IB · HL · Biology

4 hours 30 questions

Structured Questions

Cell Respiration

Adenosine Triphosphate (ATP) / Cell Respiration / Cell Respiration: Skills / Oxidation & Reduction (HL) / Glycolysis (HL) / Anaerobic Respiration (HL) / The Link Reaction & The Krebs Cycle (HL) / Oxidative Phosphorylation (HL) / Respiratory Substrates (HL)

Easy (10 questions)	/73
Medium (10 questions)	/91
Hard (10 questions)	/103
Total Marks	**/267**

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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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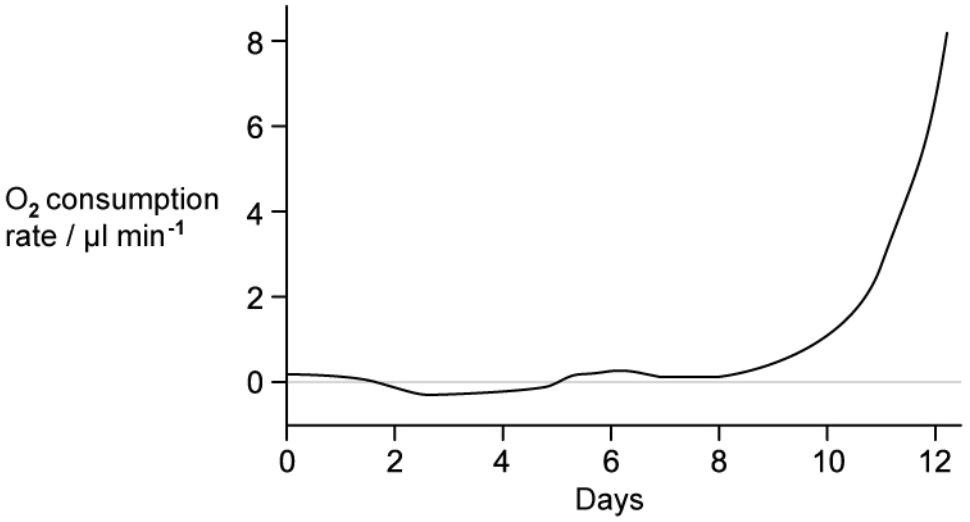
(4 marks)

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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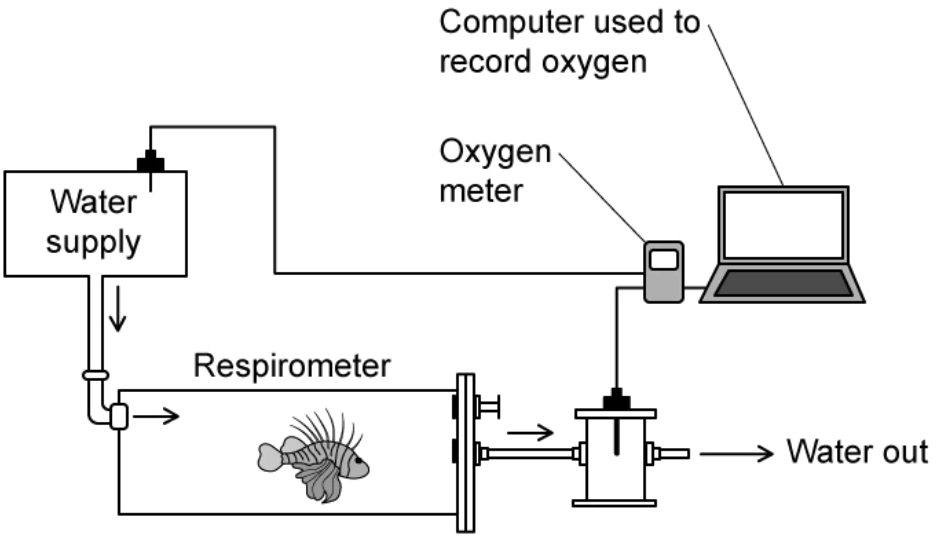
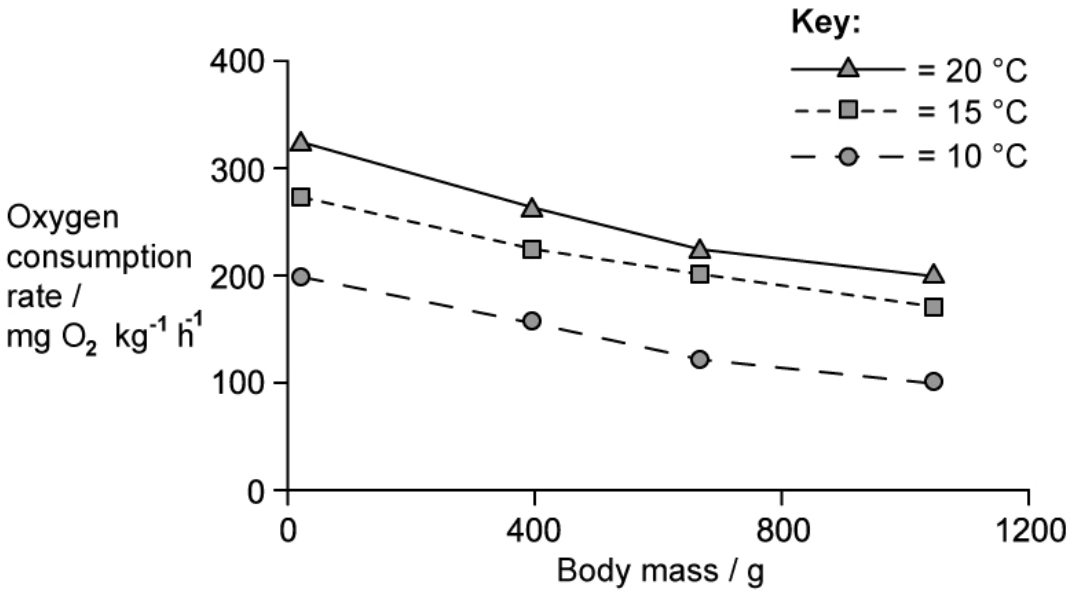
(2 marks)

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*.

.....

(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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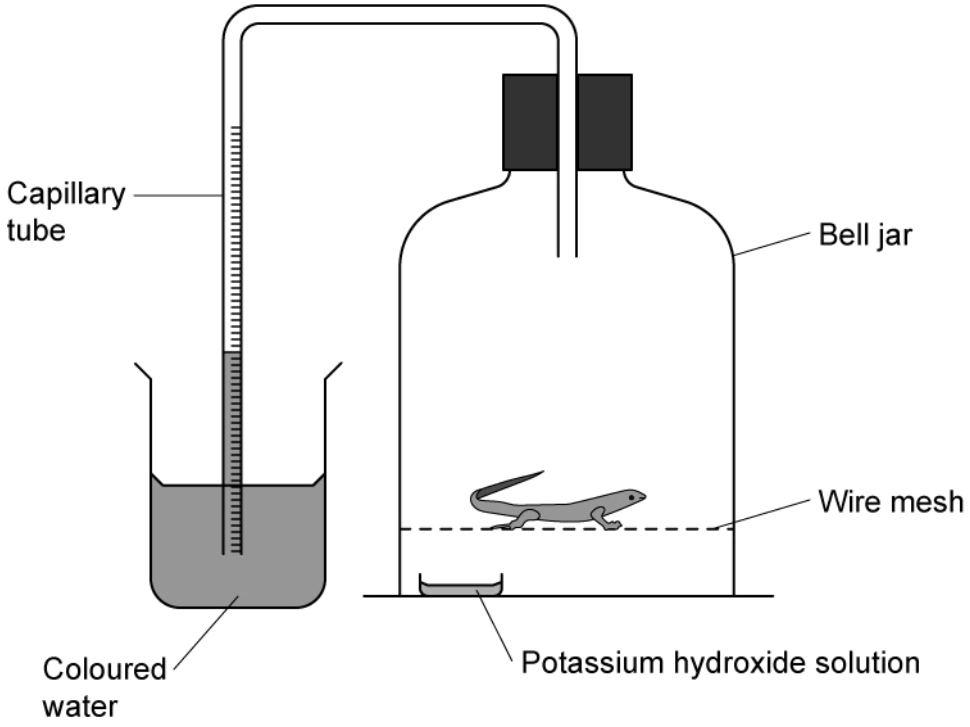
(2 marks)

5 (a) 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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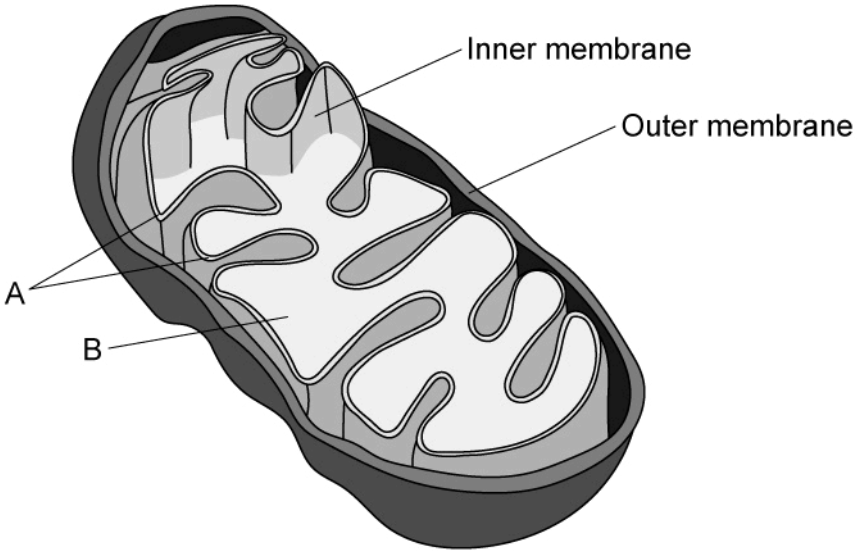
(3 marks)

6 (a) The diagram shows a mitochondrion.



