Photosynthesis as an Energy Transfer Process (13.1): Cambridge (CIE) A Level Biology 9700 Exam Questions by Top

22 questions · 68 marks · about 82 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 4 · October/November 2022 (42) · Q3(a)(i) · 2 marks

3 (a) Photosynthesis is an energy transfer process that takes place in chloroplasts of plant cells.

(i) Fig. 3.1 shows a diagram of a chloroplast.

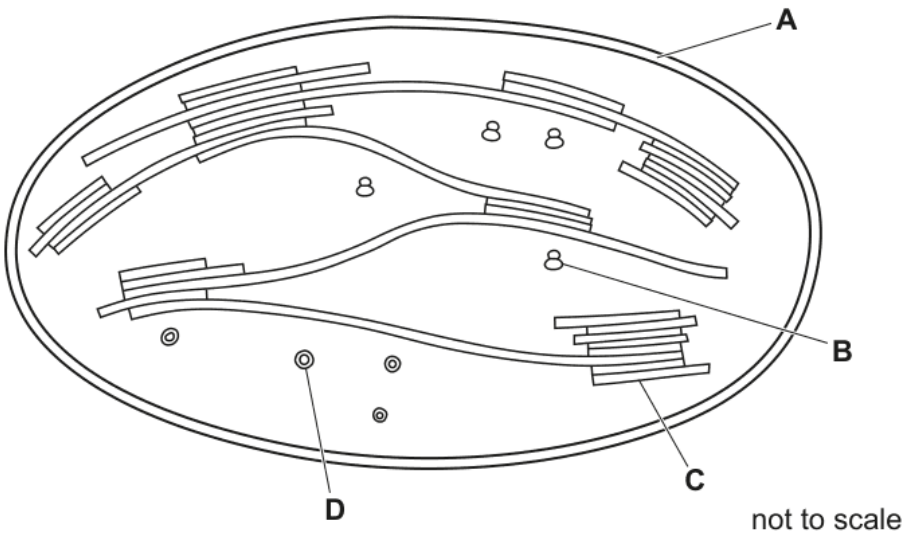


Fig. 3.1

Using the letters **A**, **B**, **C** or **D**, identify the structure that:

- contains genes that code for some of the enzymes used in photosynthesis

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- is the site of synthesis of some of the enzymes used in photosynthesis.

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[2]

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Question 2 · Paper 4 · October/November 2022 (42) · Q3(a)(ii) · 4 marks

(ii) Explain how grana are adapted for their specific role in photosynthesis.

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1 Fig. 1.1 shows a transmission electron micrograph of part of a chloroplast.

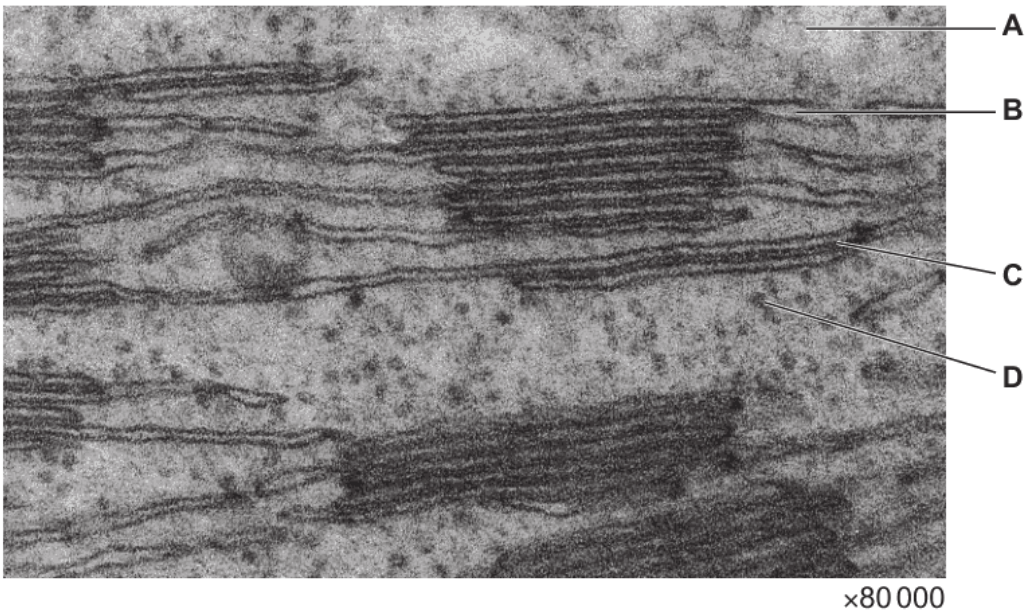


Fig. 1.1

(a) Table 1.1 describes some functions that occur in different parts of a chloroplast.

Complete Table 1.1 by identifying the letter on Fig. 1.1 that is a location matching the description. Each letter may be used once, more than once, or not at all.

