

Photosynthesis

Mark Scheme



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1. Photosynthesis is the fundamental process by which green plants and some other organisms convert light energy into chemical energy in the form of glucose. Answer the following questions. Circle the letter of the correct answer for each.

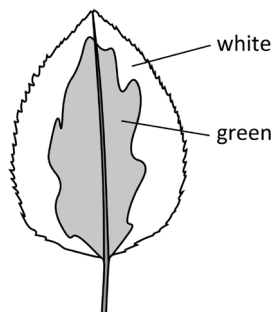
- a) The diagram shows an experiment to investigate the balance between respiration and photosynthesis. In which tube are photosynthesis and respiration both taking place at the same time?

D – is the only correct answer.	1 mark
	Total: 1 mark

- b) The equation for photosynthesis is shown.
Which words correctly complete gaps 1, 2 and 4?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) A plant with variegated leaves was kept in bright sunlight for 4 hours.
The figure below shows the leaf.



A leaf was taken from the plant and the chlorophyll was removed by boiling it in ethanol. The leaf was then tested for starch using iodine solution. Which diagram shows the correct result of the test?

B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 3 marks)

2. Plants carry out photosynthesis in order to have chemical energy for their processes.

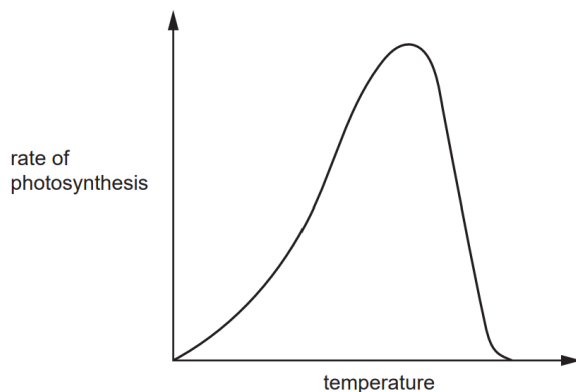
a) Identify the **two** substances produced by photosynthesis.

1 mark for each product of photosynthesis	
Glucose	1 mark
Oxygen	1 mark
	Total: 2 marks

b) Give the balanced symbol equation for the process of photosynthesis.

$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$	
1 mark for the correctly balanced reactants.	1 mark
1 mark for the correct formula for glucose. ($\text{C}_6\text{H}_{12}\text{O}_6$)	1 mark
1 mark for the correctly balanced products.	1 mark
	Total: 3 marks

A student investigated how temperature affects the rate of photosynthesis. The figure below shows the rate of photosynthesis as temperature increased.



All other variables were kept constant.

c) Explain why the rate of photosynthesis decreased after 25 degrees Celsius.

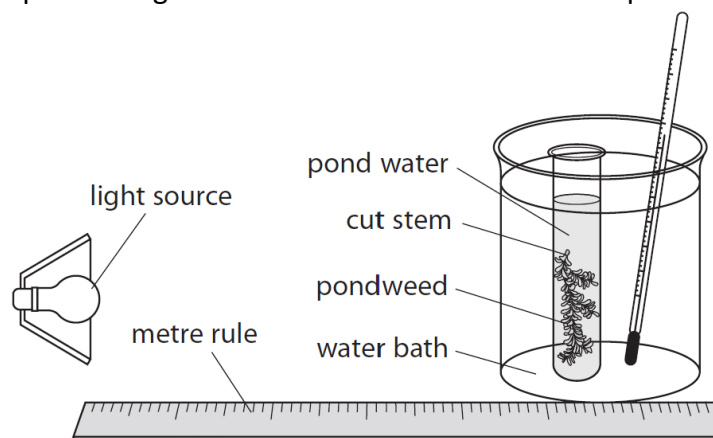
An explanation to include any three of the following:	
Photosynthesis is controlled by / involves enzymes.	1 mark
At high temperatures / temperatures above the optimum / above 25 °C the enzyme(s) denature / denatures.	1 mark
The active site (of the enzyme) changes shape	1 mark
So the substrate / reactants cannot bind / fit (into the active site).	1 mark
Accept: enzyme-substrate complex cannot form.	
This leads to a decrease / slowing / stopping of the reaction / rate of photosynthesis.	1 mark
	Total: 3 marks

d) Identify **two** other variables that would need to be kept constant during this practical.

