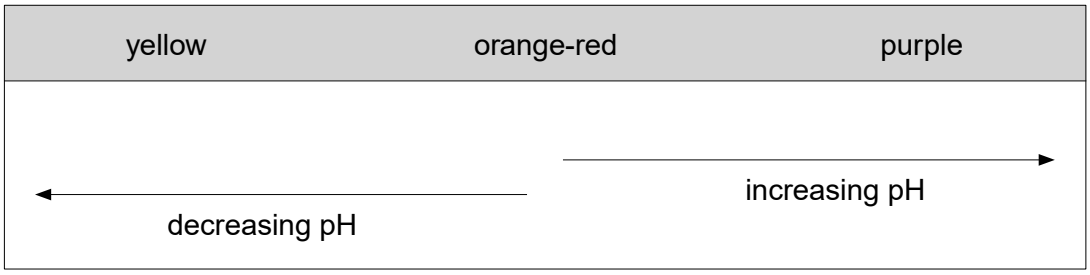
1. An experiment was carried out into the effect of different wavelengths of light on the rate of photosynthesis.

Four sealed test-tubes were set up, each containing three leaf discs from the same plant suspended above hydrogencarbonate indicator solution. This solution changes colour at different pH values, as shown below.



At the start of the experiment, the contents of all four tubes were orange-red.

Each tube was illuminated by a lamp with a coloured filter in front of it. The tubes were illuminated for the same length of time. The colour changes were noted and the results are shown in the table below.

colour of filter	final colour of hydrogencarbonate indicator
colourless	purple
blue	purple
green	orange-yellow
red	red

A fifth tube was set up in the same way as the other tubes. This tube was then covered in black paper before being illuminated for the same length of time. The final colour of the hydrogencarbonate indicator in this tube was yellow.

(i) State the purpose of the tube covered with black paper.

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[1]

(ii) State **two** precautions that need to be taken when designing and carrying out this experiment in order to obtain results from which valid conclusions can be drawn. Explain the need for each precaution.

precaution 1 .....

explanation .....

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precaution 2 .....

explanation .....

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[2]

(iii) Name the pigment at the reaction centre of photosystems I and II.

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[1]

(iv) Explain the change observed in the tube exposed to green light.

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[3]

[Total 7 marks]

2. In order to maximise production, market gardeners often grow plants in glasshouses. Light conditions can be controlled along with a number of other factors.

How can factors **other than light conditions** be controlled to increase the rate of photosynthesis and maximise production?

In your answer you should explain why the rate of photosynthesis is affected by the controlled factors you have discussed.

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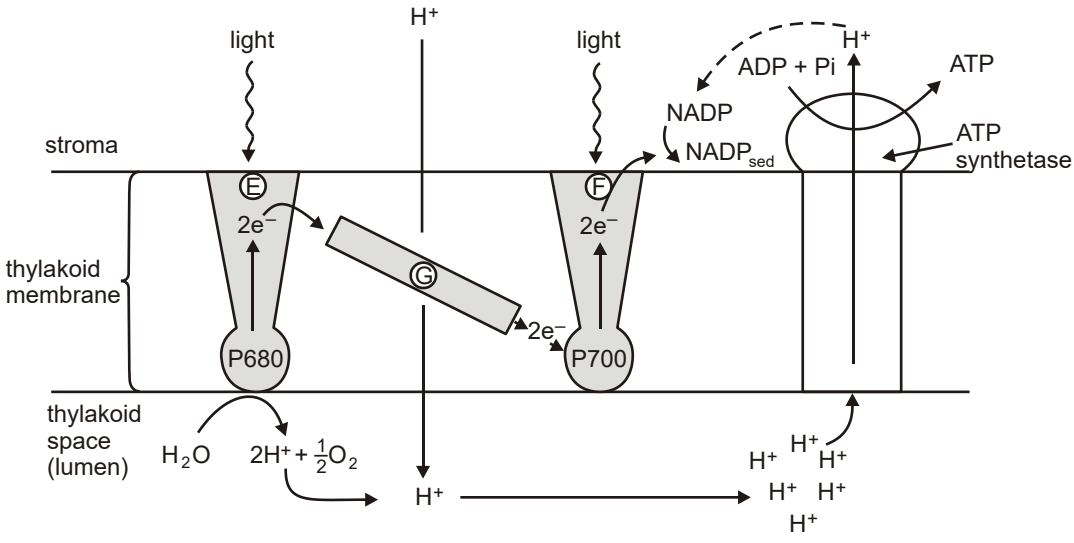
[Total 4 marks]