Identify the parts labelled **A** and **B**.

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(2 marks)

(b) The stages of respiration take part in different locations in a cell as shown in the table below.

Complete the missing parts of the table.

Stage of respiration	**Location in cell**
	Cytoplasm
Link Reaction	
Krebs cycle	Matrix of mitochondria
Oxidative phosphorylation	

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(3 marks)

(c) Mitochondria are highly adapted to carry out respiration. One adaptation is a highly folded inner membrane, the cristae.

Describe how the folding of a membrane is an adaptation of an organelle such as the mitochondria.

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(1 mark)

(d) Anaerobic respiration also occurs in cells, but not in the mitochondria.

State the names of the two types of anaerobic respiration. One type occurs in animal cells and the other type occurs in yeast cells.

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(1 mark)

7 (a) Respiration can be represented by a chemical equation.

State the balanced chemical equation for aerobic respiration.

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(2 marks)

(b) Respiration involves the oxidation and reduction of chemical compounds.

Define oxidation in terms of electrons lost or gained.

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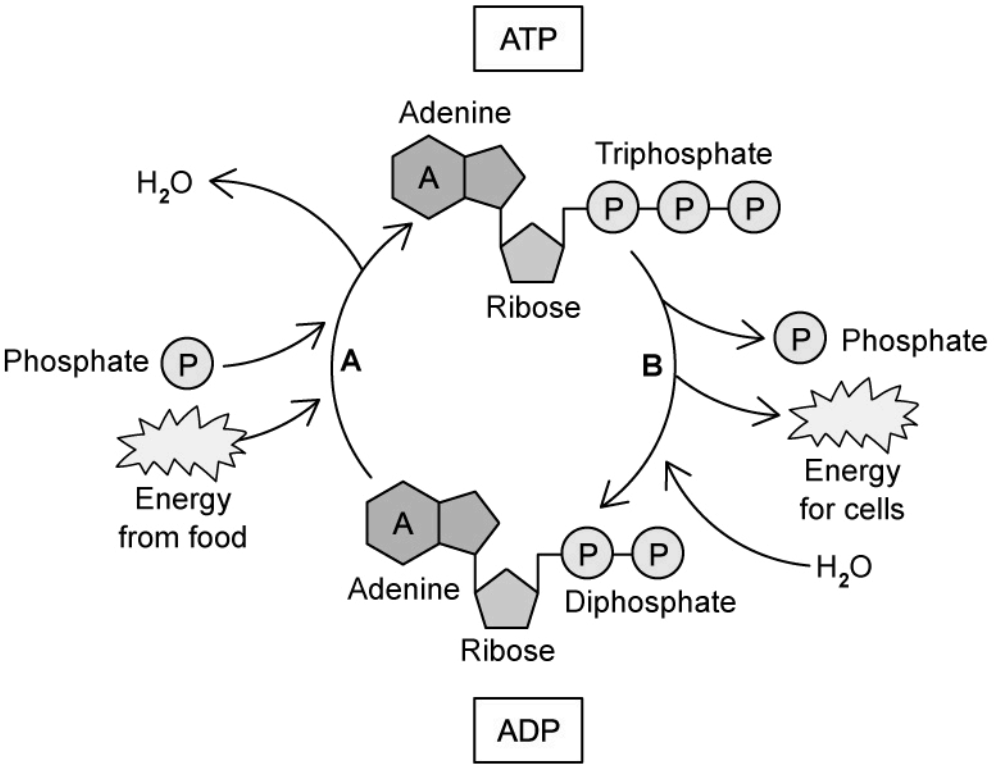
(1 mark)

(c) The diagram below shows the cyclic formation of ATP from ADP.

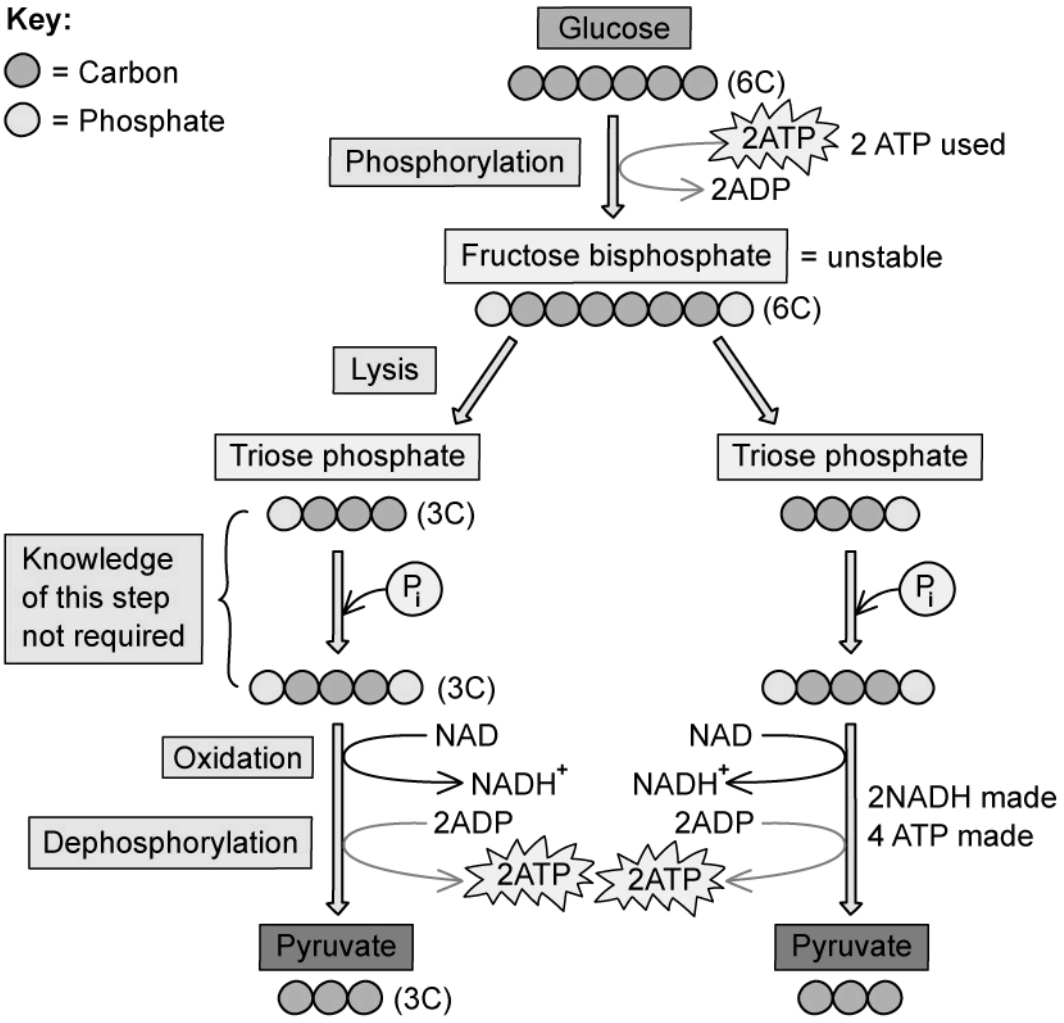
Use the diagram to identify which of processes **A** and **B** is the process of phosphorylation.



(1 mark)

(d) Phosphorylation occurs during the process of glycolysis.

Use the diagram below to describe phosphorylation during glycolysis.



(2 marks)

8 (a) The Link Reaction is described as an oxidative decarboxylation reaction.

State which molecule is decarboxylated during the Link Reaction.

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(1 mark)

(b) Coenzyme A is a molecule used in the Link Reaction,

State the role of coenzyme A in the Link Reaction.

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(2 marks)

(c) During the Krebs cycle, two molecules of carbon dioxide are released.

State how many molecules of carbon dioxide are released in the Krebs cycle per glucose molecule.

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(1 mark)

(d) The coenzyme NAD is reduced six times during the Krebs cycle stage of respiration.

Describe the events that occur to the molecule of NAD in order to reduce it.