Any two from:	
- Light intensity. - Carbon dioxide (CO_2) concentration. - Amount / mass / species / type / age of plant / pondweed / algae.	
	Total: 2 marks

(Total for Question 2 is 10 marks)

3. A student did an investigation to determine the effect of light intensity on the photosynthesis of pondweed. The student placed a light source at set distances from the pondweed.



- a) State **two** variables that should be controlled when completing this investigation.

Any two from:	
• Temperature (of water / water bath). • Carbon dioxide (CO₂) concentration. • Amount / mass / species / type / age / length of pondweed. • Wavelength / colour of light. Accept: use the same lamp or light source. • pH (of the pond water). • Time allowed for counting bubbles	
	Total: 2 marks

- b) Give the **word** equation for the process of photosynthesis.

Carbon dioxide + water → glucose + oxygen	
1 mark for correct reactants.	1 mark
1 mark for correct products.	1 mark
	Total: 2 marks

- c) Describe the role of chlorophyll in photosynthesis.

A description to include:	
The chlorophyll absorbs or traps light energy. Accept 'collects light'	1 mark
Light energy is then used in photosynthesis.	1 mark
Accept 'transfers energy to make glucose / sugar / food'.	
	Total: 2 marks

- d) Which organelle is the site of photosynthesis within the plant cell?

Chloroplast	1 mark
	Total: 1 mark

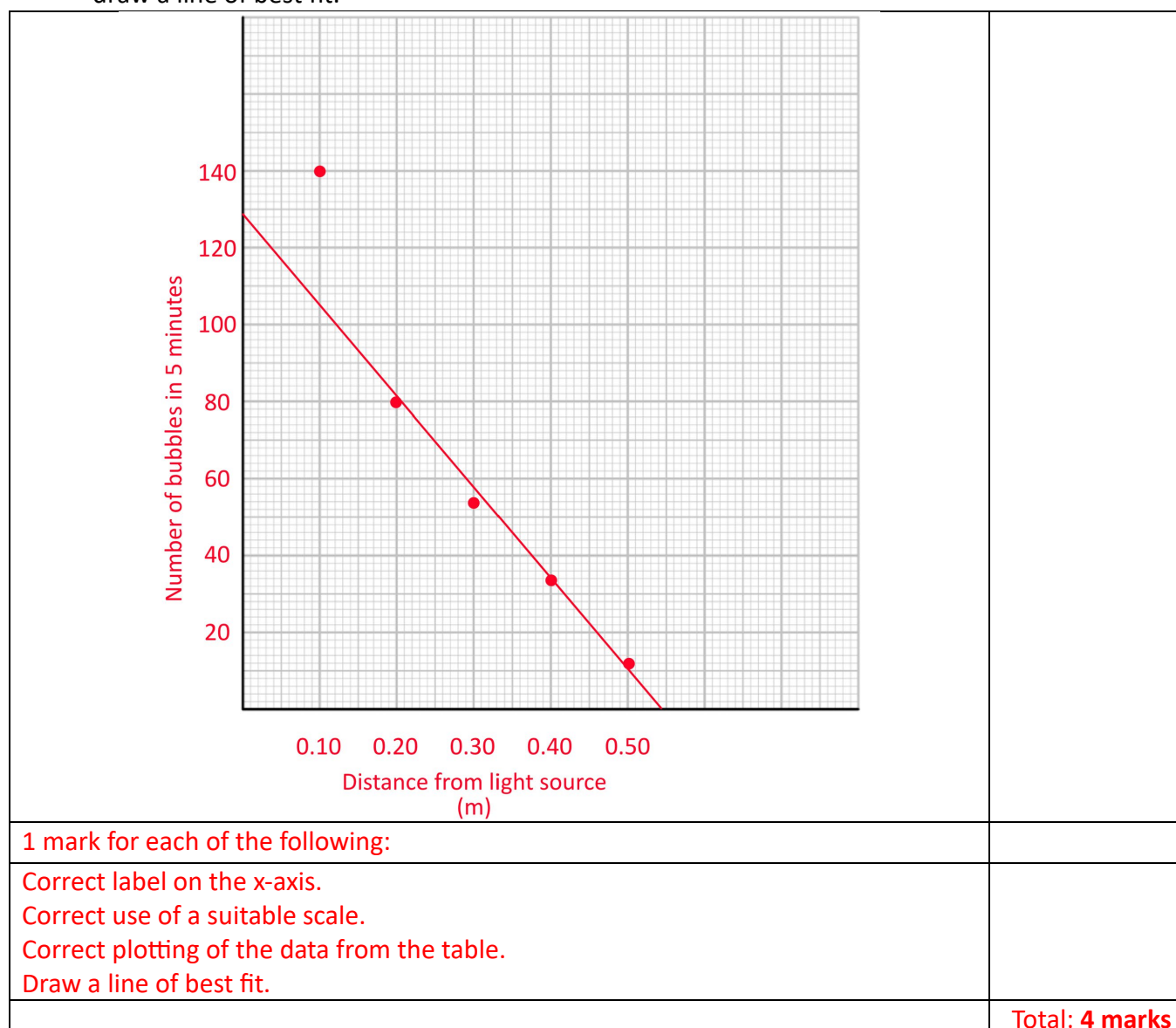
- e) Why did the student include a water bath in their apparatus.

