Question			answer	Marks	Guidance
1	(a)	(	**W** (chloroplast outer) membrane / envelope **;** **X** granum / grana **;** **Y** <u>stroma</u> **;** **Z** thylakoid(s) / (intergranal) lamella(e) **;**	**4**	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then **= 0 marks** **W DO NOT CREDIT** cell / plasma **,** membrane **DO NOT CREDIT** inner membrane alone but **IGNORE** if stated together with outer **X ACCEPT** granal stack / thylakoid stack **Y DO NOT CREDIT** stoma / matrix / cytoplasm
1	(a)	(i	**1** (DNA) coding for **,** gene(s) / protein / enzyme **or** (ribosome) protein / enzyme **,** synthesis **;** **2** (enzymes for production of / proteins for) chlorophyll synthesis / pigment synthesis / photosystem **;** **3** (protein for) electron **,** acceptor(s) / carrier(s) **;** **4** ATP synth(et)ase **;** **5** (enzyme / PSII) for **,** photolysis / splitting of water **;** **6** (enzymes for) Calvin cycle / light independent reaction **;**	**2 max**	**DO NOT CREDIT any** mps in context of respiration **1 IGNORE** 'information' **/** ref to replication **DO NOT CREDIT** making amino acids **3 CREDIT** named acceptor / carrier (e.g. NADP / cytochrome) **6 CREDIT** Rubisco

Question			Answer	Marks	Guidance
1	(b)		<table><tr><th>statement</th><th>letter</th></tr><tr><td>ATP is produced</td><td>B</td></tr><tr><td>an electron leaves photosystem I</td><td>B</td></tr><tr><td>electrons are passed along an electron carrier chain</td><td>B</td></tr><tr><td>electrons leave both photosystem I and photosystem II</td><td>N</td></tr><tr><td>an electron from a water molecule replaces the electron lost from the photosystem</td><td>N</td></tr><tr><td>the same electron returns to the photosystem</td><td>C</td></tr></table>	5	**Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks **ACCEPT** lower case letters **DO NOT CREDIT** 'N and C' *instead of* B, as they have been asked to use B **IGNORE** 'N and C' if stated *in addition to B* in rows 1 and 2 **ACCEPT B** for this row
			Total	**11**	

Question			Expected Answer	Mark	Additional Guidance
2	(a)	(i)	0.0017 ; ;	2	• Correct answer, given to 4 dp = 2 marks • If answer **not** shown on answer line, **CREDIT** correct answer written in the appropriate space in the table. • If answer is incorrectly rounded **or** rounded to the wrong number of dp **or** written in standard form (1.7×10^{-3}) then award 1 working mark • If answer is incorrect then award 1 working mark for seeing $1 \div 576$ **or** $1 \div 24^2$
2	(a)	(ii)	**1** (internal) radius / diameter **,** of capillary tube ; **2** cross-sectional area (of capillary tube) ; **3** (use) $\pi r^2 h$;	1 max	***1*** **ACCEPT** radius / diameter **,** of bubble **ACCEPT** width of tube ***2*** **ACCEPT** cross-sectional area of bubble
2	(a)	(iii)	**1** (sodium) hydrogen carbonate ; **2** bubble in **,** CO_2 / exhaled air ; **3** dry ice ;	1 max	***1*** **ACCEPT** bicarbonate **DO NOT CREDIT** carbonate

Question			Expected Answer	Mark	Additional Guidance
2	(b)	(i)	*idea that some of the oxygen* **1** would dissolve in the water **;** **2** used in **,** respiration / oxidative phosphorylation **;** **3** may escape the collection apparatus **;** **4** trapped in **,** a bubble attached to / air spaces in **,** the leaf **;**	**2 max**	***1*** **IGNORE** 'oxygen is in the water' **2** **IGNORE** produces energy
2	(b)	(ii)	**1** (nitrogen) was present in the air (spaces) in the **,** leaf / plant **;** **2** (nitrogen) leaves the plant with the oxygen **;** **3** *idea that* (nitrogen) comes out of solution / 'undissolved' (as less soluble in warm water) **;**	**1 max**	
2	(b)	(iii)	**1** higher than **,** expected / normal / in atmosphere **;** **2** (plant is) respiring / produces CO_2 during respiration **;** **3** CO_2 **,** has been added to water / is present in excess **;** **4** (CO_2) comes out of solution / 'undissolved' (as less soluble in warm water) **;** **5** less / low(er) **,** as some CO_2 will dissolve in **,** water / solution **;** **6** less / low(er) **,** as CO_2 used in photosynthesis **;**	**3 max**	***2*** **IGNORE** produces energy ***5*** **DO NOT CREDIT** if in context of lower than O_2 and N_2 ***6*** **DO NOT CREDIT** if in context of lower than O_2 and N_2

