6 The molecules listed below are all associated with photosynthesis.

amino acid	**reduced NADP**
ATP	**ribulose bisphosphate (RuBP)**
carbon dioxide	**rubisco**
glycerate-3-phosphate (GP)	**triose phosphate (TP)**
oxygen	**water**

From these molecules, identify:

(a) the enzyme.

..... **[1]**

(b) a product of the light-dependent reaction that is **used** in the light-independent reaction.

..... **[1]**

(c) a 3-carbon compound.

..... **[1]**

(d) a compound that can be made from TP but is **not** part of the Calvin cycle.

..... **[1]**

(e) a 5-carbon compound.

..... **[1]**

(f) a product of the light-dependent reaction that **is not** used in the light-independent reaction.

..... **[1]**

[Total: 6]

END OF QUESTION PAPER

Answer **all** the questions.

1 **(a)** Fig. 1.1 is a diagram representing a three-dimensional view of a chloroplast.

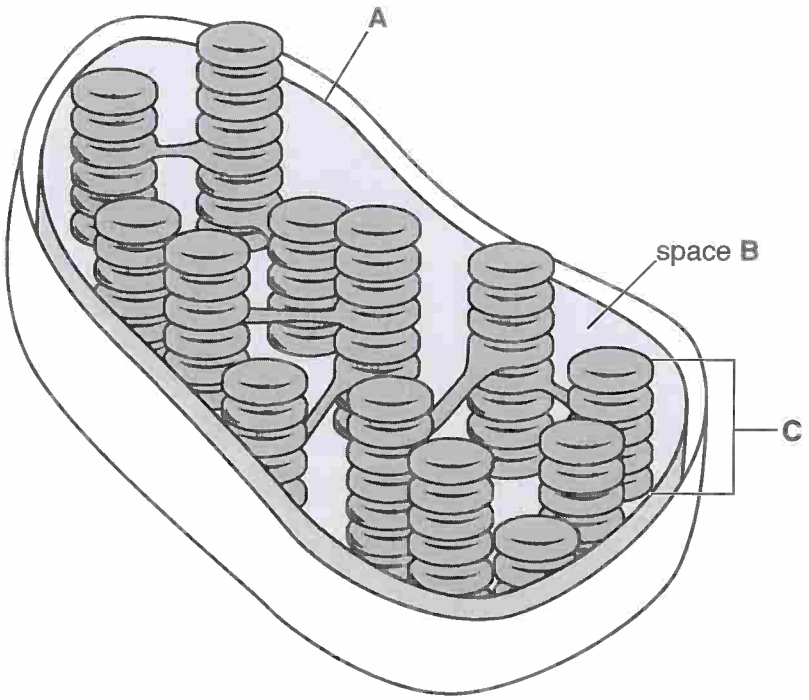

Fig. 1.1

(i) Name parts **A** to **C** in Fig. 1.1.

A .....

B .....

C ..... **[3]**

(ii) Describe **two** ways in which the structure of part **C** is adapted to its function.

.....

.....

.....

.....

.....

..... **[2]**

(iii) A key aspect of photosynthesis is the metabolic pathway involving carbon dioxide.

Place a tick (✓) in the appropriate box to indicate the part of the chloroplast (**A**, **B** or **C**) in which the metabolic pathway involving carbon dioxide is located.

A	
B	
C	

[1]

(b) Fig. 1.2 shows the theoretical and actual relationship between light intensity and the rate of photosynthesis.

