Q1.

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

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

NADP, ATP and water. ☐

Reduced NADP, ATP, water and carbon dioxide. ☐

NADP, ADP, Pi and water. ☐

(1)

(b) Describe what happens during photoionisation in the light-dependent reaction.

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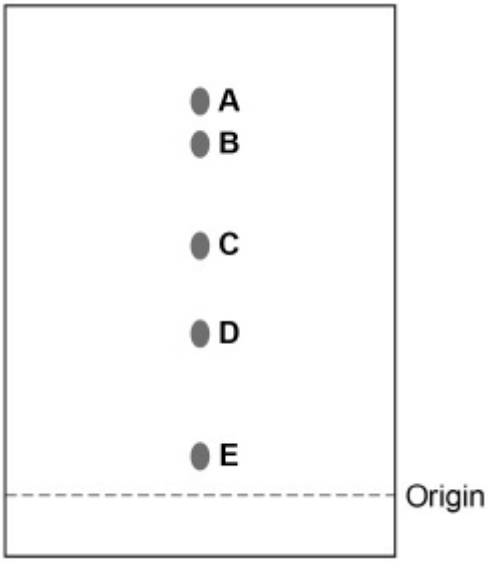
(2)

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

The diagram shows the chromatogram produced.



(c) Explain why the student marked the origin using a pencil rather than using ink.

_____

_____

_____

(1)

(d) Describe the method the student used to separate the pigments after the solution of pigments had been applied to the origin.

_____

_____

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_____

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_____

(2)

(e) 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 the diagram above to calculate the R_f value of pigment **C**.

R_f value of pigment **C** = _____

(1)

(f) The pigments in leaves are different colours. Suggest and explain the advantage of having different coloured pigments in leaves.

_____

_____

_____

_____

(1)

(Total 8 marks)

Q2.

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.

(a) Heat stress decreases the light-dependent reaction of photosynthesis.

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

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(2)

(b) 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.

_____

_____

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(2)

(c) Where precisely is rubisco found in a cell?

_____

_____

(1)

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

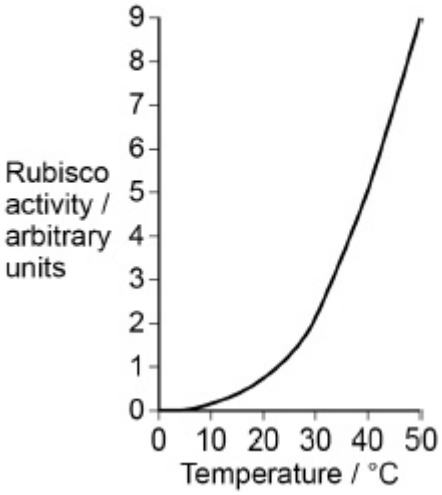
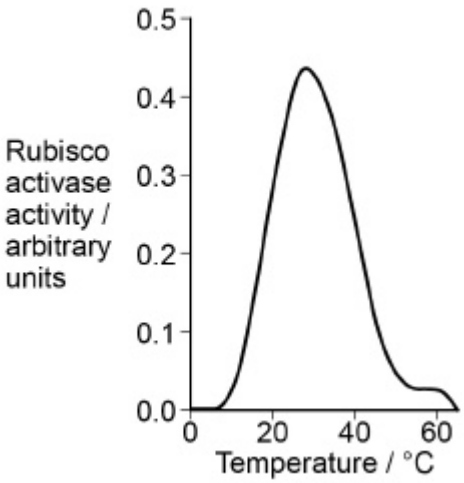


Figure 2



(d) 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)

(Total 9 marks)

Q3.

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 the table.

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

(a) 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)

(b) Explain why the student set up **Tube 1**.

_____

_____

_____

_____

(2)

(c) Explain the results in **Tube 3**.

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_____

_____

_____

(2)

(d) 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.

_____

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_____

(1)

(e) Explain how chemicals which inhibit the decolourisation of DCPIP could slow the growth of weeds.

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_____

_____

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_____

(2)

(Total 9 marks)

