PEARSON EDEXCEL A-LEVEL BIOLOGY B · 9BI0

BIOLOGY



EXAM QUESTION PACK

TOPIC 5: ENERGY FOR BIOLOGICAL PROCESSES

PHOTOSYNTHESIS

SCORE	PERCENTAGE
/175	%

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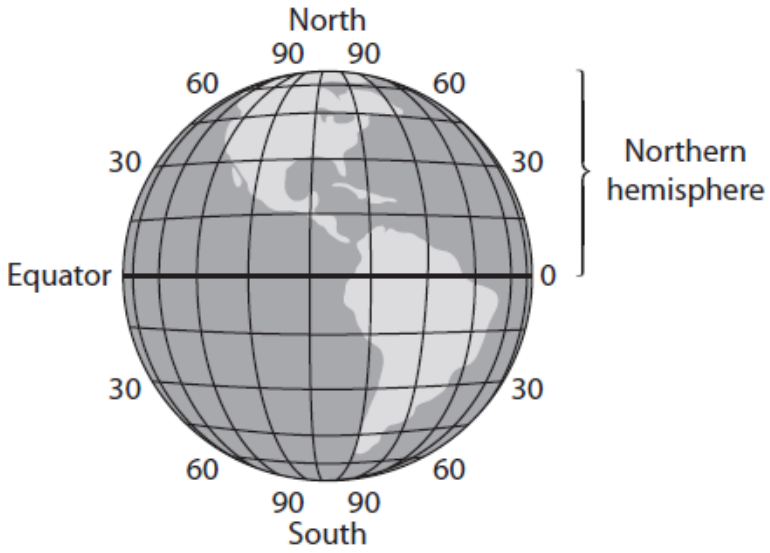
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Q1.

Plant productivity is affected by the abiotic and biotic factors that exist at different latitudes.

The diagram shows latitudes of the Earth.



The table shows the productivity of plants growing on land at different latitudes in the Northern hemisphere.

Latitude / degrees	Productivity / g m^{-2} yr^{-1}
0 to 10 (equatorial conditions)	900 to 1500
30 to 40 (warm temperate conditions)	400 to 800
40 to 60 (cool temperate conditions)	200 to 600
60 to 70 (alpine to arctic conditions)	0 to 200

A student concluded that primary productivity is determined by abiotic factors that affect the light-dependent and light-independent stages of photosynthesis.

Discuss the validity of this conclusion.

(Total for question = 9 marks)

Q2.

Compare and contrast the way in which ATP is synthesised in mitochondria and in chloroplasts.

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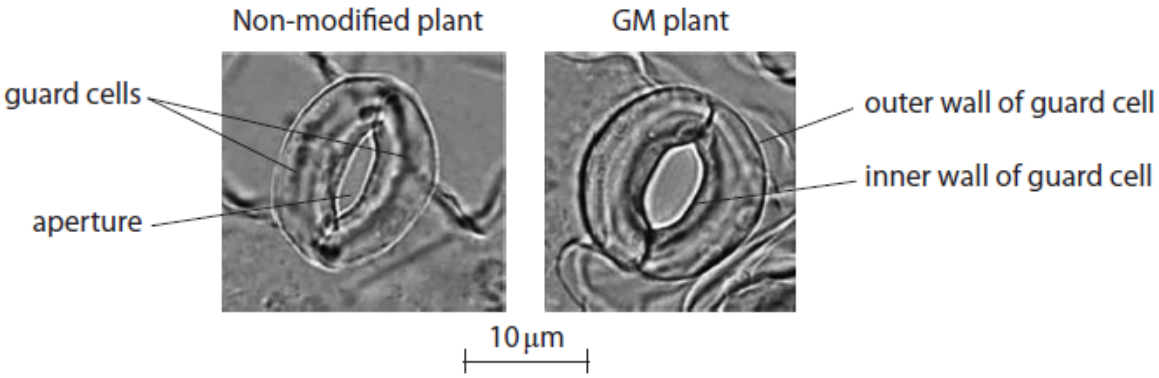
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Q3.

Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

(i) Calculate the magnification of the GM plant photograph using the scale bar.

Give the answer in standard form.

(2)

Answer .....

(ii) Calculate how many times wider the aperture of the stoma of the GM plant is

compared with the stoma of the non-modified plant.

(1)

Answer .....

(Total for question = 3 marks)

Q4.

Mitochondria and chloroplasts in eukaryotic cells are thought to have originated millions of years ago by a process called endosymbiosis.

In endosymbiosis, free-living prokaryotic organisms were engulfed by their new host cells.

Chloroplasts are thought to be derived from cyanobacteria.

It is estimated that there are 1×10^{10} carbon atoms in one cyanobacterial cell.

Ten photons of light are needed to fix one carbon atom.

(i) Calculate the number of photons of light needed to fix enough carbon to form one cyanobacterial cell.

(1)

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(ii) Explain why the value calculated in part (i) is likely to be an underestimate.

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(iii) Describe how carbon fixation takes place in chloroplasts.

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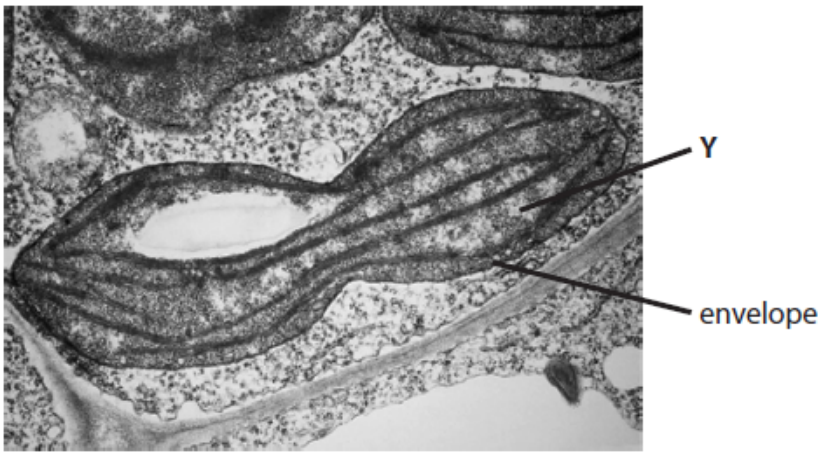
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(Total for question = 6 marks)

Q5.

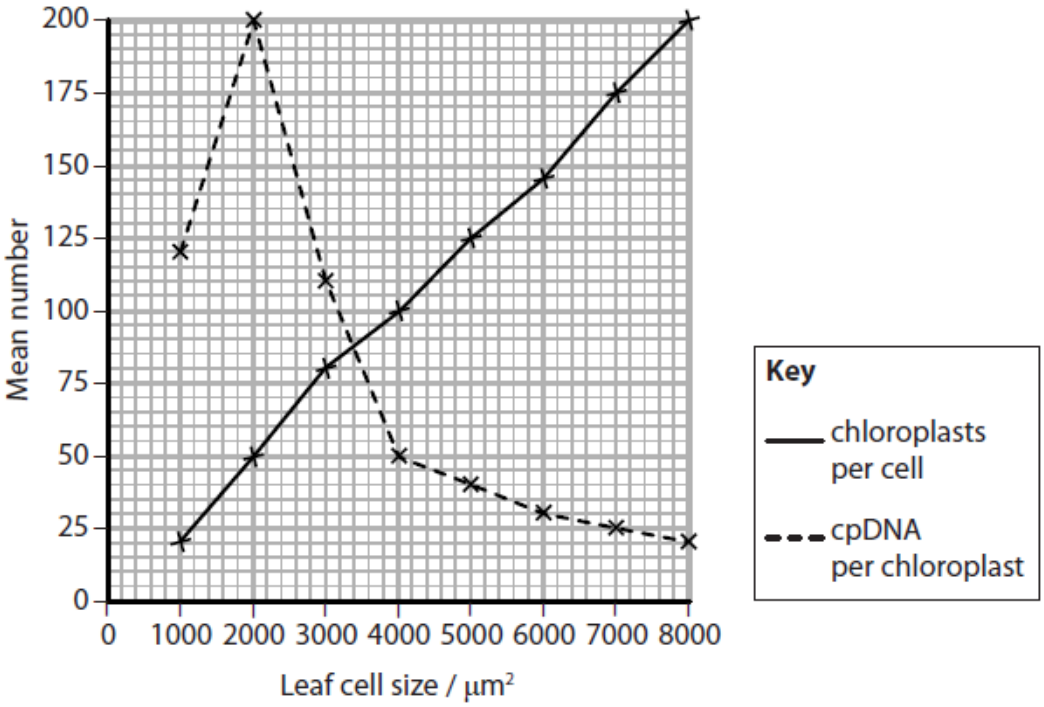
When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.

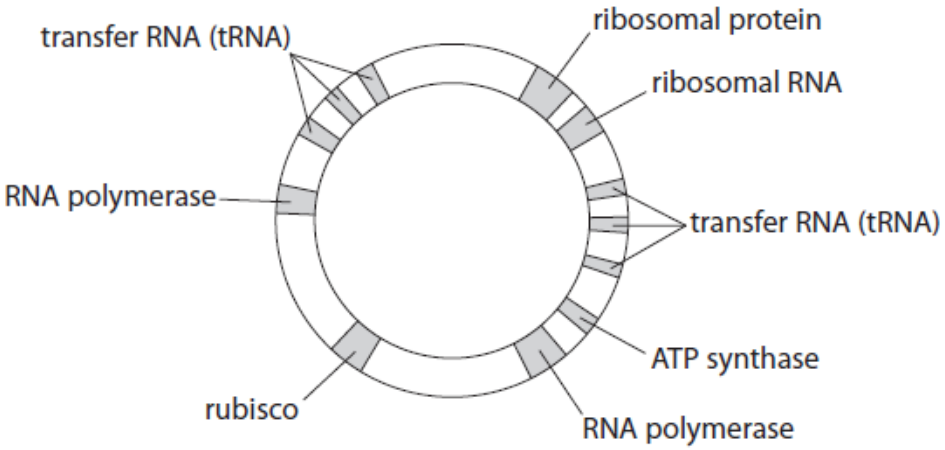


* In an investigation, the mean size of leaf cells was determined. The mean number of chloroplasts per cell and the mean number of DNA molecules (cpDNA) per chloroplast were also determined.

The graph shows the results of this investigation.



The diagram shows the location of some genes found in cpDNA.



Analyse the information to explain the changes that occur in a leaf cell as it grows.

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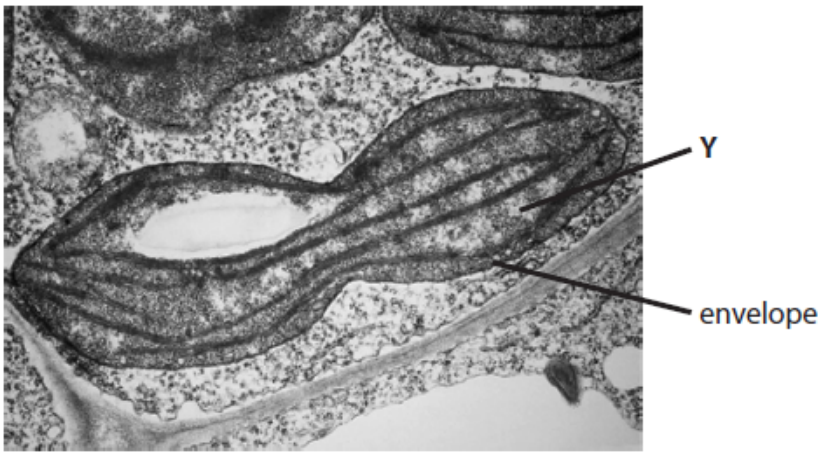
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(Total for question = 6 marks)

Q6.