3. The light-dependent stage of photosynthesis takes place on thylakoid membranes in chloroplasts. These membranes surround the thylakoid space (lumen) and are arranged into stacks known as grana. Below is a diagram showing the arrangement of photosystems in the thylakoid membrane, and summarising the processes that take place there.



(a) (i) Name the pigment represented by P680 and P700.

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[1]

(ii) Name the **type** of molecule represented by **G**.

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[1]

(b) Explain, **using the information in the diagram**, why the pH of the thylakoid space (lumen) is lower than that of the stroma **and** what significance this has for ATP production.

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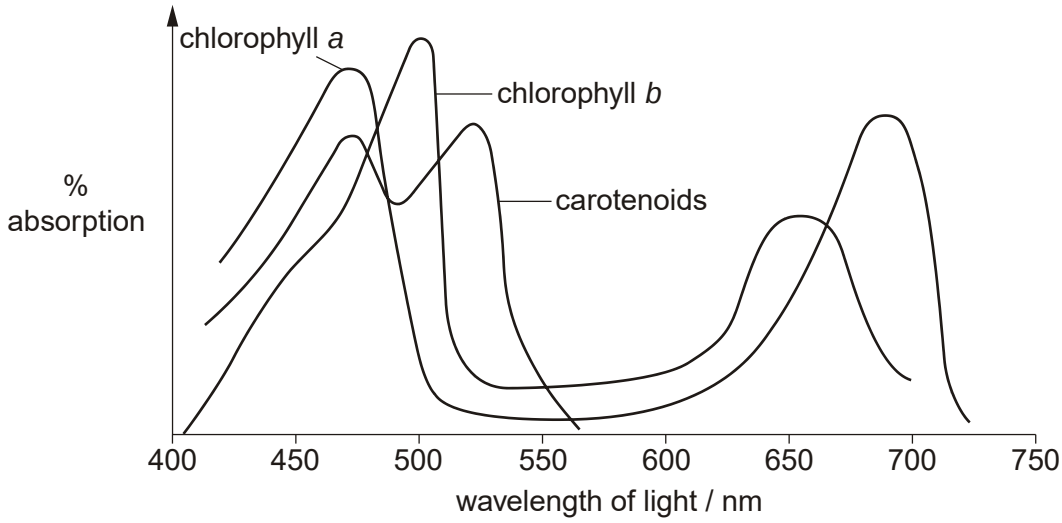
[4]

[Total 6 marks]

4. The figure below shows the absorption spectra for three different photosynthetic pigments.



(i) Explain what is meant by the term *photosynthetic pigment*.

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[3]

(ii) Using the figure above, describe the pattern shown by chlorophyll *a*.

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[2]

[Total 5 marks]

5. Photosynthetic pigments fall into two categories: primary pigments and accessory pigments.

Explain the difference between primary and accessory pigments.

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[Total: 2 marks]

6. In this question, one mark is available for the quality of the use and organisation of scientific terms.

Photosynthetic pigments are arranged in light-harvesting clusters called photosystems.

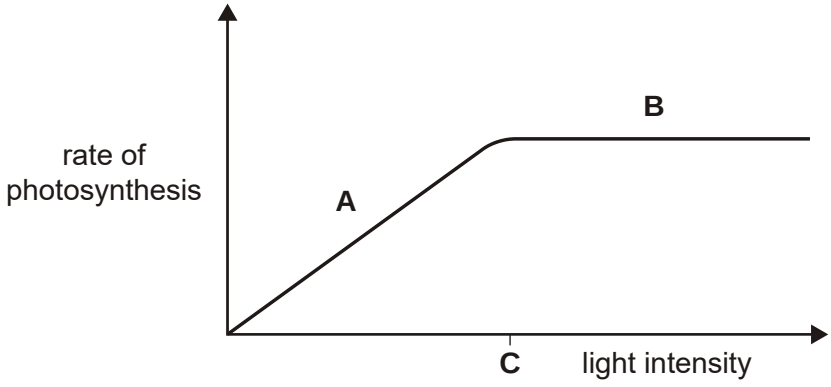
Describe how the light energy absorbed by these photosystems is converted into chemical energy in the **light dependent stage** of photosynthesis.

