

Question	Answer	Marks	Guidance
6 (a)	rubisco ;	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
6 (b)	ATP / reduced NADP ;	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 DO NOT CREDIT oxygen (as it is not used in the light independent reaction)
6 (c)	glycerate-3-phosphate / GP / triose phosphate / TP ;	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
6 (d)	amino acid ;	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
6 (e)	ribulose biphosphate / RuBP ;	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 ACCEPT ribulose biphosphate
6 (f)	oxygen ;	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 DO NOT CREDIT ATP / reduced NADP (as they are used in the light independent reaction)
	Total	6	

Question	Answer	Mark	Guidance
1 (a) (i)	<p>A inner membrane (of, double membrane / envelope, surrounding organelle);</p> <p>B stroma;</p> <p>C granum / grana / granal stack / thylakoid stack;</p>		<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>A DO NOT CREDIT inter membrane DO NOT CREDIT inner envelope membrane DO NOT CREDIT ref to cell / surface / plasma / membrane</p> <p>B correct spelling only</p> <p>C IGNORE thylakoid unqualified / lamellae</p>
1 (a) (ii)	<p>1 contain, (named) pigment (molecules) / photosystems;</p> <p>2 contain, (named) electron carriers / ETC / ATP synth(et)ase;</p> <p>3 <i>idea that has a large surface area (in a small volume) for, light absorption / light dependent reaction(s) / light dependent stage / electron transport;</i></p>	3	<p>1 IGNORE 'accessory'</p> <p>2 IGNORE enzymes unqualified</p> <p>3 IGNORE ref to different wavelengths</p> <p>Note: 'the membranes containing the pigments have a large surface area for absorbing light' = 2 marks (mps 1 & 3) Note: 'there is a large surface area for electron transport chain' = 2 marks (mps 2 & 3)</p>
		2 max	

Question	Answer	Mark	Guidance						
1 (a) (iii)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">A</td> <td></td> </tr> <tr> <td style="text-align: center;">B</td> <td style="text-align: center;">✓</td> </tr> <tr> <td style="text-align: center;">C</td> <td></td> </tr> </table> ;	A		B	✓	C			DO NOT CREDIT if more than one tick entered
A									
B	✓								
C									
1 (b)	<p>1 at <i>high light intensity</i> other (named) factor becomes a <u>limiting factor</u> ;</p> <p>2 <i>idea that temperature becomes limiting as ,</i> Calvin cycle / light independent reaction , involves enzymes / relies on kinetic energy of molecules ;</p> <p>3 <i>idea that CO₂ (concentration) becomes limiting as it is</i> required for , Calvin cycle / light independent reaction / formation of (named) Calvin cycle compound / reaction with RuBP / fixation by Rubisco ;</p>	1	<p>IGNORE ref to photorespiration (as Q specifies photosynthesis)</p> <p>1 ACCEPT light is no longer the <u>limiting factor</u> e.g. of named factor = temperature / CO₂ concentration DO NOT CREDIT if light is given as a limiting factor DO NOT CREDIT ref to the rate slowing down IGNORE water or other suggestions</p> <p>2 ACCEPT ref to Rubisco being limited by temp (as a named enzyme being in the Calvin cycle)</p> <p>3 e.g. of named compound = GP / TP / RuBP</p>						
		2 max							

