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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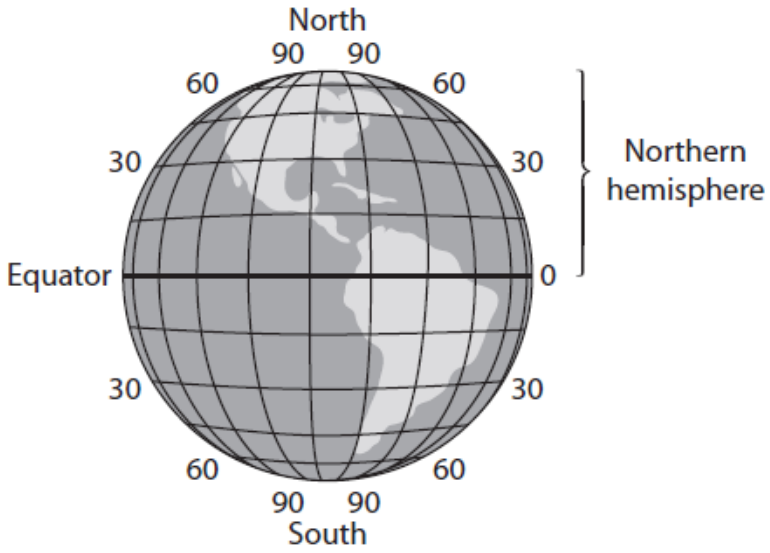
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Q1.

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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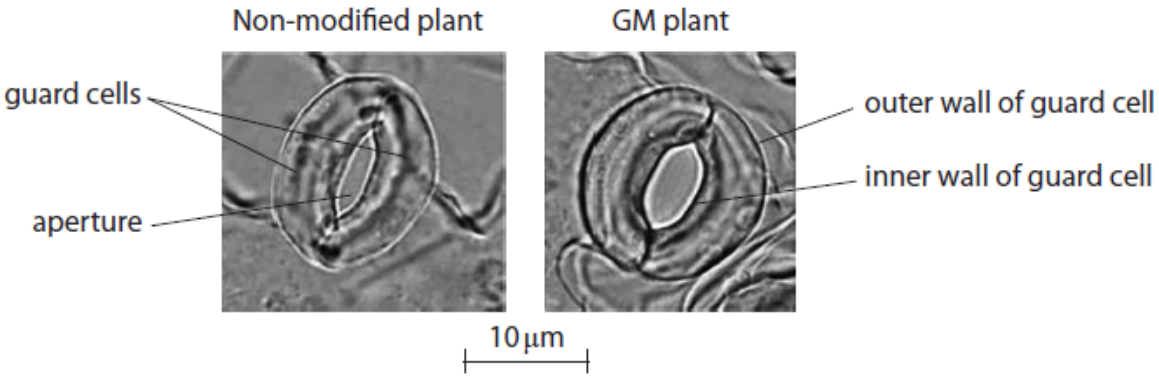
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Q3.

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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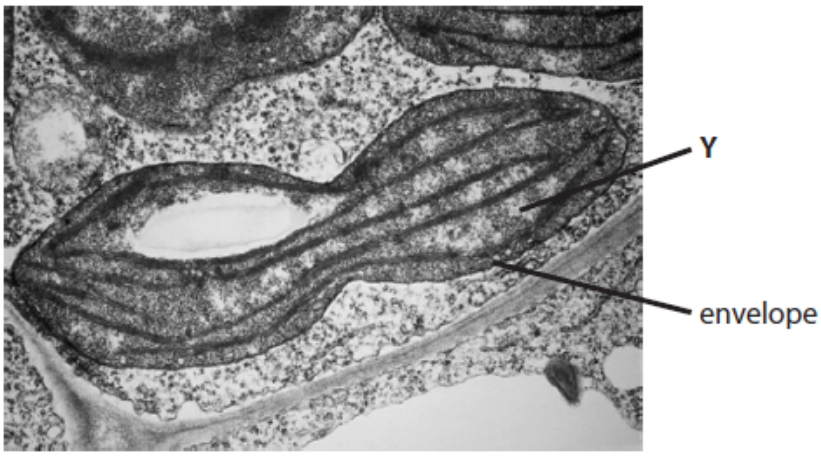
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(Total for question = 6 marks)

Q5.

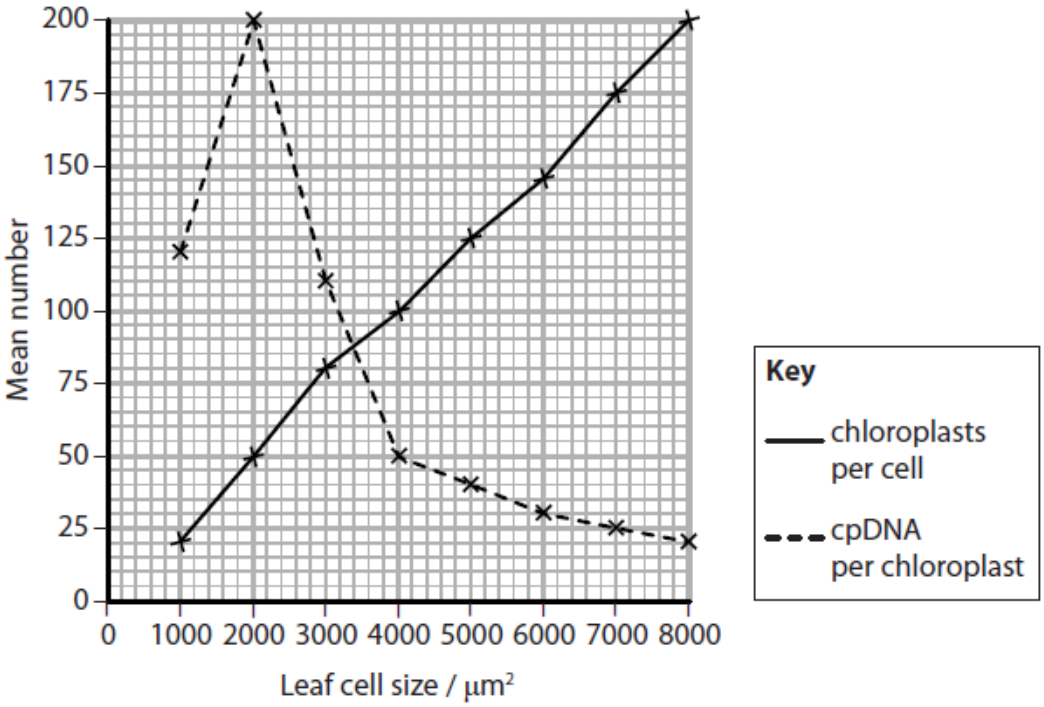
When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.