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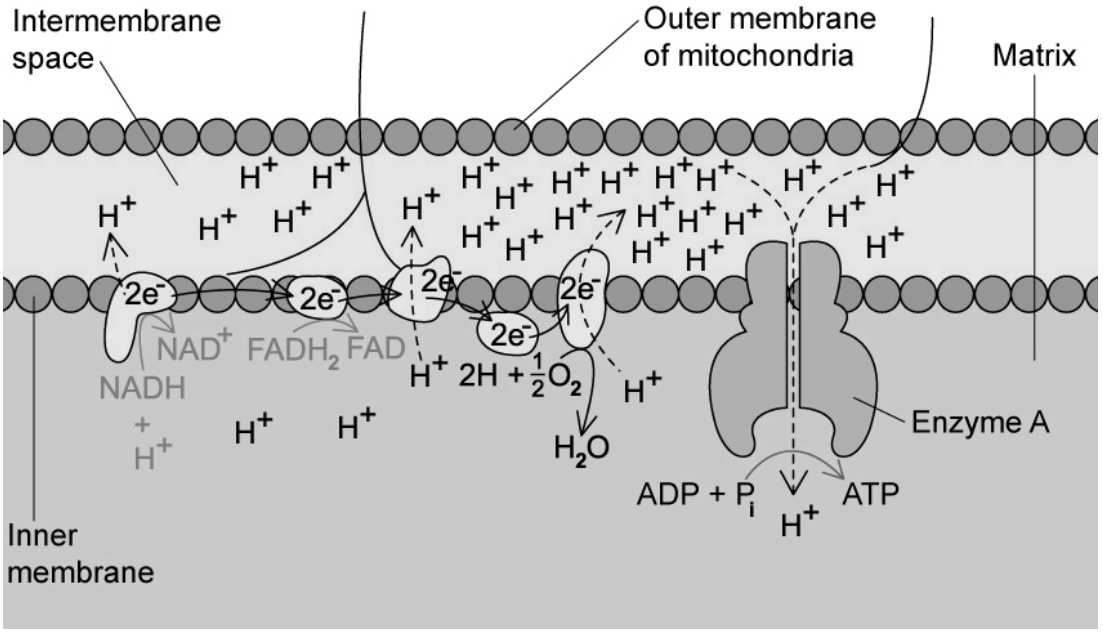
(2 marks)

9 (a) The diagram below shows the process of oxidative phosphorylation.



Identify enzyme A from the diagram.

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(1 mark)

(b) Describe the role of enzyme A from the diagram in part (a).

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(3 marks)

(c) An important process in respiration is the electron transport chain. This uses a series of redox reactions where electrons, donated from specific molecules, are transported through a chain of electron carriers.

State the two molecules which act as electron donors in the electron transport chain.

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(2 marks)

(d) Oxygen is described as the final electron acceptor in the electron transport chain.

Explain the importance of oxygen as the final electron acceptor.

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(3 marks)

10 (a) Describe the steps involved in the link reaction.

(3 marks)

(b) Describe the role of the inner membrane of the mitochondria.

(4 marks)

(c) The four main stages of aerobic respiration are glycolysis, the link reaction, Krebs cycle and oxidative phosphorylation.

Describe each stage, including the location of each.

(8 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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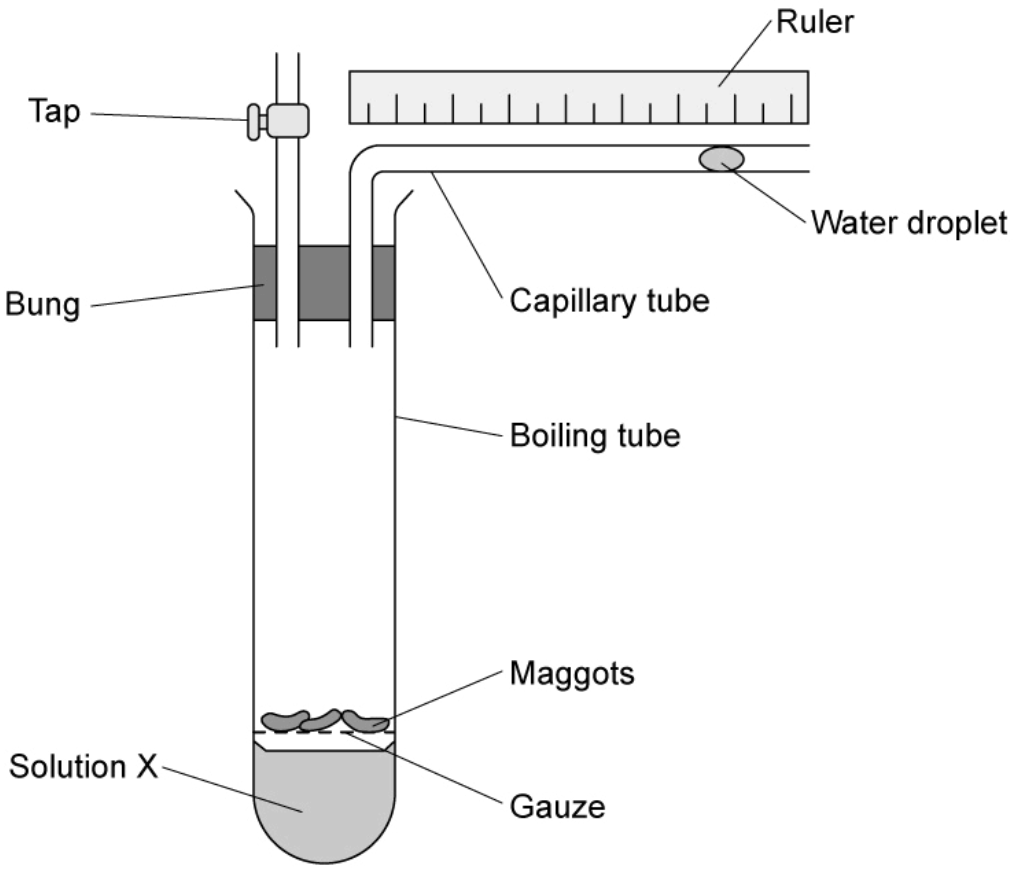
(2 marks)

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 π 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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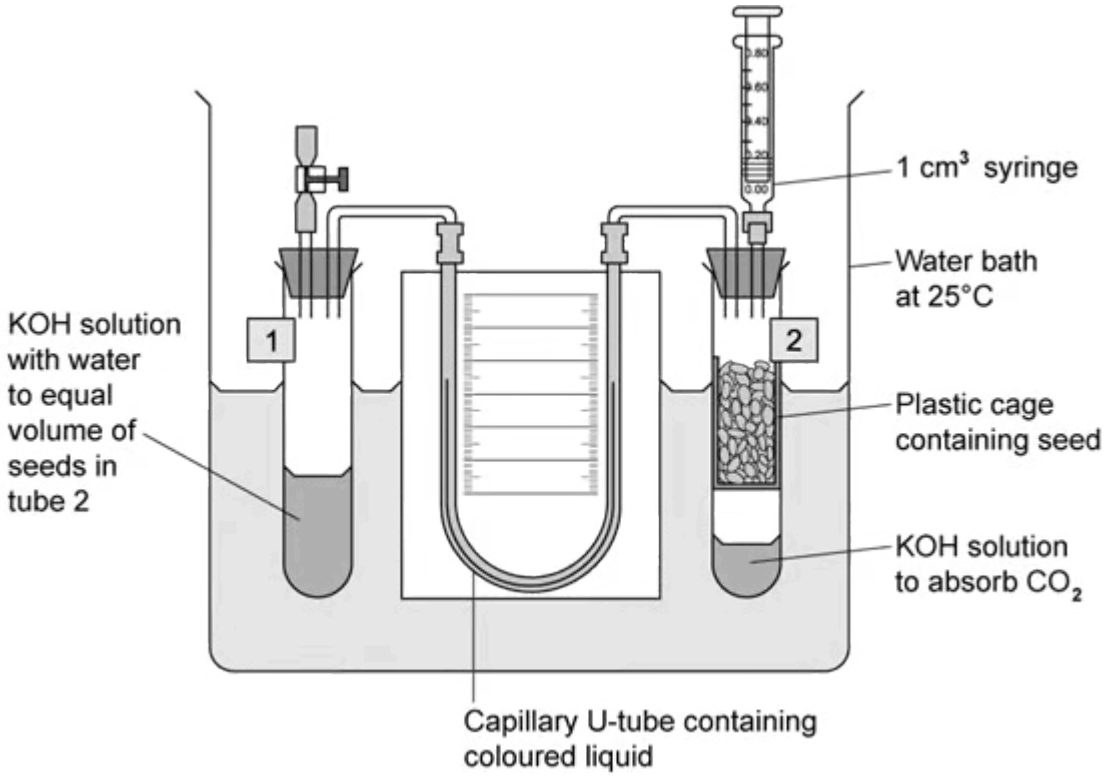
(3 marks)

