12 RESPIRATION

YOUR NOTES

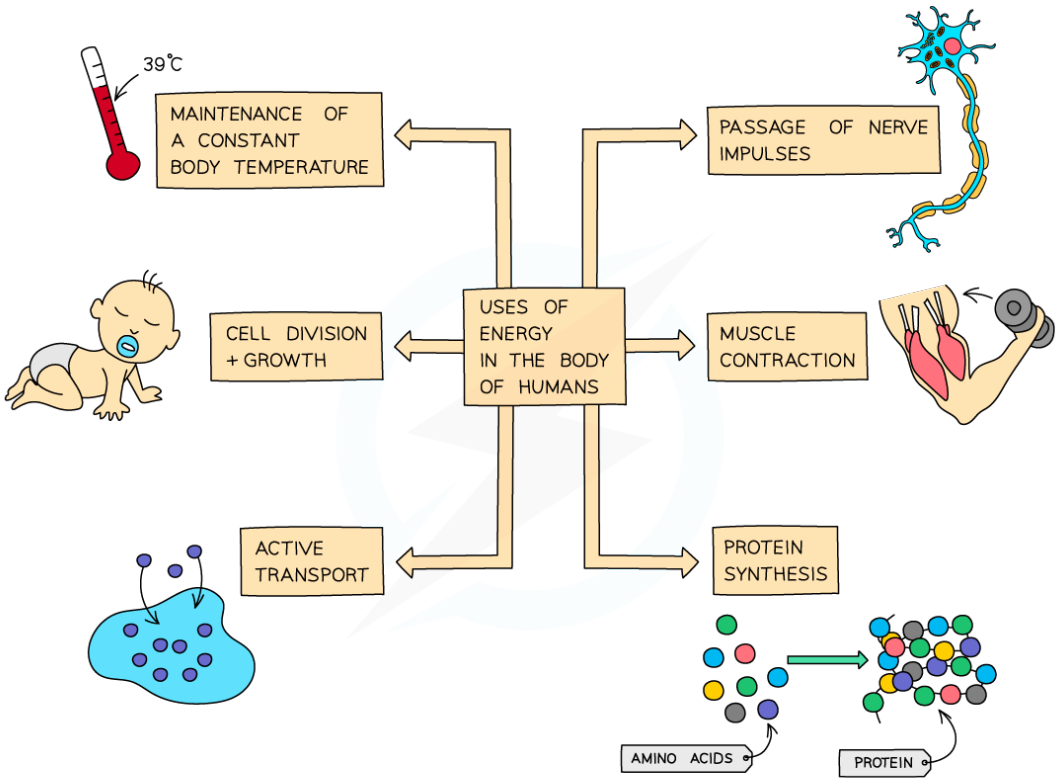
CONTENTS:

VIEW EXAM QUESTIONS

12.1 RESPIRATION BASICS

Uses of Energy in the Body

- Respiration is a chemical process that involves the breakdown of nutrient molecules (specifically glucose) in order to release the energy stored within the bonds of these molecules
- Respiration can take place with oxygen (**aerobically**) or without oxygen (**anaerobically**). Much less energy is released for each glucose molecule broken down anaerobically compared to the energy released when it is broken down aerobically
- Respiration occurs in all living cells. Most of the chemical reactions in aerobic respiration take place in the mitochondria



Uses of energy in the human body

12 RESPIRATION

12.1 RESPIRATION BASICS cont...

YOUR NOTES

- Humans need this energy to do the following things:
  - Contract muscle
  - Synthesise proteins
  - Cell division (to make new cells)
  - Grow
  - Enable active transport to take place
  - Allow nerve impulses to be generated
  - Maintain a constant internal body temperature