Table 1.1

description	letter
accumulates (builds up) a high concentration of protons	
makes triose phosphate	
makes some chloroplast proteins	
pumps protons	

[4]

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Question 4 · Paper 4 · February/March 2025 (42) · Q9(a) · 2 marks

9 The chloroplasts of leaves of tobacco plants, *Nicotiana* sp., contain chlorophyll *a* and chlorophyll *b*.

(a) Describe the role of chlorophyll *b* in photosynthesis.

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Question 5 · information from earlier in the question

(b) A mutant tobacco plant was found to contain more chlorophyll *b* than normal tobacco plants.

An investigation was carried out to measure the rate of photosynthesis of normal and mutant tobacco plants at increasing light intensities. The rate of production of oxygen was used as a measure of the rate of photosynthesis.

Other variables were kept constant.

Fig. 9.1 shows the results of this investigation.

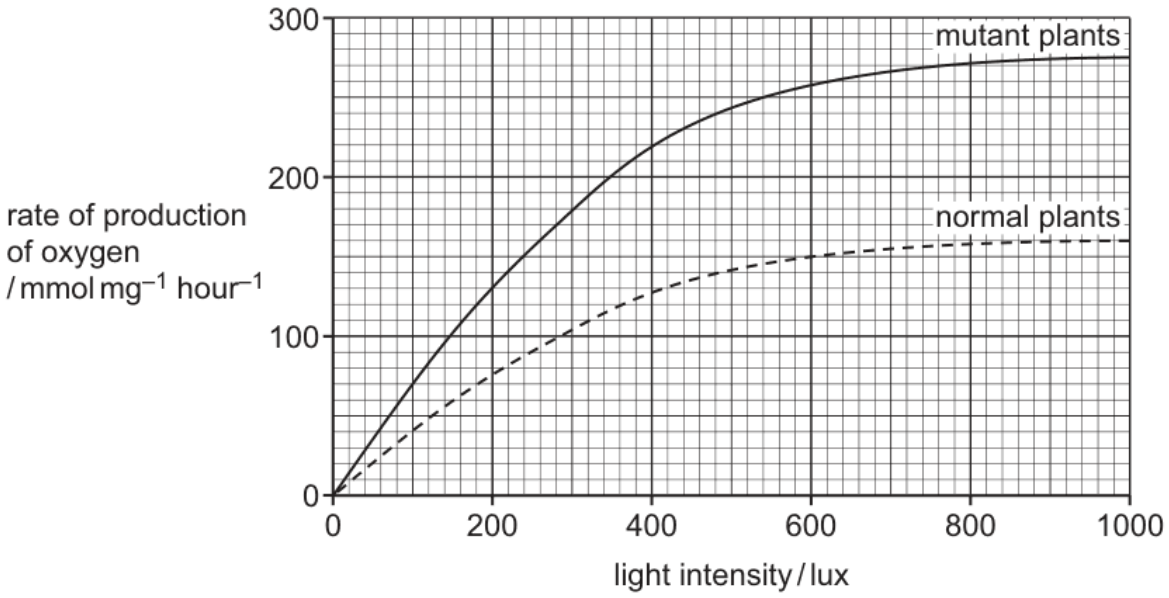


Fig. 9.1

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Question 5 · Paper 4 · February/March 2025 (42) · Q9(b)(ii) · 4 marks

(ii) It was observed that the mutant tobacco plants had a faster growth rate than the normal tobacco plants.

Suggest explanations for this observation.

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Question 6 · Paper 4 · October/November 2025 (42) · Q9(a)(i) · 2 marks

9 **(a)** Fig. 9.1 shows an absorption spectrum for chlorophyll *a* and the corresponding action spectrum for a species of plant.

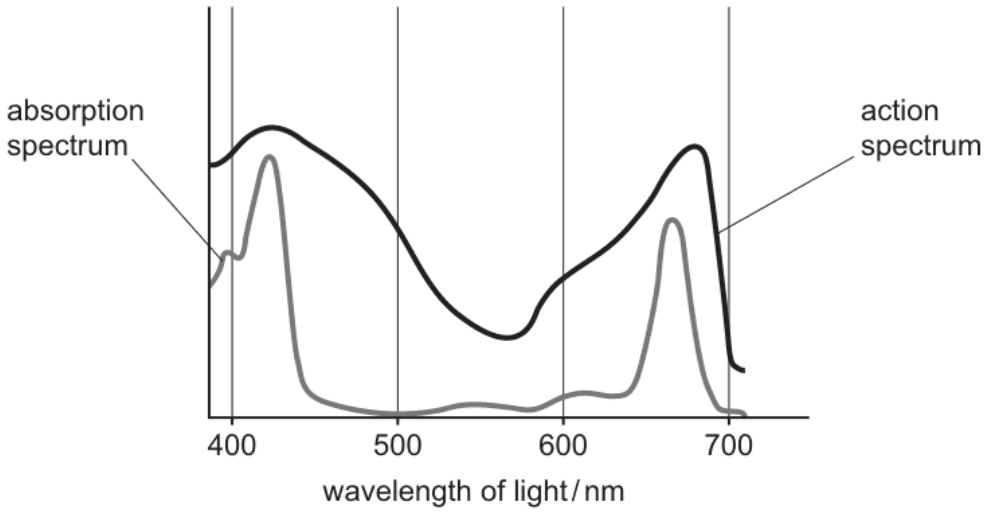


Fig. 9.1

(i) Explain what is meant by an absorption spectrum and an action spectrum.

