Past-paper walk-through

Photosynthesis ▪ 3.4

eXercise

Questions in this set

- 2023 Q4
- 2017 Q5

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 4

2023 ▪ Q4

Noncyclic electron flow and cyclic electron flow are two major pathways of the light-dependent reactions of photosynthesis. In noncyclic electron flow, electrons pass through photosystem II, then components of a chloroplast electron transport chain, and then photosystem I before finally reducing $NADP^+$ to NADPH. In cyclic electron flow, electrons cycle through photosystem I and some components of the electron transport chain (Figure 1).
[Figure 1, an energy diagram of electron flow during the light-dependent reactions, with a vertical axis labeled "Energy of Electrons" (arrow pointing up, no numeric scale). At the bottom, "H_2O" has an arrow labeled "$2e^-$" pointing up into an oval labeled "Photosystem II", with a side arrow from the same point going to "$1/2\ O_2$". From "Photosystem II", a solid vertical arrow rises to an oval labeled "Primary e^- Acceptor". A dashed arrow descends from "Primary e^- Acceptor" down to a rectangle

Question 4

labeled "Cytochrome Complex"; from the Cytochrome Complex a bolt symbol points down labeled "Energy for ATP Synthesis". A dashed arrow continues from the Cytochrome Complex down-and-right to an oval labeled "Photosystem I". From "Photosystem I", a solid vertical arrow rises to another oval labeled "Primary e^- Acceptor" (top of diagram). A heavy curved arrow labeled "Cyclic" loops from this top "Primary e^- Acceptor" back down to the "Cytochrome Complex", representing cyclic electron flow. From the top "Primary e^- Acceptor", a dashed arrow also goes down-and-right to a diamond labeled "Ferredoxin", from which a curved arrow leads to "$NADP^+$" and then to "NADPH".]

Figure 1. The pathways of noncyclic and cyclic (heavy arrows) electron flow. The cytochrome complex is a component of the electron transport chain between the two photosystems.

(a) Describe the role of chlorophyll in the photosystems of plant cells.

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(b) Based on Figure 1, **explain** why an increase in the ratio of NADPH to $NADP^+$ will cause an increase in the flow of electrons through the cyclic pathway.
(c) Using rice plants, scientists examined the effect of a mutation that results in the loss of the protein CRR6. CRR6 is a part of the photosystem I complex, and its absence reduces the activity of photosystem I. **Predict** the effect of the mutation on the rate of biomass (dry weight) accumulation.
(d) **Justify** your prediction in part (c).

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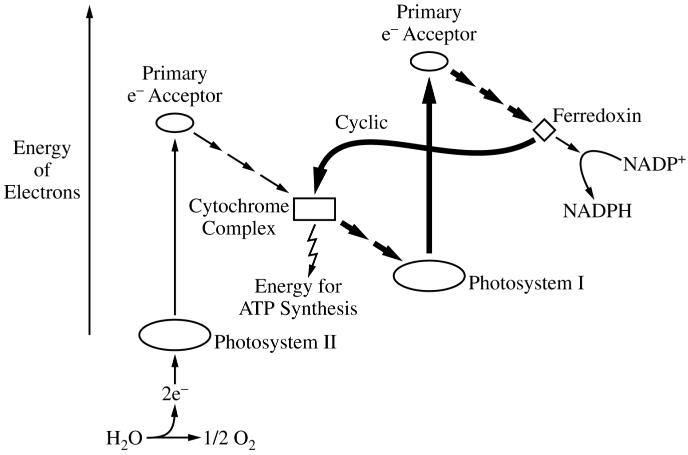

Energy
of
Electrons
Primary
e⁻ Acceptor
Primary
e⁻ Acceptor
Cyclic
Ferredoxin
NADP+
NADPH
Cytochrome
Complex
Energy for
ATP Synthesis
Photosystem I
Photosystem II
2e⁻
H2O
1/2 O2

Solution 4

(a)

Mark scheme

- Chlorophyll captures/absorbs light energy in the photosystems; it also receives electrons (e.g., from water at photosystem II) and/or transfers (donates) electrons into the electron transport chain, initiating and passing along the flow of excited electrons through the photosystems.