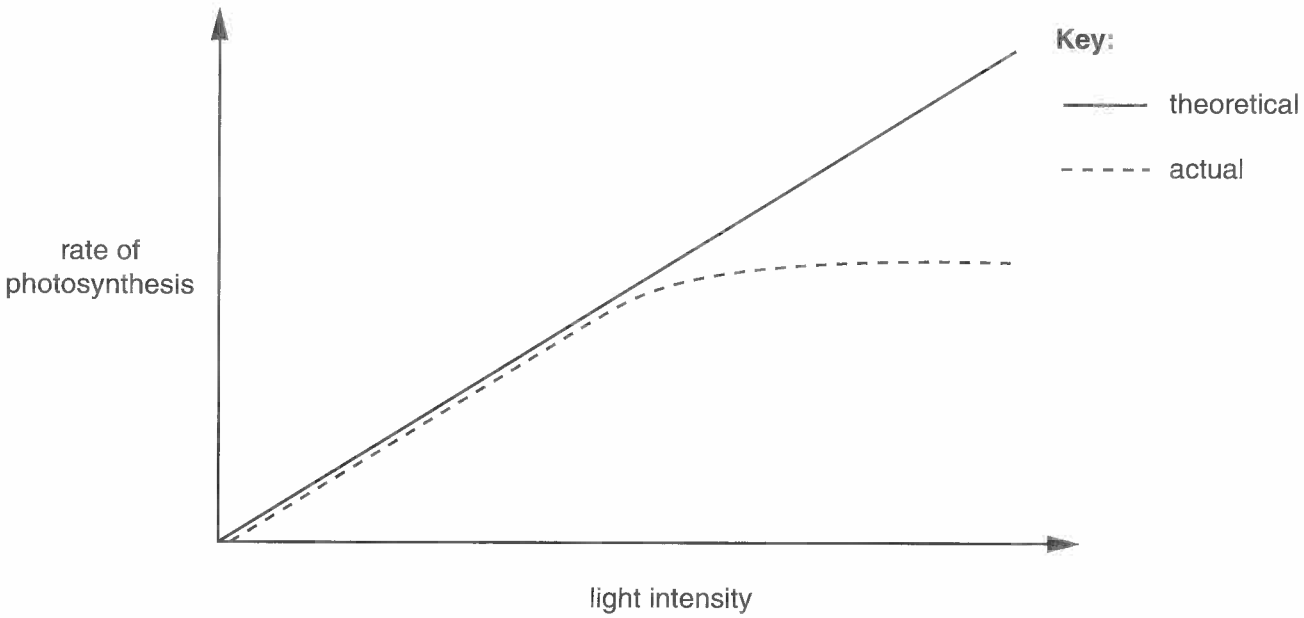

Fig. 1.2

With reference to the biochemistry of photosynthesis, explain why the theoretical rate of photosynthesis is **not** achieved at higher light intensities.

.....

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.....

.....

..... [2]

(c) Plants are usually adapted to living in conditions of different light intensities.

The rate of photosynthesis at different light intensities for two different species of plant was investigated. The results are shown in Fig. 1.3.

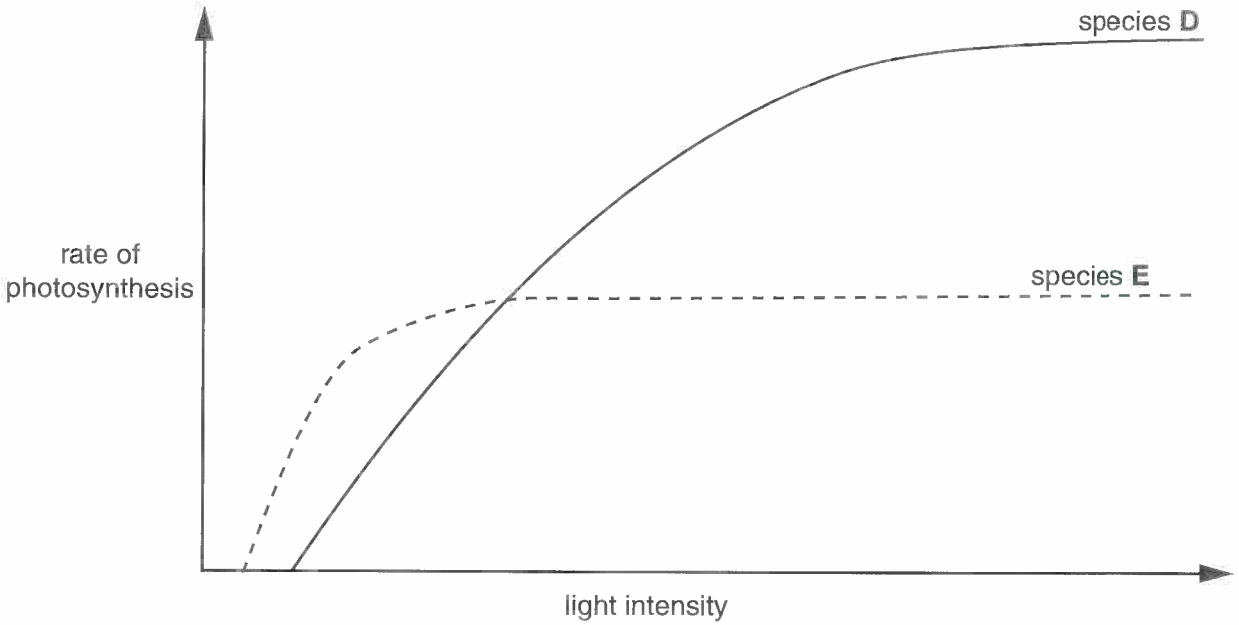

Fig. 1.3

(i) Using the information in Fig. 1.3, explain which of the two species, **D** or **E**, is better adapted to living in **shady** conditions.

