4.4 Bioenergetics
Higher

Time: 213 minutes

Marks: 212 marks

Comments:
Q1.

Diagram 1 shows the main features of human blood circulation.

(a) What changes in the composition of **blood** occur in the lungs?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Diagram 2 shows how the circulation of blood changes between rest and exercise.
Rate of supply of blood to parts of the body (cm³/min) when at rest and during exercise.

(b) (i) Use the information from Diagram 2 to complete the table below.

Parts of the body to be included:

- Digestive System
- Skin
- Brain
- Arteries of Heart
- Muscles of Skeleton
- Bone
What happens to the rate of supply of blood to the whole body with exercise?
(You should make full use of the information provided.)

Q2.
In a stable community, the processes that remove carbon are balanced by processes that return carbon.

The figure below shows a woodland community.

Describe how carbon is recycled in a woodland community.
Q3.

(a) The table shows an athlete’s breathing rate after the end of a race.

Use the information shown in the table to draw a line graph.

<table>
<thead>
<tr>
<th>Time after end of race (minutes)</th>
<th>Breathing rate (litres per second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

(Total 6 marks)
(b) The bar charts show what happens in an athlete’s muscles when running in two races of different distances.

(i) Compare what happens in the athlete’s muscles when running in the two races.

(ii) Use the information in the box to explain your answer to (i).

<table>
<thead>
<tr>
<th>Process</th>
<th>Substrate</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic respiration</td>
<td>Glucose + oxygen</td>
<td>Carbon dioxide + water</td>
</tr>
<tr>
<td>Anaerobic respiration</td>
<td>Glucose</td>
<td>Lactic acid</td>
</tr>
</tbody>
</table>
(c) Explain why the athlete breathes at a faster rate than normal for two minutes after finishing a 100 metres race.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Q4.

The diagram shows part of the carbon cycle.

![Diagram of carbon cycle]

Use the information in the diagram and your own knowledge to describe in detail how carbon is cycled between living organisms and the air.

Your answer should include the names of any processes involved.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(Total 10 marks)
Q5.
A scientist investigated the effect of oxygen concentration and temperature on the rate of decay of leaves in a container.

The scientist’s results are shown in the graph.

(a) The rate of decay is measured as the volume of carbon dioxide produced per hour. Explain why carbon dioxide is produced during the process of decay.

(b) Give two conclusions that can be made from the results shown in the graph.
Q6.
The diagram shows the mass of carbon dioxide released into and removed from the air each year in billions of tonnes.

Describe the processes **shown on the diagram** that exchange carbon dioxide with the air.

Explain the overall effect of these processes on the mass of the carbon dioxide in the air.
The diagram shows some plants growing in a greenhouse on a hot summer’s day.

Which one of the following factors is most likely to limit the rate of photosynthesis at this time?

- carbon dioxide concentration
- light intensity
- temperature

Factor __________________________________________________________

Explain the reason for your answer.
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

(Total 4 marks)

Q8.

Plants need nitrate ions in order to make proteins.

A plant is growing in soil flooded with water.

Explain why the plant cannot absorb enough nitrate ions.
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

_______________________________________________________________________

(Total 4 marks)
Q9.
The graph shows how the rate of photosynthesis is affected by different conditions.

(a) What patterns can you find from this graph?

(b) How useful could this information be to a grower using glasshouses? Give reasons for your answer.

Q10.
A food chain in the North Atlantic Ocean is:

\[ \text{diatoms} \rightarrow \text{small fish} \rightarrow \text{large fish} \]
The graphs show how over a year:

- the population size of diatoms in the North Atlantic varies;
- the light intensity alters;
- the concentration of nitrate and phosphate minerals alters.

(a) Explain why the light intensity is a major factor in controlling the numbers of diatoms.

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

(2)

(b) (i) Suggest two reasons why the population of diatoms decreases between spring and summer.

1. _____________________________________________________________________________________
   _____________________________________________________________________________________

2. _____________________________________________________________________________________
   _____________________________________________________________________________________

(2)

(ii) Give two reasons why the population of diatoms decreases in autumn.

1. _____________________________________________________________________________________
   _____________________________________________________________________________________

2. _____________________________________________________________________________________
   _____________________________________________________________________________________

(2)

(c) Use the information on the graph to suggest what change causes the number of diatoms to increase in the late summer. Give a reason for the change.

________________________________________________________________________________________
Q11.

Plants need chemical energy for respiration and for active transport.

(i) Write a balanced chemical equation which represents the process of respiration in plants.

(ii) Describe the process of active transport in the root hair cells of plants.

Q12.

(a) The concentration of sulfate ions was measured in the roots of barley plants and in the water in the surrounding soil.

The table shows the results.

<table>
<thead>
<tr>
<th></th>
<th>Concentration of sulfate ions in mmol per dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roots of barley plants</td>
<td>1.4</td>
</tr>
<tr>
<td>Soil</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Is it possible for the barley roots to take up sulfate ions from the soil by diffusion?
(b) Some scientists investigated the amounts of sulfate ions taken up by barley roots in the presence of oxygen and when no oxygen was present.

The graph below shows the results.

