



5 ENZYMES

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YOUR NOTES



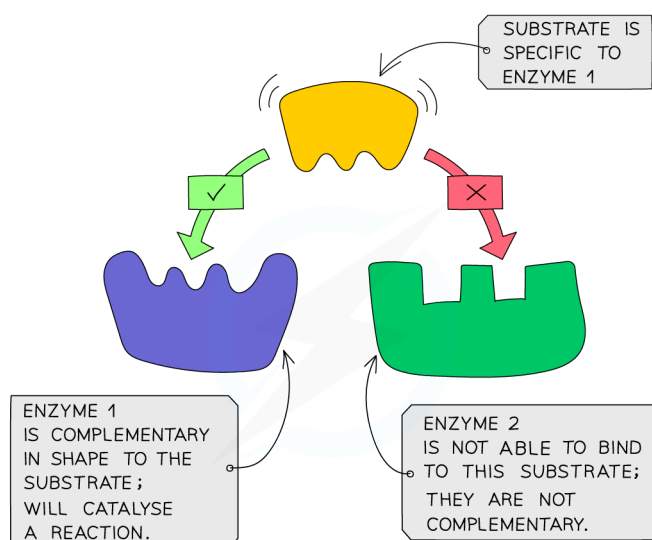
5.1 HOW ENZYMES WORK

What are Enzymes?

Enzymes:

- Are **catalysts** that **speed up** the rate of a chemical reaction **without being changed** or used up in the reaction
- Are **proteins**
- Are **biological catalysts** (biological because they are **made in living cells**, catalysts because they speed up the rate of chemical reactions without being changed)
- Enzymes are necessary to all living organisms as they **maintain reaction speeds** of all metabolic reactions (all the reactions that keep an organism alive) at a rate that can **sustain life**
- For example, if we did not produce digestive enzymes, it would take around 2 – 3 weeks to digest one meal; with enzymes, it takes around 4 hours

How do Enzymes Work?



Enzyme substrate specificity



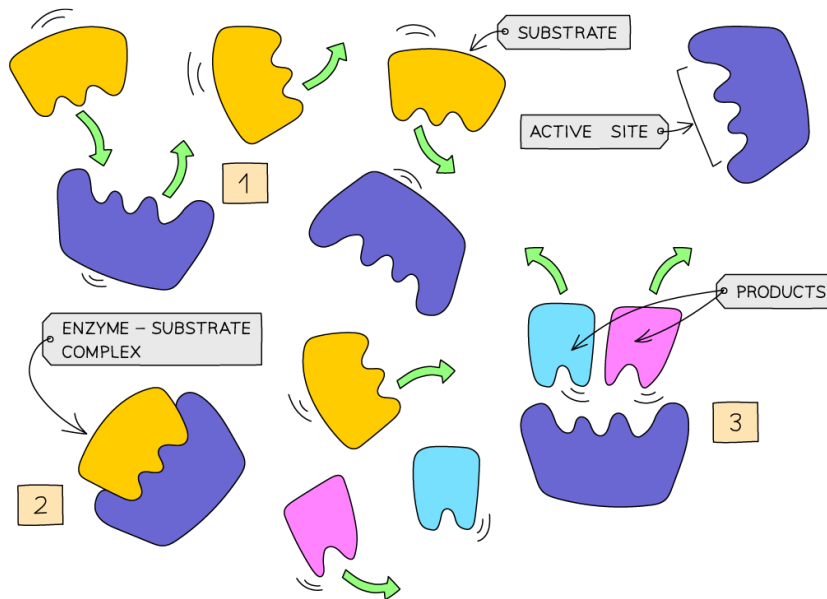
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5.1 HOW ENZYMES WORK cont...