.....

.....

.....

.....

.....

.....

..... **[2]**

(ii) The leaf of a plant that is adapted to living in shade will differ from the leaf of a plant that is adapted to living in sunlight.

Suggest **one** way in which the **structure** of these leaves will differ.

.....

.....

..... [1]

(d) Plants are autotrophs. Most other organisms are heterotrophs.

Outline the ways in which heterotrophic organisms are dependent on plants.

.....

.....

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.....

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.....

..... [3]

[Total : 14]

Answer **all** the questions.

1 Photosynthesis involves two main stages:

- the light-dependent stage, which involves photosystems
- the light-independent stage, which involves the Calvin cycle.

(a) Photosynthetic pigments are arranged in groups known as photosystems I and II.

(i) Name the primary photosynthetic pigment in these photosystems.

..... [1]

(ii) Name an accessory pigment.

..... [1]

(iii) State the advantage to the plant of having a range of accessory pigments in photosystems.

.....

.....

..... [1]

(iv) Name the compound that is synthesised in the light-dependent stage as a result of the generation of an electrical and pH gradient across the thylakoid membrane.

..... [1]

(b) The Calvin cycle takes place in the stroma of the chloroplast.

(i) Identify the enzyme that catalyses the fixation of carbon dioxide.

..... [1]

(ii) Identify the first stable product of carbon dioxide fixation.

..... [1]

(iii) Identify the compound that is regenerated in the Calvin cycle so that more carbon dioxide can be fixed.

..... [1]

(iv) Name **two different polysaccharides** that can be synthesised from the end products of the light-independent stage of photosynthesis.

.... [1]

[Total: 8]

3 **(a)** Explain what is meant by the terms *autotroph* and *heterotroph*.

autotroph .....

.....

.....

heterotroph .....

.....

.....

[2]

(b) Fig. 3.1 is a transmission electron micrograph showing part of a chloroplast, including some of the internal membranes.

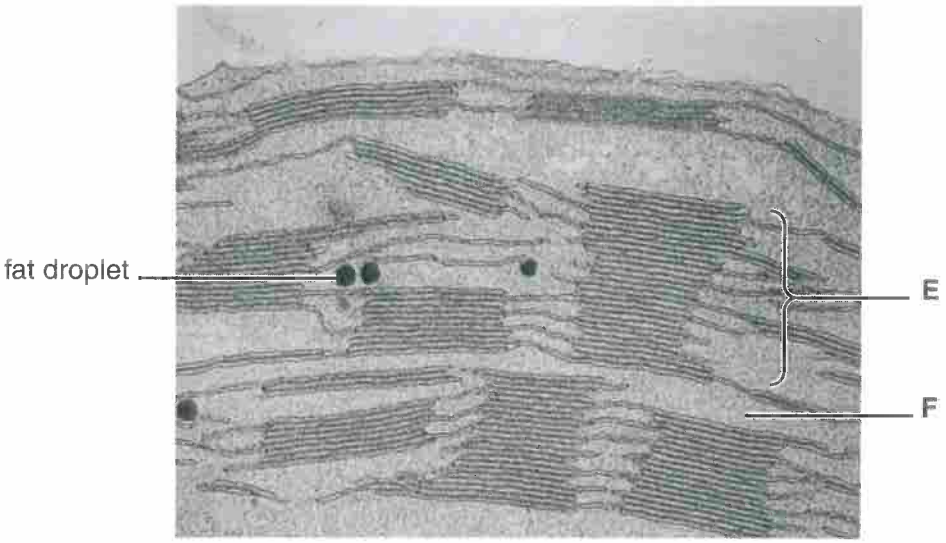

Fig. 3.1

(i) Identify **E** and **F** in Fig. 3.1.

E .....

F .....

[2]

(ii) The chloroplast contains fat droplets, as shown in Fig. 3.1. These act as a reserve of raw material **for the chloroplast**.

Suggest what this raw material might be used for in the chloroplast.

.....

.....

..... [1]

(c) Fig. 3.2 represents the light harvesting system found on the surface of the internal membranes of the chloroplast.

