B4aD Photosynthesis: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Plants convert light energy into chemical energy by photosynthesis.

(a) Name the gas produced by photosynthesis that is released to the atmosphere. **(1)**

(Total for Question 1 is 1 mark)

2 Complete the word equation for photosynthesis.

(a) Fill in the missing words: carbon dioxide + water -> + oxygen **(2)**

(Total for Question 2 is 2 marks)

3 State which part of a leaf contains most chloroplasts and so is specialised for photosynthesis.

(a) Name the tissue layer in the leaf that contains palisade cells. **(1)**

(b) Give one feature of palisade cells that helps them absorb light. **(1)**

(Total for Question 3 is 2 marks)

4 A student balances the symbol equation for photosynthesis. Balance the equation below by adding whole-number coefficients where needed.

CO2 + H2O -> C6H12O6 + O2

(a) Write the fully balanced equation using whole-number coefficients. **(2)**

(b) State the physical state symbols appropriate for CO2, H2O (inside leaf cells), C6H12O6 and O2 in the equation. **(1)**

(Total for Question 4 is 3 marks)

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5 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)**

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

(Total for Question 5 is 3 marks)

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6 In the same Elodea experiment, the student kept the lamp brightness the same but changed distance. State one control variable they should have kept the same and suggest how to control it.

(a) Give one control variable and explain how to keep it constant. **(3)**

(Total for Question 6 is 3 marks)

7 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 cm3, 2.0 cm3, 0.4 cm3, 2.0 cm3. 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)**

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(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 7 is 4 marks)

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8 Carbon dioxide concentration can be increased by adding sodium hydrogen carbonate to water in a photosynthesis experiment. Explain how increasing CO2 affects the rate of photosynthesis and what happens when CO2 is no longer the limiting factor.

(a) Explain the effect of increasing carbon dioxide concentration on rate and what occurs when CO2 stops limiting the rate. **(3)**

(Total for Question 8 is 3 marks)

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9 A farmer wants to increase crop yield in a greenhouse. Which two environmental factors could be controlled to increase the rate of photosynthesis? Give one practical method for controlling each factor.

(a) Give two factors and one method for each to control them in a greenhouse. **(3)**

(Total for Question 9 is 3 marks)

10 A leaf disc method measures rate qualitatively by observing how long it takes discs to float due to oxygen production. Which variable does the 'time for discs to float' best represent and why?

(a) Name the variable represented and give a brief explanation. **(2)**

(Total for Question 10 is 2 marks)

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11 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. **(3)**

(Total for Question 11 is 3 marks)

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12 Higher only: A balanced equation shows that 6 molecules of CO2 produce one molecule of glucose. If a plant fixes 3.0×10^{-3} moles of CO2 in a period, calculate the number of moles of glucose produced. Show your working and give the answer to two significant figures.

(a) Calculate the moles of glucose produced from 3.0×10^{-3} moles CO2. **(4)**

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(Total for Question 12 is 4 marks)

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13 A student measures net photosynthesis by measuring mass change of a plant in light and dark conditions over 24 hours. The plant lost 2.0 g in darkness and gained 4.5 g in light. Calculate the net gain due to photosynthesis over 24 hours.

(a) Calculate net gain and include unit. **(2)**

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(Total for Question 13 is 2 marks)

14 A biology class graphs rate of photosynthesis (mm3 O2 per minute) against light intensity (arbitrary units). The graph shows a curve that rises steeply at low light then levels off at high light. Explain what the shape of this curve tells you about limiting factors.

(a) Explain why the curve rises at low light and levels off at high light. **(3)**

(Total for Question 14 is 3 marks)

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15 An experiment uses pondweed in a gas syringe. The student times 10 repeats at the same light intensity and gets volumes in cm3: 2.1, 2.3, 2.2, 2.0, 2.2, 2.1, 2.2, 2.3, 2.1, 2.2. Calculate the standard deviation of these readings and comment briefly on whether the results are precise. (Use the population standard deviation formula.)

(a) Calculate the mean, then the population standard deviation. Give answers to two decimal places and include units. **(2)**

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(b) Comment on whether the results are precise. **(1)**

(Total for Question 15 is 3 marks)

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16 A gardener measures dry mass of leaves to estimate plant growth. State one reason why dry mass is a better measure of biomass than fresh mass and give one step in preparing a sample to measure dry mass accurately.