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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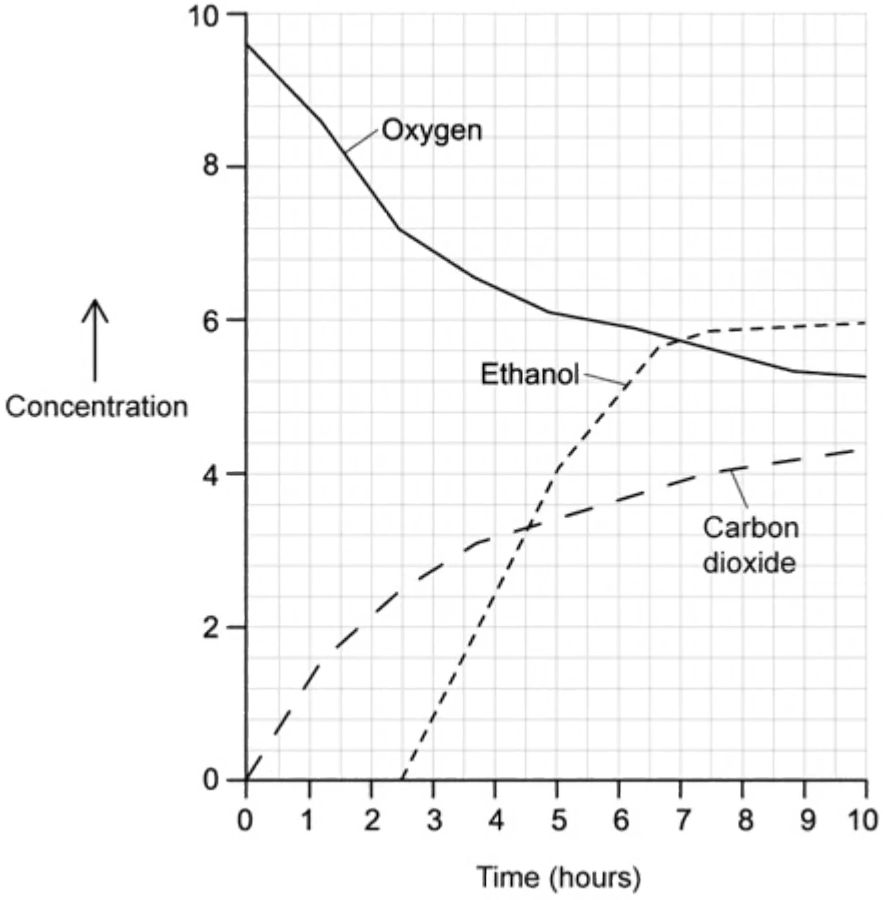
(2 marks)

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) 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)

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

Explain why this is.

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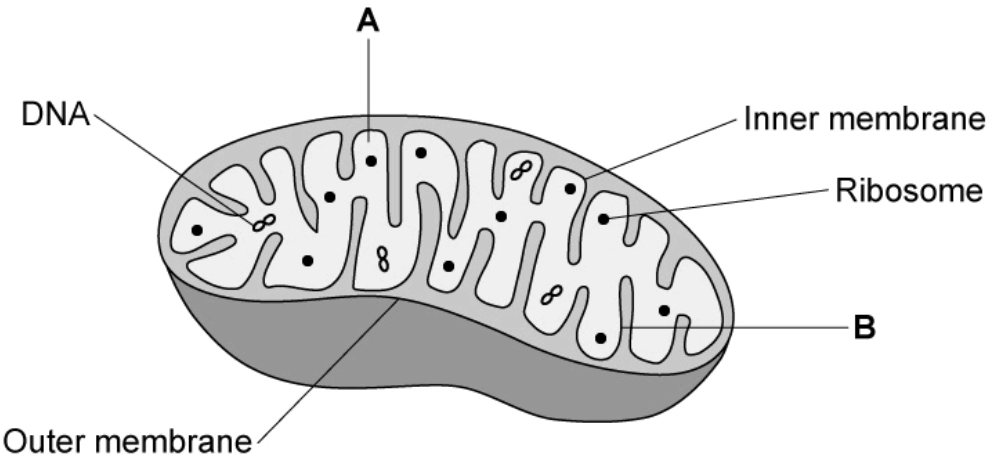
(2 marks)

(b) The diagram below shows a mitochondrion.



Identify the structures labelled **A** and **B** in the diagram

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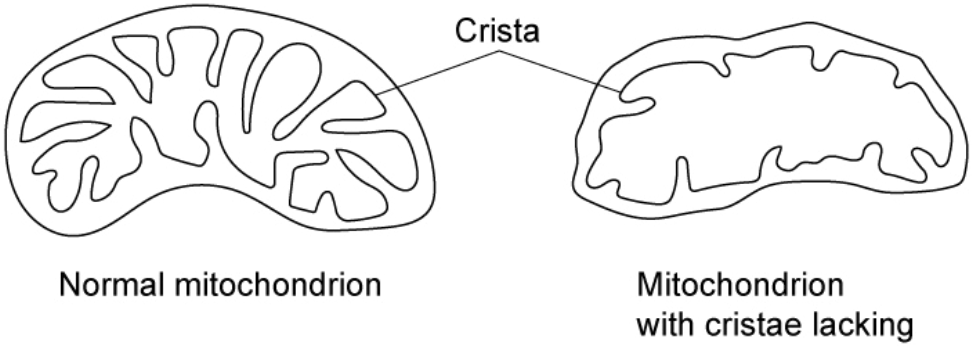
(1 mark)

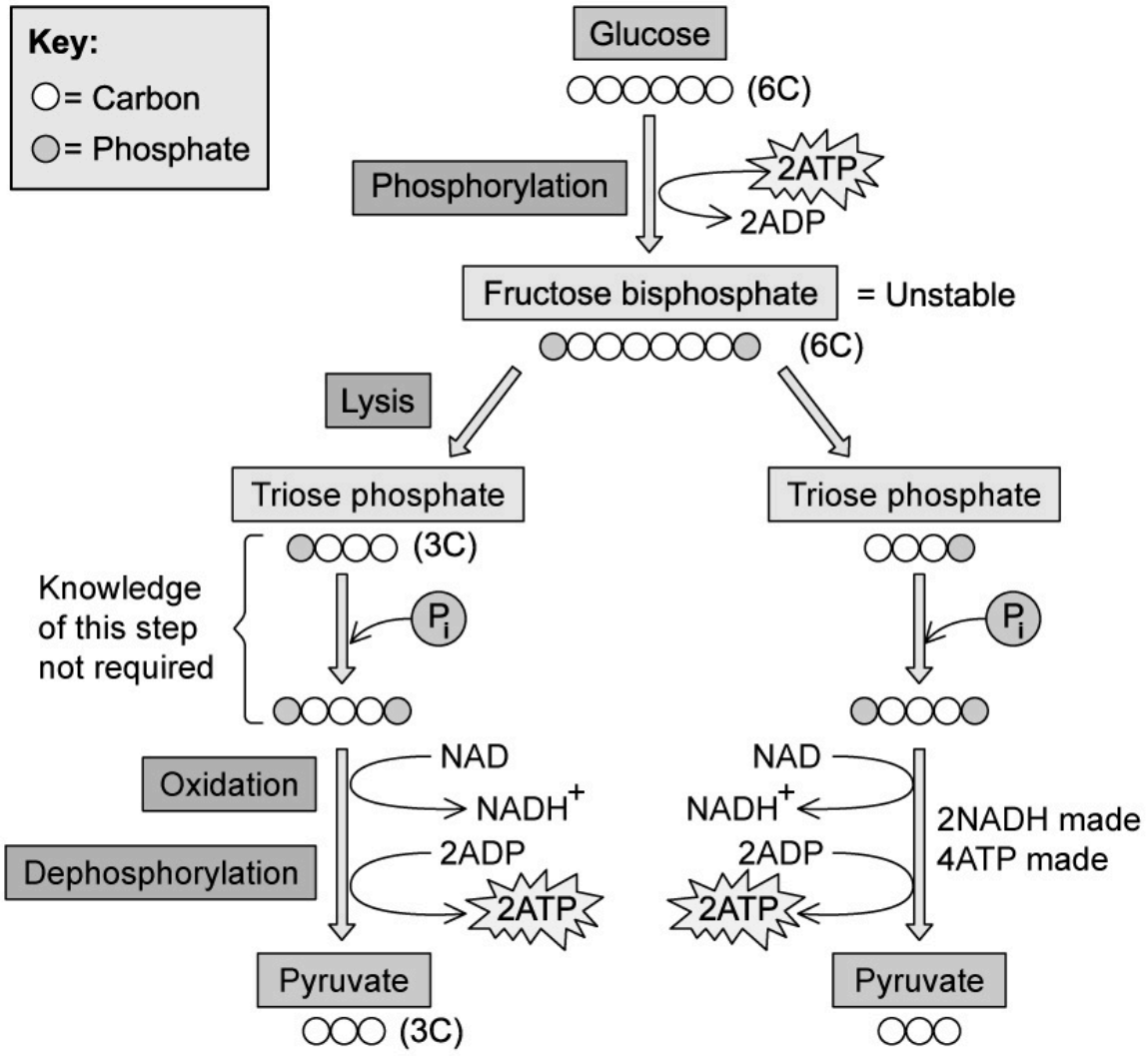
(c) Some forms of mitochondrial dysfunction result in mitochondria that lack fully formed cristae as shown in the diagram below.



Suggest, with a reason, the effect of this on the production of ATP.

(3 marks)

(d) The diagram below shows glycolysis.



State the net production of ATP and reduced NAD during glycolysis.

(1 mark)

7 (a) The Krebs cycle, which takes place in the mitochondrial matrix, releases hydrogen ions.

These hydrogen ions provide a source of energy for the synthesis of ATP, using coenzyme.

Describe the role of the coenzymes in the synthesis of ATP.

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(3 marks)

(b) Explain why the link reaction is described as an oxidative decarboxylation reaction.

