Model Answers: Medium

1a

a) The parts of a chloroplast labelled A-C are…

- A = Stroma; [1 mark]
- B = Thylakoid/thylakoid membrane; [1 mark]
- C = Thylakoid stack/granum; [1 mark]

Accept *grana instead of granum*

[Total: 3 marks]

It can be confusing to differentiate between thylakoids and grana here, so be sure that you know the difference! A single membrane-bound disc is known as a thylakoid (surrounded by a thylakoid membrane), and these thylakoids stack together to form a granum. More than one stack together are referred to as the plural, grana.

1b

b) An electron microscope rather than a light microscope is needed to view the internal structures of chloroplasts because…

Any **two** of the following:

- Electron microscopes have a higher resolving power/resolution (than light microscopes) / a resolution of 0.5 nm compared to a light microscope at 200 nm; [1 mark]
- (This means that electron microscopes) can distinguish between/resolve two objects that are close together / allow two objects that are close together to be seen as separate (rather than as a single object); [1 mark]
- Electrons have a shorter wavelength (than light) / the wavelength of light is too long; [1 mark]

[Total: 2 marks]

1c

c) Starch granules are present inside chloroplasts because…

Any **two** of the following:

- Glucose produced during photosynthesis is converted into starch/amylose/amylopectin; [1 mark]
- Condensation reactions form glycosidic bonds between glucose molecules; [1 mark]
- Starch is a storage molecule / stores chemical energy; [1 mark]
- Starch does not affect the water potential of the chloroplast / starch does not cause water to move into the chloroplast by osmosis (as it is insoluble); [1 mark]
- Starch is compact so can be stored in large quantities; [1 mark]

[Total: 2 marks]

The question here is not very specific about exactly which aspect of the presence of starch is being asked for, but the mark scheme allows for different interpretations of the question. You could think about where the starch has come from, i.e. that it is the result of bonds being formed between glucose molecules that are produced during photosynthesis, or you could think about why it is needed by the plant, i.e. as a store of chemical energy that does not affect the water potential of the organelle.

1d

d) i) The role of photosynthetic pigments in the thylakoid membrane is…

- To absorb light energy for photosynthesis; [1 mark]

d) ii) The benefit of having various pigments is that...

- Light of different wavelengths can be absorbed; [1 mark]
- Maximising the amount of light energy absorbed by the chloroplasts **OR** enables the absorption of a wider range of light wavelengths **OR** accessory pigments/chlorophyll b/carotene/xanthophyll can funnel energy towards the primary pigment/reaction centre/chlorophyll a; [1 mark]

[Total: 3 marks]

2a

a) Comparative points regarding the absorption spectra for chlorophyll b and carotenoids include...

Differences

Any **two** of the following:

- Chlorophyll b absorption peaks at 470 nm and 650 nm **WHILE** carotenoid absorption peaks at 460 nm and 520 nm; [1 mark]
- Chlorophyll b absorbs mainly blue light and red light **WHILE** carotenoids absorb mainly blue light and green light; [1 mark]
- The absorption peak for chlorophyll b at 470 nm is higher than both of the absorption peaks for carotenoids / the absorption peak for chlorophyll b at 650 nm is lower than both of the absorption peaks for carotenoids; [1 mark]

AND

Similarities

- Neither pigment absorbs light between wavelengths 560 nm and 600 (or 610) nm / yellow light; [1 mark]

Accept *answers that don't include nm units.*

Give a margin of error of 5 nm for any numbers quoted.

[Total: 3 marks]

Comparison questions require you to identify similarities and differences between two things, so be sure to look for both to get full marks.

2b

b) i) The colour of carotenoid pigments is...

- Yellow/orange/red; [1 mark]

Accept *yellow-orange or orange-red*

b) ii) The reason for this is that...

- Carotenoids do not absorb any light at these wavelengths **SO** these colours of light will be reflected; [1 mark]

[Total: 2 marks]

The wavelengths of light that are not absorbed by an object are reflected back into the eyes of a viewer, and the object will appear to be the colour of the reflected light. We can see from Fig. 2.1 that carotenoids do not absorb light in the yellow through to red parts of the spectrum, so it will reflect these light wavelengths and will appear as a colour from these parts of the spectrum.

