IB · DP · Biology

2 hours  15 questions

Structured Questions: Paper 2

# 2.7 Cellular Respiration

2.7.1 Cellular Respiration / 2.7.2 Anaerobic Respiration / 2.7.3 Aerobic Respiration / 2.7.4 Skills: Respiration

| | |
|---|---|
| Easy (5 questions) | /30 |
| Medium (5 questions) | /48 |
| Hard (5 questions) | /55 |
| **Total Marks** | **/133** |

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# Easy Questions

**1 (a)** State an appropriate chemical equation to represent the production of ATP in respiration.

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**(1 mark)**

**(b)** ATP is an energy source required for many processes in the human body.

Identify **two** uses of ATP in the human body.

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**(2 marks)**

**(c)** State the word equation for aerobic respiration.

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**(2 marks)**

**(d)** By filling each cell with either ✓ or ✗, complete the table below to compare and contrast anaerobic respiration in yeasts and in humans.

| Feature of anaerobic respiration | Yeasts | Humans |
|---|---|---|
| Relatively small ATP yield | | |
| Oxygen required | | |
| Ethanol and $CO_2$ produced | | |
| Lactate produced | | |

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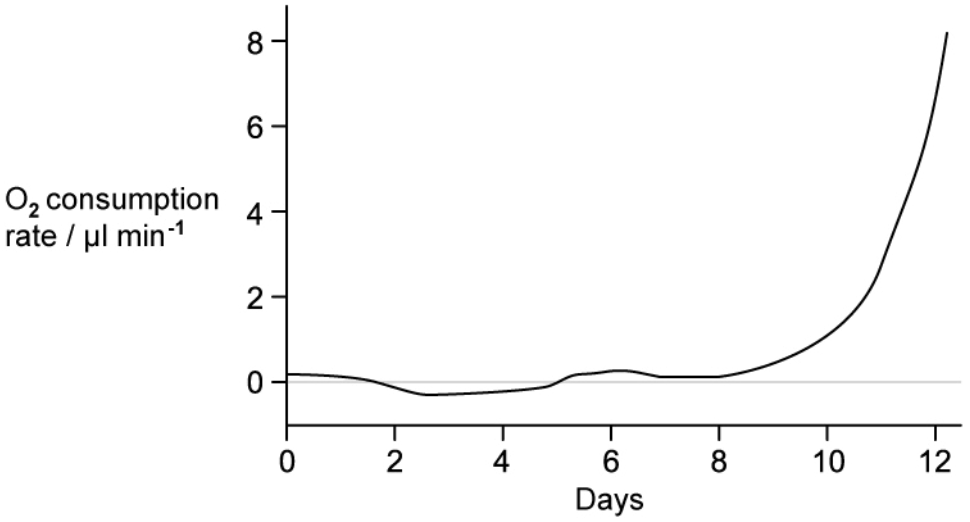
**(4 marks)**

**2 (a)** When farmers store animal feed, moisture levels need to be kept as low as possible to prevent the growth of fungi. Animal feed was exposed to 10 % moisture and placed into a respirometer. $O_2$ consumption by fungi was monitored using a respirometer over a period of 12 days. The results are shown below.




A specific amount of soda-lime was added to the respirometer before data collection began.

State why this alkali was added.

