Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U10-1

Z22-A400U10-1-R1

THURSDAY, 9 JUNE 2022 – AFTERNOON

BIOLOGY – A level component 1
Energy for Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**12**	
3.	**18**	
4.	**11**	
5.	**17**	
6.	**20**	
7.	**9**	
Total	**100**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7**.

The quality of written communication will affect the awarding of marks.

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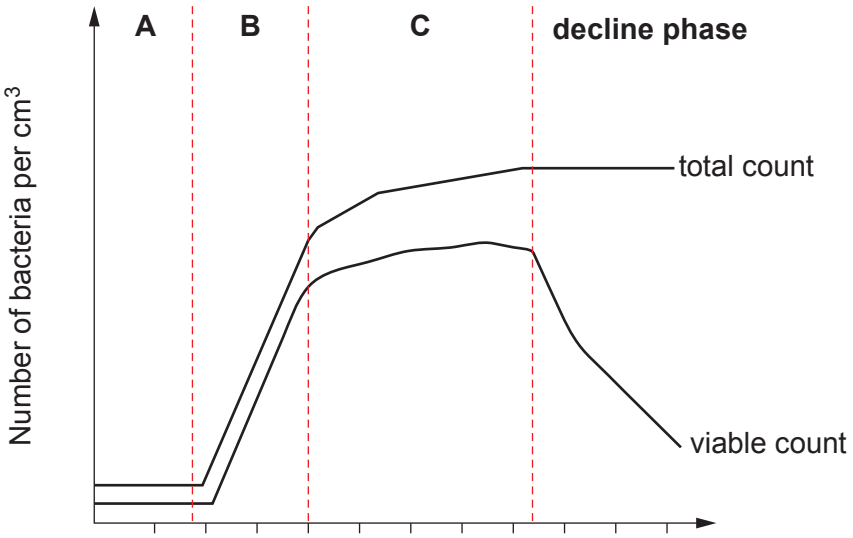
Answer **all** questions.

1. A flask of sterile culture medium was inoculated with a small number of bacterial cells. The number of bacteria per cm^3 of culture medium was monitored at regular intervals using a total count and a viable count. The results were plotted as shown in **Image 1.1**.

Image 1.1



(a) (i) **Complete the table below** to name stages **A**, **B** and **C** of the population growth curve shown in **Image 1.1** and explain the shape of the growth curve in each stage. [3]

Stage	Name of Stage	Explanation of the shape of the population growth curve
A	.....	....
B	.....	....
C	.....	....

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(ii) Explain the difference between the shape of the decline phase obtained using a total count and a viable count. [1]

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(iii) One method of estimating the number of bacteria is to dilute a sample of the bacterial culture, plate out known volumes onto agar plates and count the number of colonies following incubation. Explain why you could not use this method to collect **all** the data shown in **Image 1.1**. [1]

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(b) Bacterial cells divide at a constant rate when conditions are optimum.

The generation time for bacteria is defined as the time for a bacterial population to double in number. Generation times of different species of bacteria vary from approximately 12 minutes to 30 hours.

(i) State **two** environmental conditions that could affect the rate of bacterial cell division. [1]

