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

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Limiting factors of photosynthesis

Time allowed: 1 hour 10 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

/ 66

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 7 questions worth 66 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 Plan an investigation to determine the effect of light intensity on photosynthesis in an aquatic plant.

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..... [6]

Photosynthesis and limiting factors Click for more variations

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1	*independent variable* **1** (at least) *idea of* two / different, light intensities **;** *dependent variable* **2** (measuring) volume of, gas / oxygen, produced OR counting (number of) bubbles **;** **3 and 4** *detail of method* **;;** *max **two** from:* • method of changing light intensity e.g. different lamp distances / dimmer switch altered / different bulbs • method of, collecting gas / measuring volume of gas e.g. use of a gas syringe / *ref to* any quantitative displacement method • method to avoid heating effect of light e.g. heat shield / use LED bulbs to prevent heating • keep plant submerged / water added to cover the plant / weighing the plant down • *idea of* time for acclimatisation at each new light intensity / equilibration **5 and 6** *constant variables* **;;** *max **two** from:* • time or volume (depending on method used) e.g., time to collect a set volume of oxygen / time to count number of bubbles OR volume / number of bubbles, in a set time • concentration of hydrogencarbonate added or same source of carbon dioxide • colour / wavelength, of light • temperature • same, type / species / (named) plant / age **7** two or more repeats **;** **8** relevant safety **;**	**6**	

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2 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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2	*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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3 In an investigation, the carbon dioxide concentration in the air above a crop of maize plants was measured for 24 hours.

There was no wind blowing during the 24 hours of the investigation.

The results of this investigation are shown in Fig. 9.1.