When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.



What is the name of the part of the chloroplast labelled **Y**?

(1)

- ☒ **A** cytoplasm
- ☒ **B** matrix
- ☒ **C** nucleoplasm
- ☒ **D** stroma

(Total for question = 1 mark)

Q7.

Last year, eight million Christmas trees were bought in the UK.

There are many Christmas tree farms that supply these trees.

The photograph shows young Christmas trees growing on a farm.



Christmas tree farmers remove the other plants (weeds) in order to increase tree growth.

A farmer investigated two methods of removing weeds:

- removing weeds by hand
- spraying herbicides that inhibit weed growth.

The table shows the mean height of Christmas trees using each method, over a five-year period.

Year	Mean height of trees / cm	
	Removing by hand	Using herbicide
0	20	20
1	50	60
2	70	100
3	90	130
4	110	160
5	130	200

A student read that some herbicides work by inhibiting electron transport in photosynthesis.

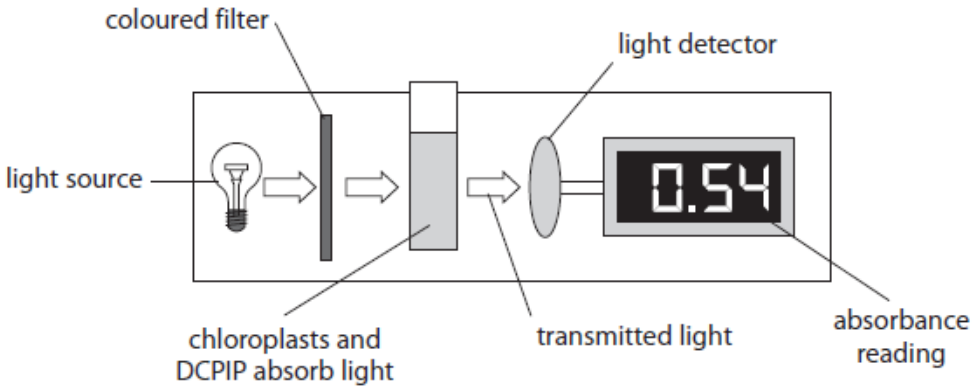
The student investigated this using the indicator DCPIP.

This indicator changes from blue to colourless when it is reduced.

The student used the following method:

- chloroplasts were suspended in two tubes, each containing a solution of DCPIP
- herbicide was added to one of the tubes and no herbicide was added to the other tube
- both tubes were exposed to light
- a colorimeter was used to measure the absorbance in each tube at five minute intervals for 20 minutes.

The diagram shows details of the workings of the colorimeter used by the student.



As DCPIP changes from blue to colourless, the absorbance of light decreases.

(i) Explain how the student used this method to collect valid data.

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The table shows the results.

Time / min	Absorbance / a.u.	
	With herbicide	Without herbicide
0	0.53	0.54
5	0.54	0.31
10	0.54	0.24
15	0.54	0.20
20	0.53	0.16

(ii) Analyse the data to explain the effect of this herbicide on the growth of weeds.

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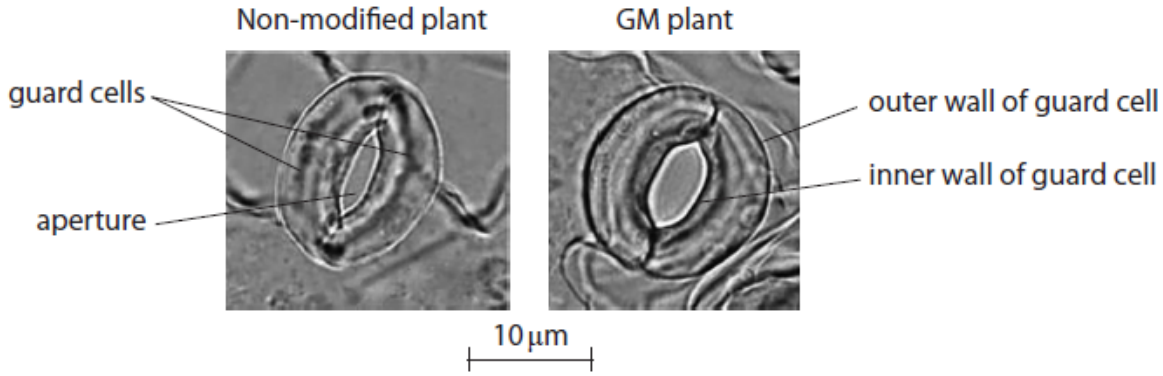
(Total for question = 8 marks)

Q8.

Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

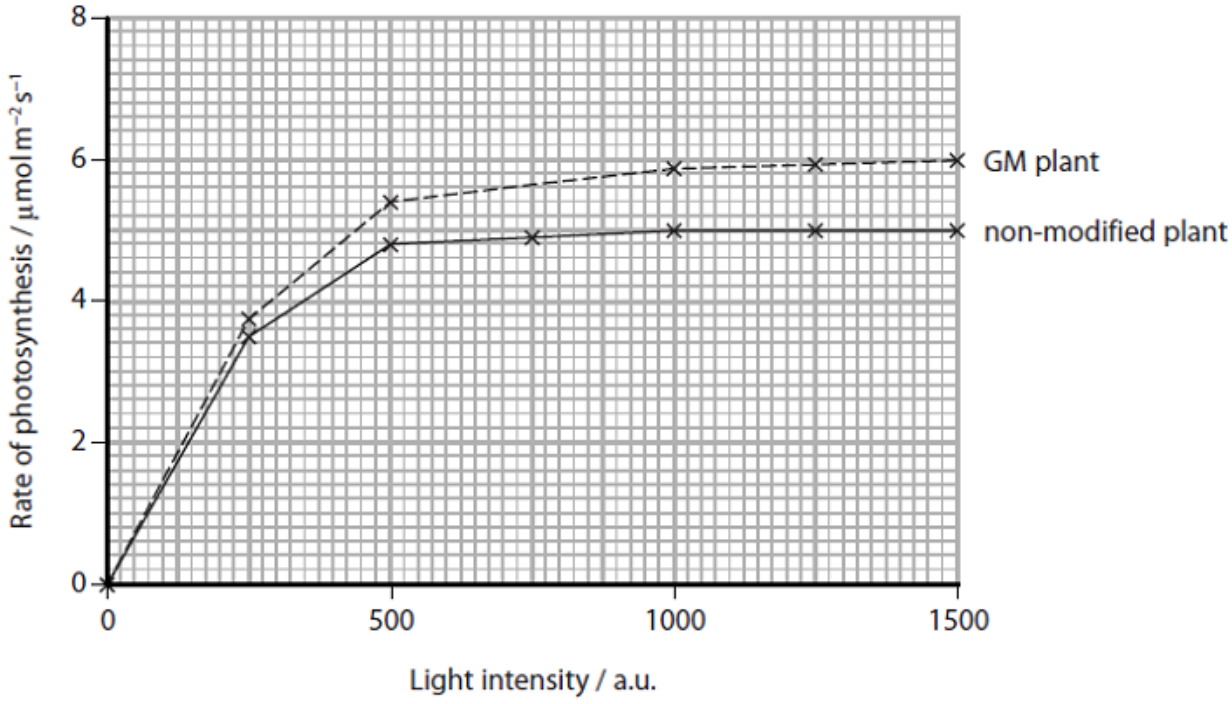
The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

An investigation was carried out to compare the effect of light intensity on the rate of photosynthesis in GM plants with the effect in non-modified plants.

The graph shows the results of this investigation.



(i) The rate of photosynthesis is expressed as µmol m^{-2} s^{-1}.

Describe what was measured to find the rate of photosynthesis.

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(ii) Explain the results of this investigation.

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(Total for question = 6 marks)

Q9.

Plant pigments are involved in photosynthesis.

The action spectrum of chloroplasts and the absorption spectrum of the pigments can be determined.

(i) State the difference between an action spectrum and an absorption spectrum.

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(ii) State how an action spectrum and an absorption spectrum show that chlorophyll is used in photosynthesis.

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(Total for question = 2 marks)

Q10.

ATP is synthesised in mitochondria.

(i) In the space below, draw and label a diagram to show the structure of a mitochondrion.

(4)

(ii) Name **one** other organelle that synthesises ATP.

(1)

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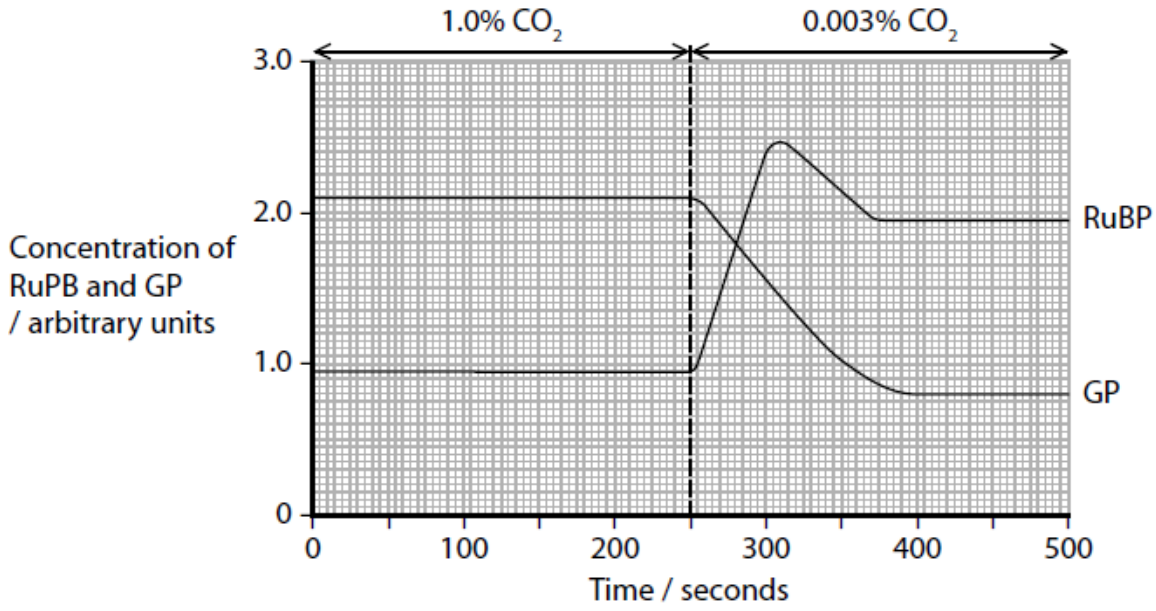
Q11.

An investigation was carried out into the effect of carbon dioxide concentration on photosynthesis.

Cells of a unicellular alga were suspended in a solution containing 1.0% carbon dioxide. After 250 seconds the carbon dioxide was changed to 0.003% CO_2.

The cells were illuminated with a bright light and some were removed at regular time intervals. The concentrations of ribulose bisphosphate (RuBP) and glycerate 3-phosphate (GP) in the cells were measured.

The graph below shows the results of the investigation.



