| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# GCE A LEVEL – NEW

1400U30-1

S17-1400U30-1

## BIOLOGY – A2 unit 3
### Energy, Homeostasis and the Environment

MONDAY, 12 JUNE 2017 – AFTERNOON

2 hours

| For Examiner's use only | | |
|---|---|---|
| **Question** | **Maximum Mark** | **Mark Awarded** |
| **1.** | **10** | |
| **2.** | **11** | |
| **3.** | **15** | |
| **4.** | **7** | |
| **5.** | **18** | |
| **6.** | **20** | |
| **7.** | **9** | |
| **Total** | **90** | |

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**ADDITIONAL MATERIALS**

In addition to this paper, you will require 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 continuation page 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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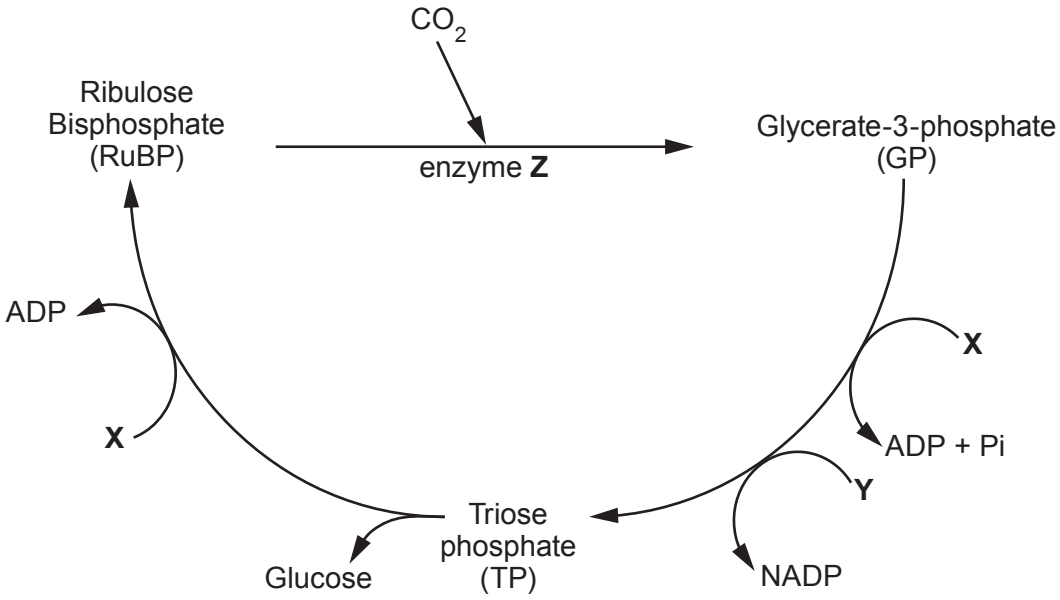
*Answer* **all** *questions.*

**1.** Tomatoes are an important food crop that can be grown in commercial greenhouses. The greenhouses often have cooling fans.

When a tomato plant is exposed to light the following reactions take place in the stroma of a chloroplast.




*(a)* (i) Identify substances **X** and **Y**. [1]

**X** .....

**Y** .....

(ii) Name enzyme **Z**. [1]

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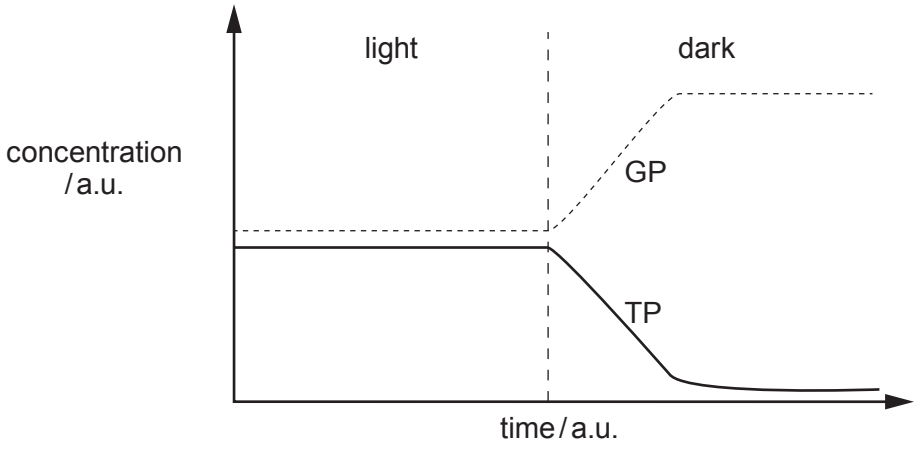
*(b)* In the absence of light, the concentration of glycerate-3-phosphate (GP) in the chloroplast stroma increases. This is shown on the graph below.