Question	Answer	Mark	Guidance
1 (c) (i)	<p>No ora</p> <p>species <u>E</u> because</p> <p>1 E starts photosynthesising at low(er) light intensity ;</p> <p>2 E reaches its maximum rate at low(er) light intensity ;</p> <p>3 E steep(er) <u>increase</u> in rate of photosynthesis (with small increase in light intensity) ;</p> <p>4 E has a , higher / greater / faster , rate of photosynthesis (than D) at low light intensities ;</p>	2 max	<p>Only credit answers stating that species E is the shade plant. Please indicate this with the green dot annotation. IGNORE ref to time / earlier / later / etc.</p> <p>2 IGNORE plateau (as this is a description of the curve) IGNORE ref to optimum rate</p> <p>3 Needs to relate to the <i>increase</i>, not just rate i.e. referring to the gradient part of the graph</p> <p>4 i.e. referring to any point at low light intensity when E is photosynthesising at a higher rate than D</p> <p>Note – ‘E has a faster <i>increase</i> in the rate of photosynthesis at low light intensities’ = 2 marks (mps 3 & 4)</p>
1 (c) (ii)	<p>shade leaf will have</p> <p>1 large(r) / more , chloroplast(s) / (palisade) mesophyll ;</p> <p>2 more , grana / thylakoids (in chloroplast) ;</p> <p>3 large(r) surface area (of leaves) ;</p>	1 max	<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>Assume shade leaf unless otherwise stated CREDIT ora for sun leaf IGNORE adaptations related to temperature</p> <p>1 ACCEPT more , chlorophyll / photosystems IGNORE ref to colour / accessory pigments</p>

Question	Answer	Mark	Guidance
1 (d)	<p>1 animals / heterotrophs (need to), eat / obtain organic material from / AW , plants / autotrophs ;</p> <p>2 (plants / autotrophs) produce (named) organic molecules during , <u>photosynthesis</u> / <u>Calvin cycle</u> / <u>light independent</u> stage ;</p> <p>3 (plants / autotrophs) produce oxygen during , <u>photosynthesis</u> / <u>photolysis</u> / <u>light dependent</u> stage;</p> <p>4 glucose / carbohydrate / oxygen , (produced in photosynthesis) are used in <u>respiration</u> by , animals / heterotrophs ;</p>	3 max	<p>IGNORE ref to providing habitat / shelter DO NOT CREDIT ref to creating (etc.) energy</p> <p>1 CREDIT (plants / autotrophs) are the start of food chain(s)</p> <p>3 IGNORE photophosphorylation</p> <p>4 ALLOW ref to other respiratory substrate</p>
	Total	14	

Question	Answer	Mark	Guidance
1 (a) (i)	chlorophyll <u>a</u> / <u>A</u> ;	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>ACCEPT chlorophyll 680 <u>and</u> chlorophyll 700 (Note that both are required for this option)</p> <p>IGNORE P680 / P700</p> <p>DO NOT CREDIT chlorophyll α.</p>
1 (a) (ii)	chlorophyll b / xanthophyll(s) / carotenoid(s) / (β / beta-) carotene ;	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>DO NOT CREDIT karatine (as could be confused with keratin)</p>
1 (a) (iii)	able to , absorb / use , a range of / different / more / other , (light) <u>wavelengths</u> / <u>λ</u> ;	1	<p>e.g. absorb wavelength(s) not absorbed by primary pigment</p> <p>IGNORE frequency</p> <p>IGNORE absorb all wavelengths</p> <p>IGNORE ref to chlorophyll b</p> <p>DO NOT CREDIT ref to reflection where a pigment absorbs and reflects the same wavelength</p>
1 (a) (iv)	ATP ;	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>DO NOT CREDIT O₂ / oxygen / red NADP / NADPH</p> <p>DO NOT CREDIT inaccurate name for ATP e.g. 'ATP (adenine triphosphate)' = 0 marks</p>

Question	Answer	Mark	Guidance
1 (b) (i)	rubisco / RuBP carboxylase / ribulose biphosphate carboxylase ;	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 ACCEPT ribulose biphosphate carboxylase IGNORE oxygenase
1 (b) (ii)	GP / glycerate(3-)phosphate ;	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 PGA / phosphoglyceric acid / phosphoglycerate DO NOT CREDIT PGAL / GALP / phosphoglyceraldehyde DO NOT CREDIT inaccurate name for GP e.g. 'GP (glycerol phosphate)' = 0 marks
1 (b) (iii)	RuBP / ribulose bisphosphate ;	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 ACCEPT ribulose biphosphate
1 (b) (iv)	starch / amylose / amylopectin <u>and</u> cellulose ;	1	Mark the first two answers. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks
	Total	8	

