Helicate

HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.5.1 Photosynthesis

Topic question bank · A-level only content

Version 2 · 15 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
8	64	No time limit	/ 64

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Total		**64**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA A-level Biology (7402), specification section 3.5.1. Not affiliated with or endorsed by AQA.

Do not write outside the box

The light-dependent reaction 3.5.1

0 1 . 1 Photolysis of water takes place during the light-dependent reaction.
Which of these shows **all** the products of photolysis?
Tick (✓) one box.

[1 mark]

Oxygen, protons and electrons ☐

Oxygen, protons and ATP ☐

Oxygen and reduced NADP ☐

Hydrogen and oxygen ☐

0 1 . 2 Explain how light energy is used to produce ATP in a chloroplast.

[5 marks]

6

Turn over for the next question

Do not write outside the box

Thylakoids are the flattened membrane sacs inside chloroplasts. Scientists isolated thylakoids from spinach leaves. They kept the thylakoids in complete darkness throughout the investigation.

In treatment **A**, the scientists:

- soaked the thylakoids in a first buffer solution at pH 4.0 for 60 minutes, so that the solution inside the thylakoids also reached pH 4.0
- quickly moved the thylakoids into a second buffer solution at pH 8.0 that contained ADP and phosphate
- measured the ATP produced in the next 15 seconds.

They changed the conditions in treatments **B** to **E**. ADP and phosphate were present in every second buffer solution. Table 1 shows their results.

Table 1

Treatment	pH of first buffer solution	pH of second buffer solution	Also added to second buffer solution	ATP produced / nmol per mg chlorophyll
A	4.0	8.0	Nothing	96
B	8.0	8.0	Nothing	3
C	4.0	4.0	Nothing	2
D	4.0	8.0	Substance **X**, which makes membranes freely permeable to protons	5
E	4.0	8.0	Substance **Y**, which blocks the channel in ATP synthase through which protons pass	4

Question 2 continues on the next page

Do not write outside the box

0 2 . 1 pH = $-\log_{10}$ $[H^+]$, where $[H^+]$ is the concentration of hydrogen ions (protons).
Calculate how many times greater the concentration of protons was inside the thylakoids than in the second buffer solution in treatment **A**, immediately after the transfer.
Give your answer in standard form.

[2 marks]

Answer ..... **times**

0 2 . 2 Explain why ATP was produced in treatment **A** but almost none was produced in treatment **B**.

[3 marks]

0 2 . 3 Explain how the results of treatments **D** and **E** support the chemiosmotic theory of ATP production.

[2 marks]

7

Turn over for the next question

Do not write outside the box

The light-independent reaction 3.5.1

0 3 . 1 Which of these is produced in the light-dependent reaction and then used in the light-independent reaction?

Tick (✓) one box.

[1 mark]

- Oxygen ☐
- Reduced NADP ☐
- NADP ☐
- Reduced NAD ☐

0 3 . 2 In the light-independent reaction, the enzyme rubisco catalyses a reaction involving ribulose bisphosphate (RuBP). GP is glycerate 3-phosphate.

Which row shows the substrates and product of this reaction?

Tick (✓) one box.

[1 mark]

Substrates	Product	
Carbon dioxide and RuBP	Two molecules of GP	☐
Carbon dioxide and RuBP	Two molecules of triose phosphate	☐
Carbon dioxide and GP	RuBP	☐
GP and reduced NADP	Triose phosphate	☐

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 The Calvin cycle stops if the supply of ATP or reduced NADP stops.
Explain why.

[3 marks]

0 3 . 4 Some triose phosphate is used to regenerate RuBP.
Give **two** other useful organic substances that plants make from triose phosphate.

