

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

Question		Answer	Marks	Guidance														
1	(b)	<table border="1"> <thead> <tr> <th>statement</th> <th>letter</th> </tr> </thead> <tbody> <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> </tbody> </table>	statement	letter	ATP is produced	B	an electron leaves photosystem I	B	electrons are passed along an electron carrier chain	B	electrons leave both photosystem I and photosystem II	N	an electron from a water molecule replaces the electron lost from the photosystem	N	the same electron returns to the photosystem	C		<p>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</p> <p>ACCEPT lower case letters</p> <p>DO NOT CREDIT 'N and C' <i>instead of</i> B, as they have been asked to use B</p> <p>IGNORE 'N and C' if stated <i>in addition to</i> B in rows 1 and 2</p> <p>ACCEPT B for this row</p>
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		Total	5 11															

Question			Expected Answer	Mark	Additional Guidance
2	(a)	(i)	0.0017 ; ;	2	<ul style="list-style-type: none"> • 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)	<p>1 (internal) radius / diameter , of capillary tube ;</p> <p>2 cross-sectional area (of capillary tube) ;</p> <p>3 (use) $\pi r^2 h$;</p>	1 max	<p>1 ACCEPT radius / diameter , of bubble ACCEPT width of tube</p> <p>2 ACCEPT cross-sectional area of bubble</p>
2	(a)	(iii)	<p>1 (sodium) hydrogen carbonate ;</p> <p>2 bubble in , CO_2 / exhaled air ;</p> <p>3 dry ice ;</p>	1 max	<p>1 ACCEPT bicarbonate DO NOT CREDIT carbonate</p>

Question			Expected Answer	Mark	Additional Guidance
2	(b)	(i)	<p><i>idea that some of the oxygen</i></p> <p>1 would dissolve in the water ;</p> <p>2 used in , respiration / oxidative phosphorylation ;</p> <p>3 may escape the collection apparatus ;</p> <p>4 trapped in , a bubble attached to / air spaces in , the leaf ;</p>	2 max	<p>1 IGNORE 'oxygen is in the water'</p> <p>2 IGNORE produces energy</p>
2	(b)	(ii)	<p>1 (nitrogen) was present in the air (spaces) in the , leaf / plant ;</p> <p>2 (nitrogen) leaves the plant with the oxygen ;</p> <p>3 <i>idea that</i> (nitrogen) comes out of solution / 'undissolved' (as less soluble in warm water) ;</p>	1 max	
2	(b)	(iii)	<p>1 higher than , expected / normal / in atmosphere ;</p> <p>2 (plant is) respiring / produces CO₂ during respiration ;</p> <p>3 CO₂ , has been added to water / is present in excess ;</p> <p>4 (CO₂) comes out of solution / 'undissolved' (as less soluble in warm water) ;</p> <p>5 less / low(er) , as some CO₂ will dissolve in , water / solution ;</p> <p>6 less / low(er) , as CO₂ used in photosynthesis ;</p>	3 max	<p>2 IGNORE produces energy</p> <p>5 DO NOT CREDIT if in context of lower than O₂ and N₂</p> <p>6 DO NOT CREDIT if in context of lower than O₂ and N₂</p>

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

Question			Expected Answer	Mark	Additional Guidance
3	(a)	(i)	<p>Credit in either order</p> <p>ATP ; reduced NADP / NADPH / NADPH₂ / NADPH + H⁺ ;</p>	2	<p>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</p> <p>DO NOT CREDIT reduced NAD / NADH / NADH₂ / NADH + H⁺</p> <p>DO NOT CREDIT oxygen / O₂ (as not used in Calvin cycle)</p> <p>e.g. ATP (✓) and NADPH (✓) and GP (-1) = 1 NADH (x) and ATP (✓) and oxygen (-1) = 0 GP (x) and H₂O (x) and ATP and NADPH = 0 ATP (✓) and NADPH (✓) and GP (-1) and H₂O (-1) = 0</p>
3	(a)	(ii)	<p>1 regenerates / produces , ribulose biphosphate / RuBP ;</p> <p>2 so cycle can continue / for (further) CO₂ fixation / to combine with CO₂ ;</p> <p>3 formation of (named) , sugar / glucose / hexose / sucrose / starch / cellulose ;</p> <p>4 formation of (named) , fat / triglyceride / lipid / fatty acids / glycerol / amino acids / protein / nucleic acids / nucleotides ;</p> <p>5 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 ;</p>	3 max	<p>3 IGNORE carbohydrate without qualification but CREDIT suitably named carbohydrate</p> <p>5 Needs to refer to both CREDIT 5/6 regenerated <u>and</u> the rest for production</p>

Question			Expected Answer		Mark	Additional Guidance
3	(b)	(i)	<p>oxygen used <u>and</u> carbon dioxide , produced / excreted ;</p> <p>(only) occurs in the light / light (energy) required or uses , (same) photosynthetic enzyme / Rubisco or involves Calvin cycle ;</p>		2	<p>DO NOT CREDIT comments that categorically state ‘it is respiration’</p> <p>CREDIT ‘sun’ instead of ‘light’ IGNORE ref to light dependent stage</p> <p>[S & C x 2]</p>
3	(b)	(ii)	1	reduces (rate of) photosynthesis / increases (rate of) photorespiration ;	3 max	<p>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</p> <p>5 IGNORE number before name unless used to & indicate more or less (compare flow charts) 6</p> <p>[S & C x 3]</p>
			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)	<p><i>idea that oxygen , not a substrate for / cannot bind to / will not compete for , PEP carboxylase</i></p> <p>or PEP carboxylase , is only specific to carbon dioxide ;</p>	1	ACCEPT PEP carboxylase cannot 'fix' oxygen [S & C x 1]
			Total	[11]	

