Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Plant nutrition

Time allowed: 1 hour 35 minutes

Subject code **0610**

Biology

Questions from Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 92

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 92 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 This question is about photosynthesis.

Complete the sentences using words from the list.

Each word may be used once, more than once or not at all.

chlorophyll	**chloroplast**	**epidermis**	**glucose**
glycogen	**membrane**	**palisade**	**starch**
stigma	**stomata**		

When plants carry out photosynthesis the chemical called ..... traps light energy.

The energy is used to combine raw materials to make ..... .

This process mainly happens in the ..... layer of the leaf.

The gas needed for photosynthesis enters the leaf through the ..... .

These are found in the ..... of the leaf.

Leaves appear green because they contain the chemical called ..... .

[6]

[Total: 6]

Photosynthesis and limiting factors Click for more variations

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1	chlorophyll; glucose / starch; palisade; stomata; epidermis; chlorophyll;	**6**	
		Total: 6	

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2 Fig. 5.1 shows a section through a leaf.

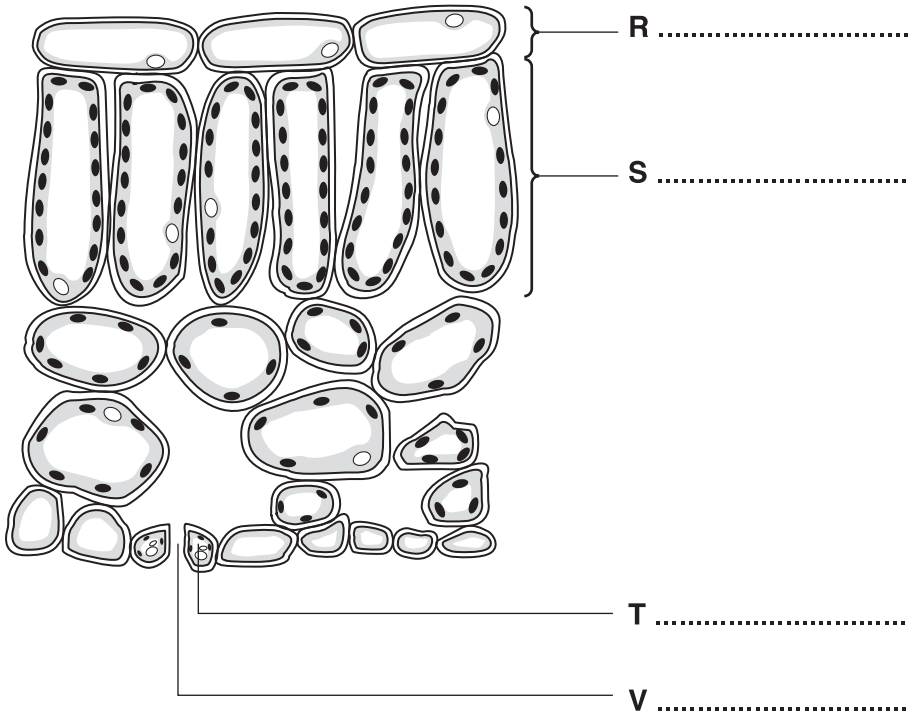


Fig. 5.1

(a) State the names of **R**, **S**, **T** and **V** on Fig. 5.1.

Write your answers on Fig. 5.1. [4]

(b) The main function of leaves is to produce carbohydrates.

Describe how plants produce carbohydrates.

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..... [4]

[Total: 8]

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Leaf structure Click for more variations

2(a)	(**R**) epidermis ; (**S**) palisade ; (**T**) guard cell / cytoplasm ; (**V**) stoma / stomata ;	**4**	
2(b)	1 photosynthesis ; 2 carbon dioxide and water (substrate) / AW ; 3 glucose and oxygen (produced) ; 4 energy needed comes from light / light energy converted to chemical energy ; 5 chlorophyll / chloroplasts, traps / absorb, the light (energy) ; 6 carbon dioxide from the air / water from the soil ;	**4**	**A** mp2 and mp3 in a correct, word / symbol equation **A** sun / sunlight mp5 must be stated (not inferred by being placed on an arrow in an equation) **I** from the roots

3 A student investigated photosynthesis in a variegated leaf.

A variegated leaf has a green part that contains a green pigment and a white part that does not contain the green pigment.

Fig. 2.1 is a photograph of some variegated leaves.

