Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U10-1

O21-A400U10-1

MONDAY, 11 OCTOBER 2021 – MORNING

BIOLOGY – A level component 1
Energy for Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**8**	
3.	**16**	
4.	**14**	
5.	**14**	
6.	**10**	
7.	**16**	
8.	**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. Do not use 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 **8**.

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

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Answer **all** *questions.*

1. Plants can harvest light energy using photosystems and use this energy to synthesise organic molecules.

(a) (i) State the precise location of photosystems in plants. [1]

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(ii) Explain how the arrangement of pigments in photosystems harvests light energy. [3]

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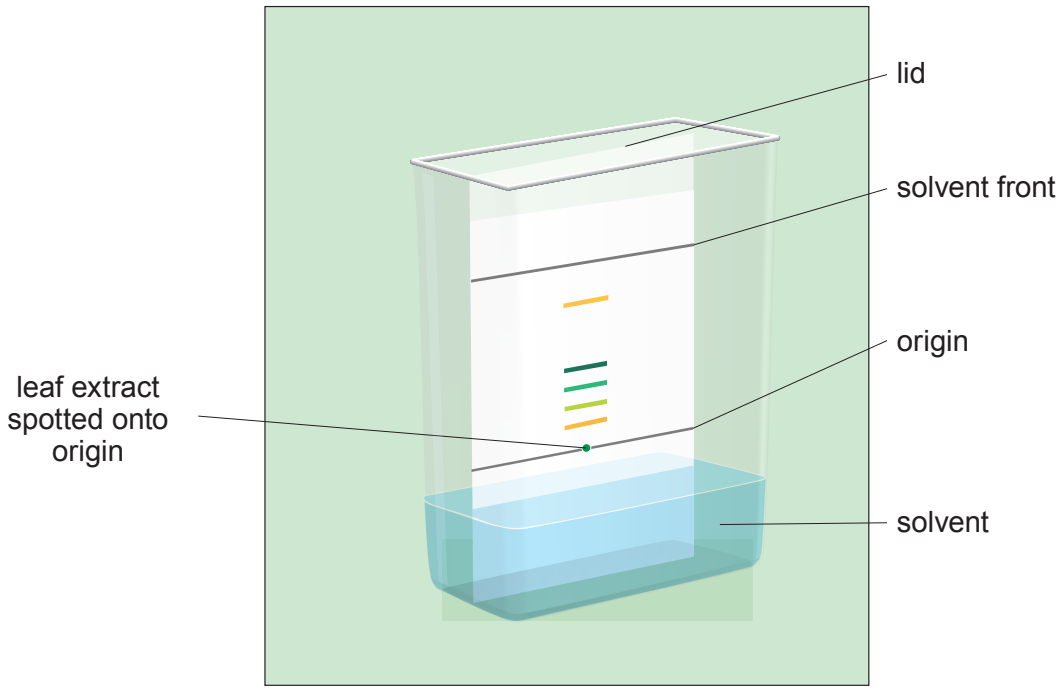
(b) The pigments in a leaf can be separated by either paper or thin layer chromatography in the apparatus shown in **image 1.1**.

Image 1.1



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The flow diagram gives an outline of the method used.

Extract pigments from leaf using a solvent.

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Draw a pencil line at the origin.

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Spot leaf extract onto the origin.

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Place in the chromatography chamber.

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Leave in solvent.

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Mark position of solvent front and position of each pigment front.

(i) Explain why the origin line is drawn in pencil **and** why the level of the solvent used is below the origin line. [2]

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(ii) Describe the method by which the pigment is concentrated on the origin line. [1]

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(iii) Complete the risk assessment below for this experiment. [1]

Hazard	Risk	Control measure
Solvents are irritants	.....	.....
	.....	.....

(iv) State **one** variable which would need to be controlled if this method was used to compare the pigments in leaves of two different species of plant. [1]

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(c) A pigment can be identified by calculating its Rf value.

$$Rf = \frac{\text{Distance travelled by pigment}}{\text{Distance travelled by solvent front}}$$

Image 1.2 below shows the separation of pigments using the method shown.