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**(1 mark)**

**(b)** State **two** conclusions that could be drawn from the results shown in the graph in part (a).

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**(2 marks)**

**(c)** List **one** variable (other than humidity) that should be controlled in this experiment.

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**(1 mark)**

**3 (a)** Define cellular respiration.

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**(2 marks)**

**(b)** State the word equation for anaerobic respiration in a human striated muscle cell.

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**(1 mark)**

**(c)** Suggest why anaerobic respiration might occur in a human striated muscle cell.

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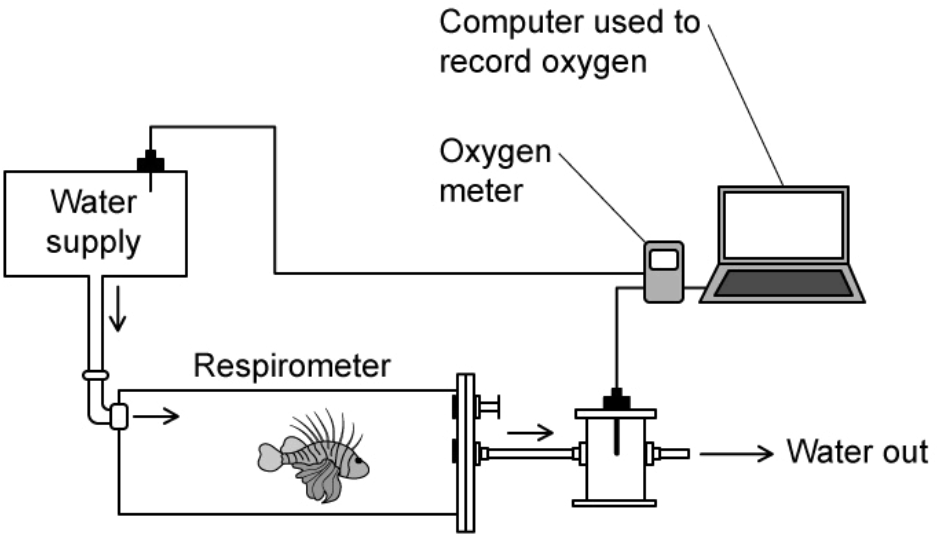
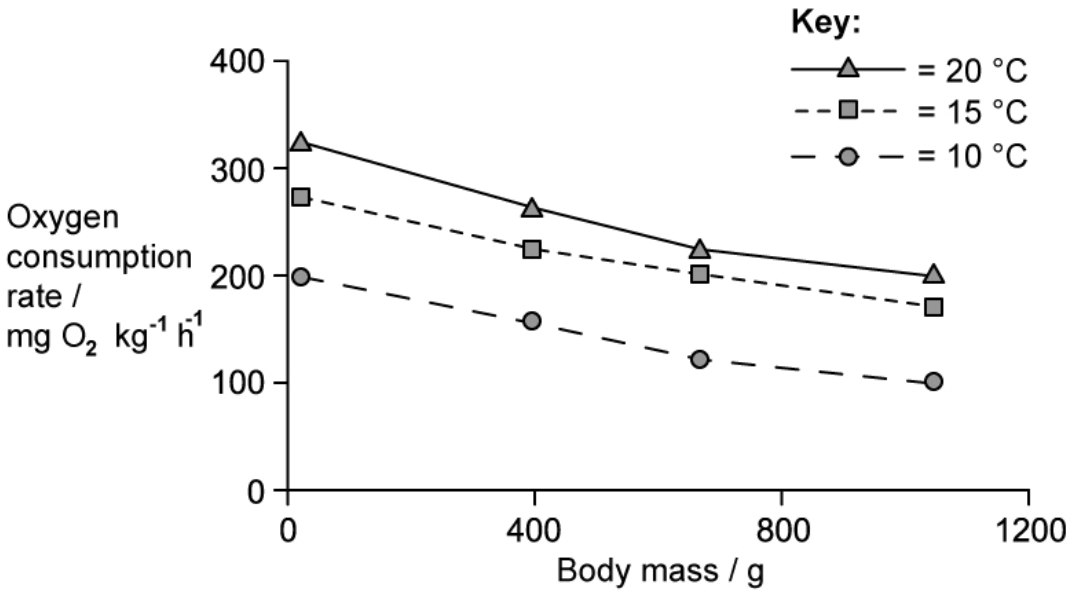
**(2 marks)**

**4 (a)** The oxygen consumption rate of the red lionfish (*Pterois volitans*) was examined in a respirometer at three different water temperatures and at four different body masses.

The experimental set-up used and the results of the experiment are shown below.




Suggest how the oxygen consumption rate of *Pterois volitans* is determined.

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**(2 marks)**

**(b)** State the relationship between body mass and the oxygen consumption of *Pterois volitans*.

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**(1 mark)**

**(c)** Based on the data, suggest what the effects of global warming on aerobic respiration in fish might be.

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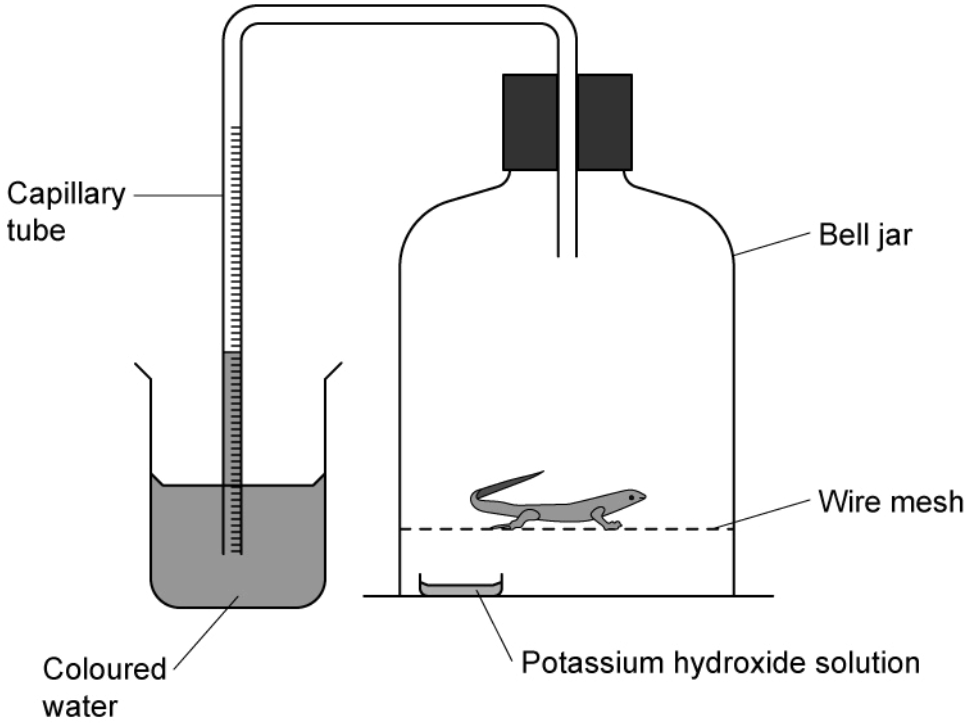
**(2 marks)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

The apparatus shown below was used as a basic respirometer to measure the oxygen consumption of a lizard.




Describe how the experimental set-up shown above can be used to measure the oxygen consumption of the lizard.

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**(4 marks)**

**(b)** Discuss the suitability of the apparatus shown in part (a) for measuring the oxygen consumption of a green plant during respiration.

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**(3 marks)**

# Medium Questions

**1 (a)** ATP is a chemical substance generated in cellular respiration; it is an immediate source of energy for the cell. ATP can easily be hydrolysed or re-synthesised.

State **two** products created when ATP is hydrolysed by water.

