Model Answers: Hard

1a

a) The rate of photosynthesis in algae that live within the cells of coral polyps is higher than that of free-living algae because…

Any **three** of the following:

- Carbon dioxide concentration is higher/increased; [1 mark]
- (The carbon dioxide is released by) respiration by the coral/polyp; [1 mark]
- (The carbon dioxide) supplies the Calvin cycle / light independent reactions (in the algae); [1 mark]
- (The carbon dioxide) binds to rubisco; [1 mark]
- (Carbon dioxide concentration is) not a limiting factor; [1 mark]

OR

Any **three** of the following:

- The temperature is higher/increased; [1 mark]
- (Due to) respiration by the coral/polyp; [1 mark]
- (This raises the rate of) the Calvin cycle / light independent reactions (in the algae); [1 mark]
- (Because) increased kinetic energy increases the number of collisions / the rate of formation of enzyme-substrate complexes; [1 mark]
- (Temperature is) not a limiting factor; [1 mark]

[Total: 3 marks]

This question requires you to apply your knowledge of the process of photosynthesis to this unfamiliar scenario. You should consider how living within the cells of the coral would change the environmental conditions (that are relevant to photosynthesis) for the algae.

Remember to pitch your answers using A Level knowledge; for example to state the Calvin cycle (as shown in marking point 3). This avoids the pitfall of answering with only GCSE-level knowledge/keywords which will restrict the marks you can earn in a question like this.

1b

b) Lamps radiating mainly violet and blue light are expected to increase the growth of coral polyps more than lamps radiating light of all wavelengths because…

Any **three** of the following:

- Pigments absorb violet-blue light / light of wavelength 400-490 nm best at 8 of the peaks (out of 10); [1 mark]
- Algae's rate of photosynthesis will increase when more light is absorbed; [1 mark]
- Algae will supply polyps with more oxygen / organic nutrients (eg. carbon compounds from photosynthesis); [1 mark]
- Coral's growth will (therefore) increase with more (algal) photosynthesis; [1 mark]
- Light is violet-blue/400-490 nm in the natural habitat of coral / places where corals live; [1 mark]

[Total: 3 marks]

Make sure that there is a clear distinction here between the photosynthesis of the **algae** and the growth of the **coral**; the algae photosynthesises, passing the products to the coral which is then able to grow more.

1c

c) The process of cyclic photophosphorylation involves...

Any **four** of the following:

- Photosystem I only; [1 mark]
- Light energy is absorbed (by accessory pigments); [1 mark]
- (Energy is) passed on to chlorophyll a / primary pigment / reaction centre; [1 mark]
- Electron(s) are excited to a higher energy level / emitted from chlorophyll; [1 mark]
- (Electrons are) collected by / pass to an electron acceptor; [1 mark]
- (Electrons are) passed along the electron transport chain; [1 mark]
- ATP is produced by chemiosmosis; [1 mark]
- Electrons return to chlorophyll (in photosystem I); [1 mark]

[Total: 4 marks]

2a

(a) Bands 3 and 4 most likely represent the two chlorophyll pigments because...

Any **two** of the following:

- Chlorophyll a and chlorophyll b should have similar solubility in the solvent **SO** move a similar distance; [1 mark]
- Chlorophyll a and chlorophyll b are both similar in (molecular) structure/polarity/size; [1 mark]
- (This means) they would be expected to be grouped close together on the chromatogram; [1 mark]
- Chlorophyll a and chlorophyll b should have similar R_f values; [1 mark]

[Total: 2 marks]

Chromatography can be used to separate and identify chloroplast pigments that have been extracted from a leaf. Each pigment has a unique R_f value, which demonstrates how far a dissolved pigment travels through the stationary phase. Molecules with a higher affinity to the stationary phase, such as larger molecules, will travel slower (causing their band to appear lower on the chromatogram) and will therefore have a smaller R_f value.

2b

(b) Someone could accurately identify the pigments in the chromatogram shown in part (a) in the following way...

Any **three** of the following:

- Measure distance travelled by solvent (front); [1 mark]
- Measure distance travelled by each pigment; [1 mark]
- Calculate R_f value (for each pigment) **OR** divide pigment distance by solvent (front) distance; [1 mark]
- Compare calculated R_f values to known R_f values; [1 mark]
- Identify the colour (of the bands) by comparing with a colour chart **OR** analysis with a spectrometer; [1 mark]

[Total: 3 marks]

2c

(c) The red pigment, phycoerythrin, might be absent from the chromatogram because...

