1.19 Photosynthesis: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Evaluate the economic (financial) advantages and disadvantages for a commercial grower of installing carbon dioxide enrichment and supplementary lighting equipment in a glasshouse, in order to increase crop yield.

(Total for Question 1 is 6 marks)

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2 In an experiment, it was found that for every 22 g of carbon dioxide absorbed by a plant during photosynthesis, 15 g of glucose was produced (assuming none of the glucose was used for anything else during the experiment).

(a) Calculate the mass of glucose that would be produced from 264 g of carbon dioxide, assuming the same ratio applies. Show your working. **(3)**

(b) A student claims that doubling the mass of carbon dioxide supplied to a plant will always exactly double the mass of glucose produced by the plant in a given time. Evaluate this claim, using the idea of limiting factors. **(2)**

(c) In a real experiment, 264 g of carbon dioxide was supplied to a plant over a fixed time, but not all of it was absorbed. The mass of glucose produced was only 165 g, with none used for anything else during the experiment. Suggest and explain one reason why less glucose was produced than the 180 g calculated in part (a). **(2)**

(Total for Question 2 is 7 marks)

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3 A commercial grower recorded the rate of oxygen production by photosynthesis from a crop in a glasshouse with supplementary lighting, over a 24-hour period. Oxygen was produced at a constant rate of 45 cm^3 per minute throughout the 12 hours of daylight (from 06:00 to 18:00), and photosynthesis did not occur during the remaining 12 hours of darkness.

(a) Calculate the total volume of oxygen produced by photosynthesis during the 12 hours of daylight. Give your answer in dm^3. **(4)**

(b) Suggest why the rate of oxygen production by photosynthesis would not actually stay exactly constant throughout the 12 hours of daylight in a real glasshouse without supplementary lighting. **(2)**

(Total for Question 3 is 6 marks)

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4 Photosynthesis can be represented by the following (unbalanced) symbol equation:

$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$

(a) Balance the symbol equation above by adding the correct number in front of each formula where needed. **(2)**

(b) Add the correct state symbols to each substance in the balanced equation, showing carbon dioxide and oxygen in the air, and water and glucose inside a leaf cell. **(2)**

(Total for Question 4 is 4 marks)

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5 The rate of photosynthesis is affected by several environmental factors.

(a) Define the term 'limiting factor'. **(1)**

(b) State three factors that can limit the rate of photosynthesis. **(3)**

(c) Give one reason why commercial tomato growers often grow their plants in glasshouses (greenhouses) where light intensity, carbon dioxide concentration and temperature can all be controlled. **(1)**

(Total for Question 5 is 5 marks)

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6 Describe one source of systematic error in gas collection during a pondweed experiment and how to reduce its effect.

(a) Describe a possible systematic error and a measure to reduce it, and explain how the measure reduces the error. **(3)**

(Total for Question 6 is 3 marks)

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7 A student investigates how light intensity affects the rate of photosynthesis using an aquatic plant Elodea. They place a lamp at three distances and record the number of bubbles produced in 2 minutes. The data are: distance 10 cm -> 48 bubbles; 20 cm -> 12 bubbles; 30 cm -> 6 bubbles.

(a) Calculate the rate of bubbles per minute at 10 cm. Give your answer to 2 significant figures and include units. **(2)**

(b) Explain why the rate falls as the lamp is moved from 10 cm to 30 cm. **(1)**

(Total for Question 7 is 3 marks)

8 A student records oxygen volume produced by a piece of pondweed over 4 one-minute intervals at a fixed light intensity. Volumes recorded: 2.2 cm^3, 2.0 cm^3, 0.4 cm^3, 2.0 cm^3. The third reading is suspected to be an anomaly.

(a) Calculate the mean oxygen volume per minute excluding the anomalous third reading. Give your answer to two decimal places and include units. **(2)**

(b) Give one possible reason why the third reading was much lower than the others and how to reduce this error in future repeats. **(2)**

(Total for Question 8 is 4 marks)

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9 A group investigated the effect of temperature on the rate of photosynthesis of pondweed, keeping light intensity and carbon dioxide concentration constant. Their results are shown in the table below.

Temperature (°C): 10, 20, 30, 40, 45, 50
Rate of photosynthesis (arbitrary units): 4, 9, 15, 18, 10, 2

Temperature (°C)	Rate of photosynthesis (arbitrary units)
10	4
20	9
30	15
40	18
45	10
50	2

(a) Describe how the rate of photosynthesis changes as temperature increases from 10 to 40°C. **(2)**

(b) Describe and explain the change in the rate of photosynthesis between 40 and 50°C. **(3)**

(c) State the approximate optimum temperature for photosynthesis shown by this data. **(1)**

(Total for Question 9 is 6 marks)

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10 A student used a gas syringe to collect the oxygen gas produced by a piece of pondweed placed under a bright lamp. In 5 minutes, the gas syringe collected 12.5 cm^3 of oxygen gas.

