| Surname | Date | Tutor |
|---|---|---|
| First name(s) | | |

BioWelsh

# GCE A LEVEL

BW-A2-3.2-W1

## TOPIC WORKSHEET 1 – 3.2 PHOTOSYNTHESIS

## BIOLOGY – A2 unit 3

### Energy, Homeostasis and the Environment

Suggested time: 3 hours 25 minutes

**For Tutor's use only**

| Question | Maximum Mark | Mark Awarded | Question | Maximum Mark | Mark Awarded |
|---|---|---|---|---|---|
| 1. | 10 | | 9. | 10 | |
| 2. | 11 | | 10. | 8 | |
| 3. | 10 | | 11. | 10 | |
| 4. | 10 | | 12. | 13 | |
| 5. | 11 | | 13. | 10 | |
| 6. | 11 | | 14. | 11 | |
| 7. | 10 | | 15. | 9 | |
| 8. | 10 | | Total | 154 | |



**ADDITIONAL MATERIALS**

In addition to this worksheet, you will require a calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use a pencil for graphs and diagrams only.
Write your name and the date in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **154** marks.
The assessment of the quality of extended response (QER) will take place in question **15**.
The quality of written communication will affect the awarding of marks.

This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic 3.2). It is not an official WJEC paper.




**Turn over.**

Tutor only

Answer **all** questions.

1. **Image 1.1** is a light micrograph of a transverse section through part of a leaf of privet, *Ligustrum*.

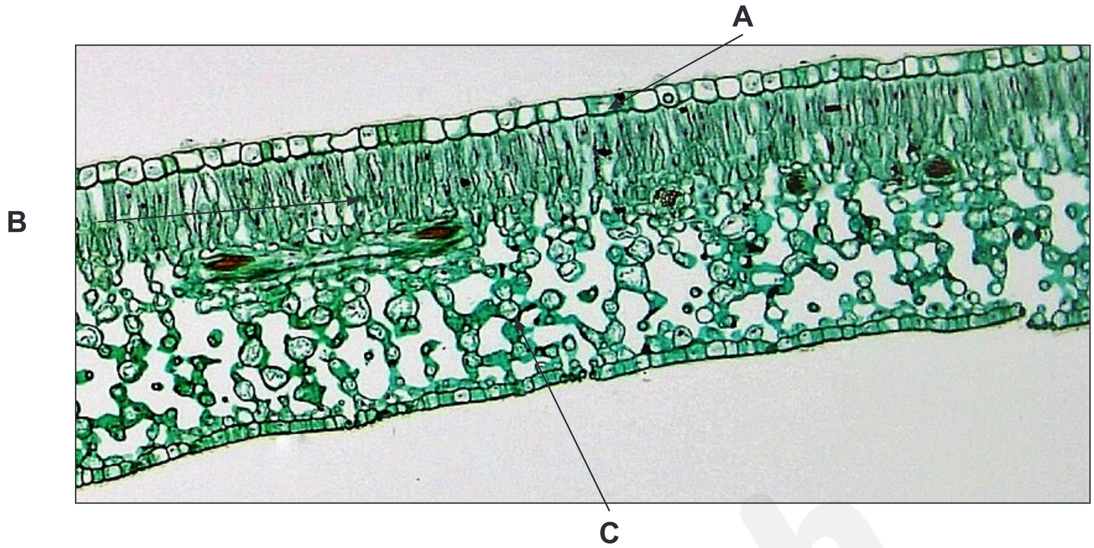


**Image 1.1**

(a) Identify the tissues labelled **A**, **B** and **C**. [2]

A ..............................

B ..............................

C ..............................

(b) Describe the distribution of chloroplasts in the leaf. [2]

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(c) Explain how the arrangement of the cells in tissue **B** allows the leaf to trap as much light as possible. [2]

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Tutor only

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Beech trees have sun leaves at the top of the tree and shade leaves lower down. **Table 1.2** shows measurements of the two types of leaf.

**Table 1.2**

| Type of leaf | Mean thickness of leaf / µm | Mean thickness of palisade mesophyll / µm |
|---|---|---|
| **sun leaf** | 190 | 95 |
| **shade leaf** | 100 | 40 |

(d) (i) Calculate the percentage of the leaf thickness made up of palisade mesophyll in each type of leaf. [2]

Sun leaf ..............................................................................................................

Shade leaf ..............................................................................................................

(ii) Suggest why shade leaves have a thinner layer of palisade mesophyll than sun leaves. [2]

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Turn over.

Tutor only

**2.** **Image 2.1** is a simplified drawing of a chloroplast from a palisade mesophyll cell.

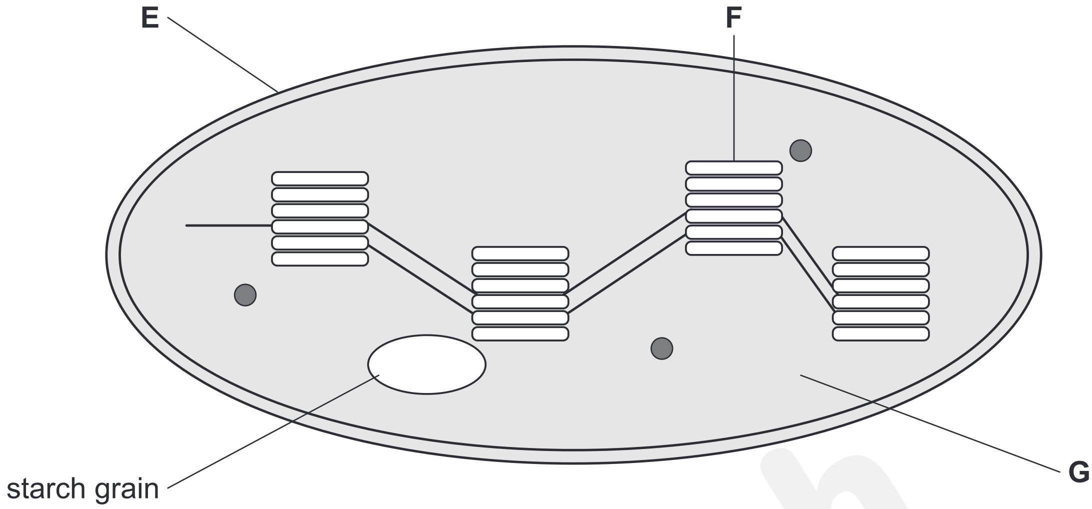


**Image 2.1**

(a) Identify the parts labelled **E**, **F** and **G**. [2]

E ..........