YOUR NOTES



- Enzymes are **specific** to one particular substrate (molecule(s) that get broken down or joined together in the reaction) as the enzyme is a complementary shape to the substrate
- The product is made from the substrate(s) and is released



Enzyme specificity: lock and key model of enzyme activity



EXTENDED ONLY

Enzyme Specificity

- Enzymes are **specific** to one particular substrate(s) as the **active site** of the enzyme, where the substrate attaches, is a complementary shape to the substrate
- This is because the enzyme is a protein and has a **specific 3-D shape**
- This is known as the **lock and key hypothesis**
- When the substrate moves into the enzyme's active site they become known as the **enzyme-substrate complex**
- After the reaction has occurred, the **products** leave the enzyme's active site as they no longer fit it and it is free to take up another substrate



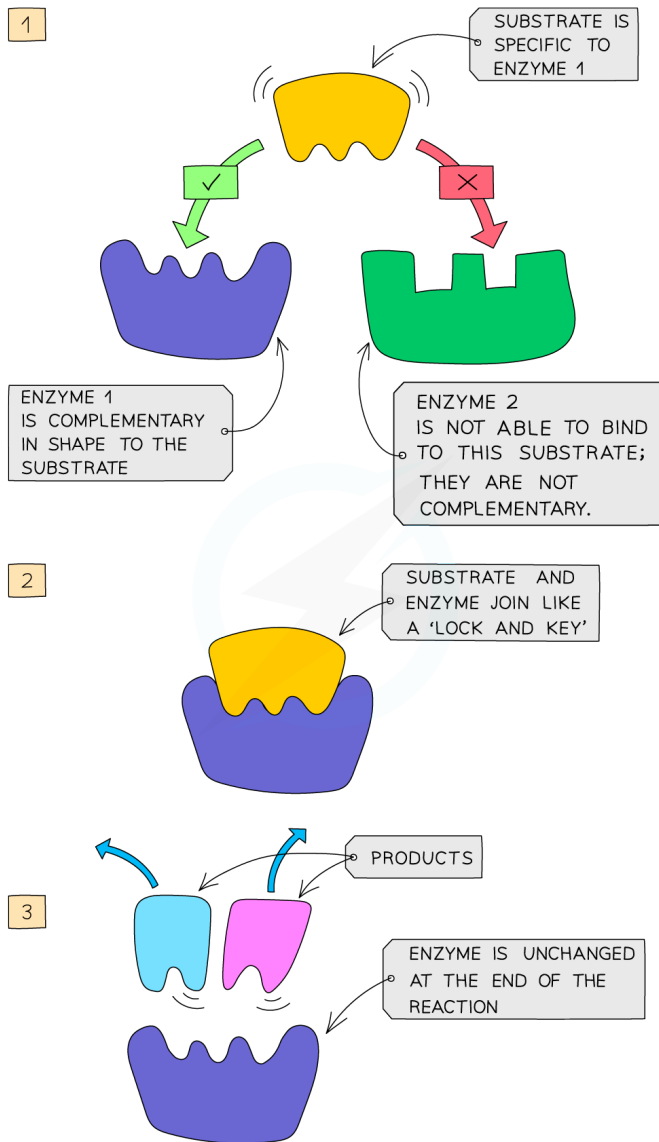
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5.1 HOW ENZYMES WORK cont...

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How enzymes work

1. Enzymes and substrates randomly move about in solution
2. When an enzyme and its complementary substrate randomly collide – with the substrate fitting into the active site of the enzyme – an enzyme-substrate complex forms, and the reaction occurs.
3. A product (or products) forms from the substrate(s) which are then released from the active site. The enzyme is unchanged and will go on to catalyse further reactions.



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5.1 HOW ENZYMES WORK cont...