2c

c) i) The information represented by an action spectrum is different to that represented by an

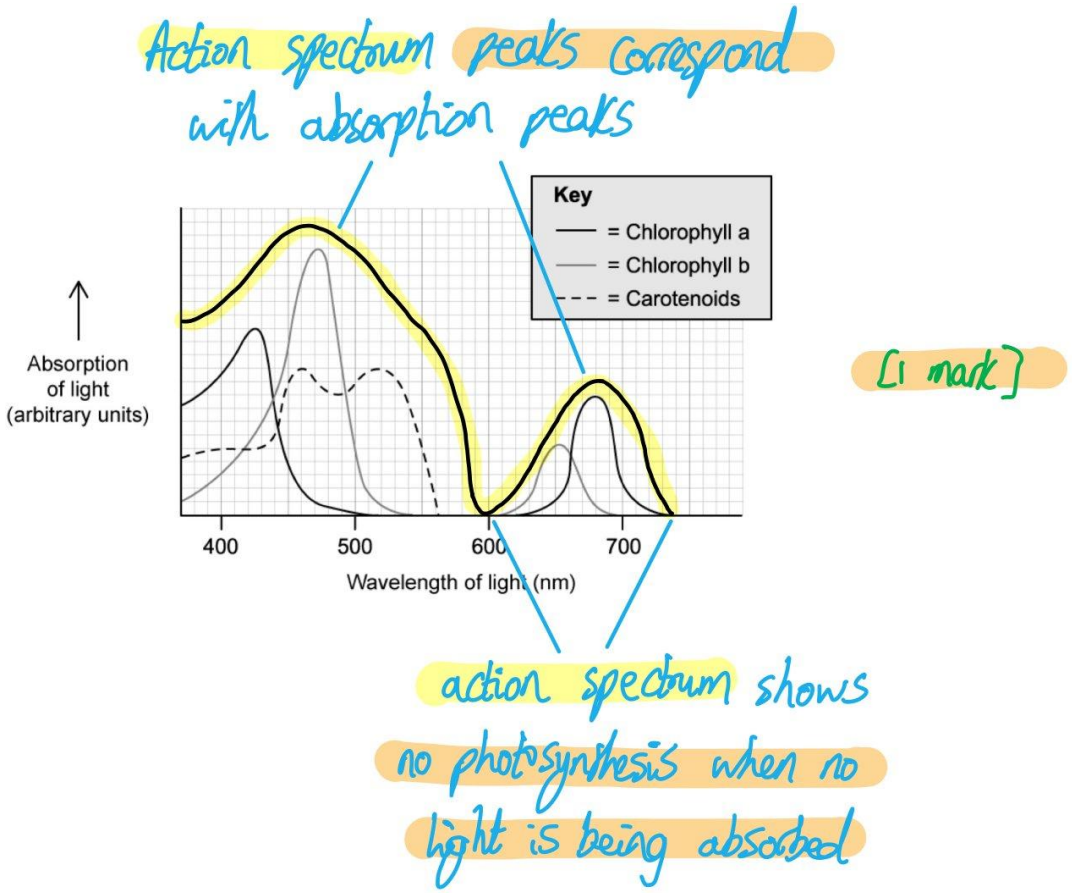
absorption spectrum in that...

- An action spectrum shows the rate of photosythesis at different light wavelengths **WHILE** an absorption spectrum shows the light absorbed by pigments at different wavelengths; [1 mark]

c) ii) A sketch of the action spectrum should show...

- A line that corresponds to all of the main peaks of the different pigments **AND** that drops to zero when no pigments are absorbing light; [1 mark]

[Total: 2 marks]



2d

d) Only a small number of plant species are found on the ground below the trees because...

