

Answer = _____ % [2]

(ii) Using the data in Fig. 6, describe the effect of 2,3-BPG on the oxygen affinity of haemoglobin.

Explain how this effect might partially compensate for the reduction in levels of haemoglobin that occur in anaemic patients.

[3]

9(a) The recovery time of the heart is a good indicator of aerobic fitness.

A widely-publicised training programme claimed to improve aerobic fitness for various exercises after three months. To evaluate this claim, an investigation was conducted:

- 20 volunteers completed a series of test exercises at increasing intensities
- recovery time was recorded after each exercise
- the volunteers followed the training programme for three months
- after three months, the test exercises and measurements were repeated.

(i) State **two** factors, other than **intensity of exercise**, that must be considered before an exercise is included in a training programme.

1

2

[2]

(ii) Suggest **one** safety precaution that should have been taken before any volunteers took part in the exercises.

[1]

(b) The results of the investigation are shown in Fig. 36.

The columns represent the mean recovery times before and after the training. The error bars represent the standard deviation above and below the mean.

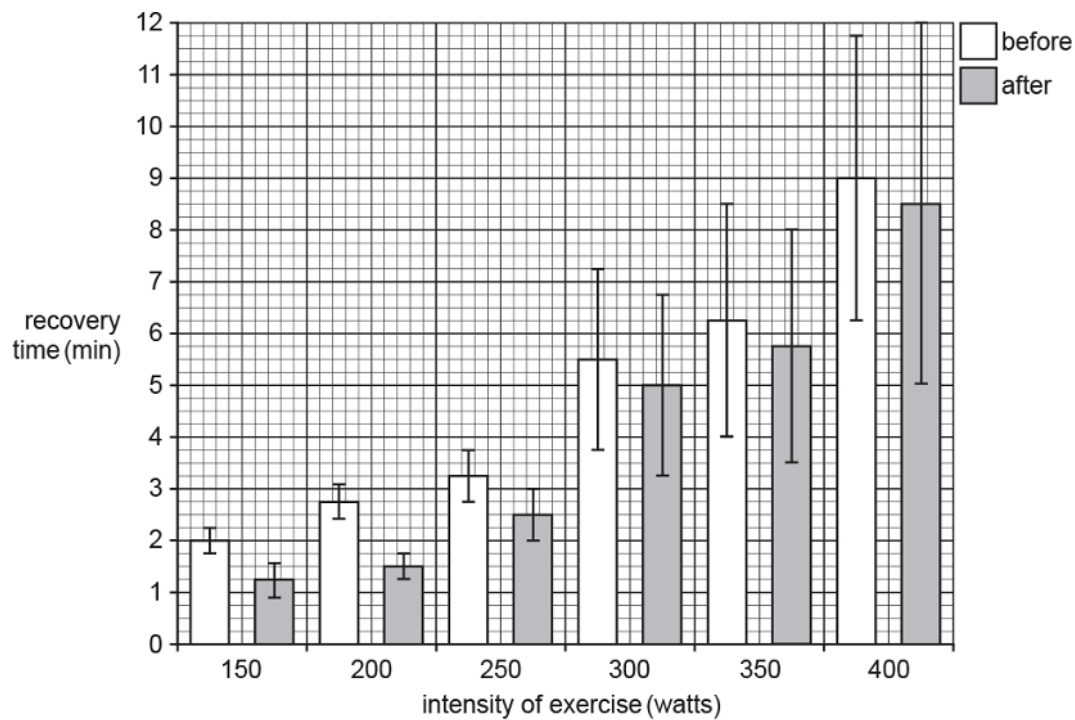


Fig. 36

(i) Name **one** statistical test that could be used to analyse the data in Fig. 36. Justify your choice.

----- [2]

(ii) Comment on how well this training programme improved fitness.

----- [2]

(iii) Promoters of the training programme claimed that it was good for training **weightlifters**. Comment on the **validity** of this statement.

----- [2]

10 ATP is required for the contraction of skeletal muscle.

Which of the options, **A** to **D**, is the result of ATP binding to the myosin head?

- A** attachment of the myosin head to actin
- B** detachment of the myosin head from actin
- C** return of the myosin head to the original (cocked) position
- D** tilting of the myosin head

Your answer

[1]

11 Some chemicals bind directly to haemoglobin.

Which of the options, **A** to **D**, correctly identifies two of these chemicals?

- A** CO_2 and H^+
- B** H^+ and HCO_3^-
- C** HCO_3^- and CO_2
- D** H_2CO_3 and H^+

Your answer

[1]

12(a) Adenosine triphosphate (ATP) is the principal source of energy in biological systems.

Fig. 32.1 is a diagram of the structure of an ATP molecule.

Two components of the molecule are labelled X and Y.

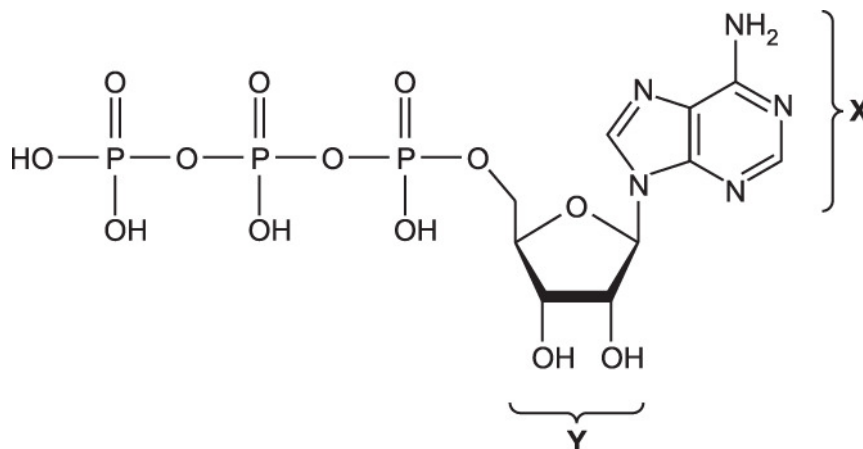


Fig. 32.1

(i) Name the parts of the molecule labelled X and Y in Fig. 32.1.

X

Y

[2]

(ii) With reference to the structure of ATP shown in Fig. 32.1, explain how this molecule provides chemical energy.

.....
.....
.....
.....
.....
.....

[3]

An experiment was conducted to investigate the roles of ATP and Ca^{2+} ions on the contraction of skeletal muscle.

The method was as follows:

1. Prepare four solutions, **A** to **D**
2. Cut frog skeletal muscle to a length of exactly 20 mm
3. Separate muscle into thin strands by cutting parallel to muscle fibres
4. Bathe muscle strands in glycerine (to make the cell membranes more permeable)
5. Place three muscle strands in solution **A** for 1 minute
6. After 1 minute, measure the length of each strand
7. Calculate the mean length of the muscle strands
8. Repeat steps 5-7 for solutions **B** to **D**.

Table 32.1 shows the chemical components that were present (✓) and absent (x) in solutions **A** to **D**.

Solution	ATP	Ca^{2+} ions	EDTA
A	x	✓	x
B	✓	x	x
C	✓	✓	x
D	✓	✓	✓

(iii)

Table 32.1

The results are shown in Fig. 32.2.

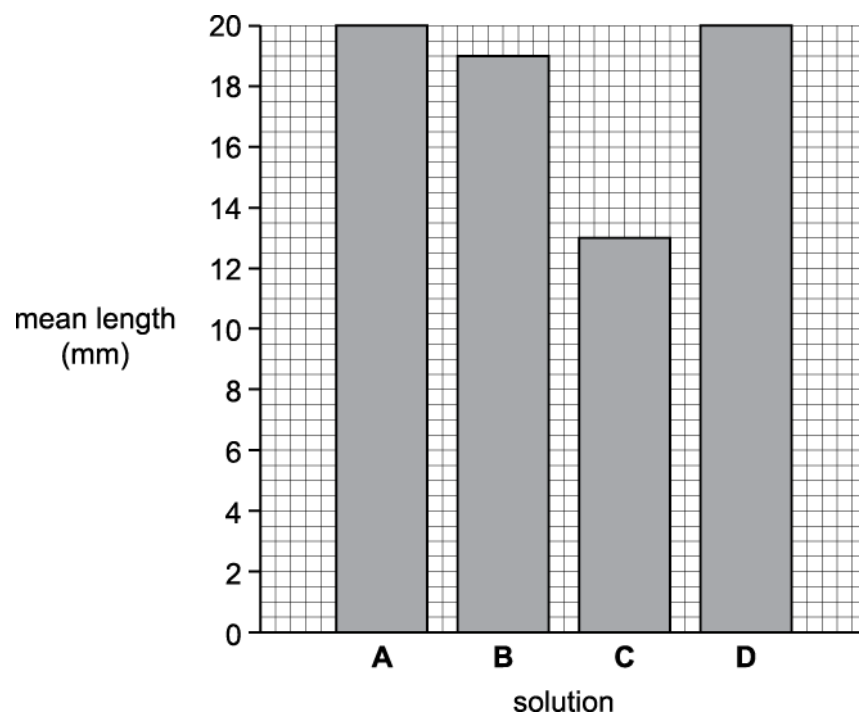


Fig. 32.2

13(a) Aerobic fitness is a measure of how well the body uses oxygen. One way to assess aerobic fitness is to measure or estimate an individual's VO_2max . VO_2max is affected by the ability of an individual to transport and use oxygen.

(i) How is oxygen transported in mammals?

----- [1]

(ii) Table 6.1 shows the VO_2max values for a group of elite endurance event athletes.

Athlete	VO_2max ($\text{cm}^3 \text{ kg}^{-1} \text{ min}^{-1}$)
Male marathon runner	92.0
Male cyclist	92.5
Male cross country skier	91.0
Female marathon runner	73.5
Female marathon runner	71.2
Female marathon runner	67.2

Table 6.1

A student concluded that male athletes had a higher VO_2max than female athletes.

Use the information in Table 6.1 to evaluate this conclusion,

----- [2]

- (c) Aerobic fitness can be measured using the lactate threshold. The lactate threshold is defined as the level of exercise intensity that can be maintained without lactate concentrations in the blood increasing continuously.

The following paragraph describes a method to detect lactate concentrations in blood. The method is similar to that which is used to detect blood glucose concentrations.

Complete the paragraph using the most appropriate terms.

Blood lactate can be detected and measured using a _____. The enzyme lactate dehydrogenase is _____ on a test strip. A drop of blood is added to the test strip and the strip is placed in a machine.

The enzyme converts lactate in the blood sample to pyruvate in the presence of NAD, which acts as a _____. NAD is _____ to NADH. An electrode converts NADH back to NAD, producing a small electrical current. A digital read out of lactate concentration in mmol dm^{-3} is obtained.

[4]

(d) An investigation was carried out to assess the effect of training on aerobic fitness. The dependent variable was blood lactate **concentration** measured after a 1000 m run at a speed of 4 m s^{-1} .

(i) Suggest one continuous independent variable other than exercise intensity that could be investigated.

-----[1]

(ii) Using the axes below, sketch and label the graph you would expect to produce if you increased the variable you identified in part (i).