F ..........

G ..........

(b) Chloroplasts are described as transducers. Explain what this means. [2]

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(c) State **precisely** where in the chloroplast the light-dependent and light-independent stages take place. [2]

Light-dependent ..........

Light-independent ..........

(d) In dim light, chloroplasts spread out along the cell walls nearest the leaf surface. In very bright light, they move to the side walls of the cell. Suggest an advantage of each of these arrangements. [2]

Dim light ..........

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Tutor only

Bright light ..............................................................................................................................

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(e) A leaf received 6000 kJ $m^{-2}$ of light energy in one day and stored 150 kJ $m^{-2}$ of energy in glucose. Calculate the percentage of the light energy that was stored. [1]

Percentage = .............................. %

(f) Suggest **two** reasons why most of the light energy was not stored in glucose. [2]

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Turn over.

Tutor only

**3.** In 1882, Theodor Engelmann shone a spectrum of light onto a filament of the green alga *Cladophora*. The water around the alga contained aerobic bacteria, which move towards higher concentrations of oxygen. **Image 3.1** shows where the bacteria gathered after a few minutes.

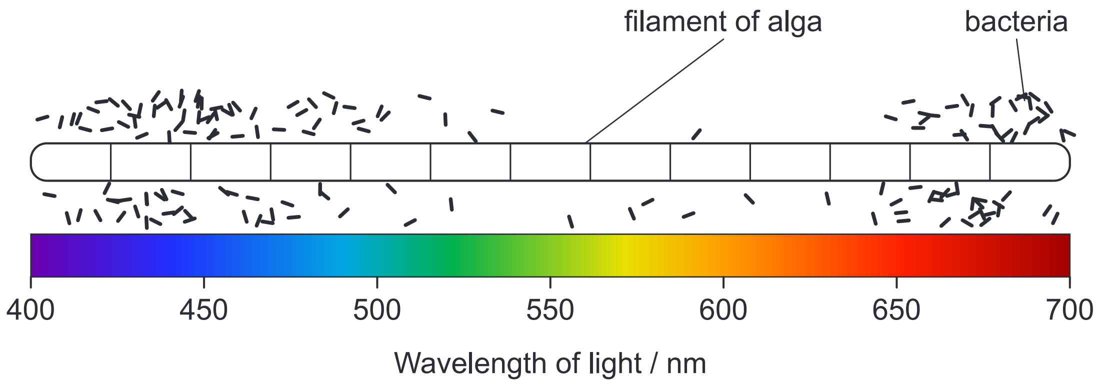


**Image 3.1**

(a) Explain why the bacteria gathered next to some parts of the filament. [2]

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(b) Use **Image 3.1** to state the **two** ranges of wavelengths at which the rate of photosynthesis was highest. [1]

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**Table 3.2** shows a count of the bacteria along equal lengths of the filament.

**Table 3.2**

| Wavelength / nm | 425 | 450 | 500 | 550 | 600 | 650 | 675 | 700 |
|---|---|---|---|---|---|---|---|---|
| **Number of bacteria** | 38 | 46 | 20 | 6 | 10 | 34 | 44 | 8 |

(c) (i) Calculate how many times more bacteria were found at 675 nm than at 550 nm. Give your answer to **1 decimal place**. [1]

Number of times = ..........

Tutor only

(ii) Explain why very few bacteria were found at 550 nm. [2]

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(d) A graph of the data in **Table 3.2** would be an action spectrum. Explain the difference between an action spectrum and an absorption spectrum. [2]

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(e) Chlorophyll *a* absorbs very little light at 500 nm. Suggest why a number of bacteria were still found at 500 nm. [2]

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Tutor only

**4.** Students extracted pigments from spinach leaves by grinding them with sand and propanone. They placed a spot of the extract on the origin of a thin-layer chromatography plate and placed the plate in a solvent in a boiling tube, as shown in **Image 4.1**.