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**(2 marks)**

**(b)** Cells hydrolyse ATP to provide energy for other reactions, or to add phosphate to other substances to make them more reactive. However, ATP needs to be re-synthesised to provide energy for future reactions.

Describe how ATP may be re-synthesised.

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**(2 marks)**

**(c)** Give **two** ways in which the properties of ATP make it a suitable source of energy for biological processes.

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**(2 marks)**

**(d)** Each day, the human body synthesises more than its weight in ATP during aerobic respiration.

Explain why it is necessary to synthesise such large amounts of ATP.

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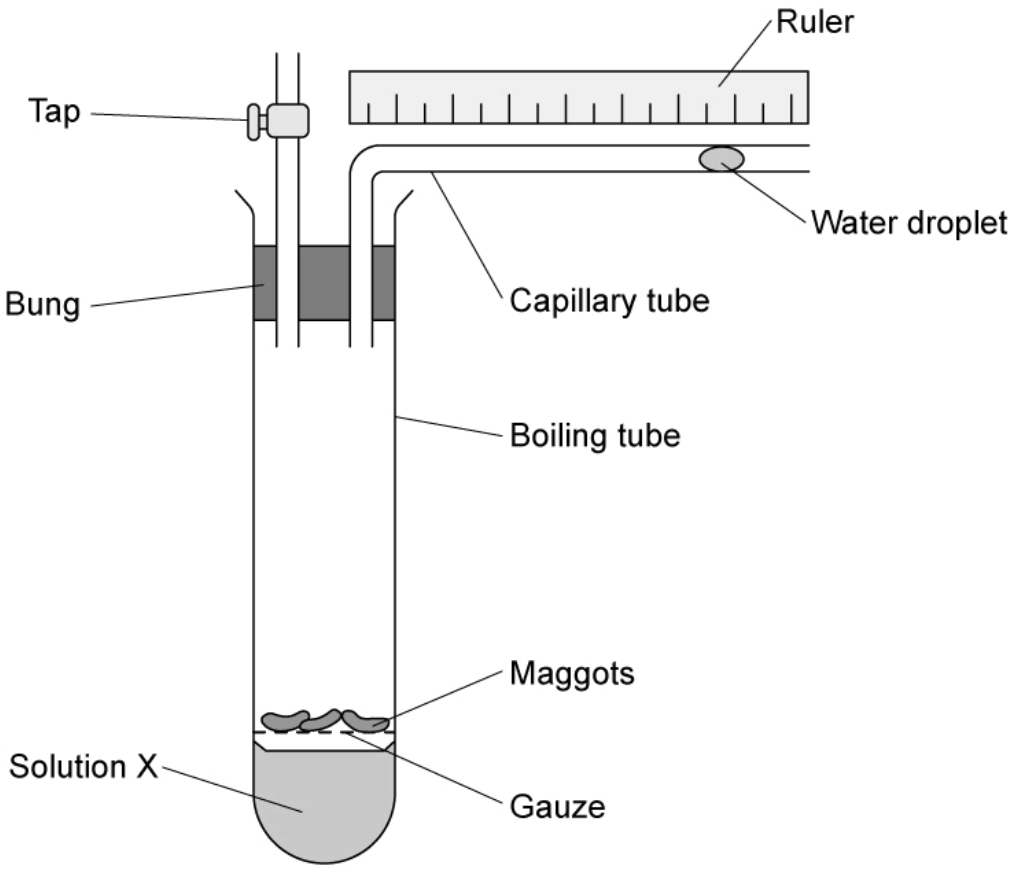
**(2 marks)**

**2 (a)** The following apparatus was set up to measure the rate of aerobic respiration by a student.




Suggest what solution **X** might be and its function within the experiment.

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**(2 marks)**

**(b)** Describe what ethical concerns the student should consider during this experiment.

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**(3 marks)**

**(c)** The student found the water droplet had moved by 2 cm in 24 hours. The diameter of the lumen of the tube is 1 mm.

The volume of the tubing is given by the equation $\pi r^2 l$ ;
Use the value of 3.14 to represent $\pi$ and note that $l$ refers to the length.

Use the equation to calculate the volume of gas produced in $cm^3$ $hour^{-1}$, give your answer in standard form.

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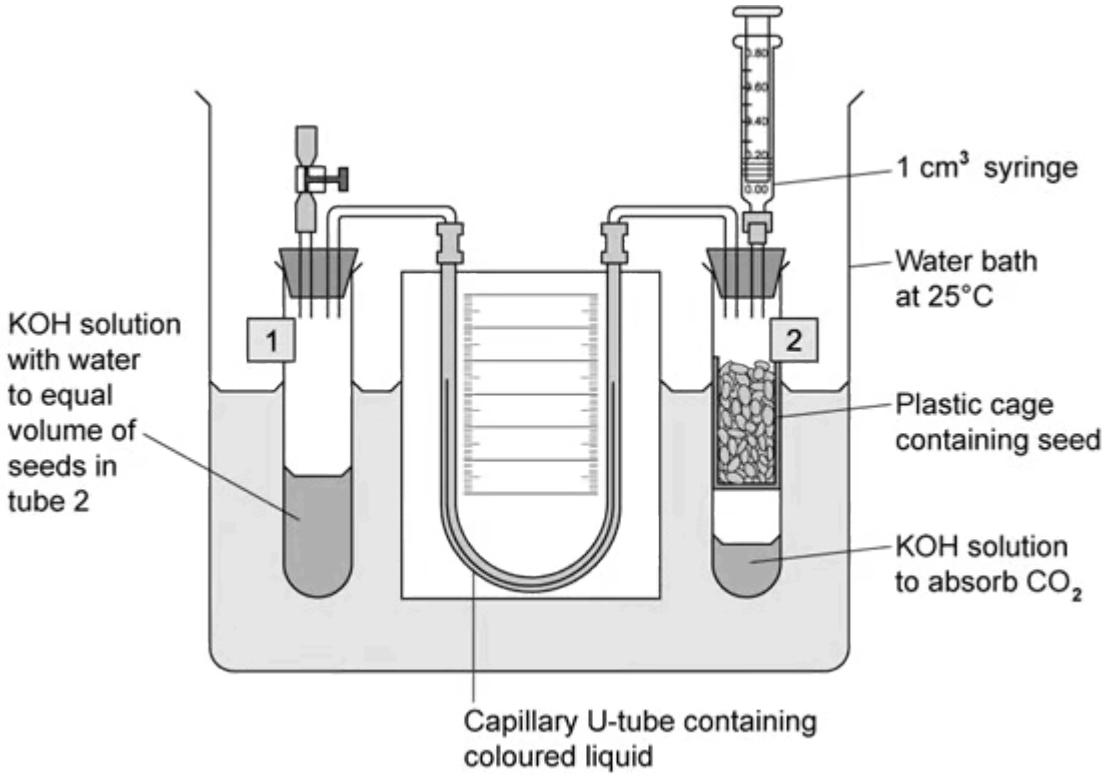
**(3 marks)**