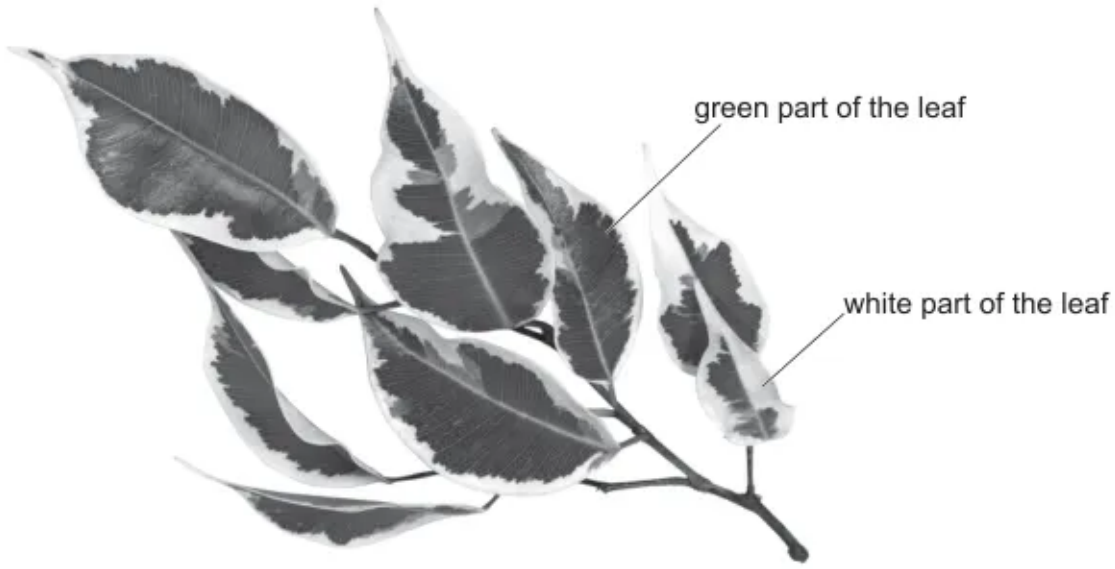


Fig. 2.1

(a) State where the green pigment is found in a plant cell.

..... [1]

(b) A student investigated a variegated leaf from a plant that had been kept in the light for 24 hours.

The student prepared the leaf by boiling it and then placing it in ethanol to remove the green pigment.

The student then tested the leaf with iodine solution.

Table 2.1 shows the results.

Table 2.1

part of the leaf	colour with iodine solution
green	blue-black
white	yellow-brown

Explain the results shown in Table 2.1 for the white part of the leaf.

.....

.....

.....

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.....

.....

..... [3]

(c) This investigation was repeated with a plant that was kept for 24 hours in an environment where all the carbon dioxide was removed.

Complete Table 2.2 to predict the results.

Table 2.2

part of the leaf	colour with iodine solution
green	
white	

[2]

(d) (i) The boxes on the left show the names of some substances that are made in plants.

The boxes on the right show uses of these substances in plants.

Draw lines to link each substance with its correct use in plants. Draw **three** lines.

substance	use in plants
	to attract insects for pollination
cellulose	
	to build cell walls
nectar	
	for transpiration
sucrose	
	for transport in the phloem

[3]

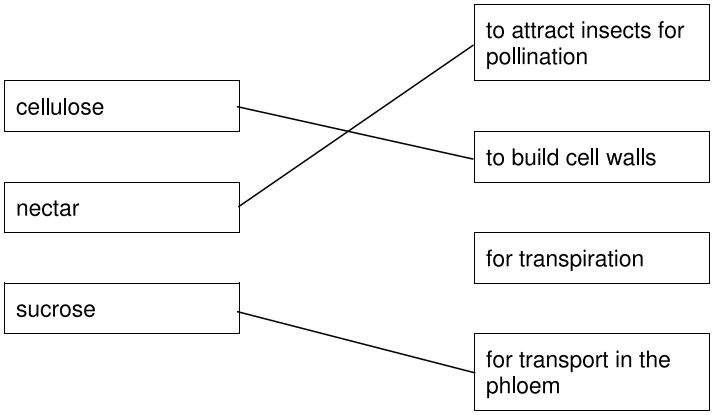
(ii) List the chemical elements contained in carbohydrates.