Fig. 6

----- the answer to this question should be drawn on Fig. 6 -----

[2]

14(a) After the London 2012 Olympic Games, a 'blog' on the UK's Department of Health website stated:

'we must deliver on our promise to create a sustainable and long term health legacy and encourage the nation to get more active, not just in the next few months but for years to come'

(14th August 2012)

There are health benefits associated with taking regular exercise.

One benefit of long term exercise is a decrease in blood cholesterol level.

(i) Why does a reduction in blood cholesterol levels benefit the cardiovascular system?

[2]

(ii) State one benefit of exercise on the **skeletal** system.

[1]

(b) The ability of the body to take in, transport and use oxygen is known as the VO_2 max.

- One consequence of taking regular aerobic exercise is that the VO_2 max increases.
- Some athletes use illegal methods such as taking recombinant erythropoietin to increase their VO_2 max.

(i) State the organelle where aerobic respiration takes place **and** the stage of aerobic respiration that requires oxygen.

Organelle

Stage of aerobic respiration

.....

[2]

(ii) Explain why the use of recombinant erythropoietin increases the VO_2 max.

.....

.....

.....

.....

.....

[2]

15(a) Storage of sperm by cryopreservation is not limited to human sperm samples.

The maintenance of the dairy cow population in the United Kingdom also relies on being able to store semen from bulls. These bulls have been bred to father offspring with a high milk yield. Their semen is used to inseminate cows that have also been bred to produce a high milk yield.

Sperm cells may become damaged during cryopreservation or during the thawing process.

Most of the damage that occurs is due to the disruption of the cell surface membranes or intracellular membranes, such as the nuclear envelope.

In addition to the nuclear envelope, identify two further **intracellular** membranes that may be damaged during the cryopreservation or thawing of sperm cells.

1

2

[2]

- (b) Following cryopreservation and thawing, it is important to be able to assess the viability of the sperm before the sample is used.

Since many samples have to be assessed, techniques have been developed that can be automated.

A technique that can be used is flow cytometry.

- Sperm cells are labelled with two different fluorescent molecules.
- A molecule that fluoresces **green**, labels only **undamaged, viable** sperm.
- A molecule that fluoresces **red**, labels only sperm with **membrane damage**.
- Samples containing approximately 10 000 sperm cells are analysed in a flow cytometer.
- The flow cytometer counts the numbers of green and red cells.

Semen from six different bulls was stored using cryopreservation and then thawed.

The thawed semen was analysed using the technique described above.

Table 6.1 on page 17 shows the results obtained.

Results:

Semen sample	Sperm fluorescing green		Sperm fluorescing red	
	Mean percentage	Standard deviation	Mean percentage	Standard deviation
1	47.6	2.5	49.3	2.6
2	56.0	1.2	37.0	1.5
3	47.3	1.5	48.7	1.7
4	50.4	1.1	45.5	1.2
5	52.8	2.7	40.9	2.9
6	47.7	2.8	49.2	2.8

Table 6.1

- (i) Using the information in Table 6.1, describe the effect of cryopreservation on the viability of the sperm in the semen samples.

[2]

- (ii) The standard deviation is a measure of the spread of data around the calculated mean.

The investigators concluded that there was no significant difference between the numbers of red fluorescing sperm cells in semen samples 2 and 5.

Does the evidence in Table 6.1 support this conclusion?

Explain your answer.

[1]

- 16 Fats can only be used as a respiratory substrate if conditions within the muscles remain aerobic **and** if some carbohydrate is available.

This is often summarised by fitness trainers in the saying:

‘Fats burn in a carbohydrate flame’.

- (i) Suggest why fats can only be broken down in aerobic respiration.

----- [2]

- (ii) Name the carbohydrate compound stored in muscle cells and briefly describe one method used by athletes to increase this store.

carbohydrate compound -----

method -----

----- [3]

17(a) The contraction and relaxation of human muscles relies on interactions between different proteins within muscle cells.

In skeletal muscles, the proteins are arranged in bundles known as **myofibrils**.

Fig. 4.1 shows simplified diagrams of some of the proteins present in muscle myofibrils.

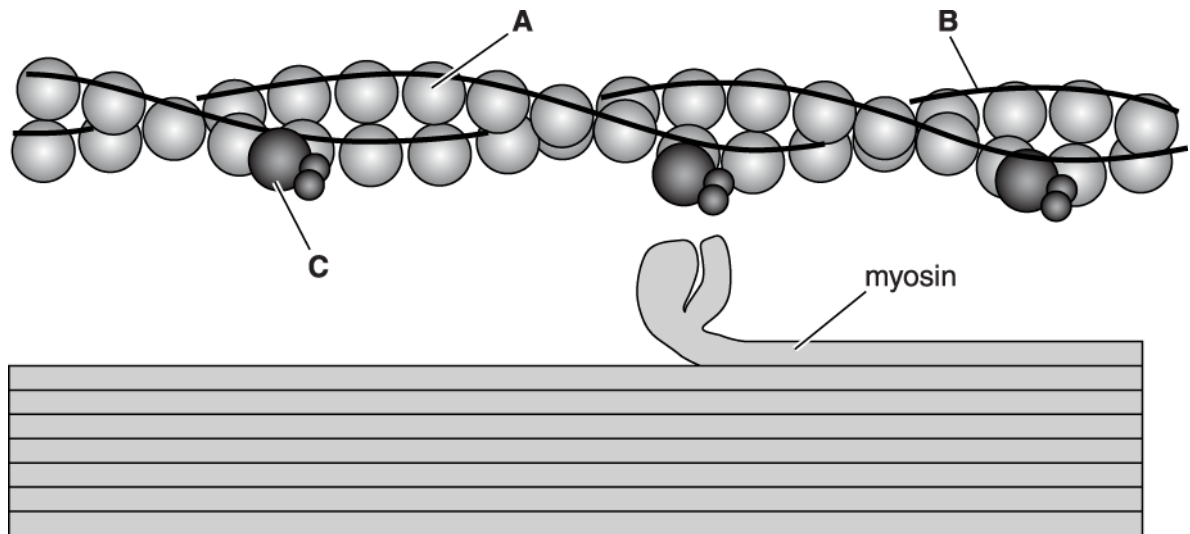


Fig. 4.1

Using the letters A, B or C, identify the following proteins on Fig. 4.1.

tropomyosin _____

troponin _____

[2]

- (b) The proteins in skeletal muscle myofibrils are arranged in groups to form a repeating pattern. As the muscle contracts, the pattern changes.

Describe how the **pattern** within a myofibril changes when skeletal muscle contracts.



In your answer, you should use the appropriate technical terms spelled correctly.

[3]

- (c) The role of dystrophin is to protect the membranes such as the sarcoplasmic reticulum from damage during muscle contraction.

The sarcoplasmic reticulum stores calcium ions in the relaxed muscle cells.

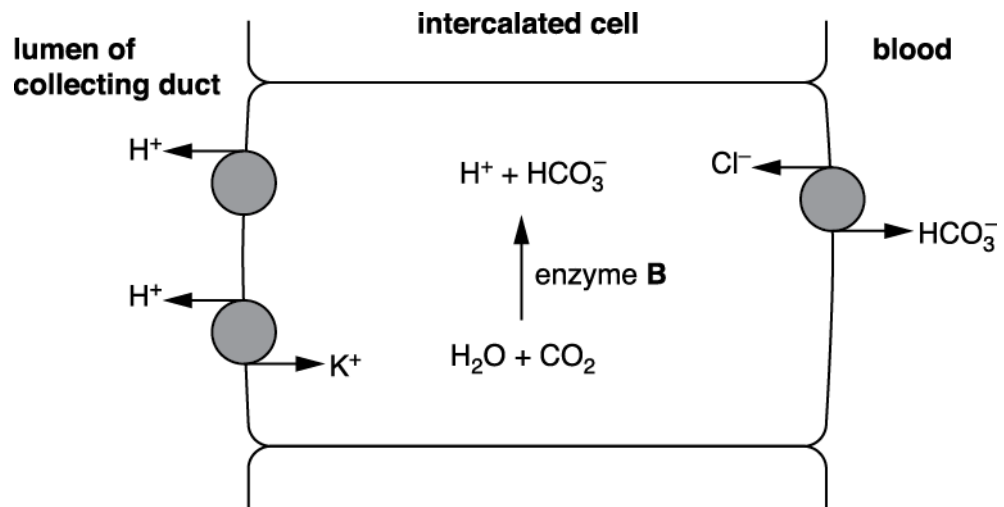
An early sign of **DMD** in muscles is a delay in muscle relaxation following a contraction.

Suggest why muscle cells fail to relax following a contraction if dystrophin is not functioning correctly or is absent.

[2]

- 18 Intercalated cells are specialised cells located in the walls of collecting ducts in the kidney. One function of intercalated cells is the regulation of the pH of blood plasma.

This figure is a diagram of an intercalated cell showing some of the mechanisms involved in the regulation of pH by the kidney.



- (i) Name the enzyme labelled **B** in the figure that catalyses the reaction shown.

-----[1]

- (ii) Using the information in the figure, suggest why intercalated cells contain large numbers of mitochondria.

-----[1]

- (iii) Identify **one other** organ system in the body that is responsible for controlling the pH of blood.

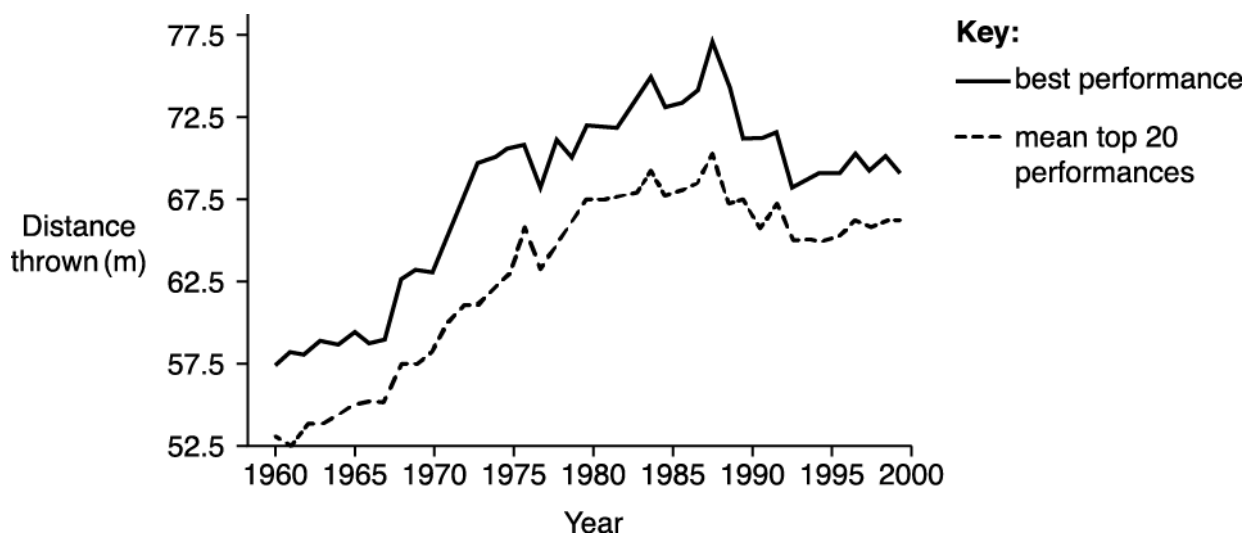
-----[1]

- 19 Anabolic steroids, such as testosterone, are steroid hormones. Steroid hormones have a chemical structure similar to that of cholesterol.