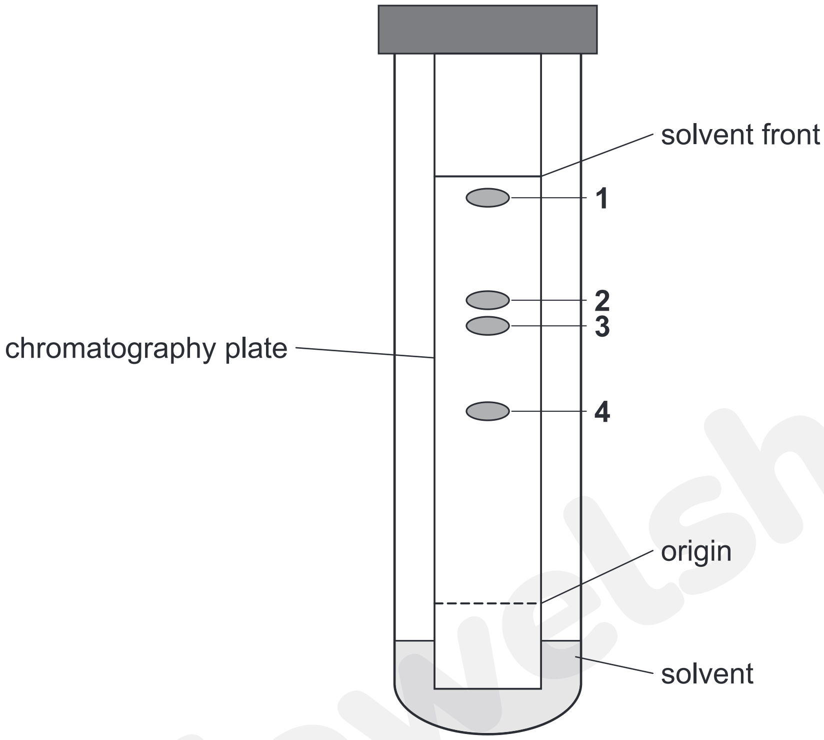


**Image 4.1**

(a) Explain why the origin was drawn in pencil and not in ink. [1]

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(b) Explain why the origin must be above the level of the solvent. [1]

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**Table 4.2** shows the distance moved by each spot and by the solvent front.

**Table 4.2**

| Spot | 1 | 2 | 3 | 4 | solvent front |
|---|---|---|---|---|---|
| **Distance moved from origin / mm** | 76 | 57 | 52 | 36 | 80 |

Tutor only

**Table 4.3** shows the $R_f$ values of four pigments in the same solvent.

**Table 4.3**

| Pigment | $R_f$ |
|---|---|
| carotene | 0.95 |
| xanthophyll | 0.71 |
| chlorophyll *a* | 0.65 |
| chlorophyll *b* | 0.45 |

$R_f$ = distance moved by pigment ÷ distance moved by solvent front

(c) (i) Calculate the $R_f$ values of spots 2 and 4. Give your answers to **2 decimal places**. [2]

Spot 2 ..........

Spot 4 ..........

(ii) Use **Tables 4.2** and **4.3** to identify spots 1 to 4. [2]

1 ..........

2 ..........

3 ..........

4 ..........

(d) Explain why the pigments move different distances up the plate. [2]

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(e) Spots 2 and 3 were close together and partly overlapped. Suggest **one** reason why this makes the results less accurate and **one** way the method could be improved. [2]

Reason ..........

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Improvement ..........

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Tutor only

**5.** **Image 5.1** shows a photosystem in a thylakoid membrane, seen from above. **L** is the reaction centre. **M** accepts electrons from the reaction centre.

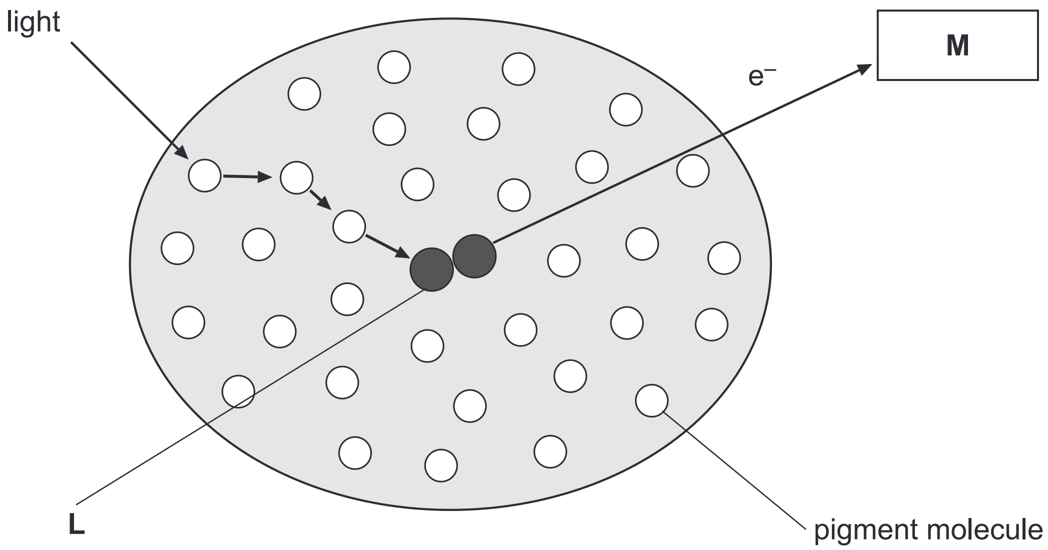


**Image 5.1**

(a) Name the pigment found at **L**. [1]

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(b) Describe how energy from light absorbed by the pigment molecules results in an electron reaching **M**. [3]

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(c) Explain the advantage of having several different pigments in a photosystem. [2]

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Tutor only

(d) State the wavelength of light best absorbed by the reaction centre of photosystem I and of photosystem II. [1]

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In 1957, Robert Emerson measured the rate of photosynthesis of an alga lit with light of 680 nm, light of 710 nm, or both together. **Table 5.2** shows results of this type.

**Table 5.2**

| Light | Rate of oxygen production / au |
|---|---|
| 680 nm only | 30 |
| 710 nm only | 8 |
| 680 nm and 710 nm together | 62 |

(e) (i) Calculate how many times greater the rate with both wavelengths together was than the sum of the rates with each wavelength alone. Give your answer to **1 decimal place**. [1]

Number of times = ..............................

(ii) Light of 710 nm is absorbed by photosystem I but not by photosystem II. Explain the results in **Table 5.2**. [3]

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Tutor only

**6.** Some herbicides kill weeds by acting on the light-dependent stage of photosynthesis. **Image 6.1** shows the flow of electrons in this stage. DCMU acts at **X** and stops electrons leaving photosystem II. Paraquat acts at **Y**, where it accepts electrons from photosystem I in place of NADP.