Image 1.2

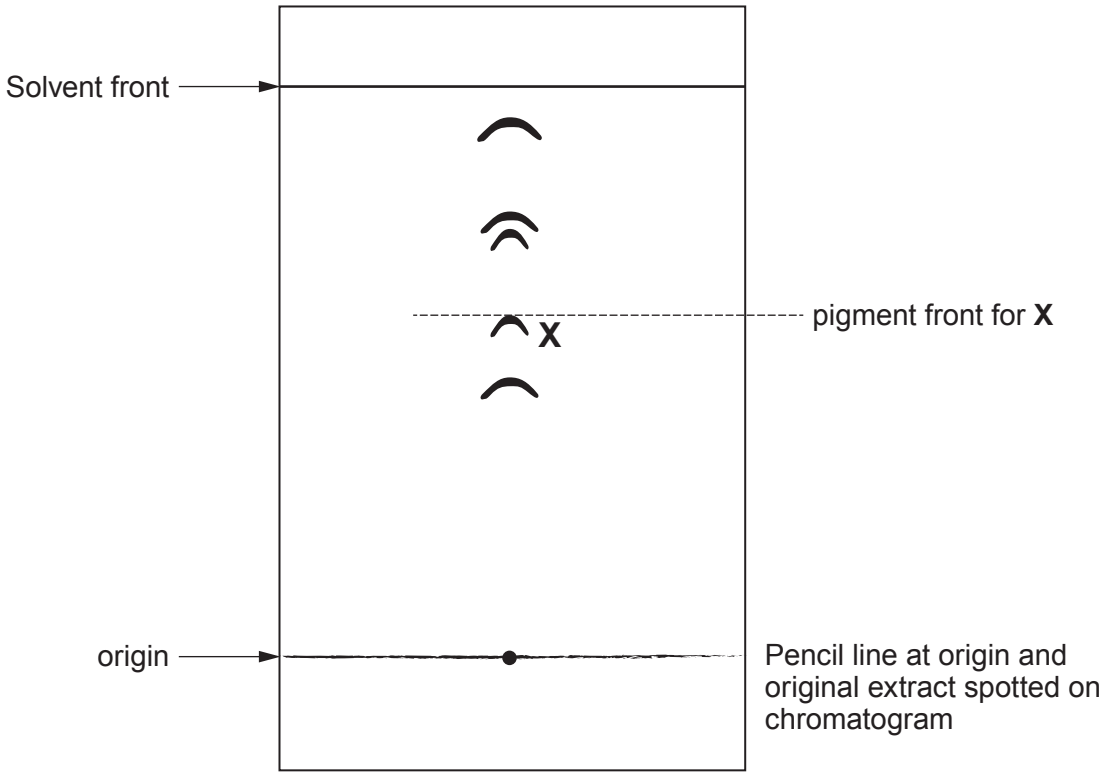

Table 1.3 shows data for separation in 2:1 propanone:petroleum ether.

Table 1.3

Pigment	Rf
β-carotene	0.96
phaeophytin	0.70
Chlorophyll a	0.60
Chlorophyll b	0.48
Xanthophyll	0.75

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(i) Calculate the Rf value for pigment **X** in **image 1.2** and use **table 1.3** to identify the pigment.
Show all your working. [2]

Rf value = ...

Pigment = ...

(ii) You are provided with a pure solution of each pigment. Describe how you could confirm that your identification of pigment **X** using the Rf value was correct. [2]

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2. Bacteria can be distinguished from each other by their size, shape, staining characteristics and their metabolic features. **Image 2.1** shows three different types of bacteria. **Image 2.2** shows two different types of bacteria after Gram staining.