(a) Give reason and one preparation step. **(2)**

(Total for Question 16 is 2 marks)

17 Explain how light intensity, carbon dioxide concentration and temperature interact to determine the rate of photosynthesis. In your answer include how a gardener might manage these factors in a greenhouse to maximise crop growth. Use clear scientific reasoning and refer to limiting factors.

(Total for Question 17 is 6 marks)

Mark scheme · B4aD Photosynthesis: Exam Drill

Question 1

- (a) **B1** oxygen cao
- **(a) Answer: Oxygen**

Question 2

- (a) **B1** glucose or sugar
- (a) **B1** oxygen cao
- **(a) Answer: Glucose and oxygen**

Question 3

- (a) **B1** palisade mesophyll cao
- **(a) Answer: Palisade mesophyll**
- (b) **B1** contain many chloroplasts or are tall and packed near the upper surface of the leaf, oe
- **(b) Answer: Contain many chloroplasts**

Question 4

- (a) **M1** shows correct partial balancing or correct coefficients for at least two species (for example 6CO2 and 6H2O) or demonstrates correct atom count for C and H
- (a) **A1** 6CO2 + 6H2O -> C6H12O6 + 6O2 cao
- **(a) Answer: 6CO2 + 6H2O -> C6H12O6 + 6O2**
- (b) **B1** CO2(g), H2O(l), C6H12O6(aq) and O2(g) oe
- **(b) Answer: CO2(g), H2O(l), C6H12O6(aq), O2(g)**

Question 5

- (a) **M1** divides 48 by 2 to get rate (substitution step)
- (a) **A1** 24 bubbles per minute cao
- **(a) Answer: 24 bubbles per minute**
- (b) **B1** less light reaches the plant at greater distance so less energy for photosynthesis so rate decreases, oe
- **(b) Answer: Less light reaches the plant at greater distance, so less energy for photosynthesis and a lower rate of bubble production.**

Question 6

- (a) **M1** identifies a valid control variable such as temperature, carbon dioxide concentration, or volume of water
- (a) **A1** gives a method to keep it constant, e.g. use water at the same temperature or place beaker in a water bath set to a fixed temperature, or add a measured volume of sodium hydrogen carbonate to supply constant CO2, oe
- (a) **B1** makes the link that keeping this variable constant reduces its effect on the rate so results isolate the effect of light distance, oe
- **(a) Answer: Example: control temperature by placing the beaker in a water bath at a constant temperature; this keeps temperature constant so rate changes are due to light distance only.**

Question 7

- (a) **M1** adds 2.2 + 2.0 + 2.0 and divides by 3 (shows method)
- (a) **A1** 2.07 cm3 per minute cao
- **(a) Answer: 2.07 cm3 per minute**
- (b) **M1** identifies a plausible cause such as a bubble stuck on the pondweed, disturbance of apparatus, or lamp briefly moved
- (b) **A1** suggests an improvement such as tapping the apparatus to release trapped bubbles, secure lamp and apparatus, or wait until steady production before timing, oe
- **(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 8

- (a) **M1** states that increasing CO_2 increases rate because more reactant is available for photosynthesis
- (a) **A1** states that the rate increases up to a point because another factor (light or temperature) becomes limiting, oe
- (a) **B1** explains that beyond that point adding more CO_2 does not increase the rate as the enzymes or light supply limit the reaction, oe
- **(a) Answer: Increasing CO_2 increases the rate because more reactant is available; however the rate rises only until another factor such as light or temperature becomes limiting, after which further CO_2 has little effect.**

Question 9

- (a) **B1** factor: light; method: use artificial lamps or extend lighting hours
- (a) **B1** factor: carbon dioxide; method: release measured CO_2 gas or burn hydrocarbon heaters with controlled vents
- (a) **B1** factor: temperature; method: use heaters and thermostats to maintain an optimum temperature (accept any two factors with methods, award appropriately)
- **(a) Answer: Examples: light - use artificial lamps to increase light intensity; carbon dioxide - add controlled CO_2 enrichment; temperature - use heaters with thermostat to keep optimum temperature.**