**3 (a)** The diagram below shows the respirometer apparatus used by a teacher for measuring the rate of oxygen consumption of seeds during aerobic respiration.




For the first 12 minutes, the tap attached to tube **1** was left open and the syringe from tube **2** was taken away.

Suggest **two** reasons why this was done.

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**(2 marks)**

**(b)** A temperature of 25 $^{o}$C was used during the experiment. The teacher explained it was very important to keep the temperature constant.

Explain why it is important to keep the temperature constant.

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**(2 marks)**

**(c)** After 12 minutes, the tap connected to tube **1** was closed and the syringe was attached to tube **2**. Every 60 seconds, the syringe plunger was moved to make the levels in the U-tube identical. The reading on the volume scale of the syringe was then recorded. The results are shown in the table below.

| Time (minutes) | Reading on volume scale of syringe ($cm^3$) |
|---|---|
| 0 | 0.86 |
| 1 | 0.83 |
| 2 | 0.80 |
| 3 | 0.77 |
| 4 | 0.75 |
| 5 | 0.73 |
| 6 | 0.70 |
| 7 | 0.68 |
| 8 | 0.65 |
| 9 | 0.62 |
| 10 | 0.59 |
| 11 | 0.57 |
| 12 | 0.54 |

Predict, with a reason, whether the coloured liquid in the U-tube would move towards tube **1** or tube **2** during the experiment.

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**(3 marks)**

**(d)** The mass of the seeds was 1.8 g.

Using the information provided in the table, calculate the rate of oxygen consumption $cm^3\ g^{-1}\ hour^{-1}$ by the seeds. Show your working.

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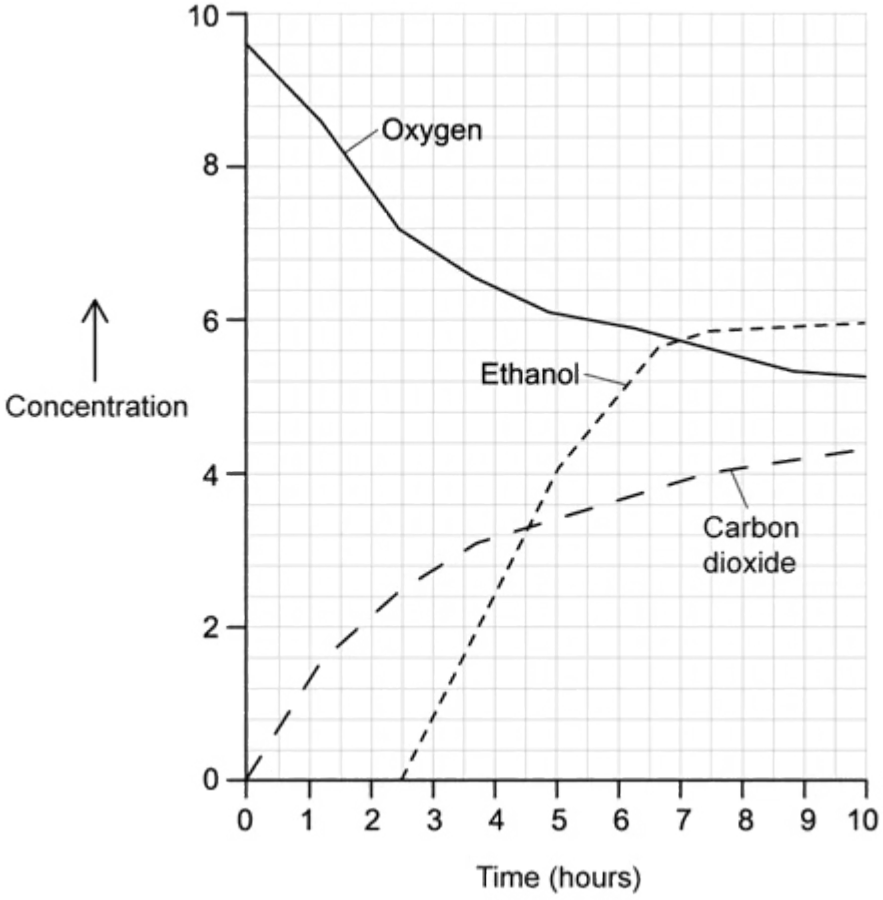
**(2 marks)**

**4 (a)** A researcher investigated the use of a new carbohydrate source (substance **L**) for the production of ethanol as biofuel. The aim was to find the optimum length of time to leave a mixture of yeast and substance **L** to produce ethanol. They set up an airtight container containing yeast and substance **L**, then measured the concentrations of oxygen, carbon dioxide and ethanol over 10 hours.