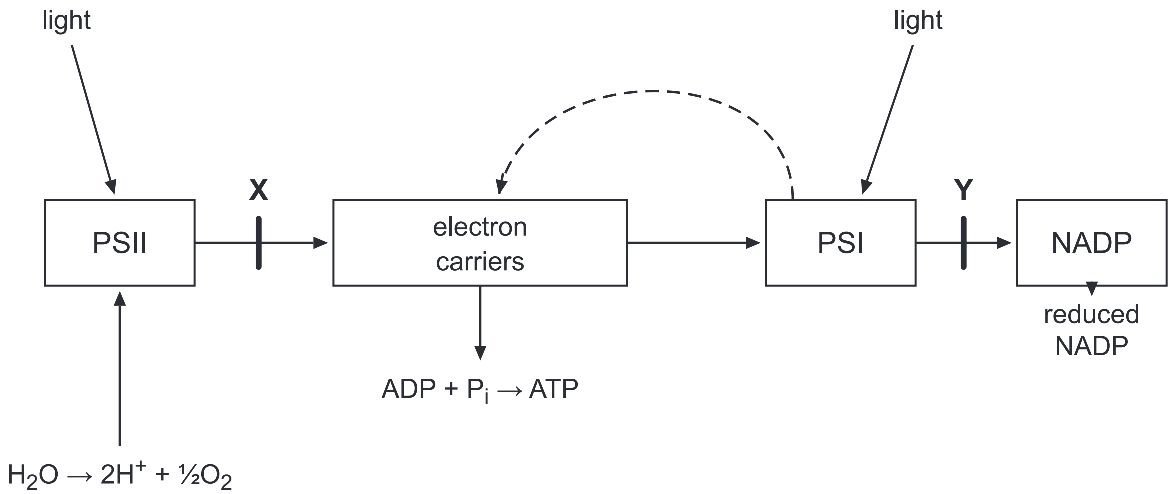


**Image 6.1**

Chloroplasts were isolated and lit in a solution containing ADP, inorganic phosphate and NADP. **Table 6.2** shows the results.

**Table 6.2**

| Herbicide added | Oxygen released / au | Reduced NADP formed / au | ATP formed / au |
|---|---|---|---|
| none | 100 | 100 | 100 |
| DCMU | 3 | 2 | 35 |
| paraquat | 96 | 1 | 92 |

(a) Name the process shown by $H_2O \rightarrow 2H^+ + ½O_2$ and state where in the chloroplast NADP is reduced. [2]

Process ..........................................................................................................

Where NADP is reduced ..............................................................................

(b) Explain why DCMU stops the release of oxygen. [3]

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Tutor only

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(c) Suggest how some ATP was still made in the presence of DCMU. [2]

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(d) Explain why oxygen was still released with paraquat, but almost no reduced NADP was formed. [2]

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(e) Suggest why weeds treated with paraquat die even though their chloroplasts still release oxygen. [2]

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Tutor only

**7.** *Anabaena* is a photosynthetic bacterium that grows as filaments of cells. Some cells become heterocysts, which fix nitrogen gas using the enzyme nitrogenase. Nitrogenase is inactivated by oxygen. Heterocysts have photosystem I but no active photosystem II. **Image 7.1** shows part of a filament.

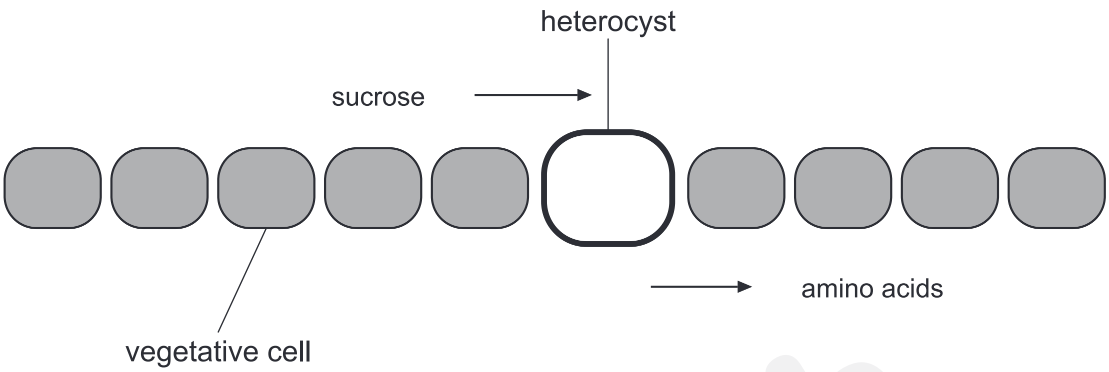


**Image 7.1**

(a) Complete **Table 7.2** to compare cyclic and non-cyclic photophosphorylation. [3]

**Table 7.2**

| Feature | Cyclic | Non-cyclic |
|---|---|---|
| photosystem(s) involved | ............ | ............ |
| photolysis of water (yes / no) | ............ | ............ |
| reduced NADP formed (yes / no) | ............ | ............ |
| oxygen released (yes / no) | ............ | ............ |

(b) Explain why heterocysts do not release oxygen. [2]

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(c) Suggest why it is important that heterocysts do not release oxygen. [1]

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Tutor only

(d) Heterocysts cannot carry out the light-independent stage. Using **Image 7.1**, explain why they rely on neighbouring cells for sucrose. [2]

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(e) Suggest why the vegetative cells benefit from the amino acids made by heterocysts. [2]

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Turn over.

Tutor only

**8.** **Image 8.1** shows the Calvin cycle in the stroma of a chloroplast. **J**, **K** and **L** are compounds. **E** is an enzyme.