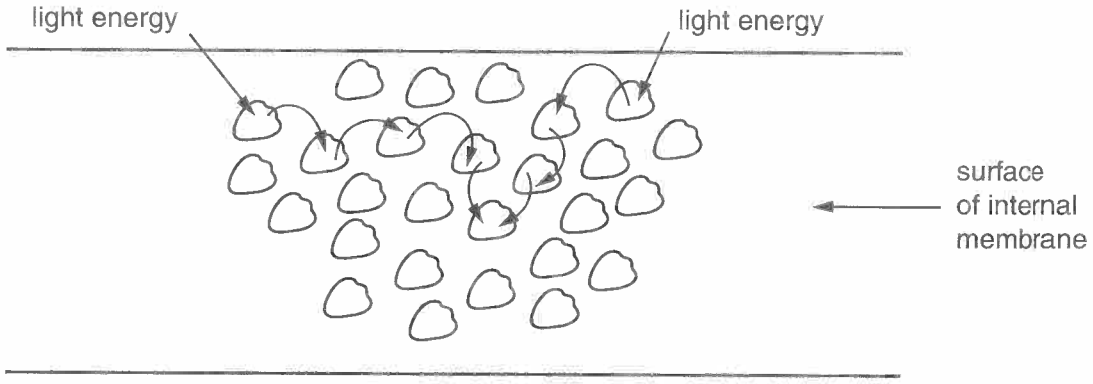

Fig. 3.2

Use the information in Fig. 3.2 to describe how light is harvested in the chloroplast membranes.

In your answer, you should use appropriate technical terms, spelled correctly.

..... [5]

(d) Many herbicides act by inhibiting photosynthesis in weeds. A series of research studies were carried out to evaluate the effectiveness of a triazine herbicide on the yield of a crop of corn, *Zea mays*. Some of the data obtained is shown in Table 3.1.

Study	Plots not treated with herbicide		Plots treated with herbicide		Yield difference with herbicide	
	Number of plots	Mean yield ($kg\,ha^{-1}$)	Number of plots	Mean yield ($kg\,ha^{-1}$)	($kg\,ha^{-1}$)	(%)
A	90	8321.4	51	8756.9	+435.5	+5.2
B	21	10344.8	3	11457.0	+1112.2	+10.8
C	30	10411.8	14	10954.5	+542.7	+5.2
D	20	13982.9	7	13607.7	−375.2	−2.7
E	2	6532.5	8	11041.6	+4509.1	+69.0
F	66	8750.2	63	8971.3	+221.1	+2.5
G	17	11671.4	7	10807.1		

Table 3.1

(i) Calculate the yield difference caused by the application of herbicide in study **G**.

Show your working.

Answer = ... $kg\,ha^{-1}$

..... % **[2]**

(ii) Suggest why the researchers concluded that the data obtained from Study **E** was not useful in evaluating the effectiveness of the herbicide.

.....

..... **[1]**

(iii) Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect that the herbicide binding to this protein will have on photosynthesis.

.....

.....

.....

..... [2]

(iv) Plants treated with triazine herbicide can, when illuminated under experimental conditions, be seen to fluoresce (emit light) and give off small quantities of heat.

Suggest how this experimental finding could be explained.

.....

.....

..... [1]

[Total: 16]

4 Biological terms are often used incorrectly. This may be because they have similar spelling or refer to similar structures.

glucagon	*glycogenolysis*
gluconeogenesis	*glycolysis*
glycogen	*insulin*
glycogenesis	*negative feedback*

Select from the list above, the term(s) that refer to:

(a) a stage in respiration

..... [1]

(b) hormone(s)

..... [1]

(c) process(es) that produce glucose

..... [1]

(d) process(es) that have glucose as a starting point

..... [1]

[Total: 4]