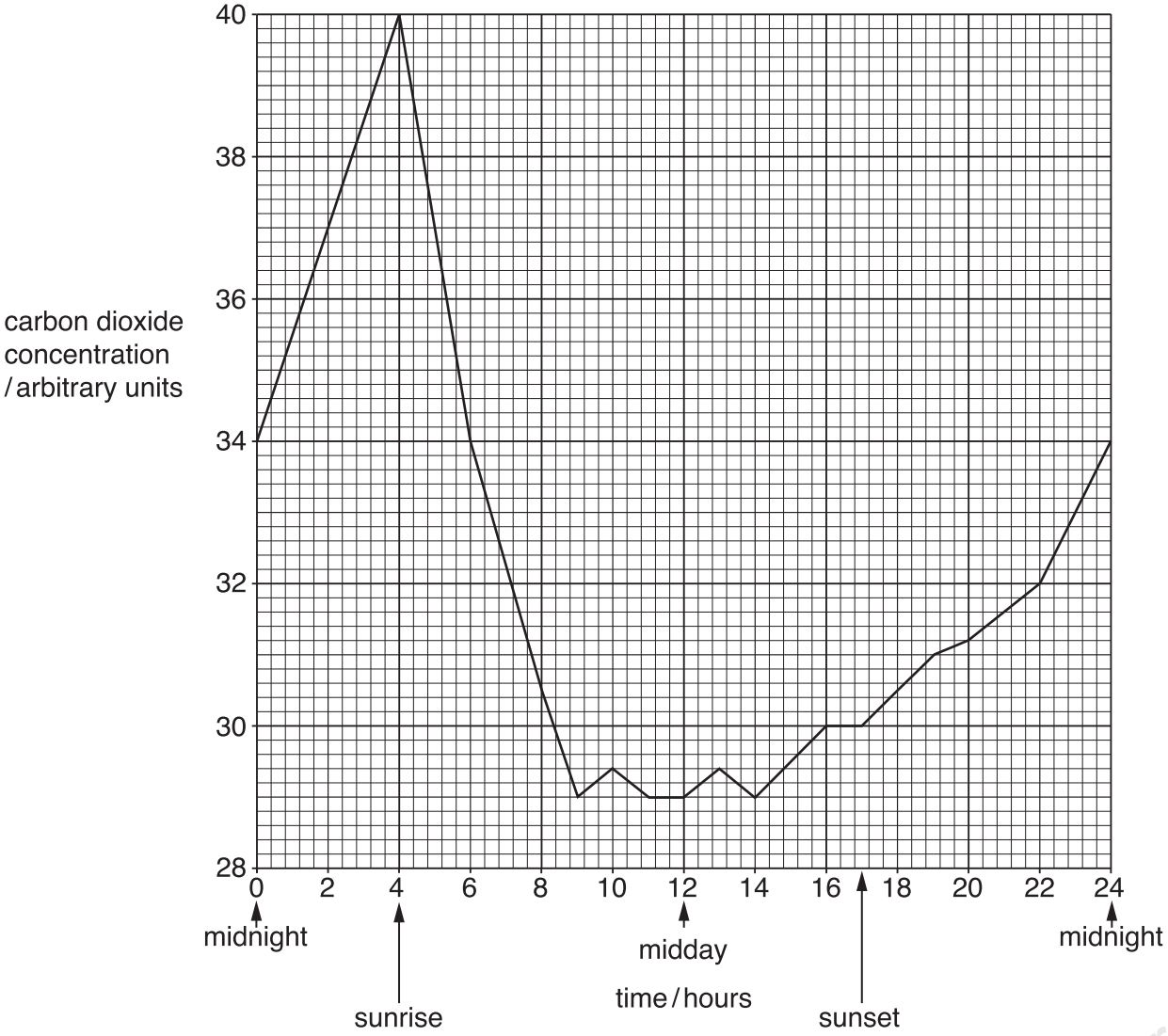


Fig. 9.1

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(a) **(i)** State the **two** times, on Fig. 9.1, at which the carbon dioxide concentration in the air was 37 arbitrary units.

..... [1]

(ii) Calculate the difference in the carbon dioxide concentration in the air between 04:00 (sunrise) and 12:00 (midday) on Fig. 9.1.

Space for working.

..... arbitrary units [1]

(iii) Explain why the concentration of carbon dioxide decreases between 04:00 and 09:00.

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..... [3]

(b) State **two** environmental factors that would affect the results of this investigation.

1 .....

2 .....

[2]

[Total: 7]

Photosynthesis and limiting factors Click for more variations

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3(a)(i)	02:00 **and** 05:00 ;	**1**	
3(a)(ii)	11 (arbitrary units) ;	**1**	**A** 10.8 to 11.1
3(a)(iii)	sunrise / light is present ; carbon dioxide, absorbed / used ; (for) photosynthesis ; photosynthesis is using carbon dioxide faster than respiration can provide it ;	**3**	 **A** photosynthesis is faster than respiration
3(b)	rain ; wind ; humidity ; temperature ; shade / clouds / time of year ;	**2**	

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

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

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..... [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 %.

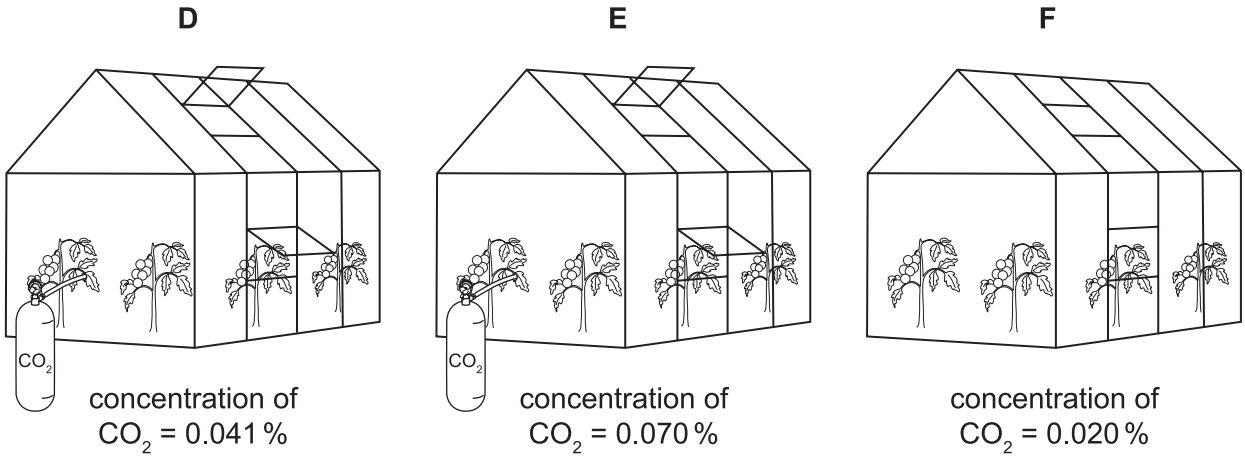


Fig. 3.1

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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4 **(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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5 A scientist investigated the effect of temperature on the rate of photosynthesis in one species of plant.

Photosynthesis involves enzyme-controlled reactions.

Discs were cut from a leaf and kept at different temperatures.

The total surface area of the discs was kept the same for each temperature.

The volume of oxygen that was produced by the leaf discs was measured and used to estimate the rate of photosynthesis.

The results are shown in Fig. 4.1.