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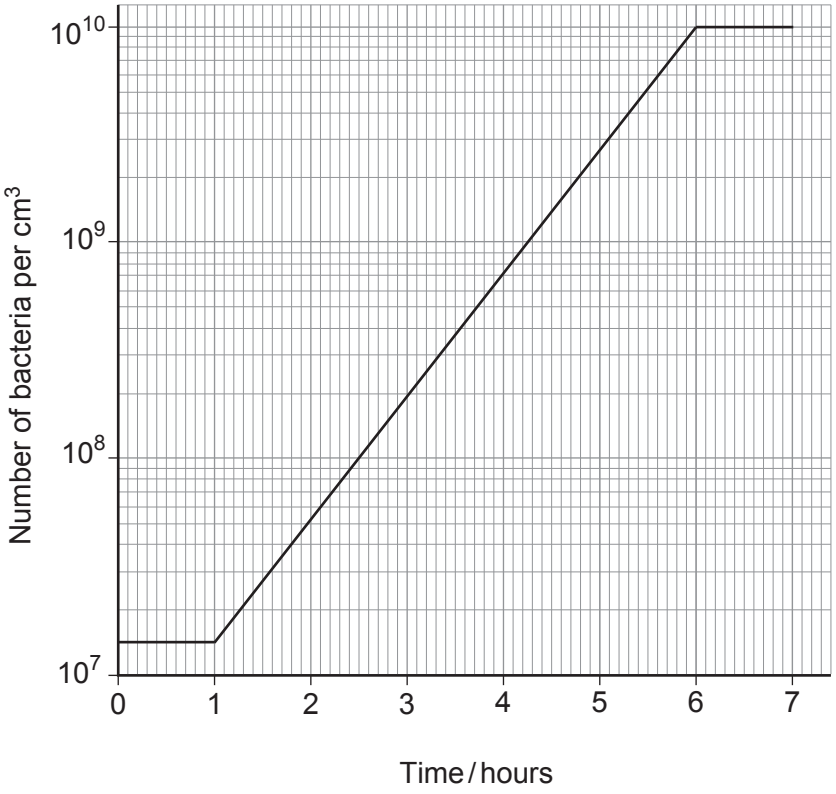
(ii) For a culture in which cells divide every 20 minutes, calculate how many cells will be produced after eight hours from a single bacterium. **Express your answer in the form 2^n where n = the number of generations.** [2]

Number of bacteria after eight hours = ...

(c) A different method of assessing the growth of bacterial populations is to determine the number of generations of bacteria produced in a given time period. **Image 1.2** shows the number of bacteria per cm^3 present in a culture over a seven hour period.

Image 1.2



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(i) Use the graph in **Image 1.2** and the formula given below to calculate the number of generations produced per hour between **2.5** hours and **6** hours. **Express your answer to one decimal place.** [3]

$$\text{Number of generations per hour} = \frac{\log_{10}[X_t] - \log_{10}[X_0]}{0.301 \times t}$$

Where:

X_t = number of bacteria per cm^3 at the end of the growth period
X_0 = number of bacteria per cm^3 at the start of the growth period
t = length of growth period in hours

Number of generations per hour = ...

(ii) Under optimum conditions this species of bacteria should have a generation time of 30 minutes. Using your calculated figure for the number of generations per hour, conclude whether the bacteria in this culture were grown under optimum conditions during this time period. Explain your answer. [2]

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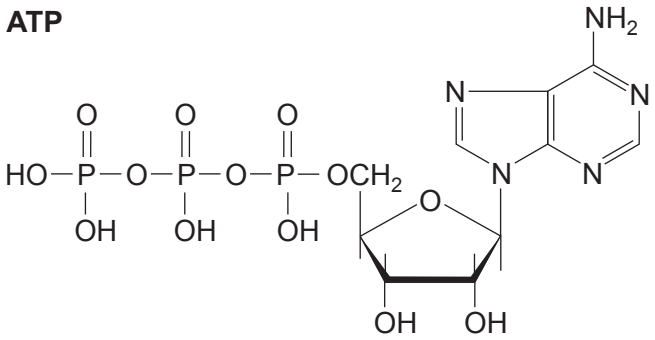
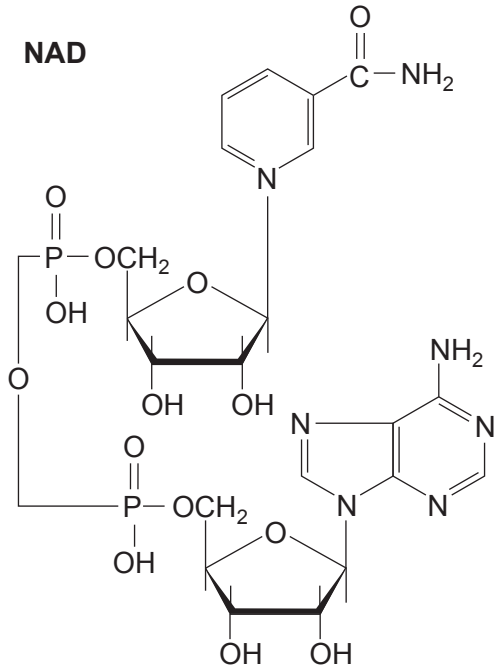
2. Both ATP and NAD (nicotinamide adenine dinucleotide) have roles in respiration. The biochemical structures of ATP and NAD are shown in **Image 2.1**.

