IB · DP · Biology

3 hours 15 questions

Structured Questions: Paper 2

# 8.3 Photosynthesis

8.3.1 Light-dependent Reactions / 8.3.2 Photophosphorylation / 8.3.3 Light-independent Reactions / 8.3.4 Investigating Carbon Fixation in Photosynthesis / 8.3.5 Chloroplast / 8.3.6 Skills: Photosynthesis

| | |
|---|---|
| Easy (5 questions) | /42 |
| Medium (5 questions) | /48 |
| Hard (5 questions) | /61 |
| **Total Marks** | **/151** |

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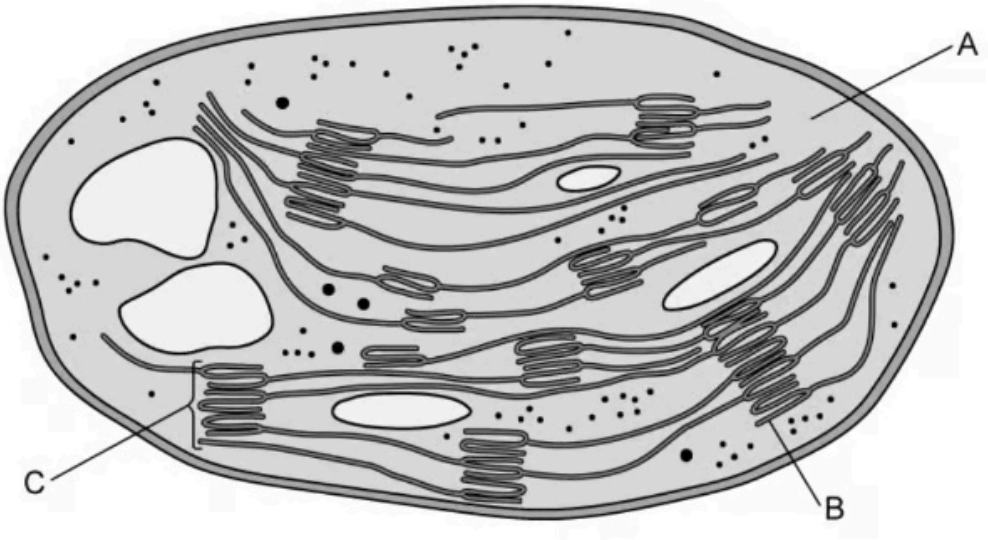
# Easy Questions

**1 (a)** The diagram below shows a chloroplast.




Identify Structure A and state the reaction that takes place there.

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**(2 marks)**

**(b)** State two products of the light independent stage of photosynthesis.

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**(2 marks)**

**(c)** ATP is required to drive the light independent reactions of photosynthesis.

Name the process which produces this ATP to be used in the light independent reactions?

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**(1 mark)**

**(d)** The light independent reactions are affected by temperature changes. Lowering the temperature slows down the light independent reactions.

Explain why a low temperature slows down the light independent reactions.

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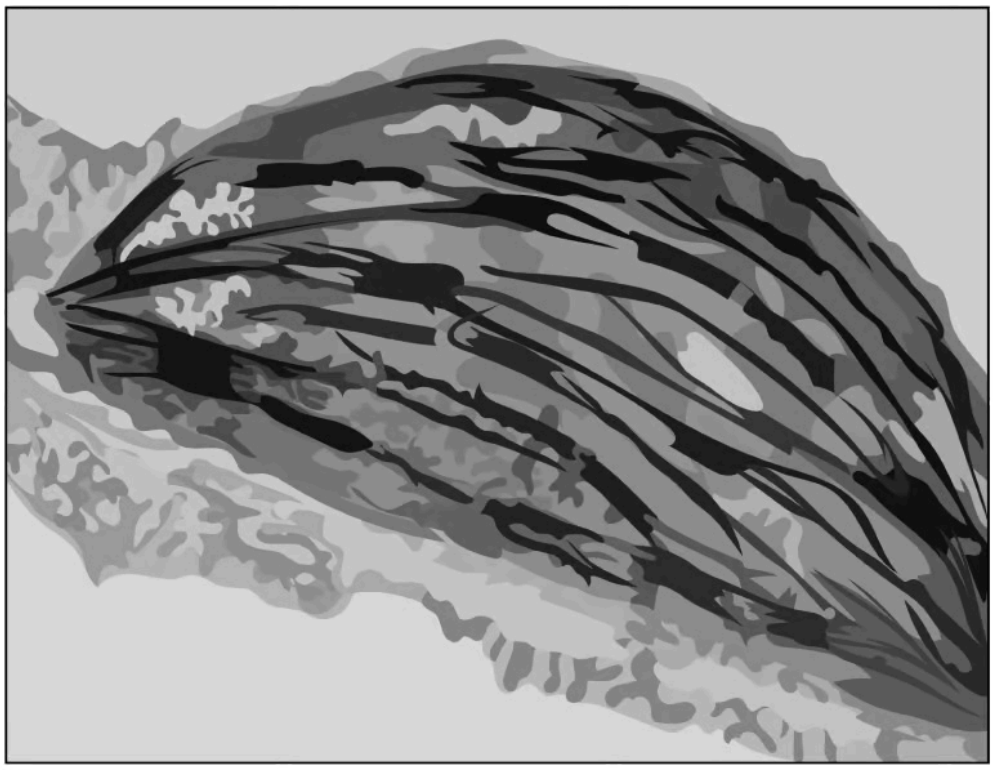
**(2 marks)**

**2 (a)** The diagram shows an electron micrograph of a chloroplast.

Annotate the diagram with the letter X to show the location of the light dependent stages of photosynthesis.