Explain the shape of the graph for both GP and TP when the plant is in the dark. [5]

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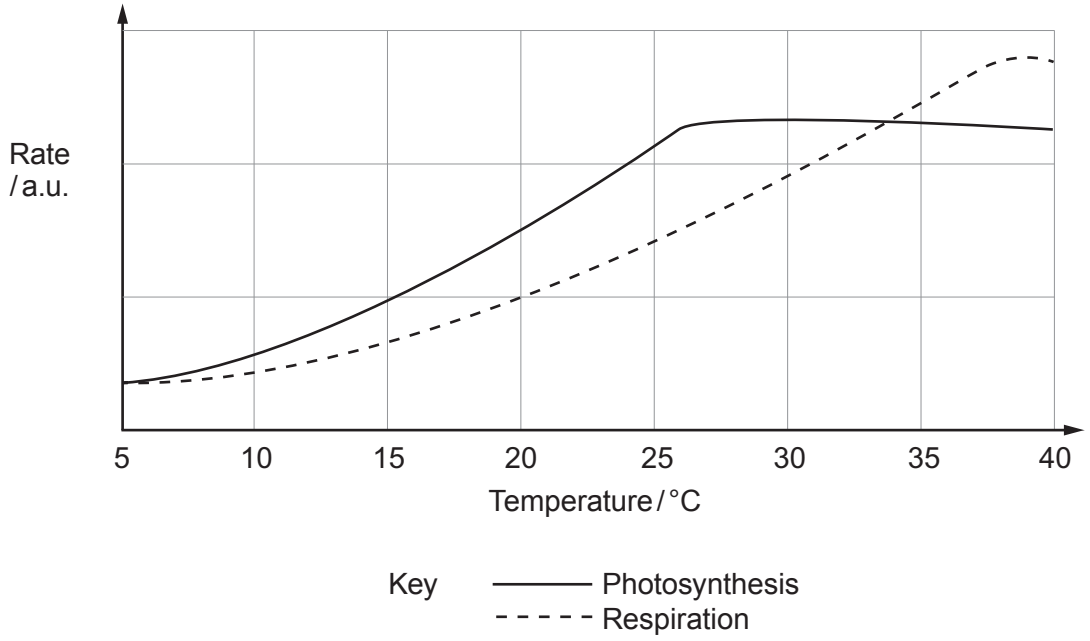
The graph below shows the relative rates of photosynthesis and respiration at increasing temperature.




*(c)* With reference to the graph, explain why tomato plants grown in a greenhouse at 27°C produce sweeter tasting fruit than those grown at 40°C. [3]

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**2.** Lidocaine is a local anaesthetic used by dentists to numb pain. It is believed that it blocks the sodium ion channels in a neurone membrane.

*(a)* Describe the function of sodium ion channels in a neurone membrane in response to a stimulus. [2]

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*(b)* Explain how lidocaine acts as a local anaesthetic. [4]

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The maximum allowable dose of lidocaine for a patient is 7 mg per kg of tissue (mg $kg^{-1}$).

*(c)* Use the equation below to calculate the maximum dose volume for a 60 kg patient if the concentration of lidocaine is 2%. [2]

$$\text{maximum dose volume } (cm^3) = \text{maximum allowable dose } (mg\ kg^{-1}) \times \frac{\text{mass of patient (kg)}}{10} \times \frac{1}{\text{concentration of lidocaine (\%)}}$$

maximum dose volume = ..... $cm^3$



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*(d)* The marine cone shell, *Conus magus*, releases a chemical which blocks calcium ion channels on the pre-synaptic membrane of a synapse. This has a potential use as an anaesthetic.

