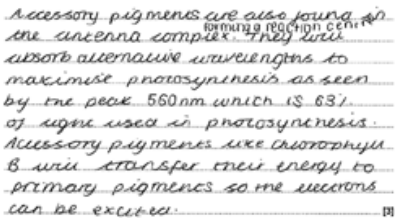
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a	i	21 or 22 or 23 or 24 (%) ✓	1	**ALLOW** e.g. 22.0 but **DO NOT ALLOW** other decimal places e.g. 22.3 **Examiner's Comments** Most candidates correctly read the correct percentage of absorbance at 680nm from the graph in **Fig. 17.2** and gave answers within the accepted range. Some lost the mark for incorrectly reading the graph or for unnecessarily trying to process the data. **OCR support** The mathematical skills handbook provides further support on estimate results (M0.4), as well as the maths for biology resources which include a tutorial and a quiz.
		ii	**1** (alga has) accessory pigments ✓ **2** (other pigments) absorb , different / other , wavelengths (of light) ✓ **3** little / not all , light (wavelengths) is absorbed by , chlorophyll a / primary pigment ✓ **4** (light) energy is transferred to reaction centre ✓ **5** for use in , light-dependent reaction / LDR ✓	max 3	**MP1 IGNORE** named pigments **MP2 ALLOW** longer / shorter / AW for different **MP2 ALLOW** λ for wavelength **MP2 IGNORE** more / wider range , wavelengths **MP4 ALLOW** chlorophyll a / primary pigment for reaction centre / photosystem **MP4 ALLOW** AW e.g. accessory pigments harvest (light) energy for reaction centre **Examiner's Comments** Some candidates did not recognise that this question was about photosynthetic pigments and described the features of hydrophytes.

					Marking points 1 and 2 were the most frequently given with only the higher attaining candidates going onto achieving a third mark. Many candidates knew that other pigments would be present, but some did not name them as 'accessory pigments' for marking point 1. Terms such as special chlorophyll, secondary pigments were used in place of accessory pigments. A common error was to write about different colours or percentages of light instead of wavelength. Credit was not given for stating that a 'wider' range of wavelengths would be absorbed or for failing to mention pigments anywhere in the account. Some candidates referred to the alga absorbing light rather than its pigments. Exemplar 1  Accessory pigments are also found in the antenna complex. They will absorb alternative wavelengths to maximise photosynthesis as seen by the peak 560nm which is 63% of light used in photosynthesis. Accessory pigments like chlorophyll B will transfer their energy to primary pigments so the electrons can be excited. [3] The exemplar shows a good response, with credit being given for marking points 1, 2 and 4.
		iii	(red) algae have pigments that absorb short(er) (light) wavelengths / AW ✓ (these wavelengths) can penetrate water to great(er) depths / AW ✓	2	**ALLOW** values in range 500 − 630nm / blue / green / yellow for short(er) wavelengths **ALLOW** e.g. can pass through water to reach the (red) algae (at depth) **<u>Examiner's Comments</u>** This question proved challenging for many candidates with regards to the use of correct terminology for features of light i.e. wavelength or intensity. Good responses showed the ability to apply knowledge of photosynthetic pigments to the context of the red alga, *Porphyra naiadum*, describing