**(1 mark)**

**(b)** The photolysis of water is an important part of the process of light dependent stages of photosynthesis.

Describe what happens in the photolysis of water.

**(2 marks)**

**(c)** Chloroplasts contain more than one photosynthetic pigment.

Suggest why chloroplasts contain more than one photosynthetic pigment.

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**(1 mark)**

**(d)** Describe a structure of the chloroplast that enables maximum absorption of light.

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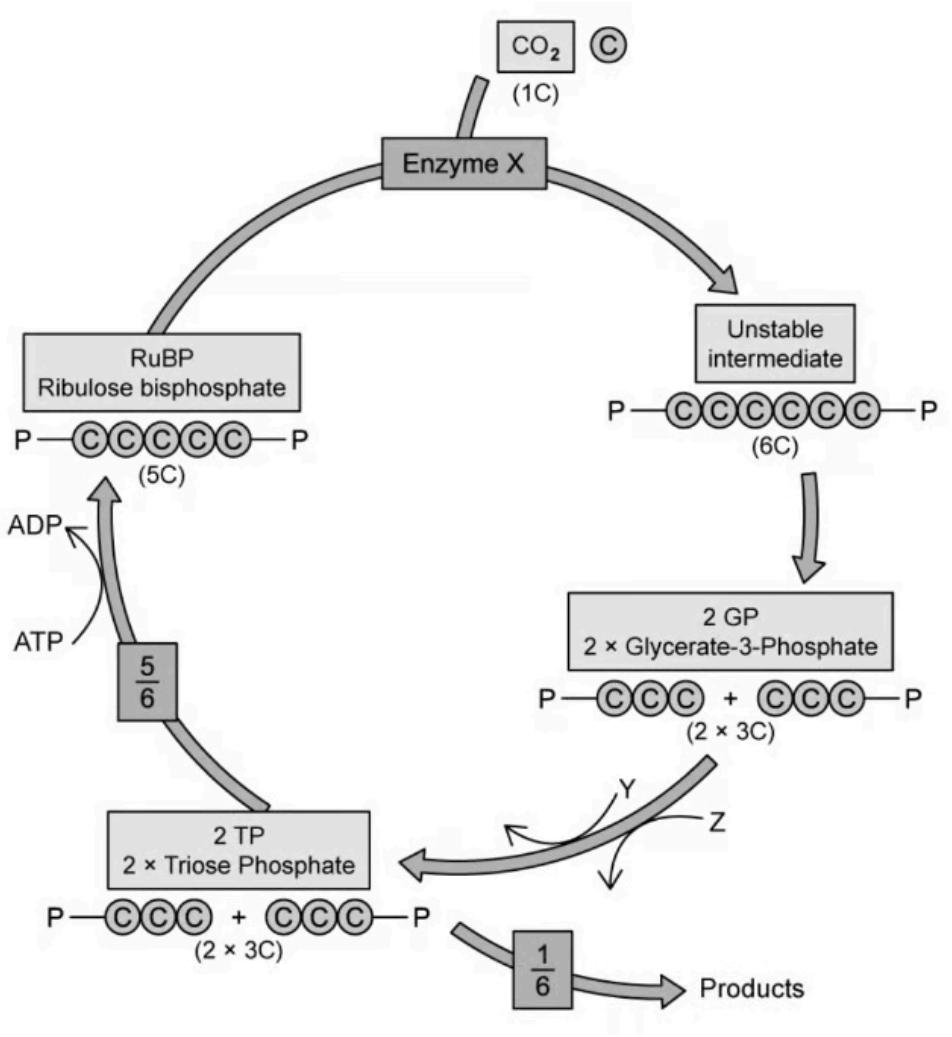
**(2 marks)**

**3 (a)** The diagram below shows the Calvin cycle.

State the name of enzyme X shown in the diagram.

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**(1 mark)**

**(b)** The molecules labelled Y and Z on the diagram are used to convert GP to TP.

Identify the molecules labelled Y and Z.

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**(2 marks)**

**(c)** One sixth of the TP is converted into usable products for the plant. One of these is hexose sugars.

State **two** uses of hexose sugars by plant cells.

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**(2 marks)**

**(d)** One sixth of TP is converted into usable products for the plant. The remaining five sixths remain in the Calvin cycle.

Explain why it is important that not all the TP is converted to usable products.

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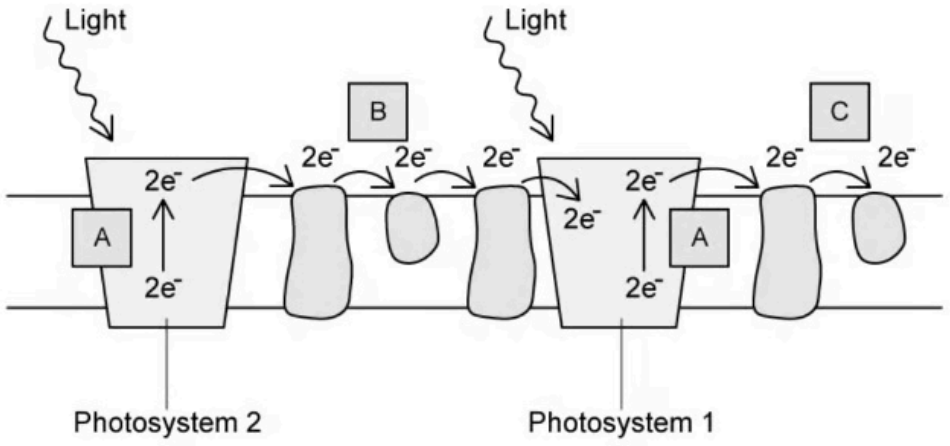
**(2 marks)**

**4 (a)** The diagram below shows some of the reactions taking place in the light dependent stages of photosynthesis.

State the exact location of the reactions shown.

