Mark schemes

**Q1.**

(a)     1.     Peaks at 420-430 and 660-670;

2.      No absorption of light between approximately 500 and 600;

3.      Highest peak at 420-430;

**2 max**

(b)     1.     Less (light) energy passes through leaves / reaches ground;

2.      Smaller range of wavelengths passes through leaves;

*Accept reference to only green (and yellow) light pass through*

3.      Little light for chlorophyll to absorb;

*Accept carotenoids can absorb this light*

4.      So insufficient photosynthesis (for growth);

*Sufficient photosynthesis for plants with carotenoids*

5.      Photosynthesis unlikely to exceed respiration;

**3 max**

(c)     1.     Light not limiting / lots of light (as no shading);

2.     Light-dependent reaction not limiting / fast;

***OR***

3.     Temperature not limiting / Warm (as no shading);

4.     Fast reactions of enzymes in light-independent reaction;

***OR***

5.     High use of CO2;

6.     Light-independent reaction is limiting;

*Mark as a pair*

**2**

**[7]**

**Q2.**

(a)     Grana / thylakoids / lamellae;

**1**

(b)     **A** = oxygen / O2**B** = ADP and phosphate / Pi  / phosphoric acid / correct formula;  
**C** = reduced NADP; ALLOW NADPH / NADPH2 / NADPH + H+

**3**

(c)     (i)      Absorbs light / energy;  
Loses electrons / becomes positively charged / is oxidised;  
Accepts electrons from water / from OH– which causes more water   
to dissociate / pulls equilibrium to the right;

**3**

(ii)     Electrons raised to higher energy level / electrons excited;  
Use of electron carriers / cytochromes / acceptors;  
For production of ACT

*[REJECT ‘energy production’]*

**3**

(d)     (i)      GP formed from RuBP + CO2;  
GP → TP / sugar-phosphate / sugar / to RuBP;  
GP formed at same rate as it is used;

**3**

(ii)     No CO2 to combine with / not enough CO2 to combine with RuBP  
RuBP not changed into GP / TP RuBP reformed from GP / TP;

**2**

**[15]**

**Q3.**

(a)     the more light absorbed, the greater the rate of photosynthesis;  
light provides the energy for light dependent reactions / photolysis /   
light independent reactions / production of reduced NADP /   
exciting electrons in chlorophyll;

*(do not give credit if energy is used in photosynthesis)*

**2**

(b)     count the number of bubbles / measure the volume of gas / measure the   
change in pH / carbon dioxide / hydrogen carbonate ions;

*(credit oxygen produced)*

**1**

(c)     530 – 630 nm;

*(any values within this range)*

limited absorption of light / (green) plants reflect green light /   
limited photosynthesis at these wavelengths of light;

*(allow references to no light absorbed or no photosynthesis)*

**2**

(d)     (i)      chlorophyll excited / reduced NADP formed;  
electrons from chlorophyll / reduced NADP changes the dye colour;

**2**

(ii)     ADP and phosphate needed to produce ATP / ATP is a product of   
the light dependent reactions;  
ADP levels are a limiting factor;

*(must explain the idea of limiting factors – do not credit answers like more ADP causes more photosynthesis)*

**2**

**[9]**

**Q4.**

(a)     (i)      Stroma (of chloroplasts);

*Reject: stoma*

**1**

(ii)     2;

**1**

(b)     1.      As oxygen (concentration) increases less Rubisco / RuBP reacts / binds with carbon dioxide;

*1. Accept - as oxygen (concentration) increases more Rubisco / RuBP reacts / binds with oxygen*

*1. Accept – less GP / more phosphoglycolate formed as oxygen (concentration) increases*

2.      Competitive inhibition / competition between oxygen and carbon dioxide for rubisco / enzyme / active site (therefore) less RuBP formed / regenerated (to join with carbon dioxide);

*2. Accept oxygen and carbon dioxide are complementary to active site*

**2**

(c)     1.      Less glycerate 3-phosphate / GP produced;

*1. Accept one GP formed rather than two GP*

2.      (Less) triose phosphate to form sugars / protein / organic (product) / any named photosynthetic product;

3.      Less RuBP formed / regenerated;

*3. Accept RuBP takes longer to form*

**3**

**[7]**

**Q5.**

(a)     adding CO2 decreases pH / makes more acid   
OR removing CO2 increases pH / makes more alkaline;

*(credit anywhere but do not credit this mark if  
stated that oxygen is an alkaline gas)*

rate of photosynthesis > rate of respiration in **A**;  
respiration only in **B**;  
rate of photosynthesis = rate of respiration in **C**;

**4**

(b)     (i)      shows that indicator alone does not change colour in light;

**1**

(ii)     so that all tubes receive same amount of heat

**1**

**[6]**

**Q1.**

(a)     This was answered well by many students, although some failed to identify the peaks accurately.

(b)     This was answered well, with many scoring three marks. Only better answers noted that at all wavelengths less light energy was passing through, for mark point 1. Very few went on to point out that photosynthesis would not exceed respiration (mark point 5). Some students stated that none of the pigments could absorb the wavelengths that pass through, rather than specifying chlorophyll.