(a) Calculate the mean rate of oxygen production, in cm^3 per minute. **(2)**

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(b) Convert this rate into mm^3 per second. Show your working. **(3)**

.....

(Total for Question 10 is 5 marks)

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Mark scheme · 1.19 Photosynthesis: 1-hour Pack

Question 1

Level 3 A detailed, logically structured evaluation of both the financial advantages and disadvantages of installing carbon dioxide enrichment and supplementary lighting, leading to a clear, justified conclusion about whether it is likely to be worthwhile for a grower. Correct scientific and economic terminology is used throughout. **5-6**

Level 2 A description of some financial advantages and disadvantages of the equipment, with a simple attempt to weigh them against each other, though the reasoning or conclusion may be incomplete or one-sided. **3-4**

Level 1 Basic, isolated statements are made about the cost or benefit of controlling growing conditions, with little or no attempt to compare them or reach a justified conclusion. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Installing carbon dioxide enrichment and supplementary lighting equipment has an initial (capital) cost to purchase and install.
- There are ongoing running costs, such as electricity for lighting and heating, and the cost of the carbon dioxide supplied (or fuel burned to produce it).
- Removing light intensity or carbon dioxide concentration as a limiting factor increases the rate of photosynthesis, increasing the amount of glucose produced and so increasing plant growth and crop yield.
- A higher yield means more produce to sell, increasing the grower's revenue (income).
- Supplementary lighting can also extend the growing season or allow crops to be grown earlier or out of season, when selling prices may be higher.
- However, if only one limiting factor is removed (e.g. only carbon dioxide added, while light is still limiting), the increase in yield may be smaller than expected, giving a poorer return on the investment.
- There are diminishing returns: once light and carbon dioxide are no longer limiting, another factor (e.g. temperature) may limit the rate, so increasing light and carbon dioxide further gives little extra benefit for the additional cost.
- The extra revenue from the increased yield must be compared with the running costs to calculate the net financial benefit each year.
- The initial equipment cost is only recovered (paid back) over a number of years, so the investment is more worthwhile if the equipment lasts a long time and running costs stay low relative to the extra revenue generated.
- A justified conclusion should weigh the increase in revenue from higher yield against the installation and ongoing running costs, for example concluding that the investment is worthwhile if the payback period is short compared with the expected lifetime of the equipment, or not worthwhile if running costs are high relative to the extra revenue gained.
- Credit any scientifically and economically accurate evaluation that is clearly supported by comparing the costs and financial benefits described.

Question 2

(a) 264 / 22 = 12 (scale factor), oe **M1**

(a) 12 x 15, method shown **M1**

(a) 180 g cao **A1**

(a) Answer: 180 g

(b) this is not necessarily true for a real plant, oe **B1**

(b) if light intensity or temperature is limiting, doubling the carbon dioxide supplied need not double the amount absorbed in the given time, so glucose production need not double; the ratio in part (a) applies to carbon dioxide absorbed, oe **B1**

(b) Answer: Not necessarily true. If light intensity or temperature is limiting, doubling the carbon dioxide supplied need not double the amount absorbed in the given time, so glucose production need not double. The ratio in part (a) applies to carbon dioxide absorbed.

(c) light intensity or temperature may have been a limiting factor during the experiment, oe **B1**

(c) so not all of the supplied carbon dioxide was absorbed during the fixed time, meaning less glucose than predicted was produced; the mass conversion ratio for carbon dioxide absorbed is unchanged, oe **B1**

(c) Answer: Light intensity or temperature may have been limiting the rate of photosynthesis, so not all of the supplied carbon dioxide was absorbed during the fixed time. Less glucose was therefore produced, although the mass conversion ratio for carbon dioxide absorbed was unchanged.

Question 3

(a) converts 12 hours to minutes: 12 x 60 = 720 (minutes), oe **M1**

(a) total volume in cm^3 = 45 x 720, oe **M1**

(a) 45 x 720 = 32400 (cm^3), oe **M1**

(a) 32.4 dm^3 cao **A1**

(a) Answer: 32.4 dm^3

(b) natural light intensity changes throughout the day (e.g. rising after sunrise, then falling before sunset), oe **B1**

(b) since light intensity is a limiting factor, the rate of photosynthesis (and oxygen production) would rise and fall with it, rather than staying constant, oe (accept: temperature also varies through the day and could also cause the rate to vary) **B1**

(b) Answer: Natural light intensity rises and falls through the day. Since light intensity is a limiting factor, the rate of photosynthesis (and oxygen production) would rise and fall with it, rather than staying constant.