(i) The graph shows that the rate of sulfate ion uptake between 100 and 200 minutes, \textbf{without} oxygen, was 0.4 arbitrary units per minute.

The rate of sulfate ion uptake between 100 and 200 minutes, \textbf{with} oxygen, was greater.

How much greater was it? Show clearly how you work out your answer.
The barley roots were able to take up more sulfate ions with oxygen than without oxygen.

Explain how.

Q13.

Low light intensity is one factor that limits the yield of a crop.

In Britain, many tomato growers use artificial lights to increase the yield of tomato crops.

The table shows the amount of natural daylight and artificial lamplight received by a tomato crop grown in a greenhouse.

<table>
<thead>
<tr>
<th>Month</th>
<th>Natural daylight received by tomato plant</th>
<th>Artificial lamplight given to tomato plant</th>
<th>Total light energy received by plant per day in J/cm²</th>
<th>Percentage increase in growth resulting from artificial light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day length in hours</td>
<td>Light energy received by plant per day in J/cm²</td>
<td>Hours of light given per day</td>
<td>Light energy received by plant per day in J/cm²</td>
</tr>
<tr>
<td>January</td>
<td>8.1</td>
<td>239</td>
<td>18</td>
<td>492</td>
</tr>
<tr>
<td>February</td>
<td>9.9</td>
<td>492</td>
<td>18</td>
<td>492</td>
</tr>
<tr>
<td>March</td>
<td>11.9</td>
<td>848</td>
<td>12</td>
<td>328</td>
</tr>
<tr>
<td>April</td>
<td>13.9</td>
<td>1401</td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>May</td>
<td>15.5</td>
<td>1786</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>16.6</td>
<td>1960</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
(a) Describe the pattern for the amount of light energy received from natural daylight by a tomato plant during the day.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(b) A tomato plant needs 600 J of light energy per cm² each day to grow and produce tomatoes.

Use this information and data from the table to suggest an explanation for the pattern of the artificial light given to the tomato plants.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Q14.

Students investigated the effect of changing the carbon dioxide concentration on the rate of photosynthesis in pieces of leaf.

Diagram 1 shows the type of leaf used by the students.
The students:

- cut pieces of leaf from the green region
- put the pieces into tubes
- added different concentrations of carbon dioxide to each tube
- shone lights on the tubes with either high or low light intensity
- recorded the concentration of oxygen in the tubes after 5 hours.

Diagram 2 shows how each experiment was set up.

(a) (i) Describe the effect of increasing carbon dioxide concentration on the rate of photosynthesis at low light intensity.
(ii) Explain the effect that you have described.
    In your answer you should refer to limiting factors.

(b) What would have been the effect on oxygen concentration over the five-hour period if a white region of the leaf had been used, instead of a green region?

Effect____________________________________________________________

Explain your answer.

Explanation _________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

(c) Some people keep indoor plants which have variegated leaves (leaves with green and white regions).

If plants with variegated leaves are kept in dim light conditions the white areas of the leaves start to turn green.

This is an advantage to the plant.

Suggest why.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

Q15.
Read the passage.
Glutton up a gum tree

Along the banks of the Cygnet River on Kangaroo Island, the branches of the dying gum trees stretch out like accusing fingers. They have no leaves. Birds search in vain for nectar-bearing flowers.

The scene, repeated mile upon mile, is an ecological nightmare. But, for once, the culprit is not human. Instead, it is one of the most appealing mammals on the planet – the koala. If the trees are to survive and provide a food source for the wildlife such as koalas that depend on them, more than 2000 koalas must die. If they are not removed the island’s entire koala population will vanish.

Illegal killing has already started. Worried about soil erosion on the island, some farmers have gone for their guns. Why not catch 2000 koalas and take them to the mainland? “Almost impossible,” says farmer Andrew Kelly. “Four rangers tried to catch some and in two days they got just six, and these fought, bit and scratched like fury.”

The diagram shows the flow of energy through a koala. The numbers show units of energy.

(i) Calculate the percentage of the food intake which is converted into new tissues for growth. Show your working.

\[
\text{Percentage} = \frac{\text{Growth}}{\text{Food}} \times 100\%
\]

(ii) Give three different ways in which the koala uses the energy released in respiration.

1. \[\text{ }\]

2. \[\text{ }\]

3. \[\text{ }\]
Q16.

The graph shows the effect of increasing the carbon dioxide content of the inhaled air on:

- the number of breaths per minute;
- the total volume of air breathed per minute.

(i) Describe the effect of increasing the percentage of carbon dioxide in the inhaled air on the total volume of air breathed.

(ii) Suggest why the total volume of inhaled air is not directly proportional to the number of breaths per minute.
The diagram shows a plant leaf during photosynthesis.

(a) Name:
   (i) gas X; _______________
   (ii) gas Y. _______________

(b) Why is sunlight necessary for photosynthesis?

(c) Some of the sugars produced by photosynthesis are stored as starch in the roots. Explain, as fully as you can, why it is an advantage to the plant to store carbohydrate as starch rather than as sugar.
Q18.