To keep the temperature constant / stable / controlled.	1 mark
As the lamp produces / gives off heat	1 mark
Accept: because temperature affects the rate of photosynthesis / enzyme activity.	
	Total: 2 marks

Distance of the light source (m)	Number of bubbles in 5 minutes
0.10	140
0.20	80
0.30	55
0.40	34
0.50	12

f) Plot the student's results on the graph below.
You should:

- label the x-axis.
- use a suitable scale.
- plot the data from the table.
- draw a line of best fit.



g) Determine the mean value of the number of bubbles produced.

$68 + 75 + 82 + 84 + 81 = 390$	1 mark
$390 \div 5 = 78$	1 mark
	Total: 2 marks

(Total for Question 3 is 15 marks)

4. Explain how light intensity, carbon dioxide concentration, and temperature can each affect the rate of photosynthesis in a plant.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple statements are made describing how at least one factor affects the rate of photosynthesis (e.g., more light increases the rate).
Level 2	3 - 4	A clear explanation is given, describing how at least two factors affect the rate of photosynthesis. There may be some attempt to link factor changes to rate changes.
Level 3	5 - 6	A detailed and coherent explanation is given, which explains how all three factors (light intensity, CO ₂ concentration, and temperature) affect the rate of photosynthesis. Logically links factor changes to rate changes, including concepts such as limiting factors, optimum temperature, and denaturation where appropriate.

Indicative content:	
Light Intensity: - Provides the energy for photosynthesis. - As light intensity increases, the rate of photosynthesis increases (up to a certain point). - Because more energy is available (for the reactions / chlorophyll). - At high light intensity, the rate becomes constant / plateaus. - Because another factor (e.g., CO₂ or temperature) is limiting the rate. Carbon Dioxide (CO₂) Concentration: - CO₂ is a reactant / substrate (used to make glucose). - As CO₂ concentration increases, the rate of photosynthesis increases (up to a certain point). - Because more substrate / CO₂ is available (to react / for enzymes). - At high CO₂ concentration, the rate becomes constant / plateaus. - Because another factor (e.g., light or temperature) is limiting the rate. Temperature: - Affects the enzymes involved in photosynthesis. - As temperature increases (up to the optimum), the rate of photosynthesis increases. - Because molecules / enzymes / substrates have more kinetic energy. - Leading to more frequent (successful) collisions (between enzymes and substrates). - Above the optimum temperature, the rate decreases. - Because the enzymes denature. (Denaturation means) the active site changes shape. - So the substrate can no longer bind (effectively).	
	Total: 6 marks