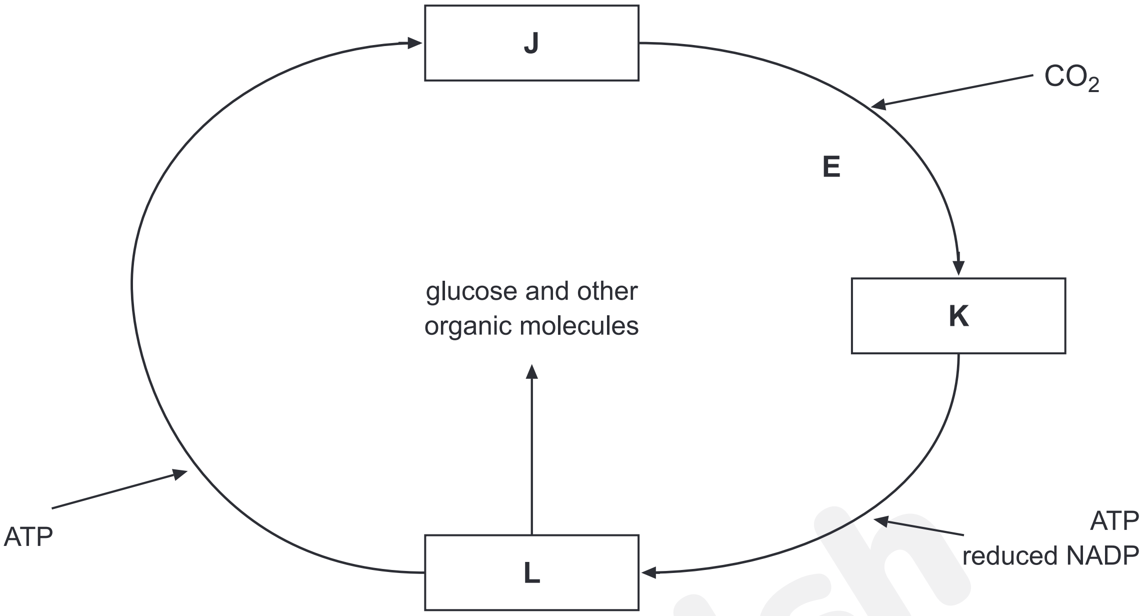


**Image 8.1**

(a) Name compounds **J**, **K** and **L** and enzyme **E**. [2]

J ..........

K ..........

L ..........

E ..........

(b) State the number of carbon atoms in one molecule of **J** and in one molecule of **K**. [1]

J ..........

K ..........

(c) Explain the roles of ATP and reduced NADP in converting **K** into **L**. [2]

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Tutor only

(d) When one molecule of carbon dioxide is fixed, 3 molecules of ATP and 2 molecules of reduced NADP are used. Calculate the number of molecules of ATP and of reduced NADP needed to make one molecule of glucose. [2]

ATP ..........

Reduced NADP ..........

(e) For every six molecules of **L** made, five are used to regenerate **J**. Calculate the percentage of **L** that is available to make other organic molecules. Give your answer to **1 decimal place**. [1]

Percentage = .......... %

(f) Explain why the regeneration of **J** is essential for photosynthesis to continue. [2]

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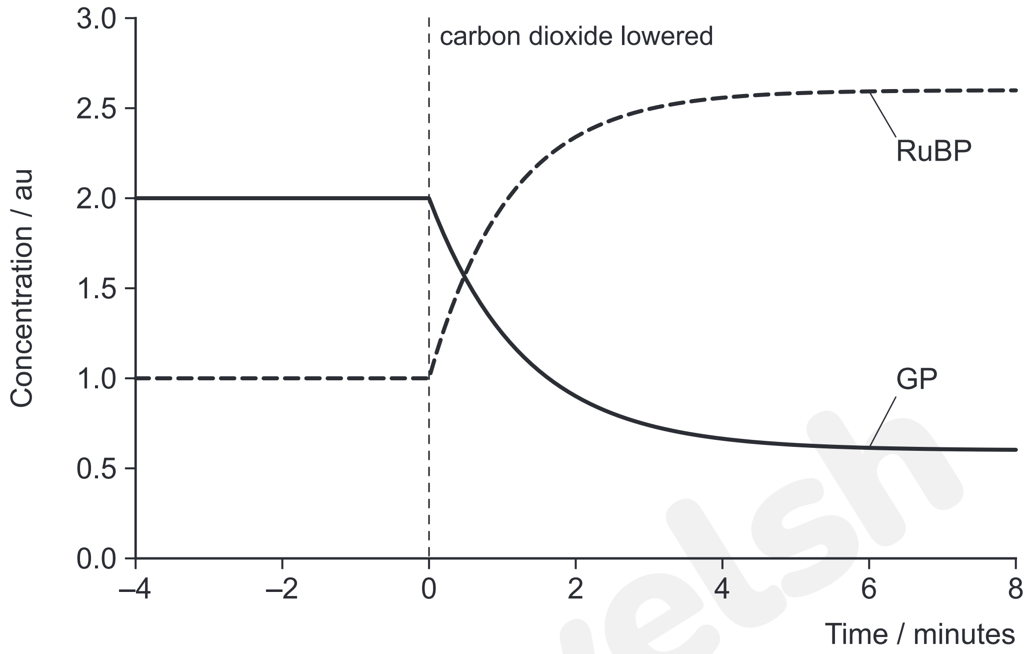
Tutor only

**9.** A suspension of the alga *Chlorella* was kept in bright light with 1 % carbon dioxide. At 0 minutes, the carbon dioxide concentration was lowered to 0.03 %. **Graph 9.1** shows the concentrations of RuBP and GP in the algal cells.




**Graph 9.1**

(a) Describe the change in the concentration of RuBP after the carbon dioxide concentration was lowered. [2]

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(b) Explain why the concentration of RuBP increased. [2]

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(c) Explain why the concentration of GP decreased. [2]

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Tutor only

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(d) Calculate the percentage decrease in the concentration of GP between 0 and 8 minutes. [2]

Percentage decrease = .......... %

(e) Predict the effect of lowering the carbon dioxide concentration on the concentration of triose phosphate. Explain your answer. [2]

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Tutor only

**10.** Triose phosphate made in the Calvin cycle is used to make other organic molecules. **Image 10.1** shows some of these. **P** is a polysaccharide stored in chloroplasts. **P**, **Q** and **R** are products.

