Photosynthesis

Model Answers 3

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Communication, homeostasis and energy
Topic	Photosynthesis
Booklet	Model Answers 3

Time allowed: **65 minutes**

Score: **/48**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

Phospholipid bilayers play crucial roles within plant cells.
Which of the following statements linked to the importance of membranes in plant cells is/are true?

Statement 1: ATP synthase embedded in thylakoid membranes maintains chemiosmotic gradients.

Statement 2: Phospholipid bilayers within the chloroplast are impermeable to protons.

Statement 3: Thylakoid membranes contain electron transport chain proteins.

A 1, 2 and 3

B. Only 1 and 2

C. Only 2 and 3

D. Only 1

[1]

ATP synthase does not **maintain** chemiosmotic gradients. It allows the hydrogen ions from the thylakoid space to return to the stroma.

Question 2

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]

- The oxygen given off is only produced in one stage of photosynthesis, it might also be used up in respiration
- Carbon dioxide produced by respiration might be used in photosynthesis
- Oxygen given off is net production / carbon dioxide uptake is net use.

The term 'net' refers to the overall change. If you have a job, then you earn (in theory) a gross wage, but what you take home is the overall or net wage, minus any outgoings such as tax.

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

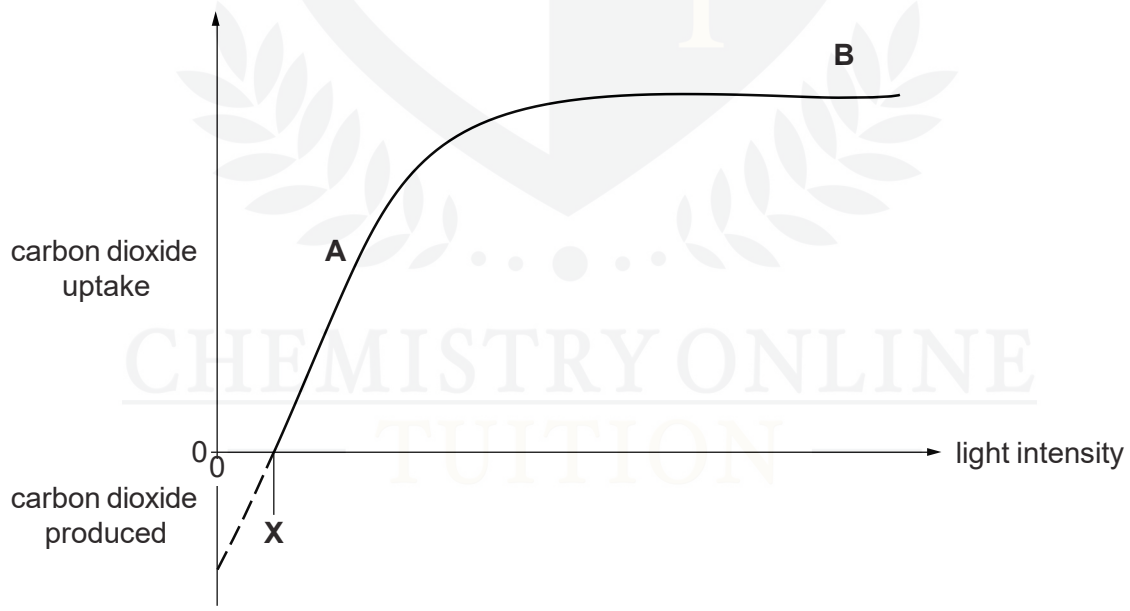


Fig. 4.1

(i) State the factor that is limiting the rate of photosynthesis at **A** on the graph. **[1]**

- Light is limiting the rate of photosynthesis at A

A limiting factor is one that, if it is increased, the rate of the process increases.