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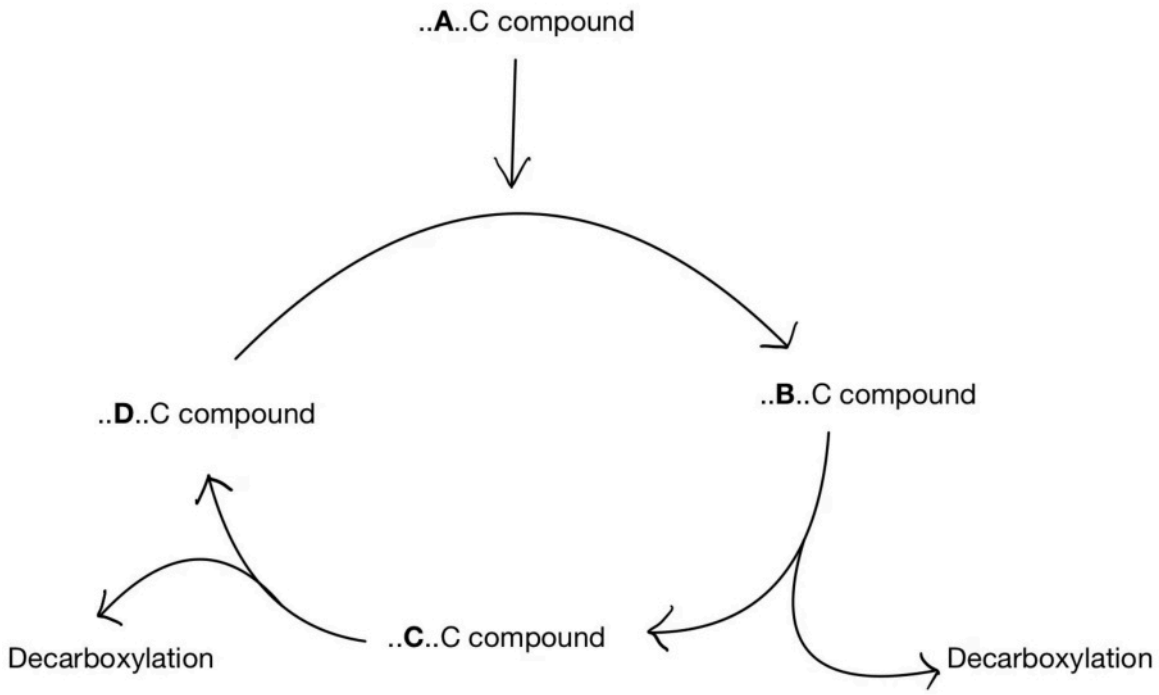
(2 marks)

(c) The diagram below shows the Krebs cycle.



Identify the number of carbon atoms (e.g. 1C) at each stage of the Krebs cycle.

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(2 marks)

(d) NAD and FAD are important electron carriers produced throughout the stages of respiration.

Complete the table below to show how many molecules of NAD and FAD are produced at each stage per molecule of glucose.

Stage of respiration	Number of NAD molecules	Number of FAD molecules
Glycolysis		
Link reaction		
Krebs cycle		
Electron transport chain		
Chemiosmosis		

.....

.....

(2 marks)

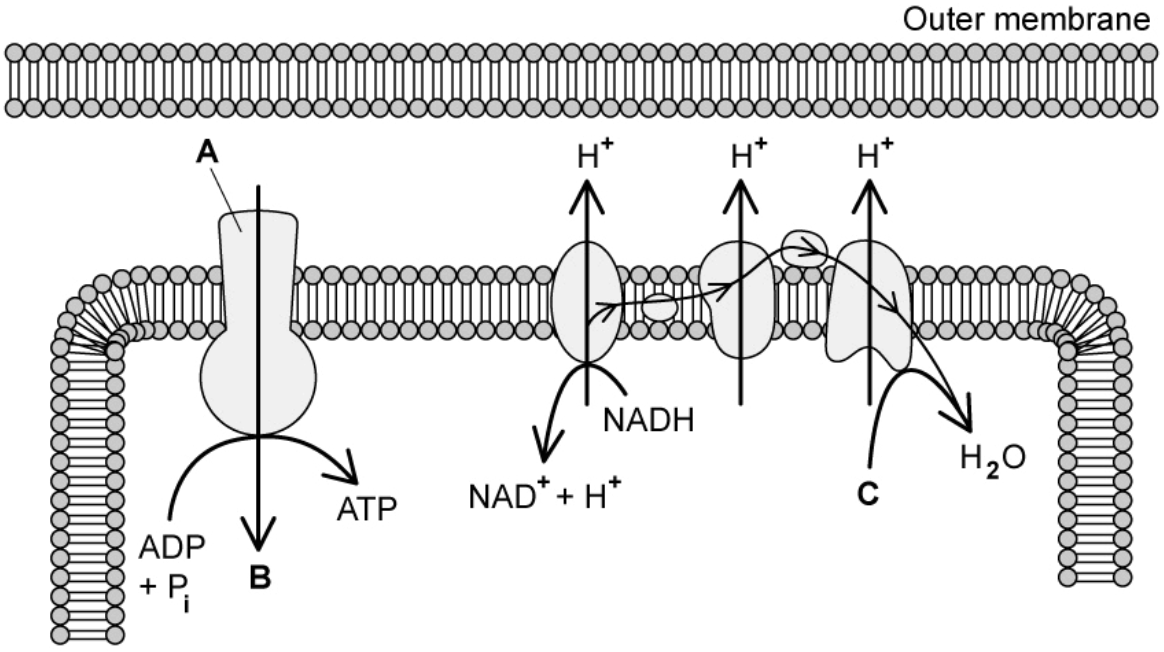
8 (a) Describe the role of oxygen in respiration.

(3 marks)

(b) Outline the events of the electron transport chain.

(3 marks)

(c) The diagram below shows part of a mitochondrion.



Suggest, with a reason, which part of the mitochondrion is shown in the diagram.

(2 marks)

(d) Label parts **A**, **B** and **C** in the diagram in part c).

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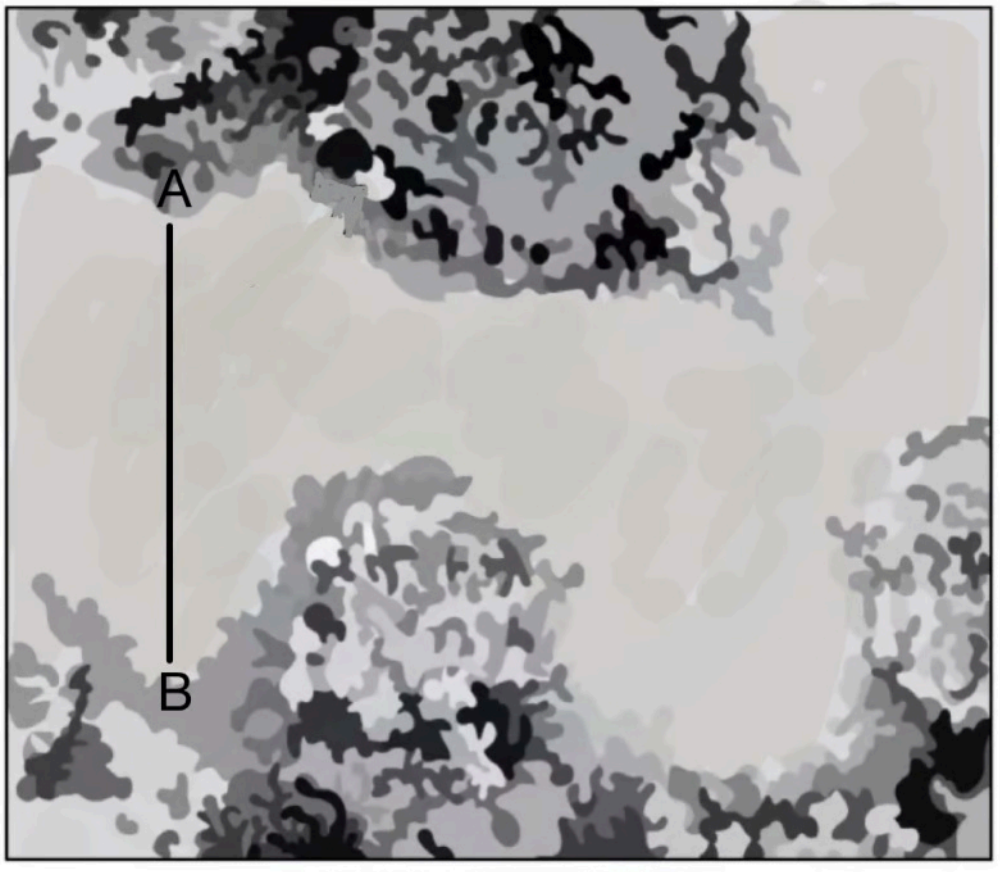
(1 mark)

9 (a) Draw an annotated diagram of a mitochondrion as seen through an electron microscope.

Your drawing should be a longitudinal cross-section; it should show the mitochondrion as if it has been cut open end-to-end.

(3 marks)

(b) The diagram below shows the cristae of a mitochondrion viewed with a magnification of x7000.