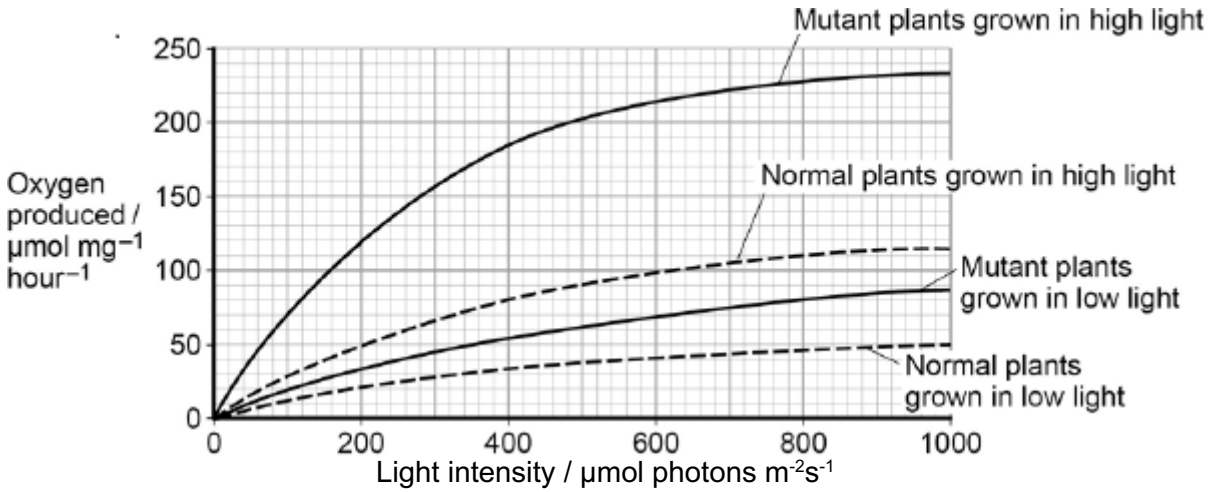
Q4.

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.

The figure below shows the scientists' results.



(a) Explain why the scientists measured the rate of production of oxygen in this investigation.

_____

_____

_____

_____

(2)

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

(b) 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}.

Show your working.

Difference _____ µmol O_2 mg^{-1} $hour^{-1}$

(2)

(c) 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.

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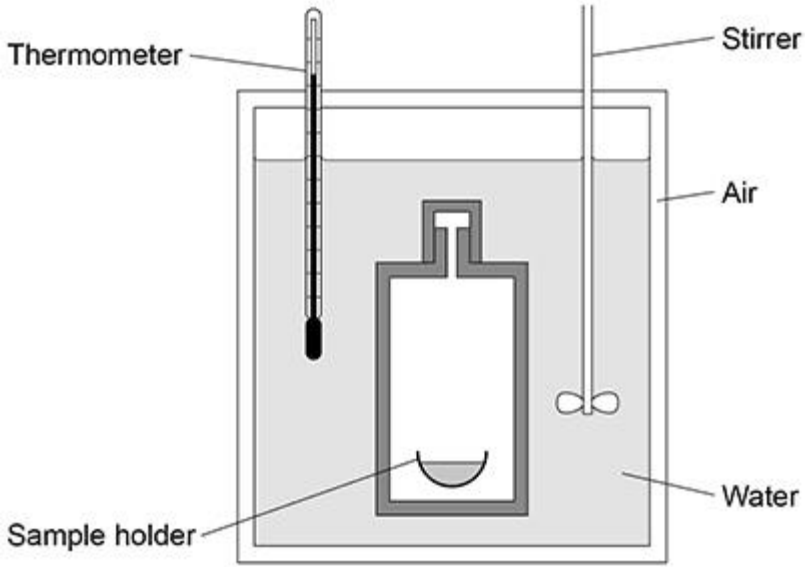
(4)

(Total 8 marks)

Q5.

The diagram below shows one type of calorimeter.



A calorimeter can be used to determine the chemical energy store of biomass. A known mass of biomass is fully combusted in a calorimeter. The heat energy released from this combustion increases the temperature of the water in the calorimeter. The increase in the temperature of a known volume of water is recorded.

(a) Other than the thermometer, explain how **two** features of the calorimeter shown in the diagram above would enable a valid measurement of the total heat energy released.

1 _____

_____

_____

2 _____

_____

_____

(2)

(b) A 2 g sample of biomass was fully combusted in a calorimeter.

The volume of water in the calorimeter was 100 cm^3

The increase in temperature recorded was 15.7 °C

4.18 J of energy are needed to increase the temperature of 1 cm^3 of water by 1 °C

Use this information to calculate the heat energy released in kJ per g of biomass.

Show your working.

Answer _____ kJ g^{-1}

(2)

Plants and algae produce fuels called biofuels. Scientists have used *Chlorella* to produce biofuel. *Chlorella* is a genus of single-celled photosynthetic alga. *Chlorella* can be grown in open ponds and fermenters.

(c) In natural ecosystems, most of the light falling on producers is **not** used in photosynthesis.

Suggest **two** reasons why.

1 _____

_____

_____

2 _____

_____

_____

(2)

(d) The light absorbed by chlorophyll is used in the light-dependent reaction.

Name the **two** products of the light-dependent reaction that are required for the light-independent reaction.

1 _____

2 _____

(2)

(e) *Chlorella* cells can divide rapidly. A culture of 2000 *Chlorella* cells was set up in a fermenter. The cells divided every 90 minutes.

You can assume that there were no limiting factors and that no cells died during the 24 hours.

Calculate the number of cells in the culture after 24 hours.

Give your answer in standard form.

Show your working.