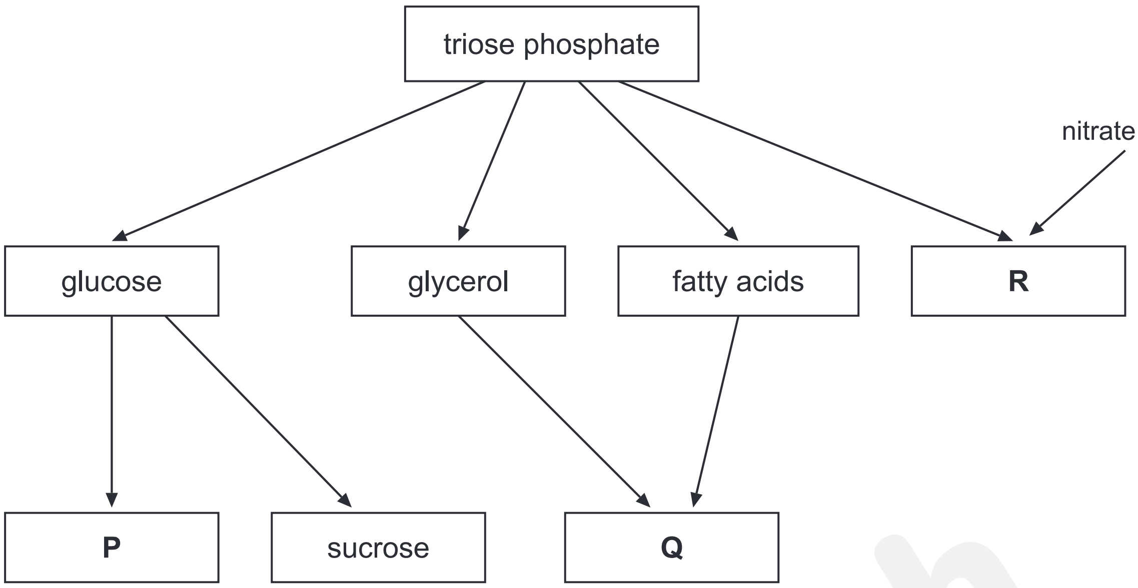


**Image 10.1**

(a) Name **P**, **Q** and **R**. [2]

P ..................................................

Q ..................................................

R ..................................................

(b) Explain why nitrate is needed to make **R**. [1]

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Tutor only

A potato leaf was given carbon dioxide containing radioactive carbon for 2 minutes. **Table 10.2** shows the percentage of the radioactive carbon found in different compounds after 10 minutes and after 60 minutes.

**Table 10.2**

| Compound | Percentage of radioactive carbon after 10 minutes | Percentage of radioactive carbon after 60 minutes |
|---|---|---|
| triose phosphate | 45 | 8 |
| sucrose | 20 | 45 |
| starch | 10 | 30 |
| amino acids | 5 | 8 |
| lipids | 2 | 4 |
| other compounds | 18 | 5 |

(c) (i) Explain the changes in the percentages for triose phosphate, sucrose and starch. [2]

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(ii) Calculate the percentage of the radioactive carbon that was **not** in triose phosphate, sucrose or starch after 60 minutes. [1]

Percentage = .............................. %

(d) Suggest why plants store carbohydrate as starch rather than as glucose. [2]

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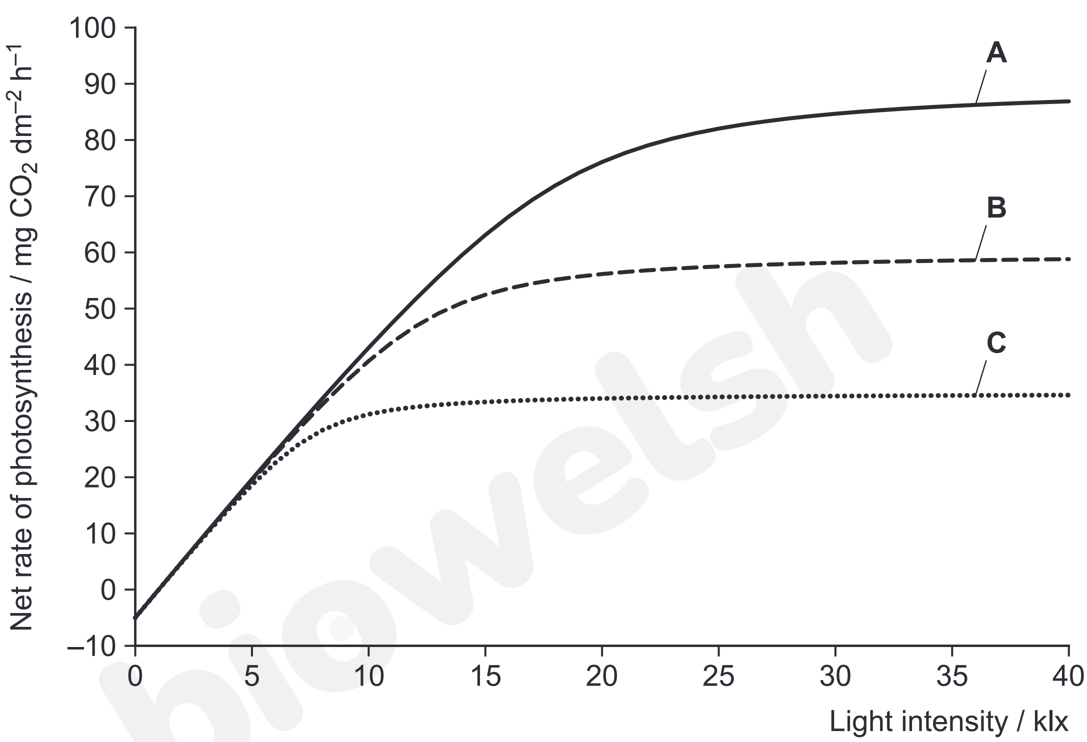
Turn over.