Use the information from the diagram and above to calculate the actual size space between **A** and **B**. You may assume that the line AB, when printed on paper, has a length of 3.5 cm.

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(1 mark)

(c) Phosphorylation occurs on the cristae membrane.

i. Describe the process of phosphorylation of ATP.
ii. State the stage(s) of respiration in which substrate level phosphorylation occurs.

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(3 marks)

10 (a) Describe the mechanism by which ATP is formed in the mitochondria.

(8 marks)

(b) Explain the relationship between the structure of the mitochondria and how it is related to its function.

(3 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]

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(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]

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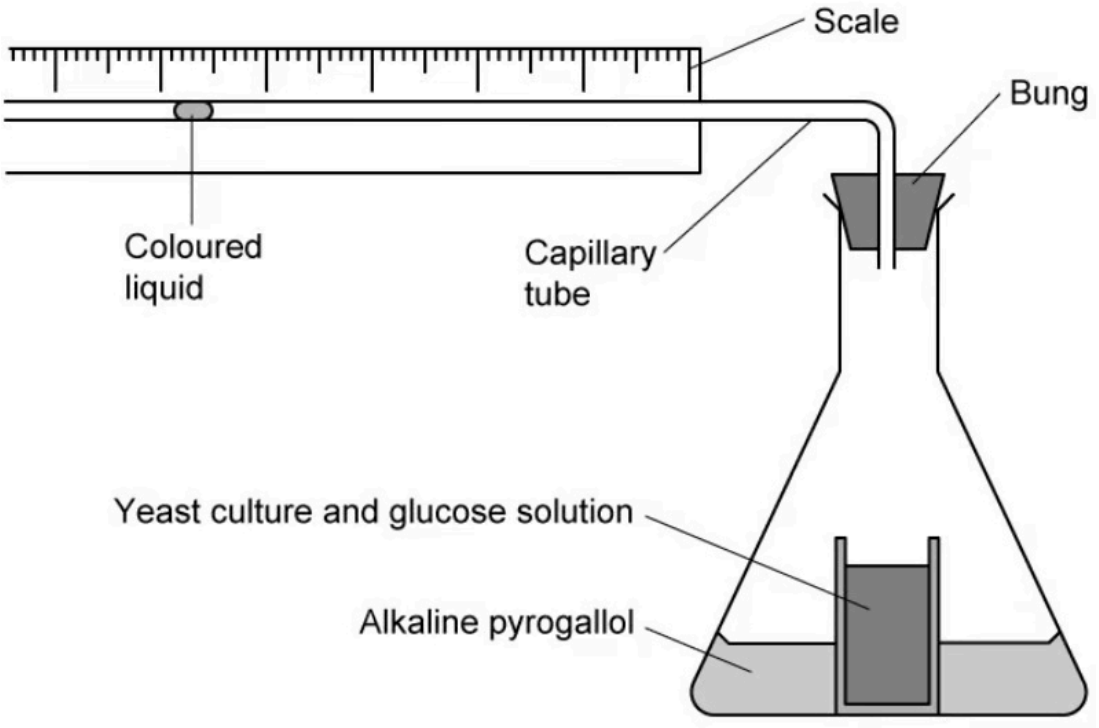
(3 marks)

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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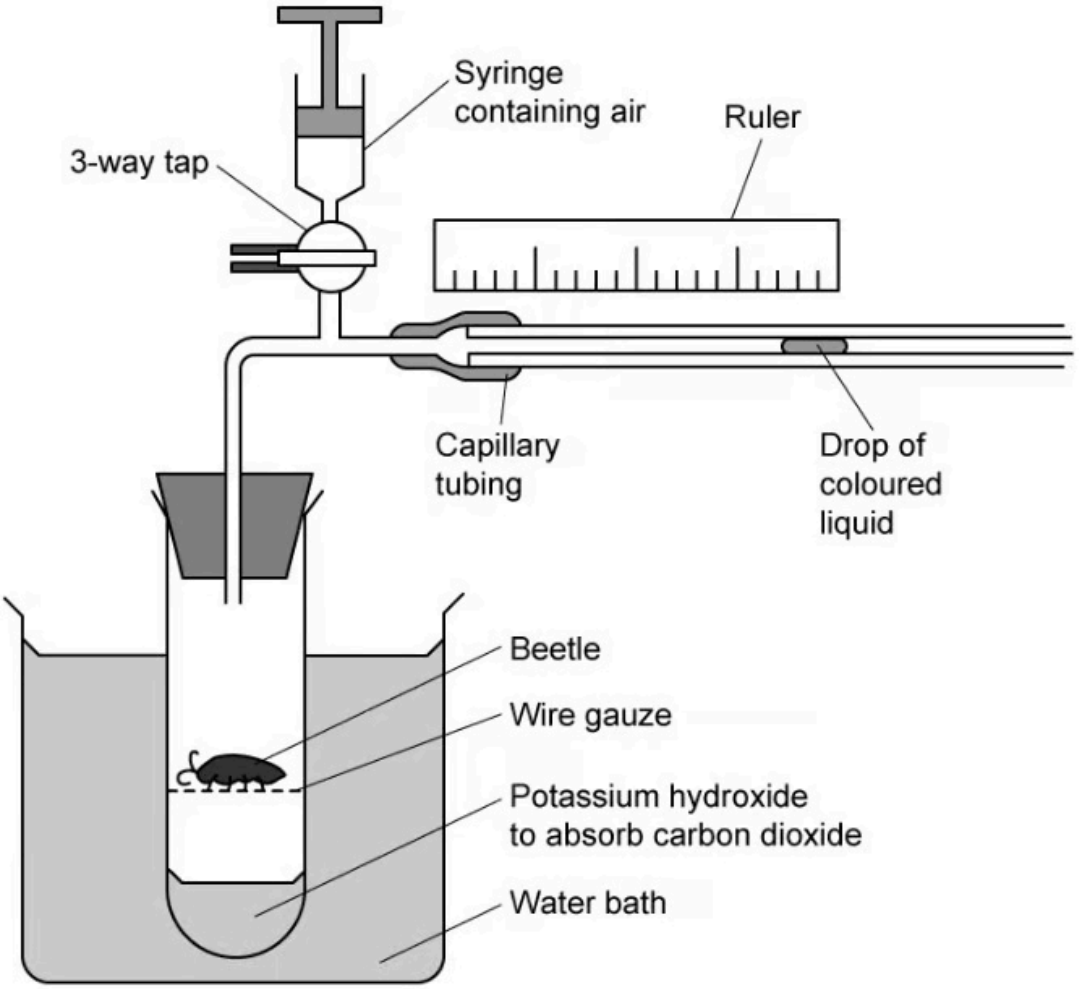
(4 marks)

(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.

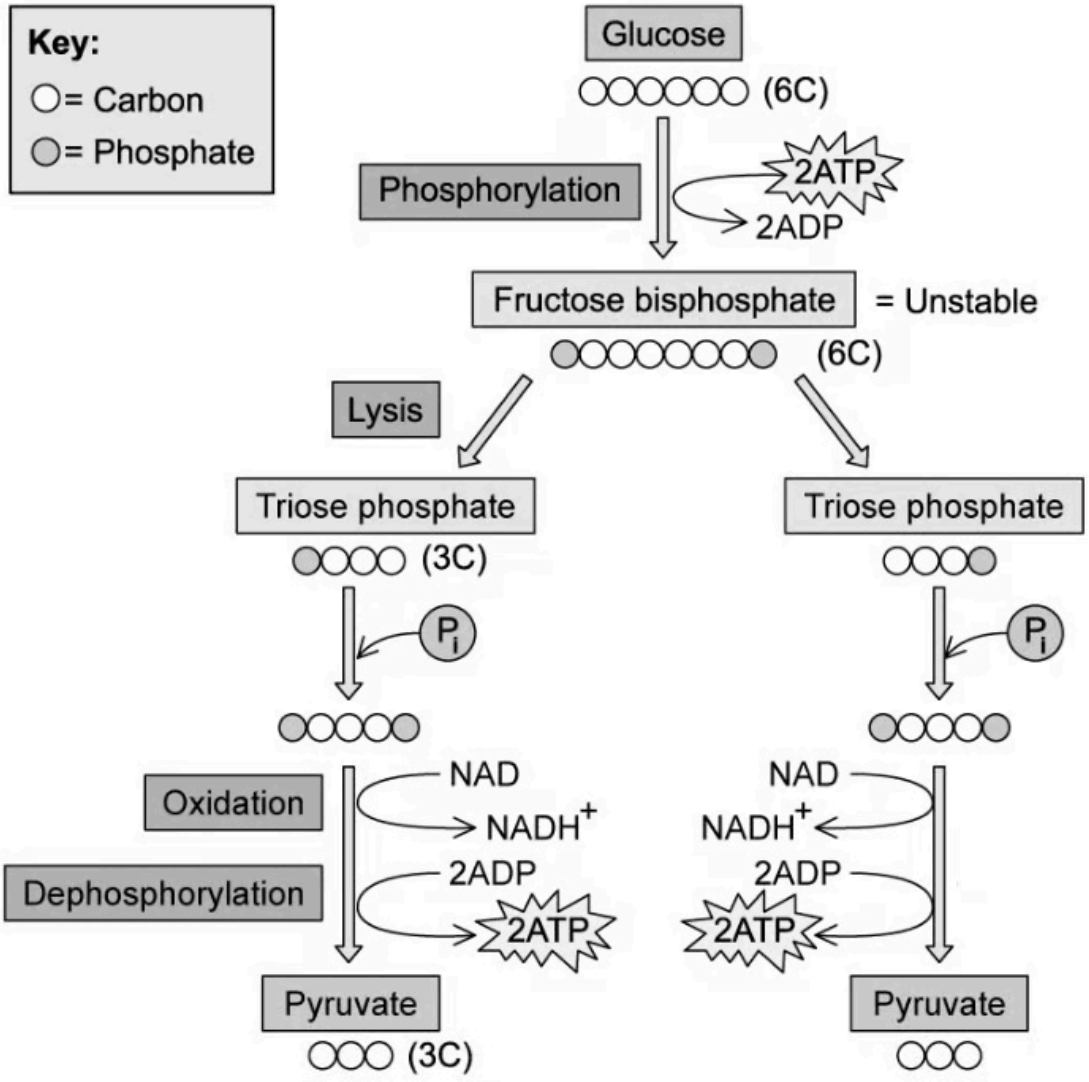
[4]