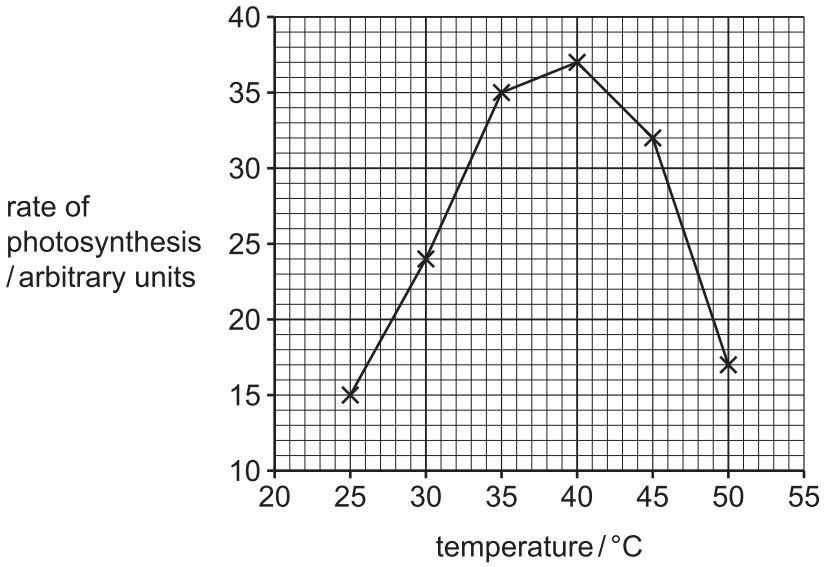


Fig. 4.1

(a) Identify the optimum temperature for photosynthesis in Fig. 4.1.

..... °C [1]

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(b) Explain the results shown in Fig. 4.1.

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..... [6]

(c) Carbon dioxide was supplied in excess at each temperature during the investigation.

Explain why.

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..... [2]

(d) Suggest why not all of the oxygen produced by the leaf is released.

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..... [1]

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(e) Describe the role of chlorophyll in photosynthesis.

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..... [2]

[Total: 12]

Photosynthesis and limiting factors Click for more variations

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5(a)	40 (°C) ;	1	
5(b)	*any six from:* *before 40 °C* 1 increasing temperature increases the kinetic energy (of reactants / molecules) ; 2 increasing the, frequency / rate, of (effective) collisions ; 3 more enzyme-substrate complexes are formed ; 4 releasing more, oxygen / glucose / products ; 5 temperature is the limiting factor ; *at 40 °C* 6 (optimum temperature) maximum number of, enzyme-substrate complexes / collisions; *after 40 °C* 7 increasing temperature changes the shape of active site(s) (of enzyme(s)) ; 8 ref. to denaturation ; 9 substrate, no longer complementary (to active sites) / can no longer fit into active sites ; 10 fewer / no, enzyme-substrate complexes are formed ; 11 fewer / no, products are released ; 12 AVP ;	6	e.g. stomata close (as high rate of transpiration) so no CO_2 enters
5(c)	*any two from:* carbon dioxide is a limiting factor / so that carbon dioxide is **not** a limiting factor / AW ; so that temperature is the only, variable / limiting factor ; to ensure that the effects are caused (only) by temperature ;	2	
5(d)	*any one from:* (some is) used, for (aerobic) respiration / to react with glucose ; some remains in air spaces ;	1	
5(e)	*any two from:* absorbs / traps / captures, light ; transfers / converts, light energy into chemical energy ; for the synthesis of, glucose / carbohydrates ;	2	

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6 Researchers in Michigan investigated the rate of photosynthesis in leaves of big-tooth aspen trees, *Populus grandidentata*, by placing some of the growing leaves inside transparent boxes.

The researchers measured the uptake of carbon dioxide by the leaves over a range of temperatures from 10–40 °C. They carried out their measurements at two different concentrations of carbon dioxide:

H – 325 ppm carbon dioxide which is close to the concentration in the atmosphere;

J – 1935 ppm carbon dioxide which is a very high concentration.

The results are shown in Fig. 3.1.