Any **four** of the following:

- Only a small amount of light energy passes through leaves / tree canopy / reaches the ground; [1 mark]
- A smaller <u>range</u> of wavelengths passes through leaves **OR** only green (and yellow) light passes through the tree canopy; [1 mark]
- There is little light energy for <u>chlorophyll</u> pigments to absorb; [1 mark]
- The rate of photosynthesis will decrease **AND** less glucose will be produced; [1 mark]
- Less energy/ATP will be available to the plants (under the trees) **SO** growth will be reduced; [1 mark]
- Carotenoids can absorb the light available on the forest floor **SO** some plants (with enough carotenoids) will be able to grow; [1 mark]

[Total: 4 marks]

When Fig.1 and 2 are compared it can be seen that the light wavelengths reaching the forest floor correspond with the light wavelengths not absorbed by chlorophylls a and b. This means that plants on the forest floor have limited light energy to absorb and their rate of photosynthesis will drop, decreasing their growth rate. Any plants that contain large enough amounts of carotenoid pigments will be able to absorb in the green part of the spectrum, so these plants will be able to grow, though not as fast as the trees above them.

While it would be correct to say that the plants in the canopy are out-competing the plants on the ground for light, saying this isn't enough for a mark; you would need to link this idea to a reduction in light energy or range of wavelengths reaching the ground.

3a

a) The R_f values for pigments X and Y in Figure 2 are...

- X = 0.55; [1 mark]
- Y = 0.94; [1 mark]

OR in the absence of both of the above marking points...

- 10.7 ÷ 19.5 / 18.33 ÷ 19.5; [1 mark]

[Total: 2 marks]

$$Rf = \frac{\text{distance moved by pigment}}{\text{distance moved by solvent}}$$

Identify values:

Distances moved by pigments

x = 10.7 cm

y = 18.3 cm

Measured from original spot to solvent front

Distance moved by solvent = 19.5 cm

Substitute values into equation:

pigment x Rf = $\frac{10.7}{19.5}$ = 0.55 [1 mark]

only in absence of other marks — [1 mark]

pigment y Rf = $\frac{18.33}{19.5}$ = 0.94 [1 mark]

3b

b) The pigments in a chloroplast are arranged as follows...

Any **three** of the following:

- Located in the thylakoid membrane; [1 mark]
- Located in photosystems (I and II); [1 mark]
- Arranged in a funnel shape; [1 mark]
- Chlorophyll a is found in the reaction centre / at the base of the funnel; [1 mark]
- Accessory pigments / chlorophyll b **and** carotenoids/carotene/xanthophyll are arranged around the sides of the funnel / channel/funnel light energy to chlorophyll a / the reaction centre / the primary pigment; [1 mark]

[Total: 3 marks]

3c

c) i) Photoactivation involves the following...

Any **two** of the following:

- Light energy is absorbed by (photosynthetic/accessory) pigments (before being funnelled to the primary pigment); [1 mark]
- Electrons in the reaction centre/chlorophyll a are excited / gain energy / raised to a higher energy level; [1 mark]
- Electrons are emitted/lost from the photosystem/reaction centre/pigments; [1 mark]

c) ii) Photolysis involves the following…

- Water is split into hydrogen ions/protons **and** electrons **and** oxygen; [1 mark]
- The reaction is catalysed by an enzyme/ oxygen-evolving complex / water-splitting complex in photosystem II; [1 mark]

[Total: 4 marks]

3d

d) Oxidation and reduction occur in the light dependent reactions in the following ways…

A maximum of **two** of the following:

- Chlorophyll a / the primary pigment / the reaction centre is oxidised when electrons are lost (during photoactivation) and passed to the electron transport chain / an electron carrier; [1 mark]
- Electron carriers / proteins of the electron transport/transfer chain molecules are oxidised when they pass on/give up electrons to the next electron carrier/photosystem/NADP; [1 mark]
- Water is oxidised when it loses electrons during photolysis; [1 mark]

AND a maximum of **two** of the following:

- Electron carriers / proteins of the electron transport/transfer chain are reduced when they accept/gain electrons from the photosystem / another electron carrier; [1 mark]
- Chlorophyll a is reduced when it gains/accepts electrons from an electron carrier during cyclic photophosphorylation / from water during non-cyclic photophosphorylation; [1 mark]
- NADP is reduced when it accepts/gains electrons (along with hydrogen ions), becoming reduced NADP or NADPH; [1 mark]

[Total: 3 marks]

Oxidation is loss (OIL) of electrons while reduction is gain (RIG) of electrons. When chlorophyll a, an electron carrier protein, or water loses electrons and passes them elsewhere they are said to be oxidised and have taken part in an oxidation reaction. When an electron carrier, chlorophyll a, or NADP gain an electron from elsewhere they are said to be reduced and have taken part in a reduction reaction.