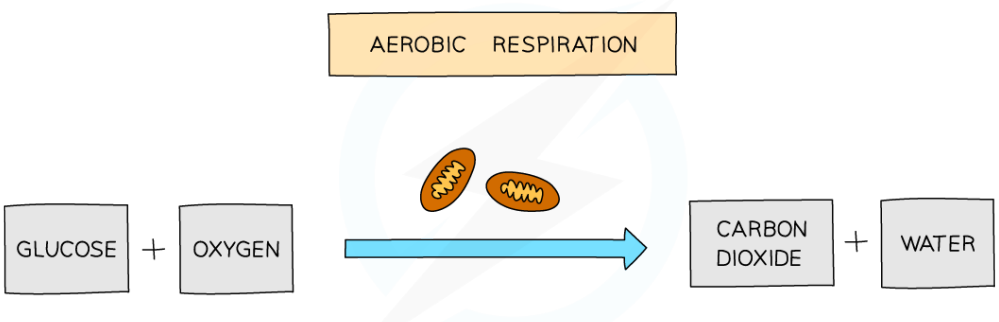
How is Respiration Controlled?

Respiration is a series of reactions which are controlled by enzymes. You need to be able to state this in an exam!

12.2 AEROBIC RESPIRATION

Aerobic Respiration: Basics

- **Aerobic** respiration requires **oxygen** and is defined as **the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy**
- It is the **complete breakdown of glucose** to release a **relatively large amount of energy** for use in cell processes
- It **produces carbon dioxide and water** as well as releasing useful cellular energy



Word equation for aerobic respiration

12 RESPIRATION

12.2 AEROBIC RESPIRATION cont...

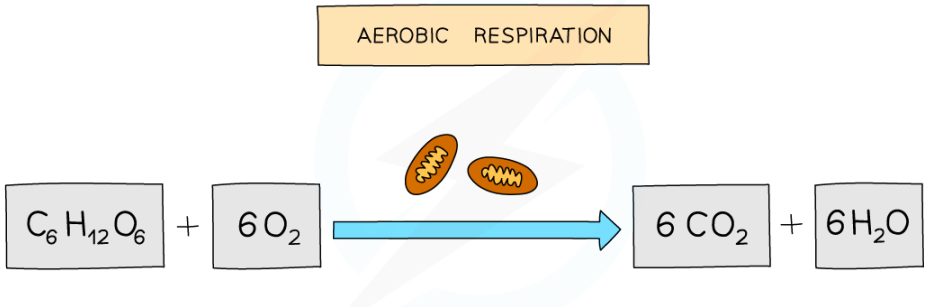
YOUR NOTES

EXAM TIP

Remember, this equation is **the same as the photosynthesis equation**, only the other way around – so if you know one, you know the other one too!

EXTENDED ONLY

Chemical Equation



Balanced equation for aerobic respiration

EXAM TIP

There are usually 3 marks given for the aerobic respiration chemical equation in an exam:

- one for getting the correct formula for glucose and oxygen
- one for getting the correct formula for carbon dioxide and water
- one for balancing the equation correctly

So make sure you can do all three to gain maximum marks!

12 RESPIRATION

12.2 AEROBIC RESPIRATION cont...

YOUR NOTES

Investigating Uptake of Oxygen by Respiring Organisms

- We can investigate aerobic respiration in living organisms by **measuring the amount of oxygen that they take from the air**
- This is done by measuring the **change in volume** in an enclosed tube containing the organisms
- However, as they respire the organisms release **carbon dioxide**, which increases the gas volume
- The carbon dioxide must therefore be removed from the tube using a chemical like **soda lime or sodium hydroxide**, otherwise it will make the experiment results inaccurate
- Any small organisms can be used in the apparatus, including **seeds** or **arthropods**
- The apparatus (shown below) is known as a **respirometer**