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**(1 mark)**

**(b)** Describe the process that occurs at location A in the diagram.

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**(2 marks)**

**(c)** The diagram from part **a)** shows the electron transport chain in the light dependent reaction.

At stage **B,** the electrons are involved in a series of reactions fundamental in the process of chemiosmosis.

State the type of reactions that take place at stage **B.**

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**(1 mark)**

**(d)** The diagram from part a) shows the movement of electrons through the electron transport chain.

(i) Identify the product labelled C.

[1]

(ii) Describe the role of the electrons in the formation of product C.

[2]

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**(3 marks)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

During the light independent stage of photosynthesis, carbon dioxide is converted into organic substances.

Describe how.

**(6 marks)**

**(b)** Outline the experiments preformed by Melvin Calvin to elucidate the pathways of carbon fixation.

**(6 marks)**

**(c)** ATP and NADPH are two products of the light-dependent reactions.

Describe the functions of each of these substances in the light-independent reactions.

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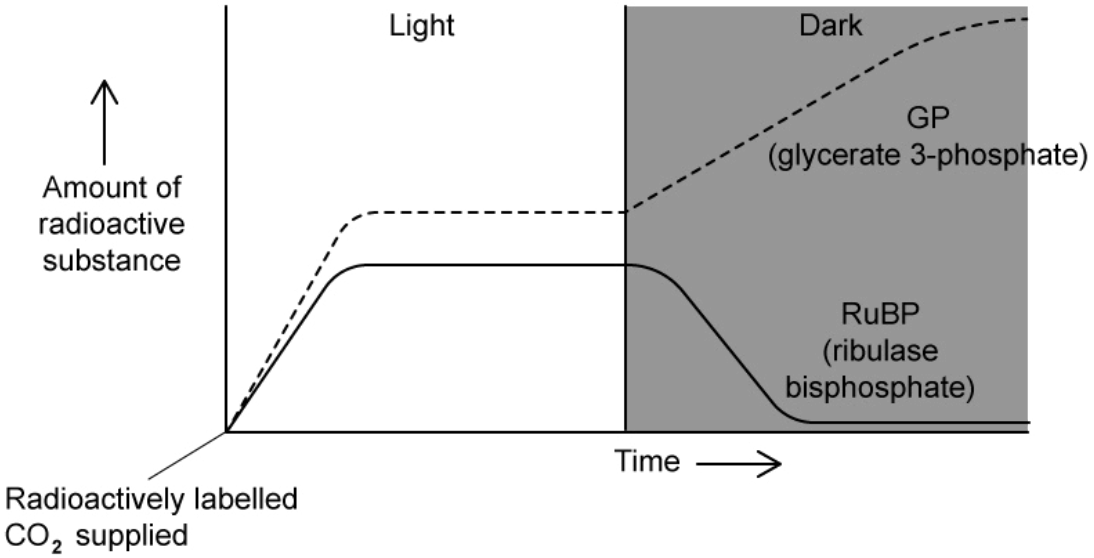
**(3 marks)**

# Medium Questions

**1 (a)** An experiment using radioactive carbon was carried out by scientists to investigate the Calvin Cycle. The algae *Chlorella* was exposed to radioactive carbon for different amounts of time. The algae was then analysed for radioactive compounds. The graph below shows the results.




Explain the changes in the amount of radioactive substances in the dark.

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**(3 marks)**

**(b)** Radioactive GP (glycerate 3-phosphate) was detected more rapidly than radioactive RuBP (ribulose bisphosphate).

Use your knowledge of the Calvin cycle to explain this finding.

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**(2 marks)**

**(c)** Melvin Calvin carried out similar experiments in the 1950s. At the time his approaches were novel and only possible because of advances in apparatus and techniques.

Describe the techniques, and their purpose, used by Calvin that allowed him to identify the compounds involved in the Calvin cycle.

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**(3 marks)**

**2 (a)** When plants are exposed to extremely high or low temperatures for a continued period of time, they are put under a lot of stress. This stress greatly impacts the rate of photosynthesis, in particular the light-dependent reaction of photosynthesis.

Explain why extreme cold leads to a decrease in the light-independent reaction.

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**(3 marks)**

**(b)** State the precise location of light-independent reactions in photosynthetic plants.

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**(1 mark)**

**(c)** Extreme cold can also cause a decrease in rubisco activity.

Explain why a decrease in the activity of the enzyme rubisco limits the rate of photosynthesis.

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**(2 marks)**

**(d)** Describe the exact role of ribulose bisphosphate (RuBP) in the Calvin cycle.

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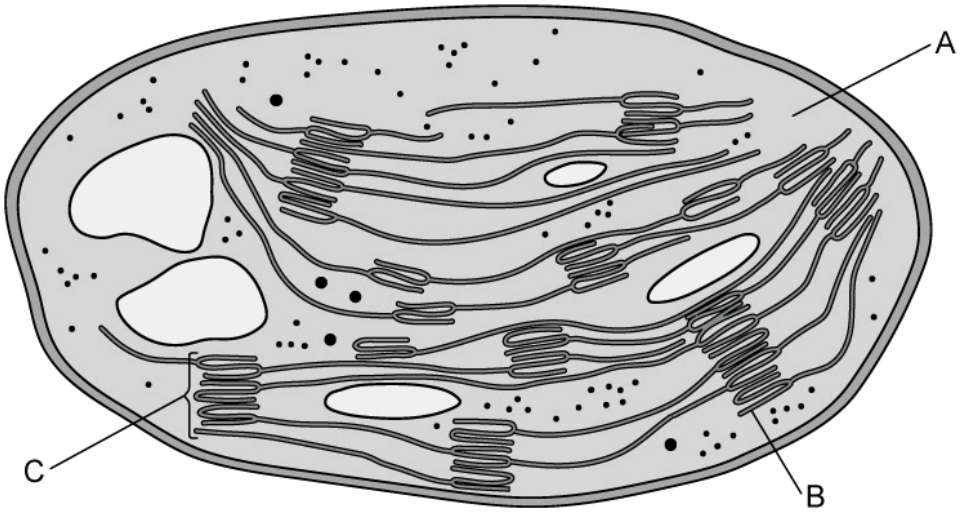
**(2 marks)**

**3 (a)** The diagram below shows a diagram of a chloroplast.




Identify the structures of a chloroplast labelled **A-C** in the diagram.