Answer _____

(2)

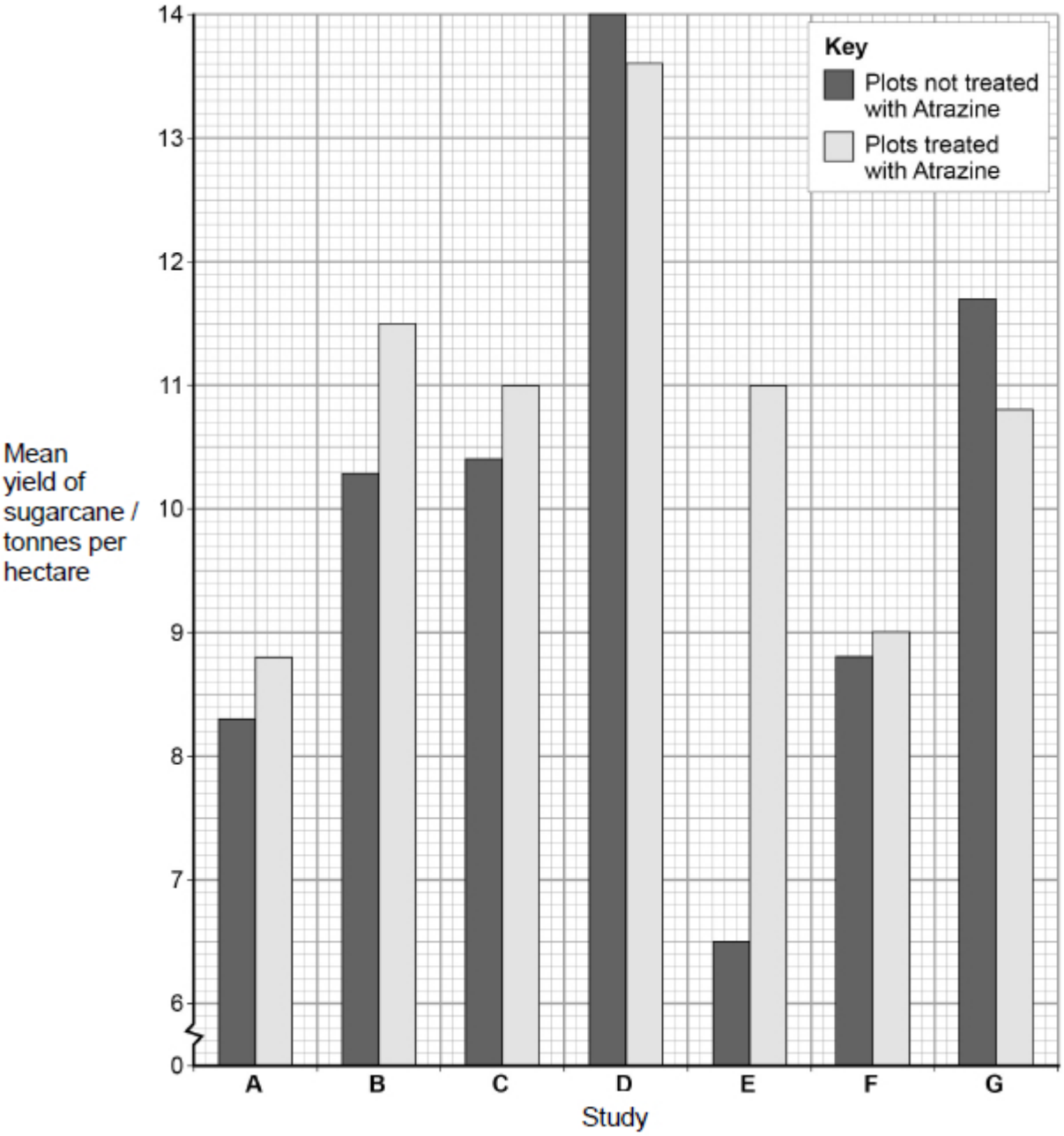
(Total 10 marks)

Q6.

Herbicides can be used to reduce the growth of weeds.

Scientists completed seven studies to determine how the use of the herbicide Atrazine affected the yield of sugarcane. In each study, some plots were treated with Atrazine and some plots were not treated with Atrazine.

The graph below shows the scientists' results. (1 hectare = 10 000 m^2)



(a) Calculate the percentage decrease in yield caused by the use of Atrazine in study **G**.

Answer = _____ %

(1)

(b) A teacher studying these data with her students told her class that no definite conclusions could be drawn when comparing the mean values in the graph.

Suggest why the teacher said this.

_____

_____

_____

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(2)

(c) Atrazine binds to proteins in the electron transfer chain in chloroplasts of weeds, reducing the transfer of electrons down the chain.

Explain how this reduces the rate of photosynthesis in weeds.

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(4)

(d) When treated with Atrazine, weeds have been shown to give off small amounts of heat.

Suggest an explanation for this observation.

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_____

_____

(1)

(Total 8 marks)