[8]

Quality of Written Communication [1]

[Total: 9 marks]

7. The rate of photosynthesis is affected by a number of environmental factors. The figure below shows the effect of light intensity on the rate of photosynthesis.



(i) State the limiting factor in region **A** of the graph.

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[1]

(ii) Explain why there is no further increase in the rate of photosynthesis beyond point **C**.

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[2]

[Total 3 marks]

8. For many plants living in temperate regions the optimum temperature for photosynthesis is approximately 25°C.

Explain why the rate of photosynthesis decreases at temperatures above 25°C.

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[Total 4 marks]

9. Plants that live in the Arctic have a relatively short growing season in which the light intensity is always relatively low. Many species growing in these conditions have a high level of anthocyanin pigments in their leaves. The combined effect of these red pigments with the green chlorophyll makes the leaves appear dark purple or black.

Suggest why this adaptation is useful in increasing photosynthetic rates.

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[Total: 3 marks]

10. All organisms require energy in order to remain alive. Plants use solar energy to combine water and carbon dioxide into complex organic molecules. Both plants and animals then break down organic molecules in respiration. Energy released in this process is used in the formation of ATP.

Describe the structure of ATP.

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[Total: 4 marks]

11. In this question, one mark is available for the quality of use and organisation of scientific terms.

There are a number of organic molecules in cells whose role is to transfer hydrogen atoms from one compound to another. Examples include NAD, FAD and NADP.

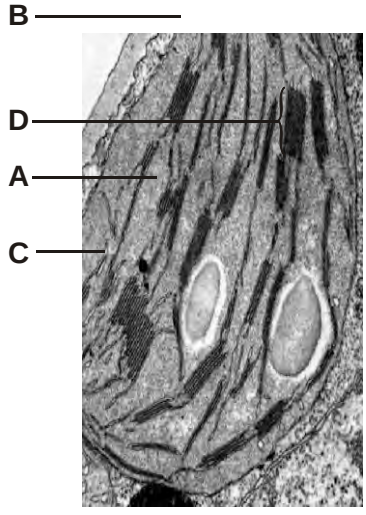
NAD, FAD and NADP are important molecules in plant cells. Describe, in detail, the role of these molecules within a **palisade mesophyll cell**.

[7]

Quality of Written Communication [1]

[Total 8 marks]

12. The figure below is an electronmicrograph of a chloroplast.



Identify the structures labelled **A** to **D**.

A .....

B .....

C .....

D .....

[Total 4 marks]

13. An investigation was carried out into photosynthesis and respiration in a leaf. The net uptake of carbon dioxide by the leaf in bright light, and the mass of carbon dioxide released in the dark were determined at different temperatures. The results are shown in the following table.

temperature / °C	5	10	15	20	25	30
net uptake of CO_2 in bright light / mg g^{-1} dry mass h^{-1}	1.3	2.4	3.0	3.3	3.0	2.2
release of CO_2 in dark / mg g^{-1} dry mass h^{-1}	0.4	.07	1.0	1.4	1.9	2.8
true rate of photosynthesis / mg CO_2 g^{-1} dry mass h^{-1}						

(i) State **two** types of tissue in a leaf where there is a net uptake of carbon dioxide in bright light.

1 .....

2 .....

[2]

(ii) Assuming the rate of respiration in the light is equal to the rate of respiration in the dark, calculate the true rate of carbon dioxide uptake in photosynthesis at each temperature and **add the figures to the table above**.