..... [1]

[Total: 10]

Photosynthesis and limiting factors Click for more variations

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3(a)	chloroplast **;**	**1**	
3(b)	*any three from:* it / the white part of the leaf, cannot photosynthesise **;** no glucose is produced **;** glucose is stored as starch **;** iodine solution remains yellow-brown in the absence of starch / the white part does not contain starch / negative result for starch / AW **;**	**3**	
3(c)	yellow-brown **;** yellow-brown **;**	**2**	
3(d)(i)		**3**	**R** each additional line
3(d)(ii)	carbon, hydrogen, oxygen **;**	**1**	any order **R** each additional element

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4 Fig. 3.1 shows a photograph of some leaves on a tree.



Fig. 3.1

(a) State **two** features of the leaves, **visible** in Fig. 3.1, that are adaptations for photosynthesis.

1 .....

2 .....

[2]

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(b) Fig. 3.2 is a diagram of part of a cross-section of a leaf.

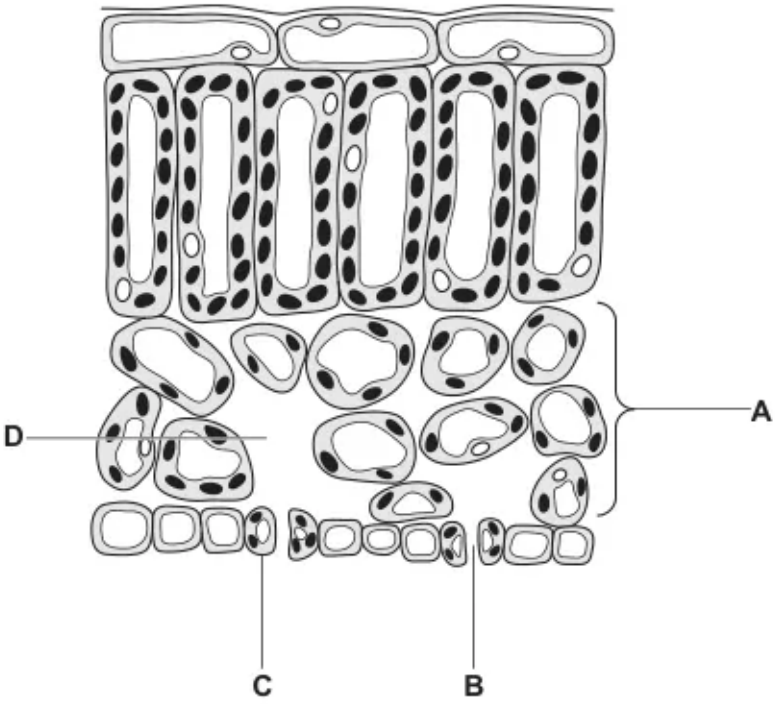


Fig. 3.2

(i) Explain how the parts of the leaf labelled **A**, **B**, **C** and **D** in Fig. 3.2 adapt the leaf for gas exchange during photosynthesis.

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..... [4]

(ii) State the name of the mineral ion that plants need to make chlorophyll.

..... [1]

(c) Complete the sentences about transport in plants.

Leaves contain ..... bundles.

The xylem in the bundles provides plants with support and transports water and

..... from the ..... to the leaves.

Phloem in the bundles transports ..... and amino acids.

[4]

[Total: 11]

Leaf structure Click for more variations

Reduced to 77% to fit the page (wider than A4).

4(a)	*any two from:* large surface area **;** thin **;** AVP **;**	**2**	e.g. *idea of* not overlapping to maximise light capture / leaves are spreading / AW
4(b)(i)	*any four from:* **A**: spongy mesophyll, (orientation of cells) allow gases to move, easily / to palisade (mesophyll) **;** **B**: stomata, hole / AW that lets (named) gases to, enter / leave, leaf **;** **C**: guard cells, open **and** close stomata OR control stomatal size AW **;** **D**: air space, allow gases, to move (easily) / to get to the palisade (mesophyll) **;** by diffusion **;** AVP **;**	**4**	
4(b)(ii)	magnesium **;**	**1**	
4(c)	vascular **;** minerals / mineral ions **;** roots **;** sucrose **;**	**4**	

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5 Many growers of crops in glasshouses use carbon dioxide enrichment to improve yields.

(a) Explain the advantages of carbon dioxide enrichment of glasshouses.

.....

.....

.....

..... [2]

Fig. 3.1 shows the carbon dioxide concentrations inside three glasshouses, **D**, **E** and **F**, on a hot day with bright sunlight.

- Glasshouses **D** and **E** received carbon dioxide enrichment and were ventilated by opening the windows.
- Glasshouse **F** did not receive any extra carbon dioxide and the windows were closed.

The carbon dioxide concentrations in the glasshouses and in the atmosphere were measured. The concentration in the atmosphere was 0.039 %.