With reference to the **pre-synaptic neurone only**, describe and explain the mechanism by which this chemical could work as an anaesthetic. [3]

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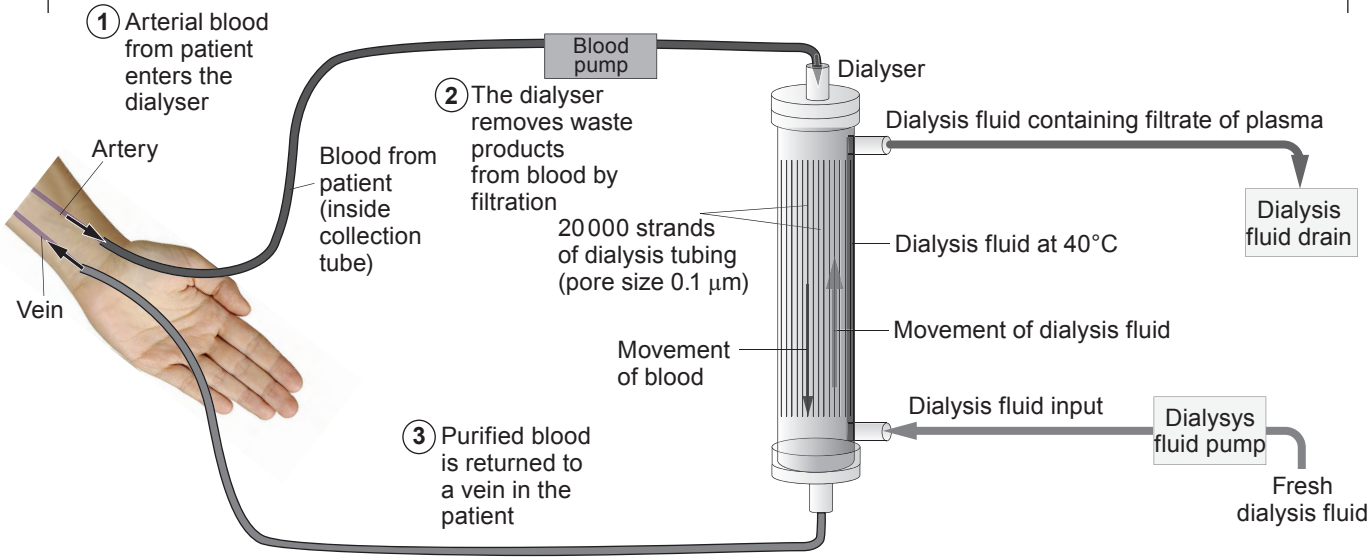
**3.** When the kidneys are damaged by disease they may not be able to excrete urea or control the water potential of the blood plasma.

Patients may have to use an artificial kidney (dialysis machine). This will carry out the filtration of molecules from the blood.
Blood is pumped from the patient and is passed through tubes formed from selectively permeable cellulose acetate membranes. The other side of the membrane has sterile dialysis fluid continually pumped over it.




*(a)* With reference to the diagram above, describe and explain how the dialysis machine makes filtration more efficient. [4]

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*(b)* Aquaporin is a type of protein channel that allows water movement through the membranes of the epithelial cells in the collecting duct. Antidiuretic hormone (ADH) is a protein made in mammals. It consists of a chain of nine amino acids.

(i) State the minimum number of nucleotides on the DNA template strand that code for ADH. [1]

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(ii) State precisely from where ADH is released into the blood stream of a human. [1]