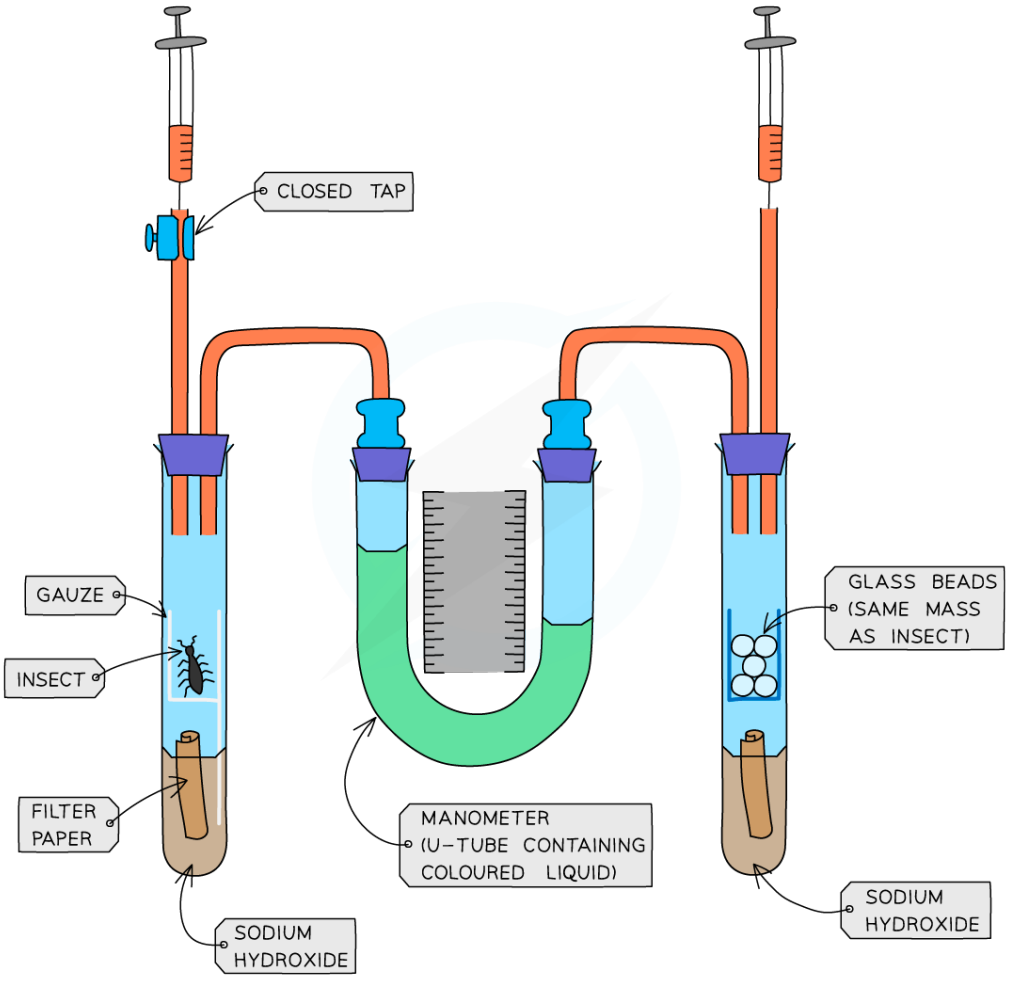


Diagram showing the setup of a respirometer

12 RESPIRATION

12.2 AEROBIC RESPIRATION cont...

YOUR NOTES

- The apparatus consists of two tubes, one containing the living organisms, and the other containing glass beads to act as a **control**
- Once the apparatus has been set up, the **movement of the coloured liquid towards the insect** will give a measure of the volume of oxygen taken up by the insect for respiration
- The reduction of volume in the tube increases pressure, causing the coloured liquid to move
- The distance moved by the liquid in a given time is measured, which will provide the **volume of oxygen taken in by the insect per minute**

EXAM TIP

What is a control?

- A control is a **duplicate experiment set up** with the condition being investigated having been removed or neutralised in some way.
- In the experiment above, the control is the glass beads. As they are not alive, they will definitely not be respiring.
- Therefore, if the volume of oxygen in the tube with the glass beads decreases during the course of the experiment, we know that the condition being investigated (respiration in living organisms) is not the cause of it.
- So, a control helps to make your experiment **valid**.