Question			Expected Answer	Mark	Additional Guidance
2	(c)				**IGNORE** ref to photosynthesis (as 'photosynthetic' stated in Q)
			intensity **1** in deeper water there is , less / lower , light <u>intensity</u> ;		
			2 (these pigments) can absorb what (little) light there is ;		***2*** **ACCEPT** trap / harvest / capture **IGNORE** use / collect
			wavelength **3** not all wavelengths of light can penetrate **or** mainly shorter wavelengths can penetrate **or** (mostly) blue light (450 – 520 nm) penetrates ;		***3*** idea of restricted range of wavelengths able to penetrate (rather than wavelengths are different) **ACCEPT** '**higher** frequency' instead of '**shorter** wavelength'
			4 (these pigments) can absorb wavelengths of light that can penetrate (deeper water) ;	**2 max**	***4*** **ACCEPT** trap / harvest / capture **IGNORE** use / collect
			Total	**12**	

Question			Expected Answer		Mark	Additional Guidance
3	(a)	(i)	**Credit in either order** ATP ; reduced NAD<u>P</u> / NAD<u>P</u>H / NAD<u>P</u>H_2 / NAD<u>P</u>H + H^+ ;		**2**	**Mark the first two answers.** If either of the answers is correct and an additional answer (i.e. 3rd etc) is given that is incorrect or contradicts the correct answer then -1 for each additional incorrect answer **DO NOT CREDIT** reduced NAD / NADH / $NADH_2$ / $NADH + H^+$ **DO NOT CREDIT** oxygen / O_2 (as not used in Calvin cycle) e.g. ATP (✓) and NADPH (✓) and GP (-1) = 1 NADH (×) and ATP (✓) and oxygen (-1) = 0 GP (×) and H_2O (×) and ATP and NADPH = 0 ATP (✓) and NADPH (✓) and GP (-1) and H_2O (-1) = 0
3	(a)	(ii)	**1** **2** **3** **4** **5**	regenerates / produces , ribulose bisphosphate / RuBP ; so cycle can continue / for (further) CO_2 fixation / to combine with CO_2 ; formation of (named) , sugar / glucose / hexose / sucrose / starch / cellulose ; formation of (named) , fat / triglyceride / lipid / fatty acids / glycerol / amino acids / protein / nucleic acids / nucleotides ; 10x TP for RuBP <u>and</u> 2x TP for production **or** most TP used to produce RuBP <u>and</u> the rest for production ;	**3 max**	***3*** **IGNORE** carbohydrate without qualification **but** **CREDIT** suitably named carbohydrate ***5*** Needs to refer to both **CREDIT** 5/6 regenerated <u>and</u> the rest for production

Question			Expected Answer		Mark	Additional Guidance
3	(b)	(i)	oxygen used <u>and</u> carbon dioxide **,** produced / excreted **;** (only) occurs in the light / light (energy) required **or** uses **,** (same) photosynthetic enzyme / Rubisco **or** involves Calvin cycle **;**		**2**	**DO NOT CREDIT** comments that categorically state 'it **<u>is</u>** respiration' **CREDIT** **'**sun' instead of 'light' **IGNORE** ref to light dependent stage [S & C x 2]
3	(b)	(ii)	**1**	reduces (rate of) photosynthesis / increases (rate of) photorespiration **;**	**3 max**	***2*** **ACCEPT** oxygen blocks active site of Rubisco **CREDIT** 'enzyme' instead of 'Rubisco' Needs to convey the idea that oxygen more successful / more oxygenase activity Be careful not to credit RuBP ***5 & 6*** **IGNORE** number before name unless used to indicate more or less (compare flow charts) [S & C x 3]
			2	less Rubisco available for CO_2 / more oxygen competing with CO_2 for Rubisco / more O_2 binding to Rubisco / O_2 outcompetes CO_2 for Rubisco **;**		
			3	less CO_2 **,** fixation / for Calvin cycle **;**		
			4	CO_2 given off **;**		
			5	less **,** glycerate 3-phosphate / GP / TP **,** produced **;**		
			6	less RuBP **,** regenerated / formed **;**		

Question			Expected Answer	Mark	Additional Guidance
3	(b)	(iii)	*idea that* oxygen , not a substrate for / cannot bind to / will not compete for , PEP carboxylase **or** PEP carboxylase , is only specific to carbon dioxide ;	1	**ACCEPT** PEP carboxylase cannot 'fix' oxygen [S & C x 1]
			Total	**[11]**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		control **;**	1	**CREDIT** a description e.g. • comparison • to compare results with • to show that (wavelengths of) light is producing the effect • to show the result produced without light • create baseline • create set point • validity **IGNORE** 'fair test' **DO NOT CREDIT** 'control variable' / 'controlled variable'