Image 2.1

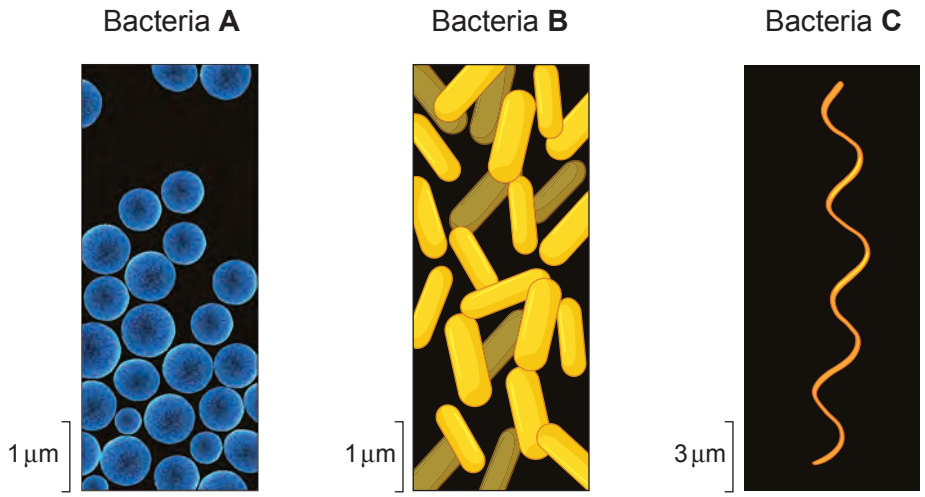
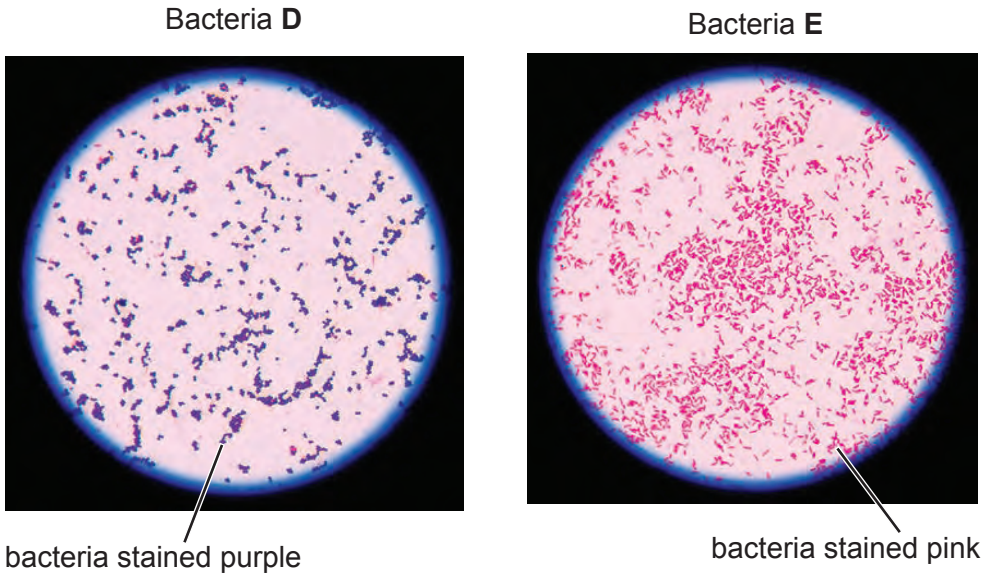


Image 2.2



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(a) (i) State the names given to the shapes of bacteria, **A**, **B** and **C** shown in **image 2.1**. [1]

A .....

B .....

C .....

(ii) State and explain what the results of the staining shown in **image 2.2** indicates about the structure of the cell walls of bacteria **D** and **E**. [2]

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(iii) Micro-organisms may be grown in the laboratory if supplied with suitable nutrients.

Explain why micro-organisms must be provided with a source of:

I. nitrogen [1]

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II. phosphorus [1]

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(b) Nutrient agars can be modified so that only particular types or species of bacteria can grow in them.
MacConkey's mannitol salt agar contains a chemical called mannitol and a pH indicator. It will only allow:

- the growth of Gram negative bacteria;
- the growth of bacteria that can tolerate high concentrations of sodium chloride (halophiles).

