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

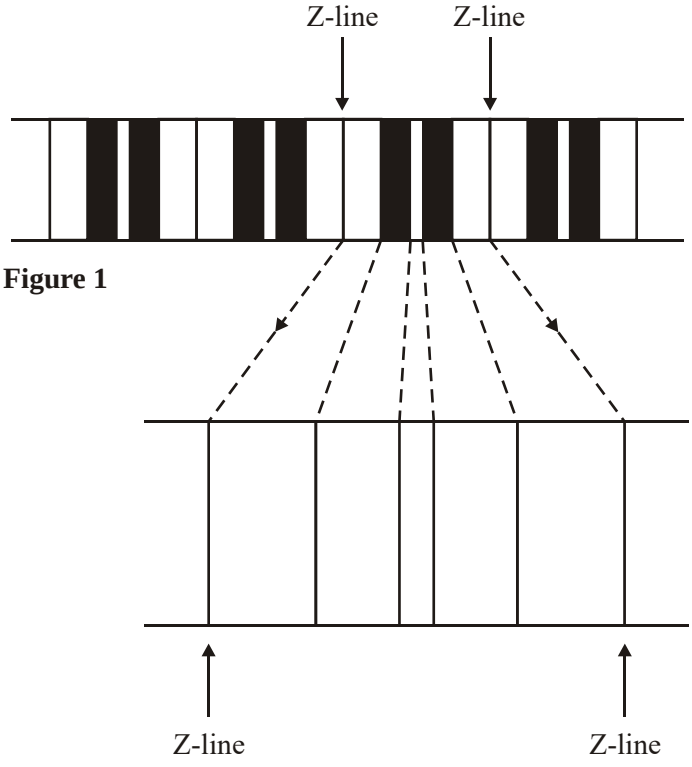

Figure 1

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?

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(1)

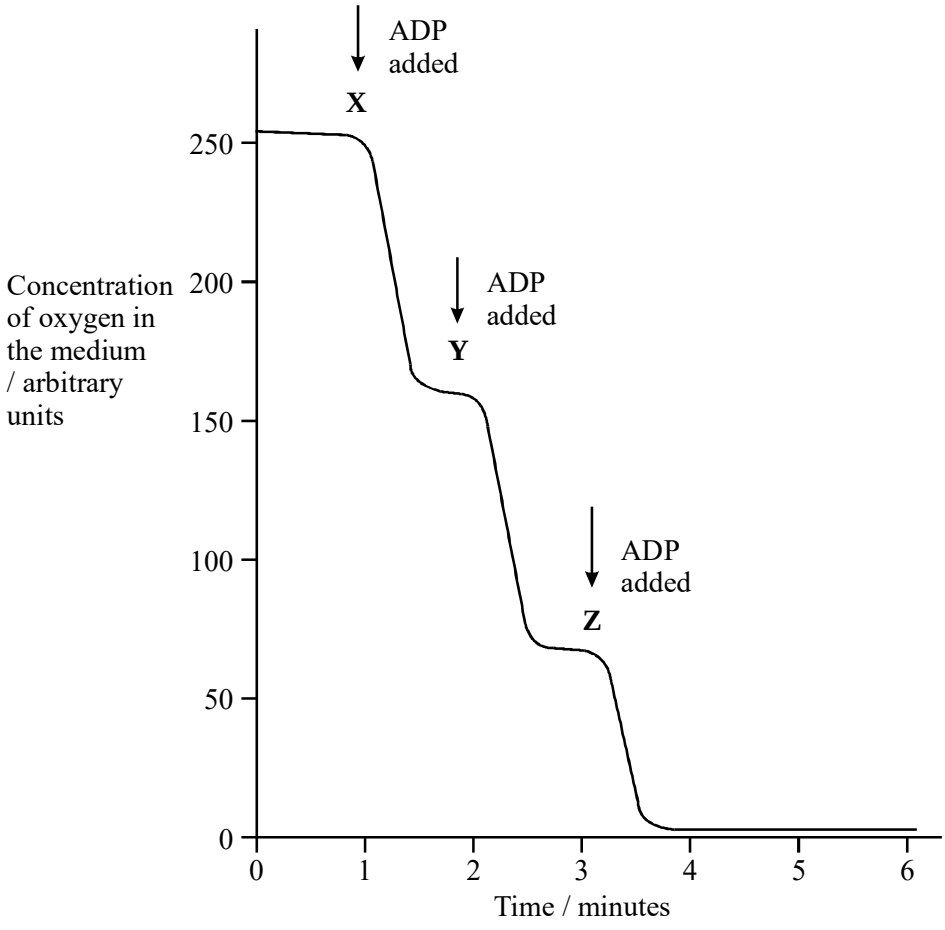
(b) The myofibril in **Figure 1** is magnified × 8000. A muscle fibre is 40 µm in diameter. Calculate the number of myofibrils which would fit side by side across the diameter of the muscle fibre. Show your working.