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(ii) Suggest **and** explain why the curve shown in Fig. 9.1 for the absorption spectrum is different from the curve for the action spectrum for wavelengths of light between 450 nm and 550 nm.

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(c) The absorption of different wavelengths of light by chloroplast pigments can be represented by an absorption spectrum.

Fig. 8.2 is an absorption spectrum of an extract of chloroplast pigments and an absorption spectrum of whole chloroplasts.

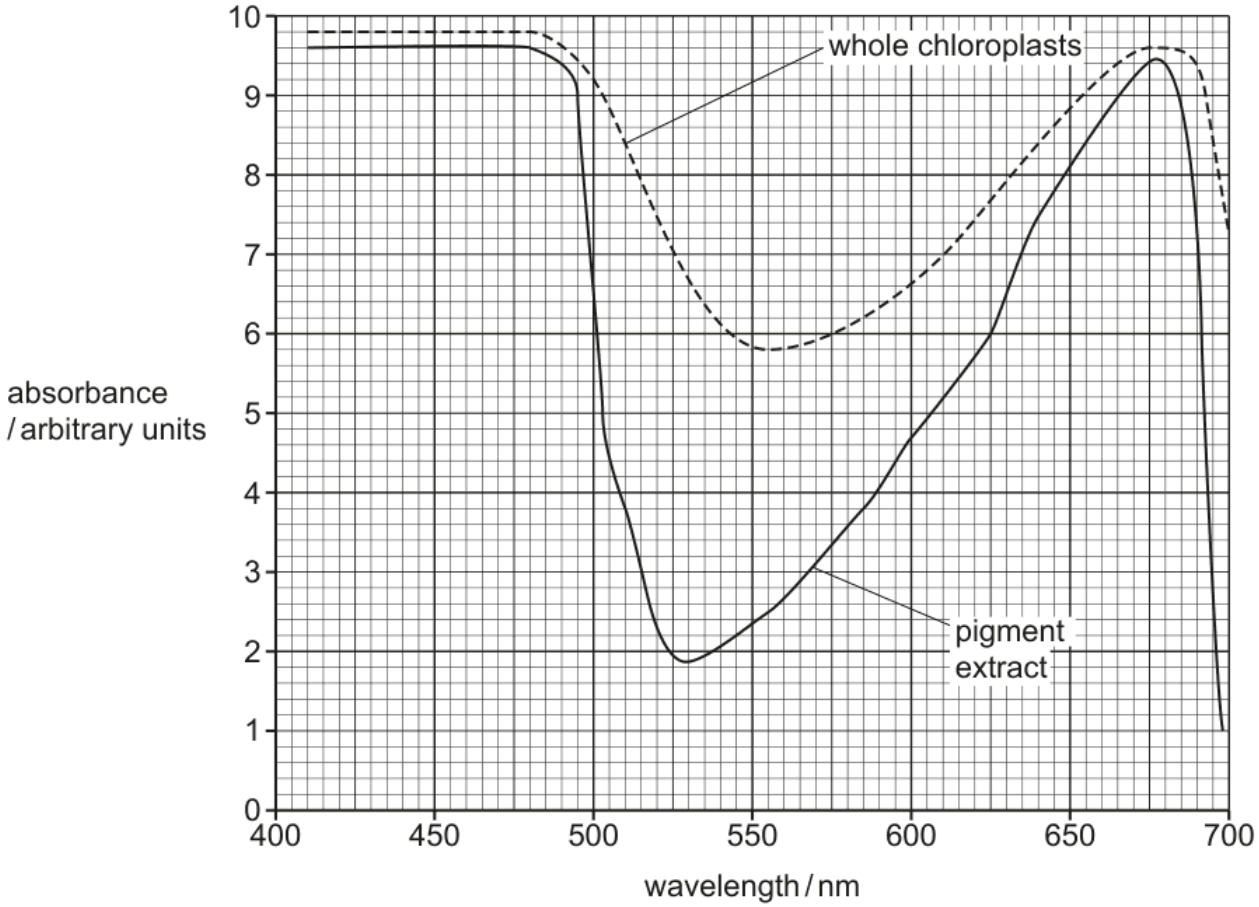


Fig. 8.2

With reference to Fig. 8.2, describe the differences between the two spectra **and** suggest explanations for the differences.

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(c) Red algae are aquatic protoctists that are multicellular. The cells of red algae have chloroplasts containing photosynthetic pigments. Many red algae live in deep water.

Two of the accessory pigments of red algae chloroplasts are:
- phycoerythrin (appears red), often present in large concentrations
- phycocyanin (appears blue).

The first few metres of water nearest the surface absorb the red wavelengths of light. If the water also contains particles of organic material it absorbs blue wavelengths.

Fig. 2.1 shows absorption spectra of some pigments in red algae chloroplasts.

