Question Number	Answer	Additional Guidance	Mark
1(a)(i)	1. Molecule P - water / H_2O ; 2. Molecule Q - oxygen / O_2 ;		(1)

Question Number	Answer	Mark
1(a)(ii)	D ATP and reduced NADP ;	(1)

Question Number	Answer	Additional Guidance	Mark
1(a)(iii)	1. reference to RUBISCO as an {enzyme / catalyst} ; 2. in the Calvin cycle ; 3. involved in {carbon fixation / bonding of CO_2 to RuBP / reaction between CO_2 and RuBP / eq} ; 4. to form GP / eq ; 5. GP converted to GALP / eq ; 6. using ATP and {reduced NADP / NADPH} (CO_2 to GALP / GP to GALP) ;	1. ACCEPT catalyses 3. ACCEPT formation of 6C intermediate from RuBP 5. ACCEPT reduced to NB Award formation of GALP from reaction between CO_2 and RuBP if mp 4 not awarded	(4)

Question Number	Answer	Mark
1(b)(i)	C stroma	**(1) COMP**

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	1. (image length) 76 / 76.5 / 77 (mm) ; 2. (correct calculation = length /7500) / eq ; 3. (correct units for given answer) µm / eq ;	Correct answer with units = 3 marks 2. CE applies 3. CE applies ACCEPT as standard form	**(3) P**

length	answer in µm	answer in mm	answer in cm	answer in m
7.6 (cm) 76 (mm) 76000 (µm)	10 10.1 10.13	0.01 0.0101 0.01013	0.001 0.00101 0.001013	0.00001 0.0000101 0.00001013
7.65 76.5 76500	10 10.2	0.01 0.0102	0.001 0.00102	0.00001 0.0000102
7.7 77 77000	10 10.3 10.27	0.01 0.0103 0.01027	0.001 0.00103 0.001027	0.00001 0.0000103 0.00001027

Question Number	Answer	Additional Guidance	Mark
1(b)(iii)	1. idea of compartmentalisation (from stroma) ; 2. site of light-dependent reaction ; 3. credit named molecules {within / on / eq} membrane ; 4. idea of {ATPase / eq } in (thylakoid) membranes ; 5. idea that (thylakoid) membranes provide a space for accumulation of H^+ ; 6. reference to photophosphorylation ;	1. ACCEPT description of separation 3. e.g. photosynthetic pigments / chlorophyll / carotenoids / photosystems / electron carrier proteins IGNORE electron acceptors 4. ACCEPT {ATP synthase / synthetase}, NADP reductase 6. ACCEPT chemiosmosis	**(3)**

Question Number	Answer	Mark
2(a)(i)	**C** reduced NADP	**(1) COMP**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	1. ADP / adenosine diphosphate ; 2. PO_4^{3-} / phosphate ;	ACCEPT either way round 2. CCEPT Pi / inorganic P	**(2) RAD**

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)	1. molecule Q is {oxygen / O_2}; 2. made from water / H_2O; 3. idea of {photolysis / light splitting the water molecule / eq} ; 4. into {O / (atom of) oxygen} (and H^+ and electrons) ; 5. idea that two water molecules are needed to form one molecule of oxygen ; 6. in chloroplast ;	1. eject O , 1/2 O_2 4. CCEPT $H_2O \rightarrow 1/2\ O_2 + 2H^+$	**(4) XP**

Question Number	Answer	Mark
2(b)(i)	**A** granum	**(1) COMP**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	1. (image length) 76 / 76.5 / 77 (mm) / eq ; 2. image length / 0.007 ; 3. (76) 10857.14286 / eq (76.5) 10928.57143 / eq (77) 11000 / eq	 2. CE applies 3. CE applies	**(3) XP**