Explain why the cells were illuminated at a high light intensity during this investigation.

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(Total for question = 3 marks)

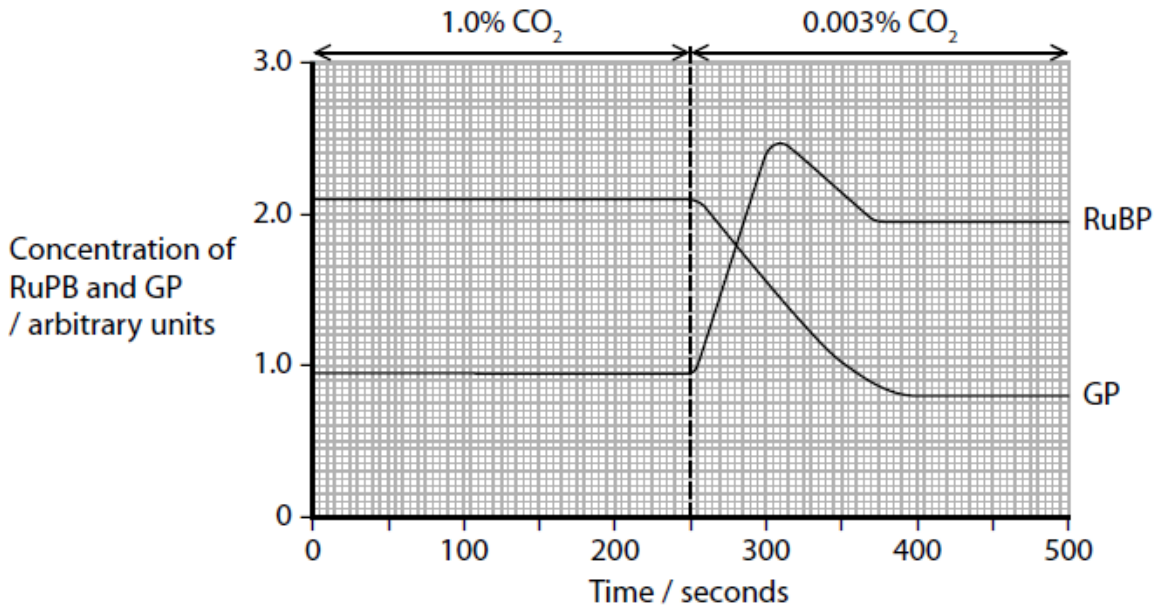
Q12.

An investigation was carried out into the effect of carbon dioxide concentration on photosynthesis.

Cells of a unicellular alga were suspended in a solution containing 1.0% carbon dioxide. After 250 seconds the carbon dioxide was changed to 0.003% CO_2.

The cells were illuminated with a bright light and some were removed at regular time intervals. The concentrations of ribulose bisphosphate (RuBP) and glycerate 3-phosphate (GP) in the cells were measured.

The graph below shows the results of the investigation.



(i) Analyse the data to explain the effect of carbon dioxide concentrations on the production of RuBP.

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(ii) Analyse the data to explain the effect of carbon dioxide concentrations on the rate of production of GP.

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(Total for question = 7 marks)

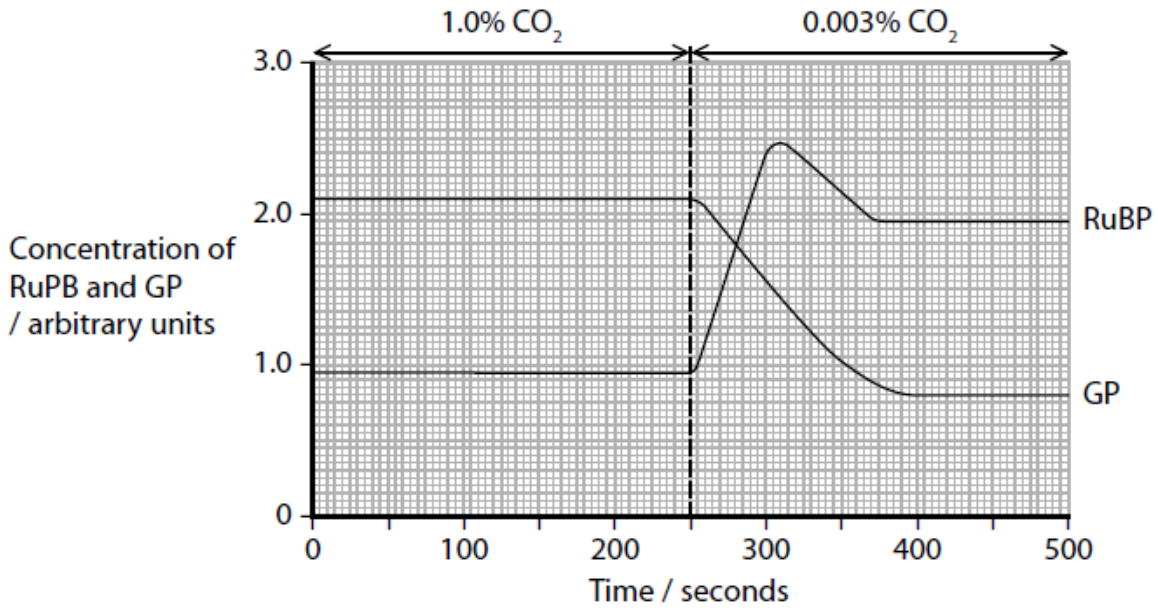
Q13.

An investigation was carried out into the effect of carbon dioxide concentration on photosynthesis.

Cells of a unicellular alga were suspended in a solution containing 1.0% carbon dioxide. After 250 seconds the carbon dioxide was changed to 0.003% CO_2.

The cells were illuminated with a bright light and some were removed at regular time intervals. The concentrations of ribulose bisphosphate (RuBP) and glycerate 3-phosphate (GP) in the cells were measured.

The graph below shows the results of the investigation.



This investigation was carried out at 25°C.

Explain the effect of lowering the temperature on the concentration of RuBP for the first 250 seconds of this investigation.

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(Total for question = 3 marks)

Q14.

The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

Explain why drought affects the quality and quantity of the food of wombats.

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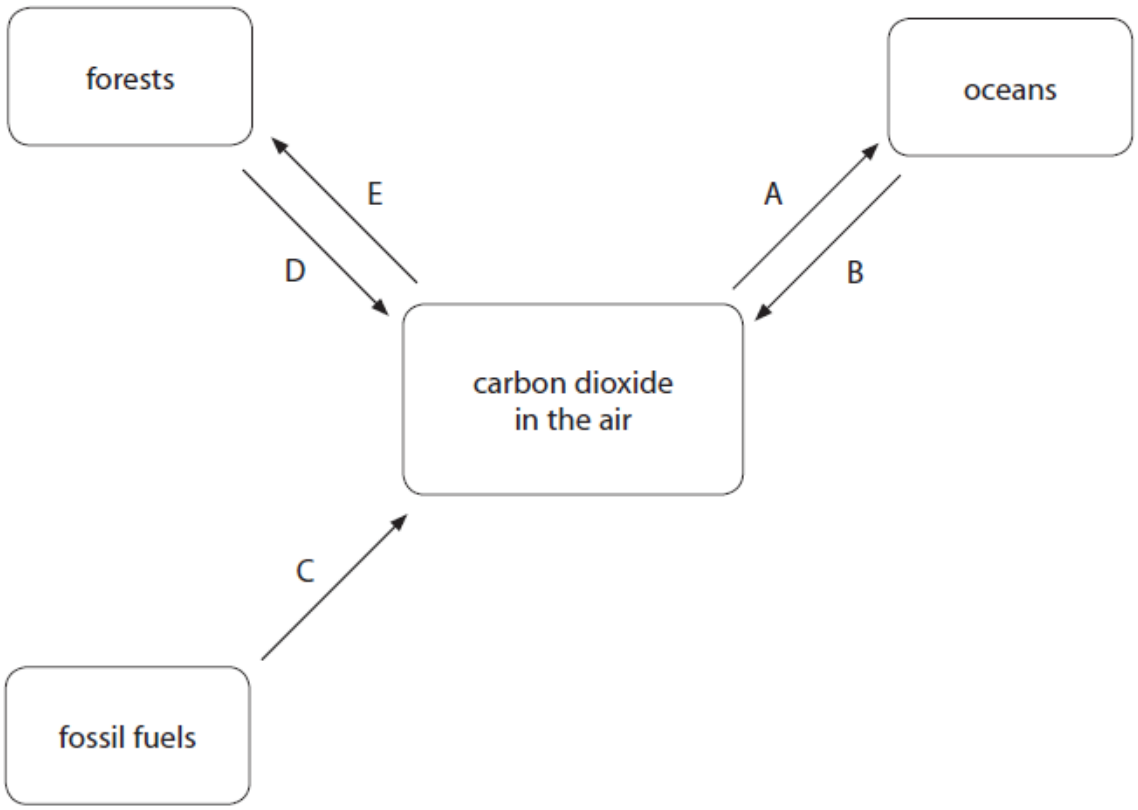
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(Total for question = 5 marks)

Q15.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Explain how carbon dioxide is removed from the air into the oceans by process A.

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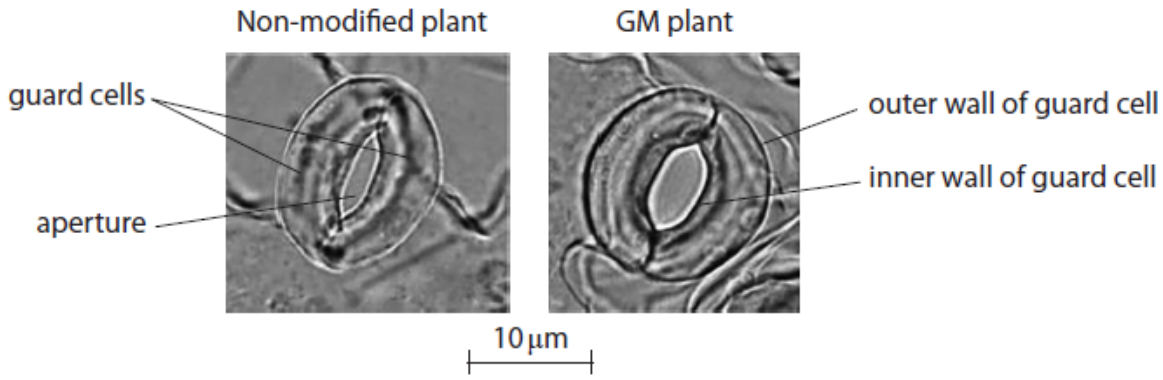
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Q16.

Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

Explain why the wider stomata in GM crop plants could increase their yield.

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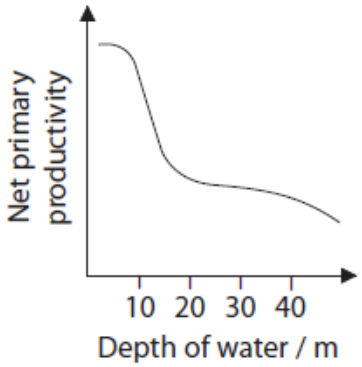
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(Total for question = 3 marks)

Q17.

The graph below shows how the depth of water in a freshwater lake affects the net primary productivity (NPP).



Suggest an explanation for the effect of depth of water on the NPP in this freshwater lake.