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**(3 marks)**

**(b)** Describe the adaptations of structures **A** and **B** from the diagram in part a).

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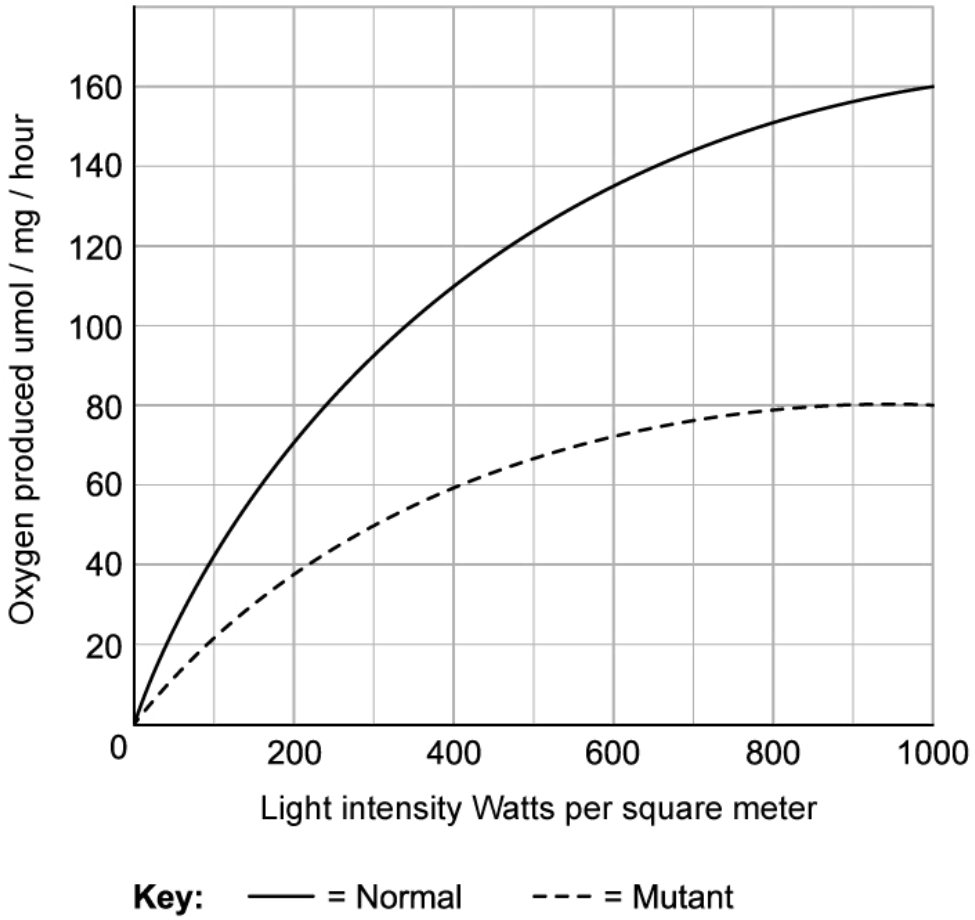
**(2 marks)**

**(c)** Plants can contain more than one type of chlorophyll, a and b. Scientists grew plants that contained a mutant version of chlorophyll a. They investigated the effect of this mutation on the rate of photosynthesis.

The scientists

- Grew the mutant and normal plants in a range of light intensities
- Isolated the chloroplasts from both types of plants
- Measured the oxygen produced by the chloroplasts over a period of 20 minutes

Their results are shown in the graph below:




Explain why the scientists used the oxygen produced as a measure of the rate of photosynthesis.

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**(2 marks)**

**(d)** Use the graph to calculate the difference in oxygen produced by the chloroplasts from normal plants compared to the mutant plants at a light intensity of 400 Watts/$m^2$.

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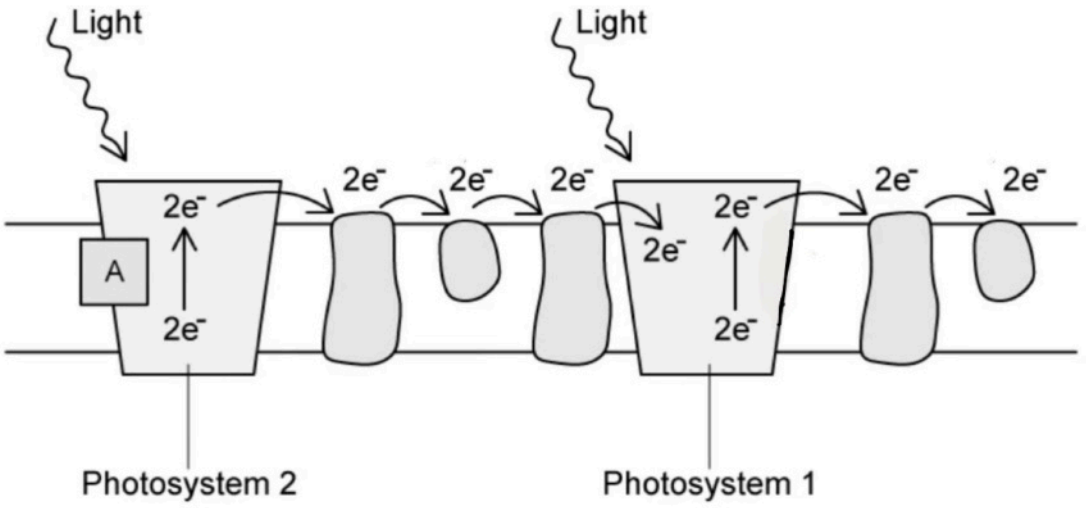
**(2 marks)**

**4 (a)** The diagram below shows a representation of some of the reactions taking place during the light dependent reactions of photosynthesis.