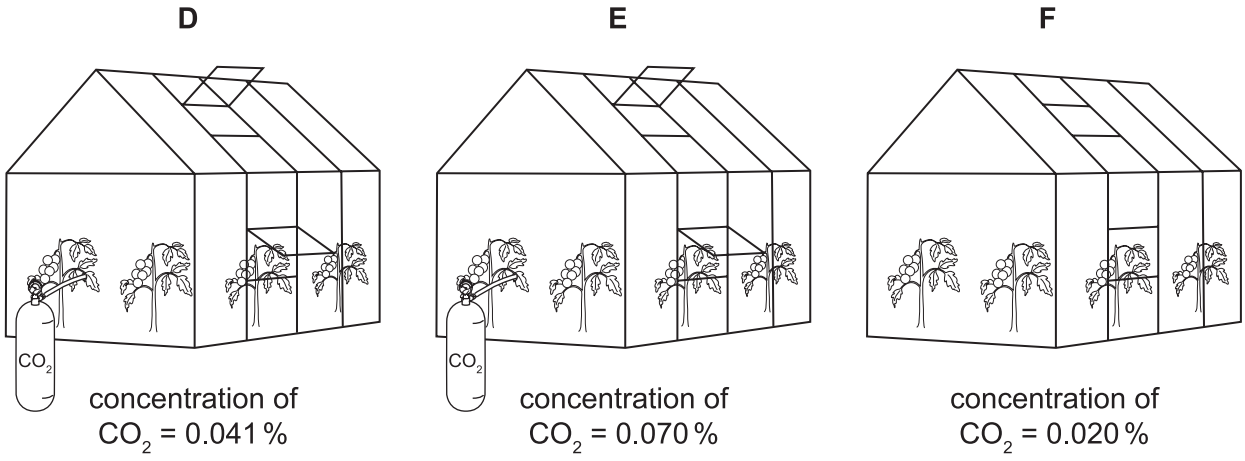


Fig. 3.1

The rate of uptake of carbon dioxide by the crop plants was measured in grams of carbon dioxide absorbed per square metre of glasshouse per hour. These results are shown in Table 3.1.

Table 3.1

glasshouse	rate of uptake of carbon dioxide by crop plants / g per m^2 per hour
D	2.5
E	5.7
F	1.0

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(b) Suggest why it may **not** be cost effective to maintain a high concentration of carbon dioxide in glasshouse **E** compared to the concentration of carbon dioxide in the atmosphere.

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..... [2]

(c) **(i)** Concentrations of carbon dioxide in all three glasshouses in Fig. 3.1 increased at night. State why this happened.

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..... [1]

(ii) Explain why it is important to ventilate glasshouses by opening the windows.

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..... [4]

[Total: 9]

Photosynthesis and limiting factors Click for more variations

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5 **(a)**	**1** **2** **3** **4** **5** **6**	carbon dioxide is required for photosynthesis ; (more carbon dioxide) more, glucose is produced ; carbon dioxide <u>concentration</u> is a <u>limiting</u> factor ; more carbon dioxide = faster rate of photosynthesis ; prevents concentration falling below that of atmosphere / AW ; ref to more, growth / yield ;	[max 2]	
(b)		carbon dioxide will diffuse out of the glasshouse ; carbon dioxide is wasted ; *idea that* extra, growth / yield, does not cover the cost of the carbon dioxide ;	[max 2]	

(c) **(i)**		plants respire at night and do not photosynthesise ;	[1]	*both ideas are needed for the mark*
(ii)	**1** **2** **3** **4** **5** **6** **7** **8**	decrease temperature on hot days / AW / avoid plants overheating ; denaturing of enzymes ; avoids plants wilting ; *idea that* open to allow carbon dioxide to enter <u>during the day</u> / ref to **F** ; *idea that* open to allow oxygen to enter <u>at night</u> ; to allow plants to respire ; allow water vapour to escape / avoids air becoming too humid ; reduces chances of (fungal) disease ;	[max 4]	
			[Total: 9]	

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6 **(a)** Fig. 4.1 shows the effect of light intensity on the rate of photosynthesis at different temperatures and concentrations of carbon dioxide.