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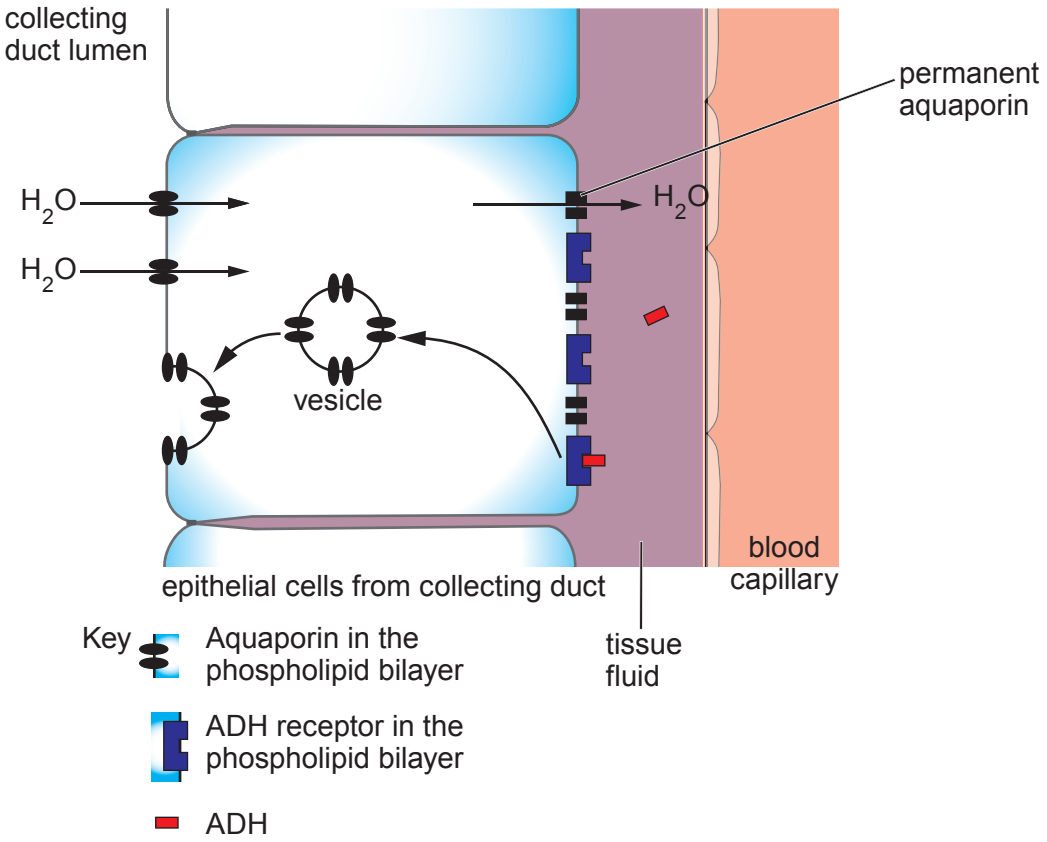


(iii) Using the diagram above and your own knowledge explain how the release of more ADH causes a smaller volume of concentrated urine to be produced. [5]

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Diabetes insipidus is a condition that results in excessive thirst and production of large volumes of dilute urine. This condition is different from diabetes mellitus which may result in increased glucose concentration in the urine.

One cause of diabetes insipidus is the patient not releasing ADH.

*(c)* Suggest how this causes diabetes insipidus. [1]

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Another form of diabetes insipidus is nephrogenic diabetes insipidus. This is a genetic condition caused by a dominant allele (N). This results in a change in the shape of the receptor sites for ADH.

*(d)* A heterozygous sufferer with this condition has a partner who is a non-sufferer. Draw a suitable genetic diagram and use this to determine the probability of them having a child who would suffer from nephrogenic diabetes insipidus. [3]

probability = .....

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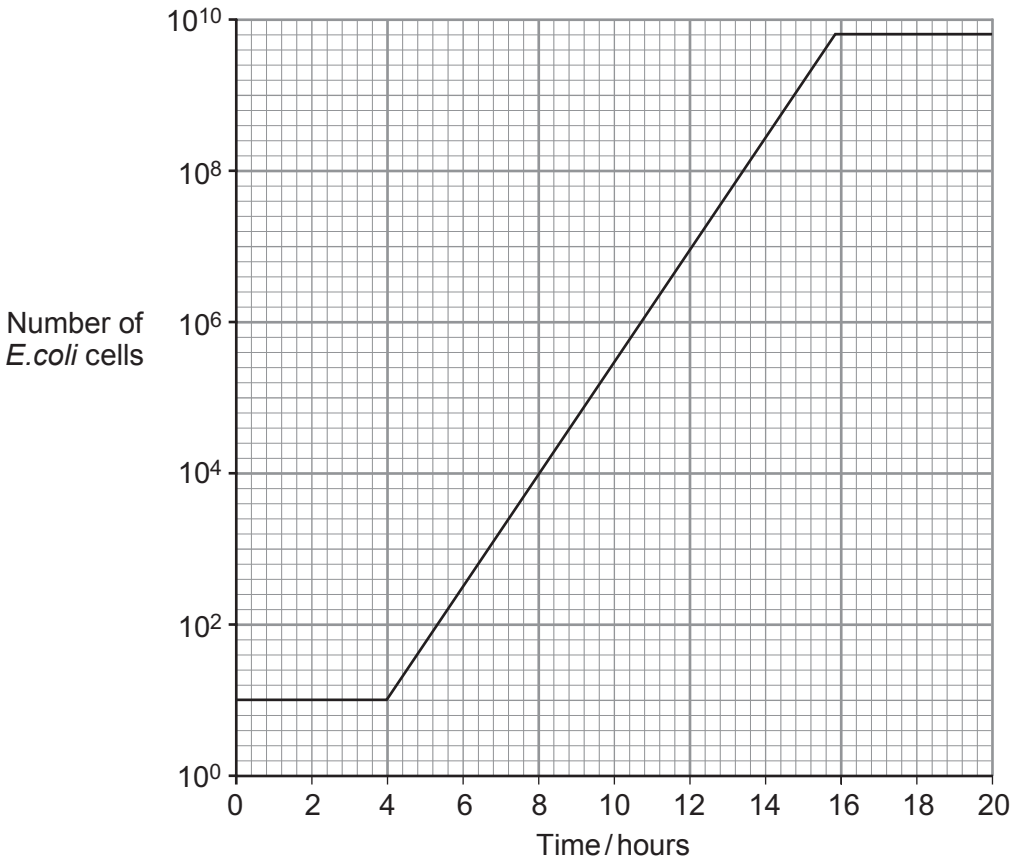
**4.** Bacterial populations grow exponentially due to binary fission. The generation time is the time interval required for the cells to divide. A scientist counted the number of living *Escherischia coli* bacterial cells present over a 20 hour period. She plotted the results on a graph as shown below.