(ii) Suggest **one** factor that may limit the rate of photosynthesis at **B**. **[1]**

At B the light intensity has no effect so carbon dioxide concentration could be limiting or the temperature

(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]**

- Aerobic or anaerobic respiration produces carbon dioxide in plants

Lactic acid or lactate (they are interchangeable) is produced by anaerobic respiration in animals

(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]**

- At zero there is no light so only respiration is taking place
- From 0 to X the rate of photosynthesis is still below that of respiration
- At X the rate of photosynthesis is equal to respiration, this is the compensation point
- At light intensities above X the rate of photosynthesis is greater than respiration

The area under the graph above X is the net primary production by photosynthesis, if you add to this the area under the graph below X, this is the gross primary production. The area under the graph is the carbon dioxide produced by respiration

(c) (i) Name the products of the light-dependent stage of photosynthesis. **[1]**

The products of the light dependent stage are oxygen, ATP and reduced NADP / NADPH / $NADPH_2$

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

Suggest how paraquat results in the death of a plant. **[2]**

- There will be less photophosphorylation
- Both cyclic and non-cyclic will be affected
- Less ATP / reduced NADP / GP will be produced
- Less sugars will be made by the plant

[Total: 13]

Question 3

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

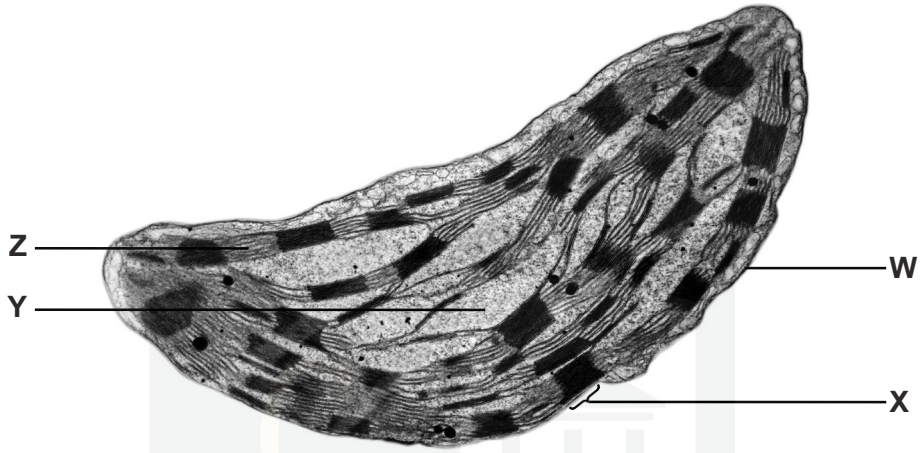


Fig. 3.1

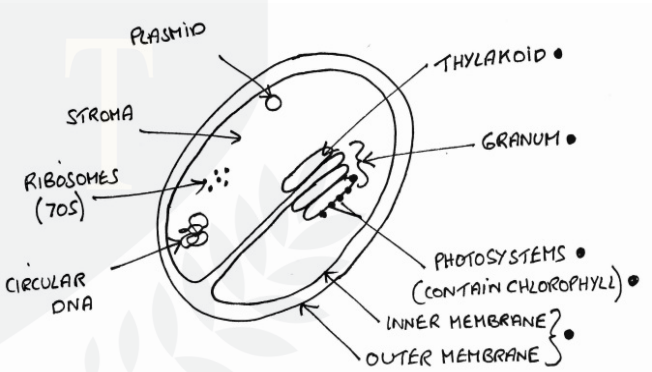
(i) Identify the structures labelled **W** to **Z**. **[4]**

W chloroplast membrane

X Granum

Y Stroma

Z thylakoid



(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]**

- The DNA codes for the sequence of amino acids in a protein such as an enzyme
- Ribosomes are where translation of the messenger RNA takes place
- Enzymes may be needed in the chloroplast, for example the enzyme RuBisCO in Calvin cycle
- Proteins may be needed for the electron transport chain
- Enzymes such as ATP synthase are also needed
- Enzymes are needed for the photolysis or splitting the water

Note the question refers in bold to processes **in the organelle** in other words **in the chloroplast**. You cannot simply describe the role of DNA and ribosomes in general terms, so give examples of where proteins and enzymes are involved in the process of photosynthesis.

