Model Answers: Hard

1a

a) The total number of stomata on the lower surface of the student's leaf is...

- $\pi r^2 = 0.7^2 = 1.54 / 220 \div 1.54 / 8 \times 142.86$; [1 mark]
- 1143 (stomata); [1 mark]

Full marks can be awarded for the correct answer in the absence of other calculations.

[Total: 2 marks]

Find area of field of view using formula:

πr^2

radius = half the diameter which is 1.4 mm

$\pi \times 0.7^2 = 1.54 \text{ mm}^2$ [1 mark]

Calculate how many times bigger the leaf surface area is than the field of view:

$220 \div 1.54 = 142.86$

[1 mark]

Multiply number of stomata by the difference in surface area:

$8 \times 142.86 = 1142.88$

[1 mark]

$= 1143$ [1 mark]

8 — counted from field of view in fig. 2.1

1143 — Round to nearest whole number

1b

b) The student could conclude the following from Fig. 2...

- The higher the atmospheric carbon dioxide concentration the smaller/narrower the stomatal aperture/opening / the smaller the stomata width in relation to length **OR** the lower the atmospheric carbon dioxide concentration the larger/wider the stomatal aperture/opening / the larger the stomata width in relation to length; [1 mark]
- Carbon dioxide concentration has a (statistically) significant effect on stomatal aperture/opening; [1 mark]

Accept *the idea of statistical significance given within the context of the first mark point, e.g. as the atmospheric carbon dioxide levels increase, the stomata become significantly smaller/narrower; [2 marks]*

[Total: 2 marks]

Note that the first mark point requires the use of comparative language; you need to be clear that the stomata become smaller or larger at different carbon dioxide levels; not just that they are small or large.

The bars representing standard deviation show no overlap, so we know that there is a significant difference between each of the data sets.

1c

c) An explanation for the results shown in Fig. 2 could be that...

- When atmospheric carbon dioxide levels are high there is a steeper concentration gradient between the atmosphere and the inside/air spaces of the leaf; [1 mark]
- (When atmospheric carbon dioxide levels are high) more carbon dioxide diffuses into the leaf / air spaces **SO** the concentration of carbon dioxide inside the leaf increases; [1 mark]
- Availability of carbon dioxide for photosynthesis is high **SO** stomata/guard cells close; [1 mark]

[Total: 3 marks]

High levels of carbon dioxide inside the leaf is a stimulus that triggers the closing of the stomata. Having stomata open is always a balance between gaining carbon dioxide and losing water, so when carbon dioxide is readily available the plant closes its stomata to avoid water loss.

1d

d) Evaluative points regarding the conclusion that rising global carbon dioxide levels could be good for the world's plants include...

In support of the conclusion

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

- At higher carbon dioxide levels there is a higher (dry) mass of plant material **OR** plants gain more mass / grow more when atmospheric carbon dioxide levels are higher; [1 mark]
- High carbon dioxide levels increase the rate of photosynthesis / prevent carbon dioxide from being a limiting factor in photosynthesis; [1 mark]
- At higher carbon dioxide levels the stomata are narrower/smaller so plants will lose less water / conserve water; [1 mark]
- Dry mass is measured so the amount of water in the plant tissues would not affect the results; [1 mark]

Against the conclusion

- There is no significant difference between the mass of the plants at high and medium carbon dioxide levels; [1 mark]
- Increased carbon dioxide levels cause temperatures to increase so plant enzyme activity might decrease / plant enzymes might denature / water availability will decrease (decreasing the rate of photosynthesis/plant growth); [1 mark]

[Total: 3 marks]

When evaluating aim to always include arguments both for and against.

There is evidence that increasing atmospheric carbon dioxide levels actually aid plant growth; there is more carbon available to be fixed during photosynthesis and plants can conserve water by narrowing their stomata while still getting plenty of carbon dioxide.

The data in Fig. 3 shows that in this study at least, there was no significant increase in plant mass as the result of rising carbon dioxide levels from medium to high. There are of course other impacts of global warming that will impact plant growth negatively, such as rising temperatures and reduced water availability.

The question refers specifically to plant growth so other negative impacts of global warming will not be relevant here. These issues must of course be considered when thinking about the bigger picture; clearly, an increased rate of plant growth does not make up for all the other devastating impacts of climate change.