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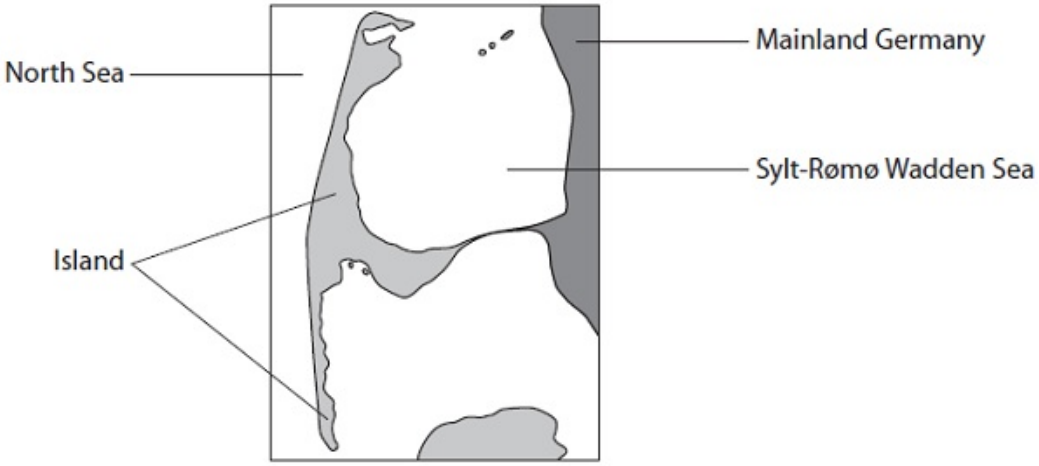
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Q18. The Sylt-Rømø Wadden Sea, shown in the diagram below, has a high gross primary productivity (GPP) which is monitored constantly.

The Sylt-Rømø Wadden Sea is protected from the North Sea by an island.

There are no large rivers flowing into the Sylt-Rømø Wadden Sea.



(a) Explain the meaning of the term **gross primary productivity (GPP)**.

(2)

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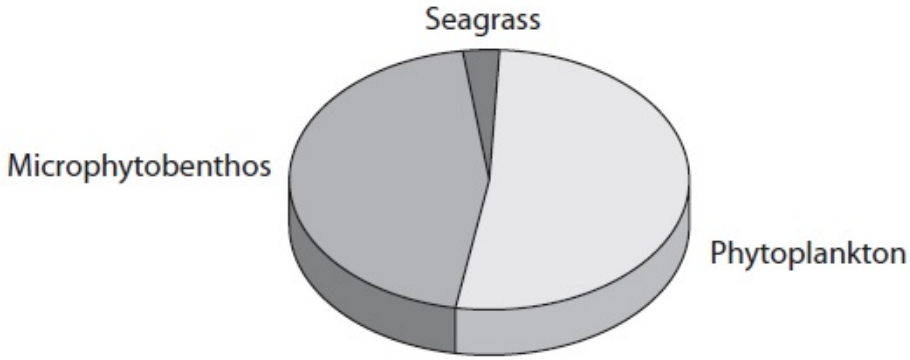
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(b) Seagrass, microphytobenthos and phytoplankton are the producers found in the Sylt-Rømø Wadden Sea.

The chart below shows the distribution of GPP between these producers.



(i) Using the chart, describe the distribution of GPP in this sea.

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(ii) The total GPP for this sea is 840×10^6 kJ m^{-2} y^{-1}.

Explain how GPP for the phytoplankton could be calculated.

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(iii) Suggest why GPP for this sea is very high.

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(c) Explain why net primary productivity (NPP) is lower than GPP.

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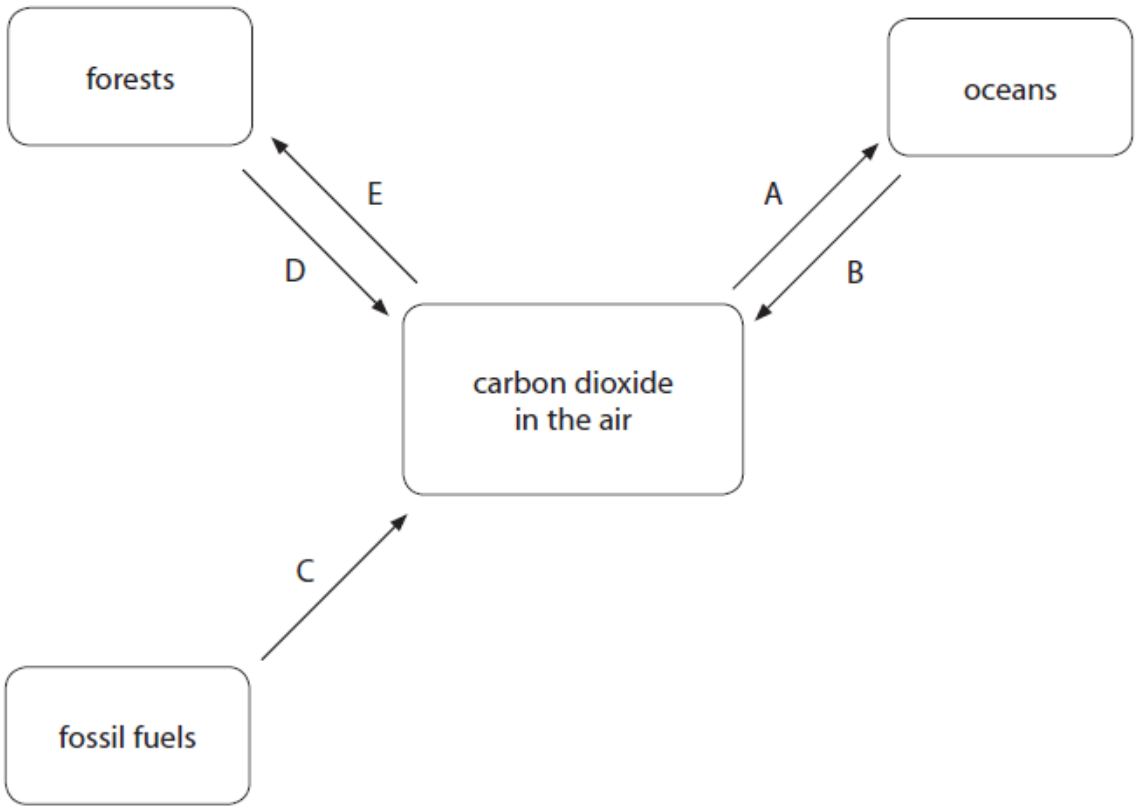
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(Total for Question = 10 marks)

Q19.

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



Place a cross ☒ in the box next to the reaction in process E that uses carbon dioxide.

(1)

☒ **A** light-dependent reaction

☒ **B** light-independent reaction

☒ **C** photolysis

☒ **D** photophosphorylation

Q20.

A student carried out an investigation to test the hypothesis that the surface area to mass ratio of leaves is affected by the amount of light they receive.

A nettle plant growing in sunlight and a second nettle plant growing in shade in a wood were selected.

The surface area and mass of several leaves were measured and the surface area to mass ratio was calculated. The table below shows the results.

Leaf	Surface area to mass ratio / $cm^2\ g^{-1}$	
	Nettle plant growing in sunlight	Nettle plant growing in shade
1	114.5	118.9
2	114.0	117.8
3	115.2	118.1

(a) Explain how the data shows how nettle plant leaves grown in the shade are adapted to growing in low light intensities.

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(b) The student was told that his method was not valid and that some biotic and abiotic variables may not be controlled.

Give five ways in which the student could modify the investigation to address these concerns.

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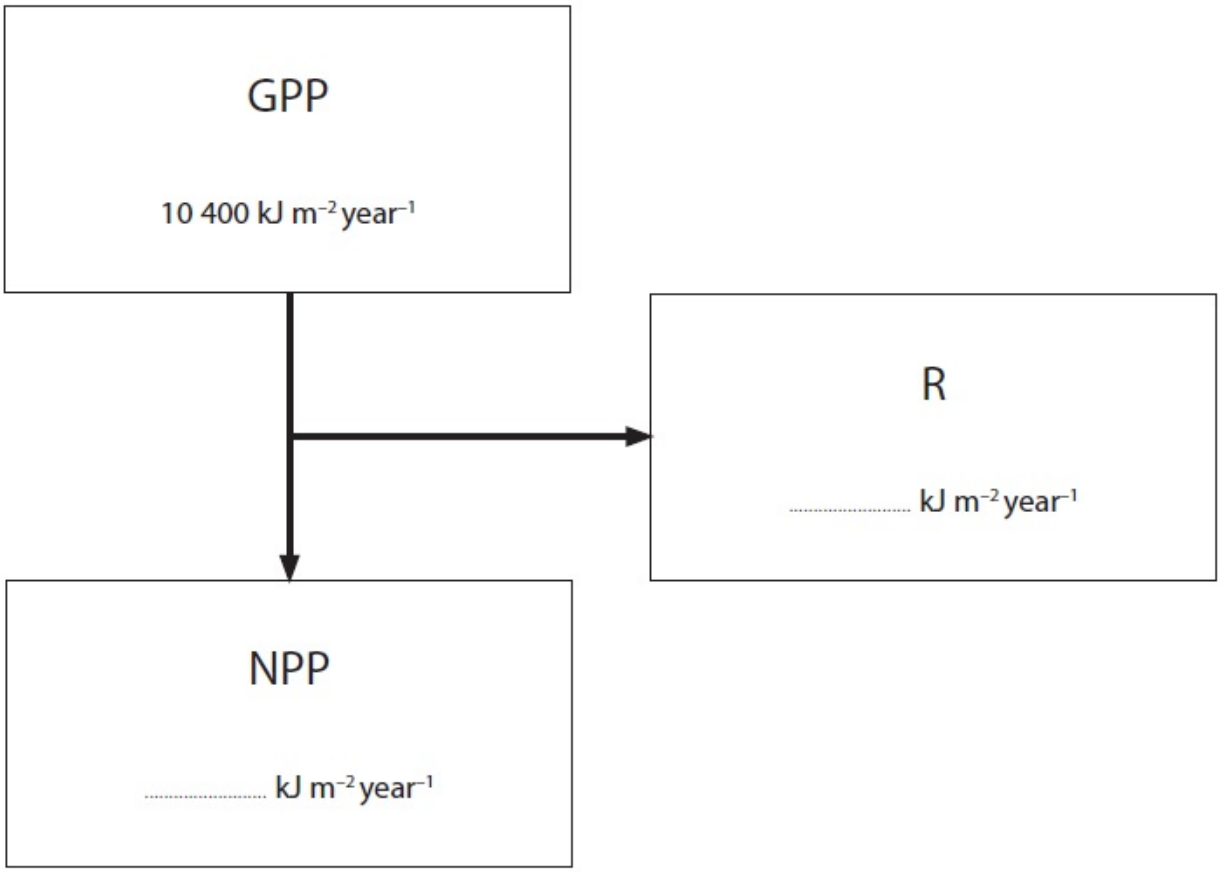
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(Total for question = 8 marks)

Q21. Farmers find it helpful to know the productivity of their land.

The diagram below shows the relationship between GPP (gross primary productivity), NPP (net primary productivity) and R (plant respiration) for an area of grassland.



(a) The efficiency of the transfer of energy from GPP to NPP for this grassland is 45%.

(i) Calculate the values for NPP and R. Write your answers in the diagram above.