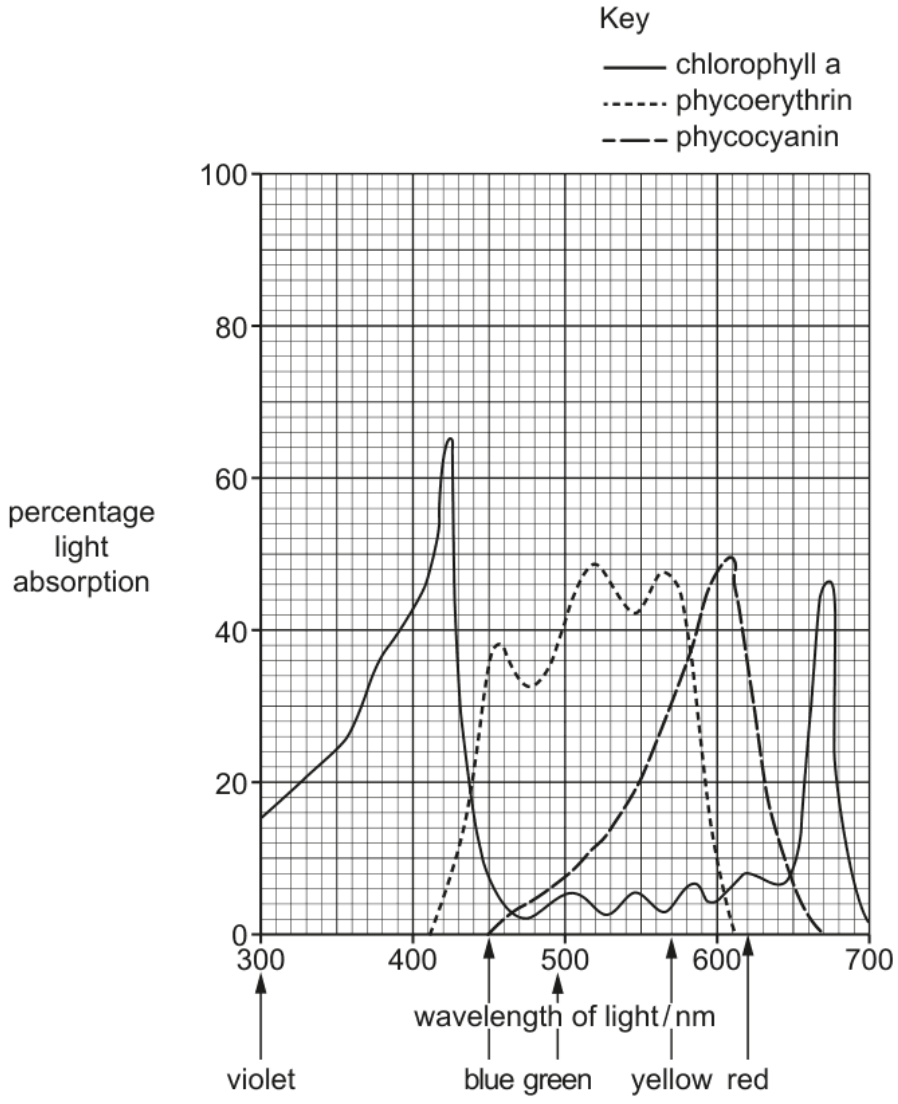


Fig. 2.1

Describe the differences in the absorption spectra of the three photosynthetic pigments shown in Fig. 2.1 and explain how these differences help red algae to survive in deep water.

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Question 10 · information from earlier in the question

4 Red algae are multicellular photosynthetic protoctists that contain phycoerythrin. Phycoerythrin is a photosynthetic pigment.

Question 10 · Paper 4 · February/March 2021 (42) · Q4(b)(i) · 1 mark

(b) Phycoerythrin is rarely found in plants that have green leaves.

(i) State the name of a technique that can be used to separate and identify photosynthetic pigments.

Question 11 · Paper 4 · February/March 2021 (42) · Q4(b)(ii) · 3 marks

(ii) Explain how the results of this technique would be used to confirm that phycoerythrin is present in red algae and **not** present in a plant with green leaves.

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Question 12 · Paper 4 · February/March 2019 (42) · Q1(c) · 5 marks

(c) Some of the light energy absorbed by the pond plant is used in cyclic photophosphorylation.

Outline the process of cyclic photophosphorylation.

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Question 13 · Paper 4 · May/June 2024 (42) · Q7(b) · 3 marks

(b) Describe the process that produces oxygen during non-cyclic photophosphorylation.

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Question 14 · Paper 4 · October/November 2023 (42) · Q8(a) · 4 marks

8 **(a)** Non-cyclic photophosphorylation occurs in the light-dependent stage of photosynthesis.

Outline the main features of non-cyclic photophosphorylation.

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Question 15 · Paper 4 · May/June 2024 (43) · Q7(b) · 4 marks

(b) In photophosphorylation, photoactivation of chlorophyll results in the synthesis of ATP.

Describe how photoactivation of chlorophyll results in the synthesis of ATP in photophosphorylation.

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Question 16 · Paper 4 · October/November 2024 (42) · Q7(c) · 7 marks

(c) The light-dependent stage of photosynthesis produces ATP and reduced NADP, which are used in the light-independent stage.