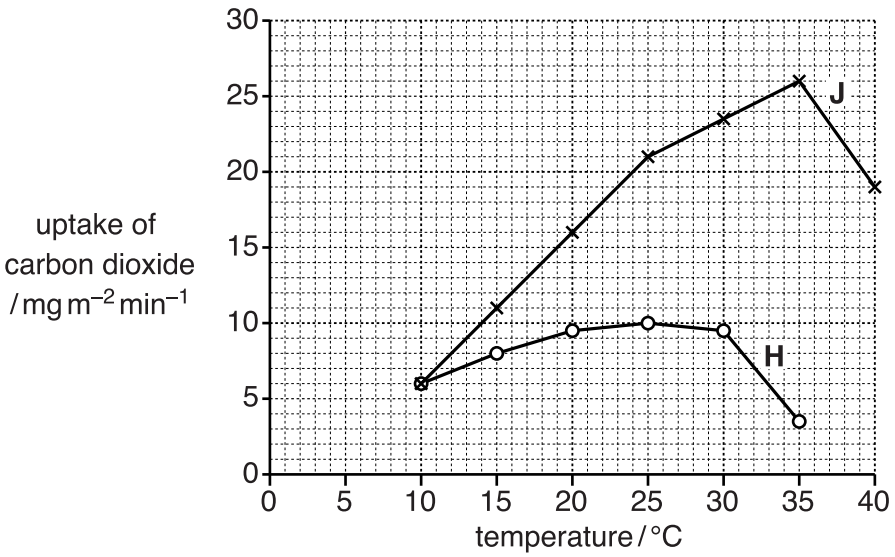


Fig. 3.1

(a) Describe how the results for the aspen leaves in batch **J** differ from the results for the aspen leaves in batch **H**. Use data from Fig. 3.1 in your answer.

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.....[3]

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(b) Explain why the rate of photosynthesis in the leaves in batch **J**:

(i) increases with an increase in temperature from 15 °C to 35 °C

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.....[2]

(ii) decreases at temperatures above 35 °C.

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.....[2]

(c) Use the results in Fig. 3.1 to suggest **and** explain the likely effect on plant growth of an increase in carbon dioxide concentration in the atmosphere as a result of the combustion of fossil fuels.

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.....[5]

[Total: 12]

Photosynthesis and limiting factors Click for more variations

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6 (a)	1 2 3 4	carbon dioxide uptake of **J** is higher (at all temperatures except at 10 °C) ; peak / optimum / maximum / best, uptake of **J** is at a higher temperature **ora** ; data recorded in **J** between 35 – 40 °C / AW (but not for **H**) ; correct use of comparative data between **J** and **H** with correct units ;	[max 3]	**A** peak uptake for **J** is higher than **H** correct units must be stated at least once
(b) (i)	1 2 3 4 5 6	temperature is a limiting factor ; increases, (kinetic / heat) energy / the movement of molecules / diffusion ; more collisions between substrate and enzymes ; to speed up chemical reactions ; stomata open wider ; therefore increased carbon dioxide entering the leaf / AW ;	[max 2]	
(ii)	1 2 3 4	enzymes are denatured ; enzymes are no longer active / AW ; stomata close ; therefore reduced carbon dioxide entering the leaf / AW ;	[max 2]	

(c)	1 2 3 4 5 6 7 8 9 10 11 12	plant growth is likely to increase ; higher rate of photosynthesis ; means more glucose / starch, is produced ; glucose is used for respiration to provide energy (for growth) ; more cellulose for cell walls ; more protein for, enzymes / cell membranes ; other limiting factors / CO_2 no longer limiting ; carbon dioxide is a greenhouse gas / reference to (enhanced) greenhouse effect ; increase in global temperatures increases rate of photosynthesis ; reference to effect of temperature on enzymes ; any relevant consequence of global warming ; AVP ; e.g. relevant use of data	[max 5]	'more' need only stated once **A** 'global warming'