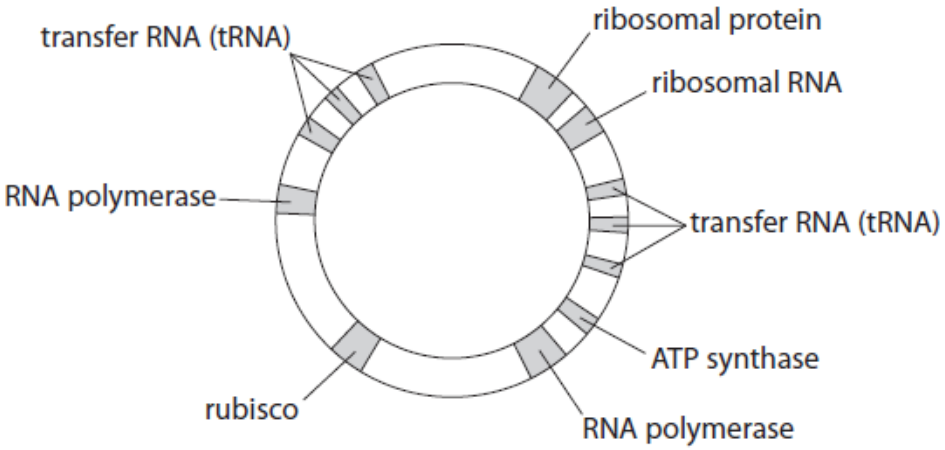


* In an investigation, the mean size of leaf cells was determined. The mean number of chloroplasts per cell and the mean number of DNA molecules (cpDNA) per chloroplast were also determined.

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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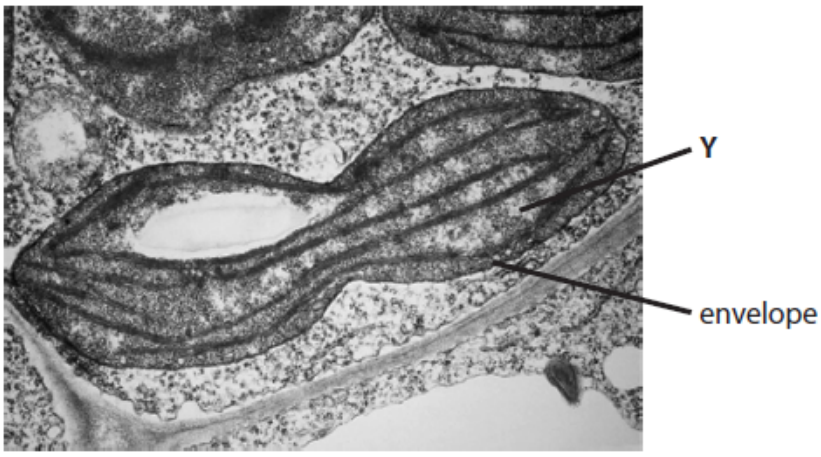
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(Total for question = 6 marks)

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.

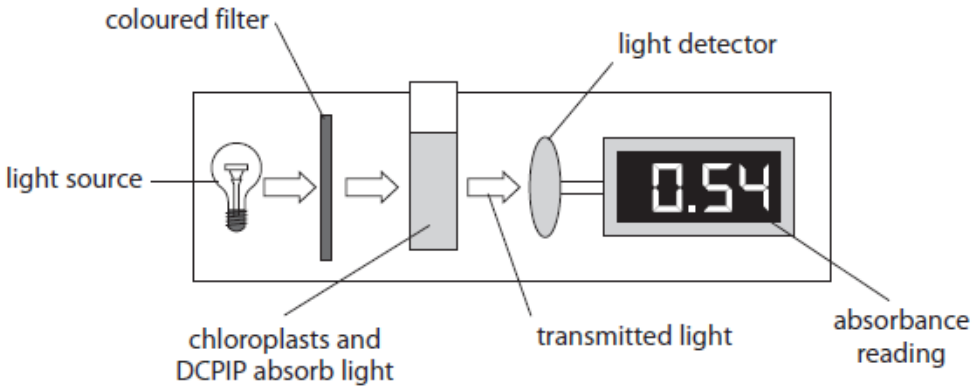
The student investigated this using the indicator DCPIP.

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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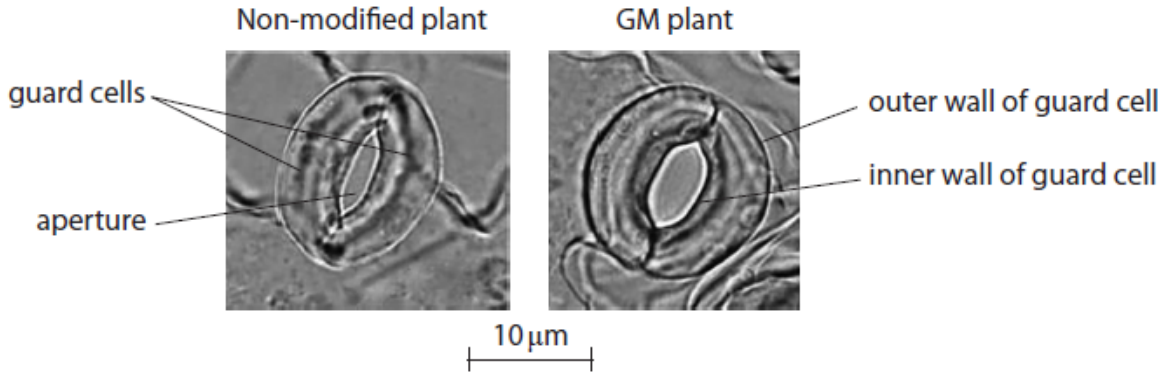
(Total for question = 8 marks)

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.