Some species of bacteria can break down mannitol producing an acid which causes the pH indicator to change from pink to yellow.

Staphylococcus aureus, *Staphylococcus epidermidis* and *Micrococcus luteus* are all species of bacteria which live on human skin.

Table 2.3 shows some information about these three species.

Table 2.3

Species of bacterium	Disease causing	Gram staining	Halophile	Breakdown of mannitol (which produces an acid)
Staphylococcus aureus	Pathogen	Gram negative	Yes	Yes
Staphylococcus epidermidis	Non pathogenic	Gram negative	Yes	No
Micrococcus luteus	Non pathogenic	Gram positive	No	No

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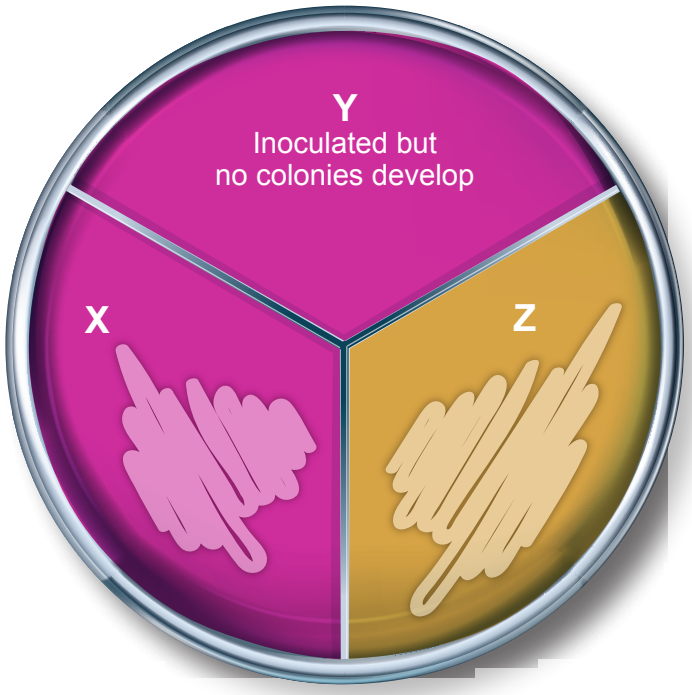
An agar plate containing MacConkey's mannitol salt agar was inoculated with pure samples of the three bacteria and incubated. The plate is shown in **image 2.4**.

Image 2.4



Use **all** the information given in **table 2.3** and **image 2.4** to **complete the table**, and identify the bacteria in zones **X**, **Y** and **Z**. [3]

	Gram staining (positive or negative)	Able to break down mannitol (✓ or ×)	Halophile (✓ or ×)	Name of bacterium
X	.....	.....	.....	.....
Y	.....	.....	.....	.....
Z	.....	.....	.....	.....