					how the alga would have pigments to absorb shorter wavelengths that could penetrate to greater depths in water.
	b	i	GP was the only compound seen after 1 , sec(ond) / s ✓ TP appears after 5 , sec(onds) / s ✓	2	**ALLOW** glycerate 3 -phosphate for GP and triose phosphate for TP **ALLOW** AW for compound e.g. molecule / product **ALLOW** e.g. GP and no other products were seen after 1 second **IGNORE** any other products after 5 seconds **Examiner's Comments** Good responses used the diagram to formulate a response that included times at 1s and 5s. Some candidates did not gain credit for marking point 1 as, although able to state when GP was first seen, they did not mention that it was the only compound seen at 1s.
		ii	(TP is) converted into / source of, sugar phosphates / (named) amino acid(s) / citrate / sucrose / RuBP ✓	1	**must be idea of synthesis into / AW not breaking down into** **ALLOW** glutamic acid / serine / glycine / aspartic acid for named amino acids **DO NOT ALLOW** GP **Examiner's Comments** Generally answered well as candidates knew the fate of TP in the Calvin cycle. Some candidates lost the mark for referring to break down or hydrolysis of TP.
			Total	**9**	
2			B	1	**Examiner's Comments** Many candidates demonstrated a good understanding of the Calvin cycle and the effect of light intensity on the concentrations of GP, TP and RuBP to choose option **B** as the correct response. Where incorrect responses were chosen, most correctly identified statement 1 as correct, but did not recognise that increased light intensity causes high

					levels of TP to be regenerated into RuBP due to more ATP and reduced NADP from the light dependent stage.
			Total	**1**	
3			A	1	**Examiner's Comments** Candidates were required to have a good understanding of water, carbon dioxide and temperature as potential limiting factors of photosynthesis. All options were seen and candidates who chose incorrect option **C**, often did not realise that water is not usually a limiting factor for the rate of photosynthesis thus excluding statement 1. Statement 3 required candidates to recognise photosynthesis as an enzyme controlled reaction and therefore apply Q_{10} = 2; those who chose incorrect option **B** or **D** showed a poor understanding of this concept.
			Total	**1**	
4		i	**X** = water / H_2O **Y** = carbon dioxide / CO_2 **Z** = oxygen / O_2 ✓✓	2	All **three** correct for **TWO** marks **One** or **two** correct for **ONE** mark **Examiner's Comments** Many candidates were able to correctly identify all three molecules in Fig.17.1. Some candidates found it difficult to interpret the diagram and so mixed up the three molecules on the answer lines or answered in terms of ATP, NAD, FAD, NADP, NADPH or electrons. **Misconception** It is a common misconception that candidates consider that ATP produced in respiration is used directly in photosynthesis.
		ii		max 3	**ALLOW** O_2 for oxygen, H_2O for water, CO_2 for carbon dioxide and $C_6H_{12}O_6$

			1 *idea that* light (energy) is the only requirement from outside the terrarium / AW ✓ **2** respiration provides carbon dioxide **and** water for photosynthesis **OR** photosynthesis provides glucose **and** oxygen for respiration ✓ **3** water used for photolysis **OR** oxygen used as final electron acceptor (in respiration) ✓ **4** carbon dioxide used for , light independent stage / Calvin cycle ✓ **5** ATP (still) produced / energy provided , for (named) cell activities ✓ **6** decomposing plant material provides (named) mineral ions ✓		for glucose throughout **MP1 ALLOW** e.g. as light (energy) can pass through glass for photosynthesis **MP1 ALLOW** e.g. plants in glass containers will have access to light **MP2 IGNORE** equations unqualified **MP5 ALLOW** e.g. active transport / protein synthesis / active uptake of mineral ions **IGNORE** produces energy **MP6 IGNORE** nutrients **Examiner's Comments** Good responses showed good application of knowledge and understanding of photosynthesis and respiration and their interaction in plants. Higher attaining candidates set out their answers in a logical sequence and gave detailed accounts of the production and use of reactants for both processes.
			Total	**5**	
5		i	*(pH, would increase / become less acidic / more alkaline)* because protons move into, chloroplasts / AW ✓ by, diffusion / down a concentration gradient / AW ✓ (for) protons (to be pumped / moved) into thylakoid, lumen / space / AW✓	2 max	**If pH decreases / becomes more acidic / less alkaline = 0 marks** **ALLOW** H+ / hydrogen ions for protons throughout **DO NOT ALLOW** H / hydrogen for protons throughout (but penalise only once) e.g. 'protons diffuse from high to low concentration into the chloroplasts' = 2 marks **IGNORE** 'along a concentration gradient' **IGNORE** active transport (*as energy provided by ETC*) **IGNORE** 'intermembrane'