Question	Answer	Marks	Guidance
3 (a)	<p><i>autotroph</i> can make, organic molecule(s) / named organic molecule(s), from, inorganic molecule(s) / carbon dioxide ;</p> <p><i>heterotroph</i> relies on / needs to use / has to obtain / feeds on and digests, (named) organic molecules (that have been made by another organism) ;</p>	2	<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>IGNORE ref to biological molecules</p> <p>ACCEPT fixes carbon dioxide to produce (named) carbohydrates / protein / lipid</p> <p>idea of need or taking in and breaking down is important 'gets its organic molecules from another organism' = 0 marks 'has to get its organic molecules from another organism' = 1 mark</p>
3 (b) (i)	<p>E granum / grana ;</p> <p>F stroma ;</p>	2	<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>E IGNORE ref to stacks of, lamellae / thylakoids</p> <p>F DO NOT CREDIT stoma / stroma</p>
3 (b) (ii)	<p>for membrane formation or phospholipid / cholesterol / glycolipid , for membrane ;</p> <p>fatty acid / (named) pigment , synthesis ;</p>	1 max	<p>IGNORE ref to ATP production (as primarily generated by photophosphorylation in a chloroplast)</p> <p>ACCEPT ref to repair of membrane ACCEPT ref to (chloroplast) envelope instead of membrane DO NOT CREDIT ref to cell surface membrane (as this is not in the chloroplast)</p>

Question	Answer	Marks	Guidance
3 (d) (i)	- 864.3 (kg ha ⁻¹) ; - 7.4 (%) ;	2	DO NOT CREDIT answer that is not given to 1 dp DO NOT CREDIT correct numerical answer without minus sign If no answers on the answer lines, then look in the appropriate boxes in the table for the answers. ALLOW ecf from candidate's value for kg ha ⁻¹
3 (d) (ii)	idea that the number of , plots / samples , was , too / very , small ;	1	Just ref to a smaller number of plots is not quite enough CREDIT idea that the number of plots was not large enough IGNORE ref to the idea that the difference is very large
3 (d) (iii)	1 prevents <u>non-cyclic photophosphorylation</u> ; 2 no electron(s) available to form reduced NADP ; 3 idea that ATP production by <u>cyclic photophosphorylation</u> is not prevented ; 4 no / less , ATP <u>and</u> no reduced NADP available for , Calvin cycle / light independent reaction / conversion of GP to TP ;	2 max	1 IGNORE ref to cyclic photophosphorylation 2 CREDIT red NADP / NADPH / NADPH + H ⁺ / NADPH ₂ for 'reduced NADP'
3 (d) (iv)	idea that <u>energy</u> given off from , high energy / excited , electron (emitted by , chlorophyll / reaction centre) ;	1	
	Total	16	

Question	Answer	Marks	Guidance
4			<p>The spelling must be unambiguous and there must be no implication that another or 'hybrid' term is being given as the answer. In particular, look for 'gly....', 'glu...', '...agon', '...ogen', '...genes...', '...genoly...'</p> <p>If a candidate has labelled each term with a number or letter and has then answered using these labels, credit appropriately.</p> <p>Also credit as appropriate if candidate has used arrows back to the original list.</p>
4	glycolysis ;	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
4	glucagon and insulin ;	1	Mark the first 2 answers. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks
4	gluconeogenesis and glycogenolysis ;	1	Mark the first 2 answers. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks
4	glycolysis and glycogenesis ;	1	Mark the first 2 answers. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks
	Total	4	