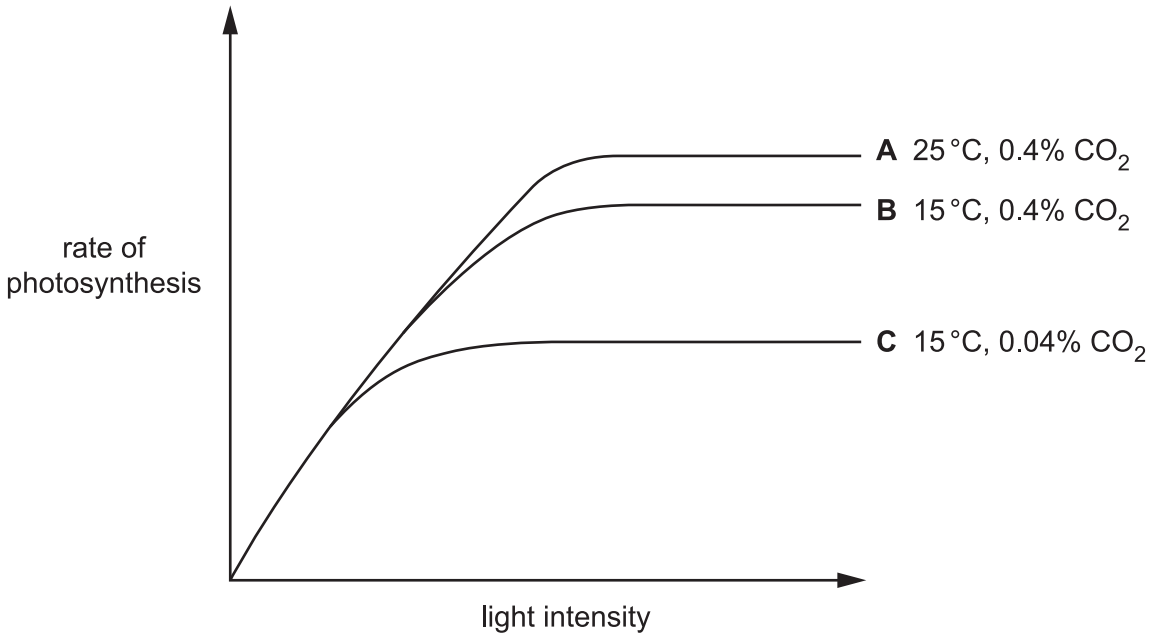


Fig. 4.1

Describe **and** explain the reasons for the shape of lines **B** and **C** in Fig. 4.1.

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..... [6]

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(b) $C_6H_{12}O_6$ is one of the products of photosynthesis.

State the chemical formula of the **other** product.

..... [1]

(c) Outline how the carbohydrates made during photosynthesis are used in plants.

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..... [4]

[Total: 11]

Photosynthesis and limiting factors Click for more variations

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6(a)	*any six from:* LIGHT (B and C as light intensity increases) the rate (of photosynthesis) increases and remains constant / AW ; rates (of photosynthesis) are the same at low(est) light intensities ; light provides energy (for photosynthesis) ; where the line rises / initially, light intensity is, limiting / the limiting factor ; line(s) / rate, levels off where light intensity is **not** limiting ; in **B** light intensity becomes limiting at higher light intensity than **C** / **ora** ; CARBON DIOXIDE *Idea that* line C levels off, at a lower rate (of photosynthesis) / lower light intensity ; carbon dioxide (concentration) is, lower for **C** / 0.04% vs 0.4% ; carbon dioxide is, reactant / substrate / raw material / needed, for photosynthesis ; in **C** carbon dioxide is a limiting factor at a lower light intensity / in **B** carbon dioxide is a limiting factor at a higher light intensity ; TEMPERATURE *idea that* temperature is limiting for **B** at high light intensities ;	**6**	**I** if C given as well (as no evidence for C)
6(b)	O_2 ;	**1**	
6(c)	*any four from:* (glucose) used, in respiration / to provide energy / to release energy / as an energy store ; (glucose) converted to / stored as, starch ; (glucose) converted to sucrose ; sucrose for, translocation / transport (in the phloem) / sent to sink(s) ; (glucose / fructose / sucrose) in nectar ; (nectar) to attract, insects / pollinators ; (glucose / fructose / sucrose) in fruits (to attract animals) ; (glucose) converted to cellulose ; cellulose to build cell walls ; lignin for cell walls ; used to make, amino acids / fatty acids ; AVP ;	**4**	e.g., used to make chlorophyll / (DNA/RNA) bases

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7 **(a)** Fig. 2.1 is a diagram of a cross-section of part of a leaf.