[1]

(iii) The term temperature coefficient (Q_{10}) is used to express the effect of a 10 °C rise in temperature on the rate of a chemical reaction. It is calculated in the following way:

$$Q10 = \frac{\text{rate of reaction at } \mathbf{t} + 10\ °C}{\text{rate of reaction at } \mathbf{t}\ °C}$$

where **t** = any given temperature.

Between 5 °C and the optimum temperature for enzyme-catalysed reactions, the Q_{10} is approximately 2.

Discuss whether the data in the table above supports this statement for both respiration and photosynthesis.

respiration .....

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photosynthesis .....

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[4]

(iv) When plants are grown in glasshouses during autumn and winter, when the natural light intensities are low, it is important that temperatures are kept relatively low.

With reference to respiration **and** photosynthesis, explain why it is essential to do this.

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[3]

[Total 10 marks]

14. The carbon dioxide taken up by a leaf enters the chloroplasts.

Name and describe the **biochemical pathway** which fixes the carbon dioxide into hexose sugars in the chloroplasts.

name of pathway .....

description .....

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[Total 5 marks]

15. *Tradescantia* is a genus of plants that is found in North and South America. The genus has many species which are found in different types of habitat. *Tradescantia sillamontana* and *Tradescantia fluminensis* are two of these species.

Fig 1 shows typical shoots of these plants. The photographs of the shoots are life size. Fig 1 **A** is *T. sillamontana* and **B** is *T. fluminensis.*

Tradescanita fluminensis

Tradescanita sillamontana

Fig 1

(a) Describe **two** ways in which the shoot of *T. sillamontana* differs from the shoot of *T. fluminensis*, as shown in Fig.1.

1 .....

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2 .....

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[2]

Table 1 shows the numbers of stomata in six random microscope fields of view of the lower epidermis from each of the species.

Table 1

number of stomata seen in microscope fields of view	
T. sillamontana	*T. fluminensis*
13	16
12	21
13	19
17	21
16	18
14	19
mean	mean

(b) (i) Calculate the mean number of stomata per field of view for each species **to the nearest whole number**. Insert your answers in Table 1.

[1]

(ii) State **two** precautions that should be taken to ensure that the data in Table 1 is a valid comparison between the two species.

1 .....

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2 .....

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[2]

T. sillamontana originates in Mexico and *T. fluminensis* in Brazil. Table 2 shows climate data for the areas from which the plants originate.

Table 2

month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mexico	mean monthly temperature / °C	14	17	20	23	26	27	28	28	26	22	18	15
	mean monthly rainfall / mm	18	23	16	29	40	68	62	76	151	78	26	20
Brazil	mean monthly temperature / °C	26	26	26	26	26	26	26	27	28	28	28	27
	mean monthly rainfall / mm	300	347	407	384	352	220	185	98	43	36	58	143

(c) *T. sillamontana* is found growing in the open, where there is no shade, whilst *T. fluminensis* is found growing in the shade of trees.

Use the information provided by Fig.1 and Tables 1 and 2 to explain how each species is adapted to its natural habitat.

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[5]

(d) Explain how the data in Fig. 2 provide information about the adaptations of *T. sillamontana* and *T. fluminensis* to their environments.