The results of this experiment are shown in the graph below.




Give **three** reasons why the container, containing the mixture, had to be airtight.

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**(3 marks)**

**(b)** Explain the relationship seen between the concentration of oxygen and the concentration of carbon dioxide between 0 and 2.5 hours.

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**(2 marks)**

**(c)** A student concluded that the yeast started to respire anaerobically when the oxygen concentration fell below a certain concentration.

Suggest, with a reason, at what time in the experiment this occurred.

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**(2 marks)**

**(d)** State the equation to show the type of respiration carried out by the yeast after 2.5 hours.

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**(1 mark)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

Compare and contrast aerobic respiration and anaerobic respiration.

**(5 marks)**

**(b)** During sprint exercise or weight lifting, the body relies on anaerobic respiration to maximise the power of muscle contraction.

Explain why anaerobic respiration can only be sustained for short periods of time.

**(4 marks)**

**(c)** Describe and explain the use of yeast in baking.

**(6 marks)**

# Hard Questions

**1 (a)** A Sports Scientist was investigating aerobic respiration in an athlete. The equation below summarises how ATP is produced, using energy from the oxidation of glucose, for this particular athlete.

**glucose + oxygen + (ADP + Pi) → carbon dioxide + water + ATP**

**170 g  124.4 $dm^3$  17.25 kg  124.4 $dm^3$  107 g  17.25 kg**

Calculate the mass of ATP produced per $dm^3$ of oxygen for the athlete.

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**(3 marks)**

**(b)** The Sports Scientist then decided to measure the volume of oxygen consumed and the mass of ATP produced by the athlete when they ran different length races.

Some of the results for the athlete are shown in the table below.

| Length of race/m | Volume of oxygen consumed in cell respiration during race/$dm^3$ | Mass of ATP produced/kg |
|---|---|---|
| 1 500 | 40 | |
| 10 000 | 160 | |
| 25 000 | | 48.545 |
| 42 000 | | 95.703 |

Complete the table by calculating the missing values.

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**(2 marks)**

**(c)** The Sports Scientist estimated that during a 100 m race, 95 g of ATP would be needed by the athlete, but the athlete only consumed 0.6 $dm^3$ of oxygen.

(i) Calculate the difference in grams between the mass of ATP required for a 100 m race and the mass of ATP produced from 0.6 $dm^3$ of oxygen.

[2]

(ii) Deduce how the remaining ATP required for the 100 m race is being produced.

[1]

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**(3 marks)**

**2 (a)** Mitochondrial diseases in humans cause their mitochondria to malfunction. Individuals that suffer from mitochondrial diseases are only able to endure an intense exercise for a short period of time.

Explain why this is.

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**(2 marks)**

**(b)** A group of researchers wanted to investigate ATP production in the preparation of isolated mitochondria taken from a person with mitochondrial disease. They suspended the mitochondria in an isotonic solution and added ADP, phosphate and a respiratory substrate. Oxygen was supplied throughout the preparation.

Explain why the solution used was isotonic.

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**(2 marks)**

**(c)** Researchers measured the rate of $CO_2$ production by three groups of insects of the same species at 15 °C, 25 °C and 35 °C. The mean mass of each group of insects was also recorded. Their results can be seen in the table below.

| **Temperature / °C** | **Mean mass / g** | **Rate of $CO_2$ release / $\mu dm^3\ min^{-1}$** | **Rate of $CO_2$ release per gram / $\mu dm^3\ g^{-1}\ min^{-1}$** |
|---|---|---|---|
| 15 | 0.051 | 0.15 | |
| 25 | 0.050 | 0.39 | |
| 35 | 0.052 | 0.61 | |

(i) Calculate the rate of carbon dioxide release per gram for each temperature in the table. Give your answer to two decimal places.

[1]

(ii) Sketch a graph of your values against temperature.

[2]