A student's breathing was monitored before and after vigorous exercise. The student breathed in and out through a special apparatus. The graphs show the changes in the volume of air inside the apparatus. Each time the student breathed in, the line on the graph dropped. Each time the student breathed out, the line went up.
(a) How many times did the student breathe in per minute:

before exercise; _____________________________________________________

after exercise? ______________________________________________________

(1)
(b) On each graph, the line A – B shows how much oxygen was used. The rate of oxygen use before exercise was 0.5 dm$^3$ per minute. Calculate the rate of oxygen use after exercise.

Rate of oxygen use after exercise = ________________ dm$^3$ per minute

(2)

(c) The breathing rate and the amount of oxygen used were still higher after exercise, even though the student sat down to rest. Why were they still higher?

(4)

(Total 7 marks)

Q19.

An athlete carried out a 6-month training programme.

Graph 1 shows the effect of the same amount of exercise on his heart rate before and after the training programme.
(a) (i) Use **Graph 1** to find the heart rate of the **trained** athlete 5 minutes after the start of the exercise.

Heart rate = _______________________ beats per minute

The stroke volume of the heart is the volume of blood pumped out of the left side of the heart in one heart beat.

**Graph 2** shows the relationship between the stroke volume and the heart rate before and after the athlete did the training programme.
(ii) The cardiac output is defined as

\[
\text{cardiac output} = \text{heart rate} \times \text{stroke volume}
\]

Calculate the cardiac output of the trained athlete 5 minutes after the start of the exercise. Use your answer to part (a)(i), and information from Graph 2.

Show clearly how you work out your answer.

\[\text{Cardiac output} = \text{ cm}^3 \text{ blood per minute}\]

(2)

(b) Graph 1 shows that, for the same amount of exercise, the heart of the trained athlete was beating more slowly than it did before the training programme.

Use information from Graph 2 to explain why.

\[\text{Graph 2}\]

(2)

(c) An increased cardiac output will provide more oxygen and more glucose to the working muscles.

Explain how this helps the athlete during exercise.
Q20.
Marathon runners are recommended to have a high carbohydrate diet prior to a race.
Three athletes tried out three dietary regimes prior to a marathon race.

These three dietary regimes were as follows.

**Athlete A**
- Up to 7 days before the race: Normal mixed diet
- 7 days before the race: Prolonged extreme physical activity
- 6-3 days before the race: Protein and fat diet; no carbohydrate
- 2 and 1 days before the race: Large carbohydrate intake

**Athlete B**
- Up to 5 days before race: Normal mixed diet
- 5 days before the race: Prolonged extreme physical activity
- 4-1 days before the race: Large carbohydrate intake

**Athlete C**
- Up to 4 days before the race: Normal mixed diet
- 4-1 days before the race: Large carbohydrate intake

The graph below shows the effect of each of these dietary regimes on glycogen levels in the athletes’ muscles.

(a) (i) What is the immediate effect of extreme physical activity on the glycogen
content of muscles?

(ii) Describe how this effect occurs.

(b) (i) Evaluate the three regimes as preparation for a marathon race.

(ii) Suggest a possible explanation for the different effects of the three regimes.

Q21.
The diagram shows where three seaweeds live on a seashore. As the tide moves in and out, these seaweeds are covered with seawater for different lengths of time.
Some students investigated the rate of photosynthesis in these seaweeds.

- They cut ten small discs from one seaweed.
- They dropped the discs into seawater in a beaker.
- They recorded the time taken for the fifth disc to float to the surface.
- They repeated this experiment with the other two seaweeds.

(a) (i) Suggest why the discs floated to the surface.

(ii) Suggest the advantage of recording the time taken for the fifth disc to reach the surface, rather than for the tenth disc.

(b) The students carried out their experiments at different light intensities. The graph shows the results they collected.
Q22.

During exercise, the heart beats faster and with greater force.

The 'heart rate' is the number of times the heart beats each minute. The volume of blood that travels out of the heart each time the heart beats is called the 'stroke volume'.

(i) Compare the rate of photosynthesis for flat wrack with the rate for saw wrack at different light intensities.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) Seawater absorbs light.

The growth rate of saw wrack is less than the growth rate of bladder wrack.

Suggest why.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(Total 6 marks)
In an investigation, **Person 1** and **Person 2** ran as fast as they could for 1 minute. Scientists measured the heart rates and stroke volumes of **Person 1** and **Person 2** at rest, during the exercise and after the exercise.

The graph below shows the scientists’ results.

(a) The ‘cardiac output’ is the volume of blood sent from the heart to the muscles each minute.

Cardiac output = Heart rate × Stroke volume

At the end of the exercise, **Person 1**’s cardiac output = 160 × 77 = 12 320 cm³ per minute.

Use information from Figure above to complete the following calculation of **Person 2**’s cardiac output at the end of the exercise.

At the end of the exercise:

**Person 2**’s heart rate = _____________ beats per minute

**Person 2**’s stroke volume = _____________ cm³

**Person 2**’s cardiac output = _____________ cm³ per minute

(3)

(b) **Person 2** had a much lower cardiac output than **Person 1**.

(i) Use information from Figure above to suggest the main reason for the lower cardiac output of **Person 2**.

__________________________________________________________
(ii) **Person 1** was able to run much faster than **Person 2**.