Selected athletes are tested for drugs during sports competitions.

'Out-of-competition' drug testing, introduced in the late 1980s, is carried out randomly on all athletes. It is believed that steroid use declined at about the same time as out-of-competition drug testing was introduced.

The figure shows the changes in performance in another Olympic throwing event, the women's discus, from 1960 to 2000.



A student stated the following:

"Previous improvements in performance before the introduction of out-of-competition drug testing must have been due to the illegal use of steroids."

Evaluate whether the evidence shown in the figure supports the student's conclusion.

[2]

20(a) Fig. 5.1 shows VO_2 max for a number of different mammals.

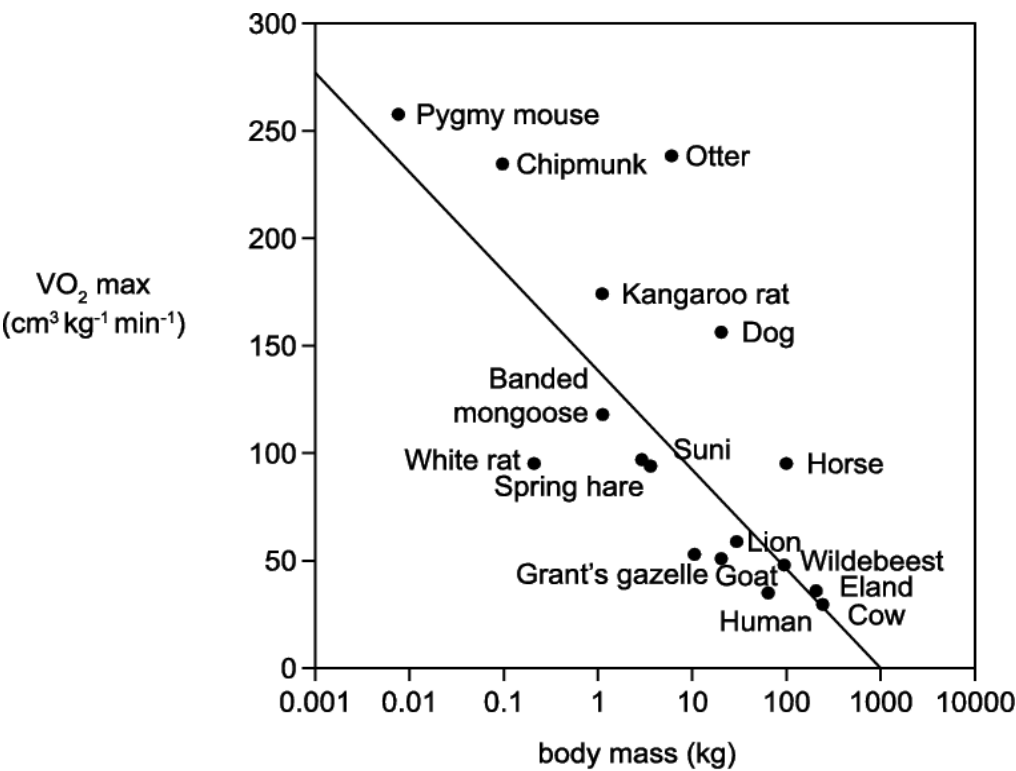


Fig. 5.1

(i) Describe the trend in the data shown in Fig. 5.1.

[1]

(ii) One point in the data, shown in Fig. 5.1, does not fit the trend.
Name the mammal.

Mammal

The data for this mammal is accurate. Suggest **one** reason why the VO_2 max for this mammal does not fit the trend.

(iii) Suggest why a logarithmic scale has been used on the x-axis of the graph in Fig. 5.1.

- (b) Higher VO_2 max is associated with better race performance. An athlete has a VO_2 max of $38 \text{ cm}^3 \text{ kg}^{-1} \text{ min}^{-1}$. The athlete's trainer suggests experimenting with carbohydrate-loading to find out if carbohydrate-loading improves VO_2 max.

During the experiment, the athlete raced once a week and each time the VO_2 max was measured. For the first 8 weeks, the athlete ate a normal diet. For weeks 9 to 20, the athlete followed a carbohydrate-loading diet plan.

The athlete's VO_2 max was measured every week during the investigation.

The results are shown in Table 5.1.

Week	Treatment	VO_2 max ($\text{cm}^3 \text{ kg}^{-1} \text{ min}^{-1}$)
1	Normal diet	38
2		37
3		37
4		39
5		41
6		41
7		40
8		38
	Mean VO_2 max ($\text{cm}^3 \text{ kg}^{-1} \text{ min}^{-1}$)	39
9	Carbohydrate-loading	39
10		40
11		39
12		42
13		43
14		39
15		44
16		40
17		40
18		41

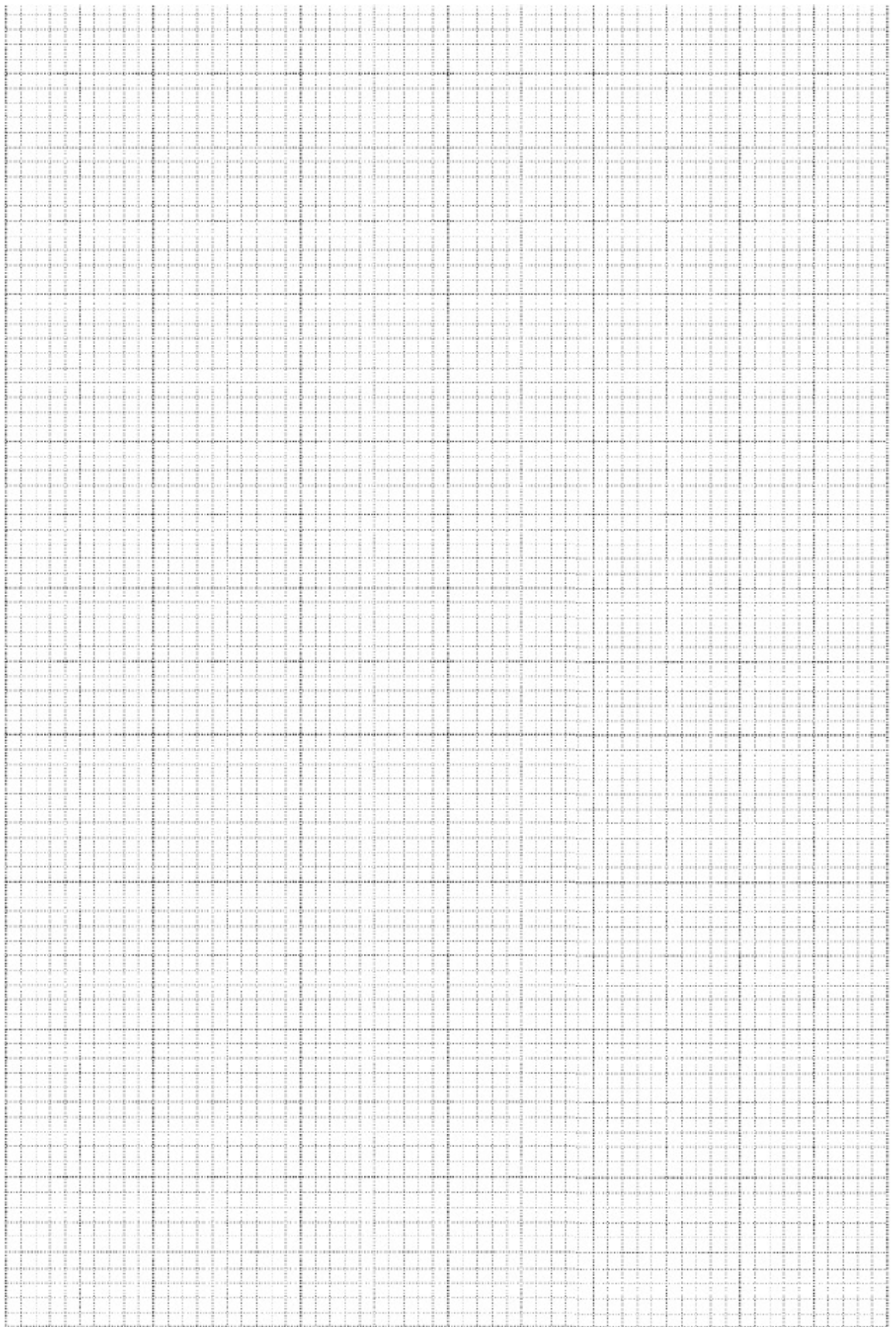
19		43
20		42
	Mean VO ₂ max (cm ³ kg ⁻¹ min ⁻¹)	41

Table 5.1

- (i) Plot a graph, on the grid provided, to show the mean values of the data shown in Table 5.1 in the most appropriate way.

Add **range bars** to show the highest and lowest VO₂ max values in each of the two treatments.

[4]



21(a) An electrocardiogram (ECG) trace represents the electrical changes that occur in heart muscle during the cardiac cycle. Electrical changes occur as a result of depolarisation and repolarisation of cardiac muscle cells.

Fig. 5.1 shows the electrical changes that occur in a normal cardiac cycle.

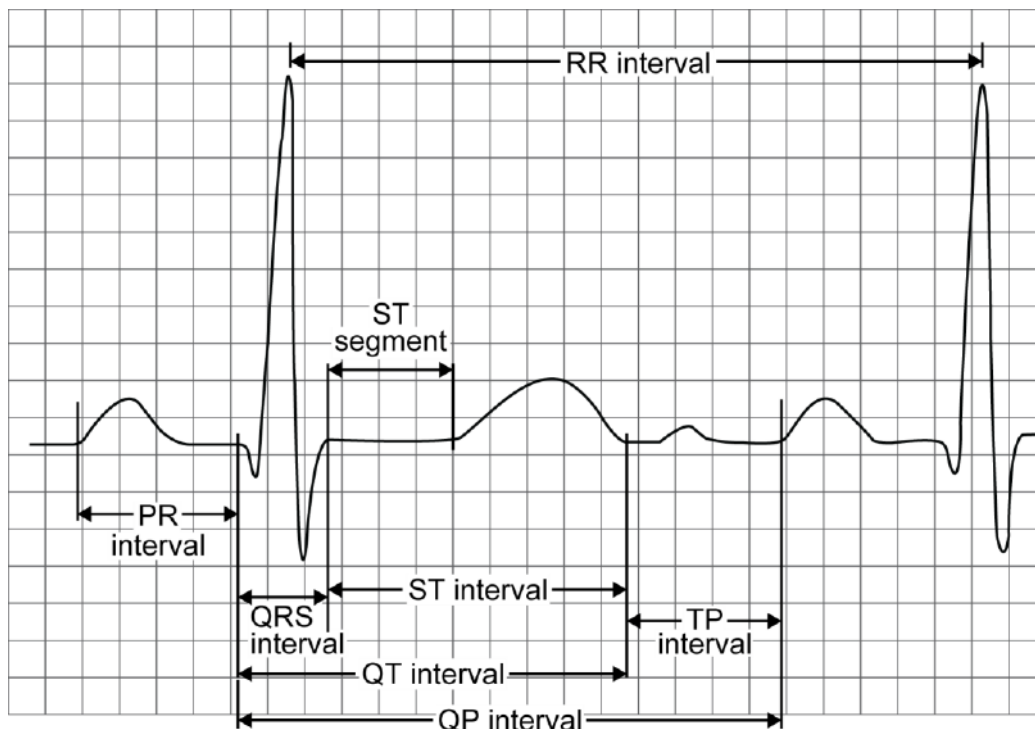


Fig. 5.1

The subject from whom the ECG trace in Fig. 5.1 was obtained had a resting heart rate of 65 bpm.