EXTENDED ONLY

Investigating the Effect of Temperature on the Rate of Respiration

- To investigate the effect of temperature on the rate of respiration of germinating seeds, the respirometer can be set up and the tubes submerged in a series of **water baths** set at different temperatures, eg 10°C, 15°C, 20°C, 25°C, 30°C
- The seeds should be kept in the water bath for 15 minutes before the start of the experiment to ensure they have **acclimated to the temperature**
- As respiration is an enzyme-controlled reaction, it is unlikely to work faster beyond around 40°C as the enzymes will denature

12 RESPIRATION

12.3 ANAEROBIC RESPIRATION

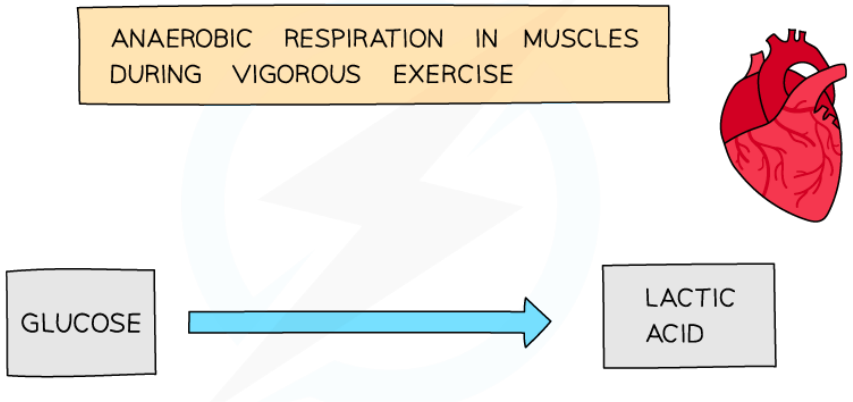
YOUR NOTES

Anaerobic Respiration: Basics

- **Anaerobic** respiration does **not require oxygen** and is defined as the **chemical reactions in cells that break down nutrient molecules to release energy without using oxygen**
- It is the **incomplete breakdown of glucose** and releases a **relatively small amount** of energy for use in cell processes
- It produces different breakdown products depending on the type of organism it is taking place in.
- You need to know the equations for anaerobic respiration in **humans** (animals) and the microorganism **yeast**.

Anaerobic Respiration in Animals

- Anaerobic respiration mainly takes place in muscle cells during vigorous exercise.
- When we exercise vigorously, our muscles have a higher demand for energy than when we are resting or exercising normally. Our bodies can only deliver so much oxygen to our muscle cells for aerobic respiration.
- In this instance, as much glucose as possible is broken down with oxygen, and some glucose is broken down without it, producing lactic acid instead.
- There is still energy stored within the bonds of lactic acid molecules that the cell could use; for this reason, less energy is released when glucose is broken down anaerobically.



Word equation for anaerobic respiration in animals

12 RESPIRATION

12.3 ANAEROBIC RESPIRATION cont...

YOUR NOTES

EXTENDED ONLY

Lactic Acid & The Oxygen Debt

- **Lactic acid** builds up in muscle cells and **lowers the pH** of the cells (making them more acidic)
- This could **denature the enzymes in cells** so it needs to be removed
- Cells excrete lactic acid into the blood. When blood passes through the liver, lactic acid is taken up into **liver** cells where it is **oxidised**, producing carbon dioxide and water (Lactic acid reacts with oxygen – this is actually **aerobic respiration** with lactic acid as the nutrient molecule instead of glucose)
- So the waste products of lactic acid oxidation are carbon dioxide and water
- This is the reason we **continue to breath heavily** and our **heart rate remains high** even after finishing exercise – we need to transport the lactic acid from our muscles to the liver, and continue getting larger amounts of oxygen into the blood to oxidise the lactic acid
- This is known as '**repaying the oxygen debt**'

EXAM TIP

Many students get confused about the products of anaerobic respiration in animals

The ONLY product made is **lactic acid**

Carbon dioxide is NOT one of the products made in anaerobic respiration in animals – it is made in aerobic respiration!