Use information from **Figure above** and your own knowledge to explain why.

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Q23.

Lactic acid production during exercise affects an athlete’s performance.

Explain why lactic acid is produced during exercise.

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Q24.

The graph shows the uptake of carbon dioxide and the release of carbon dioxide by a bean plant on a hot summer’s day.
(a) At which **two** times in the day did the rate of photosynthesis exactly match the rate of respiration in the bean plant?

1. ___________________________________________________ (1)

(b) The bean plant respires at the same rate all through the 24 hour period.

(i) How much carbon dioxide is released each hour during respiration?

_________________________________________________

(arbitrary units) (1)

(ii) How much carbon dioxide is used by photosynthesis in the hour beginning at 3 pm?

_________________________________________________

_________________________________________________

Answer = ______________________________________ arbitrary units (1)

(c) Over the 24 hour period, the total amount of carbon dioxide taken in by the bean plant was greater than the total amount of carbon dioxide given out by the bean plant.

Explain, in detail, why this was important for the bean plant.
Q25.

(a) Complete the equation for photosynthesis.

\[ \text{light energy} \rightarrow \text{___________} + \text{___________} + \text{oxygen} \]

(2) (Total 5 marks)

(b) Scientists investigated how temperature affects the rate of photosynthesis. The scientists grew some orange trees in a greenhouse. They used discs cut from the leaves of the young orange trees.

The scientists used the rate of oxygen production by the leaf discs to show the rate of photosynthesis.

(i) The leaf discs did not produce any oxygen in the dark.

Why?

(1)

(ii) The leaf discs took in oxygen in the dark.

Explain why.

(2)

(c) In their investigation, the scientists measured the rate of oxygen release by the leaf discs in the light. The scientists then measured the rate of oxygen uptake by the leaf discs in the dark.

The graph shows the effect of temperature on

• oxygen production in the light
(1) Describe the effect of temperature on oxygen production in the light.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2) Explain the effect of temperature on oxygen production in the light when the temperature is increased:

from 25 °C to 35 °C

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

from 40 °C to 50 °C.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2)

(d) A farmer in the UK wants to grow orange trees in a greenhouse. He wants to sell the
A student investigated the effect of light intensity on the rate of photosynthesis in pondweed.

(a) The formula for glucose is \( \text{C}_6\text{H}_{12}\text{O}_6 \)

Use the formula for glucose to write the balanced symbol equation for photosynthesis.

(b) **Figure 1** shows the apparatus the student used.
The student altered the distance of the lamp from the pondweed and counted the number of bubbles produced in 30 seconds for each distance.

The table below shows the student’s results.

<table>
<thead>
<tr>
<th>Distance in cm</th>
<th>Number of bubbles produced in 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
</tr>
</tbody>
</table>

Use the data in the table above to complete the graph on Figure 2.

(c) The student concluded that the rate of photosynthesis is inversely proportional to the distance of the lamp from the pondweed.

Does the student’s data support this conclusion?

Use data from Figure 2 to justify your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(d) The volume of one bubble can be calculated using the equation:
The radius of one bubble is 0.1 cm.

The value for \( \pi \) is 3.14

Use data from the table above and the information above to calculate the rate of gas production at a distance of 40 cm.

Give your answer in standard form to three significant figures.

Rate of reaction = __________________ cm\(^3\) per minute

(Total 13 marks)

Q27.

A student investigated the effect of pond organisms on the amount of carbon dioxide in their surroundings.

The student set up six boiling tubes as shown in the figure below.

They were left for 2 days.

Each boiling tube contained pond water with an indicator.

The indicator was pink at the start of the investigation.

- If the amount of carbon dioxide in the water increased the indicator turned yellow.
- If the amount of carbon dioxide in the water decreased the indicator turned purple.

(a) What is the purpose of boiling tube A?
Q28.  
(a) Complete the equation for photosynthesis.

\[ \text{_________________} + \text{water} \rightarrow \text{_________________} + \text{_________________} \]  

(b) The rate of photosynthesis in a plant depends on several factors in the environment. These factors include light intensity and the availability of water.

Describe and explain the effects of two other factors that affect the rate of photosynthesis.

You may include one or more sketch graphs in your answer.
Q29.
Green plants can make glucose.

(a) Plants need energy to make glucose.
How do plants get this energy?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(b) Plants can use the glucose they have made to supply them with energy.
Give four other ways in which plants use the glucose they have made.
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(5)
(Total 8 marks)
Q30.

Some students studied bluebell plants growing in two different habitats.

Habitat A was a sunny field next to woodland.
Habitat B was a shady, moist woodland.

A bluebell plant can have several flowers on one flower stalk. The students counted the number of flowers on each of 40 bluebell flower stalks growing in each habitat. The bar charts show the results.

(a) The students wanted to collect valid data. Describe how the students should have sampled the bluebell plants at each habitat to collect valid data.
The students used the bar charts to find the mode for the number of flowers per stalk in the two habitats. The mode for the number of flowers per stalk in habitat A was 11. What was the mode for the number of flowers per stalk in habitat B?

Mode = _________________________

(ii) The students suggested the following hypothesis:

‘The difference in the modes is due to the plants receiving different amounts of sunlight.’