(c)     Many students gained one mark here but few achieved both. Many identified that light or temperature would not be limiting but did not go on to describe how this would affect the biochemistry of photosynthesis. Some mentioned the use of carbon dioxide in the light-independent reaction but did not link this to the high use of carbon dioxide, to gain both mark points 5 and 6. Several answers were seen with a clear misunderstanding that a higher concentration of oxygen causes a lower concentration of carbon dioxide.

**Q2.**

(a)     Thylakoids or grana were well known as the site of the light-dependent reaction.

(b)     Most recognised that, in the diagram showing the light-dependent reaction, substance **A** was oxygen, **B** was ADP + phosphate and **C** was reduced NADP. One problem arose with abbreviations – while ‘Pi’ is a suitable abbreviation for inorganic phosphate, ‘P’ (unqualified) is *not* as it is the chemical symbol for phosphorus.

(c)     With respect to the role of chlorophyll in photolysis, better candidates were able to explain how the loss of electrons from chlorophyll, promoted by the absorption of light energy, meant that the chlorophyll molecule was ready to receive electrons from OH– ions and hence cause more water to dissociate. Many forgot to explain that chlorophyll actually absorbed light and examiners were left to deduce this from its described effect on the chlorophyll’s electrons.

It was evident that many candidates were conversant with the principles of electron excitation by light energy and knew that the electrons could then be passed down a series of electron-carriers, releasing energy to drive the synthesis of ATP.

(d)     Those with a thorough knowledge of the parts of the Calvin cycle which involved RuBP, carbon dioxide, GP and TP had little problem in applying it in this section. In (i), the main point omitted was that, to keep its concentration constant, GP would have to be produced at the *same rate* as it was converted to something else. In (ii), many realised that, with no carbon dioxide to combine with, RuBP would no longer be converted to GP and so the concentration of RuBP would increase. Some gave the extra detail that RuBP would continue to be formed from GP (perhaps noticing on the graph the fall in concentration of the latter).

**Q3.**

(a)     Most candidates identified the relationship between light absorption and the rate of photosynthesis, but very few went further to give a valid explanation that referred to light energy as being the cause of this relationship. Incorrect responses to this question commonly included references to the wavelength of light instead of a variable given in the question’s stem or they provided literal descriptions about the shape of the curves. An incorrect answer describing the percentage of absorbed light always being higher than the rate of photosynthesis was not uncommon.

(b)     This was usually answered correctly, but measuring the production of carbon dioxide rather than measuring how much of it is taken up by a plant was a common error.

(c)     Most candidates knew that plants reflect green light, but only a small proportion correctly translated this understanding into a valid range of wavelengths using the graph. In this respect, candidates tended to have a weak appreciation of how to use graphs to communicate their understanding of a biological principle.

(d)     This proved to be extremely difficult for nearly all candidates and it did not seem to be a good discriminator between candidates of different levels of ability. Those who could explain processes involved in the light-dependent reaction picked up a mark in part (i) for chlorophyll losing electrons or for the production of reduced NADP. Very few went further and used these electrons to reduce the dye. In part (ii), many candidates explained that ADP and Pi were needed for ATP production, but hardly any linked this back to the question and discussed why the process occurred more quickly when the concentration of these substrates was increased.

**Q4.**

(a)     (i)      Slightly more than two-thirds of students correctly identified the stroma as the precise location of the enzyme Rubisco. Common incorrect responses included the ‘matrix’, ‘grana’ and ‘cytoplasm’.

(ii)     Most students correctly gave the answer of two as the number of carbon atoms in one molecule of phosphoglycolate. The most common incorrect responses were three and five.

(b)     The majority of students clearly understood that, as the oxygen concentration increased, more Rubisco / RuBP reacts with the oxygen rather than with carbon dioxide. However, very few students realised that this was an example of competitive inhibition or mentioned that less RuBP would be regenerated. Consequently, most students obtained only one of the two marks available.

(c)     This proved to be a good discriminator. Most students gained one mark for realising that less glycerate 3-phosphate would be produced. A significant percentage of these students then gained a second mark for describing the formation of a named photosynthetic product from triose phosphate. However, less than ten percent of students referred to less RuBP being regenerated. Weaker answers often included references to the Krebs cycle rather than the Calvin cycle and linked the uptake of oxygen to respiration.

**Q5.**

Whilst a full range of marks was seen on this question, marks of seven or eight were comparatively rare. Most candidates scored between three and five marks.

(a)     Whilst most candidates recognised that the experiment was about the effect of light intensity on the rate of photosynthesis, many candidates did not appreciate that the addition or removal of carbon dioxide would affect the colour of the indicator. Only the best candidates compared rates of respiration and photosynthesis in tube A. A large proportion of candidates ignored the uptake of carbon dioxide in tube A and looked for an explanation in terms of alkaline properties of oxygen. With tube B, many saw that photosynthesis had stopped but either ignored respiration, or stated that the plant had switched to respiration. There was quite a large proportion of correct answers with regard to tube C.

(b)     In part (i), weaker candidates gave vague answers about a ‘control experiment’. A large number gained the mark by making reference to proving that the plant caused any changes. Only a small minority answered in terms of showing that light did not affect the indicator. In part (ii), very few correct answers were seen. Weak candidates thought that this would make it ‘a fair test’. Most candidates thought that it was to give equal light intensity to each tube but very few mentioned heat or temperature.