Image 2.1

ATP



NAD



(a) (i) Name the **three** biochemical components found in **both** ATP and NAD. [2]

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(ii) State how **one** biochemical component of a nucleotide found in **DNA** would differ from **both** of the molecules shown in **Image 2.1**. [1]

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(iii) ATP acts as a common energy source for reactions in the cells of all living organisms. Most ATP in eukaryotic cells is synthesised in the mitochondria. Describe the role of NAD in the synthesis of ATP. [4]

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(b) Some flowers are able to generate heat. The heat is used to evaporate chemicals. In flowers such as the titan arum, *Amorphophallus titanum*, shown in **Image 2.2**, the evaporated chemicals smell like rotting meat. These chemicals attract flies and other insects.

Image 2.2

(i) The inner membranes of mitochondria in some cells of the flowers are permeable to protons. Using your knowledge of respiration in mitochondria, explain how this enables the flower to generate heat. [3]

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(ii) Explain why the generation of heat helps to increase genetic diversity in this species. [2]

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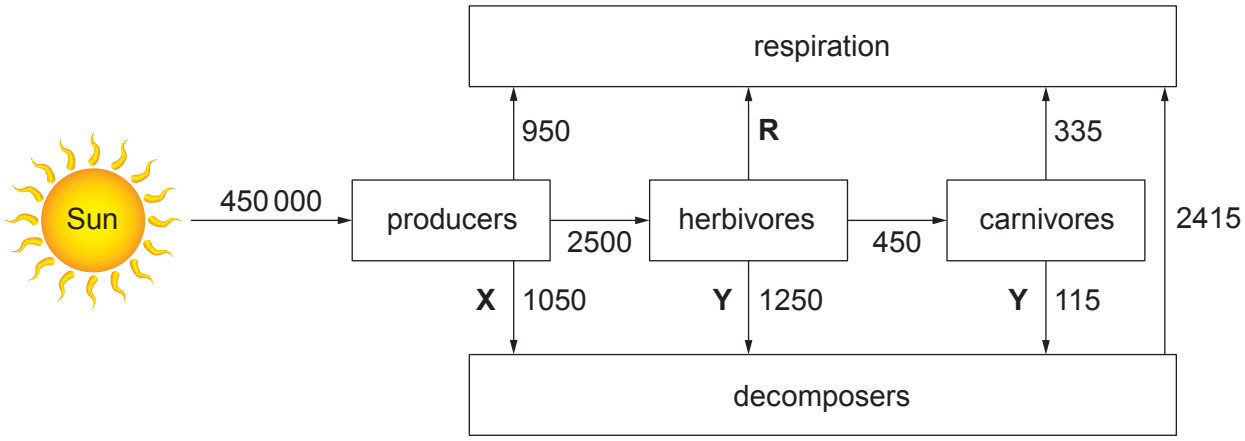
3. In terrestrial ecosystems the Sun is the ultimate source of energy. The flow of energy through one ecosystem is shown in **Image 3.1** where **R** = respiration. The figures are given in $kJ\,m^{-2}\ year^{-1}$.

Image 3.1



(a) The productivity of the producers can be represented as:

GPP = NPP + R

(i) State what is represented by the following abbreviations: [1]

GPP .....

NPP .....

(ii) Using figures from **Image 3.1**, calculate the following:

I. The **GPP** of the producers. [1]

GPP = ... $kJ\,m^{-2}\ year^{-1}$

II. The **NPP** of the producers. [1]

NPP = ... $kJ\,m^{-2}\ year^{-1}$

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(b) The energy transferred from plants and animals to the decomposers is represented in **Image 3.1** by **X** and **Y** respectively. For plants, the energy transferred at **X** is in the form of dead tissue.