Note that the question asks you to **explain** the oxidation and reduction processes, so a bit more detail is required for a each mark than just stating where electrons have been lost or gained.

4a

a) i) The process shown in Fig.1 is…

- Non-cyclic photophosphorylation; [1 mark]

a) ii) It can be identified as this because…

- It involves photosystems I and II / photosystem II is present (rather than just PS I as in cyclic photophosphorylation); [1 mark]
- Electrons do not return to their starting point (as they do in cyclic

photophosphorylation); [1 mark]

[Total: 3 marks]

4b

b) i) The process marked A that could be affected by cadmium is...

- Photoactivation; [1 mark]

b) ii) The impact that this could have on photosynthesis includes...

Any **three** of the following:

- No electrons would enter the electron transport/transfer chain (as they will not be excited in photoactivation); [1 mark]
- No ATP would be produced (at B); [1 mark]
- No NADP would be reduced / no reduced NADP/NADPH would be produced (at C); [1 mark]
- GP will not be converted into TP / no hexose sugars will be produced due to a lack of TP (in the Calvin cycle); [1 mark]

[Total: 4 marks]

Note that part b) ii) is an 'outline' question so the precise details of the impact that cadmium would have on the processes involved are not required, just the overall effects.

Preventing photoactivation would mean that no electrons enter the electron transport chain on the thylakoid membrane. This would prevent the production of ATP and reduced NADP, meaning that these products are not available to enter the Calvin cycle. The Calvin cycle will be unable to progress from GP to TP (ATP and NADPH are needed for this step) and so no TP and therefore no hexose sugars will be produced.

4c

c) The process taking place at B Fig.1 involves...

Any **five** of the following:

- Energy is released as electrons pass down the electron transport chain; [1 mark]
- The energy released is used to power a proton pump / membrane protein that pumps/actively transports hydrogen ions/protons/H^+ (from the stroma) into the thylakoid lumen/space; [1 mark]
- A H^+ (concentration) gradient is generated between the thylakoid lumen/space and the stroma / there is a higher concentration of H^+ in the thylakoid lumen/space than in the stroma; [1 mark]
- H^+ move back across the membrane by facilitated diffusion through/via ATP synthase; [1 mark]
- (This process is known as) chemiosmosis; [1 mark]
- ATP synthase catalyses the production of ATP; [1 mark]
- ATP is synthesised/produced from ADP and phosphate/P_i; [1 mark]

[Total: 5 marks]

5a

a) i) Compound M is...

- Carbon dioxide; [1 mark]

a) ii) Compound O is...

- RuBP/ribulose bisphosphate; [1 mark]

a) iii) The enzyme that catalyses the reaction between compounds M and O is...

- Rubisco/ribulose bisphosphate carboxylase; [1 mark]

[Total: 3 marks]

Don't be thrown by diagrams that are different to the representations that you may be used to. This diagram is a rotated version of the Calvin cycle and the numbers of each molecule have been altered to account for 6 molecules of carbon dioxide being fixed.

5b

b) The products of the light dependent reactions are used in the light independent reactions in the following ways...

Any **three** of the following:

- (The products) ATP **and** NADPH/reduced NADP (come from the light independent reactions); [1 mark]
- ATP can be broken down/hydrolysed to release energy; [1 mark]
- NADPH/reduced NADP is used to reduce/phosphorylate compound N (GP) / convert compound N (GP) into triose phosphate/TP; [1 mark]
- ATP is needed to regenerate RuBP / convert triose phosphate/TP back into RuBP; [1 mark]

Accept *actual name of compound N (GP) provided that it has been correctly referred to as compound N on one other occasion.*

[Total: 3 marks]

Note that you have been asked to refer to Fig.1 in your answer, so you should be sure to link the names of molecules that you know to the compounds referred to in Fig. 1. Given that compound O has already been identified in part a) and triose phosphate has not been included in the diagram, GP as compound N is the only reference that the mark scheme is looking for.

