0 4 A student isolated chloroplasts from spinach leaves into a solution to form a chloroplast suspension. He used the chloroplast suspension and DCPIP solution to investigate the light-dependent reaction of photosynthesis. DCPIP solution is blue when oxidised and colourless when reduced.

The student set up three test tubes as follows:

- **Tube 1** – 1 cm^3 of solution without chloroplasts and 9 cm^3 of DCPIP solution in light.
- **Tube 2** – 1 cm^3 of chloroplast suspension and 9 cm^3 of DCPIP solution in darkness.
- **Tube 3** – 1 cm^3 of chloroplast suspension and 9 cm^3 of DCPIP solution in light.

The student recorded the colour of the DCPIP in each of the tubes at the start and after the tubes had been left at 20 °C for 30 minutes.

His results are shown in **Table 1**.

Table 1

Tube	Colour of DCPIP in tube	
	At start	After 30 minutes
1	blue	blue
2	blue	blue
3	blue	colourless

0 4 . 1 The solution that the student used to produce the chloroplast suspension had the same water potential as the chloroplasts.

Explain why it was important that these water potentials were the same.

[2 marks]

0 4 . 2 Explain why the student set up **Tube 1**.

[2 marks]

0 4 . 3 Explain the results in **Tube 3**.

[2 marks]

0 4 . 4 The student evaluated the effectiveness of different chemicals as weed-killers by assessing their ability to prevent the decolourisation of DCPIP in chloroplast suspensions.

He added different concentrations of each chemical to illuminated chloroplast suspensions containing DCPIP. He then determined the IC_{50} for each chemical. The IC_{50} is the concentration of chemical which inhibits the decolourisation of DCPIP by 50%.

Explain the advantage of the student using the IC_{50} in this investigation.

[1 mark]

Question 4 continues on the next page

0 4 . 5 Explain how chemicals which inhibit the decolourisation of DCPIP could slow the growth of weeds.

[2 marks]

9

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 Heat stress is a condition that often occurs in plants exposed to high temperatures for a prolonged period of time. Heat stress is a major factor in limiting the rate of photosynthesis.

0 1 . 1 Heat stress decreases the light-dependent reaction of photosynthesis.

Explain why this leads to a decrease in the **light-independent reaction**.

[2 marks]

0 1 . 2 Another effect of heat stress is a decrease in the activity of the enzyme rubisco. A decrease in the activity of an enzyme means that the rate of the reaction it catalyses becomes slower.

A decrease in the activity of the enzyme rubisco would limit the rate of photosynthesis.

Explain why.

[2 marks]

0 1 . 3 Where precisely is rubisco found in a cell?

[1 mark]

Do not write outside the box

Scientists investigated the effect of temperature on the activity of two enzymes isolated from the leaf cells of cotton plants.

- Rubisco
- Rubisco activase – an enzyme that activates rubisco

Figure 1 and **Figure 2** show their results.

Figure 1

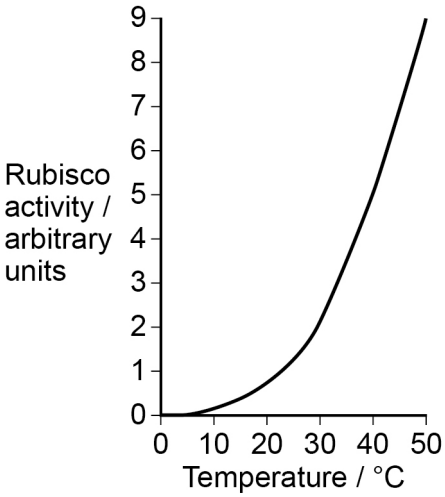
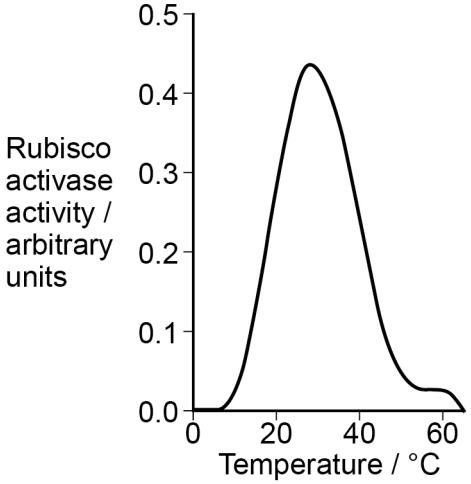