Calculate the duration of the **RR** interval. Give your answer to **three** significant figures.

Answer = _____ ms [2]

(b) Using the information in Fig. 5.1, identify which of the intervals or segments shown correspond to the following descriptions:

(i) The time taken to conduct the cardiac impulse through the AV node.

-----[1]

(ii) The time taken for ventricular depolarisation and repolarisation.

-----[1]

(iii) The time taken for ventricular diastole.

-----[2]

(iv) Two intervals which decrease during exercise.

-----[2]

(v) Will be elevated during or after a heart attack.

-----[1]

Many people in Tibet live more than 4 000 m above sea level, but they do not develop altitude sickness.

Tibetan people have a variant of the EPAS1 gene that causes them to maintain relatively low haemoglobin levels in their blood.

(i) Describe how the Tibetan variant of the EPAS1 gene has become common in Tibetan populations.

[4]

(ii) What type of adaptation is represented by the maintenance of low haemoglobin levels in Tibetan people?

(iii) State and explain **one** problem that a Tibetan person with the EPAS1 gene variant might experience.

[2]

(iv) Suggest a practical technique that could be used to compare the relative number of erythrocytes in a Tibetan population with that of another population **and** state what this technique would show.

[2]

(b) Fig. 2.1 shows oxygen dissociation curves for both haemoglobin and myoglobin.

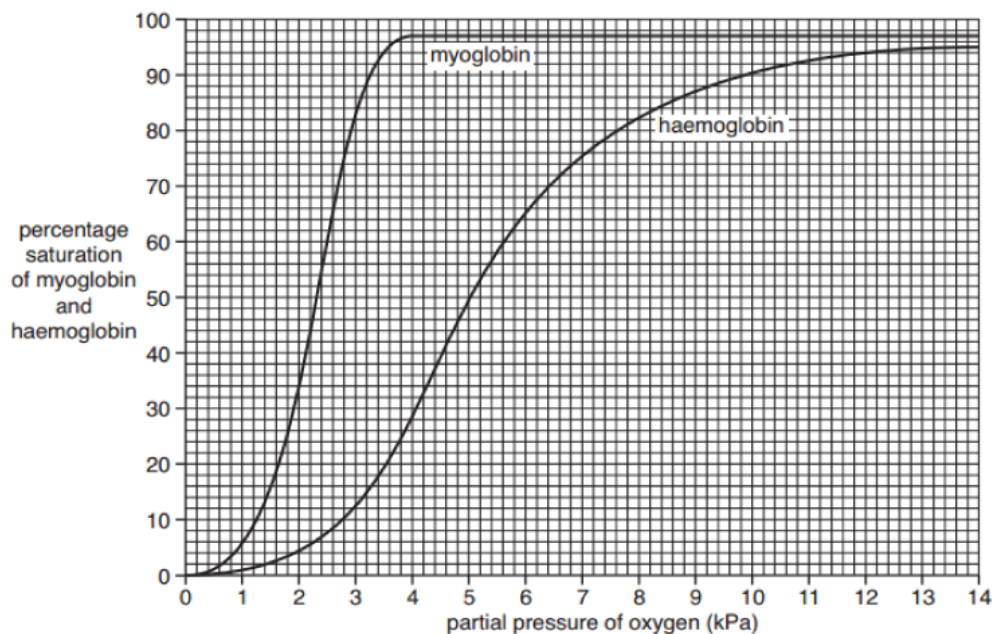


Fig. 2.1

The saturation of haemoglobin with oxygen increases as the partial pressure of oxygen is increased.

- (i) Use Fig. 2.1 to calculate the fastest rate of change in haemoglobin saturation as oxygen partial pressure increases. Determine the units for your answer.

answer _____ units _____ [3]

- (ii) Suggest where in the body a partial pressure of oxygen of 13 kPa would be found.

_____ [1]

- (iii) On Fig. 2.1, sketch the oxygen dissociation curve for human fetal haemoglobin.

_____ [1]

- (iv) Explain the biological significance of the different oxygen dissociation curves of myoglobin and adult haemoglobin.

 _____ [2]

23(a) This question is based on the Advanced Notice article **MYOKINES**, which is an insert.

IL-6 is produced by muscle cells in response to physical exercise.

(i) Using the data in **Table 1.1**, determine the mode and mean IL-6 increase after a 1.5 hour cycle ride.

Determine the mode to **one** significant figure and the mean to **three** significant figures.

mode _____ mean _____

[3]

(ii) Based on the data in **Table 1.1**, how valid are the following conclusions?

The duration of exercise affects IL-6 concentration in blood.

Running has a greater influence than cycling on IL-6 concentrations.

[4]

(b)

- (i) Suggest how IL-6 increases the uptake of glucose from the blood plasma to muscle cells **and** how it increases glucose production in the liver.

----- [3]

- (ii) * *"IL-6 increases the risk of type 2 diabetes."*

Evaluate the evidence that supports or contradicts the above statement.

Use information from the article **MYOKINES**.

----- [6]

(c) Studies F and H in **Table 1.2** both used knockout mice.

(i) Outline **one** way in which a gene can be inactivated in the knockout procedure.

----- [1]

(ii) Suggest **one** reason why mice are used as the model organism in the knockout procedure.

----- [1]

(d) Cytokines produced in muscles are called myokines. IL-6 is an example of a myokine.

Cytokines can act as chemical signals between immune cells.

Describe **one** specific role of cytokines in the immune system.

----- [2]

24 The statements below relate to biological characteristics of the respiratory pigments.

Which of the following statements is / are correct?

Statement 1: At any partial pressure of oxygen, myoglobin has a lower oxygen saturation level than adult haemoglobin.

Statement 2: The oxygen dissociation curves for fetal and adult haemoglobin are sigmoidal due to the cooperative binding of oxygen.

Statement 3: Haemoglobin releases oxygen more readily at low pH.

- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

☐

[1]

The part of the trace labelled T represents the repolarisation of the ventricles. Until this has happened, it is not possible for another heartbeat to occur.

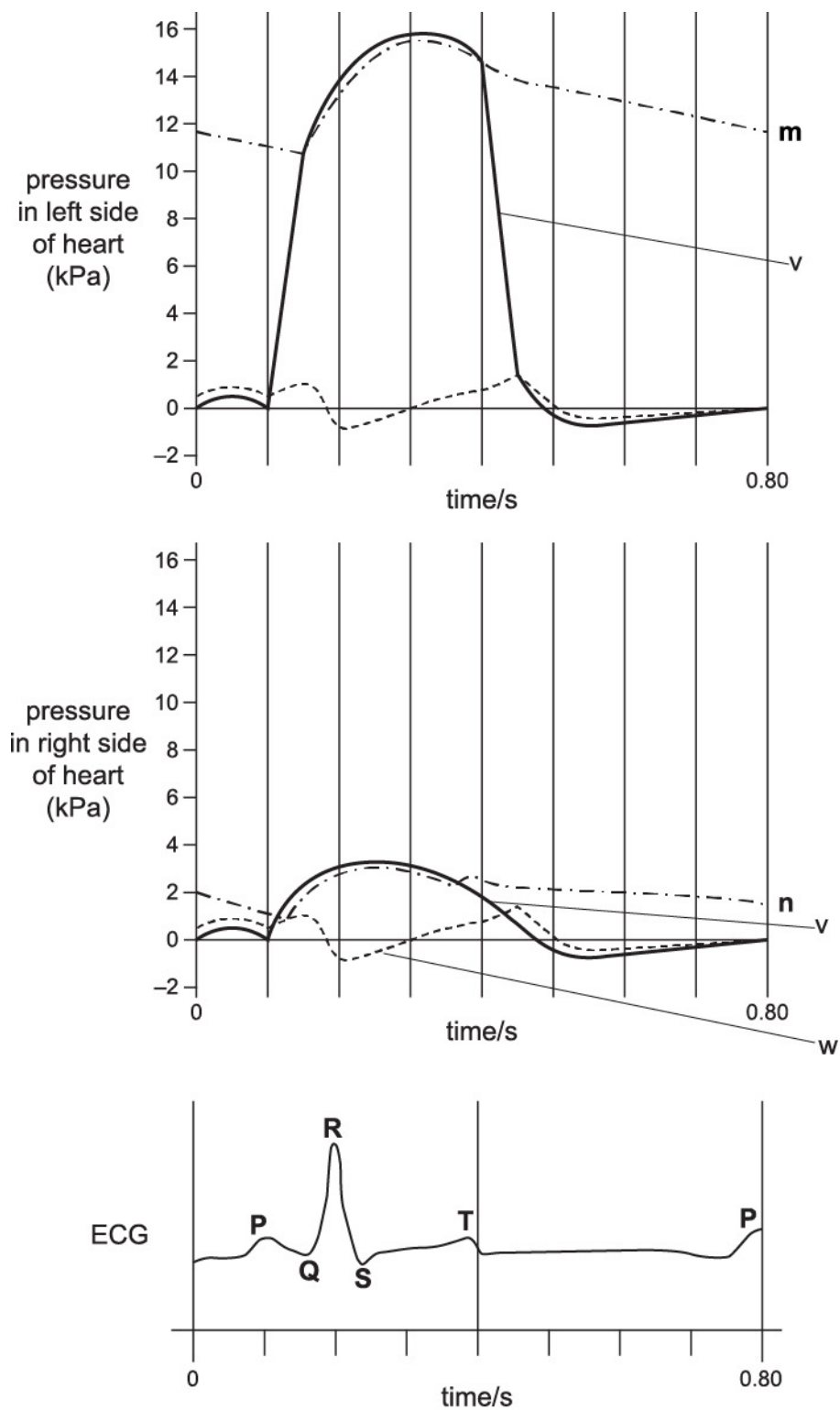


Fig. 37.1

- (i) As the heart rate increases, what happens to the time between the T wave and the P wave which signals the start of the next heartbeat?

----- [1]

- (ii) It can be dangerous in some circumstances to exercise at a level where the heart rate approaches its maximum possible.

Using the information in Fig. 37.1, calculate the maximum heart rate possible for the person from whom this trace was obtained.

Maximum heart rate ----- [2]

- (i) The enzyme lactate dehydrogenase (LDH) catalyses pathway C. When the blood supply to any tissue is limited, LDH concentrations increase in cells.

Explain why LDH concentrations in cells increase when the blood supply to tissues is limited.

----- [2]

- (ii) A heart attack occurs when blood vessels supplying the cardiac muscle become narrowed or blocked. This can lead to the death of cardiac muscle cells.

One indicator that a heart attack has occurred is a rise in concentrations of LDH in **blood plasma**.

Suggest why the death of cardiac muscle cells results in a rise in LDH concentrations in blood plasma.