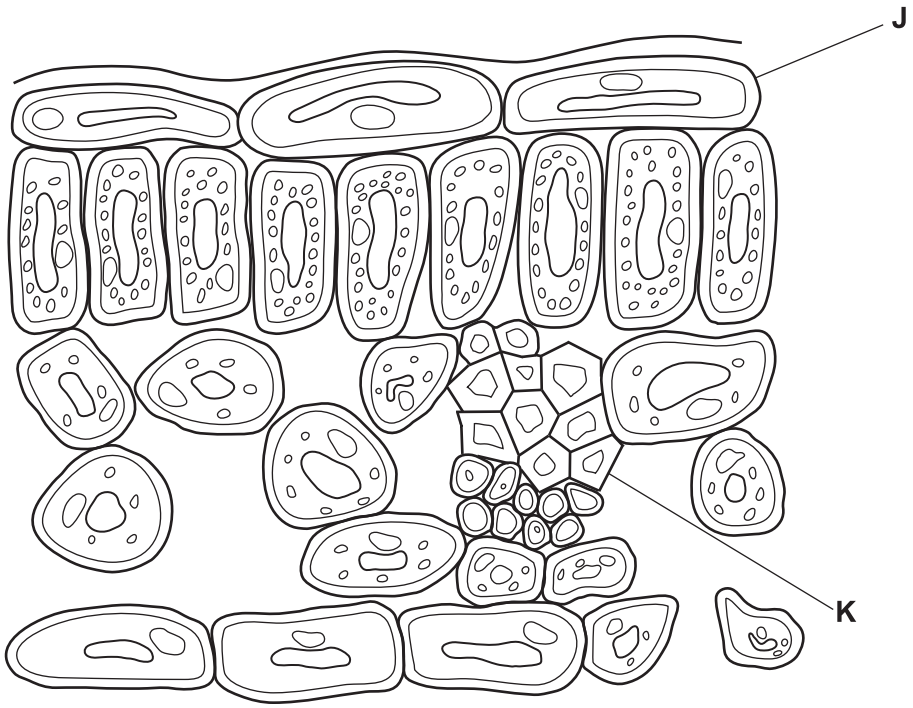


Fig. 2.1

Identify and explain how the structures labelled **J** and **K** are adapted for photosynthesis.

J .....

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.....

.....

K .....

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.....

.....

[4]

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(b) In an experiment, thale cress plants (*Arabidopsis thaliana*) were grown in normal atmospheric and high carbon dioxide concentrations. The transpiration rate, the mean number of chloroplasts per cell and the concentrations of starch and magnesium ions were measured.

The results are shown in Table 2.1.

Table 2.1

factor measured	normal carbon dioxide concentration	high carbon dioxide concentration
transpiration rate / AU	8.1	5.6
mean number of chloroplasts per cell	8	11
concentration of starch / μg per mg of leaf	38	67
concentration of magnesium ions / mg per g of leaf	2.7	2.3

Complete the sentences about the data shown in Table 2.1.

Table 2.1 shows that increasing the carbon dioxide concentration caused more starch to be produced in the leaves. This shows that, at a normal carbon dioxide concentration, carbon dioxide is a ..... for photosynthesis.

During photosynthesis, ... molecules of carbon dioxide are required to make one molecule of glucose.

The greater quantity of starch stored in the leaves grown in a high carbon dioxide concentration means, when needed, more sucrose can be produced for transport in the phloem, so the leaves act as a ..... .

The greater number of chloroplasts per cell in the leaves grown in the higher carbon dioxide concentration means that more energy can be absorbed from ..... and transferred to ..... energy.

The transpiration rate is lower when the carbon dioxide concentration is higher. This means reduced loss of ..... from the leaves.

Magnesium ion concentration is lower in these leaves because they have used the magnesium ions to make ..... .

[7]

[Total: 11]

Photosynthesis and limiting factors Click for more variations

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7(a)	**J** – (upper) epidermis (cell) **;** (translucent / transparent / thin / flat / no chloroplasts) to allow passage of light, through / to palisade (cells) / leaf / AW **;** **K** – xylem (vessel) **;** continuous tube / no cytoplasm / no (named) cell contents / hollow / no end walls / no cross walls / pits, to allow transport of, water / mineral ions (to leaf) **OR** lignin, to prevent collapse of water column / support the leaf to maximise light absorption / AW **;**	**4**	
7(b)	limiting factor **;** 6 / six **;** source **;** (sun)light **;** chemical **;** water vapour **;** chlorophyll **;**	**7**	**A** reactant / substrate / raw material