Answer ..... myofibrils.

(2)

(Total 5 marks)

2. In an investigation of aerobic respiration, isolated mitochondria were added to a prepared medium containing succinate and inorganic phosphate. Succinate is a 4-carbon compound, which occurs in the Krebs cycle, and can be used as a respiratory substrate. The medium was saturated with oxygen. Equal amounts of ADP were added at one-minute intervals, and measurements were taken of the oxygen concentration in the medium. The graph shows the results.



(a) Why was inorganic phosphate added to the medium?

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(1)

(b) Explain why the oxygen concentration in the medium decreased after adding ADP at **X**.

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(3)

(c) Explain why the fall in oxygen concentration was the same following the addition of ADP at **X** and at **Y**.

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(1)

(d) Explain why the fall in oxygen concentration, following the addition of ADP, was less at **Z** than at **Y**.

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(1)

(e) Fresh mitochondria were isolated from cells and a similar experiment was carried out. This time the medium contained glucose instead of succinate. Again, the medium was saturated with oxygen, and excess ADP was added. However, there was almost no fall in oxygen concentration, even after 10 minutes.

(i) Suggest and explain a reason for this observation.

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(2)

(ii) Explain, in outline only, how you could test your suggestion.

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(1)
(Total 9 marks)

3. (a) Mitochondria in muscle cells have more cristae than mitochondria in skin cells. Explain the advantage of mitochondria in muscle cells having more cristae.

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(2)

(b) Substance **X** enters the mitochondrion from the cytoplasm. Each molecule of substance **X** has three carbon atoms.

(i) Name substance **X**.

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(1)

(ii) In the link reaction substance **X** is converted to a substance with molecules effectively containing only two carbon atoms. Describe what happens in this process.

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(2)

(c) The Krebs cycle, which takes place in the matrix, releases hydrogen ions. These hydrogen ions provide a source of energy for the synthesis of ATP, using coenzymes and carrier proteins in the inner membrane of the mitochondrion.

Describe the roles of the coenzymes and carrier proteins in the synthesis of ATP.

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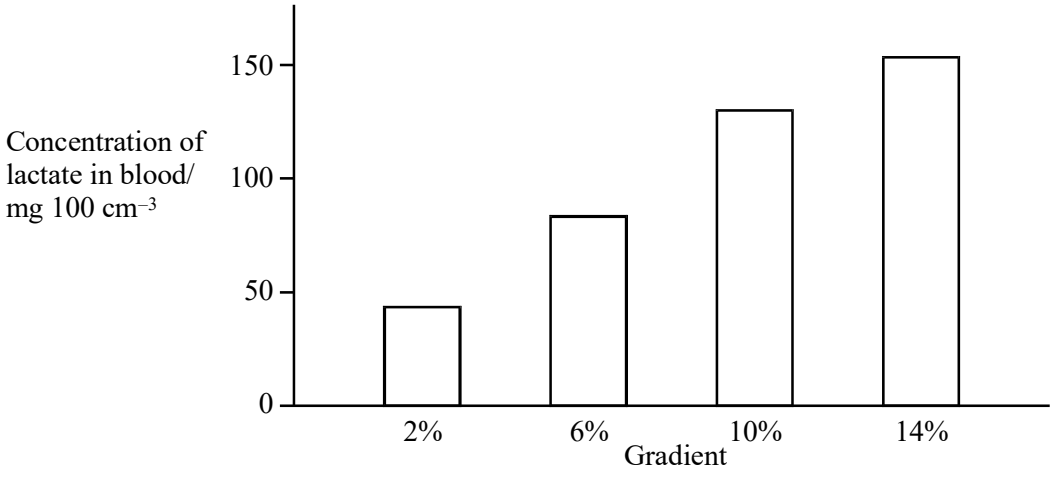
(3)
(Total 8 marks)

4. An investigation was carried out to find the effect of exercise on the concentration of lactate in the blood. Four treadmills were placed at different gradients, ranging from 2% to 14%. A different athlete ran at a constant speed on each treadmill for five minutes. Three minutes after each run a blood sample was taken from each athlete and the concentration of lactate was measured. The graph shows the results.



(a) Name the process that produces lactate during exercise.

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(1)

(b) Describe the relationship between the intensity of exercise and the concentration of lactate in the blood.

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(1)

(c) Suggest **two** ways in which the design of the investigation could be improved to give more reliable results.

1 .....

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2 .....

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(2)

(d) Suggest why the blood samples used to measure lactate concentrations were not taken from the athletes until three minutes after completion of a run.