----- [2]

- (b) Plasma LDH concentrations were used to diagnose and monitor heart attacks.

The concentration of other molecules within the plasma is now more commonly used. One of these molecules is cardiac troponin (troponin T).

- (i) Describe the role of troponin T in cardiac muscle **cells** during diastole.

----- [2]

- (ii) **Table 33.1** shows the results from an investigation comparing troponin T plasma concentrations in three different groups.

Group	Number	Concentration of plasma troponin T ($\mu\text{g dm}^{-3}$)
-------	--------	--

	of subjects	Median	Interquartile range
Normal subjects	100	0.20	0.16–0.30
Subjects where a heart attack was confirmed using an ECG	72	15.30	9.60–22.70
Subjects with other injuries but no heart attack occurred as confirmed using an ECG	13	0.29	0.23–0.43

Table 33.1

Evaluate the evidence that the use of troponin T concentration in plasma is a useful diagnostic test to confirm a heart attack.

You should use information from **Table 33.1** to support your argument.

[3]

27 Students prepared a section of muscle tissue and added drops of ATP solution to the tissue.

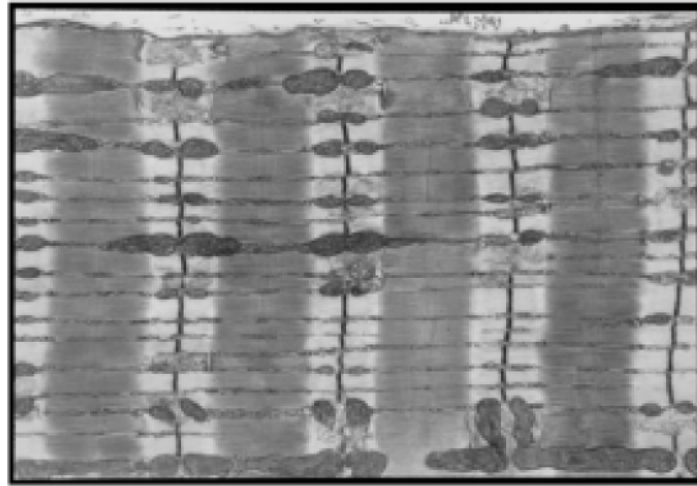


Fig. 17.1

Magnification = $\times 16800$

The students observed changes in the muscle tissue.

What would happen to the length of the sarcomere?

- A no change
- B shortens
- C lengthens
- D disappears

Your answer ☐

[1]

28 Sections of muscle tissue can be prepared and studied under a microscope.

A magnified section of muscle tissue is shown below in Fig. 17.1.

What is the approximate length of a sarcomere?

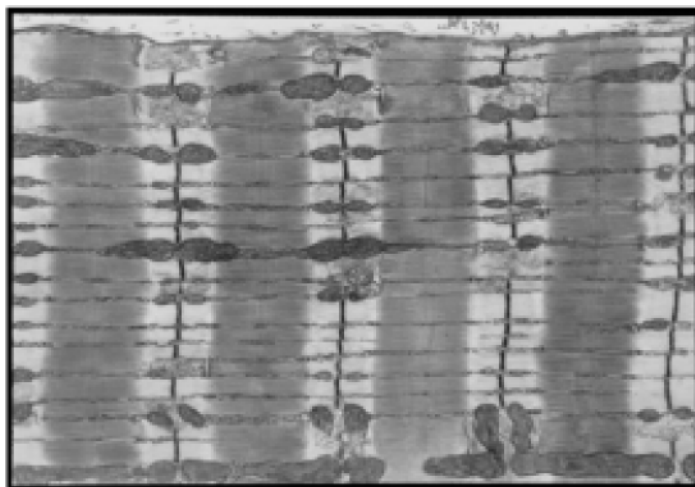


Fig. 17.1

Magnification = $\times 16800$

- A 1.5×10^{-5} m
- B 1.5×10^{-6} m
- C 1.25×10^{-5} m
- D 1.25×10^{-6} m

Your answer

[1]

29 Fig. 2.1 below is an electron micrograph showing the ultrastructure of skeletal muscle.

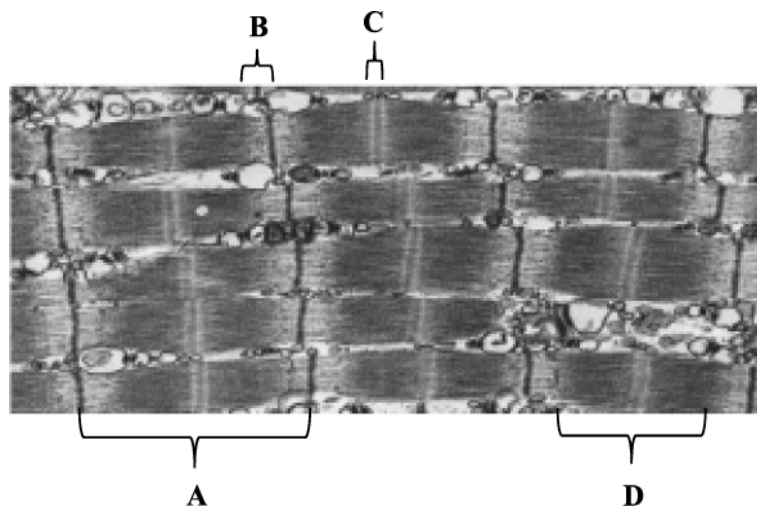


Fig. 2.1

Which of the areas labelled A–D represents the A-band?

Your answer

[1]

(i) All three types of muscle in a mammal's body contribute to the 'fight or flight' response.

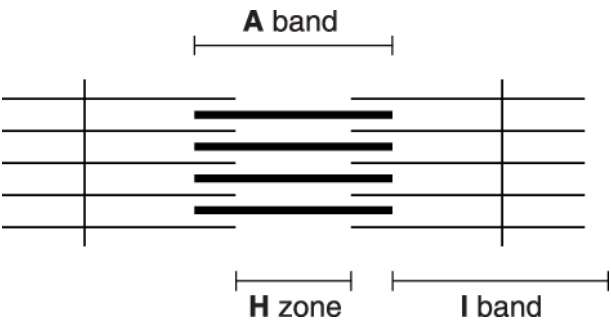
Complete the table below by filling in the blank boxes.

Organ	Type of muscle	Action of muscle in fight or flight response
heart		increases pulse rate
leg muscle		
arteriole to liver	smooth	

[3]

(ii) Muscles in a mammal's leg are made up of units.

The figure is a diagram of one unit.



The thick lines in the A band represent a protein.

Name this protein.

-----[1]

END OF QUESTION PAPER

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
1	a	<i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i> <i>In summary:</i> <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)</i> <i>Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in italics):</i> ◦ <i>award the higher mark where the Communication Statement has been met.</i> ◦ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> • <i>The science content determines the level.</i> • <i>The Communication Statement determines the mark within a level.</i> Level 3 (5–6 marks) Detailed discussion that includes wide range of benefits of improved aerobic fitness AND addresses most F.I.T.T. factors AND several other factors. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Discussion that includes some benefits of improved aerobic fitness AND EITHER at some F.I.T.T. factors OR other factors. <i>There is a line of reasoning presented with some structure. The information presented is mostly relevant and supported by some</i>	6(AO1.2) (AO3.3)	Indicative marking points e.g. Benefits of aerobic fitness: • increased stroke volume • increased VO2 max • decreased resting HR • increased capillary density in lungs and surrounding skeletal muscles • increased efficiency in lipid metabolism • increased glycogen stores in skeletal muscles • increase in number and size of mitochondria in muscle fibres • strengthening skeletal muscles • improving efficiency of circulatory system • reducing blood pressure • improving mental health e.g. reducing stress / lowering the incidence of depression • reducing risk of diabetes • reducing risk of osteoporosis 'FITT' FACTORS to be taken into account • frequency of exercise • intensity of exercise • time (duration) of exercise • type of exercise Other factors to take into account • Pre-existing medical conditions • Age • Previous level of fitness

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			<i>evidence.</i> Level 1 (1–2 marks) Brief discussion to include at least one benefit of improved aerobic fitness AND EITHER at least one of the F.I.T.T. factor OR at least one other factor. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit</i>		

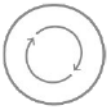
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		accurate representation of the tissue in the micrograph drawn ✓ drawing made with clear continuous lines AND no shading AND label lines horizontal without arrow heads touching observable structures ✓ two observable structures of the tissue labelled correctly ✓ e.g. • muscle fibre • detail of sarcomere e.g. A band / I band / Z line • (myocyte) nucleus • capillary two of the labelled structures annotated ✓ e.g. • muscle fibre - multi nucleate / contains numerous myofibrils • A band / dark band - contains actin and myosin • I band / light band - contains only actin • Z line – marks length of a sarcomere / junction of actin filaments • nucleus - controls activity of myocyte / contains genetic material of the myocyte • capillary – delivers nutrients to myocytes / removes lactic acid from myocyte	4(AO2.3)	ALLOW error carried forward for correct annotations if structures labelled incorrectly
			Total	10	

Mark Scheme

Question			Answer/Indicative content			Marks	Guidance
2	a		Description	Haemoglobin	Myoglobin	2(AO1.1)	3 correct = 2 marks 2 correct = 1 mark 1 correct = 0 mark
			Can bind with up to four oxygen molecules	✓			
			Has highest affinity for oxygen		✓		
			Located inside skeletal muscle		✓		
	b	i	minimal disruption to lifestyle / AW ✓ fast results ✓ small volume of blood for sample ✓			1max(AO 3.2)	IGNORE can be 'carried out at home' or 'used by patient themselves' or 'easy to carry' (as given in the question)
		ii	monitor / AW, blood disorder / named blood disorder ✓ determine the severity of, blood disorder / named blood disorder ✓ monitor / AW, response to treatment ✓ monitor suitability / AW, to become a blood donor ✓			1max(AO 1.2)	e.g. 'monitor anaemia'
		iii	low hydration levels increases concentration of solutes in plasma, leading to artificially high results / AW ✓			1(AO3.2)	
			Total			5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
3	a	i	<u>volume</u> of oxygen, used / utilised / consumed, (at maximal physical exertion), per minute / hour / any time period ✓ OR maximum <u>rate</u> of oxygen, use / utilisation / consumption, (during exercise) ✓	max 1 AO1.1	DO NOT ALLOW volume of oxygen inspired Examiner's Comments Many candidates gave vague definitions of VO_2 max such as the maximum amount of oxygen used.  AfL It is important that candidates realise that measurements of VO_2 max must be made per unit of time. It can therefore be described as the maximum rate of oxygen use OR the volume of oxygen taken up per minute/hour.
		ii	cheaper than/no need for, specialist equipment ✓ does not require training / can be carried out by non-experts ✓ non-invasive so safer / reduced risk ✓	max 1 AO2.1	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	b	Summary of instructions to markers: <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in italics):</i> ◦ <i>award the higher mark where the Communication Statement has been met.</i> ◦ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> • The science content determines the level. • The Communication Statement determines the mark within a level. Level 3 (5 – 6 marks) An outline of an appropriate method with consideration of exercise type and details of how measurements could be taken. There is reference to measures to increase the validity of the data. Detailed data analysis. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3 – 4 marks) An outline of an appropriate method with consideration of exercise type OR details of how measurements could be taken. There is reference to increasing the validity of the data. Data analysis is discussed. <i>There is a line of reasoning presented with some structure. The information presented</i>	6 AO3.3 3.4	Indicative scientific points may include: method • independent variables (exercise intensity/duration/type) and dependent variable (heart rate) • description of exercise type, e.g. treadmill • description of fitness programme • take baseline measurement • use of heart rate monitor or pulse taking • ref to control group validity • reduce other variables, e.g. age, gender, smoking status, health status • ref to repeat measurements • ref to sample size • exclusion of individuals with health conditions, e.g. hypertension, asthma • risk / health assessment data analysis/presentation • calculation of mean and standard deviation from repeat measurements • calculation of percentage change in VO₂ max or paired <i>t</i>-test <u>Examiner's Comments</u> This proved to be quite a challenging question as there are several elements to a good response. There are various aspects to the method including; how measurements of pulse rate are taken, the type of exercise undertaken before maximum heart rate is measured and details of the fitness programme. Some candidates only gave details of how to measure VO₂ max and did not mention a fitness programme. The best answers also mentioned several ways to increase the validity of the investigation and details of how the data would be analysed to test significance.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			<i>is in the most-part relevant and supported by some evidence.</i> Level 1 (1 – 2 marks) A limited outline of a method OR details of how measurements could be taken are included. There is some reference to increasing validity OR data analysis. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.		
	c	i	pO_2 / partial pressure of oxygen, reduced ✓ lower oxygen saturation of haemoglobin ✓	2 AO2.5	ALLOW hb for haemoglobin <u>Examiner's Comments</u> Only few candidates referred to the term partial pressure of oxygen. Candidates could have scored better marks if they referred to the labels on the haemoglobin dissociation graph.  Misconception There was confusion among some candidates who suggested that high altitude resulted in a lower affinity for oxygen whereas the affinity is unchanged at high altitudes but there is a lower partial pressure, so the haemoglobin is less saturated.  OCR support Topic exploration packs on oxygen dissociation curves can be downloaded from the following website: https://www.ocr.org.uk/Images/304428-oxygen-dissociation-curves.doc