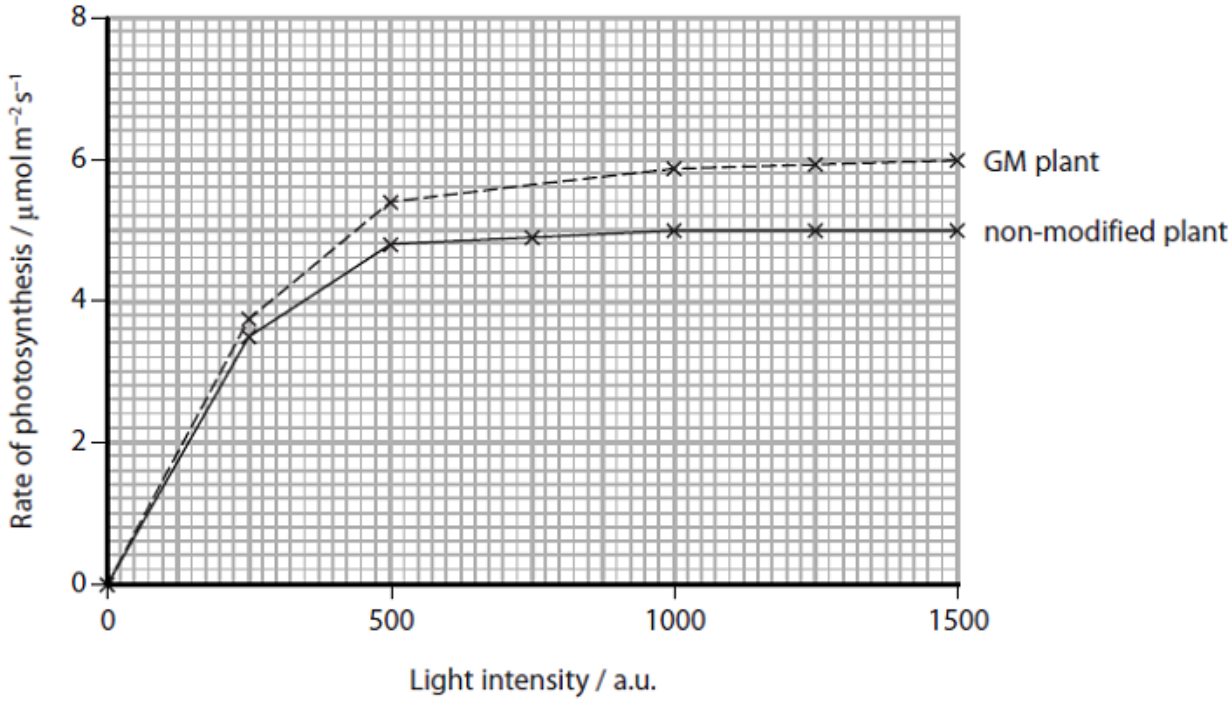
The photographs show the appearance of each type of stoma in daylight.



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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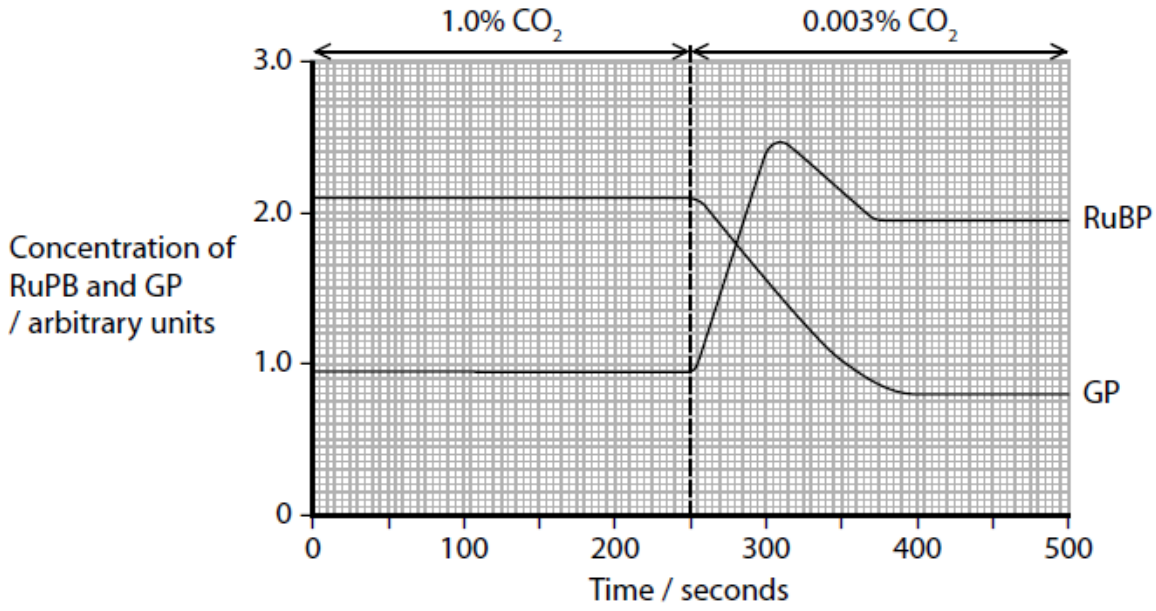
Q11.