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(1)

(e) The athlete running on the treadmill at a gradient of 14% suffered from muscle fatigue. Explain what causes muscle fatigue.

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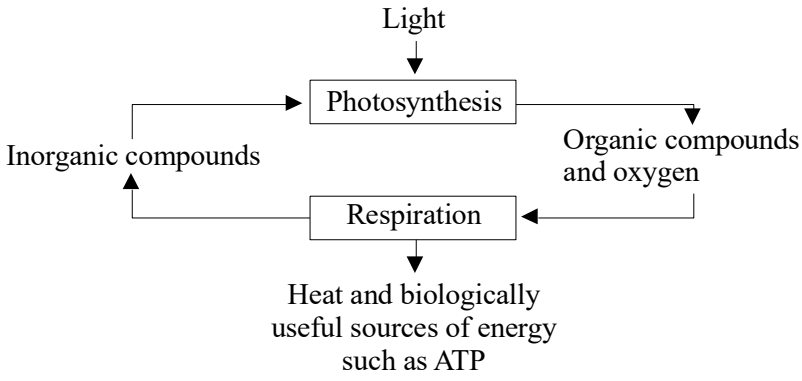
(2)

(Total 7 marks)

5. (a) The diagram summarises the relationship between photosynthesis and respiration.



(i) Name the inorganic compounds indicated on the diagram.

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(1)

(ii) Describe **two** features of an ATP molecule which make it a "biologically useful source of energy".

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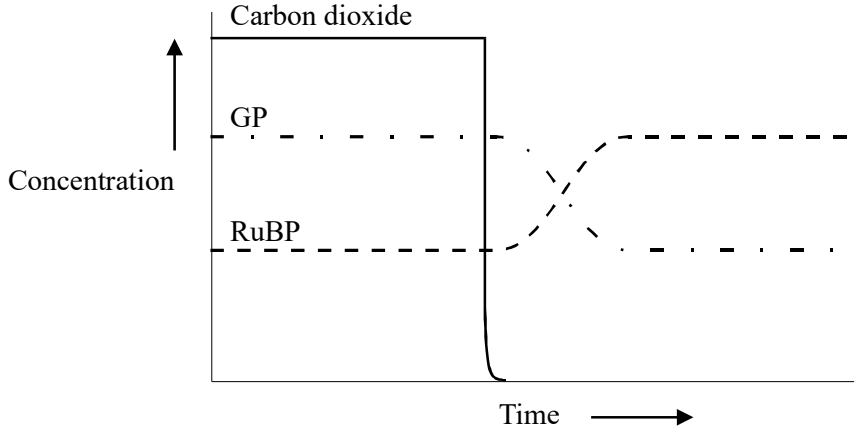
(2)

(b) In an investigation, a culture of single-celled algae was supplied with carbon dioxide and allowed to photosynthesise normally. The concentration of carbon dioxide in the culture medium was then reduced suddenly. The graph shows the effect of the reduction in carbon dioxide concentration on the concentration of glycerate 3-phosphate (GP) and ribulose bisphosphate (RuBP) in the algal cells.



(i) Write a simple equation summarising the reaction involving carbon dioxide, GP and RuBR

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(1)

(ii) Explain the changes which occurred in the concentration of RuBP immediately after the concentration of carbon dioxide was reduced.

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(2)

(Total 6 marks)

6. (a) During the first few minutes of exercise, muscles use blood glucose to obtain most of the energy they need. After this, they use stored compounds as energy sources.
Name **two** stored compounds used as energy sources during exercise.

1 .....

2 .....

(2)

(b) Describe the effect of lactate production on muscles.