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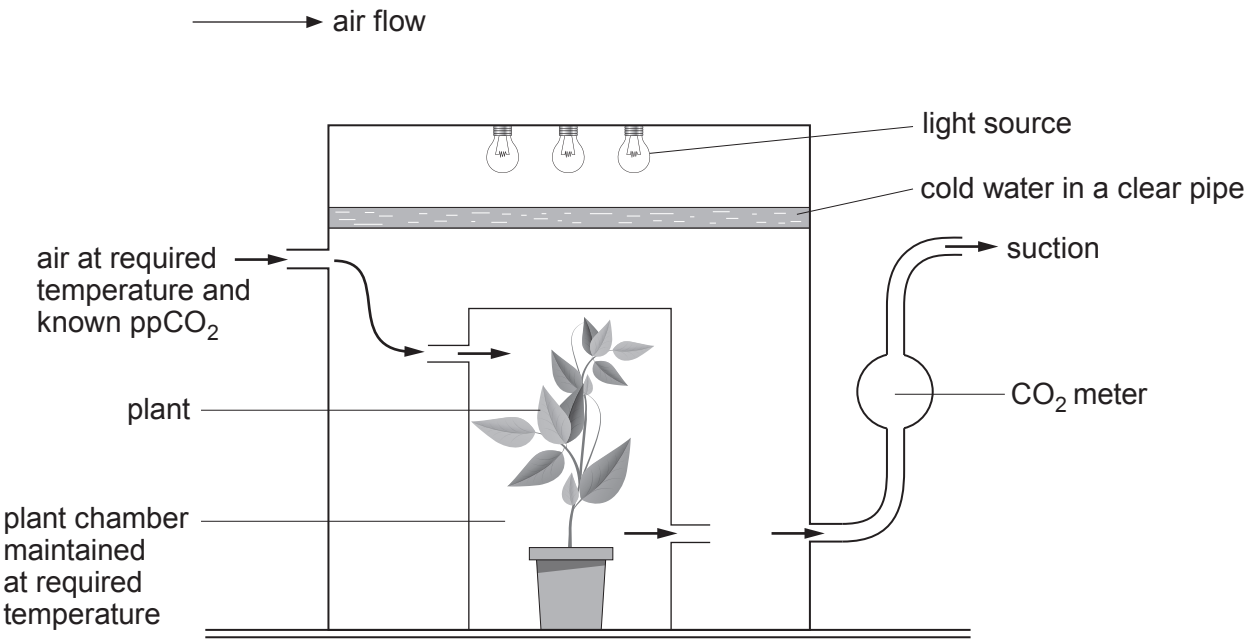
3. The rate of photosynthesis at different temperatures was determined by measuring the rate of carbon dioxide exchange using the apparatus shown in **image 3.1**.

Image 3.1



The mass of carbon dioxide absorbed by ten tomato plants in 1 hour was measured at 15, 20, 30 and 40 °C. The same group of plants were grown at the same light intensity at all temperatures.

(a) (i) Suggest why cold water was placed between the light source and plant chamber. [1]

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(ii) Explain why it is important that the same ten plants were used in all tests. [1]

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(iii) Suggest a suitable control for this experiment. [2]

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(iv) Describe how the experiment could be modified to determine the mass of CO_2 released by respiration. [1]

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The results of the experiments are shown in **table 3.2**. The rate of photosynthesis is given by the total mass of CO_2 used by photosynthesis.

Table 3.2

Temperature of the plant chamber / °C	CO_2 absorbed / mg hour^{-1}	CO_2 produced by respiration / mg hour^{-1}	Rate of photosynthesis / mg hour^{-1}
15	.....	0.2	30.4
20	.....	2.4	33.1
30	.....	5.2	35.3
40	.....	8.2	25.4

(b) (i) Explain why both the mass of carbon dioxide absorbed during photosynthesis and the mass of carbon dioxide produced during respiration are needed to determine the rate of photosynthesis. [1]

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(ii) **Complete table 3.2** to show the CO_2 absorbed at temperatures 15 °C – 40 °C. [1]

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The sugar content of tomatoes varies depending on the temperature at which they are grown. This is due to changes in temperature affecting the rate of respiration and photosynthesis differently.

(c) (i) Use the data in **table 3.2** to describe **and** explain how the temperature at which tomato plants are grown affects the sugar content of the tomato. [4]

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(ii) At high wind speeds stomata close. Explain **one** advantage and **one** disadvantage of this response to the plant. [2]

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(d) The production of certain chemicals by enzymes contribute to the sweetness of tomatoes. When tomatoes are kept below 5 °C the genes which code for these enzymes are methylated and the genes are switched off. This is a permanent change in gene expression and does not return when the tomato temperature rises.

(i) State the name given to a change in gene expression brought about by methylation. [1]

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Examiner only

(ii) Use the information given and your knowledge of protein synthesis to explain why the sweetness of the tomatoes will not increase after they have been stored at low temperatures, even if they are returned to higher temperatures. [2]

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4. Carbon dioxide and atmospheric nitrogen can be fixed by living organisms.