2a

a) i) The opening and closing of stomata in Fig. 1 shows...

Any **one** of the following:

- Stomata close / the percentage of open stomata decreases when it is dark **AND** open / the percentage of open stomata increases when it is light; [1 mark]
- Stomata open and close on a daily/24 hour cycle; [1 mark]

a) ii) Two factors that could be causing the pattern are...

Any **two** of the following:

- Temperature; [1 mark]
- Humidity; [1 mark]
- Carbon dioxide concentration; [1 mark]

[Total: 3 marks]

There are several factors that influence the opening and closing of stomata, some of which fluctuate over the course of a 24-hour cycle. Temperature tends to be higher during the day, and the higher temperatures increase the evaporation of water, raising the humidity levels. Photosynthesis increases during the day, causing plants to use up carbon dioxide and causing carbon dioxide levels to fall, while the rate of respiration overtakes the rate of photosynthesis at night, causing carbon dioxide levels to increase.

While water availability also affects the opening and closing of stomata, this doesn't tend to fluctuate on a daily cycle, so this would not be accepted as an answer here.

2b

b) The pattern in Fig. 1 is advantageous to the plant because...

- It enables carbon dioxide to diffuse into the plant/leaves through the stomata; [1 mark]
- (During the day) when plenty of products of the light dependent reactions / NADPH and ATP are available for the Calvin cycle / carbon fixation; [1 mark]

[Total: 2 marks]

Having open stomata during daylight hours is useful to the plant because it ensures a supply of carbon dioxide at a time when the Calvin cycle can take place. In daylight, the light dependent reactions will be taking place and the

products ATP and NADPH will be produced. These products are required for the Calvin cycle to occur and for carbon dioxide to be fixed.

2c

c) i) ABA levels decrease at increased light intensity due to electrons from chlorophyll causing an ABA precursor molecule to be converted into a chemical called zeaxanthin because...

- Light energy excites electrons in chlorophyll / causes photoactivation **SO** there is no precursor left to produce ABA / all of the precursor is converted into zeaxanthin (and not ABA); [1 mark]

c) ii) ABA levels decrease at increased light intensity due to glucose deactivating ABA because...

- Light energy increases the rate of photosynthesis **SO** more glucose is produced (which deactivates ABA); [1 mark]

c) iii) ABA levels decrease at increased light intensity due to the activation of enzymes that break down ABA at high oxygen concentrations because...

- Light energy increases the rate of photolysis **SO** more oxygen is produced/released (activating the enzymes that break down ABA); [1 mark]

[Total: 3 marks]

This question relies on your knowledge of the process of photosynthesis and on you being able to apply this knowledge to an unknown context.

Electrons are released from chlorophyll as a result of photoactivation, so an increase in light levels will increase the number of electrons released from chlorophyll, converting the ABA precursor into another molecule instead of into ABA; this will reduce ABA levels and therefore lead to reduced activity.

Photosynthesis occurs at a higher rate when light intensity is higher; this will produce more glucose, deactivating ABA. and reducing its activity levels.

Photolysis occurs at a higher rate when light intensity is higher; this will produce more oxygen, activating the enzymes that break down ABA. The enzymes will carry out their function, reducing ABA levels and therefore ABA activity.

2d

d) ABA affects stomata as follows...

Any **six** of the following:

- ABA binds to receptors on the cell surface/plasma membranes of guard cells; [1 mark]
- (This) inhibits proton pumps / stops H^+ ions from being pumped out of the (guard) cells; [1 mark]
- Protons/hydrogen ions/H^+ accumulates inside the cell / pH of cell cytoplasm decreases / interior of cells becomes more positive; [1 mark]
- (ABA stimulates the) movement of calcium ions/Ca^{2+} into the guard cell; [1 mark]
- Calcium ions cause protein channels to open **AND** negative ions/chloride ions leave the cells; [1 mark]
- (Exit) potassium channels open **AND** potassium ions/K^+ leave the cells; [1 mark]
- Loss of ions causes water potential of cells to increase; [1 mark]
- Water moves out of the cells by osmosis; [1 mark]
- Guard cells become flaccid / volume of guard cells decreases (causing the stomata to close); [1 mark]

[Total: 6 marks]