Unit 3 · Photosynthesis

ANSWER KEY · FOR TEACHERS

Full marks 32

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. magnesium
2. phycobilins
3. P700
4. photolysis
5. chemiosmosis
6. PGA
7. PEP carboxylase
8. Kranz

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. PQ
2. Cyt b_6f
3. Fd
4. PC
5. NADP reductase
6. ATP synthase

K · 3

Each carries 0.5 mark.

3 Multiple choice

i. **d.** phosphoglyceric acid — K · 1

3-phosphoglyceric acid (PGA), with three carbons. Oxaloacetic acid is the first product of the C_4 cycle; phosphoglycolic acid that of photorespiration; citric acid belongs to respiration.

ii. **a.** the reaction center (photocenter) — U · 1

The antenna (light-harvesting) pigments pass the energy on until it reaches the **reaction center**, the special pair of chlorophyll a, which uses it to give away an electron.

iii. **c.** primary acceptor, PQ, cytochrome complex, PC — U · 1

Pheophytin → **plastoquinone** → **cytochrome b_6f** → **plastocyanin** → P700. Ferredoxin comes after PSI.

iv. **c.** a CAM plant — A · 1

CAM plants fix carbon dioxide at night into **malic acid**, which builds up in their vacuoles and makes the leaves sour by morning, and use it by day with their stomata shut.

v. **b.** carbon dioxide — A · 1

By Blackman's law, the factor whose increase speeds up the process is the **limiting** one. More light did nothing; more carbon dioxide did, so carbon dioxide was limiting.

4 Short answers

a. MARKING SCHEME — K · 2

- ✓ The splitting of water by light (at PSII, by the manganese cluster).
- ✓ $2H_2O \rightarrow 4H^+ + 4e^- + O_2$.

b. MARKING SCHEME — U · 2

- ✓ It uses no light directly, but runs by day with the light reaction.
- ✓ It needs fresh ATP and NADPH and light-activated enzymes, so it stops in the dark.

c. MARKING SCHEME — A · 2

- ✓ Maize (C_4) has almost no photorespiration, so it does best in hot, bright summers.
- ✓ Wheat (C_3) does well in the cool, when photorespiration is low and its cycle costs less ATP.

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d. MARKING SCHEME U · 3

- ✓ RuBisCO fixes oxygen onto RuBP, and carbon dioxide is released (C_2 cycle).
- ✓ No sugar or ATP; ATP and NADPH used and fixed carbon lost.
- ✓ In C_4 plants carbon dioxide concentrated round RuBisCO in the bundle sheath outcompetes oxygen.

5 Numerical problem

ANSWER A · 4

One glucose needs 6 CO_2, 6 turns, 18 ATP and 12 NADPH (3 ATP and 2 NADPH per CO_2).

- CO_2 fixed = $3 \times 6 =$ **18**, in **18 turns** (one CO_2 a turn).
- ATP = $18 \times 3 =$ **54**; NADPH = $18 \times 2 =$ **36**.
- A C_4 plant uses 30 ATP per glucose (2 more for each PEP regenerated): $3 \times 30 =$ **90 ATP**.

MARKING SCHEME

- ✓ 18 CO_2 fixed in 18 turns.
- ✓ 54 ATP.
- ✓ 36 NADPH.
- ✓ 90 ATP for a C_4 plant.

6 Long answer

ANSWER U · 4

Any four:

Non-cyclic	Cyclic
PSII and PSI both work	PSI only
electrons flow in a line, from water to $NADP^+$	electrons go round, from P700 back to P700
first electron donor water; last acceptor $NADP^+$	P700 is both donor and acceptor
water is split, oxygen given out	no photolysis, no oxygen
makes ATP and NADPH	makes ATP only
mostly in the grana	mostly in the stroma lamellae

MARKING SCHEME

- ✓ A first correct difference.
- ✓ A second correct difference.
- ✓ A third correct difference.
- ✓ A fourth correct difference.

7 Think

ANSWER HA · 3

With far-red light only **PSI** works, so only **cyclic** photophosphorylation runs: it makes **ATP**, but no water is split, so there is **no oxygen**, and with no electrons coming in from outside, little or no **NADPH**.

Adding 680 nm light drives **PSII** too: water is split by photolysis, so **oxygen** is given out, and electrons flow from water through both photosystems to $NADP^+$ (non-cyclic), making **NADPH** as well as ATP.

MARKING SCHEME

- ✓ Far-red alone: PSI only, cyclic flow, ATP made.
- ✓ No photolysis, so no oxygen and little or no NADPH.
- ✓ With 680 nm, PSII splits water: oxygen and NADPH (non-cyclic) are made too.

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8 Activity: C_3, C_4 and CAM plants near you

(not marked)

WHAT STUDENTS SHOULD FIND

C_3: rice, wheat, potato, mustard, beans, tomato, sal, pine, mango and nearly every tree and shrub, so C_3 is by far the largest group. **C_4**: maize, sugarcane, sorghum (junelo), finger millet (kodo), amaranth (latte), dubo and many summer grasses and weeds. **CAM**: cacti (*Opuntia*), *Aloe* (ghiukumari), *Agave* (ketuki), pineapple, *Kalanchoe*.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	10	11	8	3	**32**

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