(a) State the meaning of the word *fixed* as used in this context. [1]

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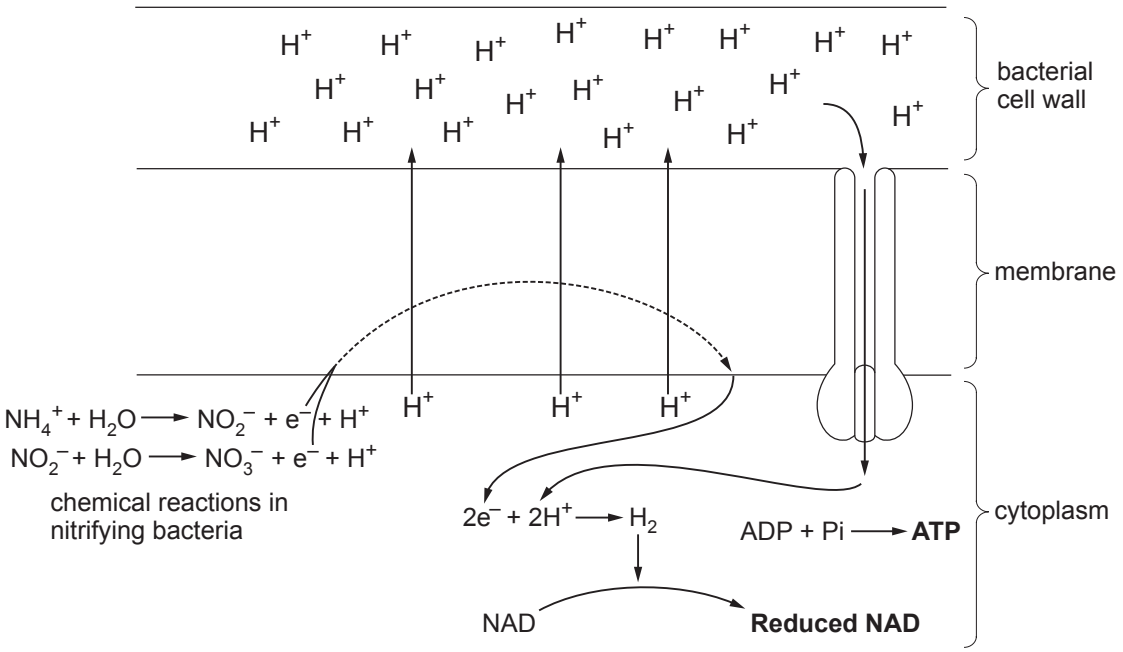
(b) **Image 4.1** represents the production of ATP and reduced NAD by nitrifying bacteria.

Image 4.1



Use the information in **image 4.1** and your own knowledge to answer the following.

(i) Name the nitrifying bacteria **and** describe how they produce a source of electrons and protons (H^+). [3]

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(ii) The electrons are passed along a series of molecules in the membrane. State the name given to this series of molecules. [1]

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(iii) Describe how the energy released from the movement of these electrons is used. [3]

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(iv) Describe how ADP is phosphorylated as a result of the reaction shown in **image 4.1**. [3]

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(c) Nitrifying bacteria are chemoautotrophs. From your knowledge of the light independent reactions of photosynthesis (Calvin cycle), suggest how the bacteria use the **products of the reactions shown in bold in image 4.1**. [3]

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5. Wading birds (waders) feed in shallow water. Areas of the Western Isles off the coast of Scotland are the most important breeding grounds for waders in Europe. The numbers of breeding pairs of lapwing, redshank, dunlin and snipe were monitored in the areas shown in **image 5.1** in 1983 and 2000. These waders are ground nesting birds.

Image 5.1

Area 1 is not colonised by hedgehogs.

Area 2 is where seven hedgehogs were introduced by a house owner to eat slugs in their garden. Since their introduction numbers have increased and they have established a large population.

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Hedgehogs normally feed on worms, insects, slugs and snails but will also eat the eggs of ground nesting birds such as waders.

The results of the monitoring of the wading birds are shown in **table 5.2**.