Question	Expected Answers	Marks	Additional Guidance
(a)			<p>Mark the first answer for each letter. 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 glycolysis ;</p>		<p>W CREDIT glycolytic pathway ACCEPT phonetic spelling but must have 'glycol' IGNORE respiration</p>
	<p>X Calvin cycle / light-independent stage (of photosynthesis) ;</p>		<p>X IGNORE dark reaction / photosynthesis ACCEPT phonetic spelling</p>
	<p>Y Krebs cycle ;</p>		<p>Y ACCEPT citric acid cycle / TCA cycle / (tri)carboxylic acid cycle ACCEPT phonetic spelling IGNORE respiration / link reaction</p>
(a)		3	
	<p>1 take place in different , parts / organelles , of the cell or compartmentalisation / reactions separated by membranes ;</p>		<p>1 Must be a clear statement and not implied from others. DO NOT CREDIT different parts of the leaf DO NOT CREDIT no interference between pathways (as rephrasing the Q)</p>
	<p>2 W / glycolysis , in cytoplasm ;</p>		<p>2</p>
	<p>3 X / Calvin cycle , in , chloroplast / stroma (of chloroplast) ;</p>		<p>3 DO NOT CREDIT if thylakoid / membranes stated or implied</p>
	<p>4 Y / Krebs cycle , in , mitochondrion / matrix (of mitochondrion) ;</p>		<p>4 DO NOT CREDIT if cristae / membranes stated or implied</p>
	<p>5 AVP ;</p>	3 max	<p>5 eg • different enzymes for each pathway • different conditions for each pathway</p>
		3 max	

Question	Expected Answers	Marks	Additional Guidance
(a)	(iii) X ; W and Y ;		<p>IGNORE names. The question has asked for letters.</p> <p><i>photosynthesis</i> Mark the first answer. If the answer is correct and an additional letter is given then = 0 marks</p> <p><i>aerobic respiration</i> Mark the first two answers. If these answers are correct and an additional letter (ie 3rd etc) is given then = 0 marks</p> <p>Both letters required for this mark, in any order.</p>
(a)	(iv) ATP / adenosine triphosphate ; water / H ₂ O ; (oxidised) NAD / FAD ;	2	<p>If any answer(s) incorrect then Max 1</p> <p>IGNORE energy / heat IGNORE numbers</p> <p>eg oxygen (x) and ATP (✓) and water = max 1 oxygen (x) and energy (ignore) = 0 ATP (✓) and energy (ignore) and H₂O (✓) = 2 reduced NAD (x) and ATP (✓) and energy (ignore) and H₂O = max 1</p>

Question	Expected Answers	Marks	Additional Guidance
(b)	<p>1 NAD / FAD / NADP , can, accept hydrogen / accept H / be reduced ;</p> <p>2 reduced , NAD / FAD , supplies / carries , electrons , to the electron transport chain / for oxidative phosphorylation ;</p> <p>3 reduced , NAD / FAD , supplies / carries , hydrogen ions for , chemiosmosis / oxidative phosphorylation ;</p> <p>4 reduced NADP , supplies / carries , hydrogen to , light independent stage / Calvin cycle / X ;</p> <p>5 coenzyme A / CoA , carries , <u>acetate</u> / <u>ethanoate</u> / <u>acetyl group</u> , to , Krebs cycle / Y ;</p> <p>6 AVP ;</p>	<p>1</p> <p>2</p> <p>3</p> <p>4</p> <p>5</p> <p>6</p> <p>3 max</p>	<p>DO NOT CREDIT hydrogen ions / protons , unless there is an electron as well</p> <p>DO NOT CREDIT accepts hydrogen molecules /H₂</p> <p>CREDIT equation showing the reduction</p> <p>ACCEPT eg NAD converted to NADH</p> <p>IGNORE 'carries hydrogen'</p> <p>Must refer to <i>reduced</i> NAD or reduced FAD or NADH / NADH⁺ / NADH₂ / FADH / FADH⁺ / FADH₂</p> <p>Must refer to <i>reduced</i> NAD or reduced FAD or NADH / NADH⁺ / NADH₂ / FADH / FADH⁺ / FADH₂</p> <p>Must refer to <i>reduced</i> NADP or NADPH / NADPH⁺ / NADPH₂</p> <p>DO NOT CREDIT acetyl CoA carries acetate</p> <p>eg • co-enzyme(s) / cytochrome(s) , transfer / accept and release , electrons along the electron transport chain</p> <p>• can be , recycled / oxidised and reduced</p>
TOTAL		13	