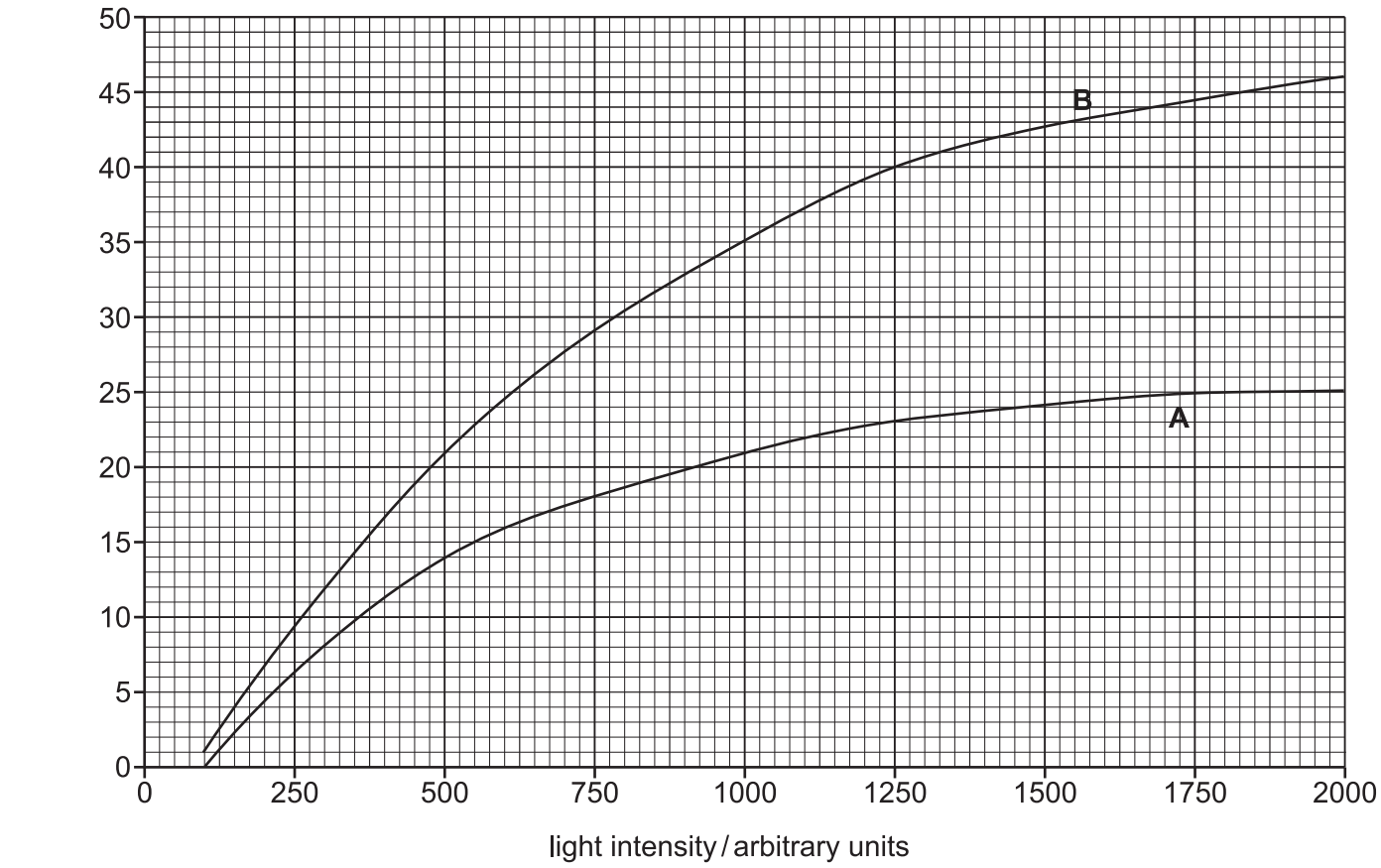
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7 **(a)** State the **word** equation for photosynthesis.

..... [2]

(b) Scientists investigated the effect of light intensity on the rate of photosynthesis in the leaves of eucalyptus trees at two different concentrations of carbon dioxide, **A** and **B**.

The results are shown in Fig. 2.1.



Key:

A carbon dioxide concentration 140 ppm

B carbon dioxide concentration 1000 ppm

Fig. 2.1

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(i) Suggest **and** explain why the scientists kept the temperature of the leaves at 20 °C while they recorded results.

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..... [2]

(ii) Calculate the percentage increase in the rate of photosynthesis at a light intensity of 1250 arbitrary units when the carbon dioxide concentration was increased from 140 ppm to 1000 ppm.

Show your working and give your answer to the nearest whole number.

..... %
[3]

(iii) Describe the effect of increasing light intensity on the rate of photosynthesis when the concentration of carbon dioxide was 140 ppm.

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..... [3]

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(iv) Explain the effect of increasing light intensity on the rate of photosynthesis when the concentration of carbon dioxide was 1000 ppm.

Use the term *limiting factor* in your answer.

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..... [4]

[Total: 14]

Photosynthesis and limiting factors Click for more variations

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7(a)	carbon dioxide + water ⟶ ; glucose + oxygen ;	**2**	
7(b)(i)	temperature is a factor that affects the rate of photosynthesis ; *reference to* kinetic energy ; *idea of* effect of temperature, on enzymes / diffusion rate (of carbon dioxide) ; *idea that* temperature is a variable that should be standardised ; AVP ;	**2**	
7(b)(ii)	74 ;;;	**3**	
7(b)(iii)	rate (of photosynthesis) increases and, reaches a plateau / AW ; rate (of photosynthesis) increases until 1750 (a.u) / 25 μmol per m^2 per s ; any comparative use of figures for rate ;	**3**	
7(b)(iv)	light intensity is the limiting factor, at all light intensities used / AW ; because rate of photosynthesis does not level off (even at high light intensities) ; carbon dioxide / temperature / chlorophyll / another factor, was not a limiting factor ; *correct reference* to (light) energy ; light is absorbed by chlorophyll ; AVP ;	**4**	

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