(Total for Question 4 is 6 marks)

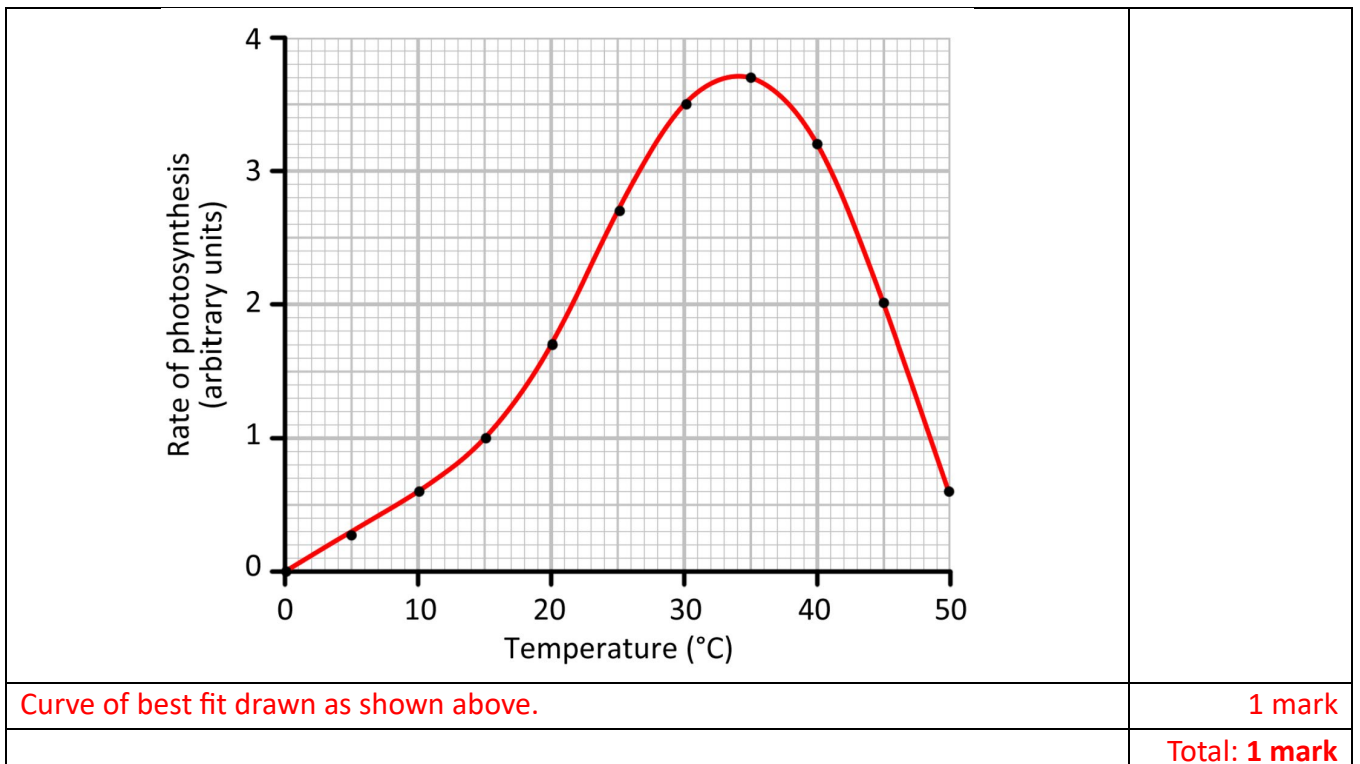
5. Photosynthesis involves reactions that are endothermic.

a) What is an endothermic reaction?