Describe the **light-independent** stage of photosynthesis.

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Question 17 · information from earlier in the question

2 (a) Photosynthesis is affected by many environmental factors.

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(ii) The concentration of carbon dioxide (CO_2) can also be a limiting factor. It has an effect on the Calvin cycle in the light-independent stage of photosynthesis.

Ribulose bisphosphate (RuBP), triose phosphate (TP) and glycerate 3-phosphate (GP) are three important molecules in the Calvin cycle.

Fig. 2.1 shows how the concentration of GP changes when the concentration of CO_2 is reduced from 0.04% (atmospheric) to 0.008%.

Complete Fig. 2.1 by sketching the lines for RuBP and TP when the concentration of CO_2 is reduced from 0.04% to 0.008%.

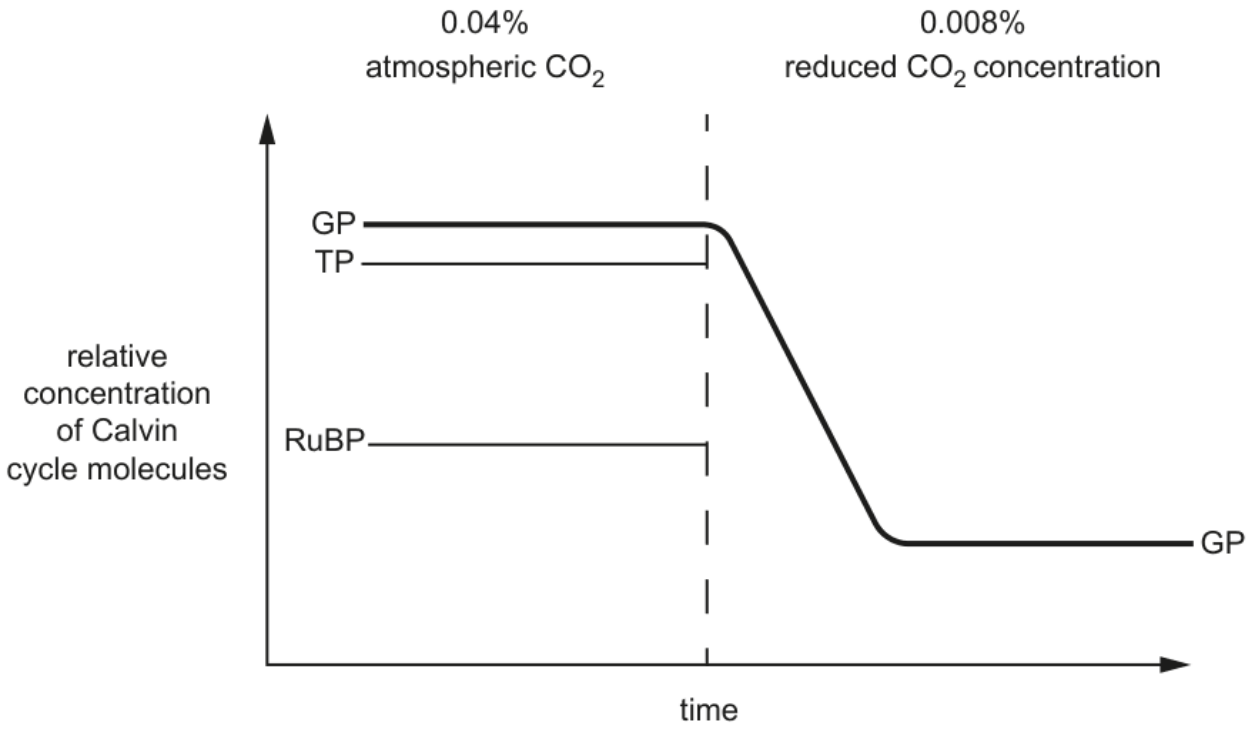


Fig. 2.1 [2]

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Question 18 · Paper 4 · May/June 2023 (42) · Q8(b)(i) · 1 mark

(b) Fig. 8.2 shows an outline of the Calvin cycle.