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)

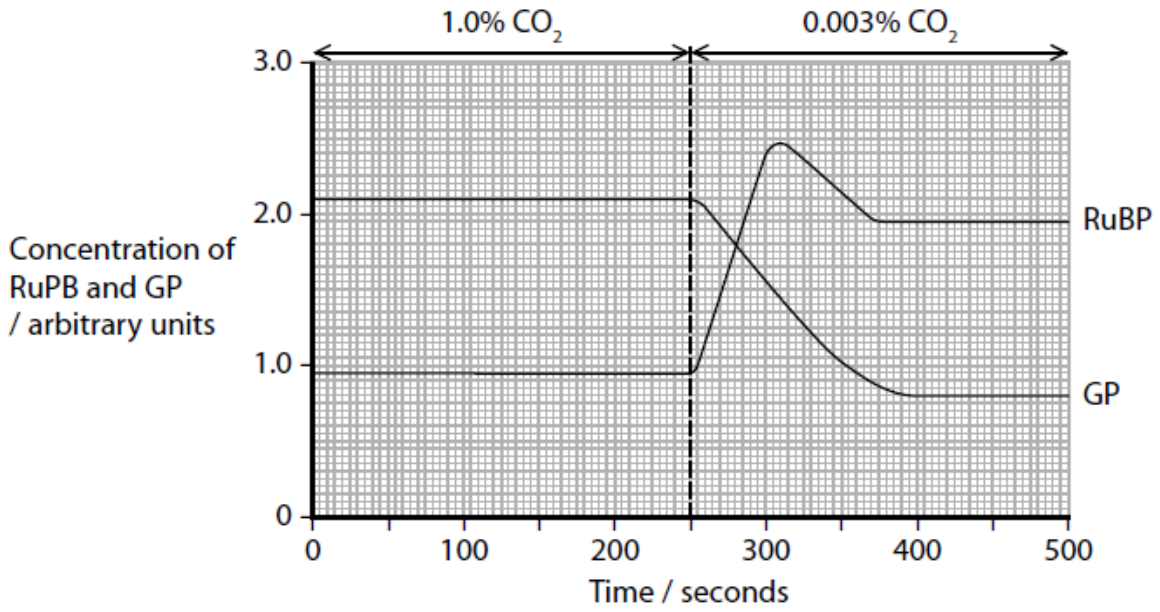
Q12.

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)

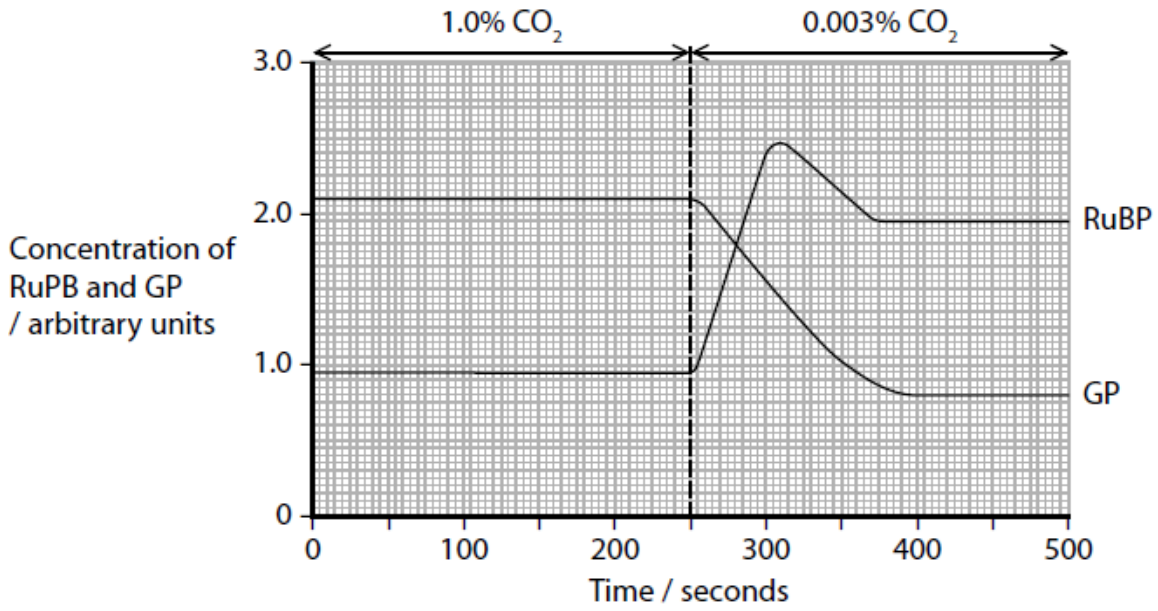
Q13.