					(as confusing chloroplasts with mitochondria) **Examiner's Comments** This was a challenging question, but a reasonable number of candidates managed to interpret the information provided and explain why the pH of the solution would increase. Some candidates that understood the principles of the process did not gain both marks because they described how the H+ ions would be used inside the chloroplasts without initially explaining that these ions would need to move into the chloroplasts and then into the thylakoid spaces. Other candidates explained that the protons would move from the solution into the chloroplasts, which was credited, but their answer did not state that the protons would move down a concentration gradient by diffusion.
		ii	*(ATP produced in 3 / pH 8 solution, but not 2 / pH 4 solution, because)* proton gradient between thylakoid (lumen / space) and solution 3 ✓ protons diffuse through ATP synthase (into solution 3) ✓	2	**If ATP produced in 2 but not 3 or ATP production is, higher / highest, in 3 or more ATP produced in 3 than 2 = 0 marks** **ALLOW** H+ / hydrogen ions for protons throughout **DO NOT ALLOW** H / hydrogen for protons throughout (but penalise only once) **ALLOW** electrochemical gradient for proton gradient **ALLOW** higher concentration of protons in thylakoid (lumen / space) than in solution 3 **ALLOW** no proton gradient / equal proton concentration, between thylakoid (lumen) and solution 2 **ALLOW** no protons diffuse through ATP synthase into solution 2 **DO NOT ALLOW** 'pumped through by diffusion' **ALLOW** 'pass' / move / travel' for 'diffuse' **Examiner's Comments**

					This was the most challenging question in the examination. Candidates were required interpret the information and make several logical steps to realise that ATP production would occur in solution 3. The majority of candidates suggested that ATP production would be higher in solution 2; the logic of these answers was often that the lower pH and therefore higher H+ ion concentration in that solution had the potential to provide more protons for chemiosmosis. Only the higher performing candidates realised that the initial placement of the thylakoids, in the dark, in a solution of pH 4 would have resulted in a pH of 4 inside the thylakoids. As a consequence, no concentration gradient would have existed across the thylakoid membranes in solution 2 (and no light was present to activate the ETC to allow protons to be pumped into the thylakoids). A concentration gradient would have existed in solution 3, allowing the diffusion of protons through ATP synthase even without the ETC functioning.
			Total	**4**	
6		i	rate of NPQ ✓ rate of CO_2 fixation ✓	1 max (AO3.4)	**Examiner's Comments** This question was answered correctly by most candidates who demonstrated a good knowledge of variables. The most common mistake was to give light intensity as the answer. Some lost the mark for stating the amount of CO_2 taken in rather than rate of CO_2 fixation.
		ii	greater rate (of carbon fixation in GM plants) because , less light energy is converted to heat energy / lower NPQ rate / more energy remains as light ✓ (so) more electrons enter electron transport chain / AW ✓ more, ATP / NADPH / reduced NADP	2 max (AO2.1) (AO3.1)	**ora** for unmodified plants **ALLOW** ref to figures for comparison of rates **ALLOW** 'light-independent stage' for Calvin cycle or a description of the

			, generated for / supplied to , Calvin cycle (from light-dependent stage) ✓		Calvin cycle **Examiner's Comments** Some candidates misinterpreted the data and stated that genetic modification 'decreased the rate of carbon fixation'. These answers compared the rate at 0 and 150 seconds for the GM plant rather than making the correct comparison; GM and non-GM plants at 150 seconds. Some explained why the rate of fixation fell with reduced light rather than why fixation was higher in the GM plants or described the higher rate of fixation in the GM plants (including quoting data from the table) but did not explain why. Nonetheless, many answers did state that the rate was increased by genetic modification because of a reduced NPQ rate. Far fewer were able to make the link between reduced NPQ and increased ATP and NADPH for the Calvin cycle.
		iii	*idea that* company could charge high prices (to farmers / countries) ✓ *idea that* GM crop not available to everyone ✓	1 max (AO1.1)	e.g. 'poorer farmers cannot afford GM seed' **Examiner's Comments** Candidates generally had the right idea and gained the mark for this question. Marks were mostly awarded for the idea of the plant being expensive. A few described what a 'patent' is rather than the possible consequences. Some candidates gave other possible concerns around GM plants which were not related to patenting/access.
			Total	**4**	
7			C ✓	1 (AO2.1)	**Examiner's Comments** This question is an example of a statement style multiple choice question. Candidates needed to use the information in the diagram and their knowledge to process