(i) Apart from dead tissue, name **two** other processes carried out by herbivores and carnivores that would also transfer energy to decomposers at **Y**. [2]

I. .....

II. .....

(ii) Using figures from **Image 3.1**, calculate the secondary productivity of the herbivores and use this to calculate **R** for this trophic level. [2]

Secondary productivity = ... $kJ\,m^{-2}\,year^{-1}$

R = ... $kJ\,m^{-2}\,year^{-1}$

(iii) State **two** types of organisms which act as decomposers. [1]

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(iv) In the UK, most plants die or shed their leaves in the Autumn. Using your knowledge of the nitrogen cycle, explain why you would expect the nitrogen content of soil to **increase during the winter** but then **decrease during the spring and summer months**. [4]

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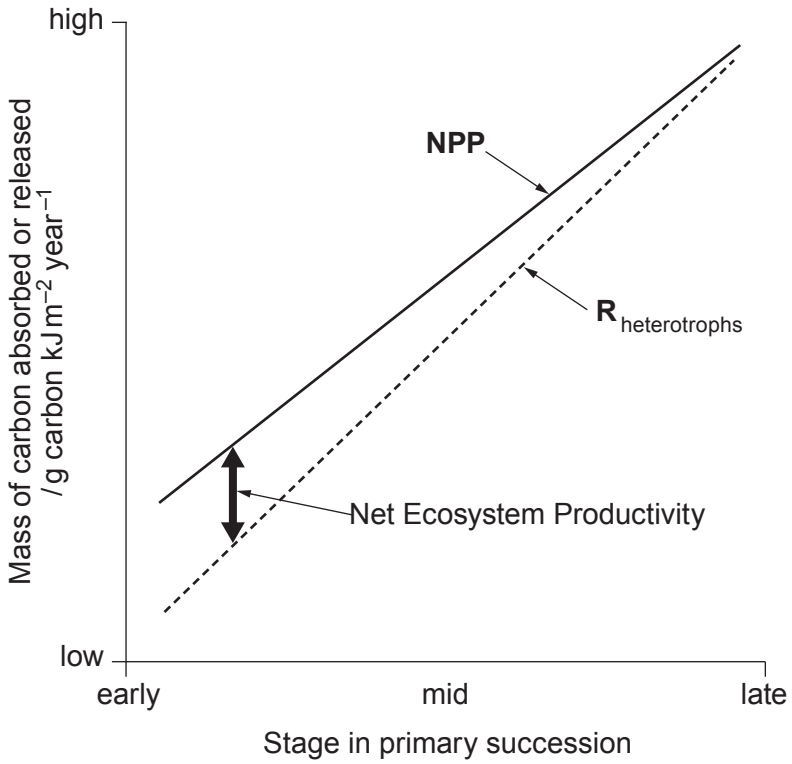
(c) Net Ecosystem Productivity (NEP) is defined as the rate of accumulation of organic matter in an ecosystem. It can be calculated as:

$$\mathbf{NEP = NPP - R_{heterotrophs}}$$

Image 3.2 summarises the relationship between **NPP** and the rate of respiration by heterotrophs during the development of a forest ecosystem.

Image 3.2



(i) A forest is often the final stage in the development of an ecosystem which can then exist for hundreds of years. State the term used to describe the last stage in the development of an ecosystem. [1]

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(ii) With reference to the terms **GPP** and **R**, explain why the productivity of an ecosystem can be expressed in terms of absorption of carbon dioxide or by the release of carbon dioxide. [2]

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(iii) With reference to the information provided and your knowledge of succession, conclude why Net Ecosystem Productivity eventually approaches zero. [3]

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4. Respiration is a catabolic process during which glucose, lipids and proteins can be broken down to release energy. Some of the energy is transferred to chemical energy in the form of ATP.

(a) Theoretically, the energy released from one molecule of glucose by aerobic respiration is sufficient to produce 38 molecules of ATP. The removal of the terminal phosphate group from one ATP molecule by hydrolysis releases 30.6 kJ mol^{-1}. When glucose reacts directly with oxygen 2870.0 kJ mol^{-1} are released.

(i) Calculate the efficiency of aerobic respiration of glucose. **Give your answer to a suitable number of decimal places.** [2]

Efficiency of aerobic respiration = ... %

(ii) State what happens to the energy which is not used to generate ATP. [1]

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(iii) **Table 4.1** compares figures from the respiration of carbohydrate and lipid.