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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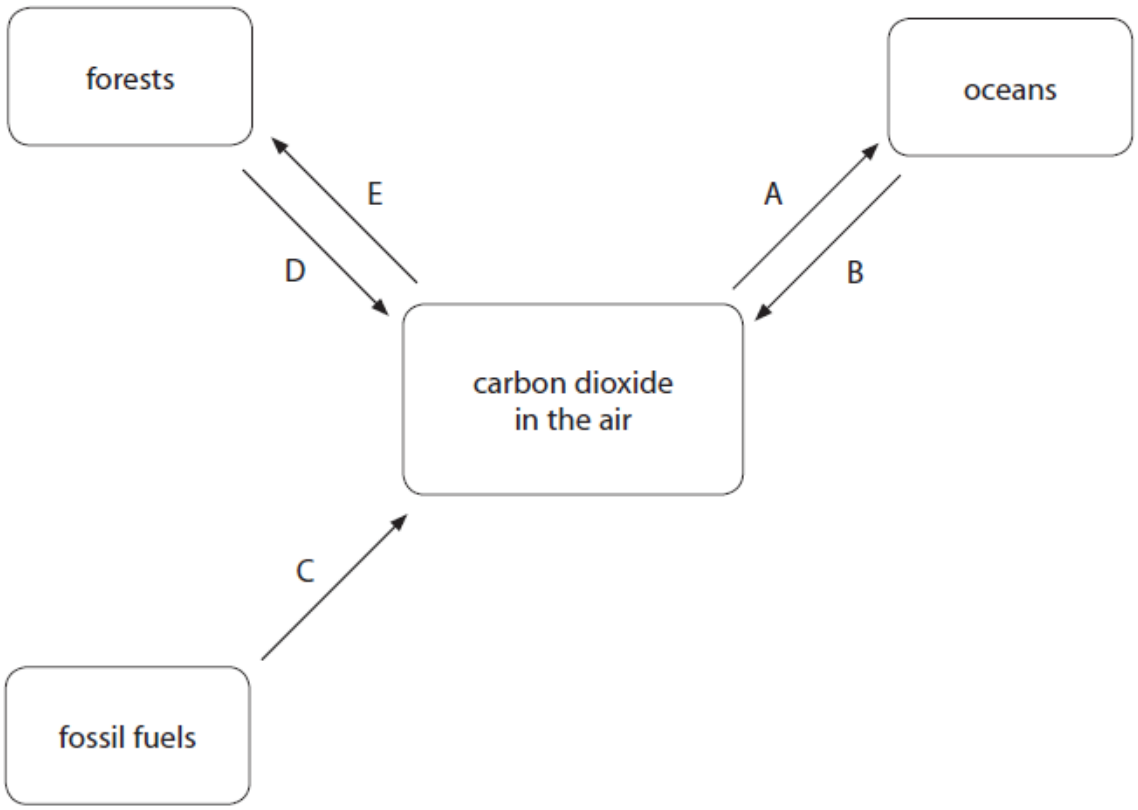
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(Total for question = 5 marks)

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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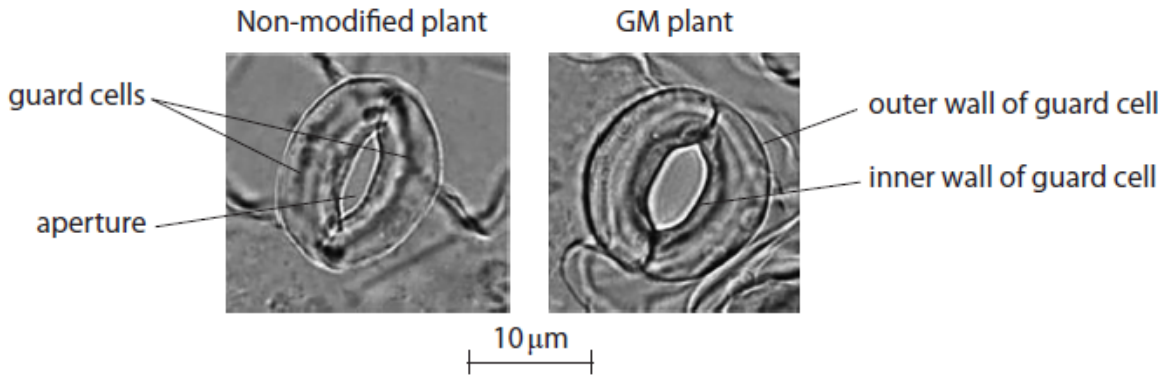
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Q16.

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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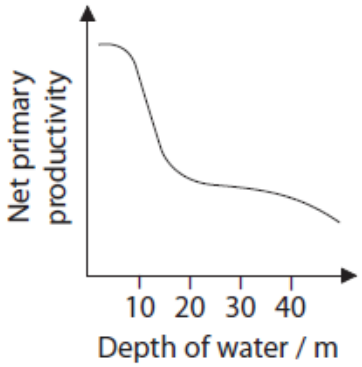
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(Total for question = 3 marks)

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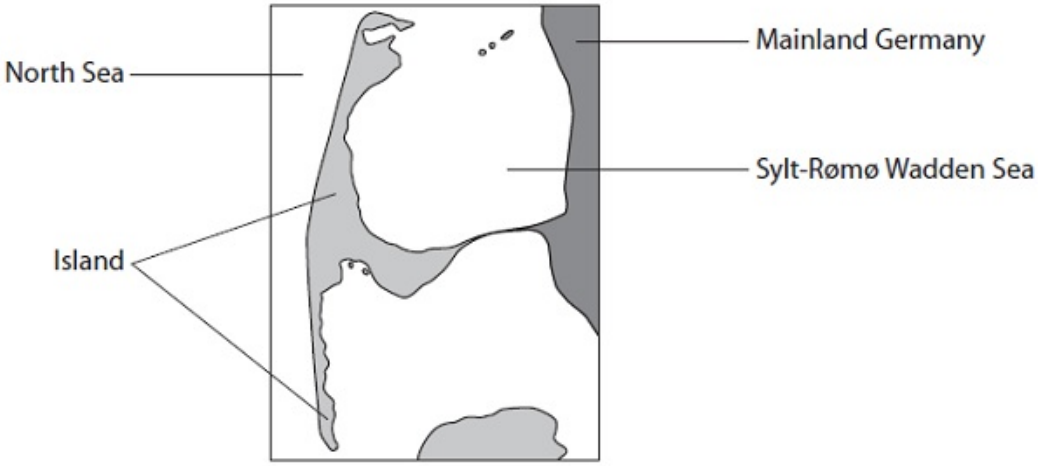
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Q18. The Sylt-Rømø Wadden Sea, shown in the diagram below, has a high gross primary productivity (GPP) which is monitored constantly.

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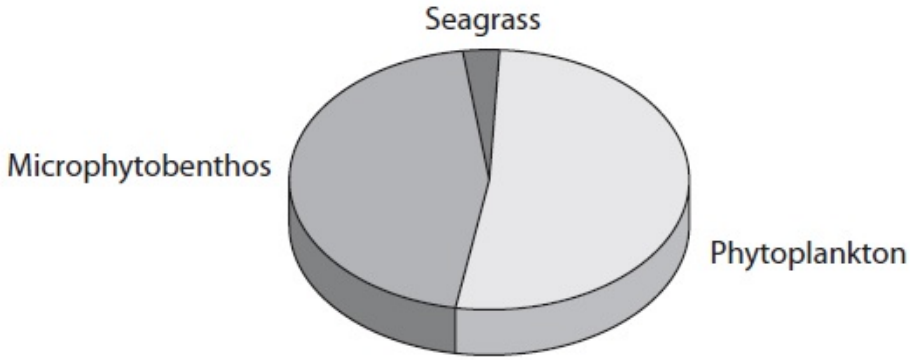
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(b) Seagrass, microphytobenthos and phytoplankton are the producers found in the Sylt-Rømø Wadden Sea.