Figure 2



0 1 . 4 The scientists concluded that heat stress reduces the activity of rubisco in plant leaves by affecting rubisco activase.

Use all the information to evaluate their conclusion.

[4 marks]

9

Turn over ►

Do not write outside the box

0 7 . 1 In photosynthesis, which chemicals are needed for the light-dependent reaction?
Tick (✓) **one** box.

[1 mark]

Reduced NADP, ADP, Pi, water and oxygen. ☐

NADP, ATP and water. ☐

Reduced NADP, ATP, water and carbon dioxide. ☐

NADP, ADP, Pi and water. ☐

0 7 . 2 Describe what happens during photoionisation in the light-dependent reaction.

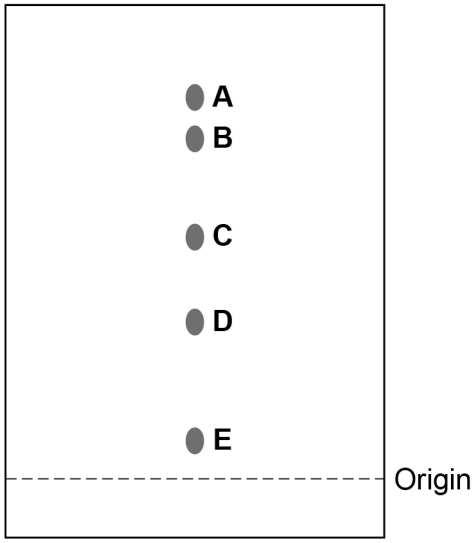
[2 marks]

Question 7 continues on the next page

A student obtained a solution of pigments from the leaves of a plant. Then the student used paper chromatography to separate the pigments.

Figure 5 shows the chromatogram produced.

Figure 5



0 7 . 3 Explain why the student marked the origin using a pencil rather than using ink.

[1 mark]

0 7 . 4 Describe the method the student used to separate the pigments after the solution of pigments had been applied to the origin.

[2 marks]

Do not write outside the box

0 7 . 5 Calculating the R_f values of the pigments can help to identify each pigment. An R_f value compares the distance the pigment has moved from the origin with the distance the solvent front has moved from the origin.

$$R_f = \frac{\text{distance pigment has moved from the origin}}{\text{distance solvent front has moved from the origin}}$$

The distance each pigment has moved is measured from the middle of each spot.

Pigment **A** has an R_f value of 0.95

Use **Figure 5** to calculate the R_f value of pigment **C**.

[1 mark]

R_f value of pigment **C** = _____

0 7 . 6 The pigments in leaves are different colours. Suggest and explain the advantage of having different coloured pigments in leaves.

[1 mark]