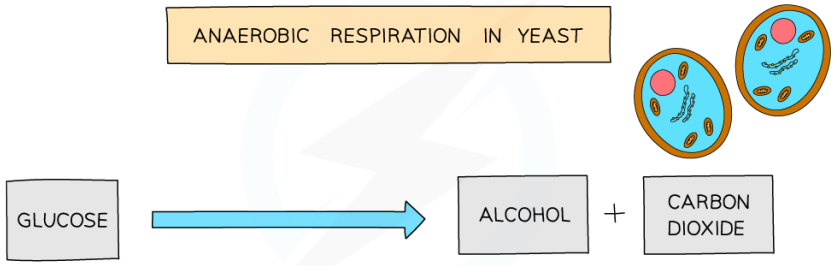
Anaerobic Respiration in Yeast

- We take advantage of the products of anaerobic respiration in **yeast** by using it in **bread making** (where the carbon dioxide produced helps dough to rise) and in **brewing** (where the ethanol produced makes beer)

12 RESPIRATION

12.3 ANAEROBIC RESPIRATION cont...

YOUR NOTES

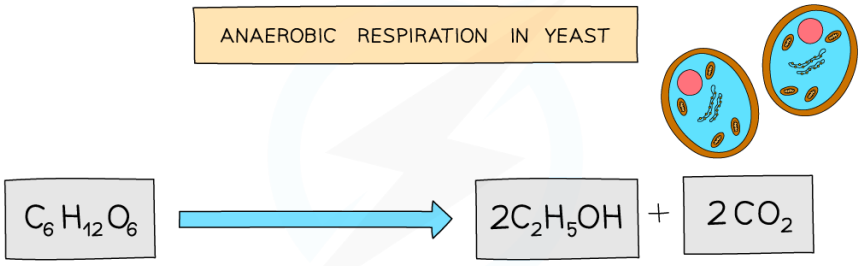


Word equation for anaerobic respiration in yeast

EXTENDED ONLY

Chemical Equation

The balanced chemical equation for anaerobic respiration in yeast is:



Balanced equation for anaerobic respiration in yeast

Comparison of Aerobic & Anaerobic Respiration

	AEROBIC	ANAEROBIC
OXYGEN	NEEDED	NOT NEEDED
GLUCOSE BREAKDOWN	COMPLETE	INCOMPLETE
PRODUCTS	CARBON DIOXIDE AND WATER	ANIMAL CELLS: LACTIC ACID YEAST: CARBON DIOXIDE AND ETHANOL
ENERGY RELEASED	A LOT	A LITTLE

> NOW TRY SOME EXAM QUESTIONS

12 RESPIRATION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which row in the table below shows the correct products produced by anaerobic respiration in yeast and in animals?

	animals		yeast	
	lactic acid	carbon dioxide	lactic acid	carbon dioxide
A	✘	✔	✘	✘
B	✔	✘	✘	✔
C	✘	✔	✔	✘
D	✔	✔	✔	✘

QUESTION 2

Glucose is broken down in the chemical processes of aerobic respiration.

Which row of the table below shows the correct products of this breakdown?

	animals		yeast	
	energy	water	lactic acid	carbon dioxide
A	✘	✘	✔	✘
B	✔	✘	✘	✔
C	✘	✔	✘	✔
D	✔	✔	✘	✔

QUESTION 3

Which of the following is the correct word equation for aerobic respiration in plants?

A glucose + oxygen → carbon dioxide + water

B carbon dioxide + water → glucose + oxygen

C glucose + water → carbon dioxide + oxygen

D glucose + carbon dioxide → water + oxygen

12 RESPIRATION

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 4

During vigorous exercise, such as cycling uphill, lactic acid builds up in the muscles.

How is this lactic acid removed during recovery?

A excretion of lactic acid by the kidneys

B anaerobic respiration of lactic acid in the muscles

C aerobic respiration of lactic acid in the liver

D excretion of lactic acid by the lungs

QUESTION 5

Four metabolic reactions that can occur in living organisms are shown below:

1 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

2 glucose → lactic acid

3 $6CO_2 + 6H_2O \rightarrow C6H_{12}O_6 + 6O_2$

4 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Which of the above reactions take place in yeast cells to release energy?

A 1 and 2 **B** 1 and 3 **C** 3 and 4 **D** 1 and 4

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