Explain the process that occurs at label **A**.

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**(3 marks)**

**(b)** Describe how the protein ferredoxin is involved in the reduction of NADP during the light dependent reaction.

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**(3 marks)**

**(c)** The diagram from part a) shows the loss of electrons from photosystem 2, but does not show how these electrons are replaced.

State and explain the source of the electrons that replace those lost at stage **A**.

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**(2 marks)**

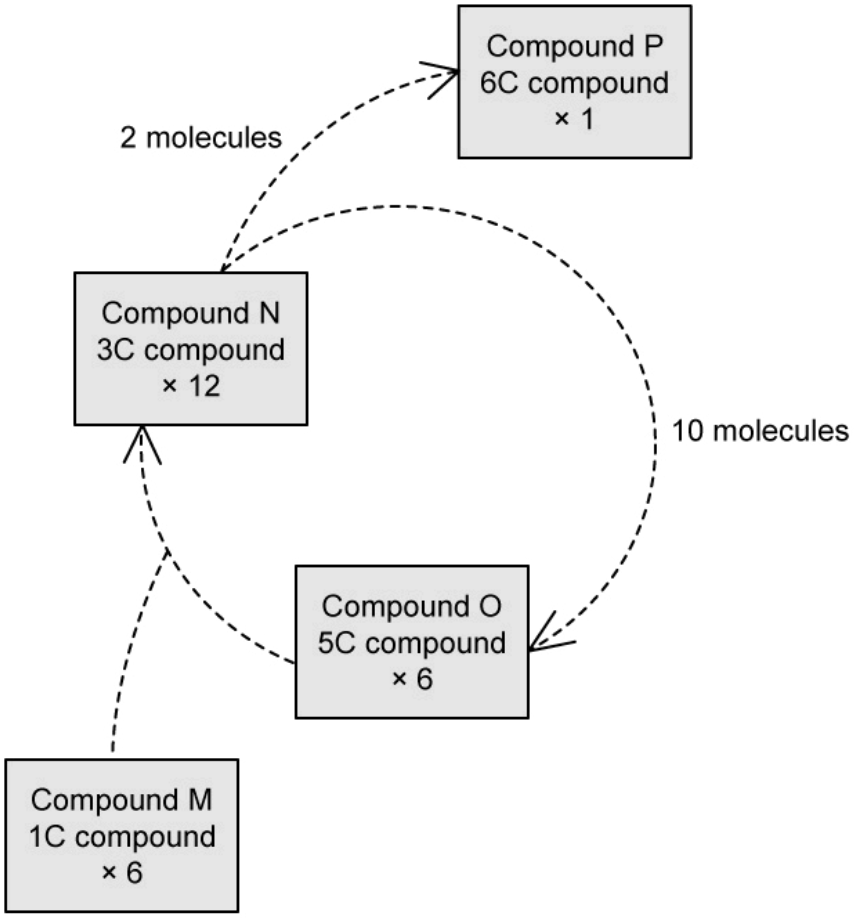
**5 (a)** *One mark is available for clarity of communication throughout this question.*

Crops absorb and use light energy for the production of photosynthetic products.

Describe how light energy is used by crop plants during the light-dependent reaction.

**(5 marks)**

**(b)** The diagram below depicts the light-independent reactions of photosynthesis.




Describe the mechanism of these reactions and explain how they allow for the continuous synthesis of 6-carbon sugars.

**(7 marks)**

**(c)** Explain the role of protons in the light dependent reaction of photosynthesis.

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**(3 marks)**

# Hard Questions

**1 (a)** Explain why the light independent reactions of photosynthesis stop in the absence of light.

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**(2 marks)**

**(b)** Some species of bacteria that live on the ocean floor do not have access to light for photosynthesis. Instead, they use the process of chemosynthesis to make glucose using energy stored in substances such as methane, hydrogen sulfide ($H_2S$) and carbon dioxide. A simplified equation of one such reaction is shown below.

carbon dioxide + water + hydrogen sulfide → glucose + sulfur + sulfur compounds

Use your knowledge of photosynthesis to suggest what hydrogen sulfide is used for in the process of chemosynthesis.