[2 marks]

1

2

7

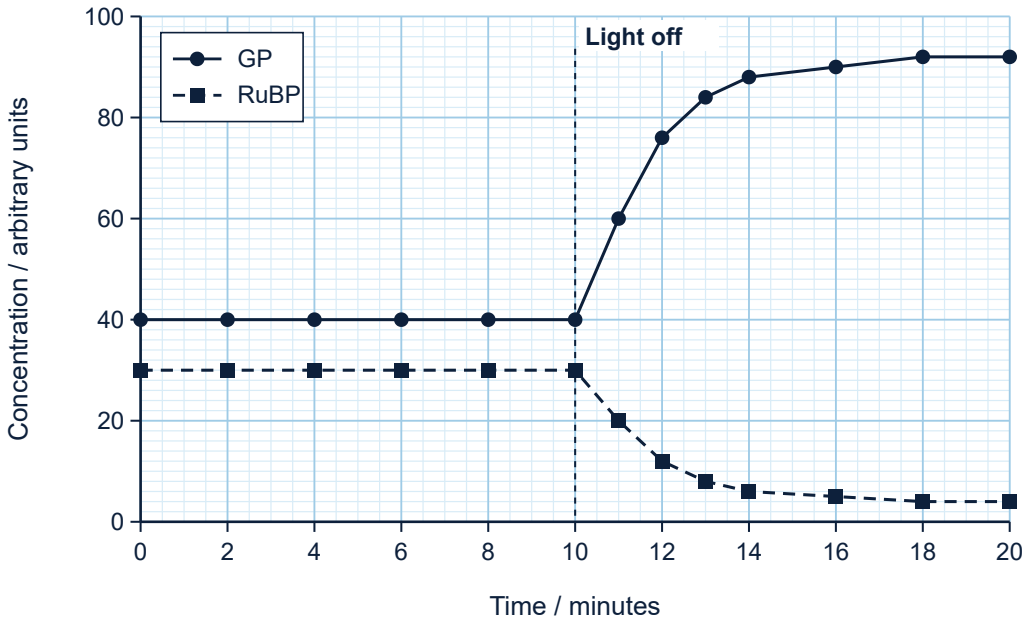
Turn over for the next question

Do not write outside the box

Scientists grew single-celled algae in light, with a constant supply of carbon dioxide. They measured the concentrations of RuBP and GP in the algae at intervals. After 10 minutes, they switched the light off.

Figure 1 shows their results. Both concentrations are in the same units.

Figure 1



0 4 . 1 Use Figure 1 to calculate the ratio of the increase in GP concentration to the decrease in RuBP concentration between 10 minutes and 20 minutes.

[1 mark]

Answer ..... **: 1**

0 4 . 2 Explain the value of this ratio.

[1 mark]

Question 4 continues on the next page

Do not write outside the box

The scientists repeated the investigation. This time, they kept the light on throughout and lowered the concentration of carbon dioxide at 10 minutes.

0 4 . 3 Explain the changes in the concentrations of GP and RuBP shown in Figure 1 after the light was switched off.
Predict how the concentrations of GP and RuBP would change after the carbon dioxide concentration was lowered in the repeat investigation. Explain your prediction.

[6 marks]

8

Turn over for the next question

Do not write outside the box

Limiting factors and agricultural practice 3.5.1

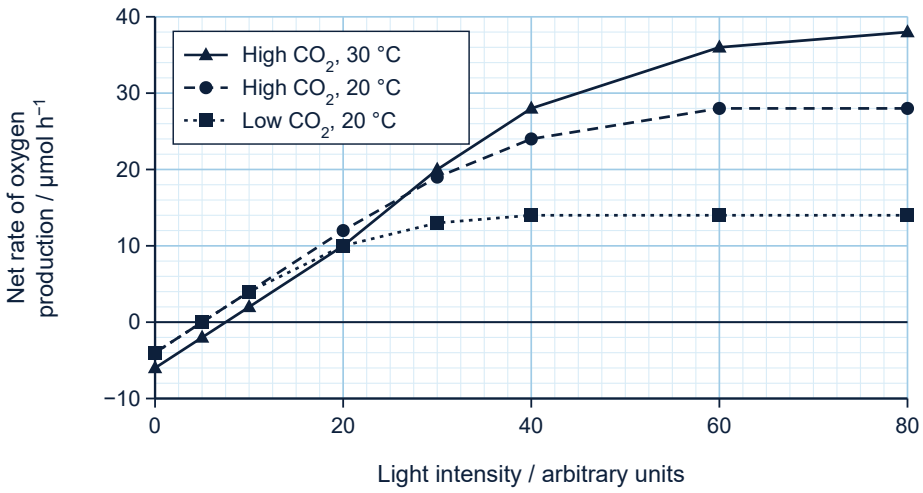
Students trapped single-celled algae in small beads of jelly (immobilised algal beads). They put 20 beads into each of several glass tubes. Each tube contained a hydrogencarbonate solution, which supplies carbon dioxide. They used an oxygen sensor to measure the net rate of oxygen production at different light intensities, with:

- a low carbon dioxide concentration at 20 °C
- a high carbon dioxide concentration at 20 °C
- a high carbon dioxide concentration at 30 °C.

Net rate of oxygen production = rate of oxygen production in photosynthesis − rate of oxygen uptake in respiration.

Figure 2 shows their results. The two 20 °C lines overlap from light intensity 0 to 10.

Figure 2



0 5 . 1 Explain why the net rate of oxygen production was negative at a light intensity of 0.

[1 mark]

Question 5 continues on the next page

Do not write outside the box

0 5 . 2 The compensation point is the light intensity at which the rate of photosynthesis is equal to the rate of respiration.
Use Figure 2 to find the compensation point for the algae at a high carbon dioxide concentration and 30 °C.

[1 mark]

Answer ..... **arbitrary units**

0 5 . 3 Use Figure 2 to identify the factor limiting the rate of photosynthesis in each of these conditions. Give the evidence for each answer.

[3 marks]

Light intensity 10, high carbon dioxide, 20 °C .....

.....

Light intensity 60, low carbon dioxide, 20 °C .....

.....

Light intensity 60, high carbon dioxide, 20 °C .....

.....

0 5 . 4 Suggest why the students:

[2 marks]

placed a glass tank of water between the lamp and the tubes .....

.....

.....

used algal beads rather than algae suspended in solution .....

.....

.....

7

Turn over for the next question

Do not write outside the box

Glasshouse growers often use two practices to increase crop yields:

- carbon dioxide enrichment, in which gas is burned to raise the carbon dioxide concentration in the glasshouse
- supplementary lighting, in which lamps give extra light on dull days and in the early morning and evening.

A grower of sweet peppers tested these practices in 4 areas of one glasshouse for one growing season. All 4 areas were kept at the same temperature. Table 2 shows the results. The grower sells peppers for £2.00 per kg.

Table 2

Area	Carbon dioxide concentration / parts per million	Supplementary lighting	Yield of peppers / kg m^{-2}	Extra cost of treatment / £ m^{-2}
1	400	No	25.0	0.00
2	1000	No	30.0	2.10
3	400	Yes	27.5	7.50
4	1000	Yes	35.0	9.60

0 6 . 1 Calculate the percentage increase in yield caused by carbon dioxide enrichment alone.

[2 marks]

Answer ..... **%**

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Explain why carbon dioxide enrichment increased the yield of peppers.

[2 marks]

0 6 . 3 The grower concluded that supplementary lighting is not worth its cost.
Use Table 2 to evaluate this conclusion.

[4 marks]

8

Turn over for the next question

Do not write outside the box

Required practical 7: chromatography of photosynthetic pigments 3.5.1 (RP7)

A student used thin-layer chromatography to compare the pigments in the leaves of a shade-tolerant species, **S**, and a shade-intolerant species, **T**. She:

- ground leaves of each species with sand and propanone to extract the pigments
- drew a line (the origin) near one end of each of two chromatography plates
- put several small drops of one extract on the origin of each plate, letting each drop dry before adding the next
- stood each plate in a beaker containing a small depth of solvent, with a lid on the beaker
- removed each plate before the solvent reached the top, and marked the solvent front.