_____

_____

_____

_____

8

Turn over for the next question

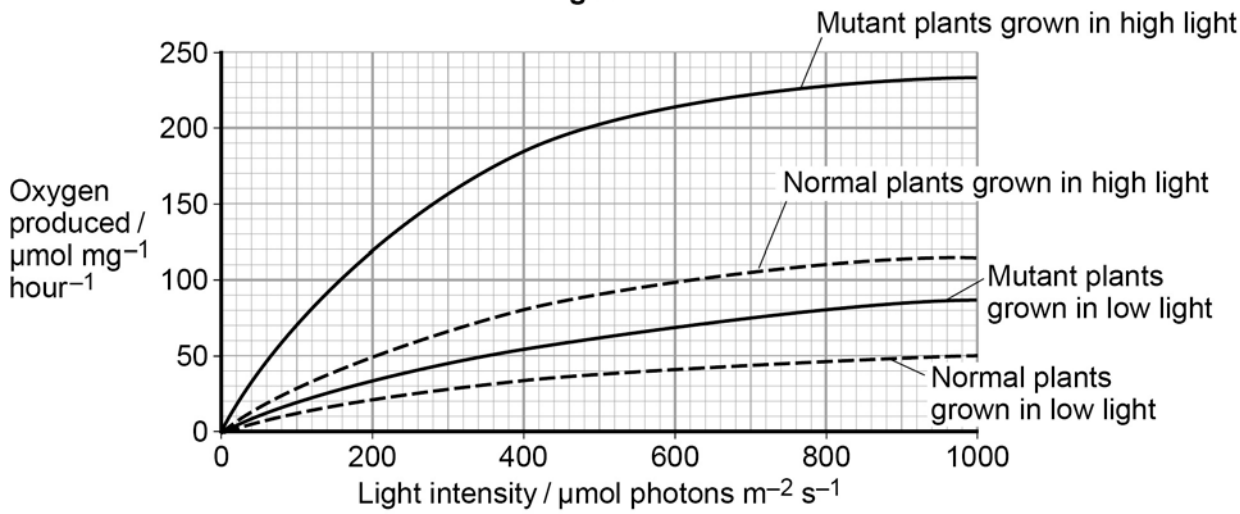
8 Chloroplasts contain chlorophyll a and chlorophyll b. Scientists found tobacco plants with a mutation that caused them to make more chlorophyll b than normal tobacco plants. They investigated the effect of this mutation on the rate of photosynthesis.

The scientists carried out the following investigation.

- They grew normal and mutant tobacco plants. They grew some of each in low light intensity and grew others in high light intensity.
- They isolated samples of chloroplasts from mature plants of both types.
- Finally, they measured oxygen production by the chloroplasts they had isolated from the plants.

Figure 7 shows the scientists' results.

Figure 7



0 8 . 1 Explain why the scientists measured the rate of production of oxygen in this investigation.

[2 marks]

In each trial, the scientists collected oxygen for 15 minutes.

0 8 . 2 Calculate the difference in the oxygen produced by the chloroplasts from mutant plants grown in low and high light intensities at a light intensity of 500 µmol photons m^{-2} s^{-1} during these trials.

Show your working.

[2 marks]

Difference _____ µmol O_2 mg^{-1}

0 8 . 3 The scientists suggested that mutant plants producing more chlorophyll b would grow faster than normal plants in all light intensities.

Explain how these data support this suggestion.

[4 marks]

[Extra space] _____

	3. Comparison of mode = one mark i.e. Adult (fibres) peak/most common/frequent/mode at 50 (µm) **and** young (fibres) peak/most common/frequent/mode at 30 (µm);		3. Accept: adult (fibres) peaks at higher diameter or young (fibres) peak/most frequent at lower diameter. 3. Reject: reference to mean/average.

Question	Marking Guidance	Mark	Comments
04.1	1. Osmosis does not occur; 2. Chloroplast/organelle does not burst/lyse/shrivel/shrink;	2	1. Accept: osmosis would occur if water potentials were not the same. 1 and 2, Accept: correct reference to osmotic lysis for **2 marks**. 2. Accept: chloroplast would burst/lyse/shrivel/shrink if water potentials were not the same. 2. Reject: 'cell bursts/shrivels' 2. Ignore: damage to chloroplasts on its own is not enough for a mark. 2. Reject: becomes turgid/flaccid.
04.2	1. To show light does not affect DCPIP; 2. To show chloroplasts are required;	2	Ignore: comparison with other tubes.
04.3	1. Reduction of DCPIP by electrons; 2. (From) chlorophyll/light dependent reaction;	2	1. Accept: hydrogen/H for electrons but not protons/hydrogen ions/H^+ on their own. 2. Accept: from chloroplasts/photosystems/water.