*(a)* Use the equation below to calculate the generation time of the bacterial population between 4 and 8 hours of growth. Give your answer to the nearest minute. [3]

$$G = \frac{t}{3.3\left(\frac{\log b}{\log B}\right)}$$

Where:
G = generation time (minutes)
t = time interval (minutes)
B = number of bacteria at the beginning of the time interval
b = number of bacteria at the end of the time interval

time = ..... minutes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The scientist carried out the experiment again but counted the living bacteria present each hour for 60 hours.

*(b)* (i) Describe and explain the expected shape of the population growth curve between 20 and 60 hours. [2]

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(ii) Explain how the growth curve would differ if a total count had been used to measure the population density. Suggest a disadvantage of this technique. [2]

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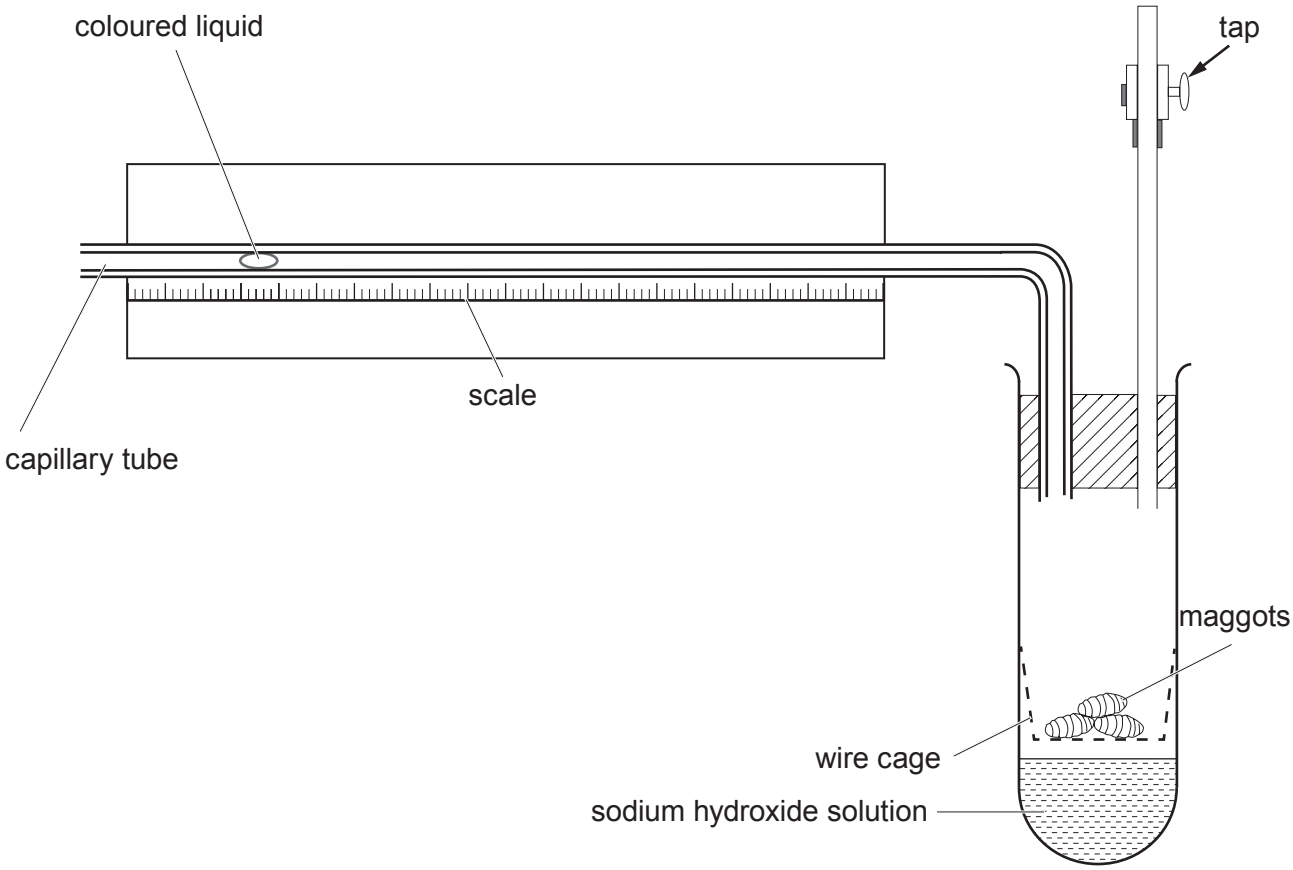
**5.** A class of 20 students investigated respiration in maggots over a 5 minute time period. The diagram below shows the apparatus that they used.