Question	Expected Answers	Marks	Additional Guidance
6 (a)	124 (%) / 123.7 (%) ; ;	2	<ul style="list-style-type: none"> • Correct answer = 2 marks $(208 - 93) \div 93 \times 100$ • ACCEPT 55 (%) / 55.3 (%) for 2 marks $(208 - 93) \div 208 \times 100$ • Correct numerical answer but inappropriate units (eg 124 μm) = 1 mark • If answer not rounded correctly (to nearest whole number or to 1 dp) or if answer incorrect, then allow 1 mark for seeing either 115 or $(208 - 93)$

Question	Expected Answers	Marks	Additional Guidance
6 (b)	<p>1a <i>benefit</i> allows entry of more CO₂ ;</p> <p>2a <i>explanation</i> (CO₂) for , light-independent reaction / Calvin cycle <i>or</i> light-dependent reaction is taking place quickly / reduced NADP building up / ATP building up <i>or</i> CO₂ not as limiting (than when there are fewer stomata) <i>or</i> <i>idea that</i> increases access to air spaces for distribution of CO₂ ;</p> <p>OR</p> <p>1b <i>benefit</i> reduces transpiration ;</p> <p>2e <i>explanation</i> <i>idea of</i> stomata sheltered from , air currents / heat (when on lower surface) <i>or</i> <i>idea that</i> diffusion shells maintained ;</p> <p>2f</p>	2	<p>Read through complete answer. Award 2 marks if a benefit and explanation are correctly linked.</p> <p>If benefit and explanation are <u>not</u> correctly linked: Award Max 1 for <u>either</u> a benefit <u>or</u> an explanation.</p> <p>1a Must indicate the idea of <i>more</i> and <i>imply going in</i> eg 'allows more gas exchange so that there is more CO₂ for photosynthesis' the mention of gas exchange implies that the CO₂ must be going in</p> <p>2a DO NOT CREDIT 'CO₂ fixed' without further qualification (eg ref to Rubisco / GP formation)</p> <p>2b</p> <p>2c CREDIT with fewer stomata CO₂ is limiting</p> <p>2d</p> <p>1b DO NOT CREDIT description of transpiration ACCEPT 'plant less likely to wilt'</p> <p>2e</p> <p>2f</p>

Question	Expected Answers	Marks	Additional Guidance
6 (c)	<p>1 equal sample size for sun and shade leaves / increase sample size of shade leaves / greater numbers of sun and shade leaves ;</p> <p>2 measure thickness of cuticle / make cuticle observations quantitative ;</p> <p>3 record range / calculate SD / calculate SE / (named) statistical analysis ;</p> <p>4 record data on leaf, length / width / area / colour / chlorophyll content ;</p> <p>5 record data on , size of stomata / stomatal count on upper surface ;</p> <p>6 define what is a sun or shade leaf / measure light levels to classify type of leaf ;</p> <p>7 repeat / replicate , the (whole) experiment / using other plants of the same species ;</p>	<p>2 max</p> <p>6</p>	<p>DO NOT CREDIT refs to controlling temperature or light or wind or time</p> <p>1</p> <p>2</p> <p>3</p> <p>4</p> <p>5</p> <p>6</p> <p>7 IGNORE ref to other species DO NOT CREDIT 'repeats' unqualified or implying the same individual plant</p>
	TOTAL	6	