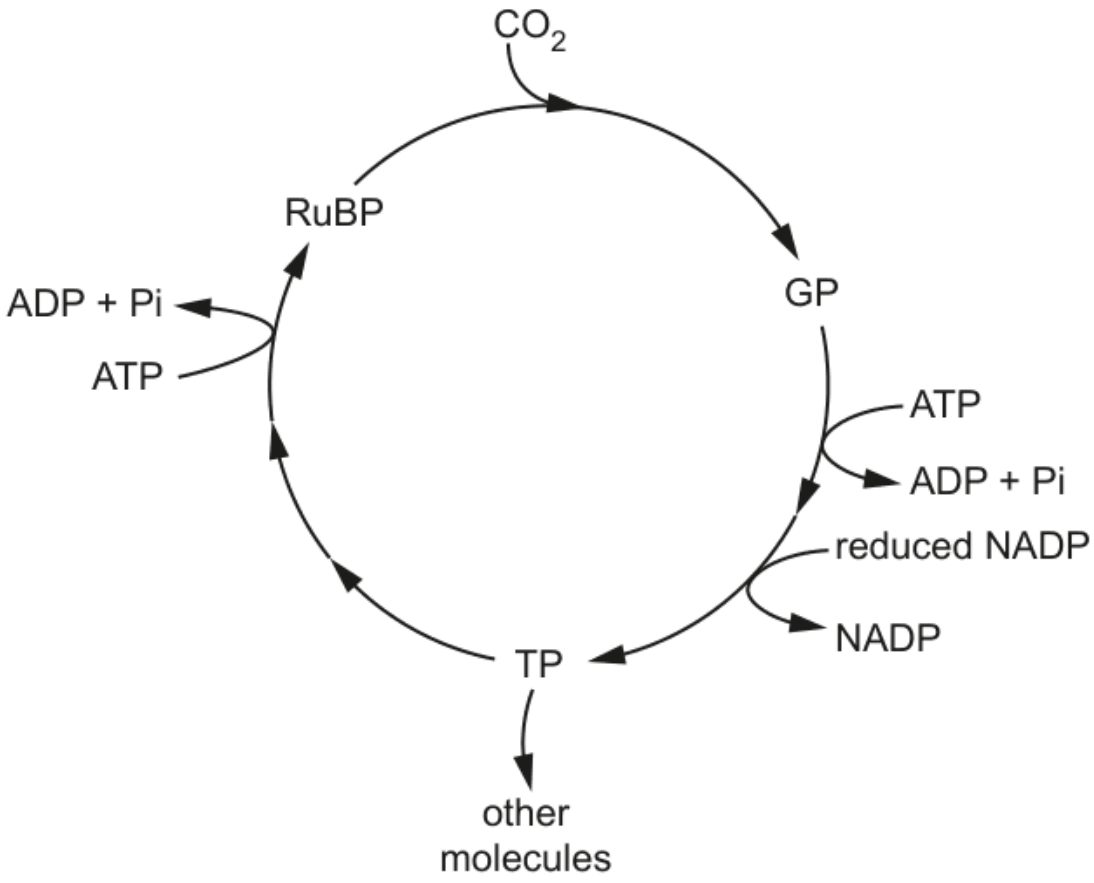


Fig. 8.2

(i) Name the process that involves the enzyme rubisco.

Question 19 · Paper 4 · May/June 2023 (42) · Q8(b)(ii) · 1 mark

(ii) State the type of reaction that occurs when GP is converted to TP.

Question 20 · Paper 4 · May/June 2023 (42) · Q8(b)(iii) · 1 mark

(iii) RuBP is regenerated from molecules of TP.

State how many molecules of RuBP are produced from 10 molecules of TP.

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Question 21 · Paper 4 · May/June 2023 (42) · Q8(b)(iv) · 2 marks

(iv) TP molecules that are **not** involved in the regeneration of RuBP can be used in the synthesis of other molecules.

State **two** molecules that can be produced from these TP molecules.

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Question 22 · Paper 4 · February/March 2022 (42) · Q6(b)(ii) · 2 marks

(ii) Pitcher plants grow in bogs and wet grassland where the soil has a low concentration of minerals such as nitrates. The plants obtain nitrates from the digestion of insects.

Calvin cycle intermediates are used to synthesise more complex compounds, some of which need nitrogen from nitrates.

Name **one** compound that needs nitrogen from nitrates **and** name the Calvin cycle intermediate from which it is synthesised.

compound that needs nitrogen .....

Calvin cycle intermediate .....

[2]

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Mark schemes

Question 1 · Paper 4 · October/November 2022 (42) · Q3(a)(i) · 2 marks

3(a)(i)	D ; B ;	2

Question 2 · Paper 4 · October/November 2022 (42) · Q3(a)(ii) · 4 marks

3(a)(ii)	*any **four** from:*	**4**
	1 thylakoid stacks or discs / many thylakoids, for, increased or large, surface area ;	
	2 increased or large, surface area maximises the absorption of light (energy) / AW ; **Ignore** trap (light energy)	
	mp 3–5 thylakoid membranes / grana contain	
	3 photosynthetic / named / primary / accessory, pigments to absorb light (energy) ;	
	4 electron carriers / ETC, to, transfer / release, energy (from excited electrons) ;	
	5 photosystems / antenna complex and reaction centre, are light harvesting structures ;	
	6 thylakoid space or lumen to, form proton gradient / have high concentration of protons ;	
	7 thylakoid membrane is (relatively) impermeable, to maintain the proton gradient (for chemiosmosis) ;	
	8 ATP synthase to make ATP ;	
	9 contains oxygen-evolving complex / OEC, for the photolysis of water ;	

Question 3 · Paper 4 · May/June 2023 (41) · Q1(a) · 4 marks

1(a) **4**

description	letter
accumulates (builds up) a high concentration of protons	**B ;**
makes triose phosphate	**A ;**
makes some chloroplast proteins	**D ;**
pumps protons	**C ;**

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Question 4 · Paper 4 · February/March 2025 (42) · Q9(a) · 2 marks