Table 5.2

Species of wading bird	Percentage change in number of breeding pairs between 1983 and 2000	
	Area 1 (hedgehogs absent)	**Area 2** (hedgehogs present)
lapwing	+24	–31
redshank	+51	.....
dunlin	–30	–56
snipe	–2	–57

(a) (i) Calculate the percentage change in the number of breeding pairs of redshank in **Area 2** if the population in 1983 was 1288 breeding pairs and in 2000 it was 760 breeding pairs.

Write your answer in the table. [3]

(ii) With reference to the data in **table 5.2** and the information provided, evaluate the conclusion that hedgehogs are the main reason for the decline in wading bird numbers. [2]

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(iii) Explain **one** advantage and **one** disadvantage of expressing the change in the number of breeding pairs as a percentage. [2]

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(iv) State **two** factors which could have allowed a very large population of hedgehogs to have been produced from the original seven individuals. [2]

I. .....

II. .....

(b) Brown rats, polecats and gulls are also predators of wader eggs. An investigation into the effect of hedgehogs on wader eggs was carried out as follows:

- Two plots of land were enclosed by hedgehog-proof fencing and all the hedgehogs were removed from these plots.
- An area of land adjacent to each plot of similar size was not fenced. These acted as control areas.
- Egg loss in the fenced and unfenced areas was compared and the type of predator causing the egg loss recorded.

(i) State why it was necessary to carry out such a study before a decision was made to control the number of hedgehogs. [2]

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Examiner only

(ii) The number of hedgehogs in the British countryside is now under 1 million which is a 97 % fall since the 1950s.

The following measures were proposed to control the hedgehog numbers in the Western Isles. Suggest **one** ecological problem for each control measure.

I. Trapping and moving hedgehogs to the mainland. [1]

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II. Remove hedgehogs from wader breeding areas and then erect 1 metre high hedgehog-proof fencing around the area. [1]

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III. Trapping of hedgehogs followed by humane killing. [1]

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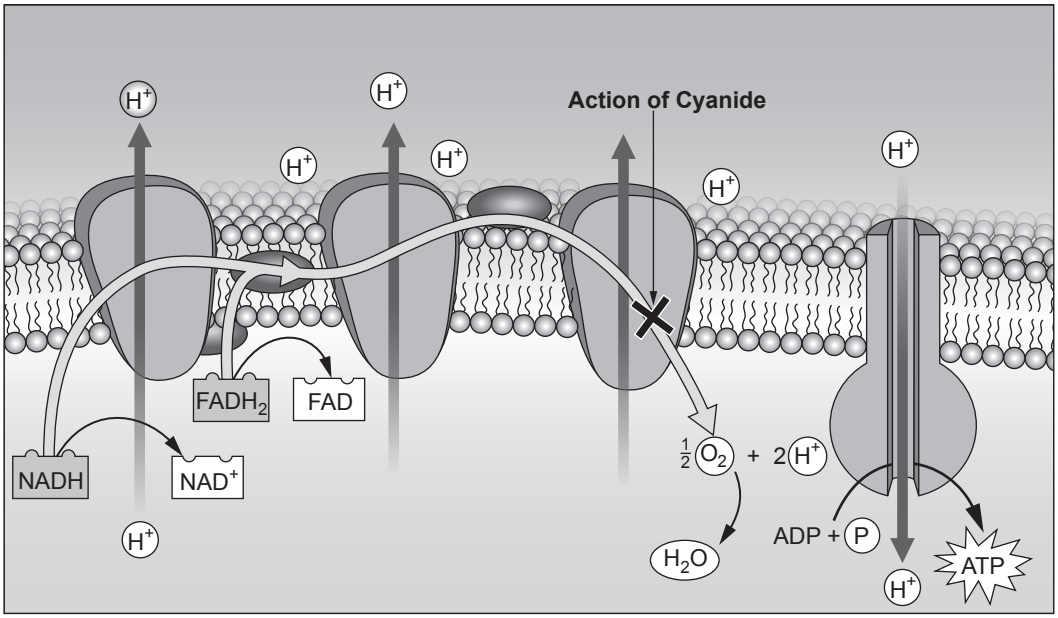
Turn over.