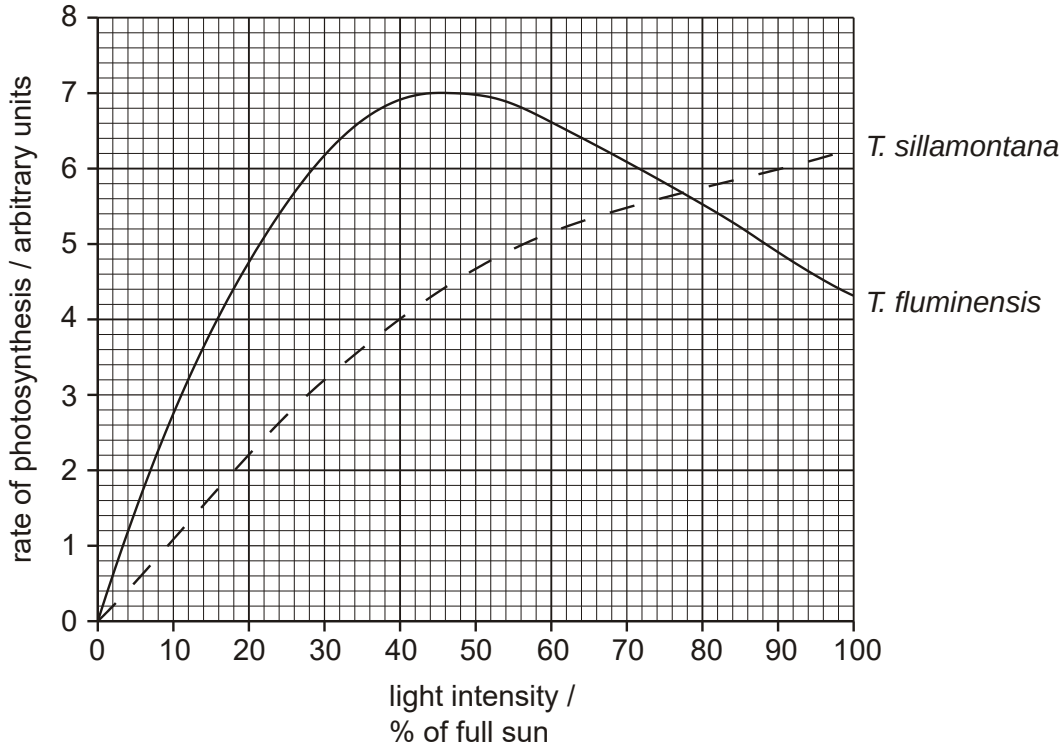

Fig. 2

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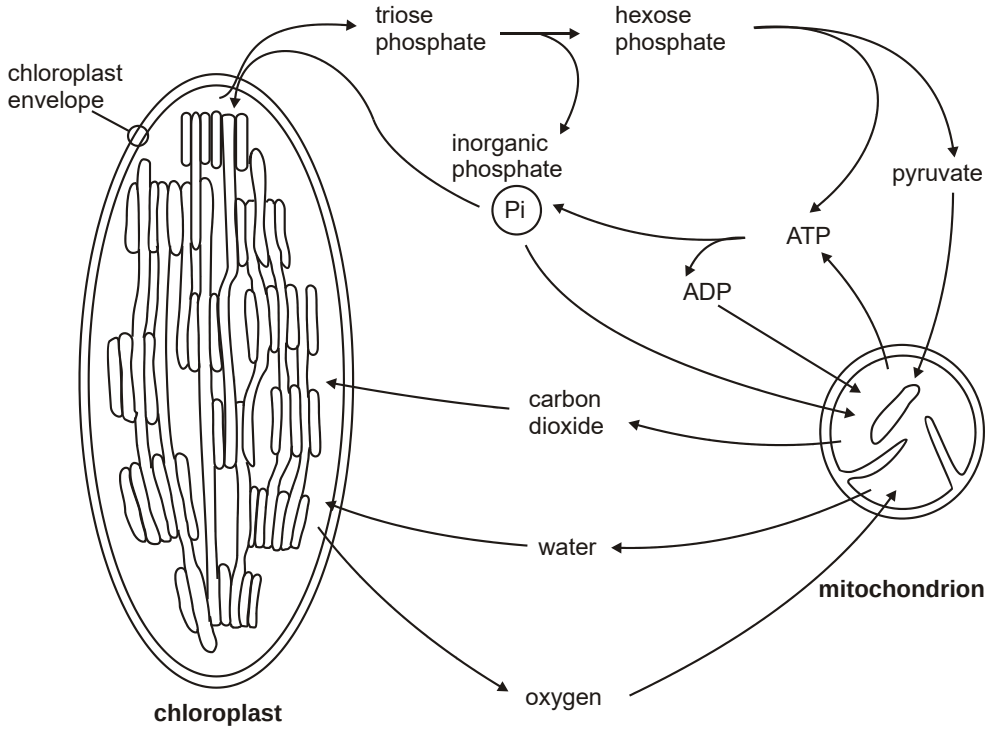
[3]

[Total 13 marks]

16. Palisade cells have both chloroplasts and mitochondria. Exchanges between a mitochondrion, a chloroplast and the cytoplasm surrounding them are shown in the figure below.



