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Topics Covered:

- Photosynthesis

/ Mark 50

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1. a) Define photosynthesis. [2]

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b) Write the word equation for photosynthesis. [2]

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c) Write the balanced chemical equation for photosynthesis. [2]

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2. a) Name the pigment responsible for absorbing light energy in plants. [2]

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b) Explain how chlorophyll converts light energy into chemical energy during photosynthesis. [3]

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3. Leaf Structure and Adaptations

a) Draw a labelled diagram of a cross-section of a leaf, showing the following structures: [4]

- Upper epidermis
- Palisade mesophyll
- Spongy mesophyll
- Stomata
- Xylem and phloem

b) Explain how the palisade mesophyll is adapted for photosynthesis. [3]

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4. a) Define the term "limiting factor" in the context of photosynthesis. [2]

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b) List three factors that can limit the rate of photosynthesis. [3]

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c) Explain how increasing the light intensity affects the rate of photosynthesis, assuming other factors are constant. [3]

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5. Mineral Requirements in Plants

a) State the role of nitrate ions in plant growth. [2]

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b) Explain the effect of magnesium ion deficiency on a plant. [3]

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c) Describe how a plant absorbs minerals from the soil. [2]

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6. a) Compare the processes of photosynthesis and respiration in plants. [4]

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b) Explain why plants release oxygen during the day but consume oxygen at night. [3]

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7. a) Describe the steps involved in testing a leaf for starch. [4]

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b) Explain why the leaf must be destarched before the experiment. [2]

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c) What would you observe if a leaf tested positive for starch? [1]

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8. a) Explain how increasing carbon dioxide concentration in a greenhouse can improve crop yields. [3]

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b) Describe how farmers control temperature and light in greenhouses to optimize photosynthesis. [3]

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c) Why is it important to use red and blue light in greenhouses rather than green light? [1]

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9. a) Explain the role of photosynthesis in the carbon cycle. [3]

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b) Describe how carbon atoms are recycled between plants, animals, and the atmosphere. [4]

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10. A student wants to investigate the effect of carbon dioxide concentration on the rate of photosynthesis. Describe how the student could set up the experiment, including: [6]

- The apparatus used
- How to measure the rate of photosynthesis
- How to control other variables

Answers:

1. Photosynthesis Equation

a) **Definition of photosynthesis**:
Photosynthesis is the process by which green plants, algae, and some bacteria convert light energy into chemical energy, using carbon dioxide and water to produce glucose and oxygen. (2 marks)

b) **Word equation for photosynthesis**:
Carbon dioxide + Water → Glucose + Oxygen
(2 marks)

c) **Balanced chemical equation for photosynthesis**:
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
(2 marks)

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2. Chlorophyll and Energy Conversion

a) **Pigment responsible for absorbing light energy**:
Chlorophyll. (1 mark)

b) **How chlorophyll converts light energy into chemical energy**:
Chlorophyll absorbs light energy, primarily from the red and blue wavelengths, and uses it to excite electrons. These excited electrons are passed through an electron transport chain, generating ATP and NADPH. These energy carriers are then used in the Calvin cycle to convert carbon dioxide into glucose. (3 marks)

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3. Leaf Structure and Adaptations

a) **Labeled diagram of a cross-section of a leaf**:
(4 marks)
(Note: A diagram should include the following labeled structures: upper epidermis, palisade mesophyll, spongy mesophyll, stomata, xylem, and phloem.)

b) **Adaptation of palisade mesophyll for photosynthesis**:
The palisade mesophyll is located near the upper surface of the leaf, where it receives maximum light. It contains densely packed chloroplasts to maximize light absorption. The cells are elongated and arranged vertically to increase the surface area for photosynthesis. (3 marks)

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4. Limiting Factors in Photosynthesis

a) **Definition of limiting factor**:
A limiting factor is a variable that, when in short supply, restricts the rate of a process such as photosynthesis. (2 marks)

b) **Three factors that can limit photosynthesis**:

1. Light intensity
2. Carbon dioxide concentration
3. Temperature
   (3 marks)

c) **Effect of increasing light intensity on photosynthesis**:
As light intensity increases, the rate of photosynthesis increases proportionally, as more light energy is

available for the light-dependent reactions. However, once a certain light intensity is reached, the rate plateaus as other factors (e.g., CO_2 concentration or temperature) become limiting. (3 marks)

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5. Mineral Requirements in Plants

a) **Role of nitrate ions in plant growth**:
Nitrate ions are essential for the synthesis of amino acids, which are used to build proteins. Proteins are required for growth and repair in plants. (2 marks)

b) **Effect of magnesium ion deficiency**:
Magnesium is a key component of chlorophyll. A deficiency leads to chlorosis (yellowing of leaves) due to reduced chlorophyll production, which in turn reduces photosynthesis and stunts growth. (3 marks)

c) **How plants absorb minerals from the soil**:
Minerals are absorbed by root hair cells through active transport, which requires energy. The minerals dissolve in water and are taken up along with water through the roots. (2 marks)

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6. Photosynthesis and Respiration

a) **Comparison of photosynthesis and respiration**:

- **Photosynthesis**: Occurs in chloroplasts, uses CO_2 and H_2O, produces glucose and O_2, and requires light energy.
- **Respiration**: Occurs in mitochondria, uses glucose and O_2, produces CO_2 and H_2O, and releases energy (ATP).
  (4 marks)

b) **Why plants release oxygen during the day but consume oxygen at night**:
During the day, photosynthesis produces oxygen as a byproduct, which is released into the atmosphere. At night, photosynthesis stops, but respiration continues, consuming oxygen and releasing carbon dioxide. (3 marks)

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7. Starch Test Experiment

a) **Steps to test a leaf for starch**:

1. Boil the leaf in water to kill the cells and stop chemical reactions.
2. Boil the leaf in ethanol to remove chlorophyll.
3. Rinse the leaf in water to soften it.
4. Add iodine solution to the leaf. If starch is present, the leaf will turn blue-black.
   (4 marks)

b) **Why the leaf must be destarched before the experiment**:
To ensure that any starch detected is produced during the experiment and not from prior photosynthesis. (2 marks)

c) **Observation if the leaf tests positive for starch**:
The leaf turns blue-black. (1 mark)

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8. Greenhouse Farming

a) **Effect of increasing CO_2 concentration on crop yields**:
Higher CO_2 concentrations increase the rate of photosynthesis, leading to greater glucose production and improved crop yields. (3 marks)

b) **How farmers control temperature and light in greenhouses**:

- Temperature is controlled using heaters, fans, and ventilation.
- Light is controlled using artificial lighting (e.g., LED lights) and shading.
  (3 marks)

c) **Importance of red and blue light in greenhouses**:
Red and blue light are the most effective wavelengths for photosynthesis, as chlorophyll absorbs them most efficiently. Green light is reflected and less useful. (2 marks)

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9. Carbon Cycle and Photosynthesis

a) **Role of photosynthesis in the carbon cycle**:
Photosynthesis removes carbon dioxide from the atmosphere and converts it into organic compounds (e.g., glucose), which are stored in plants. This reduces atmospheric CO_2 levels and provides energy for ecosystems. (3 marks)

b) **Recycling of carbon atoms between plants, animals, and the atmosphere**:

- Plants absorb CO_2 during photosynthesis and convert it into glucose.
- Animals consume plants and use the carbon for respiration, releasing CO_2 back into the atmosphere.
- Decomposers break down dead organisms, releasing CO_2 through respiration.
- Combustion of fossil fuels also releases CO_2 into the atmosphere.
  (4 marks)

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10. Experimental Design

a) **Experiment to investigate the effect of CO_2 concentration on photosynthesis**:

- **Apparatus**: Aquatic plant (e.g., Elodea), sodium hydrogen carbonate (to vary CO_2 levels), light source, water, beaker, and a stopwatch.
- **Measuring the rate of photosynthesis**: Count the number of oxygen bubbles produced per minute.
- **Controlling variables**:
    - Keep light intensity and temperature constant.
    - Use the same plant species and size.
    - Repeat the experiment multiple times for reliability.
      (6 marks)