Any **one** of the following:

- The pigment was not extracted successfully/properly/fully when the pigments from the algae were extracted; [1 mark]

- The pigment is insoluble / didn't dissolve in the organic solvent/propanone/acetone used for the chromatography / to separate the pigments; [1 mark]
- The pigment travelled too far up the thin layer chromatography plate / TLC plate **OR** a longer TLC plate is required; [1 mark]
- The pigment may have degraded / broken down for some reason (e.g. due to the organic solvent used); [1 mark]

[Total: 1 mark]

As the question asks you to suggest why something *might* have occurred, this indicates that any reasonable suggestion would be considered and if appropriate, would be awarded the mark.

2d

(d) Red algae can live at greater depths than many other algae because...

- Blue light has shorter wavelengths **SO** penetrates water to greater depths (than red light, which has longer wavelengths); [1 mark]
- Red algae contain phycoerythrin which absorbs blue light **SO** they can photosynthesise at greater depths (than most other algae); [1 mark]

[Total: 2 marks]

Part (c) tells us that the *Palmaria* contain the pigment phycoerythrin, and that this pigment absorbs blue light, while part (d) tells us that light of short wavelengths can penetrate deeper into water. You should know from your knowledge of diagrams showing the visible light spectrum that blue light has a shorter wavelength than other colours of light, so it is blue light that will penetrate deeper into water than light of other wavelengths. The phycoerythrin pigment can absorb this blue light, so *Palmaria* can photosynthesise at depths that other aquatic algae cannot.

3a

(a) The changes in carbon dioxide occur because...

Any **five** of the following:

- There is a high(er) concentration of carbon dioxide at night (at all heights) **AS** photosynthesis stops at night / in the dark; [1 mark]
- Photosynthesis stops in the dark **AS** light energy is required for photolysis / splitting water molecules; [1 mark]
- There is a high(er) concentration of carbon dioxide at night **AS** organisms (continue to) produce carbon dioxide during respiration / respiration rate is higher than the rate of photosynthesis (when it is dark); [1 mark]
- During the day carbon dioxide levels are low(er) **AS** plants use carbon dioxide during photosynthesis; [1 mark]
- During the day carbon dioxide levels are low(er) **AS** rate of photosynthesis is greater than rate of respiration; [1 mark]
- There is a decrease in carbon dioxide concentration with height **AS** at ground level there are fewer leaves / is less light / rate of photosynthesis is lower; [1 mark]
- Carbon dioxide is denser than other gases in air **SO** sinks towards the ground; [1 mark]

[Total: 5 marks]

Note that this is an 'explain' question so each statement must have an element of

explanation to achieve a mark.

Photosynthesis uses up carbon dioxide while respiration produces it. During the night photosynthesis stops, so the rate of uptake of carbon dioxide decreases, while at the same time respiration rate remains constant, producing carbon dioxide and causing overall levels to increase. During the day photosynthesis occurs at a greater rate than respiration, using up carbon dioxide and causing levels to fall. The fall will be greatest in the regions of the woodland where the most photosynthesis is occurring; this is likely to be high in the canopy where light levels are high and there are many leaves.

3b

(b) The level of GP decreased at low carbon dioxide concentration because…

- There is less CO_2 available for the RuBP to combine with; [1 mark]

[Total: 1 mark]

It isn't enough to state that, "CO_2 is the limiting factor". Examiners will want to see a clear statement that CO_2 combines / reacts with RuBP as part of the Calvin Cycle.

3c

(c) The relative levels of GP and RuBP remained the same both before and after the experiment because …

Any three of the following:

- Temperature becomes a limiting factor / below optimum; [1 mark]
- Light intensity becomes a limiting factor / below optimum; [1 mark]
- The rate of photosynthesis becomes limited by reduced NADP / ATP availability/production; [1 mark]
- The rate of photosynthesis becomes limited by RuBP availability/production; [1 mark]
- The rate of photosynthesis becomes limited by the rate at which the enzyme / Rubisco catalyses the reaction; [1 mark]

[Total: 3 marks]

To gain the third mark, you'll need to look beyond the well-understood three limiting factors of photosynthesis (CO_2, temperature and light intensity). Availability of reduced NADP and ATP from the light-dependent stage may become limiting. Rubisco is a poor enzyme in terms of its design and activity; it can become the limiting factor due to its poor catalytic activity just as another enzyme can limit the rate of reactions by being present in very low concentrations.

3d

(d) Hydrogen sulfide is used…

- As a source of protons and electrons; [1 mark]
- So that reducing reactions can be carried out; [1 mark]
- (As a source of electrons) for the electron transport chain; [1 mark]

[Total: 3 marks]

This question requires you to see the link between sulfur and oxygen, which are both in the same group of the Period Table and show some similarities in their chemical properties. H_2O (in photosynthesis) and H_2S (in chemosynthesis) both act in the same manner as reactants, providing protons and electrons for reducing reactions. Electrons are provided to the

electron transport chain. There is unlikely to be any chlorophyll in organisms that occupy a dark habitat, but electrons will still need to be transferred to release energy for anabolic reactions such as the synthesis of hexose sugars.