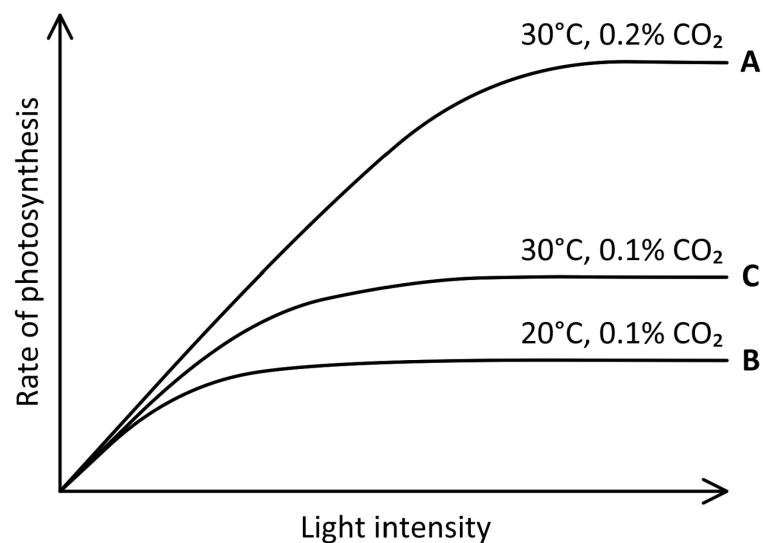
A reaction that takes in energy (heat) or absorbs energy.	1 mark
From the surroundings.	1 mark
	Total: 2 marks

b) The graph is from an experiment to show the effect of temperature on the rate of photosynthesis.

Draw the line of best fit for this graph.



Look at the graph. It shows how light intensity affects the rate of photosynthesis. The lines show different carbon dioxide concentrations and temperatures.



- c) Explain what is limiting the rate of photosynthesis at the three points A, B and C on the graph. Use evidence from the graph in your answer.

An explanation to include:	
Point A. Limiting factor: Light (intensity) Evidence: Because rate increases as light intensity increases (along the initial slope) / all three lines are following the same initial path which rises with light intensity / the graph starts at zero rate with zero light.	1 mark
Point B: Limiting factor: Temperature. Evidence: Because increasing light intensity (beyond B) does not increase the rate / the line has flattened/plateaued AND the rate at B (20 °C) is lower than the rate at C (30 °C) (at the same light intensity and CO ₂ concentration).	1 mark
Point C Limiting factor: Carbon dioxide / CO ₂ (concentration) Evidence: Because increasing light intensity (beyond C) does not increase the rate / the line has flattened/plateaued AND the rate at C (0.1% CO ₂) is lower than the rate on the top curve (0.2% CO ₂) (at the same light intensity and temperature).	1 mark
	Total: 3 marks

- d) Give the balanced symbol equation for the process of photosynthesis.

$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$	
1 mark for the correctly balanced reactants.	1 mark
1 mark for the correct formula for glucose. (C ₆ H ₁₂ O ₆)	1 mark
1 mark for the correctly balanced products.	1 mark
	Total: 3 marks