3 Fig. 3.1 represents some of the reactions that take place in a leaf cell of a flowering plant.

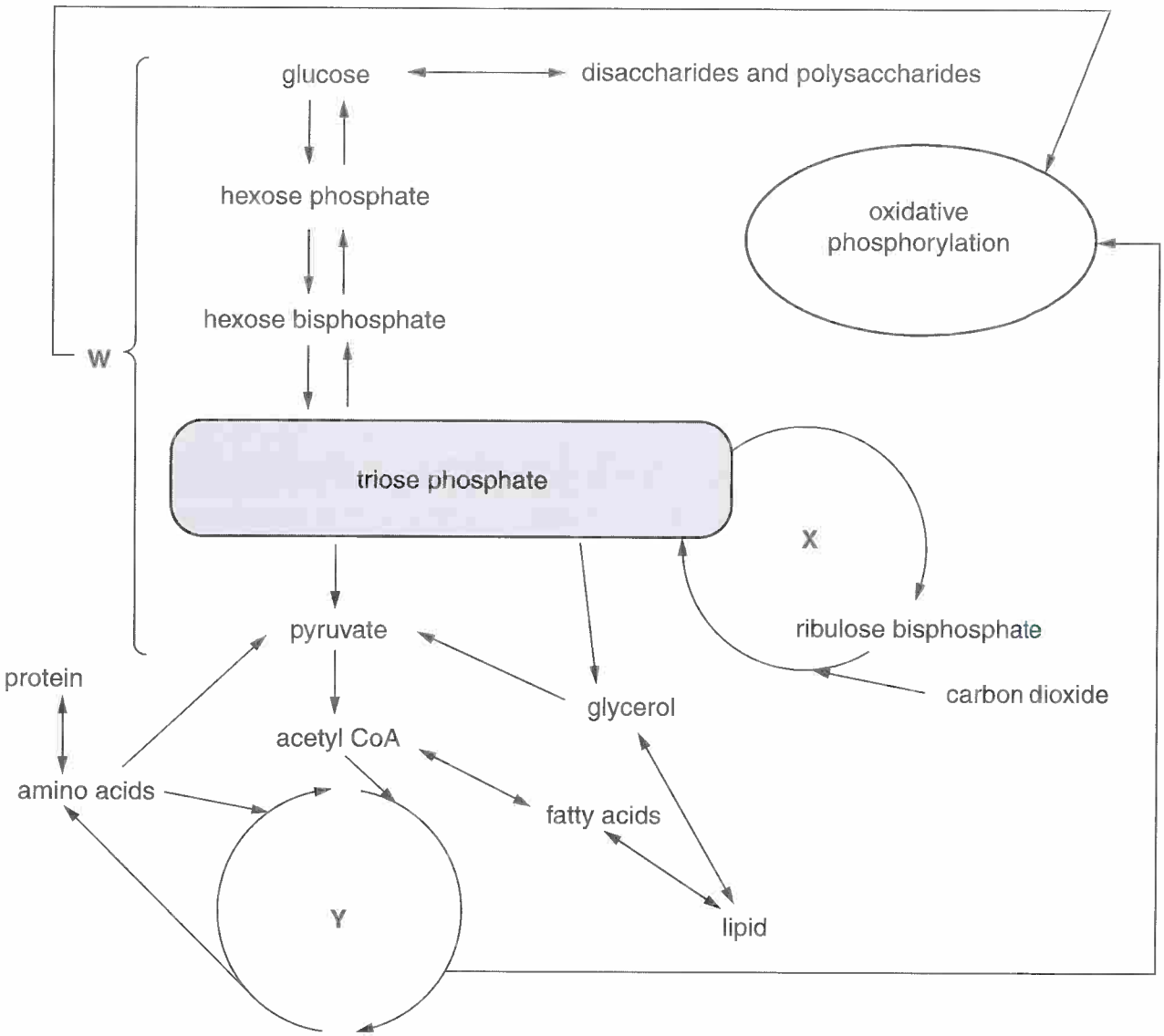

Fig. 3.1

(a) (i) Name the reaction pathways indicated by the letters **W**, **X** and **Y**.

W .....

X .....

Y ..... **[3]**

(ii) Triose phosphate is a compound that is central to the metabolism of this cell.

Explain how **the three** reaction pathways (**W**, **X** and **Y**) are able to work independently of each other in the same leaf cell.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(iii) Identify which of **these three** reaction pathways (**W**, **X** and **Y**) are associated with:

photosynthesis .....

aerobic respiration..... [2]

(iv) Fig. 3.1 shows that compounds from two of the three pathways are used in oxidative phosphorylation.

State the products of oxidative phosphorylation.

.....

..... [2]

(b) Explain the role of coenzymes in this leaf cell, with respect to the metabolic reactions outlined in Fig. 3.1.

.....

.....

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.....

.....

.....

.....

..... [3]

[Total: 13]

6 The leaves of flowering plants have the ability to develop differently, depending on environmental conditions such as the amount of sun or shade a leaf receives.

A student carried out an investigation into sun and shade leaves from different parts of the same plant. Her observations and results are shown in Table 6.1.

Table 6.1

type of leaf	number of leaves studied	mean no. of stomata per mm^2 on lower surface	mean thickness of leaf (μm)	cuticle
sun	55	170	208	thick
shade	8	92	93	thin

(a) Calculate the percentage difference in the **mean thickness** of the sun leaves compared to the shade leaves.

Show your working.

Answer = ... **[2]**

(b) Suggest **and** explain one benefit of the greater **mean number** of stomata per mm^2 on the lower surfaces of the sun leaves.

.....

.....

.....

.....

..... **[2]**

(c) Describe **two** ways in which the student could improve her investigation.

.....

.....

.....

.....