Tutor only

**11.** A grower measured the net rate of photosynthesis of lettuce leaves at different light intensities in three sets of conditions, shown in **Table 11.1**. **Graph 11.2** shows the results.

**Table 11.1**

| Curve | Carbon dioxide concentration / % | Temperature / °C |
|---|---|---|
| **A** | 0.10 | 25 |
| **B** | 0.10 | 15 |
| **C** | 0.04 | 25 |




**Graph 11.2**

(a) State the factor limiting the rate of photosynthesis in all three sets of conditions at 5 klx. [1]

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(b) Identify the factor limiting the rate of photosynthesis of curve **C** at 30 klx and of curve **B** at 30 klx. Use **Graph 11.2** to give evidence for each. [3]

Curve C ..........................................................................................

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Curve B ..........................................................................................

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Tutor only

(c) Calculate the rate of increase in the net rate of photosynthesis between 0 and 5 klx. Give the units. [2]

Rate of increase = ..............................

(d) State the light intensity at which the net rate of photosynthesis is zero and explain why there is no net uptake of carbon dioxide at this light intensity. [2]

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(e) In winter, the light intensity in the greenhouse is about 6 klx. The grower plans to raise the carbon dioxide concentration to 0.10 %. Use **Graph 11.2** to evaluate this plan. [2]

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Tutor only

**12.** A student investigated the effect of carbon dioxide concentration on the rate of photosynthesis of the pondweed *Cabomba*, using the apparatus in **Image 12.1**. The concentration of sodium hydrogencarbonate solution was changed and the length of the gas bubble collected in 5 minutes was measured. Three trials were carried out at each concentration.

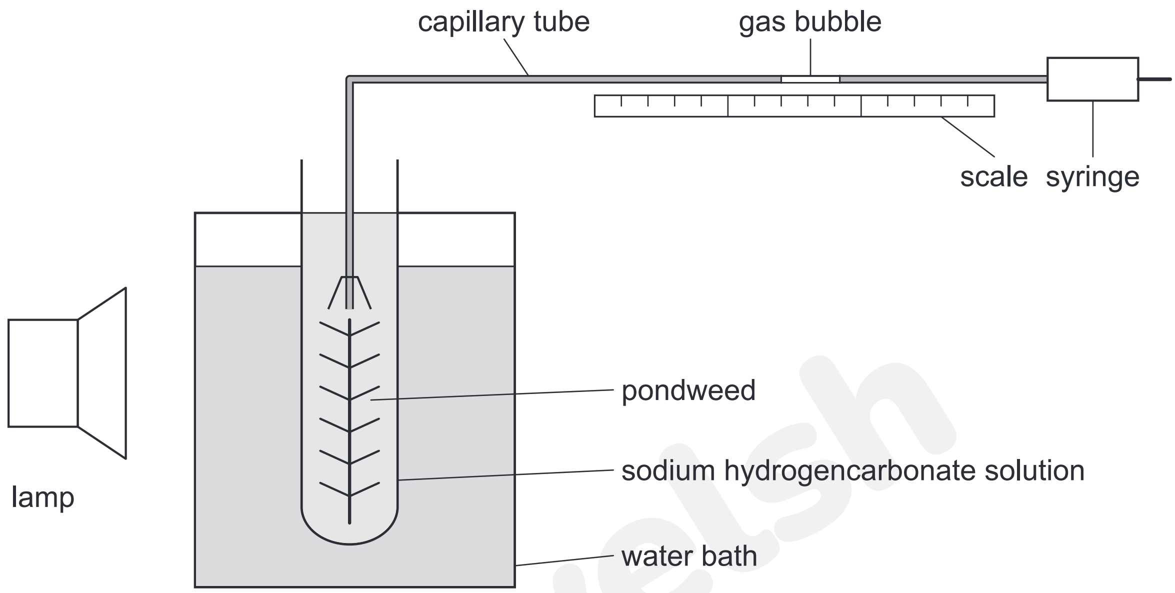


**Image 12.1**

(a) State why sodium hydrogencarbonate solution was used. [1]

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**Table 12.2** shows the results.

**Table 12.2**

| Concentration of sodium hydrogencarbonate / % | Trial 1 / mm | Trial 2 / mm | Trial 3 / mm | Mean length / mm | Rate / mm min$^{-1}$ |
|---|---|---|---|---|---|
| 0.00 | 2 | 3 | 2 | 2.3 | 0.5 |
| 0.25 | 14 | 15 | 13 | 14.0 | 2.8 |
| 0.50 | 25 | 27 | 26 | 26.0 | .................. |
| 1.00 | 41 | 39 | 52 | .................. | .................. |
| 1.50 | 46 | 47 | 45 | 46.0 | 9.2 |
| 2.00 | 47 | 46 | 48 | 47.0 | 9.4 |

(b) (i) Identify the anomalous result. [1]

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Tutor only

(ii) Complete **Table 12.2**. Do **not** include the anomalous result. [2]

(c) The radius of the capillary tube is 0.5 mm. The volume of a cylinder is $\pi r^2 l$, where $\pi$ = 3.14. Calculate the volume of gas collected per minute at 1.00 % sodium hydrogencarbonate. Give your answer to **1 decimal place**. [2]

Volume = .............................. $mm^3\ min^{-1}$

(d) Plot a graph of rate against concentration of sodium hydrogencarbonate on the grid below. Join the points with straight lines. [4]



(e) Explain the results between 1.50 % and 2.00 %. [2]

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Tutor only

(f) Explain why the pondweed was left for 5 minutes at each new concentration before measurements began. [1]

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Tutor only

**13.** Leaf discs were cut from spinach leaves. Air was removed from the discs by drawing them into a syringe of 0.2 % sodium hydrogencarbonate solution and pulling the plunger, so that the discs sank. Ten discs were placed in a beaker of the same solution under a lamp covered by a coloured filter, and the time taken for five of the discs to float was recorded. **Table 13.1** shows the mean results.