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	influences, affinity / binding, of oxygen to haem groups ✓	1 AO2.5	ALLOW example, e.g. heat breaks bonds between oxygen and haem groups, or ref to disruption of secondary and tertiary structure of haemoglobin <u>Examiner's Comments</u> Most candidates mentioned ideas around temperature affecting the kinetic energy of molecules. Only a few candidates identified that high temperatures would affect the binding of oxygen to the haemoglobin.
	d		re-oxygenation of, haemoglobin / myoglobin ✓ balancing / replenishing, hormones ✓ cell repair ✓ converting lactate to, pyruvate / glucose ✓ regenerating ATP ✓ meeting demands of increased metabolism from thermogenesis of brown fat tissue ✓	max 2 AO1.2	ACCEPT replenishing glycogen <u>Examiner's Comments</u> In general, this question was well answered. Some candidates lost marks through lack of detail. For example, to aid the breakdown of lactic acid was insufficient whereas to convert lactate to pyruvate would be credited.
	e		(34)b wider H zone ✓ wider, isotropic / I, band ✓ longer sarcomere ✓	2 AO3.2	ACCEPT Z lines further apart / greater distance between M and Z lines
	f		C.....A.....E.....B.....D..... ✓✓	2 AO1.2	any 2 correct = 1 mark
			Total	17	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
4			C	1 AO2.8	<u>Examiner's Comments</u> Most candidates recognised that both aerobic and anaerobic respiration were taking place, since very few candidates selected option D. Product X is produced only when oxygen levels are practically zero and thus must be a product of anaerobic respiration which takes place in the cytoplasm. Carbon dioxide is not produced as a product of anaerobic respiration in mammals and it is shown here as still increasing, thus option C is correct.
			Total	1	
5			A	1	<u>Examiner's Comments</u> This proved to be a challenging question with a small proportion of candidates selecting the correct answer. The most common response was option B suggesting that candidates didn't recognise Q as an area where there would be overlap between actin and myosin during muscle contraction. It would therefore need to be responsive to ATP molecules.
			Total	1	
6			C	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7		i	measure number of, red blood cells / RBCs / erythrocytes ✓ high number of RBCs indicates use of rhEPO ✓ use of (fluorescent) antibodies to detect rhEPO ✓	2 max	ALLOW use flow cytometry ALLOW use of ELISA / immunoassay, to detect rhEPO <u>Examiner's Comments</u> This was well answered with many candidates stating the use of haemocytometers for counting red blood cells. A number of candidates thought that the presence of rhEPO could be detected by the presence in the blood of recombinant DNA coding for rhEPO, or even recombinant plasmids. A few candidates suggested using a Biuret test, so although they appreciated EPO was a protein, they did realise this would detect all blood proteins.
		ii	rhEPO is identical to the normal EPO ✓ normal EPO concentrations vary (so difficult to know when rhEPO is added) ✓	2	ALLOW cannot tell difference between types of EPO ALLOW difficult to establish normal EPO concentration <u>Examiner's Comments</u> The majority of candidates did not appreciate the presence of normal EPO as well as rhEPO and thus could not compare the structures of the two. Most answers discussed the limitations in methods available in the past.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8		i	(correct determination of P_{50} for both curves) normal = 3.5 and anaemia = 4.5 ✓ (calculation of % increase to 3 sig. figs) 28.6 ✓	2	ALLOW ± 0.2 for each P_{50} value ALLOW ECF from incorrect P_{50} values Examiner's Comments The calculation in (a)(i) was correctly worked out by the majority of candidates. Marks were lost for quite high P_{50} values, particularly for the anaemia curve.
		ii	Hb / its, affinity (for O_2) would decrease / reduce ✓ oxyhaemoglobin, dissociates at <u>higher</u> pO_2 / has lower (%) saturation (than normal control) at same pO_2 ✓ (limited) haemoglobin releases oxygen more, easily / readily ✓ so <u>more</u> oxygen to (respiring) tissues ✓	3	Examiner's Comments There appeared to be 2 interpretations for (a)(ii). Those candidates that felt BPG increased Hb oxygen affinity described the relevance of this to a drop in haemoglobin levels in anaemic patients with a sensible, logical pattern. However they had not related the shift in the curve to the Bohr shift and thus a decrease in affinity. Candidates should be reminded that the affinity of haemoglobin for oxygen is relevant when oxygen needs to be released as well as needing to pick up oxygen. Candidates that understood the decrease in affinity then followed through with clear, logical answers.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9	a	i	frequency of exercise ✓ time / duration, of exercise ✓ type of exercise ✓	max 2	Examiner's Comments Both (a)(i) and (ii) were answered well. Candidates are advised to be specific when referring to safety precautions and avoid generalisations such as 'health checks'.
		ii	(check for) asthma / heart condition / pregnancy / high blood pressure ✓ equipment training ✓	1	Examiner's Comments Both (a)(i) and (ii) were answered well. Candidates are advised to be specific when referring to safety precautions and avoid generalisations such as 'health checks'.
	b	i	(Student's) t-test ✓ paired / measurements from same people (before and after) ✓	2	Examiner's Comments It was encouraging to see that over 60% of candidates were awarded at least one mark when asked about the type of statistical test that could be used to analyse the data in (b)(i). A significant number of candidates justified their choice, clearly explaining how measurements were taken from the same people before and after exercise.
		ii	improvement in recovery time (at all intensities / wattages of exercise) ✓ improvement falls as intensity / wattage rises ✓ uncertainty in making conclusion because standard deviations / error bars (for before-and-after) overlap ✓	2	ORA Examiner's Comments (b)(ii) was another example where candidates showed that they could describe data clearly. They were also able to identify that large error bars illustrated the data was variable but often failed to develop the idea of lack of significance when error bars overlapped.
		iii	higher intensity / wattage exercises such as weightlifting show less improvement in recovery time ✓ weightlifting is not an aerobic exercise ✓ weightlifting occurs over a short duration / in short bursts ✓	2	ORA ALLOW if not awarded in (b)(ii) uncertainty in making conclusion (about weightlifting) because standard deviations / error bars (for before-and-after) overlap Examiner's Comments (b)(iii) required candidates to understand that weightlifting is not an aerobic exercise and occurs in short bursts so this training programme, which candidates were told focused on aerobic fitness, would not be appropriate.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	9	
10			B ✓	1	Examiner's Comments A disappointing number of candidates failed to recall this straightforward fact about the role of ATP in muscle contraction.
			Total	1	
11			A ✓	1	Examiner's Comments This question was straightforward recall but less than half of all candidates remembered the chemicals that bind to haemoglobin.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
12	a	i	X adenine (base) ✓ Y ribose (sugar) ✓	2	DO NOT ALLOW adenosine
		ii	transfer / release, of, <u>last / terminal</u> , phosphate (group) ✓ to produce, ADP / adenosine diphosphate ✓ via hydrolysis reaction ✓ breaking of high-energy bond between phosphates ✓	max 3	ALLOW release of, inorganic phosphate / Pi ALLOW 'using a water molecule'
	b		<i>*Summary of instructions to markers:</i> <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in italics):</i> ◦ <i>award the higher mark where the Communication Statement has been met.</i> ◦ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> • <i>The science content determines the level.</i> • <i>The Communication Statement determines the mark within a level.</i>		

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Level 3 (5 – 6 marks) A detailed description and explanation of the results, including the roles of Ca^{2+} and/or ATP. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3 – 4 marks) A good description and explanation of the results, with reference to the roles of Ca^{2+} and/or ATP. <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1 – 2 marks) A limited description and explanation of the results. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.	6	Indicative scientific points may include: General description of data • no contraction with buffers A and D • some contraction with buffer B • greatest contraction with C Ca^{2+} explanation • idea that EDTA blocks effects of Ca^{2+} • ref to residual Ca^{2+} in muscle (intracellular Ca^{2+} stores) • details of sliding filament theory, e.g. Ca^{2+} ions bind troponin, unmasking of myosin binding site on actin/displacement of troponin, myosin head binds actin/ref to cross-bridge, tilting of myosin head/movement of myosin relative to actin/power stroke ATP explanation • details of sliding filament theory, e.g. ATP permits detachment of myosin from actin and hydrolysis provides energy for contraction by resetting myosin head AVPs • shortening of sarcomere • muscle shortening is cumulative effect of shortening many sarcomeres
	c		thickness of muscle strands ✓ same length of time in glycerine ✓ concentration of buffer components ✓ volume of buffer ✓	max 2	
			Total	13	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13	a	i	<i>idea of</i> (reversibly) bound to haemoglobin ✓	1	ALLOW 'as oxyhaemoglobin'
		ii	<i>statement in support</i> mean values higher for males than females AND data quotation ✓ <i>alternative statement</i> <i>idea that</i> conclusion not valid AND a reason ✓	2	e.g. too small a sample, different sporting disciplines compared, training would vary (between individuals or disciplines), only endurance sports looked at and not other athletic disciplines
	b		(women have) less haemoglobin so able to transport less oxygen ✓ <i>idea that</i> (women have) smaller heart / lower stroke volume, so less oxygen pumped ✓ <i>idea that</i> (women have) less muscle and more body fat / adipose tissue which is less metabolically active ✓	3	ALLOW reverse argument for men throughout ALLOW idea that muscle cells have more mitochondria than adipocytes
	c		biosensor ✓ immobilised ✓ coenzyme ✓ reduced ✓	4	ALLOW a term which describes immobilisation e.g. covalently bonded
	d	i	frequency of exercise OR time / duration of exercise ✓	1	
		ii	X axis to be labelled with variable in part (i) AND appropriate units ✓ Y axis to be labelled lactate concentration (following run) AND appropriate units ✓ Slope downwards from left to right / negative correlation ✓	max 2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	13	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14	a	i	<i>idea that</i> reduces, (risk /cases / AW, of) atherosclerosis / atheroma (s); <i>idea that</i> reduces, (risk / cases, of,) coronary heart disease / heart attacks;	2	<i>The question refers to the effect of blood cholesterol not exercise on the cardiovascular system.</i> ACCEPT a description e.g. less plaque, or less fatty deposit in artery walls DO NOT CREDIT 'less ON artery wall or IN artery' DO NOT CREDIT idea that atherosclerosis causes high blood pressure ACCEPT a description e.g. prevents CHD / MI / Angina IGNORE heart disease unqualified, IGNORE ref to strokes as the question is about benefits to the cardiovascular system Examiner's Comments This question asked about the benefits of exercise in terms of the beneficial effects of lowering blood cholesterol, the effects of exercise on the skeletal system and the practical aspects of investigating aerobic fitness including data analysis. The question tested AO1, AO2 and AO3. In part (i) many candidates were well aware of the reduced risk of atherosclerosis and named heart problems. A number of candidates who made references to strokes had not read the question properly missing the fact that it was about benefits to the cardiovascular system. There was some confusion in answers where candidates were clearly answering in terms of the effects of exercise on the cardiovascular system and not the effects of a reduction in blood cholesterol. Hence many answers

