

Question number	Answer	Marks	Guidance
1 a	X	1	
1 b i	1 Reduced NADP – reduces GP to triose phosphate (TP) 2 ATP – releases energy for reactions	2	Reject ATP produces energy, accept provides energy and phosphate for production of RUBP.
1 b ii	Any three from: 1 Photolysis 2 Light energy hits chlorophyll and electrons are lost/excited 3 Electrons are replaced by splitting of water 4 Protons/H ⁺ and electrons (and oxygen) are released	3 max	Spelling of photolysis must be correct for the mark Accept points 3 and 4 as an equation.
		6	
2 a	1 Bubbles contain oxygen from photosynthesis/oxygen is a product of photosynthesis/oxygen is a product of photolysis 2 Higher rate of photosynthesis results in more bubbles being released	2	
2 b i	10 (cm)	2	Allow $\sqrt{\frac{1}{0.010}}$ for 1 mark.
2 b ii	Any two from: 1 Rate limited by light intensity 2 Because rate of photosynthesis increases as light intensity increases 3 Increase in light intensity results in greater activation of chlorophyll/more electrons released 4 So more photolysis/greater dissociation of water releasing oxygen	2 max	
2 b iii	Any two from: 1 Light intensity not limiting 2 Another factor is limiting 3 Carbon dioxide concentration/temperature/chlorophyll concentration limiting	2 max	
		8	
3 a	Any three from: 1 Grind up leaves with solvent 2 Spot extract on origin line 3 Dry between spotting to produce concentrated spot 4 Place chromatography paper in a tank with solvent	3 max	

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	5 Paper dipped into solvent with origin line above level of solvent		
3 b	1 Separate according to solubility in solvent 2 More soluble move further	2	
3 c	1 Distance from origin to solvent front 2 Distance from origin to chlorophyll a spot	2	
		7	
4 a i	To compare because total mass is not same for each type of lighting	1	Do not award mark for 'to compare' – must have a reason.
4 a ii	37.0	2	58.8 / 159 × 100 for 1 mark.
4 b	Any two factors with reason: 1 Temperature – affects enzyme reactions/transpiration 2 Carbon dioxide concentration – can be limiting factor for photosynthesis 3 Watering/irrigation – water needed for photosynthesis/transpiration 4 Fertiliser concentration – minerals/named mineral needed for growth	2 max	Accept other valid environmental factors with valid reasons. 3. Reject rainfall as indoors.
4 c	1 The percentage yield of grain is very similar for each type of lighting But 2 Only trialled with one type of crop/wheat 3 No information about other factors which could affect yield	3	
4 d	Any two from: 1 Need a lot of land to grow wheat crop – too expensive to cover 2 Wheat does not sell for high price so cost not likely to be recouped 3 No rainfall so need to irrigate	2 max	'Not cost effective' with no further explanation does not get a mark.
		10	
5 a	Difference between highest value and lowest value	1	
5 b	SD does not give undue emphasis to 'outliers' (one-off extreme results)/range only shows extremes/SD uses all data/SD shows spread about the mean	1	
5 c	1 Student t-test 2 Comparing means of samples (for significant difference)	2	

Question number	Answer	Marks	Guidance
5 d	Any three from: 1 White light contains all colours of light blue, green and red light 2 Chlorophyll absorbs mainly blue and red light 3 More electrons excited 4 More photolysis so more oxygen released	3 max	
		7	
6 a	ATP Reduced NADP/NADPH/NADPH ₂	2	
6 b i	1 Change in GP/RuBP occurs in the dark/200 s (to approx. 250 s) 2 GP rises/RuBP falls	2	Ignore statements referring to periods in the light
6 b ii	Any two from: 1 GP falls/RuBP rises when light restored/at 1700+ seconds 2 RuBP falls in the dark 3 GP/RuBP constant in first light period	2 max	
6 c	GP converted into other substances/used in respiration	1	No marks awarded if TP or RuBP suggested
		7	