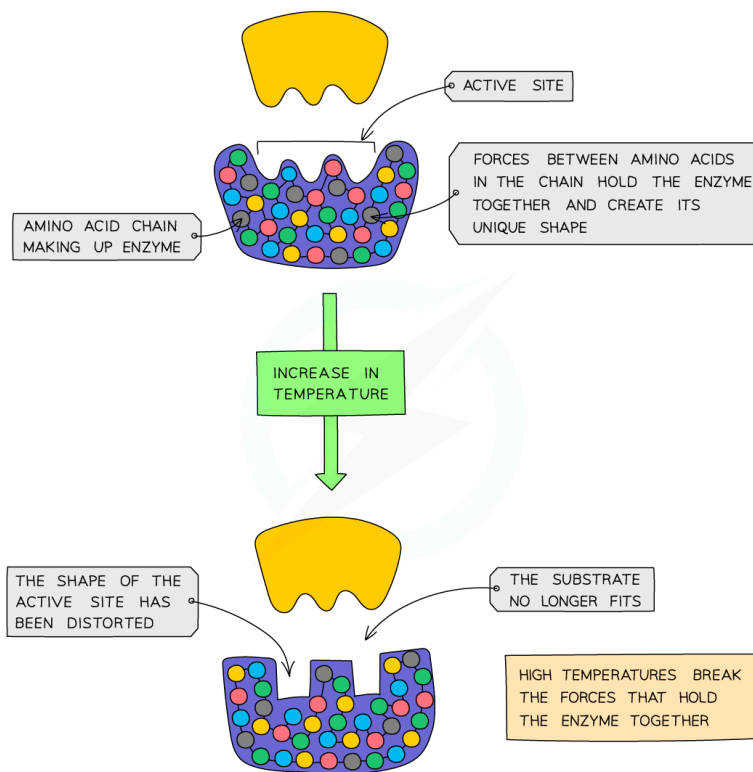
YOUR NOTES



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Effect of Temperature on Enzyme Function

- Enzymes are **proteins** and have a **specific shape**, held in place by **bonds**
- This is extremely important around the **active site** area as the specific shape is what ensures the **substrate will fit into the active site** and enable the reaction to proceed
- Enzymes work fastest at their '**optimum temperature**' – in the human body, the optimum temperature is 37°C
- Heating to high temperatures (beyond the optimum) will **break the bonds** that hold the enzyme together and it will lose its shape -this is known as **denaturation**
- Substrates cannot fit into denatured enzymes as the shape of their active site has been lost
- Denaturation is **irreversible** – once enzymes are denatured they cannot regain their proper shape and activity will stop



Effect of temperature on enzyme activity



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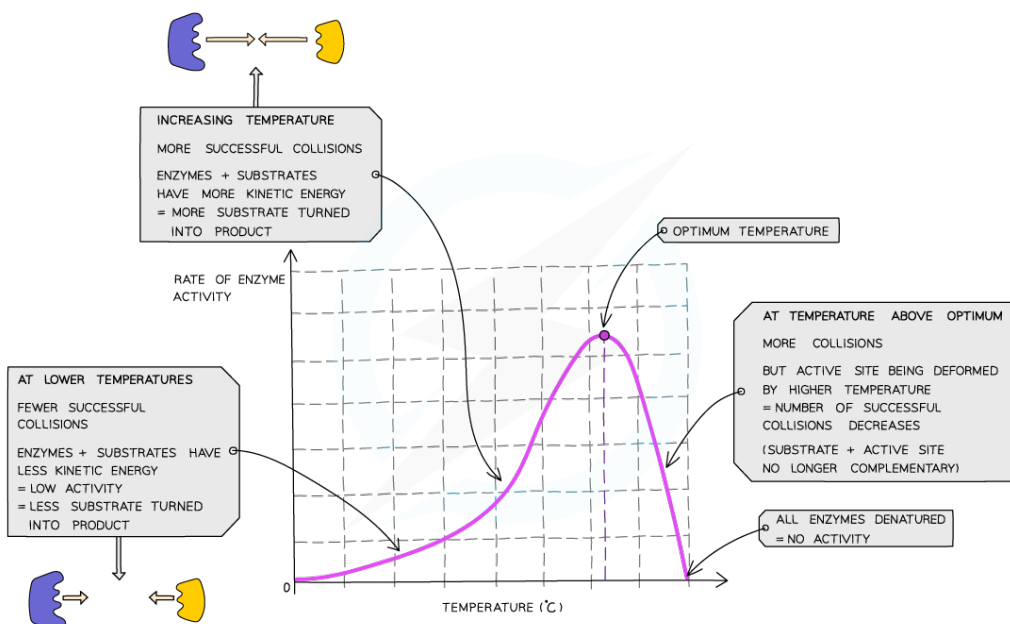
5.1 HOW ENZYMES WORK cont...