**Table 13.1**

| Filter | Wavelengths transmitted / nm | Mean time for five discs to float / min | Rate / $min^{-1}$ (1 ÷ time) |
|---|---|---|---|
| none | 400 to 700 | 8.0 | 0.125 |
| blue | 430 to 490 | 12.5 | 0.080 |
| green | 500 to 560 | 38.0 | ............ |
| red | 620 to 700 | 11.0 | ............ |

(a) Explain why the discs floated. [2]

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(b) Explain why air was removed from the discs at the start. [1]

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(c) Complete **Table 13.1**. Give your answers to **3 decimal places**. [2]

(d) Explain why the rate was lowest with the green filter. [2]

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(e) The filters did not transmit the same light intensity. Explain why this reduces the validity of the conclusion and suggest how the method could be improved. [2]

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Turn over.

Tutor only

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(f) Suggest why sodium hydrogencarbonate solution was used instead of water. [1]

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Tutor only

**14.** Magnesium and nitrate ions are needed for healthy plant growth. **Image 14.1** shows a maize leaf from a plant growing in soil that lacks magnesium.

**Image 14.1**

(a) Describe the appearance of the leaf in **Image 14.1**. [1]

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Wheat seedlings were grown for four weeks in three culture solutions, which were bubbled with air. **Table 14.2** shows the results.

**Table 14.2**

| Culture solution | Mean dry mass of shoots / g | Mean chlorophyll content / mg $g^{-1}$ |
|---|---|---|
| complete | 1.84 | 2.4 |
| lacking nitrate | 0.62 | 0.9 |
| lacking magnesium | 1.10 | 1.1 |

(b) Explain why a lack of magnesium reduced the dry mass of the shoots. [3]

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Turn over.

Tutor only

(c) Calculate the percentage decrease in dry mass of the seedlings lacking nitrate compared with the complete solution. Give your answer to **1 decimal place**. [2]

Percentage decrease = .............................. %

(d) Suggest why a lack of nitrate reduced growth more than a lack of magnesium. [2]

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(e) Explain why dry mass was measured rather than fresh mass. [1]

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(f) Explain why the culture solutions were bubbled with air. [2]

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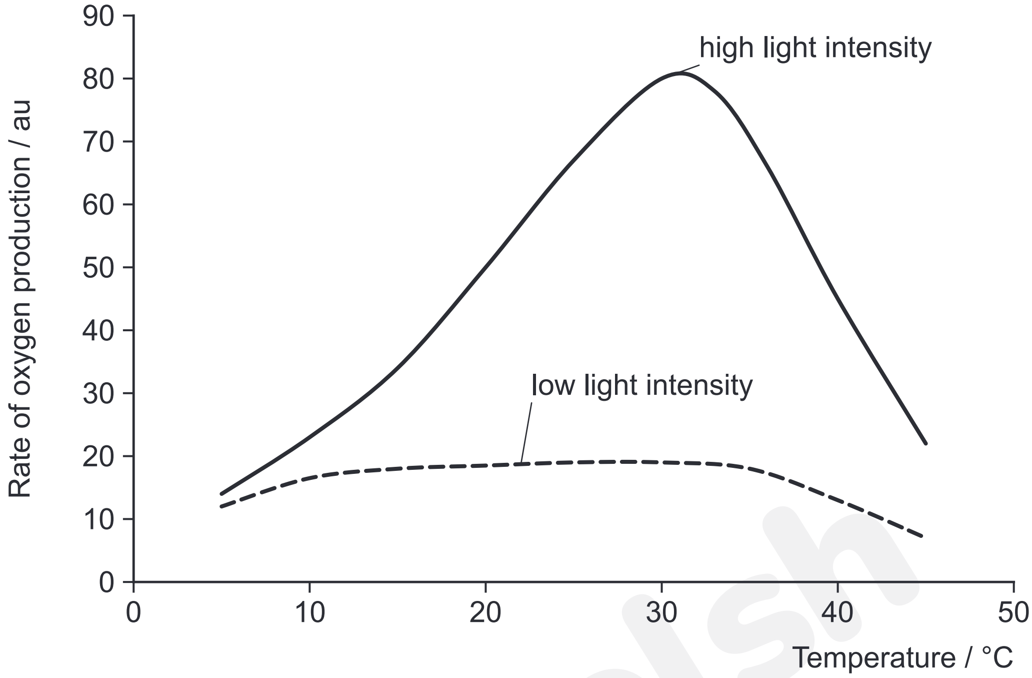
Tutor only

**15.** **Graph 15.1** shows the rate of oxygen production by a water plant at different temperatures in high and low light intensity.




**Graph 15.1**

Describe how light energy is used in non-cyclic photophosphorylation to produce ATP and reduced NADP. Explain how these products are used in the light-independent stage to make triose phosphate and to regenerate RuBP. Use **Graph 15.1** and the concept of limiting factors to explain the differences between the two curves. [9 QER]

Tutor only

**END OF WORKSHEET**

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## A Tutor Meets Tutee project

BioWelsh worksheets are written and checked by Tutor Meets Tutee tutors for WJEC A level Biology students.

Mark this worksheet with the BioWelsh mark scheme **BW-A2-3.2-W1** (MS).


### Acknowledgements

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