Question			Expected Answers		Marks	Additional Guidance
4	(a)					**Read as paragraph. Mark the first 2 responses only.** **DO NOT CREDIT** ref to **time** / same **number** of leaf discs / **same plant** (as these given in the question) **IGNORE** 'fair test' without further explanation
			1	discs, the same size / cut with same cutter, ***so*** same surface area **;**		**1** **ALLOW** for same amount of pigment / chloroplast
			2	discs taken from same part of the leaf / leaves used from the same part of the plant ***so*** same amount of **,** pigment / chloroplast **;**		
			3	tubes same distance from light source ***so*** light intensity is the same **;**		
			4	light bulb the same (wattage) each time ***so*** light intensity is the same **;**		
			5	same thickness of filter ***so*** light intensity is the same **;**		
			6	carry out in darkened room / only 1 light source in room / completely cover tube with filter, ***so*** only light of desired wavelength enters **;**		
			7	CO_2 in excess / AW, ***so*** CO_2 not limiting / enough CO_2 for photosynthesis / enough CO_2 for Calvin cycle / enough CO_2 for light independent stage **;**		
			8	same **,** <u>volume</u> / <u>concentration</u> / batch, of indicator ***so*** that colour changes are comparable **;**		
			9	heat, sink / shield, between light source and tube ***to*** reduce temperature changes **;**		
			10	carry out at, same / constant, temperature ***as*** temperature affects enzyme, activity / structure **;**		**10** Enzyme ref must be qualified
			11	carry out **,** repeats / replicates, ***to***, calculate <u>mean</u> / identify anomalies **;**		**11** **IGNORE** ref to improving reliability **IGNORE** how anomalies dealt with **DO NOT CREDIT** preventing anomalies
			12	AVP (to include precaution and explanation) **; ;**	**2 max**	**12** **CREDIT** any reasonable precaution with a suitable explanation (even if explanation already given) e.g. • rinse test tubes with distilled water ***so*** starting pH is the same

Question			Expected Answers		Marks	Additional Guidance
4	(a)	(	chlorophyll a ;		1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ALLOW** chlorophyll A / chlorophyll α **IGNORE** p680 / p700 / PSI / PSII **DO NOT CREDIT** chlorophyll a and b **DO NOT CREDIT** chlorophyll alone
4	(a)		**1**	chlorophyll / pigments / leaf, reflect / does not absorb / absorbs little, green light / light of this wavelength ;	3 max	**1** Needs to refer to green rather than other colours
			2	(green light) cannot be used in photosynthesis / no photosynthesis / little photosynthesis / no light dependent reaction (or described) / little light dependent reaction (or described) correct ref to action spectrum in green region ;		**2** Needs to refer to green rather than other colours
			3	little / no, photolysis / splitting of water ;		**3** **CREDIT** (some) photolysis with accessory pigments
			4	little / no, CO_2 , taken up / fixed (in light independent reaction) ;		
			5	some CO_2 produced during respiration ;		
			6	(slight) increase in CO_2, increases acidity / decreases pH ;		**6** **CREDIT** increase in H^+ decreasing pH for accessory pigments
			7	AVP ;		**7** e.g. • accessory pigments absorb (some) green light

Question			Expected Answers		Marks	Additional Guidance	
4	(b)				S & C		**Question is asking for an <u>increased</u> rate of photosynthesis and maximum production** **IGNORE LIGHT**
			1	photosynthesis / named stage, is controlled by / needs / involves / uses , (named photosynthetic) enzymes ;		1	Needs to be a clear generalised statement – cannot be implied from a description of the effects **IGNORE** 'enzymes are affected by temperature'
			2	temperature can be, increased by heater / reduced by ventilation (or fan) maintained by air conditioning (or other method) ;		2	Needs to indicate ***how*** factor is controlled
			3	increase CO_2 concentration (in environment) by burning, fuel / gas / paraffin ;		3	Needs to indicate ***how*** factor is controlled **CREDIT** increase in CO_2 by other reasonable methods
			4	*idea that* increased / more / high<u>er</u>, CO_2 (conc), so CO_2 no longer a limiting factor / increases CO_2 fixation / (or described) increases Calvin cycle (or described) ;		4	**ALLOW** ref to maximum rate for increase in rate
			5	*idea that* easier to control, water supply / irrigation (to prevent wilting) / humidity / minerals / fertiliser ;		5	Look for the idea that factors can be more easily regulated in the greenhouse rather than outside **CREDIT** use of hydroponics
			6	*idea that* easier to control use of, pesticides / pest control / biological control ;		6	Look for the idea that factors can be more easily regulated in the greenhouse rather than outside
			7	AVP ;		7	e.g. • gas / paraffin , heater supplies heat **and** CO_2 • prevents described damage of plants by, wind chill / frost / wind / hail / etc • description / effect, of photorespiration
					4 max		
				Total	**11**		