Suggest why.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

(iii) Suggest how the students could test their hypothesis for the two habitats.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

(c) Suggest how receiving more sunlight could result in the plants producing more flowers per stalk.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

Q31.

The UK contains large areas of peat bogs that have been present for thousands of years.

(a) Peat is removed from peat bogs.

The peat can be mixed with air and added to garden compost.
The release of carbon dioxide from peat is a problem.

Give **two other** reasons why gardeners should use less peat-based compost in the future.

1. _______________________________________________________________________
2. _______________________________________________________________________

(b) **Explain why mixing peat with air leads to the release of carbon dioxide.**

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

(4) 
(Total 6 marks)
Mark schemes

Q1.

(a) idea
O₂ increases
CO₂ decreases
for 1 mark each

(b) (i) reduced  unchanged  increased
    digestive system  brain  muscles
    bone  skin  heart and arteries

All (6) correct gains 4
5 correct gains 3
4 correct gains 2
2/3 correct gains 1

Correct wording not needed if unambiguous. No mark if organ repeated.

(ii) more/higher/quicker/faster
    gains 1 mark

but
7500 more/from 5,000 to 12,500 more
    gains 2 marks

but
7500 cm³/min more
    gains 3 marks

or 2½ times more

Q2.

any six from:

only credit release of carbon dioxide once when linked to a correct process
ignore references to burning

• (plants) photosynthesise
• (plants) take in carbon dioxide
• (plants) produce carbohydrates / fats / proteins
    accept produce glucose
• (carbon compounds transferred by) feeding
• respiration
• breaks down carbon compounds / carbohydrates
    accept glucose
• releases carbon dioxide
• organisms die / produce wastes / excrete
• (which are) decomposed / decayed by microorganisms
allow broken down
allow bacteria / fungi / microbes / decomposers
• (which) release carbon dioxide

Q3.

(a) • appropriate scales (> halfway along each axis)
• all points correctly plotted to better than \( \frac{1}{2} \) a square
• lines carefully drawn

(allow point to point in this case)

N.B.
• no mark available for labelling axes
• allow either orientation

for 1 mark each

(b) (i) ideas that
• energy transferred faster in 100m race
  (not more energy transferred)
• carbon dioxide produced faster during 1500m race
  for 1 mark each

(allow more carbon dioxide produced)

correct reference to twice / half as fast in either / both cases

for 1 further mark

(ii) • respiration during 100m race (mainly) anaerobic
• respiration during 1500m race aerobic
• aerobic respiration produces carbon dioxide
• anaerobic respiration doesn’t produce carbon dioxide
  / produces lactic acid

any two for 1 mark each

(c) ideas that
• there is an oxygen debt / more than normal oxygen needed
• lactic acid needs to be oxidised / combined with oxygen

for 1 mark each
Q4. plants absorb CO\textsubscript{2} for photosynthesis

\textit{ignore carbon}  

all organisms / any named organism respire(s) and release(s) CO\textsubscript{2}

\textit{ignore breathing}

\textit{ignore carbon}  

any four from:

\begin{itemize}
  \item carbon compounds / named compound made by plants
  \item plants eaten by animals
  \item dead organisms / faeces are decomposed / decayed \textit{allow broken down}
  \item by bacteria / microorganisms
  \item dead plants and animals (may) form fossil fuels
  \item when (fossil) fuels are burnt they release CO\textsubscript{2} into the air
\end{itemize}  

Q5. (a) microorganisms / bacteria / fungi

\textit{allow correct named organisms}

\textit{allow detritus feeders / decomposers / worms}  

break down / digest / feed on (dead organisms)

\textit{accept use carbohydrates / glucose}

\textit{allow decomposes}

\textit{ignore decay / rot}  

(and release carbon dioxide when they) \textbf{respire}

\textbf{do not allow respiration if linked to leaves / dead organisms}  

(b) any two from:

\begin{itemize}
  \item the higher the temperature the faster the rate of decay \textit{allow faster / more carbon dioxide for faster rate of decay}
  \item the higher the oxygen concentration the faster the rate of decay \textit{allow faster / more carbon dioxide for faster rate of decay}
  \item the rate increases faster (with increasing oxygen concentration) at 20 °C (than 15 °C)
\end{itemize}  

Q6. \textit{read 'the gas' or 'it' as carbon dioxide}
(plants) photosynthesise

(plants) absorb carbon dioxide / \( CO_2 \) (from the air)
  allow take in / use carbon dioxide / \( CO_2 \) (from the air)

(overall) more carbon dioxide / \( CO_2 \) is being released into the air than is being removed
  allow 470 (billion tonnes) released but / and 450 (billion tonnes) taken in

(by) respiration (by all organisms / any named organism)
  ignore breathing
  ignore carbon

(and) combustion / burning
  ignore carbon

(so) amount of carbon dioxide / \( CO_2 \) in air is increasing
  allow 20 (billion tonnes) of carbon dioxide / \( CO_2 \) added to air each year