Question	Answer	Marks	Guidance
3 (a) (i)	<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>
3 (a) (ii)	<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														
3 (b)	<table border="1"> <thead> <tr> <th data-bbox="560 1167 596 1845">statement</th> <th data-bbox="560 1167 596 1279">letter</th> </tr> </thead> <tbody> <tr> <td data-bbox="596 1167 633 1845">ATP is produced</td> <td data-bbox="596 1167 633 1279">B</td> </tr> <tr> <td data-bbox="633 1167 719 1845">an electron leaves photosystem I</td> <td data-bbox="633 1167 719 1279">B</td> </tr> <tr> <td data-bbox="719 1167 805 1845">electrons are passed along an electron carrier chain</td> <td data-bbox="719 1167 805 1279">B</td> </tr> <tr> <td data-bbox="805 1167 892 1845">electrons leave both photosystem I and photosystem II</td> <td data-bbox="805 1167 892 1279">N</td> </tr> <tr> <td data-bbox="892 1167 978 1845">an electron from a water molecule replaces the electron lost from the photosystem</td> <td data-bbox="892 1167 978 1279">N</td> </tr> <tr> <td data-bbox="978 1167 1046 1845">the same electron returns to the photosystem</td> <td data-bbox="978 1167 1046 1279">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	5	<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' <u>instead of</u> B, as they have been asked to use B</p> <p>IGNORE 'N and C' if stated <u>in addition to</u> B in rows 1 and 2</p> <p>ACCEPT B for this row</p>
statement	letter																
ATP is produced	B																
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	Total	11															

Question	Answer	Marks	Guidance
4 (a)	<p>oxygen</p> <p>1 oxygen only produced in one (named) stage of photosynthesis ;</p> <p>2 oxygen produced might be used for respiration ;</p> <p>carbon dioxide</p> <p>3 CO₂ only used in one (named) stage of photosynthesis ;</p> <p>4 CO₂ produced during respiration might be used for , photosynthesis / light independent reaction / Calvin cycle ;</p> <p>5 O₂ / CO₂ / both , could be an underestimate or represents net production (O₂) or represents net use (CO₂) ;</p>	2 max	<p>1 CREDIT for O₂ 'only measures the rate of the light dependent stage / photolysis'</p> <p>3 CREDIT for CO₂ 'only measures the rate of the Calvin cycle'</p> <p>5 ACCEPT a description e.g. 'measurement is less than expected because not all the oxygen produced can be measured' (but not if expressed in terms of terms of experimental error -- e.g. dissolves in the water)</p> <p>IGNORE refs to reliability / accuracy</p>
4 (b) (i)	light <u>intensity</u> ;	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>

Question	Answer	Marks	Guidance
4 (b) (ii)	carbon dioxide <u>concentration</u> / partial pressure of CO ₂ / temperature ; AVP ;	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>DO NOT CREDIT 'high' or 'low', as these indicate situations rather than factors</p> <p>eg</p> <ul style="list-style-type: none"> • stomatal density • stomatal size • chlorophyll concentration • number of chloroplasts • enzyme turnover rate <p>IGNORE (temporary) changes in stomatal, opening / closing</p> <p>IGNORE ref to water availability</p>
(b) (iii)	(aerobic / anaerobic) respiration ;	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>ACCEPT Krebs cycle / link reaction / decarboxylation DO NOT CREDIT photorespiration (as light intensity stated as being low)</p>

Question	Answer	Marks	Guidance
4 (b) (iv)	<p>1 at 0 , respiration only / no photosynthesis ;</p> <p>between 0 and X</p> <p>2 idea that (rate of) respiration is greater than (rate of) photosynthesis ;</p> <p>at X</p> <p>3 idea that (rate of) respiration equals (rate of) photosynthesis / at compensation point ;</p> <p>after X</p> <p>4 idea that (rate of) photosynthesis is greater than (rate of) respiration ;</p>	3 max	<p>Assume that candidate is answering in the same order as the bullet points, unless otherwise indicated. IGNORE photorespiration throughout</p> <p>CREDIT 'Calvin cycle' for 'photosynthesis' throughout For mps 2, 3 & 4 must include clear ref. to both respiration and photosynthesis</p> <p>2 DO NOT CREDIT no photosynthesis</p>
4 (c) (i)	<p>reduced NADP / NADPH / NADPH₂ / NADPH⁺ ; ATP ; oxygen ;</p>	3	<p>Mark the first 3 answers. IGNORE numbers of molecules</p> <p>ACCEPT O₂ (to be consistent with the other answers to this question)</p>