(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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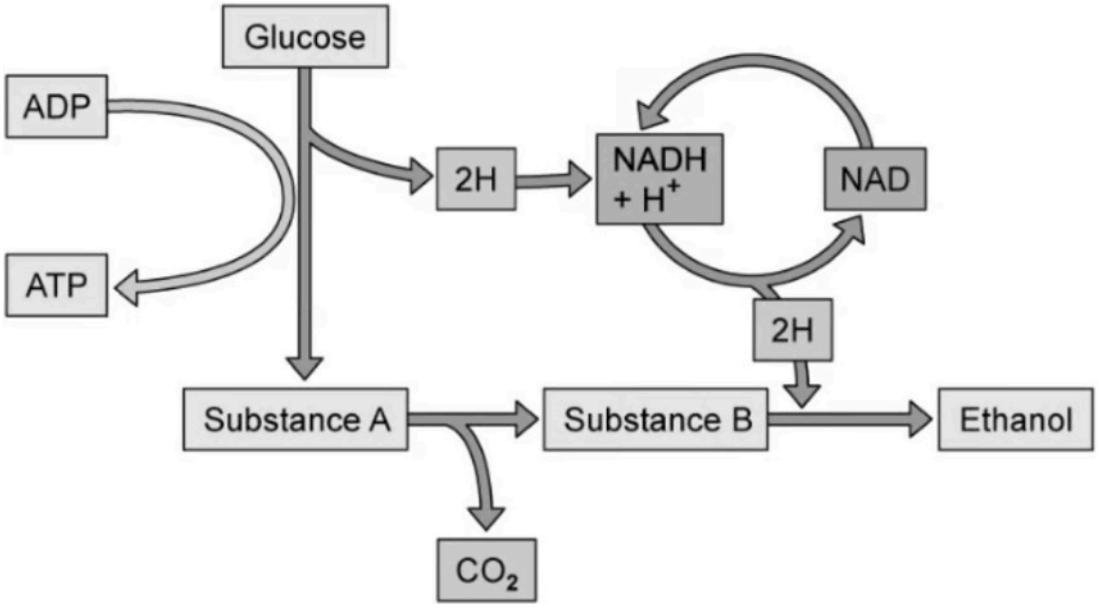
(3 marks)

(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) 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.

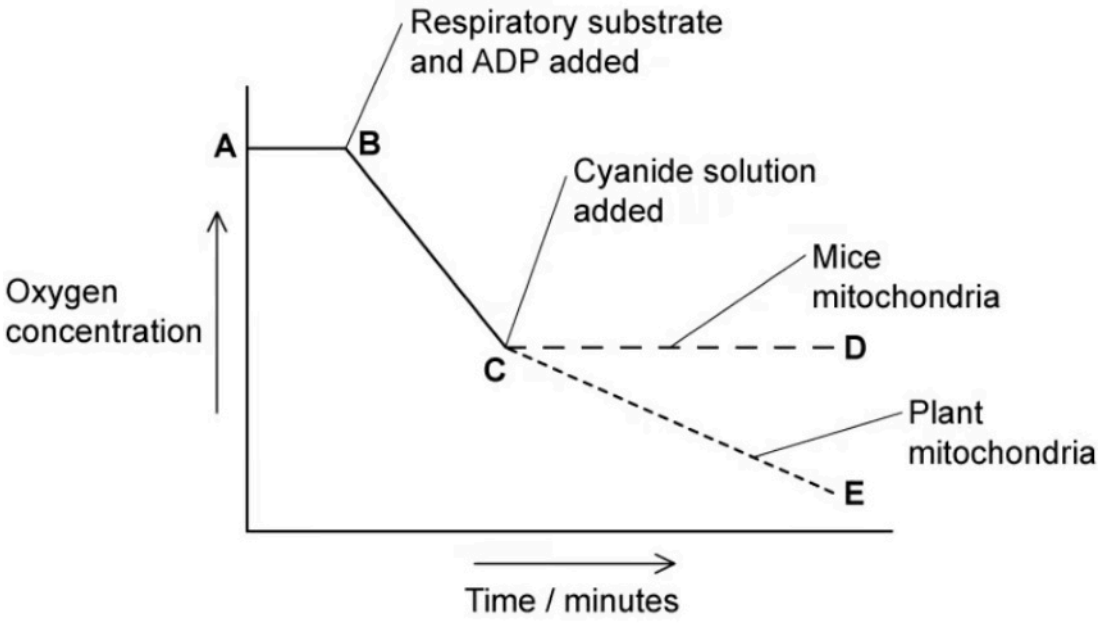
[5]

(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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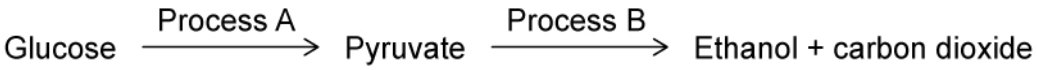
(7 marks)

6 (a) Most plants can respire aerobically and anaerobically. The diagram below shows a summary of anaerobic respiration.



State precisely in the cell where Process A occurs.

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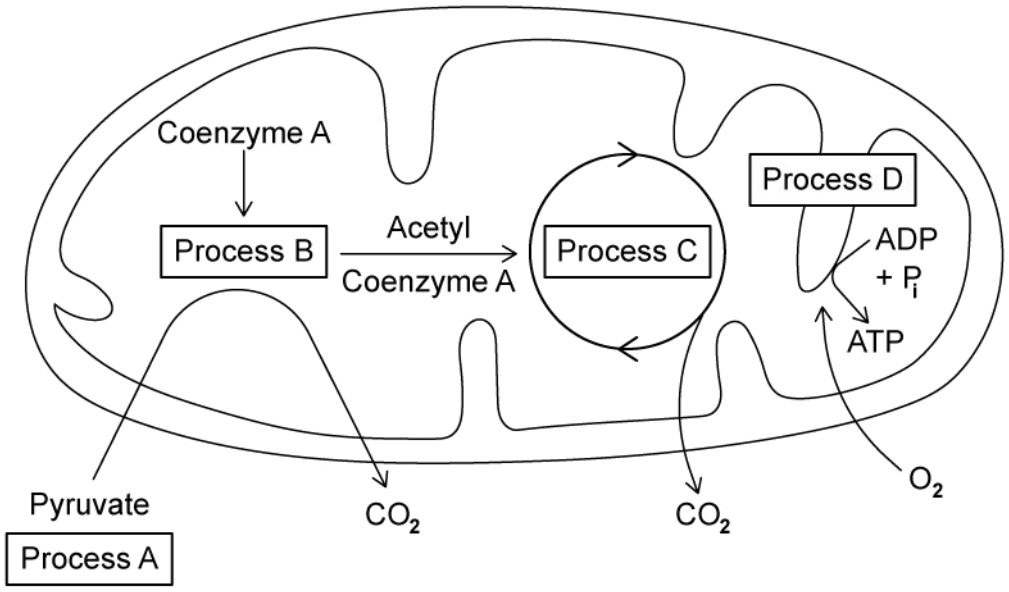
(1 mark)

(b) The diagram below shows a summary of the processes involved in aerobic respiration.



Explain how Process D enables Process A to continue

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(2 marks)

(c) Aerobic respiration produces more ATP per molecule of glucose than anaerobic respiration.

Explain why.

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(3 marks)

(d) Different stages of respiration can be inhibited by a range of substances. DNP is a steroid drug used in the weight loss industry. It inhibits respiration by preventing a proton gradient being maintained across membranes. When added to isolated mitochondria it caused the following effects:

- Less ATP produced
- Increase in heat production
- No change in the uptake of oxygen

Explain how DNP caused these changes.

(3 marks)

7 (a) The Krebs cycle takes place in the mitochondrial matrix. The process releases hydrogen ions which provide a source of energy for the synthesis of ATP, using co-enzymes and carrier proteins.

Describe the role of co-enzymes and carrier proteins in the production of ATP.