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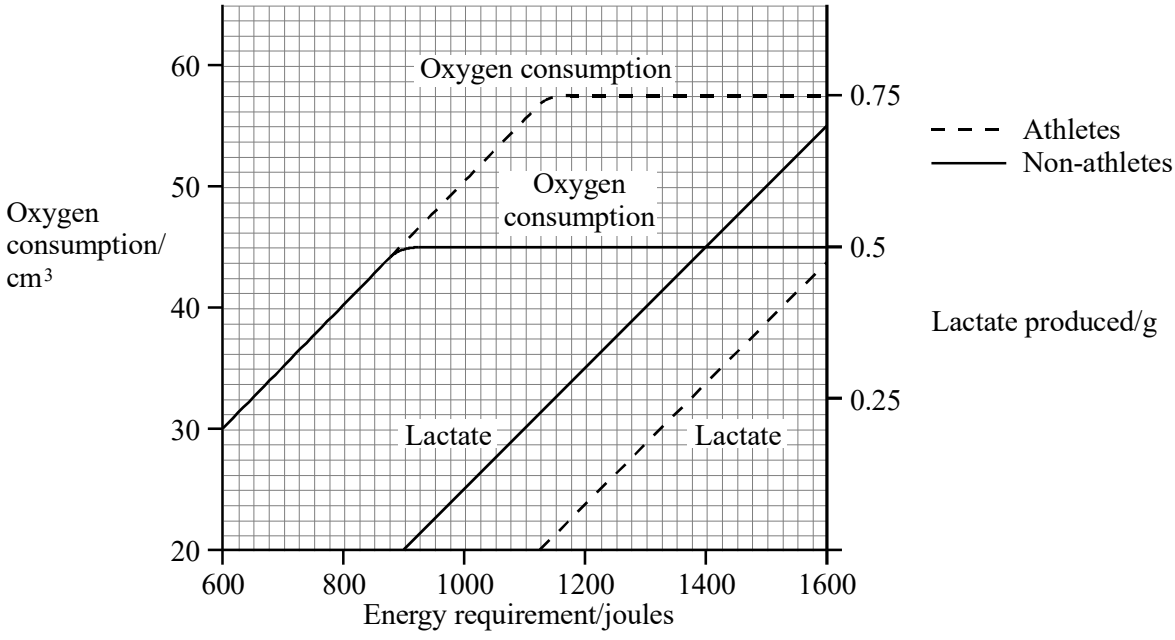
(2)

(c) An investigation was carried out to find the effect of exercise on oxygen consumption and lactate production in athletes and non-athletes. The graph shows the results of this investigation. All units are per kilogram of body mass per minute.



(i) Use the graph to find the difference in lactate production between athletes and non-athletes at an energy requirement of 1200 joules per kilogram per minute.

Answer .....

(1)

(ii) Compared with non-athletes, athletes can run at a rate that has a higher energy requirement before lactate production begins.
Use information provided in the graph to explain how athletes can sustain a higher energy requirement before lactate production commences.

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(3)
(Total 8 marks)

7. (a) Which substance is the immediate source of energy for muscle contraction?

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(1)

(b) (i) Which substance is the waste product of anaerobic respiration in muscles?

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(1)

(ii) Describe what happens to this waste product when the muscles start respiring aerobically.

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(2)

(c) In an investigation, athletes ran as fast as they could for three different periods of time. The percentage of energy derived from aerobic and anaerobic respiration during each test was measured. The table shows the results.

Length of test / s	Energy obtained from	
	aerobic respiration/%	anaerobic respiration/%
10	3	97
30	28	72
90	46	54

(i) The world record for the 100m sprint is 9.84s.
A top-class sprinter does not need to breathe in during a 100m sprint. Use information in the table to explain why.

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(2)

(ii) In the test that lasted 90s, the speed at which the athletes ran decreased before the end of the test.
Suggest and explain **one** reason why their speed of running decreased.

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(2)
(Total 8 marks)

8. When one mole of glucose is burned, 2800 kJ of energy are released. However, when one mole of glucose is respired aerobically, only 40% of the energy released is incorporated into ATP. Each mole of glucose respired aerobically produces 38 moles of ATP.

(a) (i) Calculate how much energy is incorporated into each mole of ATP. Show your working.

Answer ..... kJ

(2)

(ii) When glucose is respired what happens to the energy which is **not** incorporated into ATP?

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(1)

(b) (i) When one mole of glucose is respired anaerobically, only 2 moles of ATP are produced. Explain why less energy is released in anaerobic respiration.

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(1)

(ii) At the end of a sprint race, a runner continues to breathe rapidly for some time. Explain the advantage of this.

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(2)

(Total 6 marks)

9. (a) Name the **two** substances produced by anaerobic respiration in humans.

1 .....

2 .....

(2)

(b) When an athlete runs in a 100 metre race, 90% of the energy needed is provided by anaerobic respiration.

(i) Explain why most of the energy is provided by anaerobic respiration rather than aerobic respiration.

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(2)

(ii) The athlete continues to breathe deeply for several minutes after the race ends. Explain why this is necessary.

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(2)
(Total 6 marks)

10. (a) Pyruvate is formed in the breakdown of glucose during respiration. When there is sufficient oxygen, this pyruvate is fully broken down. Name **two** substances formed from the pyruvate.

1 .....

2 .....

(1)

(b) (i) If there is a shortage of oxygen in muscle cells during exercise, some pyruvate is converted into lactate. Explain why muscles become fatigued when insufficient oxygen is available.

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(2)

(ii) Some of the lactate is oxidised to pyruvate by muscles when they are well-supplied with oxygen. Suggest an advantage of the lactate being oxidised in the muscles.

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(2)

(Total 5 marks)