..... **[2]**

[Total: 6]

END OF QUESTION PAPER

3 **(a)** Fig. 3.1 is an electron micrograph of a chloroplast from a tobacco leaf.

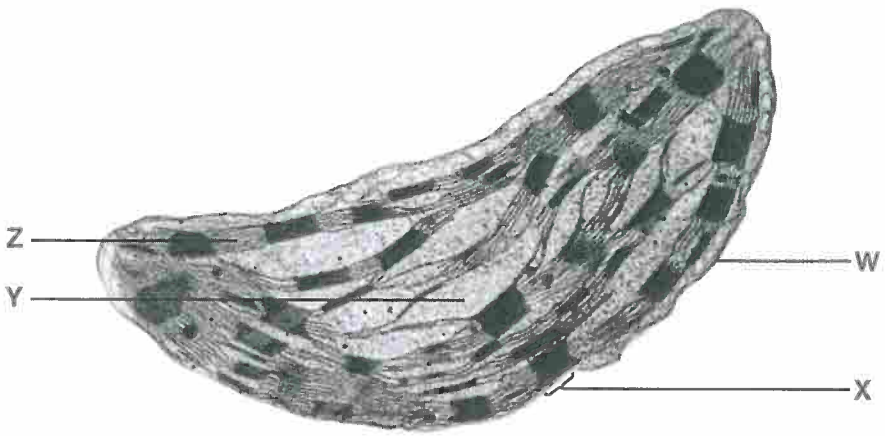

Fig. 3.1

(i) Identify the structures labelled **W** to **Z**.

W .....

X .....

Y .....

Z ..... **[4]**

(ii) In addition to the structures seen in Fig. 3.1, a chloroplast also contains DNA and ribosomes.

Suggest the role of DNA and ribosomes **in this organelle**.

.....

.....

.....

.....

.....

..... **[2]**

(b) The table below contains statements that refer to the light-dependent stage of photosynthesis.

Complete the table, indicating with the letters **C**, **N** or **B**, whether each statement applies to:

- cyclic photophosphorylation only (**C**)

  or

- non-cyclic photophosphorylation only (**N**)

  or

- both cyclic and non-cyclic photophosphorylation (**B**)

The first one has been completed for you.

statement	letter
ATP is produced	**B**
an electron leaves photosystem I	
electrons are passed along an electron carrier chain	
electrons leave both photosystem I and photosystem II	
an electron from a water molecule replaces the electron lost from the photosystem	
the same electron returns to the photosystem	

[5]

[Total: 11]

4 One way to determine the rate of photosynthesis is to measure the uptake of carbon dioxide.

(a) Discuss why measuring carbon dioxide uptake may or may not give a better indication of photosynthetic activity than measuring oxygen production.

.....

.....

.....

.....

.....

..... **[2]**

(b) Fig. 4.1 shows the relationship between light intensity and the relative carbon dioxide uptake and production in a plant.

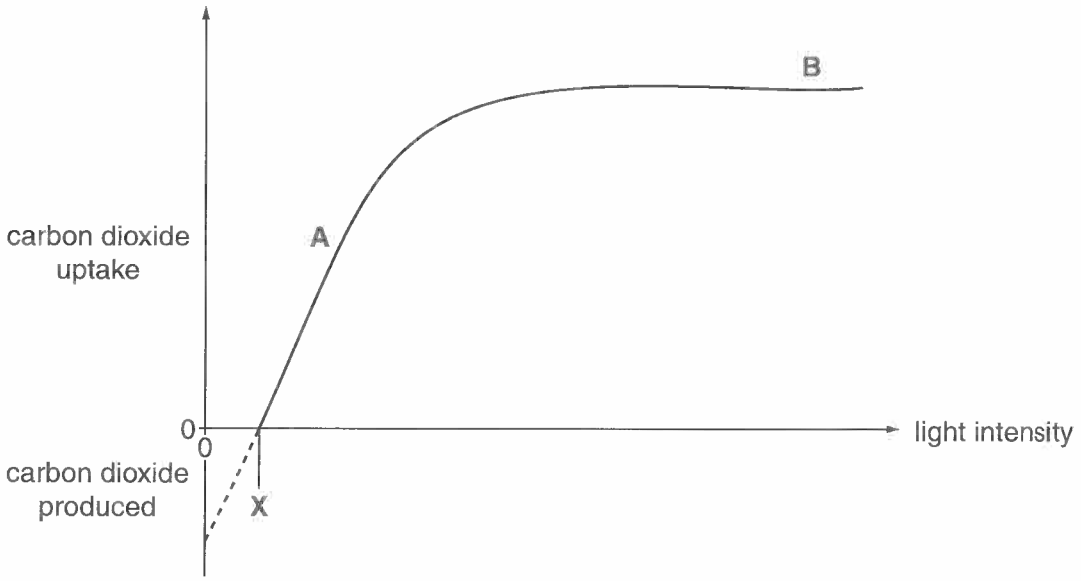

Fig. 4.1

(i) State the factor that is limiting the rate of photosynthesis at **A** on the graph.