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					incorrectly included references to changes in blood pressure. There were still a lot of references to fats blocking, or clogging, arteries, only the higher scoring candidates using the correct terminology to describe atherosclerosis.
		ii	stronger bones / increased bone density / maintains bone density; thicker joint cartilage;	Max 1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks CREDIT reduction in risk of osteoporosis IGNORE ref to muscles / tendon / ligament Examiner's Comments ☐ Stronger bones or a reduction in the risk of osteoporosis was the main answer given in (ii). Errors made were largely associated with references to increased muscle mass.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	<i>organelle</i> mitochondrion; <i>stage in aerobic respiration</i> oxidative phosphorylation;	2	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks ACCEPT mitochondria IGNORE ref to matrix or cristae IGNORE electron transport chain / chemiosmosis Examiner's Comments Most candidates seem to know that aerobic respiration takes place in the mitochondrion and that oxidative phosphorylation was the stage requiring oxygen instage requiring oxygen in (i). The most common error was referring to the electron transport chain. In part (ii) most candidates knew that RhEPO increases erythrocyte production enabling increased oxygen transport.
		ii	<i>idea that</i> RhEPO increases production of, erythrocytes / red blood cells / more haemoglobin; Increased oxygen, transport / carrying capacity / AW;	2	
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																					
15	a		mitochondrial, (membrane / envelope); acrosome (membrane);	2	DO NOT CREDIT endoplasmic reticulum / Golgi apparatus (as these are not present in spermatozoa) CREDIT lysosome only if candidate indicates that the acrosome is a modified lysosome Examiner's Comments This was about the effects of cryopreservation and subsequent thawing on the viability of sperm samples obtained from the semen of bulls. This was a data question and data was provided for candidates to assess both the effects of cryopreservation on viability and if there was a significant difference between samples. Most candidates were aware of mitochondrial membranes being damaged with the more able ones also being aware of the acrosome membrane.																					
	b	i	(cryopreservation) causes a drop in viability / AW; correct data quoted for two named samples and two percentages AND units(mean) percentage / %;		Only CREDIT if 'percentage' or '%' is used with the figures at least once. <table><tr><th>Semen sample</th><th>Mean percentage fluorescing green</th><th>Mean percentage fluorescing red</th></tr><tr><td>1</td><td>47.6</td><td>49.3</td></tr><tr><td>2</td><td>56.0</td><td>37.0</td></tr><tr><td>3</td><td>47.3</td><td>48.7</td></tr><tr><td>4</td><td>50.4</td><td>45.5</td></tr><tr><td>5</td><td>52.8</td><td>40.9</td></tr><tr><td>6</td><td>47.7</td><td>49.2</td></tr></table>	Semen sample	Mean percentage fluorescing green	Mean percentage fluorescing red	1	47.6	49.3	2	56.0	37.0	3	47.3	48.7	4	50.4	45.5	5	52.8	40.9	6	47.7	49.2
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1	47.6	49.3																								
2	56.0	37.0																								
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6	47.7	49.2																								

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<i>yes because</i> <i>idea that</i> S.D. indicate data overlaps OR <i>idea that</i> difference between the means is small; <i>no because</i> <i>idea that</i> a S.D only overlaps slightly OR there is a difference between the means;	1	No mark available for stating 'yes' or 'no' DO NOT CREDIT ref. to green fluorescing sperm Only CREDIT if Examiner's Comments Very few candidates answered (i) correctly, they needed to relate the effect of cryopreservation on the viability of sperm. Many described the extent of membrane damage or compared samples without even using the term viability in their answer. Part (ii) involved a straightforward consideration of mean values and/or consideration of the spread of data related to the standard deviation values to assess if there was a significant difference between the two samples. Candidates who appreciated this managed a clear concise answer, but there were those who did not seem to be aware of what was needed. Those who quoted data from the sperm fluorescing green failed to score the marking point.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16		i	<i>idea that</i> fats contain, large number of, hydrogen (atoms) / carbon hydrogen bonds; hydrogen and oxygen form water (in aerobic respiration); <i>idea that</i> metabolic pathway (for fat respiration) is in mitochondria; (mitochondria) use oxygen as terminal acceptor (for hydrogen ion / electron);	2	IGNORE DO NOT CREDIT H ⁺
		ii	glycogen; carbo(hydrate)depletion / described (for around 10 days before event); (followed by) carbo(hydrate)loading / described (for around 3 days before event);	3	Correct spelling only CREDIT a description of diet high in protein and low in carbohydrate or foods which meet this description DO NOT CREDIT 'eat only protein' for 'carbodepletion' CREDIT a description referring to foods high in carbohydrate such as rice, pasta etc. Examiner's Comments Many candidates struggled and seemed to find part (i) hard and few seemed aware that fats contained a large number of hydrogen atoms, or the involvement of oxygen in the formation of water. Some of the more able candidates recognised the fact that oxygen was a terminal hydrogen ion acceptor even if they did not make the earlier links. Most candidates knew that glycogen was the carbohydrate storage compound in part (ii), and that carbohydrate depletion should be followed by carbohydrate loading within specified time limits. Unfortunately many candidates lost a marking point, as they did not distinguish between the two stages putting the whole procedure under the description of carbohydrate loading.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
17	a		B; C;	2	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks Examiner's Comments This required an understanding of the interaction between the different proteins involved in muscle contraction and how a genetic mutation can bring about changes in a protein (dystrophin). An explanation of the consequent effects of this mutation was then required. The reason for lack of detection of the condition by amniocentesis or CVS was also tested.
	b		Z (lines), move closer / AW; as) sarcomere, shortens / AW; I (band) and H (zone), decrease / get shorter / AW; A (band) stays the same, size / length; QWC;	2 1	Both I band and H zone needed for the mark Award if any 3 of the following are used correctly with correct spelling Z line sarcomere I band A band H zone Examiner's Comments There were some very good answers but others failed to remember all the details or a detailed description of the interchanges between actin, myosin and the binding of calcium to troponin. Many candidates knew that the sarcomere shortens even if they didn't know anything else. There seemed to be a lot of confusion between lines, zones and bands, but many managed to get the QWC mark anyway.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		calcium ions / Ca^{2+} / Ca^{++}, are not reabsorbed / AW; (calcium ions / Ca^{2+} / Ca^{++},) stay bound to / not released from, troponin; (so) binding sites, on actin, (still) exposed / AW; cross bridges / AW, keep forming;	2	IGNORE reference to release of calcium ions CREDIT tropomyosin still displaced CREDIT a description 'myosin stays bound to actin, Examiner's Comments Many answers to (i) failed to score marking points due to a systematic lack of detail in each stage involved. Many answers 'jumped' from a gene mutation (without the detail of specific possible changes in DNA) to a change in an amino acid or change in protein shape. All the marking points appeared in various answers but few scored beyond three marking points due to missing out necessary detail. Although many candidates related the failure to relax to the continued release of calcium ions rather than their lack of reabsorption, many had a good understanding of the reason for the failure to relax in terms of myosin remaining bound to actin, and also that calcium ions remain bound to troponin.
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18		i	carbonic anhydrase;	1	
		ii	(mitochondria) for synthesis of / AW, ATP, for active transport / transport of ions;	1	CREDIT hydrogen ions / H^+ / protons / chloride ions / Cl^- / hydrogen carbonate ions / HCO_3^- IGNORE mitochondria providing energy
		iii	gas exchange (system);	1	Mark the first answer IGNORE 'lungs' or 'brain' or a region of the brain since these are not organ systems CREDIT 'respiratory' system CREDIT nervous system Examiner's Comments Biochemistry is often a weakness with Human Biology candidates and very few were able to identify carbonic anhydrase in (i). In (ii) although many correct statements were made regarding active transport and ATP, candidates failed to link this to the role of mitochondria is synthesising ATP while in (iii) many candidates did not spot that it was an organ system that was required rather than an organ and answers such as 'lung' or 'medulla oblongata' could therefore not be credited.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
19			YES performances declined after ban; NO performances did not drop back to 1960s level;	Max 2	IGNORE ref. to distance figures quoted from the graph CREDIT ORA CREDIT performances declined, after testing introduced / late 1980s / 1985 onwards DO NOT CREDIT performances declined after 1980-1984 DO NOT CREDIT performance continued to improve after late 1980s IGNORE performance continued to improve after 1980 (as testing was not introduced until the late 1980s) Examiner's Comments This looked at factors that contribute to improved athletic performance based on the taking of anabolic steroids. Initially the mechanism of their entry into the nucleus was considered. The percentage increase in an athlete's performance who had taken anabolic steroids was calculated from graphical data. Two ways in which anabolic steroids could improve athletic performance were taken into account followed by an evaluation of athletic performance before and after out of competition drug testing was introduced in the late 1980s. The question tested both AO1, AO2 and AO3. Although many candidates correctly identified a decline in performance after the late 1980s when out-of-competition drug testing was introduced. Few succeeded in noting that the reduced levels of performance were still higher than those achieved in 1960 and therefore could not be due to the use of steroids. Evaluative questions require that both sides of an argument are stated. A noticeable number