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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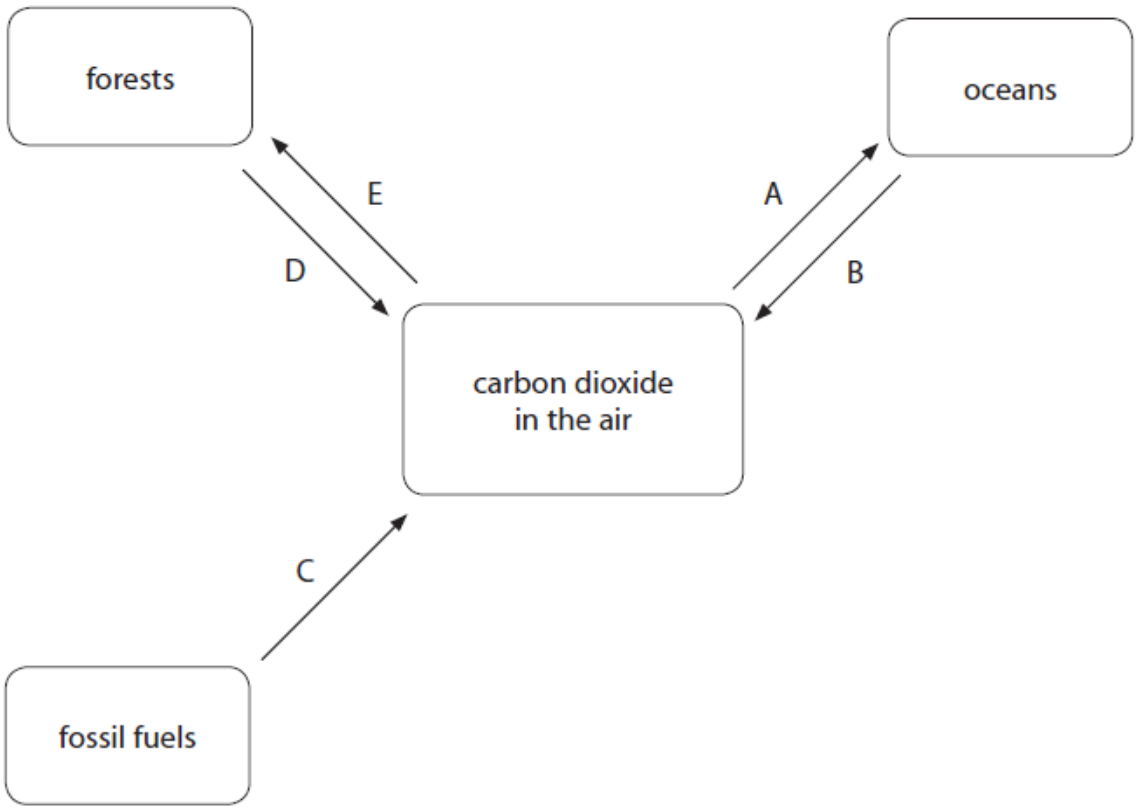
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(Total for Question = 10 marks)

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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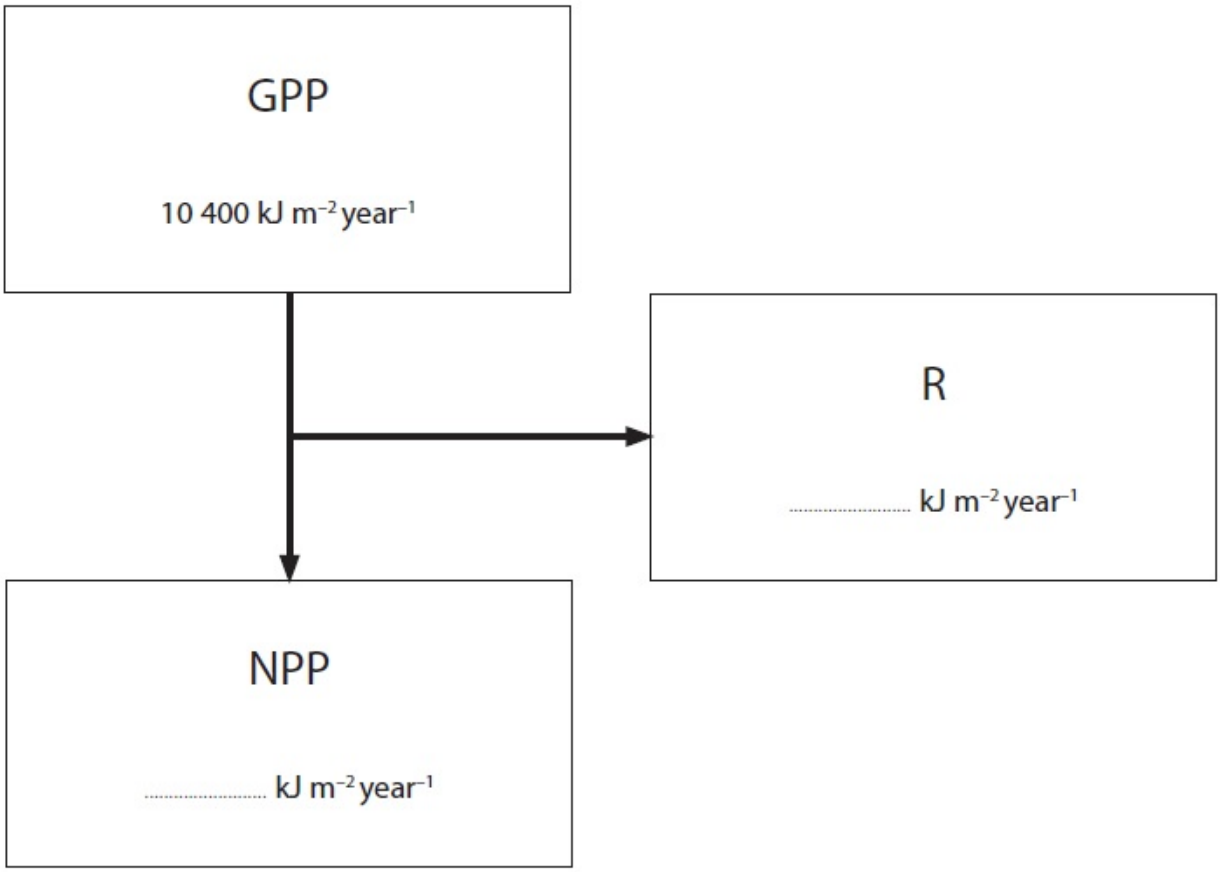
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(Total for question = 8 marks)