**(3 marks)**

**(d)** (i) Describe the effect of temperature on the rate of $CO_2$ release for these insects.

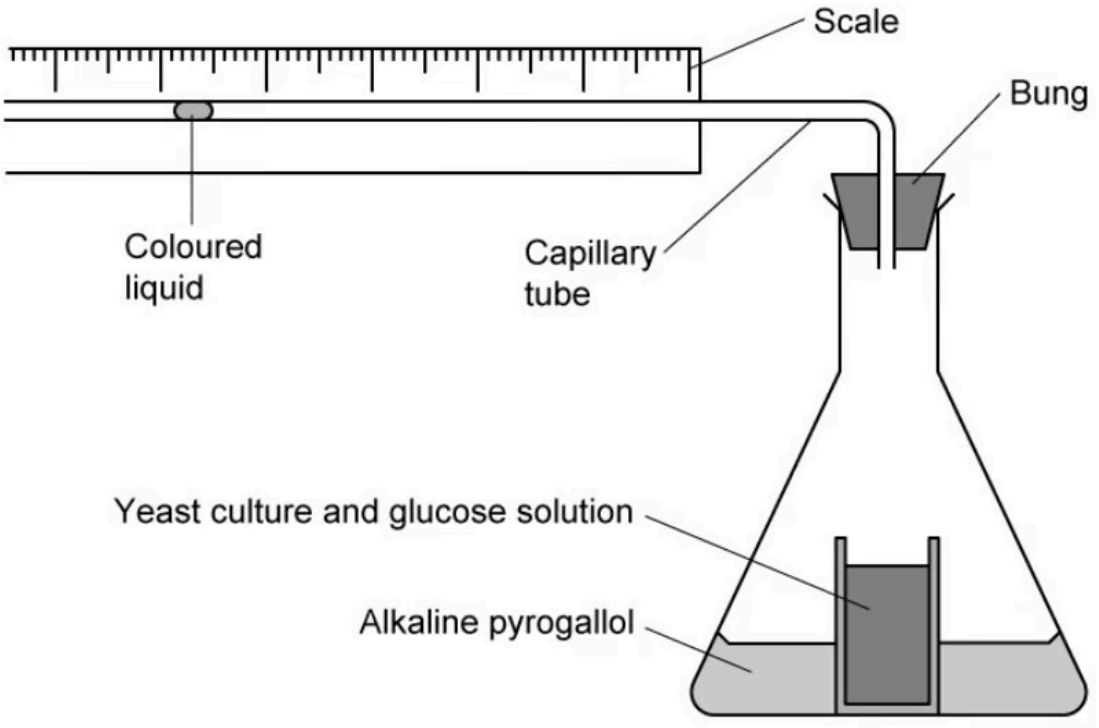
[1]

(ii) Explain this effect.

[2]

**(3 marks)**

**3 (a)** A researcher used the apparatus shown below to measure the rate of respiration in yeast. The researcher placed the flask in a water bath with the bung open (so that the yeast culture reached a constant temperature), before adding the alkaline pyrogallol, inserting the bung and starting the investigation. In an alkaline solution, pyrogallol absorbs oxygen from the air.




When the researcher inserted the bung and began the experiment, the coloured liquid initially moved to the right. After a period of time, the coloured liquid slowed, stopped and reversed its direction, moving to the left.

Use the diagram above and your knowledge of respiration to explain these observations.

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**(5 marks)**

**(b)** When the coloured liquid in part (a) moved to the left, the researcher measured that the coloured liquid moved 1.8 cm in 16 hours. The internal diameter of the capillary tubing was 1.3 mm. The volume of the capillary tubing is given by $\pi r^2 l$, where $l$ = length.

Calculate the volume of gas produced and from this, the rate of gas production in $mm^3$ $hr^{-1}$. Show your working and give your answer to an appropriate number of significant figures.

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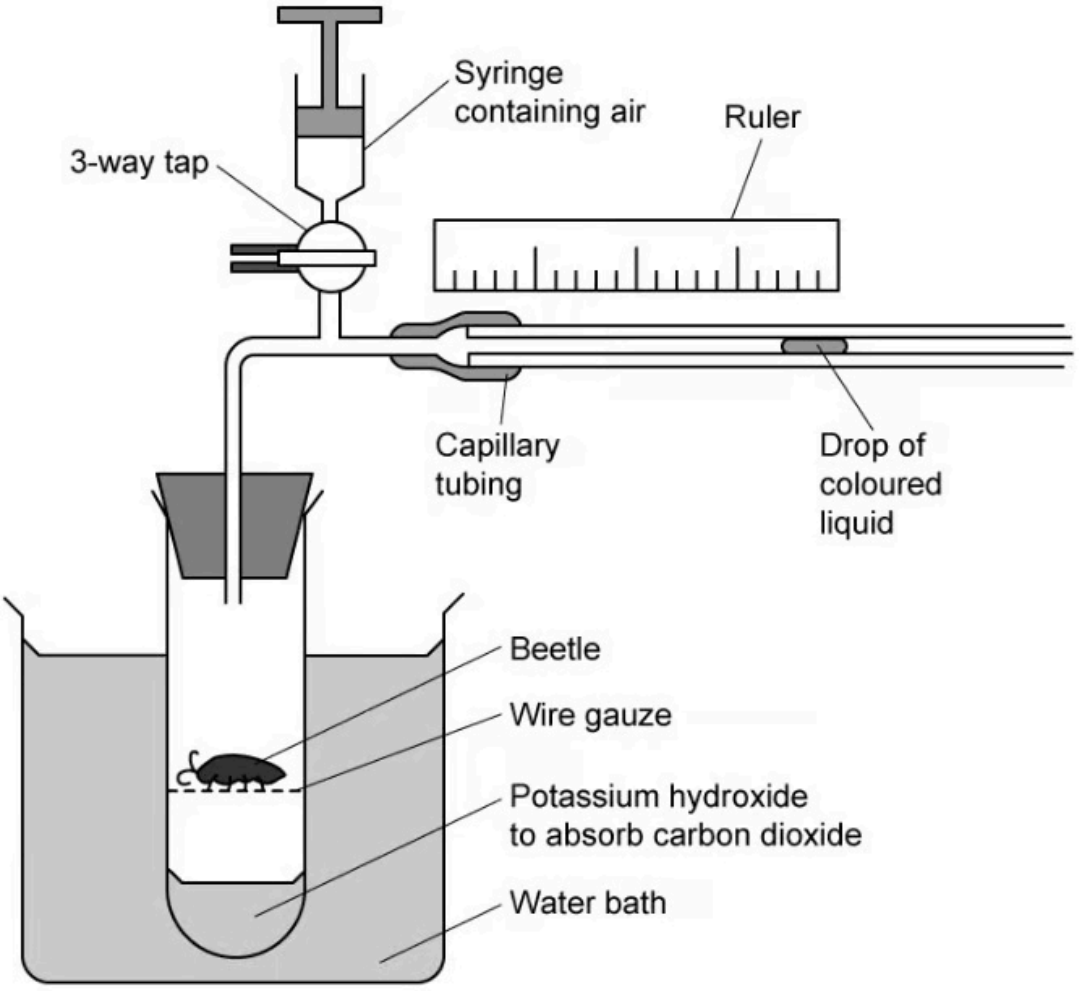
**(4 marks)**

**(c)** The researcher then wanted to measure and compare the rate of aerobic respiration in different species of beetle (with different masses) using the experimental set-up shown below.