..... **[1]**

(ii) Suggest **one** factor that may limit the rate of photosynthesis at **B**.

..... **[1]**

(iii) Carbon dioxide is given off by the plant when the light intensity is lower than **X**.

Name the process that **produces** carbon dioxide in the plant.

..... [1]

(iv) With reference to Fig. 4.1, explain the biochemical processes that are occurring in the plant:

- as light intensity increases from 0 (zero) to **X**.
- at light intensity **X**.
- at light intensities greater than **X**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(c) (i) Name the products of the light-dependent stage of photosynthesis.

.....

.....

..... **[3]**

(ii) Paraquat is a weedkiller. It binds with electrons in photosystem I.

Suggest how paraquat results in the death of a plant.

.....

.....

.....

.....

.....

..... **[2]**

[Total: 13]

QUESTION 5 STARTS ON PAGE 12

2 A student carried out an experiment to investigate the effect of light intensity on the rate of photosynthesis in an aquatic plant, using the apparatus shown in Fig. 2.1.

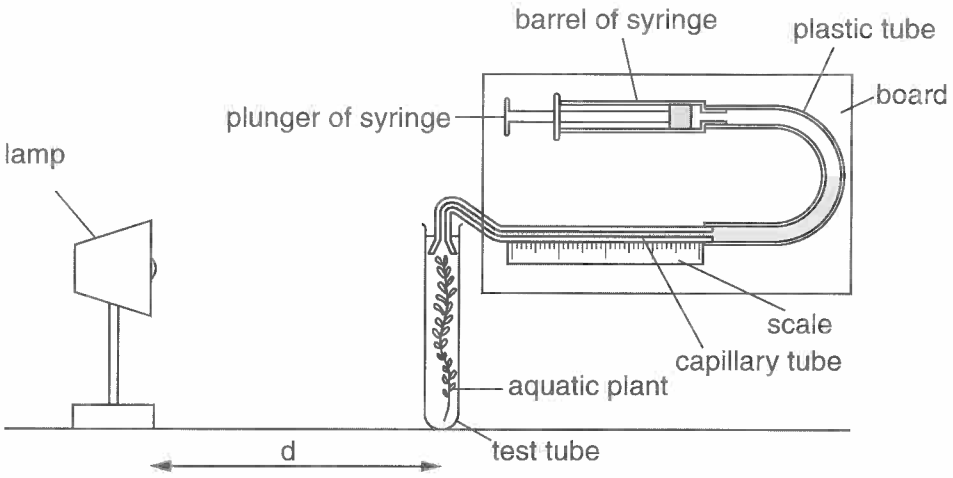

Fig. 2.1

The student decided to measure the rate of photosynthesis by measuring the gas produced over a five minute period. The gas collected in the capillary tube.

After five minutes, the length of the bubble was measured along the scale.

The light intensity was varied by altering the distance (d) between the lamp and the photosynthesising plant.

The student prepared Table 2.1 to calculate the light intensity.

Table 2.1

distance (d) from lamp to plant (cm)	light intensity $\left(\frac{1}{d^2}\right)$
4	0.0625
8	0.0156
12	0.0069
16	0.0039
20	0.0025
24	
60	0.0003

(a) **(i)** Calculate the light intensity when the lamp was 24 cm from the plant.

Show your working.

Answer = ... **[2]**

(ii) The length of the gas bubble was measured (in mm).

State what additional information would be required to calculate the **volume** of gas produced.

.....

.....

..... **[1]**

(iii) Suggest how the student supplied the aquatic plant with a source of carbon dioxide.

.....

.....

..... **[1]**

(b) Certain assumptions are made when using the apparatus shown in Fig. 2.1 to measure the rate of photosynthesis.

(i) One of these assumptions is that all of the oxygen produced by the plant during photosynthesis is collected.

Suggest why not all of the oxygen produced by the plant is collected.

.....

.....

.....

.....

.....

..... **[2]**

(ii) Another assumption is that all of the gas collected is oxygen.

Analysis of the gas collected reveals that it has the following composition:

- oxygen 50%
- nitrogen 44%
- carbon dioxide 6%

Suggest a reason for the presence of nitrogen in the gas collected.

