Photosynthesis in Higher Plants

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. The first stable product of the Calvin (C3) cycle is:

(a) glucose **(b)** RuBP

(c) oxaloacetic acid **(d)** 3-phosphoglyceric acid (PGA)

2. How many molecules of NADPH does the Calvin cycle use to make 4 molecules of glucose?

(a) 48 **(b)** 72 **(c)** 24 **(d)** 12

3. Where does the build-up of protons for ATP synthesis take place?

(a) The inner (lumen) side of the thylakoid membrane

(b) The stroma of mesophyll chloroplasts

(c) The bundle sheath cells

(d) The thylakoid lumen

4. Rice is a:

(a) CAM plant only **(b)** non-photosynthetic plant

(c) C4 plant **(d)** C3 plant

5. Hatch and Slack is known for showing that:

(a) the C4 pathway

(b) glucose is made in chloroplasts and stored as starch

(c) the first action spectrum, using Cladophora and aerobic bacteria

(d) only the green parts of plants, in sunlight, restore air

6. Which leaf pigment appears yellow to yellow-orange on a paper chromatogram?

(a) Xanthophylls **(b)** Chlorophyll a **(c)** Chlorophyll b **(d)** Carotenoids

7. When 4 molecules of water are split in the light reactions, the number of electrons released is:

(a) 16 **(b)** 8 **(c)** 2 **(d)** 4

8. Assertion (A): Fixing 30 molecules of CO_2 in the Calvin cycle uses 90 molecules of ATP.
Reason (R): Each CO_2 fixed uses 2 ATP and 3 NADPH.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. What is the difference between cyclic and non-cyclic photophosphorylation?

10. To make 1 molecule of glucose, how many CO_2 molecules must be fixed, how many turns of the Calvin cycle are needed, and how many ATP and NADPH are used?

11. How many ATP does a C4 plant use to fix 24 molecules of CO_2, compared with a C3 plant? Why the difference?

12. Where does the first fixation of CO_2 by PEP carboxylase in C4 plants take place?

13. What did T. W. Engelmann show about photosynthesis?

14. In the light reactions, 20 molecules of oxygen are released. How many water molecules were split, and how many electrons were passed to the electron transport chain?

15. Is sugarcane a C3 or a C4 plant? Name its CO_2 acceptor and first stable product.

16. Which leaf pigment appears yellow to yellow-orange on a chromatogram, and is it the main or an accessory pigment?

Section C — Word problems — 4 × 4 = 16 marks

17. Describe the light reactions (the Z scheme).

18. A C3 plant and a C4 plant each make 10 molecules of glucose. For each, find (a) the CO_2 fixed, (b) the ATP used, (c) the NADPH used. (d) Why do C4 plants still do better in hot, dry conditions?

19. During the light reactions 18 molecules of O_2 are released. Find (a) the water molecules split, (b) the electrons released, (c) the protons released into the lumen by photolysis, (d) the NADPH that these electrons can make. Name the photosystem where water is split.

20. Compare mustard (C3) and pearl millet (bajra) (C4): CO_2 acceptor, first product, cells where the Calvin cycle runs, leaf anatomy and photorespiration.

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Answer key

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Q	Answer	Working
1	**(d) 3-phosphoglyceric acid (PGA)**	—
2	**(a) 48**	6 CO_2 per glucose; 3 ATP and 2 NADPH per CO_2
3	**(d) The thylakoid lumen**	—
4	**(d) C3 plant**	Calvin cycle only, first product PGA
5	**(a) the C4 pathway**	—
6	**(d) Carotenoids**	—
7	**(b) 8**	$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$
8	**(c) A is true, but R is false.**	A is true: 3 × 30 = 90. R is false.
9	**Non-cyclic uses both photosystems; electrons from water pass to $NADP^+$, so it makes ATP and NADPH and releases oxygen. Cyclic uses only PS I; electrons return to PS I, so it makes only ATP and no NADPH or oxygen.**	—
10	**6 CO_2; 6 turns; 18 ATP and 12 NADPH**	one turn fixes one CO_2, using 3 ATP and 2 NADPH
11	**C4: 120 ATP; C3: 72 ATP. C4 plants spend 2 more ATP per CO_2 to regenerate PEP for the first fixation.**	5 ATP per CO_2 in C4; 3 in C3
12	**The mesophyll cells**	—
13	**The first action spectrum, using Cladophora and aerobic bacteria**	—
14	**40 water molecules; 80 electrons**	$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$
15	**C4: PEP (phosphoenol pyruvate); oxaloacetic acid**	—
16	**Carotenoids; an accessory pigment**	—
17	**Light absorbed by PS II excites the P680 electron, which passes along an electron transport chain (with cytochromes) to PS I; water is split to replace PS II electrons, releasing O_2. PS I (P700) is excited again and its electrons pass down a second chain to $NADP^+$, reducing it to NADPH. The electron path looks like a Z. Protons pumped into the lumen drive ATP synthase.**	—
18	**(a) 60 CO_2 each; (b) C3 180 ATP, C4 300 ATP; (c) 120 NADPH each; (d) they**	C3: 3 ATP + 2 NADPH per CO_2; C4: 5 ATP + 2 NADPH per CO_2

Q	Answer	Working
	avoid photorespiration by concentrating CO_2 round RuBisCO, so they fix carbon efficiently even with stomata partly closed	
19	**(a) 36; (b) 72; (c) 72; (d) 36 (2 electrons per NADPH); water is split at photosystem II**	$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$; $NADP^+ + 2e^- + H^+ \rightarrow NADPH$
20	**Mustard: RuBP; 3-PGA; mesophyll; no Kranz anatomy; photorespiration present. Pearl millet (bajra): PEP; oxaloacetic acid; bundle sheath (after fixation in mesophyll); Kranz anatomy; little or no photorespiration.**	—

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