(i) Outline the different measurements that the researcher would need to take in order to calculate the aerobic respiration rate and to accurately compare these respiration rates between different beetle species.

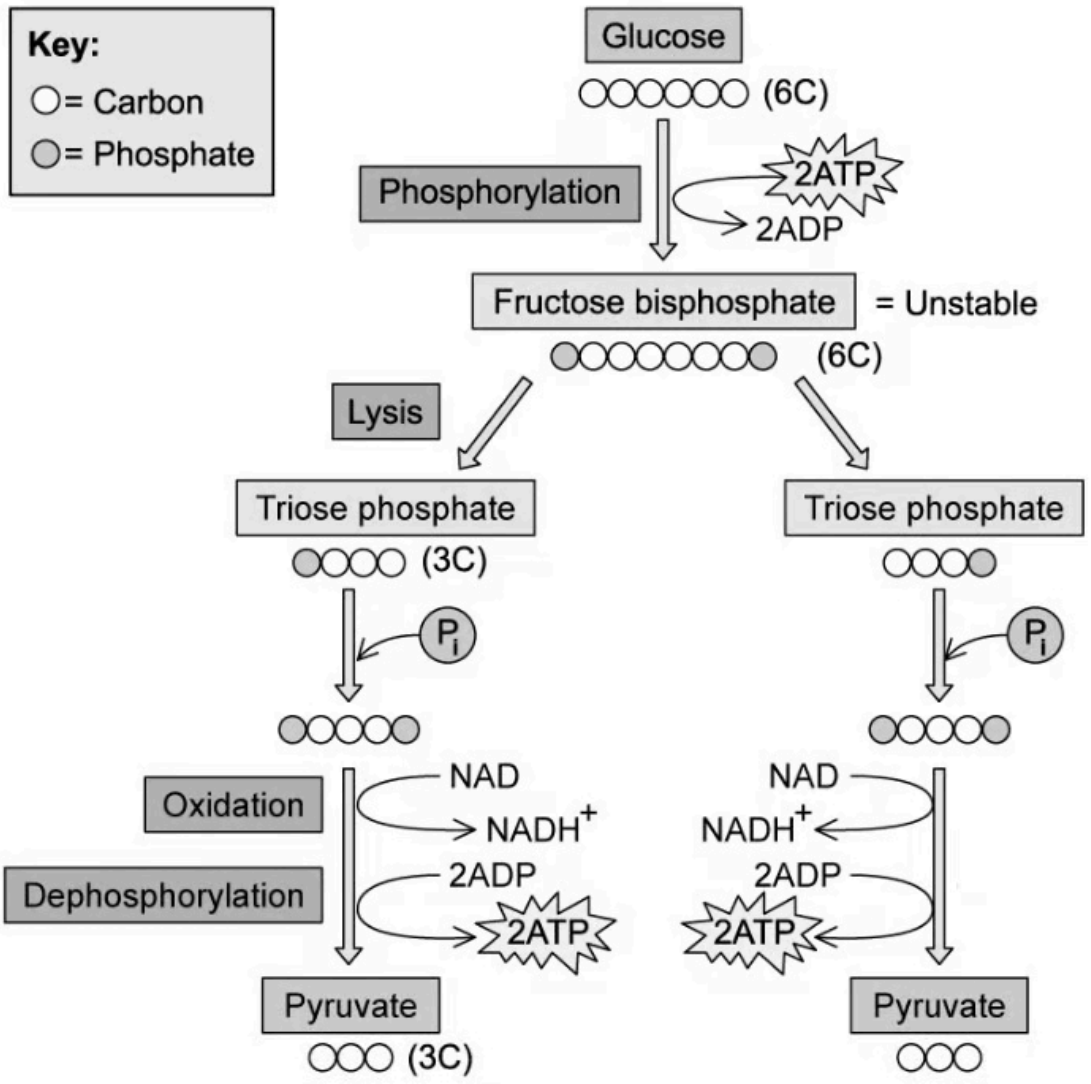
[4]

(ii) Suggest suitable units of respiration rate, based on the different measurements that the researcher would need to take.

[1]

**(5 marks)**

**4 (a)** The diagram below shows the process of glycolysis. Glycolysis is the first stage of respiration. It takes place in the cytoplasm of the cell and involves trapping glucose in the cell by phosphorylating the molecule and then splitting the glucose molecule in two.




Give the net ATP production from glycolysis.

