Materials
For this paper you must have:
- Ruler
- Pencil, Rubber, Protractor and Compass
- Scientific calculator, which you are expected to use when appropriate

Instructions
- Answer all questions
- Answer questions in the space provided
- All working must be shown
- Do all rough work in this book. Cross out any rough work you don't want to be marked

Information
- The marks for the questions are shown in brackets
Plants make glucose by photosynthesis.

(a) Complete the word equation for photosynthesis.

\[ \text{__________________} + \text{__________________} \rightarrow \text{glucose} + \text{__________________} \]  

(b) What is the name of the chemical that makes a leaf look green?

Tick one box.

- Cellulose
- Chlorophyll
- Chloroplast
- Chromosome

(c) A test for starch is used to show that a plant has photosynthesised.

How does the presence of starch show that photosynthesis has taken place?

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A student investigated where starch was made in a leaf.

She used a leaf that was part green and part white as shown in the diagram.

This is the method used.

1. Put the leaf in boiling water for 1 minute.
   Reason: stops all chemical reactions in the leaf.

2. Transfer the leaf to boiling ethanol for 5 minutes.
   Reason: removes the green colour.

3. Dip the leaf in hot water.
   Reason: softens the leaf.

4. Spread the leaf on a white tile and test with iodine solution.
   Reason: stains any starch.

(d) If the chemical reactions in the leaf were not stopped, the amount of starch in the leaf would decrease.

Give the reason why.

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(1)

(e) Suggest why it is important to remove the green colour from the leaf before adding iodine solution.

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(1)
(f) Ethanol is flammable.

The student wore safety goggles when testing the leaf for starch.

Give one other safety precaution the student should have taken.

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(g) Look at the leaf in the diagram.

What colour would part A and part B stain with iodine solution after the starch test?

A ______________________
B ______________________

(Total 8 marks)

Green plants can make glucose.

(a) Plants need energy to make glucose.

How do plants get this energy?

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(Total 8 marks)
(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.

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(4) (Total 6 marks)
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’.

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 cm$^3$ per minute.

Use information from the 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 = _______________ cm$^3$

Person 2’s cardiac output = _______________ cm$^3$ per minute
(b) **Person 2** had a much lower cardiac output than **Person 1**.

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

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________________________________________________________________________

(1)

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

Use information from the figure above and your own knowledge to explain why.

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(5)

(Total 9 marks)
Plants absorb light to photosynthesise.

(a) What is the correct word equation for photosynthesis?

Tick one box.

- carbon dioxide + glucose $\rightarrow$ oxygen + water
- glucose + oxygen $\rightarrow$ carbon dioxide + water
- oxygen + water $\rightarrow$ carbon dioxide + glucose
- water + carbon dioxide $\rightarrow$ oxygen + glucose
Figure 1 shows some of the apparatus that can be used to measure the rate of photosynthesis.

The rate of photosynthesis in the pondweed is affected by different colours of light.

Describe a method you could use to investigate this.

You should include:

• what you would measure
• variables you would control.

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A scientist carried out a similar investigation.

Her results are shown in Figure 2.

The scientist said:

‘Light stops being a limiting factor at a light intensity of 20 units.’

Give evidence from Figure 2 to support this statement.

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(d) What could be limiting the rate of photosynthesis at a light intensity of 25 units?

Give one factor.

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(Total 9 marks)
After running for several minutes, the athlete’s leg muscles began to ache. This ache was caused by a high concentration of lactic acid in the muscles.

(a) The equation shows how lactic acid is made.

\[
\text{glucose} \rightarrow \text{lactic acid (} + \text{ energy)}
\]

Name the process that makes lactic acid in the athlete’s muscles.

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(1)
(b) Scientists investigated the production of lactic acid by an athlete running at different speeds.

In the investigation:

• the athlete ran on the treadmill at 4 km per hour
• the scientists measured the concentration of lactic acid in the athlete’s blood after 2 minutes of running.

The investigation was repeated for different running speeds.

**Figure 2** shows the scientists’ results.

(i) How much more lactic acid was there in the athlete’s blood when he ran at 14 km per hour than when he ran at 8 km per hour?

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Answer = _____________ mmol per dm$^3$

(2)
(ii) Why is more lactic acid made in the muscles when running at 14 km per hour than when running at 8 km per hour?

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(3)
(Total 6 marks)

The diagram below shows a single-celled alga which lives in fresh water.

6

(a) Which part of the cell labelled above:

(i) traps light for photosynthesis

______________________________________________________________

(ii) is made of cellulose?

______________________________________________________________

(b) In the freshwater environment water enters the algal cell.

(i) What is the name of the process by which water moves into cells?

______________________________________________________________

(1)
(ii) Give the reason why the algal cell does not burst.

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(1)

(c) (i) The alga can photosynthesise.