Q7.
  carbon dioxide concentration
    since atmospheric concentration very low / value give e.g. 0.03%
      allow carbon dioxide used up

    temperature high
      allow if light chosen as a factor

    light intensity high
      allow If temperature chosen as a factor

Q8.
  (nitrate) ions are absorbed by active transport

  (active transport) is the movement of ions against the concentration gradient
    allow (active transport) is the movement of ions from a dilute to a more concentrated solution

  (active transport) requires energy from respiration

  (respiration) requires oxygen
no / little oxygen / air in water-logged soil

Q9.
(a) + light = + photosynthesis
+ light = + photosynthesis to a limit
  limit depends on temp/CO₂ levels
+ CO₂ = + photosynthesis
+ temp = + photosynthesis
  each for 1 mark

(b) need to raise optimum levels
    when one other raised
    to get max/economic yield
  each for 1 mark

Q10.
(a) diatoms photosynthesise or are producers

    the amount of growth depends upon the energy or light they get

    accept more light means more growth
    or they multiply more in more light
    do not accept they need light

(b) (i) eaten by small fish

    do not accept eaten by fish

    minerals or nitrate or phosphates
    or nutrients or food supply used up
    or reduced

    (ii) any two from

    gets colder
    light decreases
    end of their life span or die

    accept more being eaten than being formed

    eaten by small fish

    do not accept a decrease in nitrates
    or phosphates

(c) increased minerals or nitrates or phosphates

    any one from
due to death or decay of diatoms or fish
do not accept death of large fish

influx of minerals in an ocean current
do not accept extraneous pollution or
dumping by a ship

Q11.
(i) \( \text{C}_6\text{H}_{12}\text{O}_{6} + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \)
energy is neutral

formulae all correct
with no omissions / deletions
correctly balanced
credit 1 mark if the answer is the exact
reverse of an incorrect answer for (a)

(ii) and three from
take up of (soluble) substances / ions against the concentration gradient
or when the concentration (of the
substance / ions) is greater inside the
cell / cytoplasm than outside it

through the (semi-permeable) (cell) membrane energy from mitochondria
or energy from respiration
not just energy

Q12.
(a) No
no mark
if yes max 1 for correct statement
diffusion is down the concentration gradient
accept by diffusion ions would leave the root

to enter must go up / against the concentration gradient
or concentration higher in the root
or concentration lower in the soil

(b) (i) 0.9 or 3.25
for correct answer with or without working
if answer incorrect 1.3 or their rate – 0.4 gains 1 mark
or 130 – 40 or 90 gains 1 mark
(ii) (uptake) by active transport

requires energy

more energy from aerobic respiration

or

more energy when oxygen is present

Q13.
(a) low in winter / named months / when the days are short
    accept increases in spring / Dec – June

high in summer / named month(s) / (when days are long
    decreases in autumn / June – December

reasonable quantitative statement
    accept any reasonable calculated / translated quantitative statement
    higher in summer than in winter for 2 marks
    comparative statements may be worth 2 marks
    but
    8/11 times higher in summer than in winter for 3 marks

(b) no artificial light given in summer / light only given in winter

since natural light greatly exceeds minimum / 600 J (required to produce tomatoes)
    accept day length if linked to light energy

OR

light only given in winter

as natural light less than the minimum needed (to grow them) or 600 J

OR

for 2 marks:
    percentage increase in growth from artificial] light only significant in winter

Q14.
(a) (i) increase (and then level off) and max / up to at 0.15 (%) (carbon dioxide)
    ignore references to oxygen concentration only
    ignore mention of 23
(ii) \( \text{CO}_2 \) is limiting at low \( \text{CO}_2 \) / at first

\[ \text{ignore specific numbers} \]

light is limiting at high \( \text{CO}_2 \) / at end

(b) mark both parts together

effect: (oxygen) falls

explanation: (oxygen) used for respiration

\textbf{if no other marks awarded allow (effect) no change and}

(explanation) no photosynthesis for 1 mark

(c) more chlorophyll / chloroplasts

allows more photosynthesis / description

\textit{for both marks must refer to more at least once} 1

Q15.

(i) \( 0.25 \times 100 / 25 \)

\[ \text{gains 1 mark} \]

but

1%

\[ \text{gains 2 marks} \]

(ii) muscle contraction / limb movement / moving around / chewing

heartbeat / breathing / internal muscle activity

maintaining body temperature / keeps body warm

active uptake synthesising substances (reject growth)

\textit{any three for 1 mark each} 3

Q16.

(i) increase in \( \text{CO}_2 \) concentration leads to increase in volume of air inhaled

increase of % carbon dioxide has little effect over most of range / large increase when % carbon dioxide > 5.6 %

\[ \text{each for 1 mark} \]

(ii) idea that

depth of breathing changes at low % carbon dioxide, increase in % \( \text{CO}_2 \) results in volume of each breath increasing without increase / little increase in number of breaths

\[ \text{each for 1 mark} \]
Q17.
(a) (i) carbon dioxide / \( \text{CO}_2 \) (reject CO) for 1 mark each 2
(ii) oxygen / \( \text{O}_2 \) / O (water vapour neutral) for 1 mark each