Question 10

- (a) **M1** identifies that time to float is inversely related to rate of photosynthesis (i.e. a shorter time means a higher rate)
- (a) **A1** explains that oxygen produced fills the discs and makes them buoyant, so faster oxygen production gives shorter float time, oe
- **(a) Answer: Time to float, which is inversely related to rate of photosynthesis: a shorter time means a higher rate because more oxygen is produced faster, making discs buoyant.**

Question 11

- (a) **M1** identifies a systematic error such as temperature drift, leaking connections in gas syringe, or calibration error in measuring cylinder
- (a) **A1** 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
- (a) **B1** explains how the measure reduces the bias in results (for example sealing stops gas loss so measured volume is closer to true volume), oe
- **(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 12

- (a) **M1** states relationship glucose moles = CO_2 moles / 6 and substitutes: $3.0 \times 10^{-3} / 6$
- (a) **A1** 5.0×10^{-4} mol cao
- (a) **B1** gives answer to two significant figures (5.0×10^{-4}) and includes mol unit
- (a) **C1** correct final answer with units cao
- **(a) Answer: 5.0×10^{-4} mol**

Question 13

- (a) **M1** subtracts respiration loss from light gain: 4.5 - 2.0
- (a) **A1** 2.5 g cao
- **(a) Answer: 2.5 g**

Question 14

- (a) **M1** states that at low light the light is limiting so small increases in light give large increases in rate
- (a) **A1** states that at higher light levels another factor such as CO_2 concentration or temperature becomes limiting
- (a) **B1** explains that when another factor is limiting additional light does not increase rate so curve levels off, oe
- **(a) Answer: At low light the rate is limited by light so small increases give large increases in rate; at high light another factor (CO_2 or temperature) becomes limiting, so further increases in light do not increase the rate and the curve levels off.**

Question 15

- (a) **M1** calculates mean = sum / 10 = 21.7 / 10 = 2.17 cm3 or shows equivalent
- (a) **A1** correct standard deviation = 0.09 cm3 (to two dp) cao
- **(a) Answer: Mean = 2.17 cm3; standard deviation = 0.09 cm3**
- (b) **B1** states that the results are reasonably precise because the SD is small relative to the mean (for example SD about 4% of mean), oe
- **(b) Answer: The results are precise because the standard deviation is small compared with the mean (about 4% of the mean), showing little spread between repeats.**

Question 16

- (a) **B1** because fresh mass varies with water content whereas dry mass reflects actual biomass more reliably
- (a) **B1** dry samples in an oven at a set temperature until mass is constant or dry to constant mass and then weigh, oe
- **(a) Answer: Dry mass is better because fresh mass varies with water content; to measure dry mass, dry the leaves in an oven at a set temperature until the mass is constant, then weigh.**

Question 17

- **Level 3** (5-6): Detailed explanation. Candidate explains how each factor affects photosynthesis, describes interactions and limiting factors, and suggests linked, practical greenhouse management measures with justification.
- **Level 2** (3-4): Coherent explanation. Candidate explains two factors and recognises interaction or limiting factor concept; gives at least one reasonable management suggestion.
- **Level 1** (1-2): Basic points. Candidate identifies one or two factors with simple statements and limited or no explanation of interactions or management.
- **Indicative content:**
  - Light intensity increases rate because more energy is available for the light-dependent reactions; at low light this is often the limiting factor.
  - Carbon dioxide is a raw material; increasing CO2 increases rate until another factor limits the process.
  - Temperature affects enzyme activity in the Calvin cycle; low temperatures slow enzyme activity, high temperatures denature enzymes reducing rate.
  - Interaction: when light is high and CO2 low, CO2 is limiting; when CO2 is high and temperature low, temperature is limiting. The rate is determined by the current limiting factor.
  - Greenhouse management: use artificial lighting to raise light intensity during short days, enrich air with controlled CO2 supplies to avoid CO2 limitation, and maintain optimal temperature with heaters and ventilation; explain trade-offs such as cost and risk of overheating or CO2 wastage.
  - Reference to practical monitoring and balancing of factors to ensure none becomes limiting, and the need to avoid extreme temperatures that damage enzymes.