(2)

(ii) Using the information given, explain the relationship between GPP and NPP.

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(b) Suggest why NPP values would be of use to a farmer who wanted to use this land for cattle.

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(c) The units (kJ m^{-2} $year^{-1}$) used in the diagram show a rate of energy production. Suggest why this is more useful than measurements of biomass in the grassland on a particular day.

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(Total for Question = 10 marks)

Q22.

Soya beans are an important crop for the production of food and oil.

A study of the nutritional content of soya beans from non-transgenic soya bean plants and from transgenic soya beans plants was carried out in two regions of Brazil.

The regions were Ponta Grossa and Londrina.

Tables 1 and 2 show the results of this study.

Table 1

Type of plant	Region	Mean mineral content / mg per 100 g dried soya beans		
		Iron	Copper	Manganese
Non-transgenic	Ponta Grossa	3.34	0.76	1.38
Transgenic	Ponta Grossa	3.44	0.86	1.40
Non-transgenic	Londrina	4.59	1.35	2.20
Transgenic	Londrina	4.15	1.25	2.02

Table 2

Type of plant	Region	Mean organic content / mg per 100 g dried soya beans		
		Protein	Lipid	Carbohydrate
Non-transgenic	Ponta Grossa	38.61	21.09	23.88
Transgenic	Ponta Grossa	38.80	21.19	23.41
Non-transgenic	Londrina	41.68	18.56	25.74
Transgenic	Londrina	40.62	19.87	25.26

* (i) Analyse the data to assess the nutritional content of soya beans from transgenic and from non-transgenic soya bean plants grown in these two regions.

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(ii) The soil in Londrina is more fertile than the soil in Ponta Grossa. Londrina has higher temperatures and rainfall during the growing season.

Explain the differences in the nutritional content of soya beans grown in these two regions.

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(iii) Explain why this study also analysed the types of fatty acid found in soya beans from transgenic plants and from non-transgenic plants.

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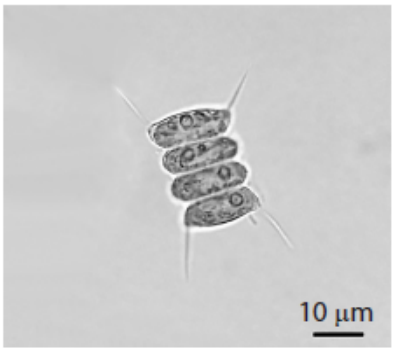
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(Total for question = 13 marks)

Q23.

The green alga, *Scenedesmus quadricauda*, lives in fresh water.
Each cell has a single chloroplast.

The photograph shows some *Scenedesmus* cells.



Photosynthesis can be measured if these algae are placed in a solution containing hydrogen carbonate indicator.

When the carbon dioxide concentration is the same as that of atmospheric air, the hydrogen carbonate indicator is red.

As the carbon dioxide concentration decreases, the hydrogen carbonate indicator changes colour from red to pink and then to purple.

Explain why the carbon dioxide concentration of the solution decreases when the algae carry out photosynthesis.

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Q24.

Photosynthesis can be divided into two main stages, the light-dependent stage and the light-independent stage.

(a) Explain why the light-independent stage cannot take place without the light-dependent stage.

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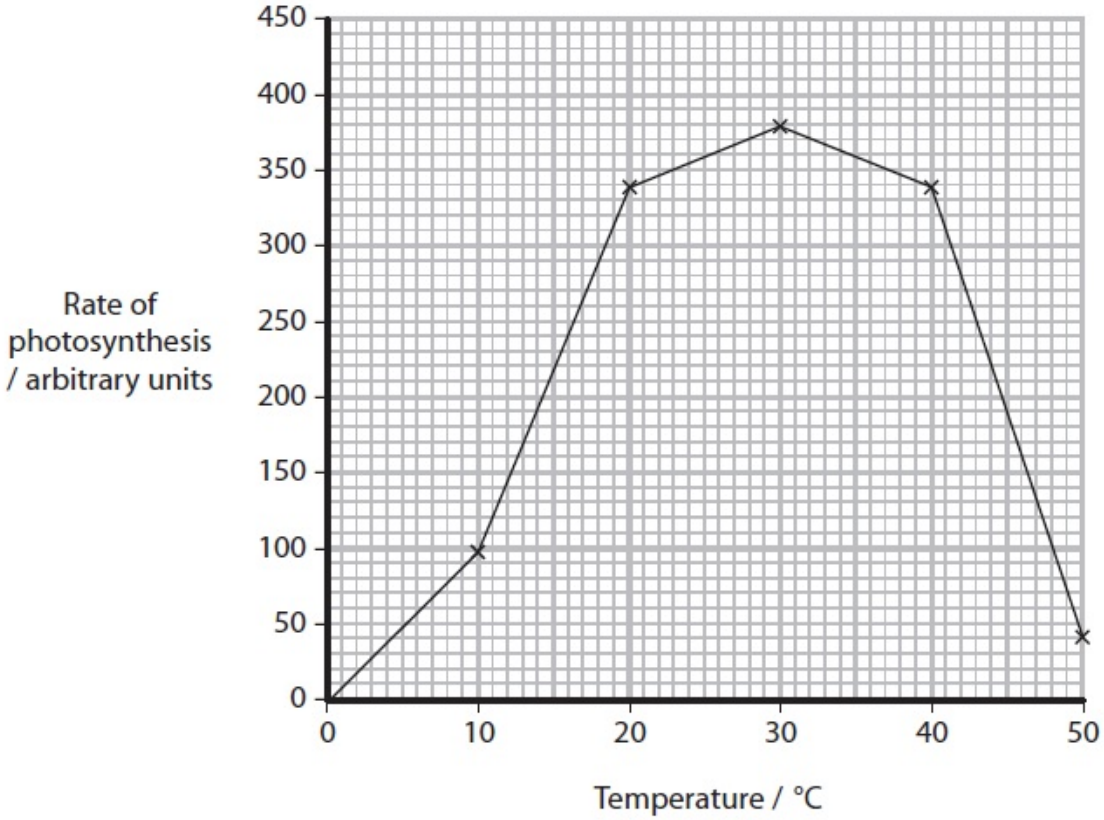
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(b) An investigation was carried out by a student, to find the effect of temperature on the rate of photosynthesis in *Elodea canadensis* (Canadian pondweed).

The rate of photosynthesis was measured over a period of two hours at a fixed temperature. This was repeated at different temperatures.

All other abiotic factors were controlled.

The results of this investigation are shown in the graph below.



(i) Place a cross (☒) in the box next to the statement that describes what could be measured to find the rate of photosynthesis in this investigation.

(1)

☒ **A** increase in mass of Elodea

☒ **B** mass of nitrate absorbed

☒ **C** volume of carbon dioxide produced

☒ **D** volume of oxygen produced

(ii) The temperatures used in this investigation were 0ºC, 10ºC, 20ºC, 30ºC, 40ºC and 50ºC.

Suggest what the results of the investigation show about the minimum temperature required for photosynthesis in *Elodea*. Give a reason for your answer.

(2)

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(iii) Explain the meaning of the following statement.

"All other abiotic factors were controlled."

(2)

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(iv) The student, who carried out this investigation, wrote the following as part of her conclusion.

Enzymes control the rate of photosynthesis in Elodea.

Discuss how far the results of this investigation support her conclusion.

(4)

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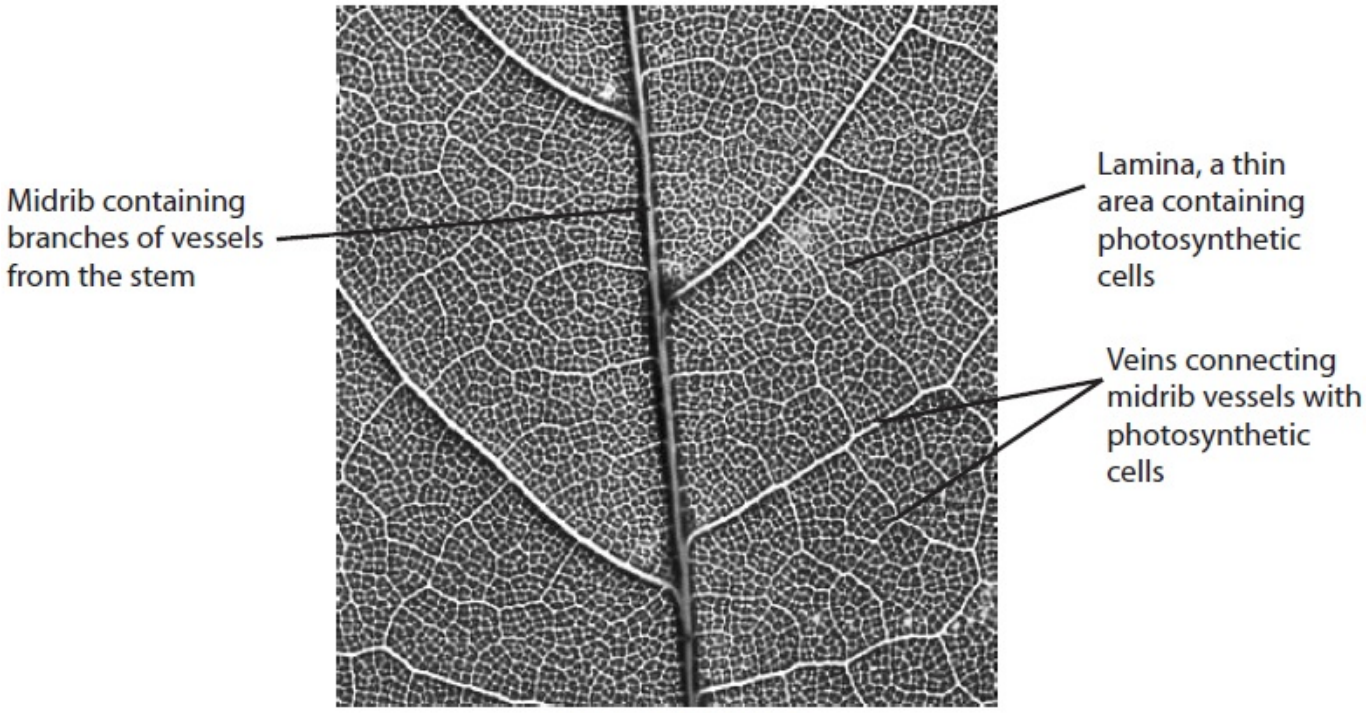
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(Total for question = 12 marks)

Q25. The photograph below shows part of a leaf, as seen using a hand lens.



Magnification ×20

(a) Suggest why each of the following is important for the production of carbohydrates in the photosynthetic cells.

(i) The thin lamina

(2)

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(ii) Vessels in the midrib

(2)

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(b) The photosynthetic cells contain many chloroplasts.

(i) Complete the table below by naming the part of the chloroplast where each of the reactions, **R**, **S** and **T**, takes place.

(3)

Reaction	Details	Part of the chloroplast
R	ADP + inorganic phosphate → ATP	
S	RuBP + CO_2 → 2 × GP	
T	2 × GP → 2 × GALP	

(ii) Place a cross ☒ in the box next to the name of reaction **R**.

(1)

☒ **A** carbon fixation

☒ **B** hydrolysis

☒ **C** phosphorylation

☒ **D** photolysis

(iii) Place a cross ☒ in the box next to the name of the enzyme involved in reaction **S**.