Table 4.1

Energy source	Energy released / kJ g^{-1} food	Metabolic water produced / g g^{-1} food	Oxygen consumed / dm^3 g^{-1} food
Carbohydrate	17.2	0.56	0.83
Lipid	38.9	1.07	2.02

With reference to the figures in **Table 4.1**:

I. Explain why the food store in many plant seeds is in the form of a lipid rather than carbohydrate. [2]

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II. Suggest why animals living in very dry habitats use lipids to supply their energy rather than carbohydrates. [1]

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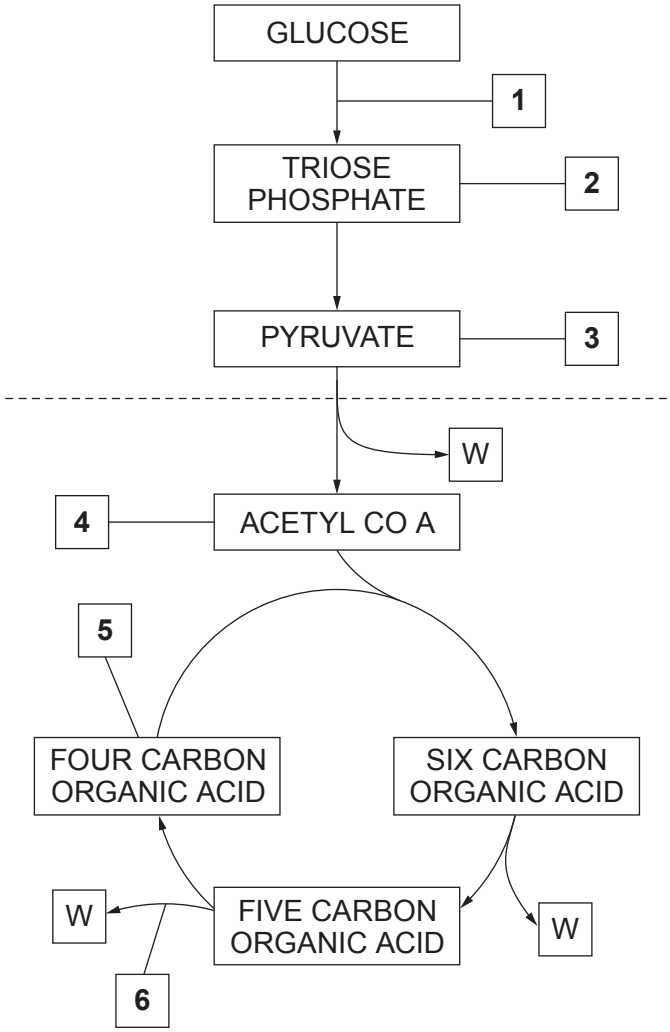
(b) **Image 4.2** shows a summary of the stages involved in the aerobic respiration of glucose.

Image 4.2



(i) Lipids are digested into glycerol, a three carbon compound, and fatty acids. The fatty acids are then broken down further in the liver into two carbon fragments.

Using numbers from **Image 4.2** indicate where the products of fat digestion could enter the respiratory pathway. [2]

Glycerol .....

Fatty acids .....

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(ii) Before proteins can enter the respiratory pathway they must be hydrolysed. Describe how proteins are hydrolysed and suggest which stage of respiration the products of protein hydrolysis are **most likely** to enter. [3]

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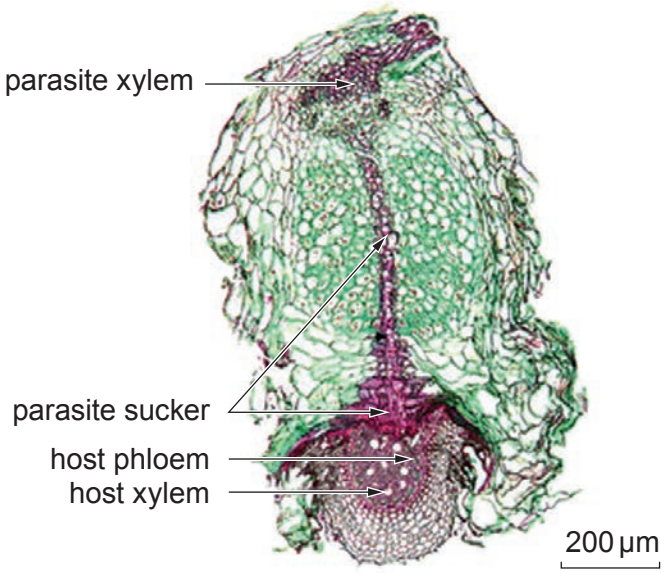
5. Yellow rattle, *Rhinanthus minor*, is a plant which is a parasite of grass. It absorbs its nutrients from grass roots. **Image 5.1** shows the flowers of yellow rattle growing in grassland and **Image 5.2** shows a transverse section through a grass root parasitized by yellow rattle.