Complete the **word** equation for photosynthesis.

\[
\text{water} + \underline{\text{___________}} \rightarrow \underline{\text{___________}} + \text{oxygen}
\]

(2)

(ii) The flagellum helps the cell to move through water. Scientists think that the flagellum and the light-sensitive spot work together to increase photosynthesis.

Suggest how this might happen.

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(2)

(d) Multicellular organisms often have complex structures, such as lungs, for gas exchange.

Explain why single-celled organisms, like algae, do **not** need complex structures for gas exchange.

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(3)

*(Total 11 marks)*
A student ran on a treadmill for 5 minutes.
The speed of the treadmill was set at 12 km per hour.

The graph below shows the effect of the run on the student’s heart rate.

(a) (i) What was the student’s heart rate at rest?

_______________ beats per minute

(1)

(ii) After the end of the run, how long did it take for the student’s heart rate to return to the resting heart rate?

_______________ minutes

(1)
(b) During the run, the student's muscles needed larger amounts of some substances than they needed at rest.

(i) Which two of the following substances were needed in larger amounts during the run?

Tick (√) two boxes.

- carbon dioxide
- glucose
- lactic acid
- oxygen
- protein

(ii) Why are the two substances you chose in part (b)(i) needed in larger amounts during the run?

Tick (√) one box.

- To help make more muscle fibres
- To release more energy
- To help the muscles to cool down
(c) After exercise, a fit person recovers faster than an unfit person.

Let the student’s heart rate at the end of exercise = \( a \).

Let the student’s heart rate after 2 minutes of recovery = \( b \).

The table below shows how the difference between \( a \) and \( b \), \((a - b)\), is related to a person’s level of fitness.

<table>
<thead>
<tr>
<th>((a - b))</th>
<th>Level of fitness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 22</td>
<td>Unfit</td>
</tr>
<tr>
<td>22 to 52</td>
<td>Normal fitness</td>
</tr>
<tr>
<td>53 to 58</td>
<td>Fit</td>
</tr>
<tr>
<td>59 to 65</td>
<td>Very fit</td>
</tr>
<tr>
<td>&gt; 65</td>
<td>Top athlete</td>
</tr>
</tbody>
</table>

What is the student’s level of fitness?

Use information from the graph and the table.

\( a = \) ___________ beats per minute

\( b = \) ___________ beats per minute

\((a - b) = \) ___________ beats per minute

Level of fitness = __________________________________
(d) The student repeated the run with the treadmill set at 16 km per hour.

The student’s heart rate took 3 minutes longer to return to the normal resting rate than when running at 12 km per hour.

Give reasons why it took longer to recover after running faster.

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(Total 12 marks)

(a) Complete the equation for photosynthesis. Draw a ring around each correct answer.

\[
\text{Carbon dioxide} + \text{hydrogen} + \text{nitrogen} + \text{water} \rightarrow \text{light energy} \rightarrow \text{alcohol} + \text{glucose} + \text{oxygen} + \text{methane}
\]
Some students investigated the effect of light intensity on the rate of photosynthesis in pondweed.

The diagram shows the apparatus the students used.

The closer the lamp is to the pondweed, the more light the pondweed receives.

The students placed the lamp at different distances, \( d \), from the pondweed.

They counted the number of bubbles of gas released from the pondweed in 1 minute for each distance.

(b) A thermometer was placed in the glass beaker.

Why was it important to use a thermometer in this investigation?

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(3)
(c) The students counted the bubbles four times at each distance and calculated the correct mean value of their results.

The table shows the students’ results.

<table>
<thead>
<tr>
<th>Distance d in cm</th>
<th>Number of bubbles per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
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<tr>
<td>10</td>
<td>52</td>
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<tr>
<td>20</td>
<td>49</td>
</tr>
<tr>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

(i) Calculate the mean number of bubbles released per minute when the lamp was 40 cm from the pondweed.

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Mean number of bubbles at 40 cm = ______________________

(2)
(ii) On the graph paper below, draw a graph to show the students’ results:

- add a label to the vertical axis
- plot the mean values of the number of bubbles
- draw a line of best fit.

(iii) One student concluded that the rate of photosynthesis was inversely proportional to the distance of the lamp from the plant.

Does the data support this conclusion?

Explain your answer.

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(2)
Light intensity, temperature and concentration of carbon dioxide are factors that affect the rate of photosynthesis.

Scientists investigated the effects of these three factors on the rate of photosynthesis in tomato plants growing in a greenhouse.

The graph below shows the scientists’ results.
A farmer in the UK wants to grow tomatoes commercially in a greenhouse.

The farmer read about the scientists’ investigation.

During the growing season for tomatoes in the UK, natural daylight has an intensity higher than 30 000 lux.

The farmer therefore decided to use the following conditions in his greenhouse during the day:

• 20°C
• 0.1% CO₂
• no extra lighting.

Suggest why the farmer decided to use these conditions for growing the tomatoes.

You should use information from the scientists’ graph in your answer.

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(4)
(Total 17 marks)