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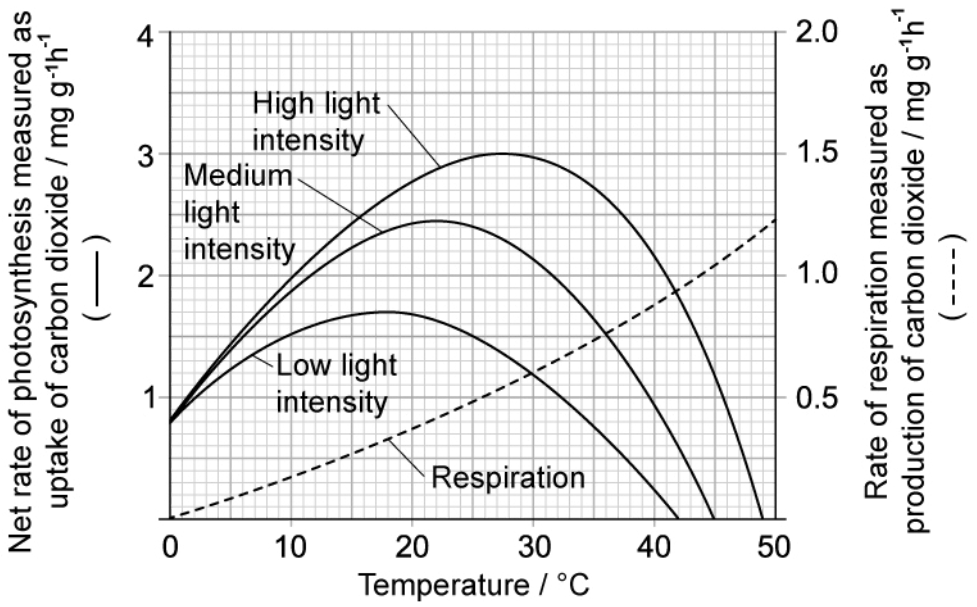
**(3 marks)**

**(c)** The rate of photosynthesis can be expressed as either gross or net rates. Gross photosynthesis is the total rate of carbon fixation (reduction of $CO_{2)}$ without considering that some of the $CO_2$ is lost in respiration. Net photosynthesis is the carbon fixation rate minus the rate of $CO_2$ loss in respiration.

The graph below shows the effect of temperature on the net rate of photosynthesis at three different light intensities and the effect of temperature on the rate of respiration.




Use the graph to calculate the gross rate of photosynthesis at 15°C and low light intensity.

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**(1 mark)**

**(d)** The average global temperature is 14°C. Scientists predict that over the course of the next 100 years, the average temperature could increase by up to 4°C. It is also predicted to become cloudier in many regions.

Use the graph to describe and explain how these changes are likely to affect the growth of plants.

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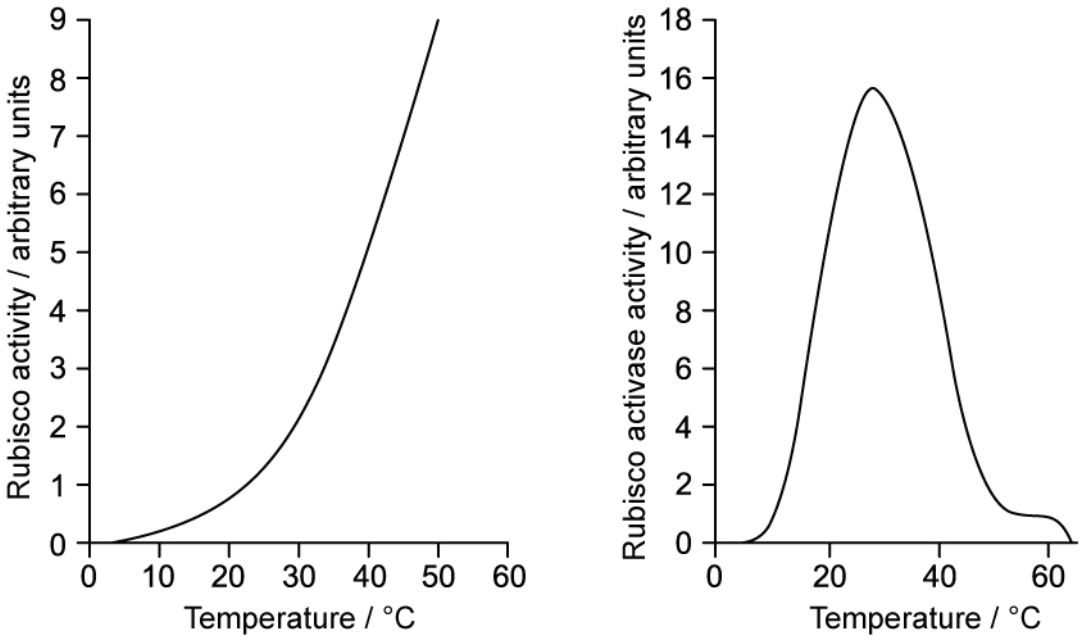
**(3 marks)**

**2 (a)** Researchers investigated the activity of two enzymes isolated from the leaf cells of lavender plants.

The two enzymes were:

- Rubisco
- Rubisco activase

The results of the investigation are shown in the graphs below.




The scientists concluded that heat stress reduces the activity of rubisco in plant leaves by affecting rubisco activate.

Use the data to evaluate their conclusion.

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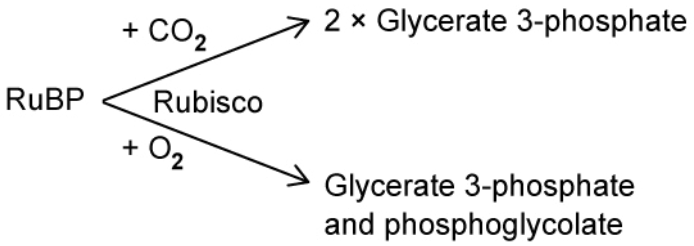
**(4 marks)**

**(b)** The enzyme rubisco catalyses the reaction between RuBP and carbon dioxide to form two molecules of glycerate-3-phosphate (GP). Rubisco can also catalyse a reaction

between RuBP and oxygen to form one molecule of GP and one molecule of phosphoglycolate.

The reactions are shown in the diagram below.




Use the diagram to deduce to number of carbon atoms in one molecule of phosphoglycolate.