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					of candidates lost marks by incorrectly relating their answer to testing starting after 1980 and not in the late 1980s.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20	a	i	the greater the body mass of the mammal the lower the VO_2 max / AW ORA	1	
		ii	otter AND (otter is terrestrial but) spends much time underwater hunting prey so needs to use oxygen efficiently	1	ALLOW because other similar sized mammals have much lower VO_2 max OR VO_2 max of that value should be smaller / lighter / lower mass ALLOW highly active ALLOW diving animal
		iii	range of values (of body mass), very large / too large to fit on (non-log) x-axis	1	ALLOW will give a straight line (of best fit / graph)
	b	i	bar chart drawn with equal width bars, not touching AND x axis labelled as "Treatment" AND y axis labelled as "Mean VO_2 max (cm^{-3} $kg^{-1}min^{-1}$)" (1) equidistant vertical scale used so that plot area covers at least 50% of the y axis space (1) both means plotted accurately (1) range bars plotted accurately (1)	4	IGNORE labels on bars showing "normal diet" or "carbohydrate loading" ALLOW units shown in brackets or with solidus ALLOW +/- 1 mm Normal diet mean = 39, range 37–41 Carb loading diet mean = 41, range 39–44

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<i>* Please refer to the marking instruction point 10 for guidance on how to mark this question. In summary:</i> <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)</i> <i>Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in italics):</i> <i>award the higher mark where the Communication Statement has been met.</i> <i>award the lower mark where aspects of the Communication Statement have been missed.</i> <i>The science content determines the level.</i> <i>The Communication Statement determines the mark within a level.</i> Level 3 (5–6 marks) Provides a comprehensive evaluation of the method used for obtaining the data. Most of the variables are considered, reproducibility and repeatability are commented on and validity is questioned. <i>There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.</i> Level 2 (3–4 marks) Provides some evaluation of the method used for obtaining the data. Some of the variables are considered, reproducibility or repeatability is commented on and validity	6	Indicative scientific points may include Variables: - sex of athlete - mass of athlete - training regime - fitness of athlete Confidence - only one athlete - lacks reproducibility - has limited repeatability - small number of data points (for stats test) Validity - only one athlete, extrapolation unjustified - sex of athlete, extrapolation unjustified - mass of athlete may not be constant - training regime not detailed - limited detail of carbohydrate- loading regime - method may not be appropriate to reach expected outcomes

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			is considered. <i>There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.</i> Level 1 (1–2 marks) Provides a limited evaluation of the method used for obtaining the data. Some variables are omitted. A consideration is made of confidence and validity. <i>There is a logical structure to the answer. The explanation, though basic, is clear.</i> 0 marks No response or no response worthy of credit.		
			Total	13	
21	a		923 (ms) (1)(1)	2	If answer is incorrect, look for $60 \div 65$ or 0.923 (s) = 1 mark
	b	i	PR interval (1)	1	Mark first answer only. If a second answer is given that is incorrect = no mark
		ii	QT interval (1)	1	Mark first answer only. If a second answer is given that is incorrect = no mark
		iii	TP (1) PR (1)	2	Answers in any order
		iv	RR (1) TP(1) QP (1)	2	Answers in any order
		v	ST (segment) (1)	1	
			Total	9	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
22	a	i	selection pressure, (is) high altitude / risk of altitude sickness <i>idea of</i> individuals with, mutated gene / allele / Tibetan variant, will survive better at high altitude / have selective advantage <i>idea that</i> allele frequency for Tibetan EPAS1 increases over many generations natural selection	4	
		ii	physiological	1	ALLOW biochemical
		iii	Any 2 from: <i>idea of</i> less oxygen able to be transported in their blood (the potential for) less / reduced / AW, respiration partial pressure / concentration, of oxygen is lower at high altitude	2	
		iv	(erythrocyte cell count using) haemocytometer measures / AW, concentration of (red blood) cells OR flow cytometry measures / AW, volume / morphology / concentration, of (red blood) cells	2	ALLOW numbers of / types of protein in / amount of protein in, (red blood) cells
	b	i	Answer (in a range between) = 20 – 22 Units = % kPa ⁻¹	3	1 mark can be awarded if there is evidence that the candidate has identified the steepest part of the slope as (any value between) 3.6–4.6 kPa ALLOW % per kPa
		ii	lungs / alveoli	1	
		iii	curve placed anywhere between the myoglobin and haemoglobin curves	1	The fetal haemoglobin curve can merge with either of the other two lines after 10 kPa
		iv	myoglobin has, greater affinity / AW, for oxygen (at the same kPa) <i>idea that</i> oxygen will be transferred to myoglobin / muscle, from (adult) haemoglobin	2	
			Total	16	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23	a	i	mode = 2 mean = 3.11	3	$(2 \times 9) + (2 \times 8) + (3 \times 11) + (6 \times 7) / 35 = 3.11$ Award one mark if a candidate has clearly taken the number of participants into account but has made an error in the calculation
		ii	<i>General points</i> <i>Idea of valid conclusions</i> would require information about the intensity of exercise <i>Idea that</i> (named) statistical test would confirm conclusion <i>Duration (up to a maximum of 2 marks)</i> positive correlation (suggests the conclusion is valid) many studies / repeats / AW, improves validity <i>idea of relationship / correlation</i> , clearer for cycling (than running) <i>Running vs cycling (up to a maximum of 2 marks)</i> <i>idea that</i> (conclusion is valid because) for a given duration, IL-6 increases more with running (than cycling) the number of participants varies, which makes comparison difficult	4	The general point marks can be scored for either section, but can only be scored once ALLOW 'meta-analysis' for 'many studies' ALLOW calculated example
	b	i	Any 3 from: <i>Glucose uptake</i> (IL-6) increases / AW, insulin production (IL-6) increases / AW, insulin receptor sensitivity (on muscle cells) <i>Glucose production</i> (IL-6) increases / AW, glucagon production glycogen converted to glucose (in liver cells)	3	ALLOW acts like a hormone ALLOW glycogenolysis
		ii	* Level 3 (5–6 marks) Candidate's evaluation demonstrates excellent judgement of the data, providing conclusions that address all the significant issues. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i>	6	Examples of relevant scientific points at L3 (in addition to points at L1 and L2) <i>experimental & epidemiological evidence</i> • discussion of <i>in vitro</i> v <i>in vivo</i> experiments (e.g. the conflicting results in A and B; <i>in vitro</i> experiments might lack important factors, for example, found in <i>in vivo</i>) • discussion of the link between TNF and IL-6 (e.g. G and H. IL-6 could, for

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Level 2 (3–4 marks) Judgement is made on a range of aspects of the data, but conclusions are not comprehensive. <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Simple conclusions are made, drawing on limited aspects of the data. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.		example, be high in certain cases because it has a defensive role against TNF) i.e. detailed links made between studies in Table 1.2 and impact on diabetes risk - in depth discussion of correlation v causation (e.g. C and D show correlation but not causation). <i>biological knowledge</i> - detailed understanding of the causes and symptoms of type 2 diabetes. Examples of relevant scientific points at L2 (in addition to points at L1) <i>experimental & epidemiological evidence</i> - discussion of correlation v causation - linking exercise, low baseline IL-6 and possible effects on diabetes risk - quite detailed links made, some in detail, between studies in Table 1.2 and the impact on diabetes risk. <i>biological knowledge</i> - good understanding of the causes and symptoms of type 2 diabetes. Examples of relevant scientific points at L1 <i>experimental & epidemiological evidence</i> - basic links made between studies in Table 1.2 and the impact on diabetes risk. <i>biological knowledge</i> - some understanding of the causes and symptoms of type 2 diabetes.
	c	i	<i>idea that</i> (gene is) replaced / disrupted / AW, with, artificial / synthetic / AW, DNA	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Any 1 from: (mice have) similar, genome / DNA sequences, to humans (mice have) similar, metabolism / physiology, to humans (mice are) easy / cheap, to, house / manipulate / breed	1	
	d		chemotaxis attraction of neutrophils (to site of infection) OR cause / stimulate, B cells / T cells, to, differentiate / proliferate cause / stimulate, B cells to release antibodies OR inhibit virus replication activation / AW, of T killer cells	2	ALLOW (undergo) clonal expansion
			Total	20	
24			C	1	
			Total	1	
25		i	Time between them gets less / AW	1	
		ii	Any 2 from: Minimum time for 1 beat = 0.3 seconds (distance from first P to T wave) $60 \div 0.3$ Answer = 200 bpm / beats per minute	2	
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
26	a	i	(limited blood supply) reduced oxygen available ref to, increased / more, anaerobic respiration	2	IGNORE reference to glucose DO NOT ALLOW anaerobic respiration alone – need the idea of more anaerobic respiration
		ii	<i>idea that</i> (muscle) cell surface / plasma, membrane is, damaged / AW <i>idea that</i> LDH, diffuses, out of cytoplasm / into blood plasma	2	
	b	i	troponin, binds to / AW, tropomyosin myosin binding site is blocked (by tropomyosin) / <i>idea that</i> myosin is prevented from binding to actin	2	
		ii	comparison of median values in support of a statement / comparison of interquartile range values in support of a statement <i>plus any two from the following marks up to a maximum of 3</i> <i>idea that</i> (very) high concentrations are only seen where a heart attack is confirmed / heart attack subject have significantly higher median values than other groups <i>idea that</i> bottom of interquartile range for confirmed heart attacks is significantly higher than other groups / top of interquartile range of other groups is significantly below bottom of range for group with heart attack <i>idea that</i> unlikely to get 'false positives' or 'false negatives' <i>idea that</i> sample sizes are very different in the three groups and could affect the validity of the data	3	DO NOT ALLOW a simple description of the concentrations for each group – look for a clear statement that the high levels are specific to a heart attack or that they are significantly higher for this group.
			Total	9	
27			B	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
28			D	1	
			Total	1	
29			D	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
30		i	<table><tr><th>Organ</th><th>Type of muscle</th><th>Action of <u>muscle</u> in fight or flight response</th></tr><tr><td>Heart</td><td>cardiac</td><td>increase pulse rate ;</td></tr><tr><td>Leg muscle</td><td>voluntary / skeletal/striated</td><td>contract ;</td></tr><tr><td>Arteriole to liver</td><td>smooth</td><td>contract / relax ;</td></tr></table>	Organ	Type of muscle	Action of <u>muscle</u> in fight or flight response	Heart	cardiac	increase pulse rate ;	Leg muscle	voluntary / skeletal/striated	contract ;	Arteriole to liver	smooth	contract / relax ;	3	Mark the first answer in each box. If that answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks. IGNORE relax for second box ACCEPT (vaso)constrict / (vaso)dilate for third box (as in context of effect of muscle on arteriole) IGNORE increases/decreases, blood flow IGNORE increases/decreases, diameter Examiner's Comments The mark most often scored in (c)(i) was for naming cardiac muscle as being present in the heart. Striated muscle for contraction often scored a second mark but candidates were prone to contradict themselves in the third line of the table, saying the effects of arteriole smooth muscle contraction caused dilation or increased blood flow to liver rather than constriction (and reduced blood flow).
Organ	Type of muscle	Action of <u>muscle</u> in fight or flight response															
Heart	cardiac	increase pulse rate ;															
Leg muscle	voluntary / skeletal/striated	contract ;															
Arteriole to liver	smooth	contract / relax ;															
		ii	myosin;	1	IGNORE thick filament. DO NOT CREDIT myelin Mark the first answer. If that answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks. Examiner's Comments Most candidates correctly identified the thick filaments in the A band as myosin. A few wrote actin instead, and very occasionally tropomyosin was given as the answer.												
			Total	4													