In experiment 1:

- 5 $cm^3$ of sodium hydroxide solution was placed into the test tube.
- Ten maggots were placed into the wire cage.
- The tap was left open.
- The test tube containing the maggots was placed in a water bath at 25°C.
- After 10 minutes, the tap was closed and the position of the coloured liquid noted.
- The apparatus was left for five minutes and the position of the coloured liquid was noted at one minute intervals.

Sodium hydroxide absorbs carbon dioxide and is corrosive.

In experiment 2, the same procedure was carried out using 5 $cm^3$ of water instead of sodium hydroxide solution.

*(a)* (i) Suggest why the maggots were placed in the wire cage. [1]

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(ii) Give **two** reasons why the apparatus was left in the water bath with the tap open for ten minutes before readings were taken. [2]

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(iii) Suggest a suitable control for these experiments. Give a reason for your answer. [2]

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Each student carried out both experiments and the class results were combined. The mean results are shown in the table below.

| Time / minutes | Mean position of coloured liquid / mm | |
|---|---|---|
| | Experiment 1 (with sodium hydroxide) | Experiment 2 (with water) |
| 0 | 0 | 0 |
| 1 | 13 | 0 |
| 2 | 22 | 0 |
| 3 | 35 | 0 |
| 4 | 49 | 0 |
| 5 | 61 | 0 |

*(b)* (i) Explain why the coloured liquid moved in experiment 1 but did not move in experiment 2. [3]

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(ii) Explain the advantages of collecting results from the **whole** class. [2]

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(iii) In these experiments the diameter of the lumen of the capillary tube was 1.2 mm and the total mass of maggots was 0.5 g.
Calculate the rate of oxygen consumption per g for the maggots during the 5 minutes of the experiment. Give the answer in $mm^3\ g^{-1}\ minute^{-1}$ to 1 decimal place. [3]

The formula for the volume of a cylinder = $\pi r^2 h$

$\pi = 3.14$

rate of oxygen consumption = ..... $mm^3\ g^{-1}\ minute^{-1}$



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*(c)* Scientists can use the volume of carbon dioxide produced and the volume of oxygen consumed in a given time to give the respiratory quotient (RQ).
The equation for working out the RQ is:

$$RQ = \frac{\text{number of molecules of } CO_2 \text{ produced}}{\text{number of molecules of } O_2 \text{ consumed}}$$

The equation for respiration of glucose is:

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

As the equation shows, 6 molecules of $CO_2$ are produced and 6 molecules of $O_2$ are consumed when 1 molecule of glucose is respired.

The RQ value for glucose is 1.