9(a)	*any **two** from:*	**2**
	1 accessory pigment ;	
	2 absorbs light wavelengths **not** absorbed by, reaction centre / primary pigment / chlorophyll a ;	
	3 so extends the range of wavelengths absorbed ;	
	4 pass **energy** to, reaction centre / primary pigment / chlorophyll *a* ;	
	5 *idea that* improves efficiency of light-dependent stage ;	

Question 5 · Paper 4 · February/March 2025 (42) · Q9(b)(ii) · 4 marks

9(b)(ii)	*any **four** from:*	**4**
	1 absorbs more light ;	
	2 so faster rate of, photosynthesis / light-dependent stage ;	
	3 more ATP and reduced NADP produced ;	
	4 more turns of Calvin cycle / AW ;	
	5 more, triose phosophate / TP, produced ;	
	6 more, hexose/ AW, for respiration ;	
	7 more energy for growth ;	
	8 more synthesis of, amino acids / proteins / lipids / cellulose / starch ;	

Question 6 · Paper 4 · October/November 2025 (42) · Q9(a)(i) · 2 marks

9(a)(i)	*absorption spectrum* absorption of **different** wavelengths (of light) by (named) pigment(s) ; *action spectrum* **rate** of photosynthesis at different wavelengths (of light) ;	**2**

Question 7 · Paper 4 · October/November 2025 (42) · Q9(a)(ii) · 3 marks

9(a)(ii)	*any **three** from :*	**3**
	1 chlorophyll b / carotenoids / accessory pigments (are present) ;	
	2 (these other pigments) absorb light (energy), between 450 and 550 nm / of wavelengths that chlorophyll a does not absorb ;	
	3 energy passed on to, reaction centre / chlorophyll a / primary pigment ;	
	4 for, light-dependent reactions / photophosphorylation / photolysis (of water) / photoactivation ;	

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Question 8 · Paper 4 · May/June 2023 (43) · Q8(c) · 4 marks

8(c)

1 absorption higher for (whole) chloroplasts (throughout) ; **4**

2 comparative data quote **or** greatest difference at 525 / 530 nm ;

wavelength / nm	absorbance / au ±0.05	
	whole	pigment
500	9.2	6.4
510	8.4	3.8
520	7.4	2.3
525	7.0	1.95
530	6.6	1.85
540	6.2	2.05
550	5.8	2.35
560	5.8	2.7
600	6.65	4.7
650	8.85	8.1
670	9.6	9.2

3 (because) pigments arranged for better absorption in chloroplasts / thylakoid membranes are stacked / AW ;

4 (because) chloroplasts contain more pigments ;

Question 9 · Paper 4 · May/June 2022 (41) · Q2(c) · 7 marks

2(c) **7**

*any **seven** from:*

description

D1 identify wavelengths for chlorophyll (a) absorption ;

D2 identify wavelengths for phycoerythrin absorption ;

D3 identify wavelengths for phycocyanin absorption ;

D4 chlorophyll (a), has peaks / absorbs mainly, in blue and red ;
D5 phycoerythrin absorbs in blue and green and yellow ;
D6 phycocyanin absorbs in (green) yellow and red ;

explanation

E7 red algae / deep water, get(s) green (and yellow) light ;
E8 chlorophyll (a) absorbs, no / little, green (and yellow) light ;
E9 phycoerythrin / phycocyanin / accessory pigments, absorbs wavelengths not absorbed by chlorophyll (a) ;
E10 combined pigments absorb, greater range of / any / all, wavelengths ;
E11 increases / more / high(er) rate of, light dependent stage / photosynthesis ;
E12 (so) more / lots of, (named) organic compounds / growth ;

Question 10 · Paper 4 · February/March 2021 (42) · Q4(b)(i) · 1 mark

4(b)(i)	chromatography ; 1

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Question 11 · Paper 4 · February/March 2021 (42) · Q4(b)(ii) · 3 marks

4(b)(ii)	*any **three** from:*	**3**
	1 calculate R_f value(s) ;	
	2 compare R_f values of pigments (in red algae and green plant) ;	
	3 find pigment present (on chromatogram) from red algae but absent from green plant **or** R_f value of phycoerythrin will not be the same as Rf values of pigments in green leaves ;	
	4 identify pigment using reference values (to confirm it is phycoerythrin) ;	

Question 12 · Paper 4 · February/March 2019 (42) · Q1(c) · 5 marks

1(c)	*any **five** from:*	**5**
	1 ref. to (only) photosystem 1 / P700 ;	
	2 light <u>energy</u> absorbed by, chlorophyll <u>*a*</u> / primary pigment / reaction centre ;	
	3 electrons, excited / move to higher energy level ;	
	4 (electron) emitted by, chlorophyll <u>*a*</u> / primary pigment / reaction centre ;	
	5 (to) electron, carrier / acceptor ;	
	6 passes along, <u>electron transport chain</u> / <u>ETC</u> ;	
	7 chemiosmosis / description ;	
	8 (leading to) ATP synthesis ;	
	9 electron returns to, photosystem 1 / P700 / chlorophyll <u>*a*</u> / primary pigment / reaction centre ;	