Question		Expected Answers	Marks	Additional Guidance
4	(a)	control ;	1	<p>CREDIT a description e.g. <ul style="list-style-type: none"> • comparison • to compare results with • to show that (wavelengths of) light is producing the effect <ul style="list-style-type: none"> • to show the result produced without light • create baseline • create set point • validity </p> <p>IGNORE 'fair test' DO NOT CREDIT 'control variable' / 'controlled variable'</p>

Question		Expected Answers	Marks	Additional Guidance
4	(a)	<p>1 discs, the same size / cut with same cutter, so same surface area ;</p> <p>2 discs taken from same part of the leaf / leaves used from the same part of the plant so same amount of , pigment / chloroplast ;</p> <p>3 tubes same distance from light source so light intensity is the same ;</p> <p>4 light bulb the same (wattage) each time so light intensity is the same ;</p> <p>5 same thickness of filter so light intensity is the same ;</p> <p>6 carry out in darkened room / only 1 light source in room / completely cover tube with filter, so only light of desired wavelength enters ;</p> <p>7 CO₂ in excess / AW, so CO₂ not limiting / enough CO₂ for photosynthesis / enough CO₂ for Calvin cycle / enough CO₂ for light independent stage ;</p> <p>8 same , <u>volume</u> / <u>concentration</u> / batch, of indicator so that colour changes are comparable ;</p> <p>9 heat, sink / shield, between light source and tube to reduce temperature changes ;</p> <p>10 carry out at, same / constant, temperature as temperature affects enzyme, activity / structure ;</p> <p>11 carry out , repeats / replicates, to, calculate <u>mean</u> / identify anomalies ;</p> <p>12 AVP (to include precaution and explanation) ; ;</p>	2 max	<p>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</p> <p>1 ALLOW for same amount of pigment / chloroplast</p> <p>10 Enzyme ref must be qualified</p> <p>11 IGNORE ref to improving reliability IGNORE how anomalies dealt with DO NOT CREDIT preventing anomalies</p> <p>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</p>

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4	(a)	(chlorophyll a ;	1	<p>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</p> <p>ALLOW chlorophyll A / chlorophyll α</p> <p>IGNORE p680 / p700 / PSI / PSII</p> <p>DO NOT CREDIT chlorophyll a and b</p> <p>DO NOT CREDIT chlorophyll alone</p>
4	(a)		<p>1 chlorophyll / pigments / leaf, reflect / does not absorb / absorbs little, green light / light of this wavelength ;</p> <p>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 ;</p> <p>3 little / no, photolysis / splitting of water ;</p> <p>4 little / no, CO₂ , taken up / fixed (in light independent reaction) ;</p> <p>5 some CO₂ produced during respiration ;</p> <p>6 (slight) increase in CO₂, increases acidity / decreases pH ;</p> <p>7 AVP ;</p>	3 max	<p>1 Needs to refer to green rather than other colours</p> <p>2 Needs to refer to green rather than other colours</p> <p>3 CREDIT (some) photolysis with accessory pigments</p> <p>6 CREDIT increase in H⁺ decreasing pH for accessory pigments</p> <p>7 e.g. • accessory pigments absorb (some) green light</p>

Question		Expected Answers		Marks	Additional Guidance
4	(b)			S & C	<p>Question is asking for an <u>increased</u> rate of photosynthesis and maximum production IGNORE LIGHT</p> <p>1 Needs to be a clear generalised statement – cannot be implied from a description of the effects IGNORE ‘enzymes are affected by temperature’</p> <p>2 Needs to indicate how factor is controlled</p> <p>3 Needs to indicate how factor is controlled CREDIT increase in CO₂ by other reasonable methods</p> <p>4 ALLOW ref to maximum rate for increase in rate</p> <p>5 Look for the idea that factors can be more easily regulated in the greenhouse rather than outside CREDIT use of hydroponics</p> <p>6 Look for the idea that factors can be more easily regulated in the greenhouse rather than outside</p> <p>7 e.g. <ul style="list-style-type: none"> • gas / paraffin , heater supplies heat and CO₂ • prevents described damage of plants by, wind chill / frost / wind / hail / etc • description / effect, of photorespiration </p>
		1	photosynthesis / named stage, is controlled by / needs / involves / uses , (named photosynthetic) enzymes ;		
		2	temperature can be, increased by heater / reduced by ventilation (or fan) maintained by air conditioning (or other method) ;		
		3	increase CO ₂ concentration (in environment) by burning, fuel / gas / paraffin ;		
		4	<i>idea that</i> increased / more / <u>higher</u> , CO ₂ (conc), so CO ₂ no longer a limiting factor / increases CO ₂ fixation / (or described) increases Calvin cycle (or described) ;		
		5	<i>idea that</i> easier to control, water supply / irrigation (to prevent wilting) / humidity / minerals / fertiliser ;		
		6	<i>idea that</i> easier to control use of, pesticides / pest control / biological control ;		
		7	AVP ;		
		Total	11		