(a) A leafy shoot can be sealed inside a transparent container. The concentration of oxygen in the atmosphere within this container can be measured. In the dark, the oxygen concentration falls. At high light intensities, the oxygen concentration increases. At a particular light intensity, the oxygen concentration in the container remains constant.

Use the figure above to explain how it is possible for the oxygen concentration to remain constant.

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[4]

(b) Explain why there is no build up in the concentration of phosphate ions inside mitochondria as a result of the inward passage of phosphate ions.

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[2]

(c) Triose phosphate moves out of chloroplasts by passing through carrier proteins that are part of the chloroplast envelope. These proteins allow an inorganic phosphate ion to pass inwards at the same time as triose phosphate moves outwards.

Suggest why the movement of triose phosphate out of chloroplasts is an example of facilitated diffusion rather than active transport.

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[2]

(d) Many biologists believe that both mitochondria and chloroplasts evolved, at an early stage in the history of the earth, from prokaryotic organisms that inhabited the cytoplasm of eukaryotic host cells.

State **two** structural features of mitochondria and chloroplasts that are also present in prokaryotic cells.

1 .....

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2 .....

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[2]

[Total 10 marks]

17. There are several different pigments involved in the light-dependent reactions of photosynthesis in flowering plants.

Name **two** photosynthetic pigments found in flowering plants.

1 .....

2 .....

[Total 2 marks]

18. In this question, one mark is available for the quality of spelling, punctuation and grammar.

In the palisade cells of a leaf, the fixation of carbon dioxide occurs in the Calvin cycle.

Describe the main features of this cycle. **No credit will be given for a flow diagram of the cycle**.

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[7]

Quality of Written Communication [1]

[Total 8 marks]

19. In an investigation of photosynthesis, the rate of carbon dioxide absorption by leaves of two plants, barley and sugar cane, was measured. The leaves were provided with air, moving at a constant rate, through an apparatus that is illustrated by Fig. 1.

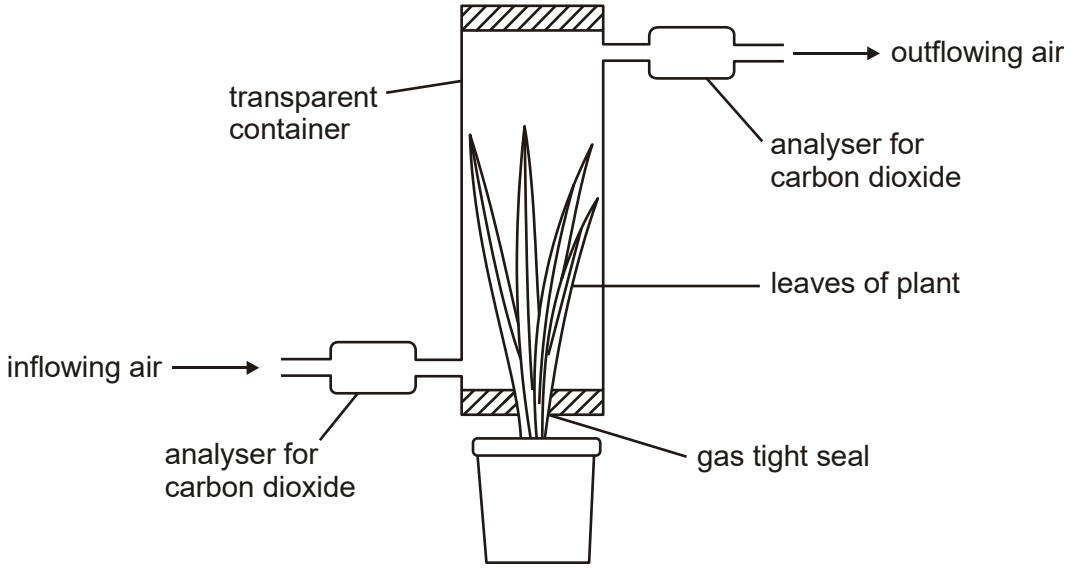

Fig. 1

- The light intensity was kept constant and high, equivalent to full sunlight.
- The concentration of carbon dioxide in the air entering the apparatus could be varied.
- The carbon dioxide taken up or given out by the leaves was determined by calculating the **difference** between the concentration in the inflowing and outflowing air.
- The leaves remained attached to the plants during the investigation.
- Two different temperatures, 10 °C and 25 °C, were used for each type of plant.