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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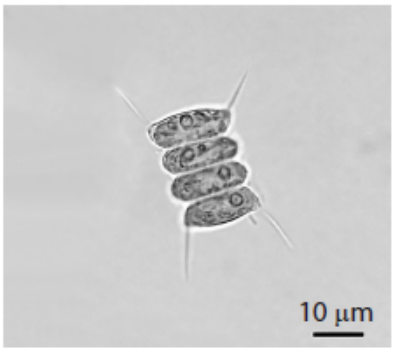
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(Total for question = 13 marks)

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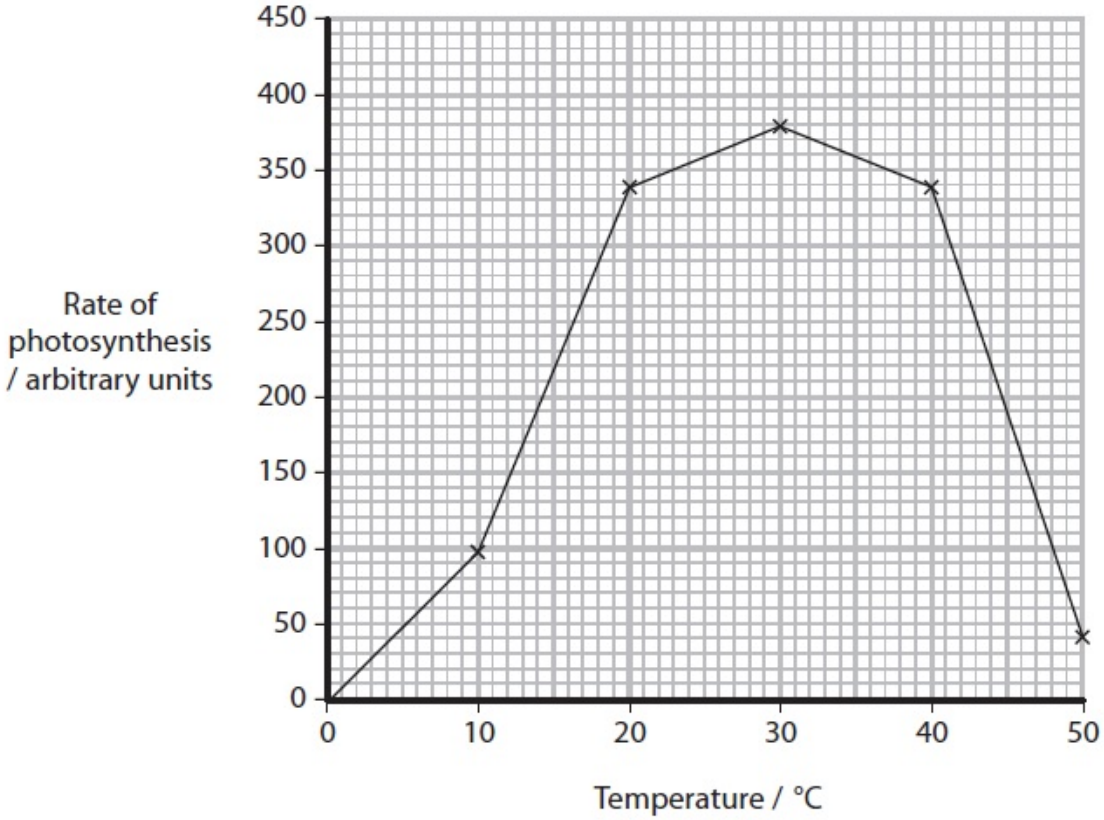
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(b) An investigation was carried out by a student, to find the effect of temperature on the rate of photosynthesis in *Elodea canadensis* (Canadian pondweed).