(b) (provides) energy for one mark 1

(c) starch insoluble therefore water not taken in by osmosis or sugar is soluble / has small molecules may diffuse out therefore lost (ignore ref. to cells bursting)

or starch has large molecules cannot diffuse therefore retained for 1 mark each 3

Q18.
(a) (before exercise) – 9 to 11 and (after exercise) – 12 or 13 both correct 1

(b) 0.75 to 0.90 ignore working or lack of working

\[ \frac{(2.35 - 1.0) \times 60}{100} \]  eg. 2.35 – 1.55 or or other suitable figures for 1 mark 2

(c) any four from:

still need to remove extra carbon dioxide
still need to remove heat / to cool
(some) anaerobic respiration (in exercise)
lactic acid made (in exercise)
oxygen needed to break down lactic acid or suitable reference to oxygen debt
lactic acid broken down to \( \text{CO}_2 \) and water or lactic acid changed into glucose 4

Q19.
(a) (i) 120
(ii) 11 760 or correct answer from candidate’s answer to (a)(i) correct answer with or without working if answer incorrect 
120 × 98 or candidate’s answer to (a)(i) × corresponding SV gains 1 mark 
if candidate uses dotted line / might have used dotted line(bod) in (a)(i) and (a)(ii) no marks for (a)(i) but allow full ecf in (a)(ii) eg 140 × 88 = 12320 gains 2 marks

(b) trained athlete has higher stroke volume / more blood per beat 
same volume blood expelled with fewer beats 
or for same heart rate more blood is expelled

(c) increased aerobic respiration 
or 
decreased anaerobic respiration allow correct equation for aerobic respiration accept don’t have to respire anaerobically 
increased energy supply / need
less lactic acid formed or to breakdown lactic acid or less O₂-debt 
can do more work or can work harder / faster / longer accept muscle contraction for work 
or less fatigue / cramp / pain

[9]

Q20.
(a) (i) reduced sharply for 1 mark

(ii) converted to glucose which is respired to produce energy (allow answers in terms of glucagon) gains 3 marks
(b) (i) athlete A’s was most effective since resulted in highest muscle glycogen level on day of race for energy release during race  
for 1 mark each  

(ii) e.g. excess carbohydrate stored as glycogen rather than fat in short term particularly if glycogen stores depleted  
for 1 mark each  

[9]

Q21.

(a) (i) oxygen produced  

(ii) any one from:  
• average / mean / median  
  ignore reliable / precise / accurate  
• some may be anomalous  
  allow some may not float  

1

(b) (i) do not allow answers in terms of time only  
if candidate answers in terms of comparing rate of change then the rate of change of photosynthesis must be in the correct direction for 1 mark  

any two from:  
• low intensity / below 12.5 / 2.5 - 12.5 (units of light) flat wrack / it, rate of photosynthesis faster or saw wrack rate of photosynthesis slower  
  allow any value in range  
• high intensity / above 12.5 / 12.5 - 15 (units of light) flat wrack / it, rate of photosynthesis slower or saw wrack rate of photosynthesis faster  
  allow any value in range  
• same (rate) at 12.5 units  

2

(ii) any two from:  
• saw wrack receives less light  
  accept converse if clear reference to bladder wrack  
• less photosynthesis  
  if first and second responses, ‘less’ needed only once  
  or  
  less carbohydrate / sugar / starch production  
• when tide is in or at high tide or any tide above low tide  
  accept saw wrack covered by water / submerged longer /
Q22.

(a) 5624

allow 2 marks for:
- correct HR = 148 and correct SV = 38 plus wrong answer / no answer
  or
- only one value correct and ecf for answer

allow 1 mark for:
- incorrect values and ecf for answer
  or
- only one value correct

(b) (i) Person 2 has low(er) stroke volume / SV / described eg Person 2 pumps out smaller volume each beat
do not allow Person 2 has lower heart rate

(ii) Person 1 sends more blood (to muscles / body / lungs)

  (which) supplies (more) oxygen

  (and) supplies (more) glucose

  (faster rate of) respiration or transfers (more) energy for use
  ignore aerobic / anaerobic
  allow (more) energy release
  allow aerobic respiration transfers / releases more energy (than anaerobic)
do not allow makes (more) energy

  removes (more) CO2 / lactic acid / heat
  allow less oxygen debt

  or less lactic acid made
  or (more) muscle contraction / less muscle fatigue
  if no other mark awarded,
  allow person 1 is fitter (than person 2) for max 1 mark

Q23.

insufficient / no oxygen available
for (just) aerobic respiration

or

respires anaerobically

Q24.

(a) 7.15 to 7.45 am and 7.15 to 7.45 pm

both required, either order

accept in 24 hr clock mode

(b) (i) 11

(ii) 32.5 to 33

allow answer to (b)(i) + 21.5 to 22

(c) any two from:

• more photosynthesis than respiration

• more biomass / carbohydrate made than used

• so plant able to grow / flower

accept plant able to store food

Q25.