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	1. idea of compartmentalisation (from cytoplasm); 2. thylakoid (membranes) are site of {light-dependent reaction / photophosphorylation / chemiosmosis} ; 3. credit named molecules {within / on / eq} membrane ; of idea of { / eq } in (thylakoid) membranes ; 4. idea that (thylakoid) membranes provide a space for accumulation of H^+ ; 5. stroma is site of {light-independent reaction / Calvin cycle / carcon fixation} ; 6. reference to {RuBP / RUBISCO / eq} ;	1. ACCEPT description of separation 3. e.g. chlorophyll / carotenoids / photosystems / electron carrier proteins / ATP synthetase / NADP reductase	**(3) EXP**

Question Number	Answer	Mark
3(a)(i)	B (between 12 and 15 hours) ;	(1)

Question Number	Answer	Mark
3(a)(ii)	D (phytochrome) ;	(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(iii)	any two of the following standardised: water / eq mineral ion concentrations / eq light intensity / eq wavelength of light CO_2 concentration, temperature pH soil type ;	IGNORE seed ACCEPT named mineral ion	(2)

Question Number	Answer	Additional Guidance	Mark
3(a)(iv)	idea of using shorter time intervals e.g. 1 hour intervals ;	ACCEPT a description e.g. repeat with 12 hours of light, 13 hours, etc Ignore ref to more data collected unqualified	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	any one from: temperature water availability the {wavelength / quality} of light intensity of light {edaphic / named edaphic} factor ;	IGNORE ref to pollinators	(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	outer segment / internal membranes / inner membranes / vesicles ;	IGNORE ref to top, end, outer layer	(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	<table><tr><th rowspan="2">Description</th><th colspan="3">Statement</th></tr><tr><th>Opsin binds to the rod cell membrane</th><th>Rhodopsin bleaches</th><th>ATP used</th></tr><tr><td>Rhodopsin responding to light</td><td>✓</td><td>✓</td><td>×</td></tr><tr><td>Rhodopsin being reset</td><td>×</td><td>×</td><td>✓</td></tr></table> Any two correct for 1 mark ;	IGNORE blank boxes IGNORE hybrid tick/crosses (✓)	(3)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	1. idea of {fast / maximum} {gas exchange / uptake of carbon dioxide / eq}; 2. idea of penetration of light ; 3. idea that carbon dioxide is used in the {light-independent stage / Calvin cycle / formation of GP}; **OR** idea that light is used in {light-dependent stage / photolysis / photophosphorylation / eq } ;	**Accept** CO_2 but **ignore** incorrect formula	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	1. transport (in xylem) of water (to the leaves) / eq ; 2. transport (in phloem) of {sucrose / sugar / carbohydrates } (away from the leaves) / eq; 3. (water) for {light-dependent reaction / photolysis / source of hydrogen (ions)}; **OR** idea of (transporting sugar) to make more room for more carbohydrate synthesis ;	**Accept** H_2O but **ignore** incorrect formula **Accept** phosphates but i**gnore** mineral ions **Not** glucose or any other name sugars **Accept** reducing power, NADPH **Accept** (phosphates) for ATP synthesis	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	<table><tr><th>Reaction</th><th>Details</th><th>Structure</th></tr><tr><td></td><td></td><td>{thylakoid (membrane) / grana / granum} ;</td></tr><tr><td></td><td></td><td>stroma ;</td></tr><tr><td></td><td></td><td>stroma ;</td></tr></table>	**Not** thylakoid space **Ignore** electron transport chain **Not** stoma / stomata **Not** stoma / stomata	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	C ;		**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(iii)	C ;		**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(iv)	1. reference to conversion (of GALP) to glucose / eq; 2. (which is) β glucose ; 3. reference to formation of glycosidic bonds ; 4. between C_1 and C_4 / these bonds are 1-4 (glycosidic bonds) ; 5. by condensation ; 6. reference to {straight / unbranched} (chains of glucose) ; 7. reference to cellulose as a {polysaccharide / polymer of glucose / eq} ;	**NB** this is a question about the **formation** of cellulose, not its structure **NB** a reference to these bonds being formed must be made	**(4)**