Image 5.1

Image 5.2



(a) (i) **Using the scale bar**, calculate the magnification of **Image 5.2**. [2]

Magnification = × .....

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(ii) Studies have shown that the parasite sucker penetrates the host phloem sieve tubes and host xylem vessels.

I. State the name of the hypothesis that provides an explanation of how sucrose could move from host to parasite tissue. [1]

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II. Water and minerals move from the host tissues to the parasite vessels through the apoplast and symplast pathways. Explain what is meant by these terms. [2]

Apoplast pathway

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Symplast pathway

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(b) Grasslands contain a wide variety of flowering plants which produce flowers at different times of the year. The biodiversity of these grasslands decreases when they are invaded by species of fast-growing grass. Using the information provided, suggest why the introduction of yellow rattle to these grasslands might restore biodiversity. [3]

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To investigate whether the introduction of yellow rattle into grassland might restore biodiversity, grassland containing a single species of fast-growing grass was divided into two equal areas, area **A** and area **B**

Area **A** was seeded using a mixture of flowering plants and yellow rattle seeds

Area **B** was seeded using the same mixture of flowering plants but with no yellow rattle seeds.

The abundance and distribution of plant species in areas **A** and **B** were determined before seeding and one year after seeding.

(c) Explain why the following steps were taken when collecting data on the abundance and distribution of plant species in both areas:

(i) Each area was divided into a grid **and** a random number generator used. [2]

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(ii) Area **B** was not seeded with yellow-rattle seeds. [2]

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(iii) The experiment was conducted **several times** on grassland with the same species of fast-growing grass. [2]

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(d) The data collected from areas **A** and **B** were used to calculate a Simpson's biodiversity index. **Table 5.3** shows the mean values of the Simpson's Diversity Index of areas **A** and **B** before and one year after seeding.

Table 5.3

	Value of Simpson's Diversity Index	
	Area **A**	Area **B**
Before seeding	0.45	0.46
One year after seeding	0.51	0.47

Based on these data only, it was concluded that seeding grassland with yellow rattle did result in an increase in biodiversity. However, it was decided that more data would be needed to improve confidence in this conclusion.

The following modifications to the method were suggested. Explain how each change to the method can be justified. [3]

Change	Justification
Calculate the biodiversity index again five years after seeding	....
Calculate the biodiversity index a number of different times in the same year	....
Carry out the investigation in different areas with different fast-growing grass species	....

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6. The traditional balanced equation for photosynthesis is given as:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

It was once believed that all the oxygen released by photosynthesis came from the carbon dioxide molecules.

(a) (i) With reference to the equation explain why this statement could be correct. [2]

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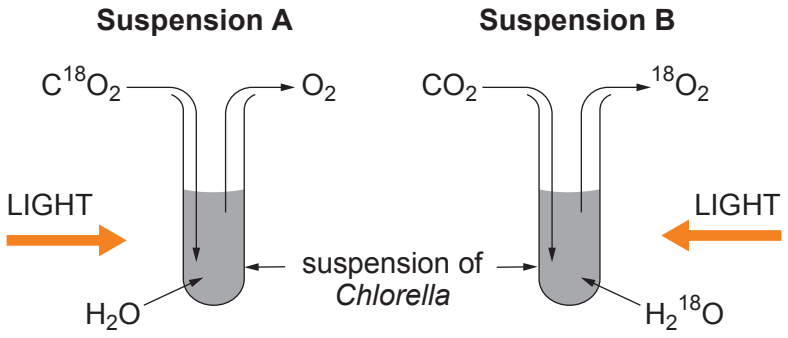
An experiment, shown in **Image 6.1**, was carried out to confirm the origin of the oxygen molecules released in photosynthesis. In this experiment two suspensions of a photosynthetic unicellular alga, *Chlorella*, were treated as follows:

Suspension A
- provided with water containing a non-radioactive isotope of oxygen (H_2O)
- and carbon dioxide containing a radioactive isotope of oxygen ($C^{18}O_2$)