(a) LHS: carbon dioxide AND water

in either order

accept CO₂ and H₂O

allow CO₂ and H₂O

if names given ignore symbols

do not accept CO₂ / H₂O / Co / CO

ignore balancing

RHS: sugar(s) / glucose / starch / carbohydrate(s)

accept C₆H₁₂O₆

allow C₆H₁₂O₆

do not accept C₆H₁₂O₆

(b) (i) light is needed for photosynthesis

or

no photosynthesis occurred (so no oxygen produced)

(ii) oxygen is needed / used for (aerobic) respiration
respiration occurs or oxygen is needed for anaerobic respiration gains 1 mark

(c) (i) (with increasing temperature) rise then fall in rate

use of figures, ie

max. production at 40 °C
or maximum rate of 37.5 to 38

(ii) 25 – 35 °C

either faster movement of particles / molecules / more collisions
or particles have more energy / enzymes have more energy

or temperature is a limiting factor over this range

40 – 50 °C
denaturation of proteins / enzymes

ignore denaturation of cells
ignore stomata

(d) above 35 °C (to 40 °C) – little increase in rate
or > 40 °C – causes decrease in rate

so waste of money or less profit / expensive

because respiration rate is higher at > 35 °C
or respiration reduces the effect of photosynthesis

Q26.

(a) \(6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\)
correct reactants

correct products

(b) correct scale and label on x axis

all 5 plots correct
tolerance ±½ small square
allow 2 or 3 plots correct for 1 mark

(c) no

no mark
although as distance increases, rate decreases

the line curves or line should be straight

suitable data quoted

examples:

- supports conclusion between 20–40 (cm)
- does not support conclusion between 10–20 (cm)

(d) volume of 1 bubble = \( \frac{4}{3} \times 3.14 \times (0.1)^3 \)

= 0.00419

at 40 cm there are 7 bubbles

vol at 40 cm = 0.02933

allow ecf from incorrect value taken from table

Rate per minute = \( \times 2 \)

= \( 5.86 \times 10^{-2} \) (cm\(^3\) per min)

allow \( 5.86 \times 10^{-2} \) with no working shown for 5 marks

answer not given in standard form or to incorrect number of sig. figs max 4 marks

Q27.

(a) control

to check that the indicator colour does not change on its own

or

to check any changes in colour are due to the organisms

(b) (tube) E

most carbon dioxide

(due to) only respiration occurring

allow no carbon dioxide used for photosynthesis

allow 1 mark max if chose tube D and give a correct reason

(c) the amount of carbon dioxide produced by respiration equalled amount absorbed for photosynthesis

[13]
Q28.

(a) LHS – carbon dioxide / CO₂
    allow CO₂
    ignore CO₂

RHS
    in either order
    glucose / carbohydrate / sugar
    allow starch
    allow C₆H₁₂O₆ / C₆H₁₂O₆
    ignore C₆H₁₂O₆

oxygen
    allow O₂ / O₂
    ignore O₂ / O

(b) any five from:

- factor 1: CO₂ (concentration)
- effect - as CO₂ increases so does rate and then it levels off or shown in a graph
- explanation:
  (graph increases) because CO₂ is the raw material or used in photosynthesis / converted to organic substance / named eg or
  (graph levels off) when another factor limits the rate.
  accept points made via an annotated / labelled graph

- factor 2: temperature
  allow warmth / heat
- effect – as temperature increases, so does the rate and then it decreases or shown in a graph
  allow ‘it peaks’ for description of both phases
- explanation:
  (rise in temp) increases rate of chemical reactions / more kinetic energy
  allow molecules move faster / more collisions

  or
  (decreases) because the enzyme is denatured.
  context must be clear = high temperature

  allow other factor plus effect plus explanation:
  eg light wavelength / colour / pigments / chlorophyll / pH / minerals / ions / nutrients / size of leaves
  2nd or 3rd mark can be gained from correct description and explanation

5
**Q29.**

(a) Light is trapped / absorbed / used

*extra answers cancel mark*

Ignore solar / sunshine

By chlorophyll / chloroplasts

*if no other marks awarded, allow 1 mark for photosynthesis / equation for photosynthesis*

(b) (to make) starch (for storage)

Ignore 'for growth' unqualified

Ignore respiration

(to make) fat / oil (for storage)

(to make) amino acids / proteins / enzymes

(to make) cellulose / cell walls

Allow for active transport

Allow any other correct, named organic substances (eg DNA / ATP / chlorophyll / hormone)

If no named examples, allow 'to make named cell structures' for max. 1 mark

**Q30.**

(a) Use of quadrat / point frame

*allow description*

Randomly placed / random sampling

Ignore reference to transects

(b) (i) 6

(ii) More light in A / in field / where sunny

Ignore sun

More / better / faster photosynthesis in A / with more light

Allow converse

(iii) Use light meter / measure light intensity in both habitats

Take many measurements at same time of the day

Or
laboratory / field investigation with 2 batches high light and low light (1)

count or number of flowers in each (1)

counting point is dependent on investigation point

(c) more glucose / energy available

allow other named product eg protein

allow if more energy produced

for growth

dependent on 1st mark

Q31.

(a) reduces biodiversity

peat is being used faster than it forms

allow peat is non-renewable

(b) decay / decomposition / rotting of peat

by microorganisms / bacteria / microbes / fungi / decomposers introduced when peat is mixed with air

that respire using substances in peat as reactant

and using oxygen that is introduced when peat is mixed with air