8 Fig. 1.1 is a diagram of part of a cross-section of a leaf.

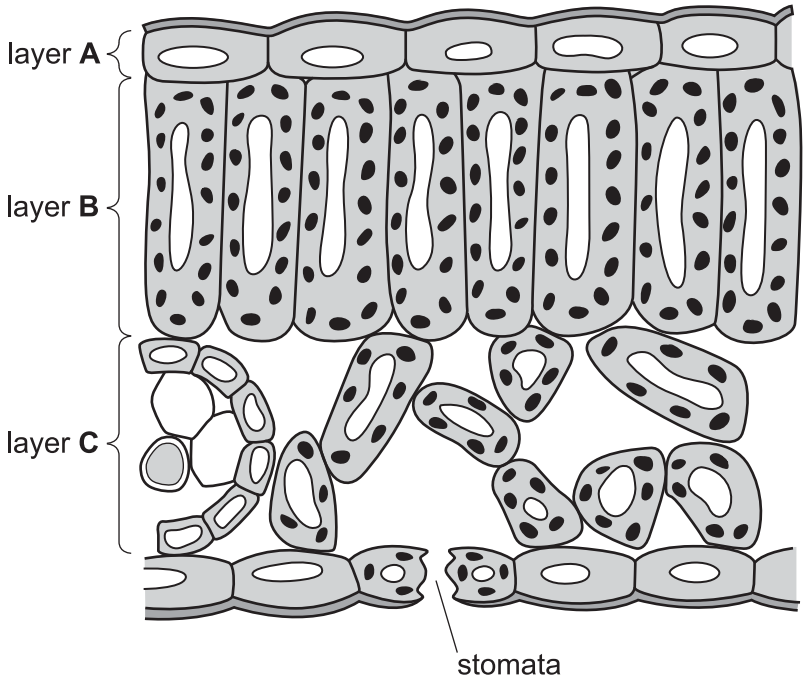


Fig. 1.1

(a) Explain why a leaf is considered to be an organ.

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..... [2]

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(b) Explain how layer **B** and layer **C** in Fig. 1.1 are adapted for their functions.

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..... [6]

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(c) A student placed a plant in a very hot room for 12 hours. There was a bright light in the room and the plant was not given any water during the 12-hour period.

Fig. 1.2 shows a series of sketches that the student made of the stomata during the investigation.

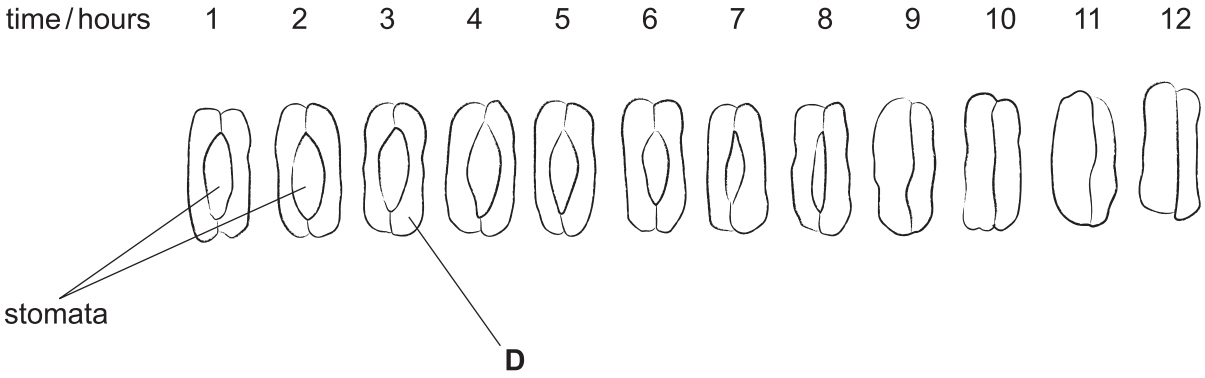


Fig. 1.2

(i) Identify the cell labelled **D** on Fig. 1.2.

..... [1]

(ii) State the main function of the stomata.

..... [1]

(iii) State the advantage to the plant of the change to the stomata shown in Fig. 1.2.

.....

.....

..... [1]

(d) The student increased the humidity in the room and repeated the investigation.

Predict and explain the effect of high humidity on the stomata.