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>information in the three statements about biochemical reactions taking place in a leaf. Many candidates gave the correct option C demonstrating sound knowledge and understanding of respiration and photosynthesis to identify statements 2 and 3 as being correct</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>8</td><td></td><td></td><td>B ✓</td><td>1
(AO2.2)</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>9</td><td>a</td><td></td><td><table><tr><th>Structure of function</th><th>Letter</th></tr><tr><td>chloroplast envelope</td><td>F ✓</td></tr><tr><td>site of light independent reactions</td><td>E ✓</td></tr><tr><td>inter-granal lamellae</td><td>D ✓</td></tr><tr><td>contains starch grains and lipid droplets</td><td>E ✓</td></tr></table></td><td>4
(AO1.1)
(AO2.1)</td><td>DO NOT ALLOW more than one letter for each response

<u>Examiner’s Comments</u>

A very straightforward end to the exam paper providing most candidates the opportunity to gain several marks. Many candidates were able to identify the chloroplast envelope correctly but the site of the light -independent reaction was often incorrectly identified as the thylakoids. The inter-granal lamellae proved the most difficult for candidates to identify.</td></tr>
<tr><td></td><td>b</td><td></td><td>RuBP / ribulose (−1,5−) bisphosphate ✓

GP / glycerate (3−) phosphate / G3P ✓

ATP ✓

NADPH / red(uced) NADP / $NADPH_2$ / $NADPH + H^+$ ✓

sucrose ✓</td><td>5
(AO1.1)</td><td>ALLOW (3−) phosphoglycerate / (3−) phosphoglyceric acid / 3PGA / 3PG / PGA

ALLOW ATP and NADPH in either order

<u>Examiner’s Comments</u>

As with Q22(a), this was quite a high scoring question, although few candidates gained full marks. Common errors seen included ribulose <u>bi</u>phosphate or a confused version of glycerate phosphate, commonly glycerol-phosphate. Candidates may find it easier to use the abbreviation RuBP and GP and not the full words, as these have much less opportunity for error. Some candidates also confused RuBP with the enzyme, RuBisCO. Other errors included NADH (i.e. missing the</td></tr>
</table>

					phosphate) for NADPH or using the oxidised version, NADP. Very few candidates spotted the reference to transport meaning that sucrose was the expected answer, not glucose.
			Total	**9**	
10			**C**	1 (AO1.2)	
			Total	**1**	
11			**A**	1 (AO1.1)	**Examiner's Comments** This question required knowledge of chloroplast structure. Most candidates understood that they had to choose the component that was **not** part of a chloroplast and correctly identified option A. However, some candidates seemed unaware that chloroplasts contain their own DNA and ribosomes, incorrectly choosing either option B or C.
			Total	**1**	
12			**C**	1 (AO2.8)	
			Total	**1**	
13			**B**	1 (AO2.8)	**Examiner's Comments** Use of mathematical skills and data analysis is a requirement of A level Biology, although statistical analysis remains challenging for some candidates. Many candidates demonstrated their knowledge by choosing the unpaired *t*-test in option B as the appropriate statistical test to use in this context. Distinguishing between a paired and an unpaired *t*-test proved the biggest challenge with option A being the most common incorrect response.
			Total	**1**	