(1)

☒ **A** endonuclease

☒ **B** phosphorylase

☒ **C** RUBISCO

☒ **D** transcriptase

(iv) Suggest how GALP, formed by reaction **T**, can be used to synthesise the cellulose in plant cell walls.

(4)

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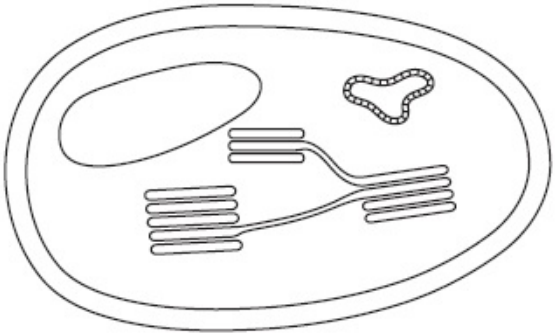
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(Total for Question = 13 marks)

Q26. Cells that photosynthesise contain many chloroplasts.

The diagram below shows a chloroplast.



(a) (i) Draw a line on the diagram to show where photophosphorylation takes place.

Label the line P.

(1)

(ii) Place a cross ☒ in the box next to the molecule produced by photophosphorylation.

(1)

☒ **A** ATP

☒ **B** NADP

☒ **C** oxygen

☒ **D** water

(b) (i) State where carbon fixation takes place in a chloroplast.

(1)

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(ii) The equation for carbon fixation is shown below.

molecule Y + CO_2 → 2 × molecule Z

Name the molecules Y and Z.

(2)

molecule Y .....

molecule Z .....

(iii) Name the enzyme involved in carbon fixation.

(1)

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*(iv) Suggest how molecule Z, the product of carbon fixation, can be used to synthesise starch.

(5)

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(Total for Question = 11 marks)

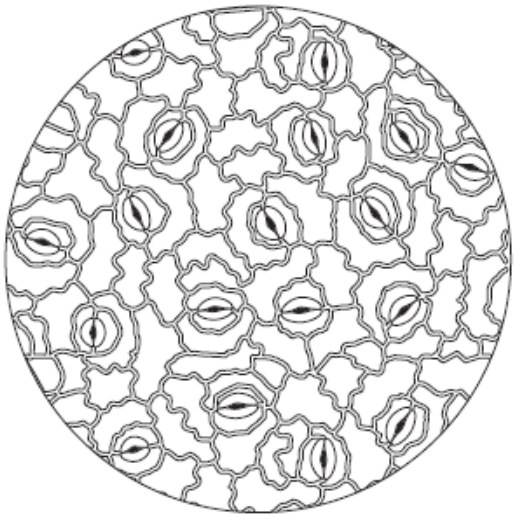
Q27.

A student investigated the effect of light intensity on the development of stomata in coffee plant leaves.

The following method was used:

- young coffee seedlings were separated into two groups
- one group was grown in bright light and the other group was grown in dim light
- leaves were selected from each group and their surfaces were painted with nail varnish
- the nail varnish was allowed to dry and then peeled off the leaf surface
- each nail varnish peel was observed using a light microscope.

The diagram shows an example of the field of view seen by the student when using the high power lens.



The results of this investigation are shown in the table.

Leaf sample	Number of stomata mm^{-2}	
	Leaves in bright light	Leaves in dim light
1	184	143
2	190	138
3	182	140
4	185	132
5	192	136
Mean ($\bar{x}$) and SD	186.6 ± 4.2	137.8

(i) Calculate the SD for the leaves in dim light.

Use the formula

$$SD = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

(2)

Answer .....

(ii) Describe how these nail varnish peel samples should be taken to allow a valid comparison between the mean numbers of stomata.

(2)

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(iii) Analyse the data to explain how fewer stomata might affect the growth of coffee plants.

(3)

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(Total for question = 7 marks)

Q28.

The electron carriers in chloroplasts are inhibited by detergent.

Detergents dissolve lipids.

Explain how detergents inhibit the functioning of electron carriers in chloroplasts.

(3)

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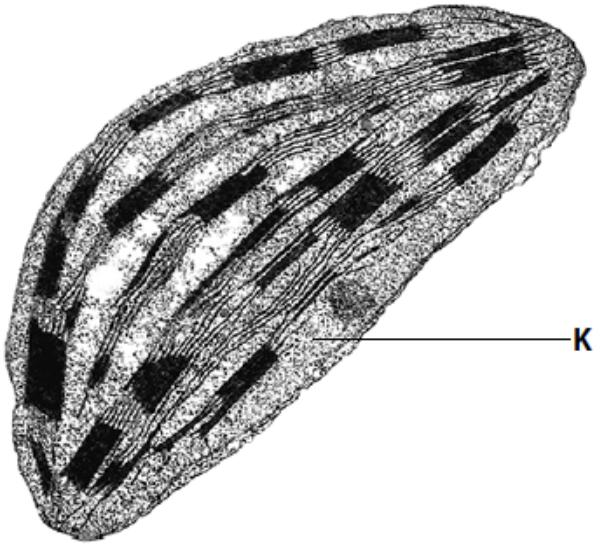
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Q29.

The photograph below shows an electron micrograph (EM) image of a chloroplast.



© Chloroplast, TEM Dr Jeremy Burgess/Science Photo Library

(a) Which of the following is correct for the part labelled **K**?

(1)

	Name	Reaction that takes place
☒ **A**	granum	light-dependent
☒ **B**	granum	light-independent
☒ **C**	stroma	light-dependent
☒ **D**	stroma	light-independent

(b) Describe the role of membranes inside the chloroplast.

(3)

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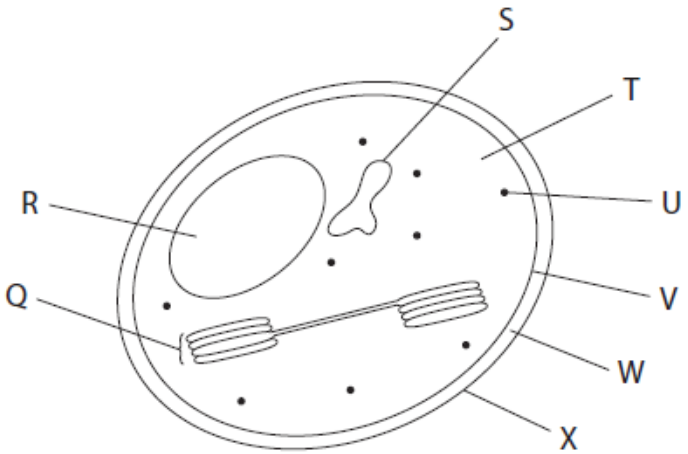
(Total for question = 4 marks)

Q30.

The light-dependent stage and the light-independent stage of photosynthesis both take place in the chloroplast.

The rate of photosynthesis is affected by a number of different factors, including carbon dioxide concentration and temperature.

The diagram shows a chloroplast.



(i) Where does the light-dependent stage take place?

(1)

☒ **A** Q

☒ **B** T

☒ **C** V

☒ **D** X

(ii) The light-dependent stage produces hydrogen ions.

Where do these hydrogen ions accumulate?

(1)

☒ **A** Q

☒ **B** R

☒ **C** S

☒ **D** W

(iii) Where does translation take place?

(1)

☒ **A** Q

☒ **B** R

☒ **C** S

☒ **D** U

(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Light:</u> **(L)** • more light at equator / less light at higher latitudes <u>Light dependent stage:</u> **(L)** • light excites electrons • photolysis occurs • ATP made / photophosphorylation • NADPH / reduced NADP made <u>Light independent stage:</u> **(L)** • Calvin cycle • NADPH / ATP used • Carbon fixation • to reduce carbon dioxide to carbohydrate / GP / GALP / glucose <u>Temperature:</u> **(L)** • temperature is higher at the equator / lower at higher latitudes • temperature affects enzymes • eg. RUBISCO enzyme • temperature affects active uptake of mineral ions • temperature affects rate of transpiration
	<u>Other abiotic variables:</u> **(A)** • identifies other abiotic variables eg carbon dioxide / water / mineral ions / pH • carbon dioxide unlikely to be a limiting factor • comment on lack of available water eg in deserts / polar regions or excess of water eg flooded areas • water needed for photolysis / mineral ion transport • use of named mineral ion eg. nitrate for amino acids / protein • soil edaphic factors • abiotic factors in the oceans discussed <u>Biotic factors:</u> **(B)** • biotic factors also affect productivity • disease / infection / bacteria / fungi / named pathogen • grazing / herbivore populations / pest populations • competition eg for light • decomposition is slower at higher latitudes (affects mineral ion availability) • human factors eg deforestation / pesticide use / fertilizer use / crop planting • biotic factors in the oceans discussed <u>Productivity factors</u> **(B)** • productivity subject to limiting factors • productivity in cool temperate can exceed warm temperate • productivity in the oceans not taken into account • unequal size of latitude ranges (makes comparison difficult) • idea of interaction between multiple / complex factors affecting productivity

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **Up to three from L, A or B**
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **At least two from L and at least two from A or B**
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **At least two from L plus at least two from A and two from B with no major errors**

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following: **Similarities** • both use an electron transport chain on membranes (1) • both use ATPase driven by { H^+ gradient / chemiosmosis / eq } (1) • in both, electrons passed from one carrier to another lose energy which drives ATP production (1)	At least one similarity and one difference must be given to gain full marks. Max 2 marks if only 3 similarities provided Max 1 marks if only 2 similarities provided	**(5)**

	Differences • energy is provided by light in chloroplasts but by { glucose / pyruvate / eq } in mitochondria (1) • ATP is made by photophosphorylation in chloroplasts but by { substrate level / oxidative phosphorylation } in mitochondria (1) • in chloroplasts, electrons are provided by chlorophyll but in mitochondria, electrons are brought by reduced { NAD / FAD } (1) • in chloroplasts, (some) electrons return to chlorophyll whereas in mitochondria, electrons are accepted by oxygen (1)	Max 3 marks if only 4 differences provided Max 2 marks if only 3 differences provided Max 1 marks if only 2 differences provided	

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	• length of scale line given in µm • magnification calculated	1.7 × 10000 / 17000 1.7×10^{3} / 0.0017×10^{6}	

Question Number	Answer	Additional Guidance	Mark
(ii)	width of GM aperture divided by width of non-modified aperture	In the range of 1.3 to {4 / 4.0} to no more than 1 decimal place DO NOT ACCEPT with units or %	

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	1×10^{11}	**Accept** 10^{11} / 100 000 000 000 / 10×10^{10} / any other equivalent ways of expressing this answer	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • because the number of carbon (atoms) in the cell has been under-estimated **(1)** • because not all the ATP is used in (light-dependent reaction / Calvin cycle / carbon fixation} **(1)** • because {photons differ in energy / not all wavelengths of light are absorbed by the plant} **(1)**	**Accept** there are more carbons in the cell **Accept** cyclic photophosphorylation is happening **Accept** process is not 100% efficient / some light is reflected / not all photons of light are absorbed	**(2)**

Question Number	Answer	Additional Guidance	Mark
(iii)	A description that makes reference to three of the following: • carbon dioxide diffuses into stroma **(1)** • carbon dioxide binds to {ribulose bisphosphate / RuBP} **(1)** • using {ribulose bisphosphate carboxylase / RUBISCO} **(1)** • resulting in the formation of {(intermediate) 6C compound / GP} **(1)**	**Accept** attaches / joins / reacts / added to **Accept** rubisco	**(3)**

Q5.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions of graph or diagram:** • as the leaf size increases so does the number of chloroplasts per cell • as the leaf size increases cpDNA per chloroplast increases then decreases • as the leaf continues to grow the number of chloroplasts per cell continues to increase but the number of cpDNA per cell drops **Explanations of graph or diagram:** • as the leaf increases in size more chloroplasts needed for photosynthesis • cpDNA replicates to provide the cpDNA for newly made chloroplasts • this ensures that the new chloroplasts have identical genetic information • the cpDNA per chloroplast begins to drop as the leaf cells get older, since there are more chloroplasts per cell **Interpretation of the genes found in the cpDNA :** • cpDNA codes for RNAs and ribosomal proteins that will be needed for transcription and translation of proteins needed in the new chloroplasts • cpDNA codes for proteins needed in photosynthesis e.g.RUBISCO

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. **Description given of the changes shown in the graph in the number of chloroplasts, cpDNA and increase in leaf size**
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. **An explanation given for these changes**
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **Links made between the genes in the cpDNA and the processes of photosynthesis and protein synthesis**

Q6.