04.4	Provides a standard / reference point OR Can compare different chemicals/weed-killers OR Can compare different concentrations of chemicals/weed-killers;	1	Accept: decolourises quicker than 100% **or** saves time waiting for complete decolourisation. Note: comparisons must be qualified. Accept: find the most effective weed-killer **or** the most effective concentration. Accept: answers relating to cost effectiveness.

04.5	1. Less/no ATP produced; 2. Less/no reduced NADP produced; 3. Less/no GP reduced/converted to TP;	2 max	2, Accept: less/no NADPH/$NADPH_2$/NADPH + H

Question	Marking Guidance	Mark	Comments
01.1	1. (Less/no) ATP; 2. (Less/no) reduced NADP;	2	2. Accept NADPH, NADPH + H, $NADPH_2$ $NADPH + H^+$ 2. Reject reduced NAD, NADH etc,
01.2	1. (Less/no) carbon dioxide (reacts) with RuBP; 2. (Less/no) GP;	2	
01.3	1. Stroma (of/in chloroplast);	1	Reject: stoma Reject stroma of cytoplasm/chlorophyll Reject stroma of mitochondrion Ignore references to Calvin cycle or the light-independent reaction
01.4	1. Rubisco activity increases with temperature **OR** Rubisco optimum temperature is above (**rubisco activase**); 2. (Rubisco) **activase** activity decreases at high temperatures (allow any temperature above 25 ºC.) **OR** (Rubisco) **activase** optimum (allow in range) 25 to 30 ºC.; 3. (Results/graphs suggest) **activase** cannot/does not affect activity of rubisco; 4. (Results are) only for cotton; 5. (Results are) for isolated enzymes; 6. No stats test;	4 max	2. Accept denatures at high temperature (allow any temperature above 25 ºC) 4. Accept may not be the same in other species/types of plant Ignore: only one study

Question	Marking Guidance	Mark	Comments
07.1	☑ NADP, ADP, Pi and water;	1	
07.2	1. Chlorophyll absorbs light **OR** Light excites/moves electrons in chlorophyll; 2. Electron/s are lost **OR** (Chlorophyll) becomes positively charged;	2	1. Ignore photosystems. 2. Ignore site/molecule from where electrons are lost. 2. Accept electrons go to electron transport/carrier chain for 'electrons lost'.
07.3	Ink and (leaf) pigments would mix **OR** (With ink) origin/line in different position **OR** (With pencil) origin/line in same position **OR** (With pencil) origin/line still visible;	1	
07.4	1. Level of solvent below origin/line; 2. Remove/stop before (solvent) reaches top/end;	2	1. Reject water or any named aqueous solution. 1. Accept named organic solvent.
07.5	Accept any answer in range of 0.58 to 0.62;	1	Accept 0.58 or 0.62. Ignore any numbers which follow numbers in range.
07.6	(Absorb) different/more wavelengths (of light) for photosynthesis;	1	Accept wider/larger range of wavelengths. Accept frequency for wavelength. Accept light-dependent reaction /photophosphorylation /photoionisation for photosynthesis.

Question	Marking Guidance	Mark	Comments
08.1	1. Oxygen produced in light-dependent reaction; 2. The faster (oxygen) is produced, the faster the light-dependent reaction;	2	
08.2	35–36 (µmol O_2 mg^{-1});;	2	Correct difference at 500 µmol photons m^{-2} s^{-1} or incorrect difference but division by 4 shown = 1 mark
08.3	At all light intensities, chloroplasts from mutant plants: 1. Have faster production of ATP and reduced NADP; 2. (So) have faster/more light-independent reaction; 3. (So) produce more sugars that can be used in respiration; 4. (So) have more energy for growth; 5. Have faster/more synthesis of new organic materials;	4 max	Accept converse points if clear answer relates to non-mutant plants