Question 13 · Paper 4 · May/June 2024 (42) · Q7(b) · 3 marks

7(b)	*any **three** from:*	**3**
	1 light absorbed by, photosystem II / P680 **or** photoactivation / photoionisation (of chlorophyll) ;	
	2 photolysis (of water) ;	
	3 water-splitting enzyme / oxygen evolving complex ;	
	4 water splits into protons, electrons and oxygen ; **A** equation	

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Question 14 · Paper 4 · October/November 2023 (42) · Q8(a) · 4 marks

8(a)	*any **four** from:* 1 both photosystem I and photosystem II involved ; **A** both photosystems 2 photoactivation of chlorophyll occurs ; 3 photolysis of water occurs / description ; 4 oxygen production / oxygen-evolving complex involved ; 5 electrons emitted by photosystem I used to reduce NADP **or** NADP is the final electron acceptor ; 6 photosystem I receives electrons from photosystem II **or** photosystem II receives electrons from photolysis (of water) ; 7 ETC / electron transport chain, sets up proton gradient **or** chemiosmosis / ATP produced ;	**4**

Question 15 · Paper 4 · May/June 2024 (43) · Q7(b) · 4 marks

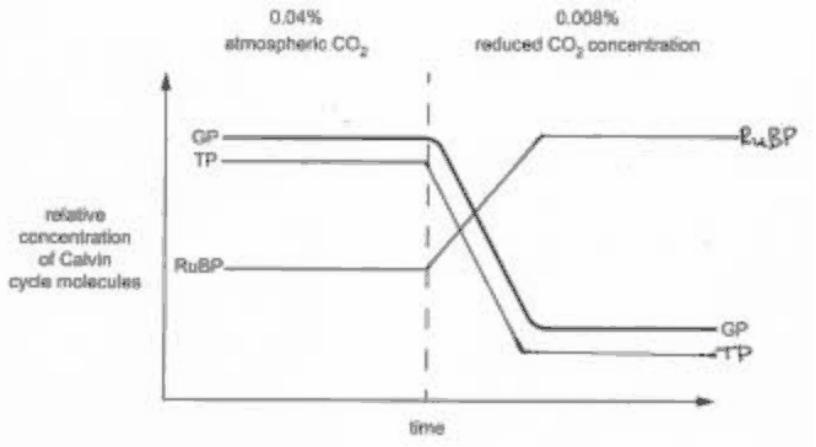
7(b)	*any **four** from:* 1 electrons, excited / emitted / described ; 2 electrons travel along ETC **and** energy released ; 3 (use energy released) to pump H^+ into thylakoid, space/ lumen ; 4 increases concentration of H^+ / protons (in thylakoid space / lumen) / creates proton gradient ; 5 H^+ / protons, diffuse through ATP synthase ; 6 (from thylakoid space) to stroma ; 7 chemiosmosis ;	**4**

Question 16 · Paper 4 · October/November 2024 (42) · Q7(c) · 7 marks

7(c)	*any **seven** from:* 1 carbon dioxide, **reacts / combines**, with, ribulose bisphosphate / RuBP ; 2 (catalysed by) rubisco ; 3 *ref. to* carbon (dioxide) fixation ; 4 unstable 6C compound ; 5 forms 2 (molecules of) glycerate 3-phosphate / GP ; 6 glycerate 3-phosphate / GP, **reduced** to, triose phosphate / TP ; 7 **by** reduced NADP and ATP ; 8 triose phosphate / TP, used to regenerate RuBP ; 9 glycerate 3-phosphate / GP, forms amino acids ; 10 (some) TP forms, (named) hexoses / sucrose / maltose / starch / cellulose / glycerol / lipids / amino acids ; 11 *ref. to* Calvin cycle ;	**7**

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Question 17 · Paper 4 · May/June 2022 (42) · Q2(a)(ii) · 2 marks

2(a)(ii)	*correctly showing that TP reduces to a plateau below GP* ; *correctly showing that RuBP increases to a plateau* ; 	**2**

Question 18 · Paper 4 · May/June 2023 (42) · Q8(b)(i) · 1 mark

8(b)(i)	carbon (dioxide) fixation ; **A** carboxylation	**1**

Question 19 · Paper 4 · May/June 2023 (42) · Q8(b)(ii) · 1 mark

8(b)(ii)	reduction / hydrogenation ;	**1**

Question 20 · Paper 4 · May/June 2023 (42) · Q8(b)(iii) · 1 mark

8(b)(iii)	6 / 5 ;	**1**

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Question 21 · Paper 4 · May/June 2023 (42) · Q8(b)(iv) · 2 marks

8(b)(iv)	*any **two** from: list rule* 1 hexose / named ; e.g. glucose / fructose 2 disaccharide / named ; e.g. sucrose / maltose 3 starch / cellulose ; 4 amino acids ; 5 glycerol / fatty acids ;	**2**

Question 22 · Paper 4 · February/March 2022 (42) · Q6(b)(ii) · 2 marks

6(b)(ii)	amino acid(s) / proteins / nucleotides ; glycerate-3-phosphate / GP **or** triose phosphate / TP ;	**2**

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