Examiner only

6. Cyanide is an extremely poisonous chemical that affects aerobic respiration in mitochondria. The symptoms of cyanide poisoning include an increase in heart rate, breathing problems and eventually death.

Image 6.1 shows the site of action of cyanide.

Image 6.1



(a) (i) With reference to **image 6.1** explain how cyanide would prevent the process of aerobic respiration. [4]

Examiner only

(ii) Explain why blood lactate concentration rises as a symptom of cyanide poisoning. [3]

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(b) Apple seeds (pips) contain cyanide. If an apple seed is swallowed whole, it passes through the gut and will not poison the animal. If the seed is chewed cyanide will be released. In small quantities this will not harm the animal but in large quantities it could be fatal.

- 125 mg of cyanide would be sufficient to kill an adult pig.
- 1 apple seed weighs 0.6 g
- 1 gram of apple seeds when chewed releases 0.09 mg of cyanide.

Calculate how many apple seeds would need to be chewed by the adult pig to cause death.

Give your answer to the nearest whole number. [3]

Number of seeds = ...

10

7. Sea otters *(Enhydra lutris)*, shown in **image 7.1**, are found in the cold waters off the Northern Pacific Ocean coastline, where they feed on sea urchins, crabs and shellfish.

Image 7.1

Sea urchins feed on kelp (a type of seaweed). In areas where sea otters are no longer present, kelp forests have declined and there has been a major decrease in biodiversity as shown in **image 7.2**.

Image 7.2

Kelp forest in an area inhabited by sea otters

Sea floor in an area where sea otters are no longer present

Examiner only

(a) Kelp forests are an example of a climax community. In areas where sea otters are reintroduced, kelp forests can regrow.

(i) Explain what is meant by a climax community **and** why regrowth of a kelp forest is an example of secondary succession. [2]

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(ii) In addition to sea urchins, sea otters also eat crabs and shellfish. Using your knowledge of **predator prey relationships**, suggest how the presence of sea otters in a habitat maintains biodiversity. [4]

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(iii) Explain why scientists consider that the destruction of sea otter populations could contribute to an increase in global warming. [3]

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Examiner only

(iv) Explain why an increase in global warming could have been a contributory factor in the planetary boundary for biodiversity being crossed. [2]

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(b) In the past, sea otters were hunted by humans for their very thick, waterproof fur and by the 1900s were almost extinct.

(i) An adult male sea otter with a surface area of $7.2 \times 10^3\,cm^2$ has approximately 8.64×10^8 hairs on its body surface.

Calculate the number of hairs per cm^2 of body surface. **Give your answer in standard form**. [2]

Number of hairs per cm^2 = ...

(ii) Suggest the homeostatic role of the high density of hair in sea otters. [1]

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Examiner only

(iii) In recent years, the numbers of sea otters has increased as a result of many different conservation measures. Describe **two** conservation measures which may have aided the recovery of the sea otter population. [2]

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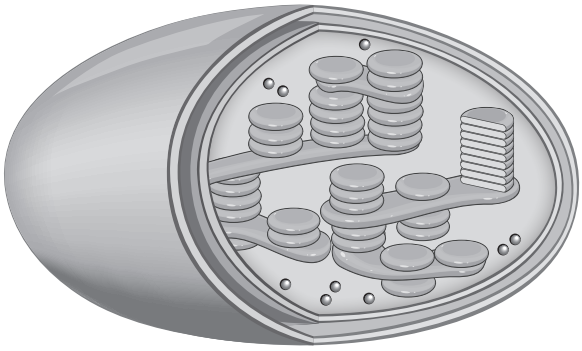
8. **Images 8.1** and **8.2** show the structure of mitochondria and chloroplasts.

Image 8.1

Mitochondria

Image 8.2

Chloroplast



Explain how the internal structures of mitochondria and chloroplasts are adapted to carry out respiration and photosynthesis respectively. Using your knowledge and evidence from the images, describe the evidence that suggests that both mitochondria and chloroplasts have evolved from bacteria. [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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