Question Number	Answer	Mark
	The only correct answer is D ***A*** *is not correct because there is no cytoplasm inside the chloroplast* ***B*** *is not correct because the matrix is found inside mitochondria* ***C*** *is not correct because nucleoplasm is found inside the nucleus*	**(1)**

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to four of the following: • use same light intensity (1) • use red filter (1) • use tube {with clean sides / no scratches / holding opaque side} (1) • use a control tube with water to {calibrate / obtain zero absorbance} (1) • same {concentration / volume} of {chloroplasts / DCPIP} (1)	**DO NOT ACCEPT** same lamp / same bulb / same power / same distance	**(4)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to four of the following: • with herbicide DCPIP not {decolourised / reduced / stays blue} (1) • no electrons available / reduced electron transport (1) • less {reduced NADP / NADPH} (1) • therefore less ATP (1) • because the {Calvin cycle / light independent stage} are affected (1)	**ACCEPT** converse **DO NOT ACCEPT** absorbance does not change **DO NOT ACCEPT** if from ETC implies respiration	**(4)**

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: • (µmol) carbon dioxide used / {oxygen / GP / GALP / glucose} made (1) • (m^{-2}) is the area of the {leaf / open stomata} (1) • (s^{-1}) in one second (1)	ACCEPT example e.g. measure for 120 seconds and divide by 120	

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: • increase in light intensity increases photosynthesis (1) • increase is greater in GM plants because the wider aperture will result in a more {gas exchange / uptake of carbon dioxide} (1) • therefore {light-independent reactions / Calvin cycle / carbon fixation} is faster (1) • rate levels off when {another factor / carbon dioxide concentration / temperature} becomes rate limiting (1)	ACCEPT GM plants photosynthesise faster than non-GM ACCEPT carbon dioxide not limiting the rate of {light-independent reactions / Calvin cycle / carbon fixation}	

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	absorption spectrum shows absorption of light of different wavelengths and action spectrum shows rate of photosynthesis at each wavelength	**ACCEPT** absorption spectrum involves wavelengths only and action spectrum involves photosynthesis / oxygen production only	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	spectra are similar / spectra overlap / peaks and troughs follow similar pattern	**ACCEPT** similar peak at blue / similar peak at red / similar trough at green	**(1)**

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	Diagram marks : 1. two membranes shown ; 2. inner membrane folded into cristae ; Label marks (correct) : [max 2 marks] 3. outer membrane and {inner membrane / cristae} ; 4. matrix ; 5. stalked particles / ATPase / eq (labelled on inner membrane) ; 6. DNA (circular / loop) ; 7. ribosomes ;	**1 NOT** if cristae shown as a 3rd membrane **NB** do not choose which labels to accept eg 2 right + 1 wrong = 1 mark 2 wrong = 0 marks **5 ACCEPT** oxisome **6 ACCEPT** plasmids **7 IGNORE** size references	**(4)**

Question Number	Answer	Additional Guidance	Mark
(ii)	chloroplast ;	**IGNORE** chlorophyll	**(1)**

Q11.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • light (intensity) will not be a limiting factor (1) • therefore carbon dioxide (concentration) is (only) limiting factor (1) • so the effect of carbon dioxide concentration can be seen (1)	Accept: {ATP / NADPH / eq} produced during light dependent reactions	**(3)**

Q12.

Question Number	Acceptable Answer	Additional guidance	Mark
(i)	An explanation that makes reference to four of the following: • reducing the carbon dioxide concentration causes the RuBP to increase (1) • (at higher carbon dioxide concentration) RuBP is low because it is converted to carbohydrate / used to fix carbon dioxide (1) • RuBP rises because being regenerated / eq (1) • RuBP falls as being used to {fix / eq} carbon dioxide (1) • RuBP level remains constant once (new) equilibrium reached (1)	Accept correct manipulation of figures Correct answer gains full marks	**(4)**

Question Number	Acceptable Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following: • the rate of GP production falls for 150 s after carbon dioxide decreased (1) • drops because less carbon dioxide available to convert into GP / less carbon fixation / carbon dioxide is limiting / eq (1) • levels out at a lower level as carbon dioxide still available but at lower level (1)	Accept correct manipulation of figures Accept sophisticated answers based on reduction of photosynthesis	**(3)**

Q13.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • RuBP concentration would be lower (1) • because low temperature reduces activity of {RUBISCO / Calvin cycle} (1) • because there is less carbon dioxide fixation / less GP or GALP available to regenerate RuBP (1)	Accept sophisticated answers based on an initial increase in RuBP concentration	**(3)**

Q14.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to five of the following: • because there would be less water to take up from the soil (1) • therefore there will be fewer {mineral ions / minerals} (transported to the rest of the plant / taken up) (1) • example of a mineral ion deficiency on the plant explained (1) • there will be less water for {photolysis / light-dependent reaction / photosynthesis} (1) • therefore there will be less GALP produced in the {light-independent reaction / Calvin cycle} (1) • therefore less {NPP / plant biomass} (1)	**ACCEPT** plants will {wilt / die} without water **ACCEPT** less glucose produced	(5)

Q15.

Question Number	Answer	Additional Guidance	Mark
	1. idea that carbon dioxide dissolves (in the water / in the oceans) ; 2. for {carbon fixation / light-independent reaction / eq} ; 3. by {photosynthesis / eq} of {seaweed / algae / (phyto) plankton / autotrophs / eq} ;	**1 ACCEPT** absorbed / reacts with /diffuses into / becomes carbonic acid **3 ACCEPT** plants (that live in the sea) **IGNORE** organisms	**(2)**

Q16.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • because (faster photosynthesis will result in) more {GALP / glucose} produced (1) • to form a named plant molecule (1)	ACCEPT biomass / other organic molecules more {oxygen / glucose} for ATP production	
	• because transpiration stream will be faster (1) • therefore more mineral ions for named product (1)	e.g. Mg^{++} for chlorophyll, nitrates for protein	

Q17.

Question Number	Answer	Additional Guidance	Mark
	1. idea that light is reduced by the deeper water ; 2. idea that carbon dioxide levels might be lower deeper down ; 3. idea that temperature might be lower deeper down ; 4. idea that {photosynthesis / eq} will be reduced ; 5. idea that less {glucose / hexose / GALP / GP / eq } produced to convert into {biomass / NPP / eq} ; 6. idea that GPP goes down but respiration {stays the same / increases} ;	**NB ACCEPT** converse of mp 1 - 5 if in context of shallow water **5 IGNORE** energy	

Q18.

Question Number	Answer	Additional Guidance	Mark
(a)	1. (rate of) { energy incorporated into / production of / eq} {biomass / organic material} ; 2. in {plants / producers} ;	**2. Accept** from photosynthesis	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. very little GPP in seagrass / majority present in {microphytobenthos and phytoplankton / phytoplankton} ; 2. (roughly) equal distribution (of GPP) between microphytobenthos and phytoplankton ;	**1. Accept** only 2.5 to 5% in seagrass, 95% in micro and phyto, more than 50% or about 55% of phyto 2. **Accept** about 50% in each **Accept** idea that GPP in microphytobenthos is slightly lower than in phytoplankton	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. idea of obtaining a value from the chart e.g. percentage, area, degrees, ratio ; 2. idea of how to use this to calculate GPP ;	**Ignore** units **1. Accept** appropriate figures in range 50 – 55 % **2. Accept e.g. (**percentage) multiplied by 8.4 x 10^6 **NB** $\frac{\text{angle}}{360} \times 840 \times 10^6$ = 2 marks $\frac{\text{area of segment}}{\text{area of circle}} \times 840 \times 10^6$ = 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. {more / fast / high / eq} photosynthesis ; 2. water less {cloudy / churned up } / shallow water / high light penetration / eq ; 3. high {nutrient / carbon dioxide} levels in the sea / eq ; 4. {high / optimum} temperatures ; 5. high light intensity (in this area) / eq ; 6. idea of less respiration ;	**2. Accept** less current, less tidal	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)	1. NPP = GPP – R / eq ; 2. energy lost as heat / eq ; 3. named use of energy (released by respiration);	**1. Accept** correct description in words **3. Accept** e.g. movement, opening of flowers, glycolysis, metabolic processes	**(2)**

Q19.

Question Number	Answer	Mark
	B light-independent reaction	**(1)**

Q20.

Question Number	Correct Answer	Additional guidance	Mark
(a)	An explanation that makes reference to the following: • the shaded leaves have a larger surface area to mass ratio and are therefore bigger and thinner than leaves in the sun (1) • bigger allows more {chloroplasts / chlorophyll} for absorption of light (1) • thinner allows shorter diffusion path for entry of carbon dioxide (1)		**(3)**

Question Number	Correct Answer	Additional guidance	Mark
(b)	An explanation that makes reference to five of the following: • growing nettles in {pots / eq} to ensure soil pH / {mineral/ named mineral} content in pots is the same (1) • {measure / control} the {light intensity / duration} for both treatments to ensure light intensities are different (1) • watering regime is the same in both treatments to ensure same potential for leaf growth (1) • use {groups of pots / measure more leaves} so that data collected is reliable (1) • use genetically identical nettles in each treatment as some genes may affect growth (1) • make sure that all pathogens / consumers are prevented from access as they can reduce growth (1)		**(5)**

Q21.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	NPP = 4680 ; R = 5720 ;	**NB** If there are no answers in the box, look for answers in the space below question If answers are the wrong way round, award 1 mark If both answers are wrong, **accept** R = 10168.9 / 10169	**(2)**

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. NPP = GPP – R / eq; 2. 55% (GPP energy) is lost / eq ; 3. energy lost as heat / eq ; 4. to provide energy for {active transport / any other named energy-requiring process} ; 5. NPP is {(stored) energy / energy available for next trophic level / eq} ;	**Accept** correct description in words eg movement (opening of flowers, turning of leaves), glycolysis **Ignore** idea that energy is **used** for respiration unqualified **Accept** biomass	**(3)**

Question Number	Answer	Additional Guidance	Mark
(b)	1. cattle {are primary consumers / herbivores / eat grass / eat plants / eq} ; 2. (therefore) gain energy (available as NPP) ; 3. idea of grazing capacity of the grassland ; 4. idea of affect on yield of {meat / milk / eq} ; 5. idea of changing to a more {efficient / NPP yielding} crop ;	**Accept** idea that farmer is ensuring that there is enough NPP available for his cattle **Accept** growth rate	**(3)**

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea of variation over short periods of time; 2. idea that whole year gives an {average / overall / eq} value ; 3. idea that biomass includes {all / undigestible / inedible / eq} organic material ; 4. idea that rate of productivity may influence how much grazing is possible ;	eg more NPP on a sunny day, seasonal	**(2)**

Q22.