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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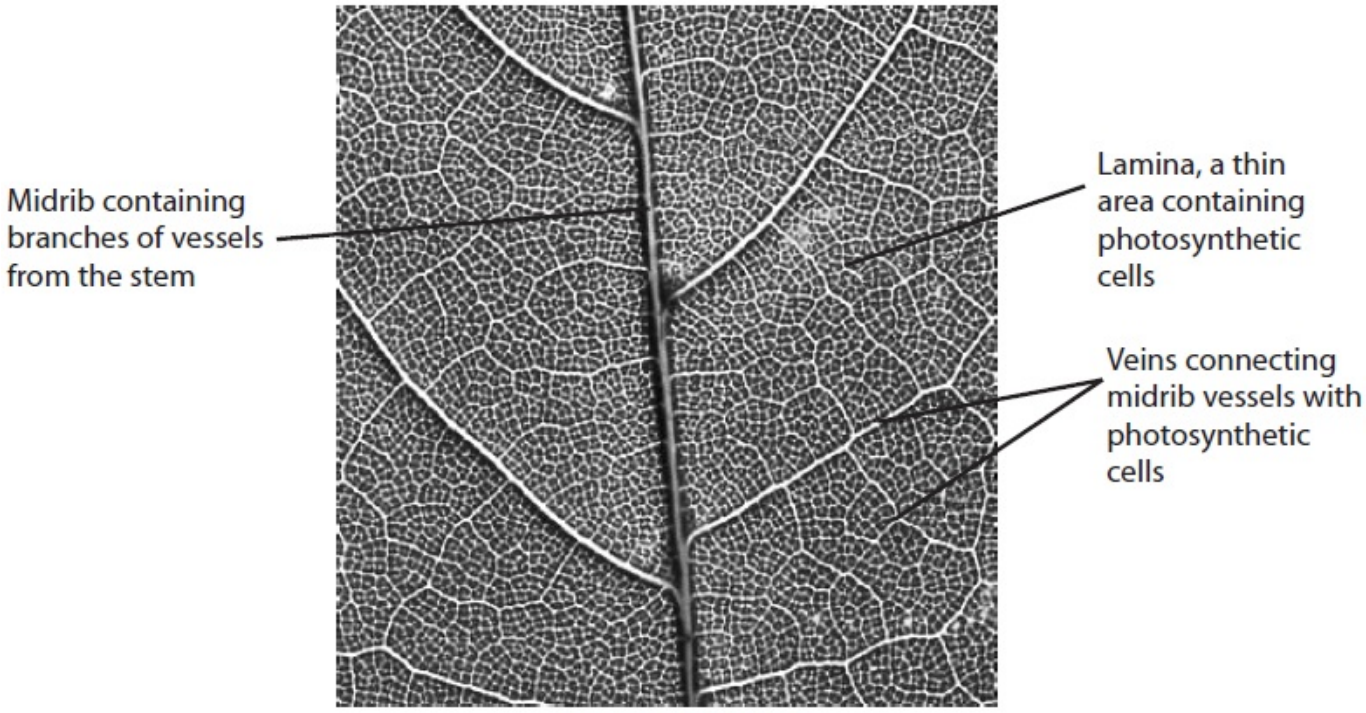
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(Total for question = 12 marks)

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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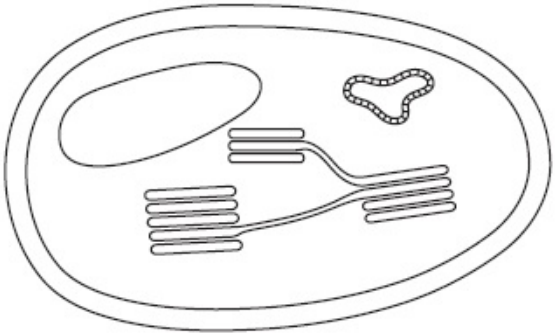
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(Total for Question = 13 marks)

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)

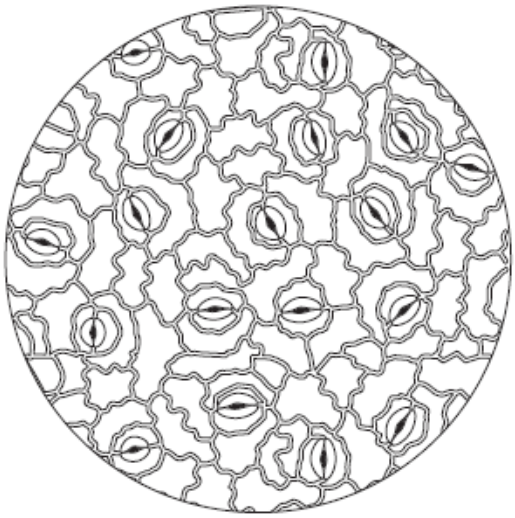
Q27.

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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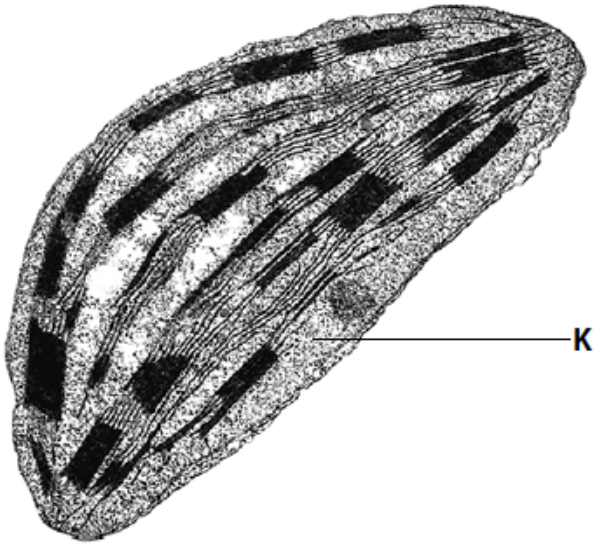
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Q29.

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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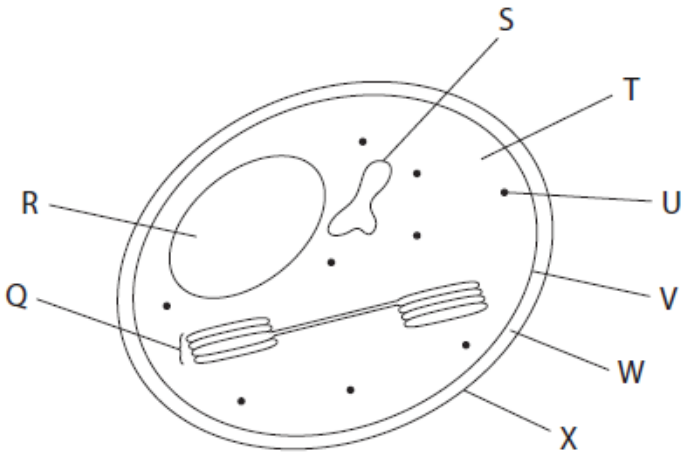
(Total for question = 4 marks)

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)