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..... [3]

[Total: 14]

Leaf structure Click for more variations

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8(a)	it is made of (named) tissues (in a leaf) ; (tissues), working together / for a specific (named) function(s) ;	**2**	
8(b)	*ref* to photosynthesis ; **B** is the palisade (mesophyll / tissue / layer / cells) and **C** contains spongy (mesophyll / tissue / layer / cells) / vascular bundles / xylem / phloem ; *any three from:* ***layer B*** cells are, tightly / vertically, packed *or* columnar *or* few cross walls ; (cells / layer) positioned (immediately) below, layer **A** / the upper epidermis ; to (maximise) light (energy) reaching, cells / chloroplasts / layer ; *ref* to many chloroplasts / lots of chlorophyll ; (large) vacuole keeps the chloroplasts towards the sides of cells ; *any three from:* ***layer C*** cells are loosely packed / layer contains (interconnecting) air spaces (between cells) ; (mesophyll / air spaces) to allow, gas exchange / diffusion of (named) gases ; (mesophyll / air spaces) to allow evaporation (of water) from cell surfaces (into air spaces) ; (xylem) has, thick / lignified / waterproofed / pitted, cell wall ; (xylem) (long) continuous tube / no cytoplasm / hollow *or* no end / cross, walls ; (xylem) to allow transport of, water / mineral ions ; (phloem) to allow, translocation / transport of, sucrose / sugar / amino acids ;	**6**	**MP1 A** transpiration
8(c)(i)	guard (cell) ;	**1**	
8(c)(ii)	gas exchange (described) / (regulation of) transpiration / AW ;	**1**	
8(c)(iii)	reduce water loss (through transpiration) ; *ref* to preventing wilting ;	**1**	
8(d)	*any three from:* stomata will take longer to close / reduces (stomatal) closure / reduces (stomatal) response ; reduced, water vapour / concentration / diffusion, gradient (between the air spaces and the outside) ; so the (guard) cells do not lose water (as, quickly / much as the first experiment) ; the (guard) cells, stay / become, turgid *or* (guard) cells take longer to become flaccid ;	**3**	

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9 Plan an investigation to determine the effect of temperature on the rate of photosynthesis in an aquatic plant.

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..... [6]

Photosynthesis and limiting factors Click for more variations

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9	*six from:* **1** *independent variable* at least two different temperatures **,** tested / stated **;** **2** *dependent variable* counting bubbles / measuring volume of gas given off **;** **3, 4, 5** *variables kept constant - max three from* **;;;** set time period (for measurement) species / type of, plant / plant tissue size / mass of plant or number of leaves age of plant carbon dioxide / HCO_3^- concentration light intensity / same lamp / same light bulb / AW pH of water nutrient content of water volume of water **6, 7** *method – max two from* **;;** use of gas syringe / upturned measuring cylinder or test-tube method of controlling the temperature fixed distance from light source use of heat shield equilibration time use of oxygen probe AVP **8** repeat investigation (at least) twice / at least two replicates **;**	**6**	**A** colour change of hydrogencarbonate indicator / measure**,** oxygen or carbon dioxide**,** concentration

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10 Hydrogencarbonate indicator can be used to determine the concentration of carbon dioxide in a solution. The table shows the colour of the indicator at different concentrations of carbon dioxide.

carbon dioxide concentration	hydrogencarbonate indicator colour
high	yellow
medium	red
low	purple

Aquatic plants photosynthesise and use up carbon dioxide when in the light. Aquatic plants respire and produce carbon dioxide in the light and in the dark.

When the carbon dioxide produced is equal to carbon dioxide used, hydrogencarbonate indicator is red.

Using an aquatic plant, plan an investigation to determine the light intensity at which the rate of photosynthesis is equal to the rate of respiration.

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..... [6]

Photosynthesis and limiting factors Click for more variations

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10	*independent variable* **1** at least three different light intensities ; *dependent variable* **2** the colour of the indicator ; **3 and 4** *details of the method* ;; • method of changing light intensity e.g. different lamp distances / dimmer switch altered / different bulbs / different lamps / different power lamps / detail of how to make one in the dark ***and*** one in the light • method to avoid heating effect of light e.g. heat shield / beaker of water between lamp and plant / use LED bulbs to prevent heating • keeping the plant under the water / weighting the plant down • sample the water around the plant and test with indicator **5 and 6 and 7** *variables kept constant* ;;; • colour / wavelength, of light • temperature • type / species / age, of plant • size / mass / length / height / surface area / number of leaves, of plant • volume of water (covering plant) • volume / number of drops, of (hydrogencarbonate) indicator • concentration of (hydrogencarbonate) indicator • set (stated) time for equilibration (to the new light intensity) • set (stated) time before noting colour **8** two or more repeats ; **9** relevant safety ;	**6**	

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