Question Number	Indicative content
* (i)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Indicative content</u> **Table 1** • Ponta Grossa: transgenic plants have higher mineral content than non-transgenic plants • Londrina: transgenic plants have lower mineral content that non-transgenic plants • Transgenic plants: plants grown in Ponta Grossa have lower mineral content than plants grown in Londrina • Non-transgenic plants: plants grown in Ponta Grossa have lower mineral content than plants grown in Londrina • Londrina:both types of soybean have more mineral content than both types in Ponta Grossa
	Table 2 • Ponta Grossa: transgenic plants have higher protein and lipid but lower carbohydrate content than non-transgenic plants • Londrina: transgenic plants have higher lipid but lower protein and carbohydrate content than non-transgenic plants • Transgenic plants: plants grown in Ponta Grossa have higher lipid but lower protein and carbohydrate content than plants grown in Londrina • Non-transgenic plants: plants grown in Ponta Grossa have higher lipid but lower protein and carbohydrate content than plants grown in Londrina • Londrina: both types of soybean have more protein and carbohydrate but lower lipid than both types in Ponta Grossa **Examples of Conclusions** • Londrina soybeans are (generally) the most nutritious • In Londrina, non-transgenic soybeans are more nutritious

	• In Ponta Grossa, transgenic soybeans are more nutritious • Very little difference in nutritional content overall	
Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. 2 / 3 comparisons / conclusions
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. 4 / 5 comparisons / conclusions
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. 6 / more comparisons and conclusions

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to five of the following: • Londrina (has a more fertile soil therefore the) soya beans will have a higher {mineral / mineral ion / ion / named mineral ion} content (1) • Londrina (has a more fertile soil therefore the) soya beans will have a higher protein content as there will be more nitrates (1) • Londrina has a higher temperature so {photosynthesis / Calvin cycle / carbon fixation} will be faster (1) • as {enzymes / RUBISCO} will {increase rate of reactions / have more kinetic energy} (1) • therefore making more {organic molecules / carbohydrate / named carbohydrate / protein} (1) • Londrina has a higher rainfall therefore more water for {photolysis / transport of minerals} (1)	**ACCEPT** {photosynthesise faster as more magnesium ions for chlorophyll / be stronger as more calcium ions for cell walls / more phosphate for ATP or nucleic acid synthesis} **ACCEPT** greater activity / work faster **ACCEPT** light-dependent reactions	**(5)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • to compare the fatty acids in the two types of soya bean (1) • so that {the (transgenic) soybeans will be less likely to increase the risk of heart disease / oxidation is less likely} (1)	**ACCEPT** to see if there were less saturated fatty acids / less linoleic acid / more oleic acid **ACCEPT** converse less likely to go rancid oleic acid less likely to oxidise than linoleic acid	**(2)**

Q23.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • photosynthesis causes a decrease in concentration of CO_2 inside the cell, producing a concentration gradient (1) • therefore CO_2 diffuses from solution into cells (1)		**(2)**

Q24.

Question Number	Answer	Additional guidance	Mark
(a)	1. idea that products of light-dependent stage are {needed for / used in / eq} {light-independent stage / Calvin cycle} ; 2. reference to (products of light-dependent stage) are {reduced NADP / eq} and ATP ; 3. reference to use of {reduced NADP / eq} for {reduction / eq} of {carbon dioxide / GP / eq} ; 4. reference to use of ATP as source of energy ;	**3. Accept** source of hydrogen ions for GALP **Ignore** ref to ATP	**(3)**

Question Number	Answer	Mark
(b)(i)	D volume of oxygen produced ;	**(1)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	1. (minimum temperature) is {between 0 °C and 10 °C / above 0 °C but less than 10 / 10 °C} ; 2. idea of no photosynthesis at 0°C but photosynthesis is taking place at 10 °C ; 3. reference to no {data / readings / measurements / evidence / eq} between 0 °C and 10 °C ; 4. idea that at 0 °C water is frozen ;	**3. Accept** if correct temp range has been given already	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(iii)	1. reference to abiotic factors {are non-living / non-biological / do not involve organisms / eq} ; 2. idea that **other factors** need to be kept constant ;	**2. Ignore** controlled	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(iv)	**Supporting conclusion:** 1. idea that shape of graph is typical of an enzyme-temperature graph ; 2. rate increases (up to 30 °C) because more {enzyme-substrate complexes / collisions between enzymes and substrates} / eq ; 3. rate decreases (after 30°C) due to enzyme denaturation / eq ; **Not supporting conclusion:** 4. idea that other factors could be affecting photosynthesis ; 5. idea of {gas / oxygen / carbon dioxide} solubility changing with temperature ; 6. idea of {correlation / not causation} ;	**1.** idea that rate of photosynthesis is affected by temperature in a similar way to enzymes	**(4)**

Q25.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	1. idea of {fast / maximum} {gas exchange / uptake of carbon dioxide / eq}; 2. idea of penetration of light ; 3. idea that carbon dioxide is used in the {light-independent stage / Calvin cycle / formation of GP}; **OR** idea that light is used in {light-dependent stage / photolysis / photophosphorylation / eq } ;	**Accept** CO_2 but **ignore** incorrect formula	**(2)**

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. transport (in xylem) of water (to the leaves) / eq ; 2. transport (in phloem) of {sucrose / sugar / carbohydrates } (away from the leaves) / eq; 3. (water) for {light-dependent reaction / photolysis / source of hydrogen (ions)}; **OR** idea of (transporting sugar) to make more room for more carbohydrate synthesis ;	**Accept** H_2O but **ignore** incorrect formula **Accept** phosphates but **ignore** mineral ions **Not** glucose or any other name sugars **Accept** reducing power, NADPH **Accept** (phosphates) for ATP synthesis	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(i)	Reaction / Details / Structure {thylakoid (membrane) / grana / granum} ; stroma ; stroma ;	**Not** thylakoid space **Ignore** electron transport chain **Not** stoma / stomata **Not** stoma / stomata	**(3)**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	C ;		**(1)**

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	C ;		**(1)**

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	1. reference to conversion (of GALP) to glucose / eq; 2. (which is) β glucose ; 3. reference to formation of glycosidic bonds ; 4. between C_1 and C_4 / these bonds are 1-4 (glycosidic bonds) ; 5. by condensation ; 6. reference to {straight / unbranched} (chains of glucose) ; 7. reference to cellulose as a {polysaccharide / polymer of glucose / eq} ;	**NB** this is a question about the **formation** of cellulose, not its structure **NB** a reference to these bonds being formed must be made	**(4)**

Q26.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	Line to diagram feature {grana / thylakoids / thylakoid membrane / inter-granal membrane } ;	**Ignore** any labelling of the line	**(1)**

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	A ; ATP		**(1)**

Question Number	Answer	Additional Guidance	Mark
(b)(i)	stroma ;	**Accept** phonetic spelling eg strona, stromma **Not** stoma / stomata	**(1)**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	Y. RuBP / ribulose bisphosphate ; Z. GP / glycerate (3) phosphate ;	**Y. Accept** ribulose biphosphate **Not** ribose **Z. Accept** (3) phosphoglyceric acid / (3) PG / PGA / 2-Hydroxy-3-phosphonooxypropanoic acid **Not** glyceraldehydes (3) phosphate / GALP	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	RUBISCO / ribulose bisphosphate carboxylase (oxygenase) ;	**Accept** ribulose biphosphate carboxylase RUBISCO written in upper or lower case or a mixture **Not** ribose	**(1)**

Question Number	Answer	Additional Guidance	Mark
*(b)(iv)	QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence 1. idea of conversion (of *GP / Z*) to *GALP* / eq ; 2. using *ATP* and reduced *NADP* / eq ; 3. idea of conversion (of *GALP*) to {*glucose* / hexose} eq ; 4. (which is) α *glucose* ; 5. reference to formation of *glycosidic bonds* ; 6. these bonds are 1-4 and 1-6 (*glycosidic bonds*) / eq ; 7. by *condensation* ; 8. ref to *amylose* and *amylopectin* ; 9. credit details of *amylose* e.g. straight chain, 1-4 bonds ; 10. credit details of *amylopectin* eg branched, 1-4 and 1-6 bonds ;	**QWC emphasis is spelling** **NB** this is a question about the **conversion** of GP and the **formation** of starch, not its structure 1. **NB** idea of conversion needed 3. **NB** idea of conversion needed **5. NB** a reference to these bonds being formed must be made	**(5)**

Q27.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculate sum of d^2 and divide (1) • calculate square root (1)	Correct answer gains full marks, with no working shown 68.8 ÷ 4 = 17.2 square root of 17.2 = 4.1 / 4.147 / 4.15 One mark for 17.2 / 68.8	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to two of the following: • leaves at {same height / same age} on stem (1) • sample at same stated position of leaf (1) • same surface of leaf (1)	**DO NOT ACCEPT** same location / same part / same place **DO NOT ACCEPT** same area / same part / same place	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to three of the following: • (reduced growth) because less carbon dioxide absorbed (1) • therefore less {GP / GALP / glucose / sucrose} (1) • less transpiration so less mineral ions (1) • therefore less named product (1)	**ACCEPT** converse **ACCEPT** cellulose / amino acids / protein / chlorophyll / DNA **DO NOT ACCEPT** starch	(3)

Q28.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • electron carrier components are on chloroplast membranes (1) • detergents disrupt the phospholipid bilayer in the membranes (1) • therefore electrons can no longer move along the chain (1)		**(3)**

Q29.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	D		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	A description that makes reference to three of the following: • compartmentalisation from stroma (1) • site of light-dependant reactions (1) • they contain {chlorophyll / photosynthetic pigments / electron carrier proteins} (1) • membranes increase the number of {pigments / proteins} that can be held (1) • contain ATP synthase / ATP synthesised (1)		**(3)**

Q30.

Question Number	Answer	Additional Guidance	Mark
(i)	**The only correct answer is A** **B** is incorrect because light-dependent stage takes place on thylakoid membrane and not in the stroma **C** is incorrect because light-dependent stage takes place on thylakoid membrane and not on the inner membrane **D** is incorrect because light-dependent stage takes place on thylakoid membrane and not on the outer membrane		(1) COMP
(ii)	**The only correct answer is A** **B** is incorrect because hydrogen ions accumulate inside the thylakoids and not in the starch grain **C** is incorrect because hydrogen ions accumulate inside the thylakoids and not in the DNA loop **D** is incorrect because hydrogen ions accumulate inside the thylakoids and not in the inner membrane space		(1) COMP

Question Number	Answer	Additional Guidance	Mark
(iii)	**The only correct answer is D** **A** is incorrect because translation occurs on the ribosomes and not inside the thylakoids **B** is incorrect because translation occurs on the ribosomes and not in the starch grain **C** is incorrect because translation occurs on the ribosomes and not in the DNA loop		(1) COMP