Solution 4

(b)

Mark scheme

- A higher NADPH-to-NADP+ ratio means there is less available NADP+ to accept electrons at the end of the noncyclic pathway (from ferredoxin). With less NADP+ to serve as the final electron acceptor, electrons are instead routed through the cyclic pathway — from ferredoxin back to the cytochrome complex — increasing cyclic electron flow.

Solution 4

(c)

Mark scheme

- Predicted effect of the CRR6-loss mutation (which reduces photosystem I activity) on biomass accumulation: the rate of biomass (dry weight) accumulation will be lower in the mutant compared with non-mutant (wild-type) rice plants.

Solution 4

(d)

Mark scheme

- Justification: reduced photosystem I activity means less ATP and/or NADPH are produced by the light-dependent reactions; because ATP and NADPH are required to power the Calvin cycle (carbohydrate/carbon fixation), insufficient ATP/NADPH limits the rate of carbohydrate synthesis and therefore lowers the rate of biomass accumulation.

Question 5

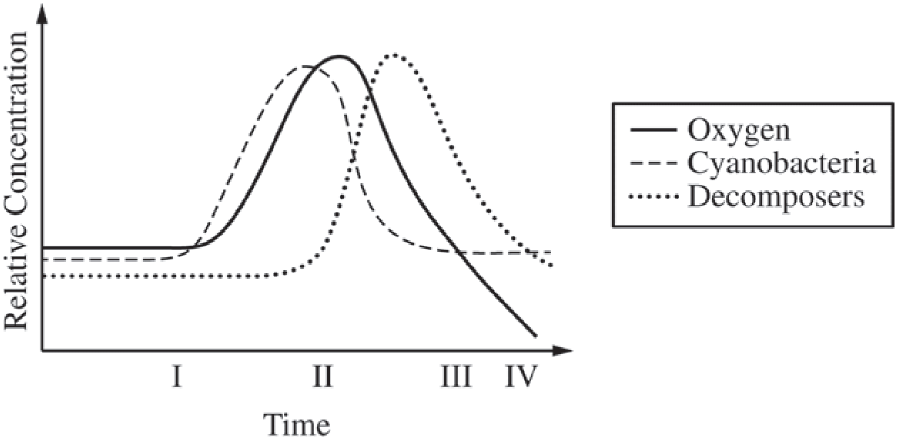
2017 ▪ Q5

[Figure 1: Line graph titled "Characteristics of a pond community over time." Y-axis: "Relative Concentration" (unscaled). X-axis: "Time", with four labeled time points I, II, III, IV. Legend shows three lines: solid = Oxygen, dashed = Cyanobacteria, dotted = Decomposers. The Cyanobacteria (dashed) curve starts at a low flat baseline, rises steeply to peak at time II, then declines back toward baseline by time III–IV. The Oxygen (solid) curve starts at a slightly higher flat baseline, stays flat until just before time II, rises to peak just after time II (slightly later/higher than cyanobacteria's peak), then declines steeply, dropping below the starting baseline by time IV. The Decomposers (dotted) curve starts at the lowest flat baseline, stays low through time II, then rises to peak between times II and III (later than both other curves), and declines gradually toward IV, remaining above its original baseline.]

Question 5

Microcystis aeruginosis is a freshwater photosynthetic cyanobacterium. When temperatures increase and nutrients are readily available in its pond habitat, *M. aeruginosis* undergoes rapid cell division and forms an extremely large, visible mass of cells called an algal bloom. *M. aeruginosis* has a short life span and is decomposed by aerobic bacteria and fungi. **Identify** the metabolic pathway and the organism that is primarily responsible for the change in oxygen level in the pond between times I and II AND between times III and IV.

Question 5



Relative Concentration
Time
I
II
III
IV
Oxygen
Cyanobacteria
Decomposers

Solution 5

Mark scheme

- 2 points per time period. Time I–II: metabolic pathway = photosynthesis (1 point); organism = cyanobacteria (Microcystis aeruginosis) (1 point) — the bloom's photosynthesis raises dissolved oxygen as the cyanobacteria population rises to its peak at time II. Time III–IV: metabolic pathway = cellular respiration (1 point); organism = decomposers/fungi/bacteria (1 point) — after the bloom dies off, aerobic decomposers respiring the dead cyanobacteria consume oxygen, driving the oxygen concentration back down as the decomposer population rises.