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**(1 mark)**

**(b)** Explain how temperature influences the rate of ATP production in respiration.

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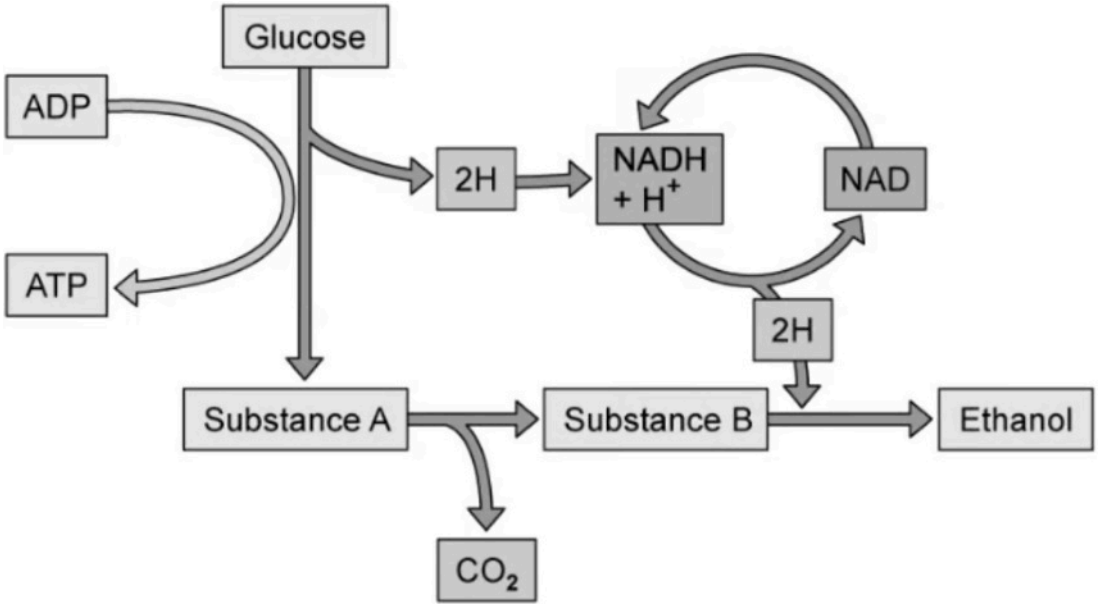
**(3 marks)**

**(c)** Identify the overall process that is occurring as shown in the diagram below and the condition under which this process must be occurring.




**(2 marks)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

Scientists investigated the effect of exercise on muscle fibres in mice. The mice were split into two groups. Group **A** undertook regular exercise for 8 weeks, Group **B** was not exercised. After 8 weeks the scientists compared how long each group of mice could carry out prolonged exercise.

(i) Identify which group was able to exercise for longer periods

[1]

(ii) Using the idea of respiration, explain the scientists' findings.

[5]

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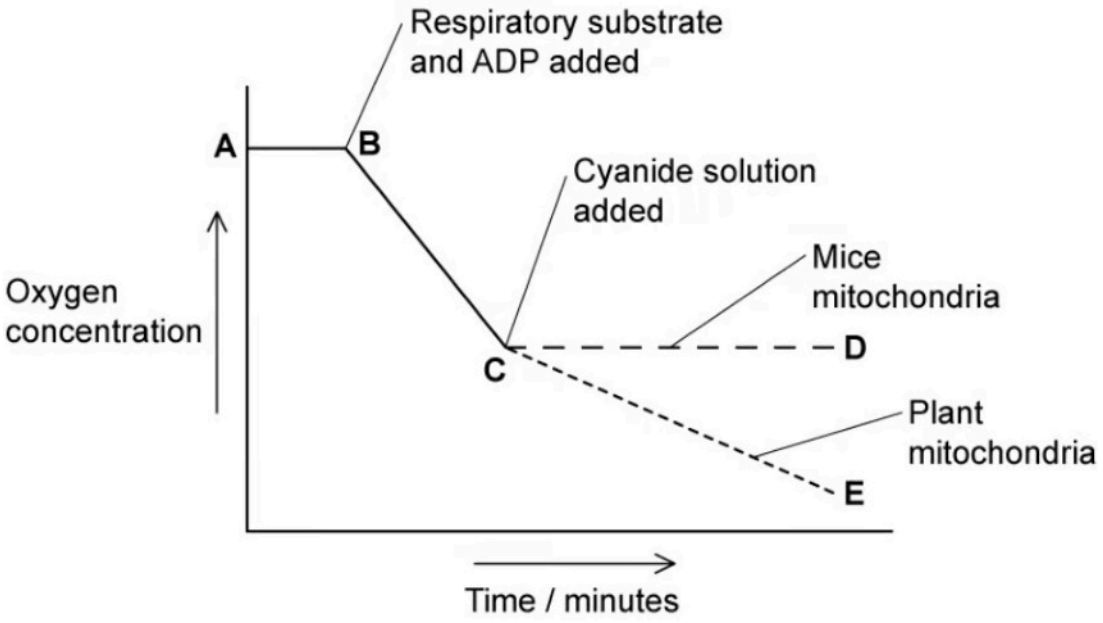
**(6 marks)**

**(b)** The scientists then investigated the effect of cyanide on the uptake of oxygen in mitochondria isolated from mice cells. Cyanide acts as an inhibitor of several enzymes involved in respiration. The scientists compared the mice's mitochondria with mitochondria isolated from plant cells. They prepared a flask of suspension of each type of mitochondria and recorded the oxygen concentration in each flask over time.

- After 10 minutes they added ADP and a respiratory substrate to each suspension.
- After 20 minutes they added cyanide to each suspension.

Their results are shown in the graph below. During time **A** to **C** the results of the two flasks overlap.




(i) Describe the differences in results between lines **C** to **D** (mice mitochondria) and **C** to **E** (plant mitochondria).

[2]

(ii) Explain these differences.

[2]

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**(4 marks)**

**(c)** (c) Compare and contrast aerobic respiration and anaerobic respiration.

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**(7 marks)**