Question	Answer	Marks	Guidance
4	(c)		
	1 prevents <u>photophosphorylation</u> ; 2 cyclic and non-cyclic ;		
	3 no / less , ATP / reduced NADP , for , light-independent stage / Calvin cycle / GP to TP ;		3 'no ATP for photosynthesis' is not quite enough DO NOT CREDIT (oxidised) NADP
	4 no (named) substrate made for <u>respiration</u> ;	2 max	4 substrate eg glucose / starch / carbohydrate / sucrose / sugars IGNORE triose phosphate / food / nutrients
	Total	13	

Question	Expected Answer	Mark	Additional Guidance
2 (a) (i)	0.0017 ; ;		<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)	1 (internal) radius / diameter , of capillary tube ; 2 cross-sectional area (of capillary tube) ; 3 (use) $\pi r^2 h$;	2	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
		1 max	

Question	Expected Answer	Mark	Additional Guidance
2 (b) (i)	<p><i>idea that some of the oxygen</i></p> <ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1 IGNORE 'oxygen is in the water' 2 IGNORE produces energy
2 (b) (ii)	<ol style="list-style-type: none"> 1 (nitrogen) was present in the air (spaces) in the , leaf / plant ; 2 (nitrogen) leaves the plant with the oxygen ; 3 <i>idea that</i> (nitrogen) comes out of solution / 'undissolved' (as less soluble in warm water) ; 	1 max	
2 (b) (iii)	<ol style="list-style-type: none"> 1 higher than , expected / normal / in atmosphere ; 2 (plant is) respiring / produces CO₂ during respiration ; 3 CO₂ , has been added to water / is present in excess ; 4 (CO₂) comes out of solution / 'undissolved' (as less soluble in warm water) ; 5 less / low(er) , as some CO₂ will dissolve in , water / solution ; 6 less / low(er) , as CO₂ used in photosynthesis ; 	3 max	<ol style="list-style-type: none"> 2 IGNORE produces energy 5 DO NOT CREDIT if in context of lower than O₂ and N₂ 6 DO NOT CREDIT if in context of lower than O₂ and N₂

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>	2 max	<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	<p>(a) (i)</p> <p>Credit in either order</p> <p>ATP ; reduced NAD_P / NADPH / NADPH₂ / NADPH + H⁺ ;</p>		<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	<p>(a) (ii)</p> <p>1 regenerates / produces , ribulose biphosphate / RuBP ; 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 and 2x TP for production or most TP used to produce RuBP and the rest for production ;</p>	2	<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	<p>(b) (i)</p> <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>		<p>DO NOT CREDIT comments that categorically state 'it <u>is</u> respiration'</p> <p>CREDIT 'sun' instead of 'light' IGNORE ref to light dependent stage</p> <p>[S & C x 2]</p>
3	<p>(b) (ii)</p> <p>1 reduces (rate of) photosynthesis / increases (rate of) photorespiration ;</p> <p>2 less Rubisco available for CO₂ / more oxygen competing with CO₂ for Rubisco / more O₂ binding to Rubisco O₂ outcompetes CO₂ for Rubisco ;</p> <p>3 less CO₂, fixation / for Calvin cycle ; 4 CO₂ given off ;</p> <p>5 less , glycerate 3-phosphate / GP / TP , produced ; 6 less RuBP , regenerated / formed ;</p>	2	<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>3 max</p> <p>[S & C x 3]</p>

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]	