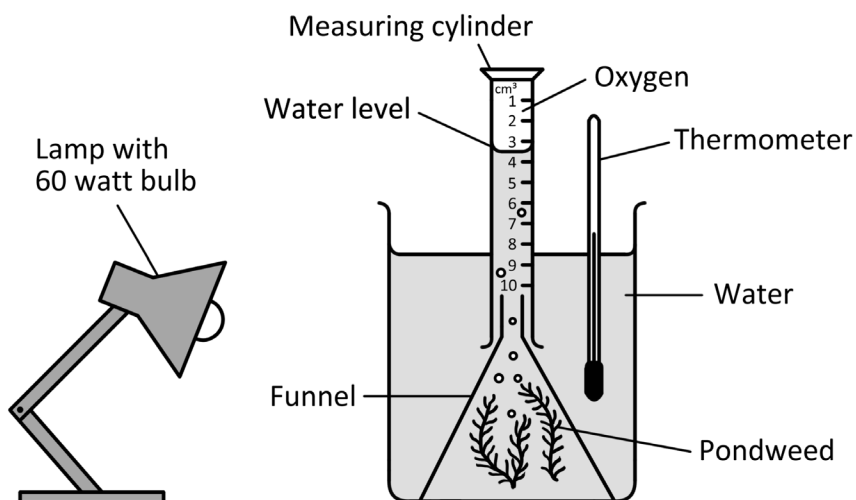
- e) Outline what happens to the glucose produced during photosynthesis in a plant.
Give at least **two** different uses.

Any three from:	
- Used for respiration (to release energy) - Converted into starch for storage - Converted into cellulose (for making) cell walls / strengthening cell walls - Converted into lipids / fats / oils (for storage / in seeds) - Used to make amino acids / proteins (requires nitrates / nitrogen) (for growth / enzymes) - Converted into sucrose for transport (in the phloem) - Converted into other carbohydrates / sugars (e.g., fructose in fruit).	
	Total: 3 marks

(Total for Question 5 is 12 marks)

6. A student is investigating the effect of light intensity on the rate of photosynthesis in a species of pondweed. They set up the following experiment:

A piece of pondweed is placed in a beaker of water connected to an inverted measuring cylinder to collect any gas produced. A lamp is used as the light source. The figure below shows the apparatus.



The distance between the lamp and the beaker is varied, and the volume of gas collected in 5 minutes is recorded at each distance.

- a) Name the gas that the pondweed is producing during photosynthesis.

Oxygen.	1 mark
	Total: 1 mark

The intensity of light decreases as the distance from the light source increases. The relationship between light intensity and distance follows the inverse square law.

- b) State the inverse square law in words, relating light intensity and distance.

Light intensity is inversely proportional to the square of the distance from the source.	1 mark
	Total: 1 mark

- c) Using the student's results, explain whether the change in the volume of gas collected supports the idea that light intensity follows the inverse square law in this experiment. You should refer to the data in your answer.

An explanation to include:	
Statement that inverse square law means if distance doubles, intensity quarters (or similar quantitative relationship e.g. triples distance)	1 mark
Statement linking light intensity to rate of photosynthesis / volume of gas collected (e.g. lower intensity means less photosynthesis/less gas).	1 mark
Selection of appropriate data points from the table (at least two distances and corresponding volumes).	1 mark
Calculation/comparison based on the inverse square law using selected data.	1 mark
Comparison of actual results vs expected results based on the inverse square law.	1 mark
Conclusion stating whether the results support (or partially support / do not support) the inverse square law, justified by the comparison.	1 mark
	Total: 4 marks

d) Suggest **one** way the student could improve the reliability of their results.

Repeat the experiment / readings (at each distance) and calculate a mean / average.	1 mark
	Total: 1 mark

e) Suggest **one** practical limitation of this experimental setup that might affect the accuracy of the results related to the inverse square law.

Any one practical limitation and linked affect from below:	
- Heat from the lamp. - Alters the temperature of the water / affects the rate of photosynthesis (independent of light intensity) / affects enzyme activity / affects gas solubility. - Other factors may become limiting at high light intensity / close distances. - Such as carbon dioxide concentration (or temperature), preventing the rate from reflecting the true light intensity increase . - Difficulty in measuring the <i>exact</i> distance. - measuring from the filament vs lamp casing vs edge of beaker / curvature of beaker affects distance light travels through water. - Ambient / background light affecting the pondweed. - Meaning the measured rate isn't solely due to the lamp's light / the effect of background light is proportionally greater at larger distances from the lamp.	
	Total: 2 marks

(Total for Question 6 is 9 marks)