0 7 . 1 Explain why the student:

[3 marks]

drew the origin in pencil rather than ink

made sure the solvent was below the origin

marked the solvent front before the solvent reached the top

Question 7 continues on the next page

Do not write outside the box

Table 3 shows the R_f values of four pigments in this solvent.

Table 3

Pigment	Carotene	Xanthophyll	Chlorophyll a	Chlorophyll b
R_f value	0.94	0.71	0.56	0.42

R_f = distance moved by pigment ÷ distance moved by solvent front

0 7 . 2 On the plate for species **S**, the solvent front was 9.0 cm from the origin. One spot was 3.8 cm from the origin.
Identify the pigment in this spot. Show your working.

[2 marks]

Pigment .....

0 7 . 3 Explain why the pigments in the extract separated on the plate.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

The student scraped each chlorophyll spot off the plates, dissolved each pigment and used a colorimeter to find the mass of each pigment. Table 4 shows her results.

Table 4

Species	Mass of pigment / mg per g of leaf	
	Chlorophyll a	Chlorophyll b
S (shade-tolerant)	1.40	0.70
T (shade-intolerant)	1.33	0.38

0 7 . 4 Calculate the ratio of chlorophyll a to chlorophyll b for each species.
Give each ratio in the form *x* : 1

[2 marks]

.....

.....

Species S ..... : 1

Species T ..... : 1

Chlorophyll b absorbs some wavelengths of light that chlorophyll a absorbs poorly. Light that reaches the ground beneath trees is much less intense than direct sunlight. Species **S** grows beneath trees.

0 7 . 5 Use Table 4 and this information to explain how the pigments in its leaves allow species **S** to grow in shade.

[3 marks]

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12

Turn over for the next question

Do not write outside the box

Required practical 8: dehydrogenase activity in chloroplast extracts 3.5.1 (RP8)

A student investigated the effect of light intensity on dehydrogenase activity in an extract of chloroplasts. She prepared the extract by blending spinach leaves in an ice-cold buffer solution, filtering the mixture and keeping the filtrate on ice.

She used a redox indicator. The indicator is blue when oxidised and colourless when reduced. The chloroplast extract is green, so the mixture changes from blue-green to green as the indicator is reduced.

She:

- mixed equal volumes of chloroplast extract and indicator in tubes placed at different distances from a lamp
- recorded the time for each mixture to become the same colour as a reference tube containing chloroplast extract and water only
- also set up two control tubes, **X** and **Y**, 10 cm from the lamp. Tube **X** was wrapped in aluminium foil. Tube **Y** contained extract that had been heated to 100 °C for 10 minutes and then cooled.

Table 5 shows her results.

Table 5

Tube	Distance from lamp / cm	Time for mixture to match the reference tube / s			Mean time / s
		Repeat 1	Repeat 2	Repeat 3	
1	10	118	131	126	125
2	15	136	147	137	140
3	20	184	201	185	190
4	30	362	395	383	380
5	40	618	690	642	650
X	10	Still blue-green after 1200 s			–
Y	10	Still blue-green after 1200 s			–

Question 8 continues on the next page

Do not write outside the box

0 8 . 1 Explain why the indicator became colourless in tubes 1 to 5.

[2 marks]

Light intensity is inversely proportional to the square of the distance from the lamp:

$$\text{light intensity} = k \div d^2$$

where d is the distance from the lamp and k is a constant. The rate of dehydrogenase activity is proportional to 1 ÷ mean time.

0 8 . 2 Calculate how many times greater:

[2 marks]

the light intensity was at 10 cm than at 20 cm

the rate of dehydrogenase activity was at 10 cm than at 20 cm

Question 8 continues on the next page

Do not write outside the box

0 8 . 3 The rate of dehydrogenase activity did not increase in proportion to light intensity between 20 cm and 10 cm.
Suggest an explanation.

[2 marks]

0 8 . 4 Explain the purpose of control tubes **X** and **Y**.

[2 marks]

X

Y

0 8 . 5 Suggest how the student could make the end point of her measurements more objective.

[1 mark]

9

END OF QUESTIONS

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