2023 Bi H2 Q11

Section: Metabolism and Survival

Topic: Metabolic Pathways

Question Summary

The question examines the light-dependent reactions of photosynthesis and the relationship between light intensity and plant yield. It also asks about another environmental factor influencing carbon fixation.

Worked Solution

(a) When light energy is absorbed by pigment molecules (such as chlorophyll), their electrons gain energy and become excited. These high-energy electrons are then transferred along an electron transport chain, releasing energy to form ATP and NADPH.

■ Answer (a): Electrons are excited to higher energy levels and transferred along an electron transport chain.

(b) Process X: Photolysis of water (the splitting of water using light energy).
Enzyme Y: ATP synthase (the enzyme that generates ATP as protons pass through it).

■ Answer (b): Process X — Photolysis of water; Enzyme Y —

ATP synthase.

(c)(i) As light intensity increases, the yield of lettuce increases up to a point, then levels off. Beyond this point, light is no longer the limiting factor — other factors such as CO_2 concentration or temperature limit further yield increase.

■ Answer (c)(i): Yield increases with light intensity up to a plateau where another factor becomes limiting.

(c)(ii) Environmental factor: Carbon dioxide concentration (or temperature).
Explanation: Increasing CO_2 concentration provides more substrate for the carbon fixation stage, increasing production of sugars and biomass. Higher (but not excessive) temperature increases enzyme activity in the Calvin cycle, accelerating carbon fixation.

■ Answer (c)(ii): Increasing CO_2 concentration increases the rate of carbon fixation by providing more substrate for RuBisCO.

Revision Tips

• Light reaction: Converts light energy into chemical energy (ATP + NADPH).
• Photolysis: Water $\rightarrow$ H^+ + e^- + O_2.
• ATP synthase: Enzyme that produces ATP from ADP + Pi using proton flow.
• Carbon fixation: Occurs in the Calvin cycle, where CO_2 is fixed into 3PG by RuBisCO.

- Limiting factors: Light intensity, CO_2 concentration, temperature.