The results of the investigation are shown in Fig. 2.

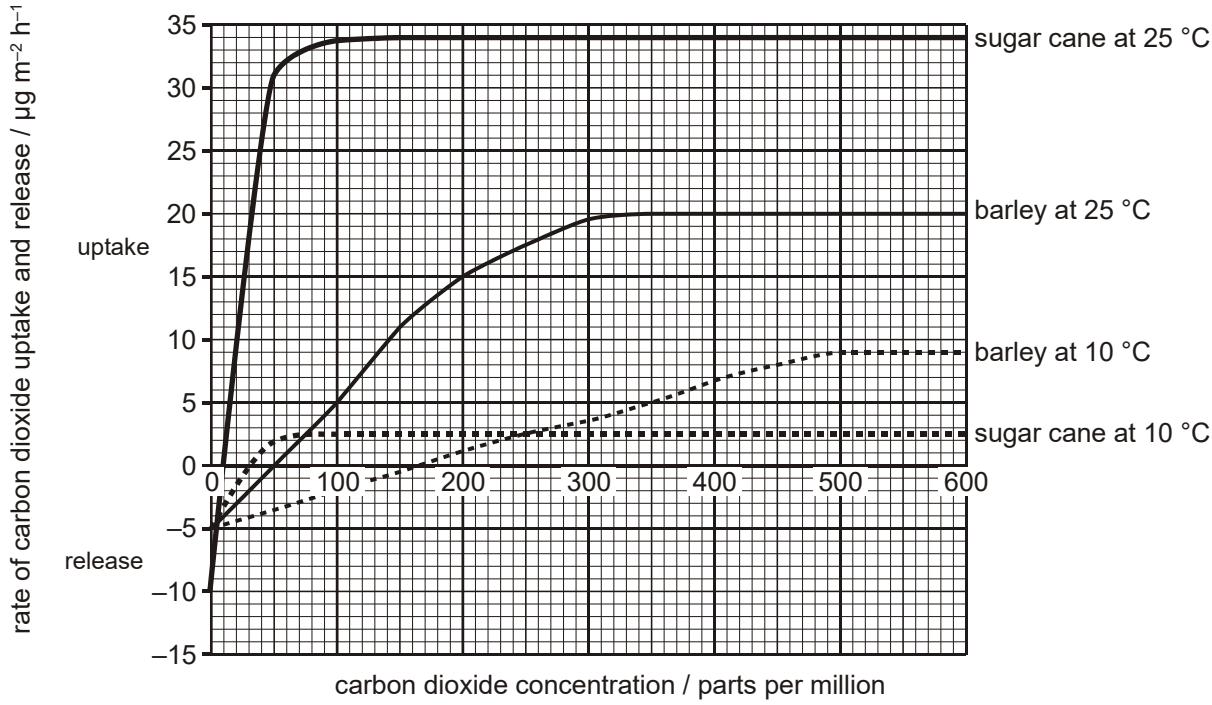

Fig. 2

(a) In all four experiments, the rate of carbon dioxide uptake reached a maximum and became constant.

Suggest why.

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[2]

(b) Explain why carbon dioxide was released when the carbon dioxide concentrations were low.

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[2]

(c) Explain why all the measurements were made at the same light intensity.

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[1]

(d) Suggest why it was important that the leaves remained attached to the plants while the measurements were made.

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[2]

(e) Comment on the similarities and differences in response of the two species, sugar cane and barley, to differences in carbon dioxide concentration and temperature.

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[5]

[Total 12 marks]