.....

.....

..... **[1]**

(iii) Comment on the percentage of carbon dioxide present in the gas collected and give reasons for this figure.

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(c) Some aquatic photosynthetic organisms, for example seaweeds, contain pigments such as fucoxanthin and phycoerythrin, in addition to chlorophyll. These pigments give seaweeds a brown or red colour and are produced in larger quantities in those seaweeds that live in deeper water.

Suggest why the presence of these pigments is an advantage to seaweeds that live in deeper water.

.....

.....

.....

.....

.....

..... **[2]**

[Total: 12]

3 **(a)** The Calvin cycle is the stage of photosynthesis during which carbon dioxide is fixed. The Calvin cycle uses the products of the light dependent stage.

(i) Name the products of the light dependent stage that are used in the Calvin cycle.

.....

..... **[2]**

(ii) Discuss the fate of triose phosphate (TP) in the Calvin cycle.

.....

.....

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.....

.....

.....

..... **[3]**

(b) A process known as **photorespiration** also takes place in photosynthetic cells. In this process, oxygen competes with carbon dioxide for the active site of the enzyme RuBP carboxylase (Rubisco).

Fig. 3.1 (a) and Fig. 3.1 (b) outline the processes of photosynthesis and photorespiration.

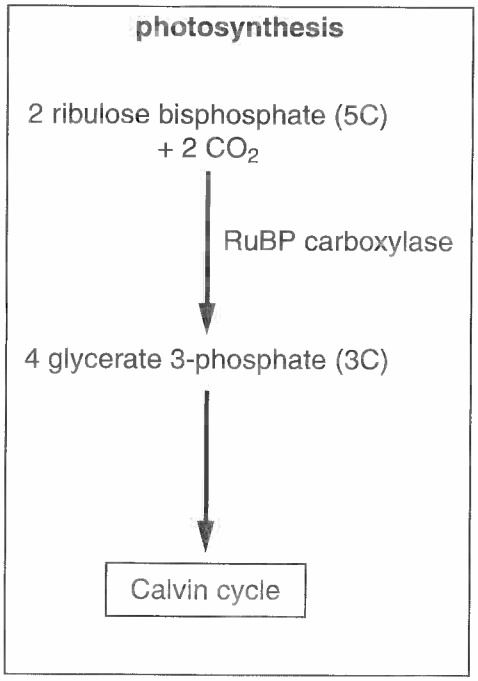

Fig. 3.1 (a)

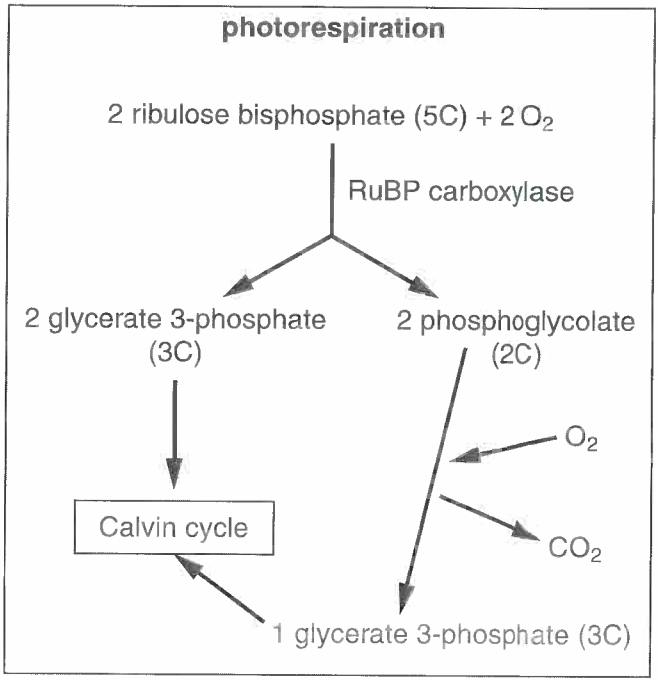

Fig. 3.1 (b)

(i) Suggest why the process outlined in Fig. 3.1 (b) is known as photorespiration.

.....

.....

.....

..... [2]

(ii) Using Fig. 3.1 (a) and Fig. 3.1 (b), describe and explain the likely effect on photosynthesis of an increase in the oxygen concentration.

.....

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.....

.....

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.....

..... [3]

(iii) Some plants, known as C_4 plants, use an enzyme called PEP carboxylase, instead of Rubisco, to fix carbon dioxide.

Suggest why these plants do **not** show photorespiration.

.....

.....

..... [1]

[Total: 11]