Suspension B
- provided with water containing a radioactive isotope of oxygen ($H_2{}^{18}O$)
- and carbon dioxide containing a non-radioactive isotope of oxygen (CO_2)

Image 6.1



(ii) Using evidence from this experiment and your knowledge of photosynthesis, deduce the actual origin of the atoms in the oxygen molecules. Explain your answer. [2]

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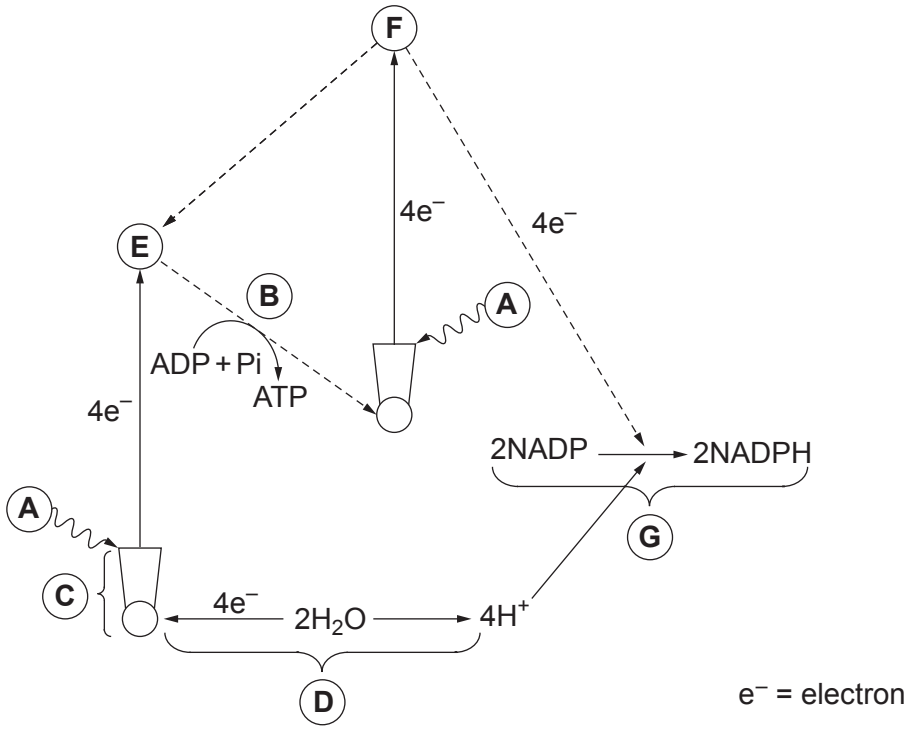
(b) The light dependent stage of photosynthesis relies on the flow of electrons between different molecules as shown in **Image 6.2**.

Image 6.2



(i) State what is represented by the following letters in **Image 6.2**. [3]

A .....

B .....

C .....

D .....

E and **F** .....

(ii) State the type of reaction occurring at **G**. Explain your answer. [2]

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(iii) The events shown in **Image 6.2** take place in chloroplasts, which act as transducers. With reference to **Image 6.2**, explain how chloroplasts act as transducers in photosynthesis. [1]