(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: **[5]**

- cyclic photophosphorylation only (**C**)

  or

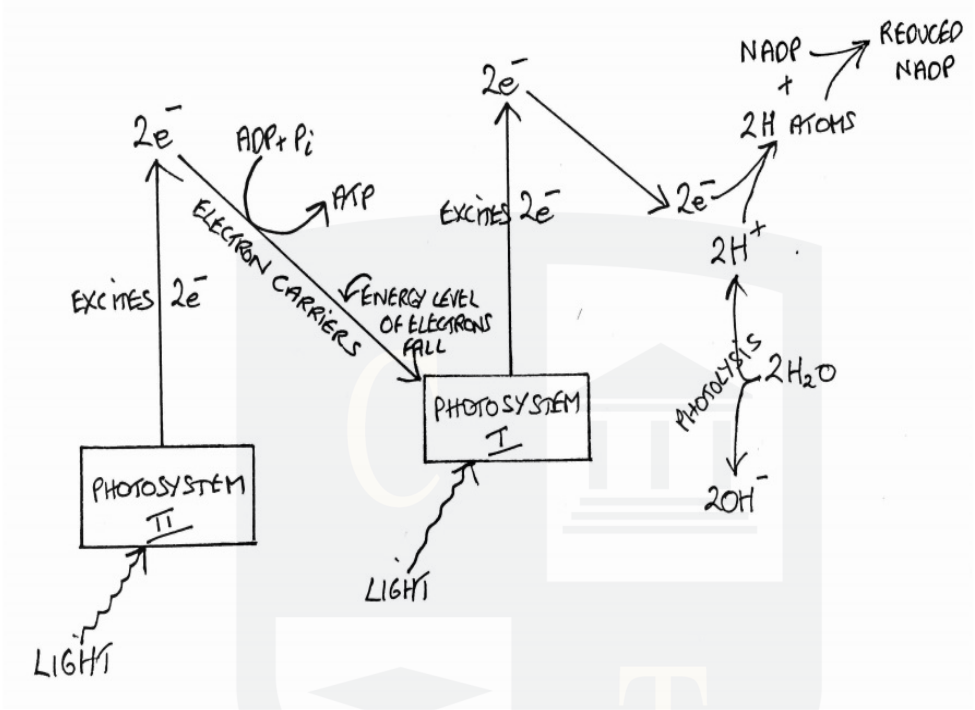
- non-cyclic photophosphorylation only (**N**)

  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	B
electrons are passed along an electron carrier chain	B
electrons leave both photosystem I and photosystem II	N
an electron from a water molecule replaces the electron lost from the photosystem	N
the same electron returns to the photosystem	C



[Total: 11]

Question 4

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.

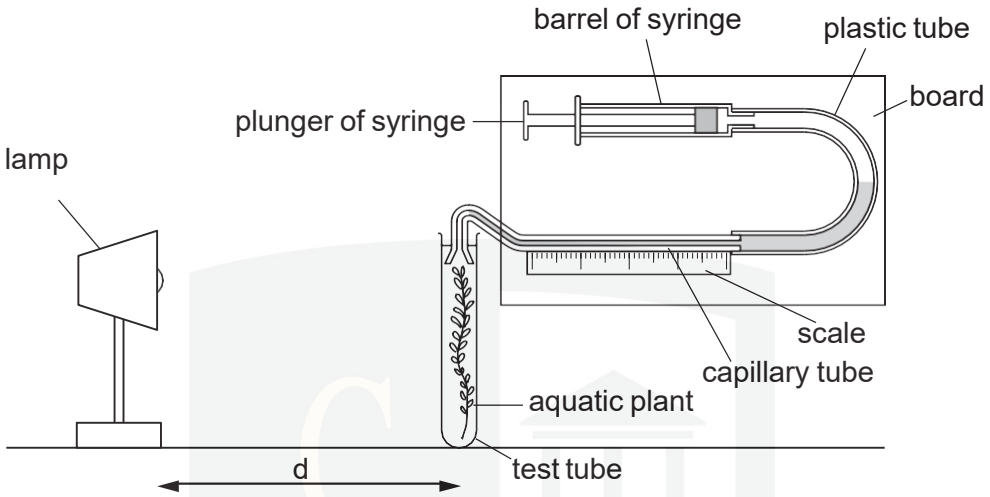


Fig. 2.1

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	0.0017
60	0.0003

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

Show your working. **[2]**

- 0.0017

Note what happens to the light intensity as the distance from the lamp to the plant decreases. When the lamp is 16 cm away, the light intensity is 0.0039 but when the distance is halved to 8 cm the light intensity has increased to 0.0156. A four-fold increase.

