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Topics Covered:

- Characteristics of Living Organisms
- Concept & Uses of Classification Systems
- Features of Organisms

/ Mark 53

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1. Write the word and symbol equations for photosynthesis. [4]

   Explain the role of chlorophyll in this process.

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2. Describe how the structure of a leaf is adapted for efficient photosynthesis. [6]

   Include the roles of the palisade mesophyll, stomata, and waxy cuticle.

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3. Explain the concept of a limiting factor in photosynthesis. [5]

   Provide examples of how light intensity, carbon dioxide concentration, and temperature can act as limiting factors.

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4. Describe the steps involved in testing a leaf for starch. [6]

   Explain why the leaf must be destarched before the experiment and why ethanol is used during the process.

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5. Compare and contrast photosynthesis and respiration in plants. [5]

   Explain how these processes affect the carbon dioxide and oxygen levels in the atmosphere.

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6. Discuss how increasing carbon dioxide concentration and temperature in a greenhouse can enhance the rate of photosynthesis. [6]

   Explain why these factors are important for maximizing crop yields.

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7. List three minerals required by plants and describe their roles in plant growth. [6]

   Explain how a deficiency in magnesium or nitrate ions would affect a plant.

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8. A student wants to investigate the effect of light intensity on the rate of photosynthesis. [6]

   Describe how the student could set up an experiment to measure the rate of oxygen production. Include details on how to control other variables.

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9. Define the term "compensation point" in relation to photosynthesis and respiration. [4]

   Explain why it is important for greenhouse growers to understand this concept.

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10. Explain the role of photosynthesis in the carbon cycle. [5]

    Describe how carbon atoms are recycled between plants, animals, and the atmosphere.

Answers:

1. Photosynthesis Equation

Word Equation:
Carbon dioxide + Water → Glucose + Oxygen
Symbol Equation:

$$6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

Role of Chlorophyll: Chlorophyll is a green pigment found in chloroplasts that absorbs light energy. This energy is used to drive the chemical reactions of photosynthesis, converting carbon dioxide and water into glucose and oxygen.

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2. Leaf Structure and Photosynthesis

The leaf is adapted for photosynthesis in the following ways:

- Palisade Mesophyll: Contains tightly packed cells with many chloroplasts to maximize light absorption for photosynthesis.
- Stomata: Small pores on the underside of the leaf that allow carbon dioxide to enter and oxygen to exit.
- Waxy Cuticle: A transparent, waterproof layer on the upper surface of the leaf that reduces water loss while allowing light to pass through.
- Spongy Mesophyll: Loosely packed cells with air spaces to facilitate gas exchange (carbon dioxide and oxygen).
- Veins (Xylem and Phloem): Deliver water and minerals to the leaf (xylem) and transport glucose away (phloem).

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3. Limiting Factors

A limiting factor is a factor that restricts the rate of a process when it is in short supply. In photosynthesis:

- Light Intensity: As light intensity increases, the rate of photosynthesis increases until another factor (e.g., carbon dioxide or temperature) becomes limiting.
- Carbon Dioxide Concentration: Increasing CO_2 levels increase the rate of photosynthesis until light or temperature becomes limiting.

- Temperature: Enzymes involved in photosynthesis work faster at higher temperatures, but if the temperature is too high, enzymes denature, slowing the rate.

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4. Starch Test

Steps:

1. Destarch the plant by placing it in the dark for 48 hours to use up stored starch.
2. Boil the leaf in water to break down cell walls and stop enzyme activity.
3. Warm the leaf in ethanol to remove chlorophyll, which would mask the results.
4. Rinse the leaf in warm water to soften it.
5. Add iodine solution to the leaf. If starch is present, the leaf turns blue-black; if absent, it remains orange-brown.

Why Destarch?: To ensure that any starch detected is produced during the experiment and not from prior photosynthesis.
Why Ethanol?: Ethanol dissolves chlorophyll, making it easier to observe the color change with iodine.

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5. Photosynthesis and Respiration

Photosynthesis:

- Removes carbon dioxide from the atmosphere and releases oxygen.
- Occurs only in the presence of light.

Respiration:

- Releases carbon dioxide and uses oxygen.
- Occurs continuously in all living cells.

Effect on Atmosphere:

- In light, photosynthesis exceeds respiration, so plants remove CO_2 and release O_2.
- In darkness, respiration exceeds photosynthesis, so plants release CO_2 and use O_2.

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6. Greenhouse Effect on Photosynthesis

- Increased CO_2 Concentration: CO_2 is a substrate for photosynthesis, so higher levels increase the rate of photosynthesis.
- Increased Temperature: Warmer temperatures speed up enzyme activity, increasing the rate of photosynthesis until an optimum temperature is reached.

- Maximizing Crop Yields: By controlling CO_2, temperature, and light in greenhouses, growers can ensure that photosynthesis occurs at its maximum rate, leading to higher crop yields.

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7. Mineral Requirements in Plants

Minerals and Their Roles:

- Nitrate (NO_3^-): Used to make amino acids and proteins. Deficiency causes stunted growth and yellowing leaves.
- Magnesium (Mg^{2+}): A component of chlorophyll. Deficiency causes chlorosis (yellowing of leaves).
- Phosphate (PO_4^{3-}): Used in DNA, RNA, and ATP. Deficiency causes poor root growth and dark green/purple leaves.

Effect of Deficiencies:

- Magnesium Deficiency: Leaves turn yellow due to lack of chlorophyll, reducing photosynthesis.
- Nitrate Deficiency: Stunted growth and yellowing leaves due to reduced protein synthesis.

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8. Experimental Design

Setup:

- Use an aquatic plant (e.g., pondweed) in a beaker of water with a light source at varying distances to change light intensity.
- Count the number of oxygen bubbles produced in a fixed time or measure the volume of oxygen collected in an inverted measuring cylinder.

Control Variables:

- Keep temperature constant using a water bath.
- Maintain CO_2 concentration by adding sodium hydrogencarbonate to the water.
- Use the same plant species and number of leaves in each experiment.

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9. Compensation Point

Definition: The compensation point is the light intensity at which the rate of photosynthesis equals the rate of respiration. At this point, there is no net uptake or release of carbon dioxide or oxygen.

Importance for Greenhouse Growers: Understanding the compensation point helps growers optimize light levels to ensure that photosynthesis exceeds respiration, leading to net growth and higher yields.

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10. Carbon Cycle

Role of Photosynthesis:

- Plants absorb carbon dioxide from the atmosphere and convert it into glucose during photosynthesis.
- Glucose is used to make other organic compounds (e.g., starch, cellulose, proteins).

Recycling of Carbon:

- Animals eat plants and use the carbon compounds for energy through respiration, releasing CO_2 back into the atmosphere.
- When plants and animals die, decomposers break down their bodies, releasing CO_2.
- This cycle ensures that carbon atoms are continuously recycled between the atmosphere, plants, and animals.