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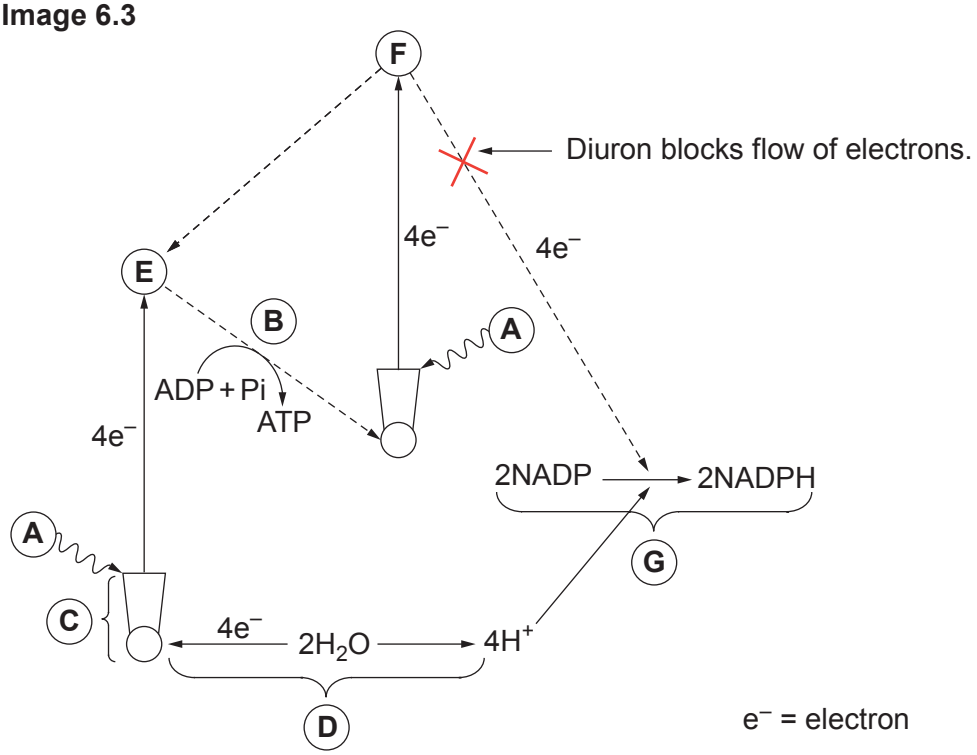
(iv) Weeds are commonly controlled by using herbicides. Diuron is a herbicide which binds to a molecule preventing the flow of electrons, as shown by **X** in **Image 6.3**.

Image 6.3



Using information from **Image 6.3**, and your knowledge of photosynthesis, suggest how the action of Diuron results in the death of weeds. [4]

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(c) DCPIP (2,6-dichlorophenol-indophenol) is a blue dye which acts as an electron acceptor and becomes colourless when it accepts electrons.

The flow diagram describes the method used by a student to isolate chloroplasts. **Image 6.4** shows a centrifuge tube containing the isolated chloroplasts.

Method

Grind spinach leaves in an ice-cold solution of sucrose and buffer.

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Filter extract.

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Centrifuge to obtain a small pellet of chloroplasts.

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Separate pellet from supernatant.

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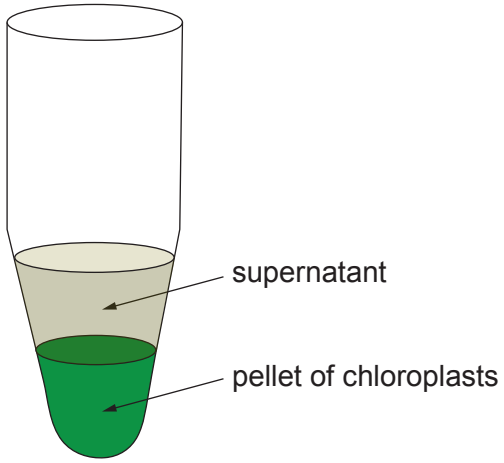
Re-suspend the chloroplasts and keep cool.

Image 6.4



(i) State the role of the buffer in this experiment. [1]

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(ii) The solution used in the experiment was isotonic to the stroma in the chloroplasts. State the meaning of the term isotonic. [1]

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The student used the isolated chloroplasts to prove that electrons are released by chlorophyll during photosynthesis. **Table 6.5** shows how four different experimental tubes were set up, whether they were exposed to light or not and the colour change observed.

Table 6.5

Tube	Volume / cm^3				Light or no light	DCPIP colour change
	suspended chloroplasts	supernatant	sucrose and buffer solution	DCPIP solution		
1	0.5			5	light	blue to colourless
2			0.5	5	light	no colour change
3	0.5			5	no light	no colour change
4		0.5		5	light	no colour change

(iii) Explain why each of the **experimental tubes 1–4** were included in this investigation and conclude whether the results prove that electrons are released by chlorophyll during photosynthesis or not. Explain your answer. [4]

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7. It has been estimated that 10 million km^2 of forest have been lost from the planet since the beginning of the 20^{th} century. One of the reasons for deforestation is to meet the demands for food for an increasing human population.

Explain how the conversion of forests to areas of intensive human food production using modern agricultural practices often leads to the death of fish and aquatic invertebrates. Describe the harmful impacts of deforestation on the environment and suggest how the conflicts of interest between food production and conservation can be resolved. [9 QER]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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