The equation for respiration of the fat tripalmitin is:

$$2\ C_{51}H_{98}O_6 + 145\ O_2 \longrightarrow 102\ CO_2 + 98\ H_2O.$$

(i) Calculate the RQ for tripalmitin. [1]

RQ = .....

(ii) Use the equation for respiration of tripalmitin to suggest why desert animals such as camels use fat as a substrate for respiration. [2]

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(iii) The respiration of fat releases more energy than the respiration of glucose produced by the breakdown of glycogen.

Explain why muscles use glycogen as an energy store rather than fat. [2]

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**6.** A group of scientists studied the sand dune ecosystem at Ynyslas, Ceredigion. They cleared a 10 m by 10 m section of land in the dunes to expose the soil. The position of this cleared area is shown by the arrow in the photograph below.

Each year, they randomly selected twenty 1 $m^2$ areas in the study area and identified the different species present. They noted how many plants of each species were present.

*(a)* (i) Describe how and explain why the sites are selected at random. [3]

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The table below shows the mean number of each species in a $1m^2$ area after five years.

| Species | Mean number of plants per $m^2$ |
|---|---|
| Ragwort | 3 |
| Birdsfoot trefoil | 6 |
| Hairy hawkbit | 2 |
| Eyebright | 9 |
| Rosebay willowherb | 4 |
| Dandelion | 2 |
| Mouse ear | 4 |
| Restharrow | 7 |
| Kidney vetch | 1 |
| Groundsel | 18 |
| Grass species 1 | 4 |
| Grass species 2 | 5 |

(ii) In the first year the scientists only found four different species in the area. Identify the type of succession that has taken place in the five years of the study and explain why the number of plant species increased. [3]

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(iii) Suggest what would happen to the number of animal species in this area. Explain your answer. [2]

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*(b)* Birdsfoot trefoil and restharrow are legumes, therefore they have root nodules that contain the bacterium *Rhizobium*. The scientists observed that they were two of the first plants to arrive in areas with nutrient poor soils.

(i) Explain why they are able to survive in soils with low nitrogen levels. [3]

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(ii) *Rhizobium* contain the enzyme nitrogenase which is responsible for fixing atmospheric nitrogen. This enzyme is inhibited if oxygen levels are high. The root nodules of legumes contain a form of haemoglobin called leghaemoglobin. This has a very high affinity for oxygen.

Suggest why leghaemoglobin is present in the root nodules of restharrow and birdsfoot trefoil. [3]

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*(c)* Close to Ynyslas is the peat bog of Cors Fochno.
This is an area of poor drainage where soil is waterlogged. No trees grow on Cors Fochno. The climax community is bog, which is permanently dominated by the moss, *Sphagnum*.

(i) Explain why bog is described as the climax community. [1]

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(ii) Explain why trees are unable to survive in waterlogged soils. [2]

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The photograph shows a plant found on the bog called sundew *(Drosera rotundifolia)*. This is an insectivorous plant which captures insects and digests them on its leaves.

The following equation shows the fixation of a nitrogen molecule ($N_2$) to ammonia ($NH_3$).

$$N_2 + 8H^+ + 8e^- + 16\ ATP \longrightarrow 2\ NH_3 + H_2 + 16\ ADP + 16\ Pi$$

*(d)* Suggest why insectivorous plants such as sundew rely on catching prey. [3]

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**7.** Fish farming is an important industry in Scotland, producing almost 180 000 tonnes of fish in 2014. It provides employment and financial gain for the areas where it is carried out. The number and size of fish farms has increased as one way of preventing overfishing.

The table below shows the estimated use and loss of two elements during the production of fish in Scotland by fish farming.

| Nutrient output per tonne of production | Nitrogen | Phosphorus |
|---|---|---|
| used in feed (kg) | 86 | 18 |
| lost as uneaten food (kg) | 4 | 1 |
| lost as organic matter in faeces (kg) | 12 | 3 |
| lost as inorganic products (e.g. ammonium ions and phosphate ions) (kg) | 37 | 9 |

Adapted from "The Interaction between Fish Farming and Algal Communities of the Scottish Waters – A Review", Rydberg, Sjoberg and Stigebrandt. Research report 2003/04.

With reference to the information provided in the table and your own knowledge, explain the possible ecological impacts of fish farming in the areas where it takes place. Describe other ways to overcome the problem of overfishing. Explain how these methods are used to prevent overfishing. [9 QER]

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