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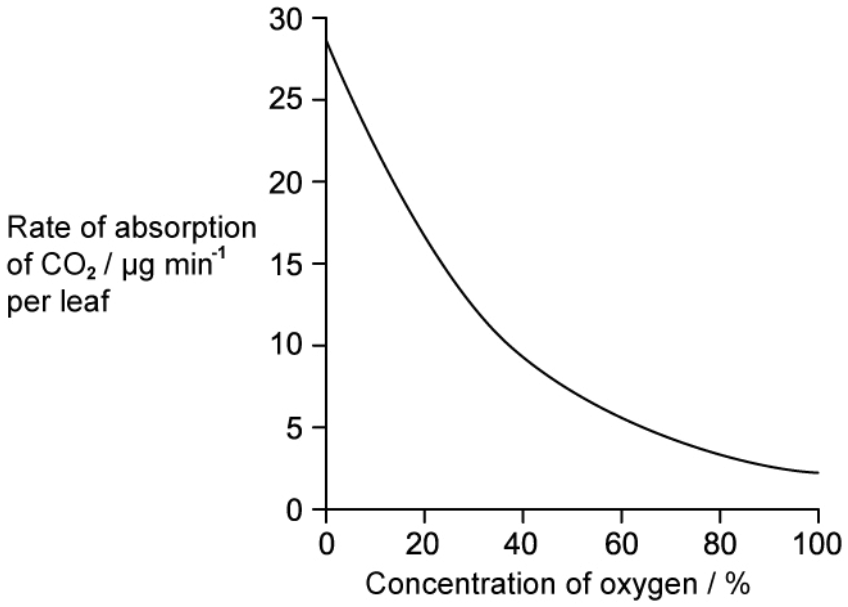
**(1 mark)**

**(c)** The scientists investigated the effect oxygen concentration had on the absorption of carbon dioxide in leaves from tomato plants. The graph below shows their results.




Explain the results in the graph above using the diagram and information from part b) of the question.

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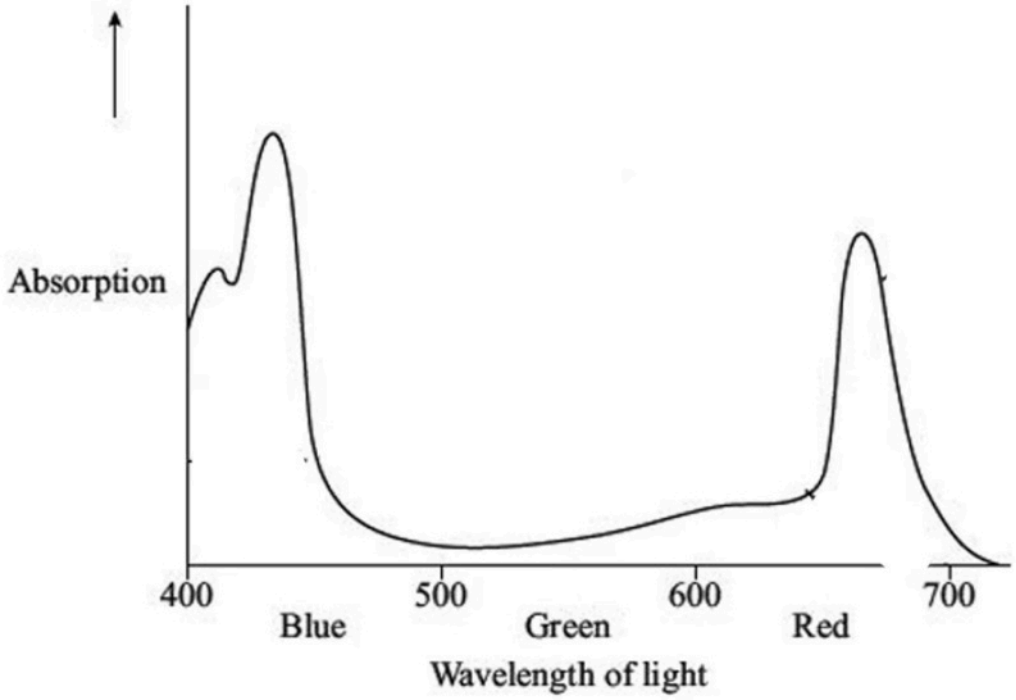
**(2 marks)**

**(d)** Use all the information provided and your knowledge of the light-independent reaction to explain why the yield from tomato plants decreases at higher concentrations of oxygen. Note: Phosphoglycolate is not used in the light-independent reaction.

**(3 marks)**

**3 (a)** Some scientists were investigating photosynthesis in seaweed. During their investigation, they applied lights of different wavelengths to study the amount of light absorbed by the seaweed species.

Their results can be seen in the graph below.




State, with a reason, the types of pigments found in these species of seaweed.

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**(1 mark)**

**(b)** The scientists also measured the rate of the light-dependent reactions in the seaweed at each of the different wavelengths.

| Species | Mean rate of photosynthesis / arbitrary units | |
|---|---|---|
| | **Lamp X 400 - 700 nm** | **Lamp Y 430 nm** |
| **A** | 1 250.3 (± 115.6) | 920.2 (± 95.1) |
| **B** | 290.4 (± 55.6) | 276.6 (± 69.6) |

Suggest how the scientists measured the rate of the light-dependent reactions.

**(2 marks)**

**(c)** The scientists repeated the investigation twice more under the following conditions

1. They increased light intensity from lamps X and Y
2. They increased the temperature of the investigation from 15 °C to 20 °C.