So when the distance between the lamp and the plant is halved the rate of photosynthesis increases by a factor of 4, unless the light intensity is so high that light is not a limiting factor.

(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]**

The radius or diameter of the capillary tube or its cross sectional area

(iii) Suggest how the student supplied the aquatic plant with a source of carbon dioxide. **[1]**

Carbon dioxide can be provided by hydrogen carbonate solution

(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]**

- Some of the oxygen produced by photosynthesis would dissolve in the water
- Some oxygen is also used up in respiration
- Oxygen may also escape the collection apparatus

To understand gases in solution you need to know that they dissolve better in colder temperatures, so if the temperature of a solution increases, then the gases will be less soluble and 'come out of solution.

(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]**

- Some of the nitrogen was present in the airspaces in the leaf of the plant
- This nitrogen leaves the plant with the oxygen

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

[3]

- The percentage of carbon dioxide is higher than expected and higher than that in the atmosphere
- The plant is respiring and producing carbon dioxide during respiration
- Carbon dioxide has also been added to the water in the form of hydrogen carbonate solution
- Then maybe less carbon dioxide than you would expect as it is used up in photosynthesis

One of the advantages of using pondweed to measure the rate of photosynthesis is that the oxygen given off can easily be collected; another is that carbon dioxide concentration can easily be controlled by adding more or less hydrogen carbonate to the solution.

(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]**

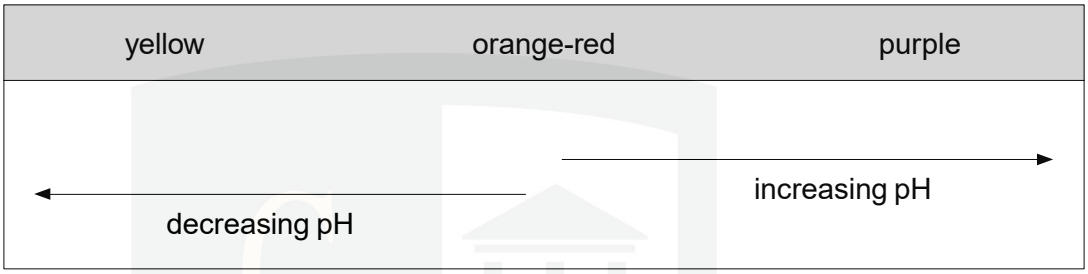
- In deeper water the light intensity is lower
- These brown or red pigments can absorb what little light there is
- Red pigments are capable of absorbing blue light which may penetrate deeper into the water
- Shorter wavelengths of light can penetrate deeper

[Total: 12]

Question 5

(a) 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 one contained 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 Table 5.1.

Table 5.1

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. **[1]**

- The purpose of the tube covered with black paper is to act as a control and as a comparison to show that it is the wavelength of light producing the effect.

It shows the results produced without light and creates a baseline to ensure the validity of the investigation

(ii) State **two** precautions that need to be taken when designing and carrying out this experiment to make sure the results allow valid conclusions to be drawn. Explain the need for each precaution. **[2]**

precaution 1

Temperature should be kept the same throughout the investigation as this affects the enzyme activity which also plays an important role in the process of photosynthesis

precaution 2

Carbon dioxide concentration should be kept the same as this too affects the rate of photosynthesis

(iii) Name the pigment at the reaction centre of photosystems I and II. **[1]**

The pigment at the reaction centre is chlorophyll a

(iv) Explain the change observed in the tube exposed to green light. **[3]**

Green light cannot be absorbed by chlorophyll pigments so hardly any photosynthesis can take place. The slight acidity is due to the production of carbon dioxide by respiration which must slightly exceed the carbon dioxide used up

(b) Market gardeners often grow plants in glasshouses in order to get maximum production. 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.

[4]

- If temperature can be increased in a glasshouse then the rate of photosynthesis will increase as enzymes such as Rubisco will affect the productivity of the plants
- Nutrients can be added regularly to the plants to increase production. Nitrates are needed for the production of proteins and magnesium is needed for the production of chlorophyll which absorbs the site needed for photosynthesis
- Diseases can be controlled by the use of pesticides and fungicides; these will reduce production by the plants as the pests will use up important nutrients

[Total: 11]