Question 4

(a) correctly balances at least two of the three formulae that need a coefficient ($6CO_2$, $6H_2O$, $6O_2$), oe **M1**

(a) fully balanced: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$, cao **A1**

(a) Answer: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

(b) (g) correctly used for carbon dioxide and for oxygen **B1**

(b) (l) correctly used for water and (aq) correctly used for glucose **B1**

(b) Answer: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

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Question 5

(a) a factor that, when in short supply, restricts (limits) the rate of a process such as photosynthesis, oe **B1**

(a) Answer: A factor that, when in short supply, restricts the rate of a process (such as photosynthesis).

(b) light intensity **B1**

(b) carbon dioxide concentration **B1**

(b) temperature **B1**

(b) Answer: Light intensity, carbon dioxide concentration and temperature.

(c) to prevent any one of these factors from becoming too low and limiting the rate of photosynthesis, keeping growth and crop yield as high as possible, oe **B1**

(c) Answer: To prevent any one factor from being too low and limiting the rate of photosynthesis, so growth and yield stay as high as possible.

Question 6

(a) identifies a systematic error such as temperature drift, leaking connections in gas syringe, or calibration error in measuring cylinder **M1**

(a) gives a linked method to reduce it such as use a thermostatted water bath, check and seal all joints with grease or tubing clips, or calibrate measuring device against a standard, oe **A1**

(a) explains how the measure reduces the bias in results (for example sealing stops gas loss so measured volume is closer to true volume), oe **B1**

(a) Answer: Example: a leaking syringe causes underestimation of gas volume. Reduce by sealing connections with clips or grease and check for leaks before starting; this prevents gas loss so collected volumes are more accurate.

Question 7

(a) divides 48 by 2 to get rate (substitution step) **M1**

(a) 24 bubbles per minute cao **A1**

(a) Answer: 24 bubbles per minute

(b) less light reaches the plant at greater distance so less energy for photosynthesis so rate decreases, oe **B1**

(b) Answer: Less light reaches the plant at greater distance, so less energy for photosynthesis and a lower rate of bubble production.

Question 8

(a) adds 2.2 + 2.0 + 2.0 and divides by 3 (shows method) **M1**

(a) 2.07 cm^3 per minute cao **A1**

(a) Answer: 2.07 cm^3 per minute

(b) identifies a plausible cause such as a bubble stuck on the pondweed, disturbance of apparatus, or lamp briefly moved **M1**

(b) suggests an improvement such as tapping the apparatus to release trapped bubbles, secure lamp and apparatus, or wait until steady production before timing, oe **A1**

(b) Answer: Possible cause: a bubble was stuck and not recorded. Improvement: tap the apparatus gently to release bubbles before timing or discard initial unstable readings and repeat.

Question 9

(a) the rate of photosynthesis increases as temperature increases, oe **B1**

(a) correctly uses data from the table to support this, e.g. from 4 units at 10°C to 18 units at 40°C, oe **B1**

(a) Answer: The rate of photosynthesis increases steadily as temperature rises, from 4 units at 10°C to 18 units at 40°C.

(b) the rate decreases (falls sharply), oe **B1**

(b) this is because the enzymes involved in the reactions of photosynthesis begin to denature above the optimum temperature, oe **B1**

(b) the active site of the enzyme changes shape, so the substrate can no longer bind (fit), reducing the rate of the enzyme-controlled reactions, oe **B1**

(b) Answer: The rate falls sharply, because above the optimum temperature the enzymes involved in photosynthesis denature; the active site changes shape so the substrate can no longer bind, slowing the reactions.

(c) 40°C cao (accept any value in the range 38-42°C, since the exact peak is not shown by the data given) **B1**

(c) Answer: Approximately 40°C.

Question 10

(a) 12.5 / 5, oe **M1**

(a) 2.5 cm^3/min cao **A1**

(a) Answer: 2.5 cm^3 per minute.

(b) converts cm^3 to mm^3: 2.5 x 1000 = 2500 (mm^3 per minute), oe **M1**

(b) converts per minute to per second: 2500 / 60, oe **M1**

(b) 41.7 mm^3/s (awrt), cao **A1**

(b) Answer: 41.7 mm^3 per second (or 41.67 mm^3/s to 2 decimal places).

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