Discuss how these changes may affect the amount of oxygen produced by the seaweed

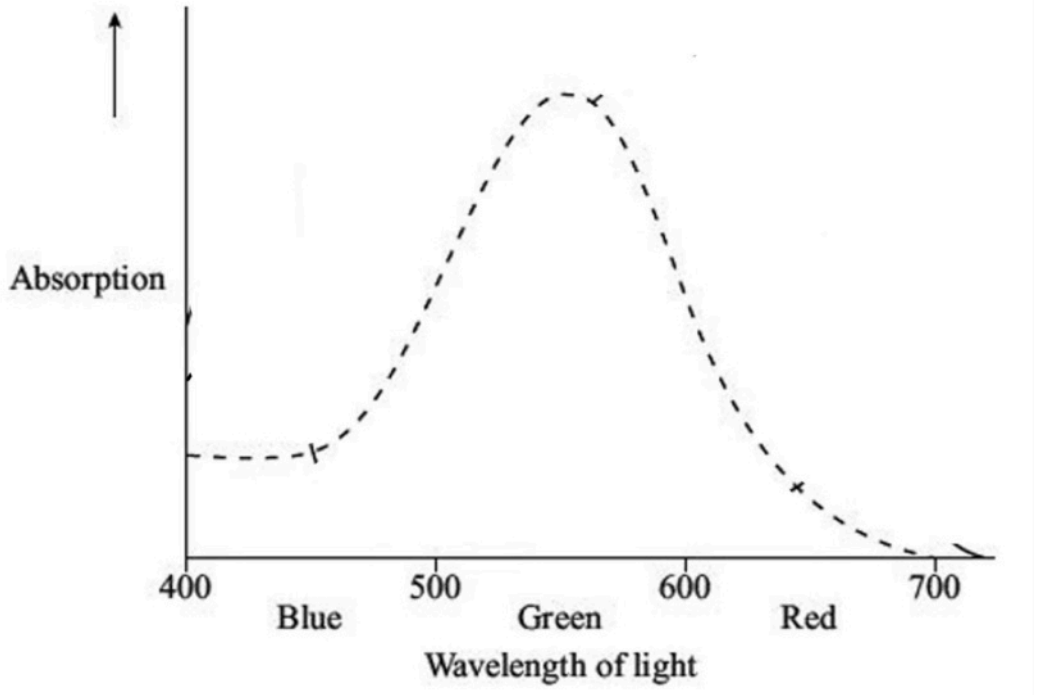
**(6 marks)**

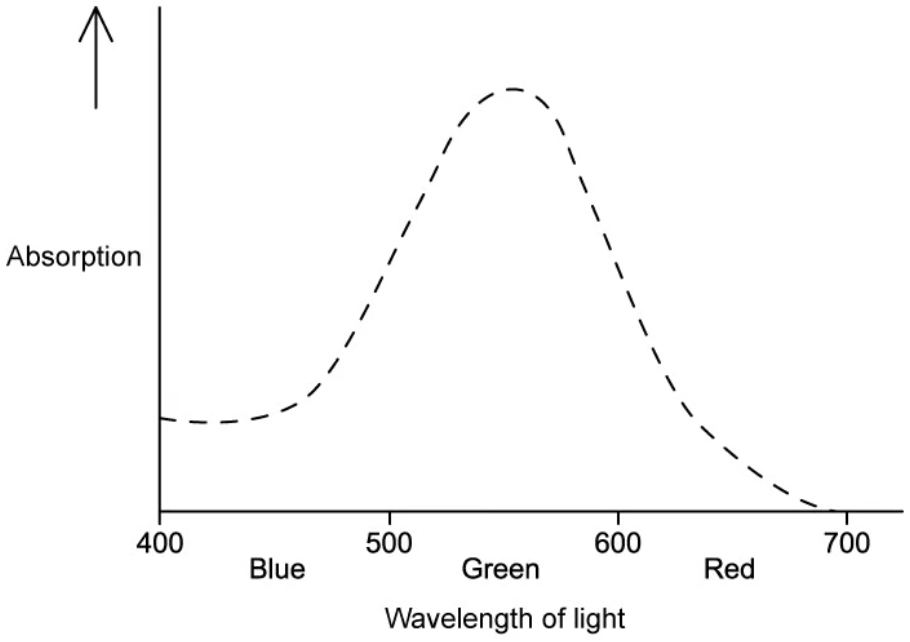
**(d)** The scientists concluded that both species of seaweed showed increased rates of photosynthesis under lamp X compared to lamp Y.

Evaluate this conclusion.

**(2 marks)**

**(e)** The scientists also isolated a species of bacteria found to absorb light at the bottom of the ocean habitat where the seaweed were found. They found these bacteria absorbed light as shown by the absorption spectrum below:




Suggest the selective advantage to the bacteria of absorbing light as shown in this absorption spectrum.

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**(3 marks)**

**4 (a)** 'Weed wonder' is a weed killer designed to inhibit plastoquinone protein in chloroplasts of weeds.

Explain how this would affect the growth of weeds.

**(5 marks)**

**(b)** Compare and contrast the processes that occur in the electron transport chain (ETC) of the light dependent reaction with the electron transport chain in respiration.

**(6 marks)**

**(c)** Oxidation and reduction are key to the metabolic pathways seen in photosynthesis.

Complete the table to indicate which substances are oxidised and which are reduced during the stages of photosynthesis.

| Stage | Substance | Oxidised / reduced |
|---|---|---|
| **Light-dependent** | NADP | |
| | PSII after photoexcitation | |
| **Light-independent** | GP | |
| | NADPH | |

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**(2 marks)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

The concentrations of carbon dioxide in the air at different heights above ground in a forest changes over a period of 24 hours.

Use your knowledge of photosynthesis to describe and explain these changes. You can assume there is no air movement through wind throughout the 24 hour period.

**(5 marks)**

**(b)** Certain types of ultraviolet radiation may induce the production of ATP in isolated plant cells by interacting with electrons found in photosystems.

Use your knowledge of phosphorylation to explain how.

**(5 marks)**

**(c)** Water absorbed by plants at the roots is carried to the leaves to be used in photosynthesis.

Explain the role of water in photosynthesis.

**(5 marks)**