5c

c) i) Compound P could be converted into...

Any **three** of the following:

- Starch; [1 mark]
- Sucrose; [1 mark]
- Cellulose; [1 mark]
- Glycerol/fatty acids/lipids; [1 mark]
- Amino acids; [1 mark]

c) ii) The type of reaction that would convert compound P into a polymer is...

- A condensation (reaction); [1 mark]

[Total: 4 marks]

Compound P is glucose, which can be converted into all of the molecules mentioned above. You are probably familiar with the first four answers but less familiar with the fact that glucose can be converted into amino acids when it combines with nitrates absorbed from the soil.

5d

d) Compound P is converted into other molecules for storage because...

Any **pair** of points from the following:

- It needs to be converted into an insoluble form; [1 mark]
- So that it doesn't lower the water potential of the plant cell / cause water to move

into the plant cell by osmosis; [1 mark]

OR

- It needs to be converted into a more compact form / a form that takes up less space; [1 mark]
- This allows the plant to store as much (carbohydrate) as possible in a small space / prevents the plant's energy stores from taking up too much space; [1 mark]

OR

- It needs to be converted into sucrose for transport; [1 mark]
- Sucrose is less reactive / less likely to be used up before it reaches its destination / can store more chemical energy (than compound P/glucose); [1 mark]

Accept *reverse argument.*

[Total: 2 marks]

6a

a) The correctly filled in locations are as follows...

compound or structure	**location**
ATP synthase	C
rubisco	B
starch grain	A
phospholipid bilayer	C

- Four correct; [3 marks]
- Three correct; [2 marks]
- Two correct [1 mark]
- One or zero correct; [0 marks]

[Total: 3 marks]

6b

b) A description and explanation of the results are...

Any **three** of the following:

Description

- The rate of oxygen production is high(est)/peaks at 450 nm AND 650 nm / blue AND red **OR** the rate of oxygen production is lowest at 535–555 nm / green; [1 mark]

Explanations for blue/red

- *Elodea/*chloroplasts absorb this (specified) wavelength/(named) colour of light; [1 mark]
- Light is used for photosynthesis/photophosphorylation; [1 mark]
- So more oxygen is produced from photolysis; [1 mark]
- (This occurs during) non-cyclic (photophosphorylation) / the light-dependent stage; [1 mark]

[Total: 3 marks]

Note that marking point 5 only refers to non-cyclic photosphosphorylation. This is because cyclic photosphosphorylation happens independently of photolysis, so would not involve oxygen production.

6c

c) The role of the accessory pigments in photosynthesis are...

Any **two** of the following:

- Pass energy/light/photons to chlorophyll *a* / the primary pigment / the reaction centre; [1 mark]
- Absorb different wavelengths to chlorophyll *a* / primary pigment / reaction centre; [1 mark]
- Form / arranged in a light-harvesting cluster / photosystem; [1 mark]

[Total: 2 marks]

It is incorrect to say that electrons, rather than energy, light or photons, are transferred from the accessory pigments to the primary pigment. This energy then causes electrons in the primary pigment to become excited and leave the photosystem.

7a

a) i) The parts of Fig. 1 are...

- Carbon (dioxide) fixation / carboxylation; [1 mark]
- Rubisco / ribulose bisphosphate carboxylase oxygenase; [1 mark]
- *Two named substances* e.g. starch, cellulose, fatty acids, lipids, sucrose; [up to 2 marks]
- Photophosphorylation / light-dependent stage; [1 mark]

a) ii) At stage **B** of the Calvin cycle there is..

- Regeneration of RuBP; [1 mark]

[Total: 6 marks]

7b

b) There is a tight ring of mesophyll cells around the bundle sheath cells in the leaves of a C4 plant because...

Any **three** of the following:

- Stops <u>oxygen</u> getting to rubisco/RuBP/bundle sheath cells; [1 mark]
- <u>Oxygen</u> does not react with rubisco / combine with RuBP; [1 mark]
- No photorespiration; [1 mark]
- No wastage of RuBP; [1 mark]

[Total: 3 marks]

Make sure to refer specifically to oxygen here, rather than air.