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(3 marks)

(b) The following reaction takes place in the Krebs cycle.

$$\text{Succinate} \xrightarrow{\text{Enzyme}} \text{Fumarate}$$

A student investigated the effect of the enzyme inhibitor malonate on this reaction. The structure of malonate is similar to the structure of succinate.

In the investigation, the student added malonate and the respiratory substrate, pyruvate, to a suspension of isolated mitochondria. She also bubbled oxygen through the suspension.

Explain why the student used pyruvate and not glucose as a respiratory substrate.

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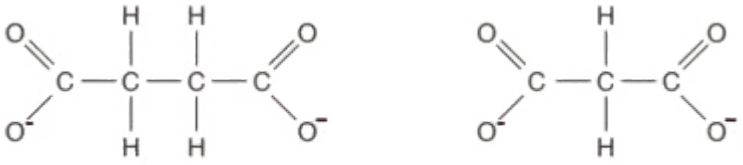
(2 marks)

(c) The structures of succinate and malonate and shown in the diagram below.



Succinate

Malonate

Suggest how malonate inhibits the formation of fumarate from succinate.

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(2 marks)

(d) The student measured the uptake of oxygen by the mitochondria during the investigation. The uptake of oxygen decreased when malonate was added.

Explain why.

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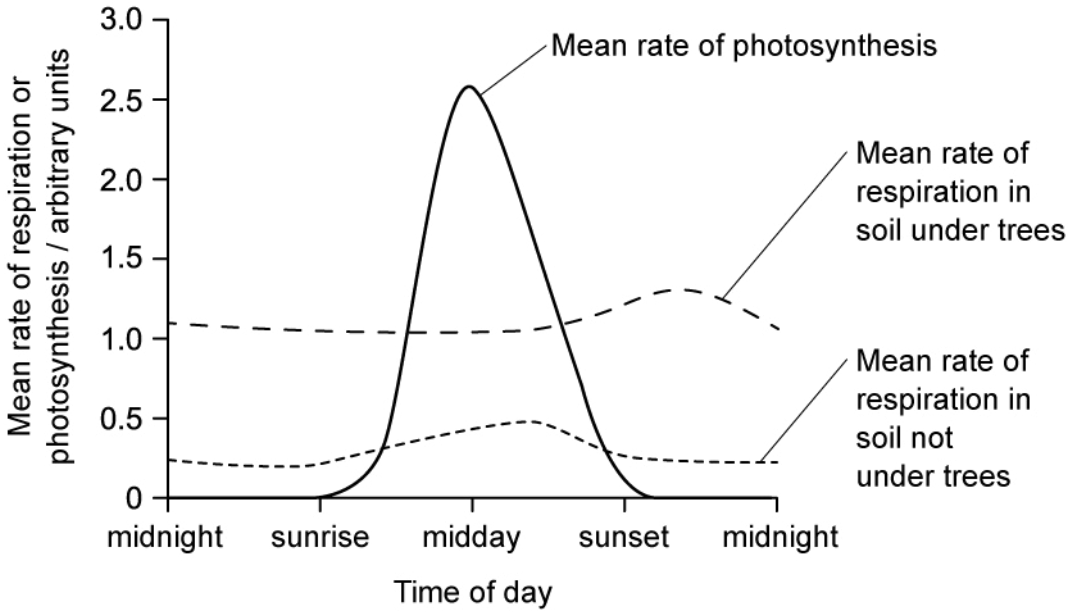
(2 marks)

8 (a) A group of scientists measured the mean rate of respiration in soil found under trees and soil that was not from under trees within the same woodland. The mean rate of photosynthesis in leaves was also measured. The measurements were taken throughout a 24 hour period during the summer.

The diagram below shows the scientists' results.



Suggest an explanation for the mean rate of respiration in soil not under the trees between midday and sunset.

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(2 marks)

(b) The mean rate of respiration is higher in soil under the trees throughout the 24hours. The scientists suggested the mean rate of photosynthesis was the cause of this.

Suggest how the rise in the mean rate of photosynthesis could lead to the rise in the mean rate of respiration in soil under trees.

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(2 marks)

(c) Suggest why there is a delay between the rise in the mean rate of photosynthesis and the rise in the mean rate of respiration.

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(1 mark)

(d) State the measurements needed for the scientists to calculate the rate of carbon dioxide production.

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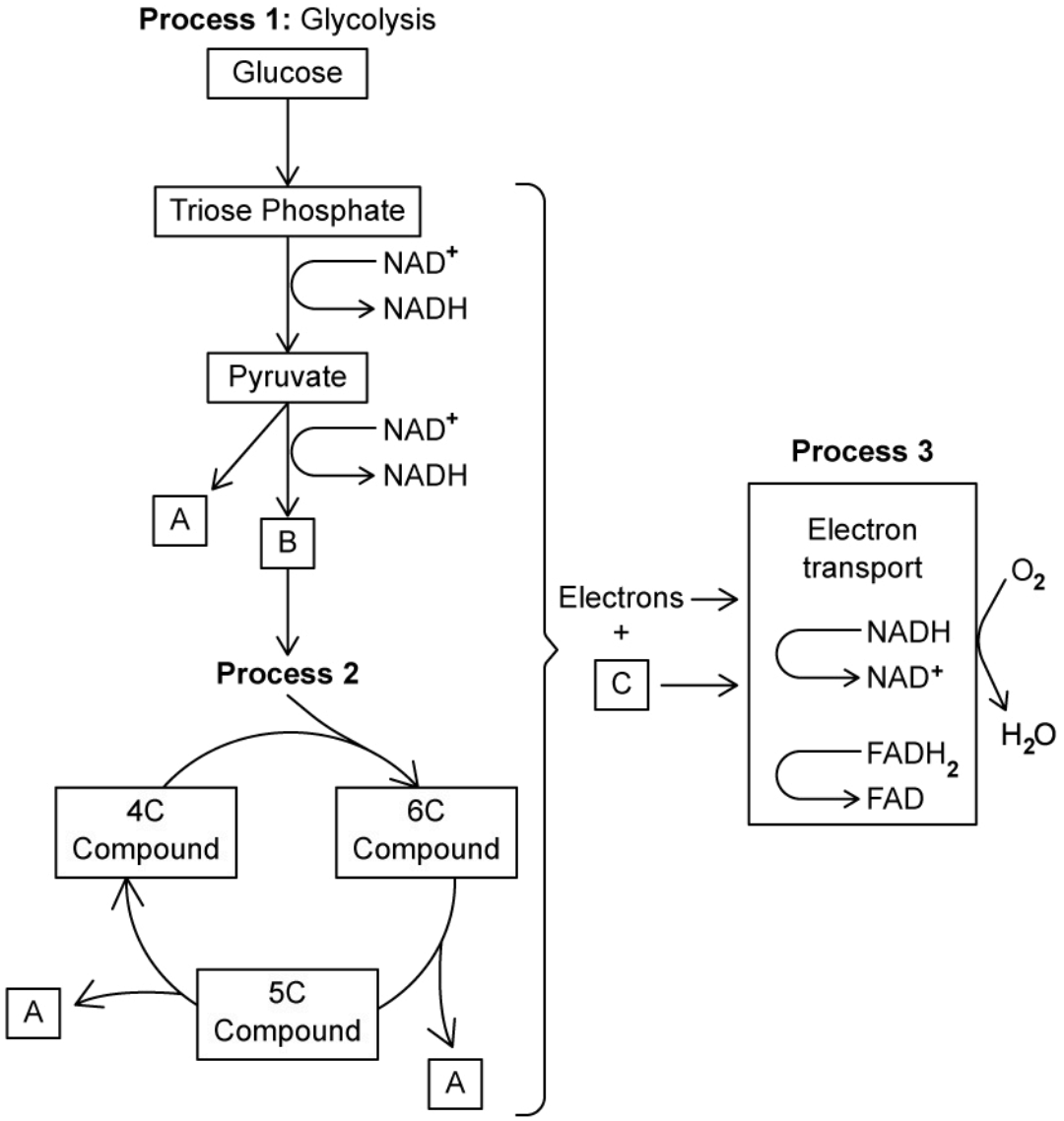
(2 marks)

9 (a) The diagram below shows the main stages of aerobic respiration.



Name substances A, B and C

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(3 marks)

(b) Annotate on the diagram,

(i) with an X, where oxidation occurs

[1]

(ii) with a Y, where decarboxylation occurs

[1]

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(2 marks)

(c) State precisely where in the cell Process 2 is occurring.

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(1 mark)

(d) Compare the roles of NAD+ and NADH in Process 1 and Process 3.

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(2 marks)

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

A large number of disorders are being linked to mitochondrial disease, MD. MD can affect the skeletal muscles, causing fatigue and weakness. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria.

One form of MD is caused by a mutation of a mitochondrial gene that codes for a tRNA. which changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

Suggest how a change in anticodon on the tRNA can lead to muscle weakness and fatigue.

(5 marks)

(b) A person with MD often has a decreased uptake of oxygen in their respiring cells. This has been attributed to an inhibitory compound of the Krebs cycle.

Explain why an inhibitor of the Krebs cycle would decrease the rate of oxygen uptake by cells.

(3 marks)

(c) Explain the role of chemiosmosis in the process of oxidative phosphorylation

(7 marks)