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- Increasing the temperature from 0°C to the optimum increases the activity of enzymes as the **more energy the molecules have the faster they move and the number of collisions with the substrate molecules increases**, leading to a faster rate of reaction
- This means that **low temperatures do not denature enzymes**, they just make them work more slowly



Graph showing the effect of temperature on the rate of enzyme activity

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5.1 HOW ENZYMES WORK cont...

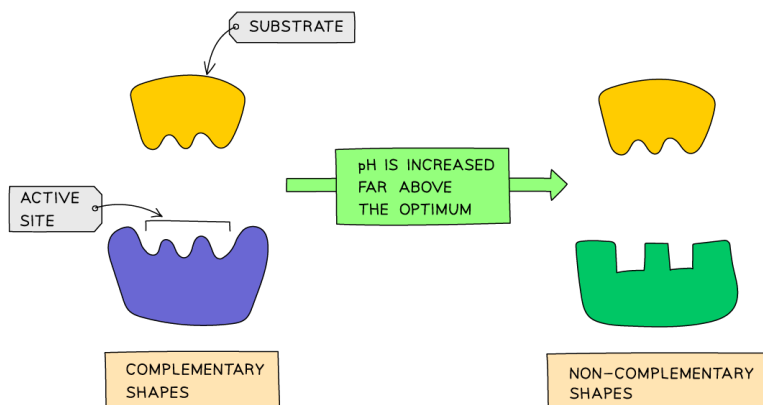
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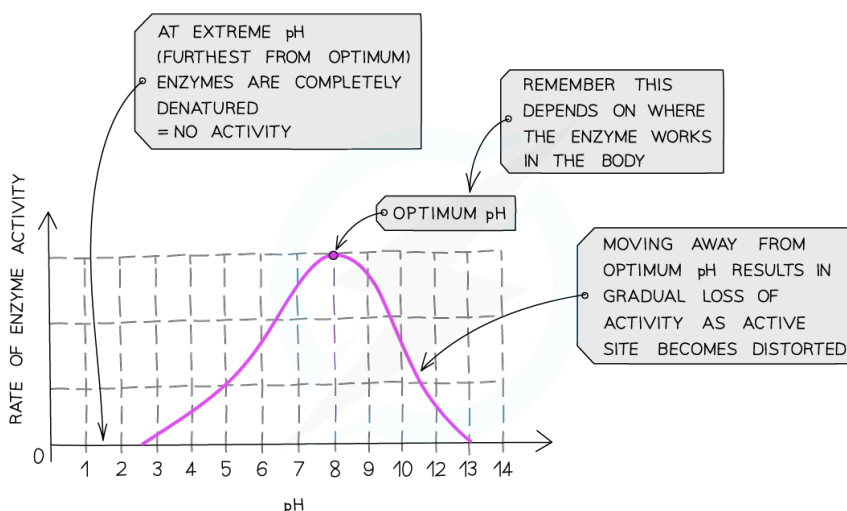
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Effect of pH on Enzyme Activity

- The optimum pH for most enzymes is 7 but some that are produced in acidic conditions, such as the stomach, have a lower optimum pH (pH 2) and some that are produced in alkaline conditions, such as the duodenum, have a higher optimum pH (pH 8 or 9)
- If the **pH is too high or too low**, the **bonds** that hold the amino acid chain together to make up the protein can be **destroyed**
- This will **change the shape of the active site**, so the substrate can no longer fit into it, reducing the rate of activity
- Moving too far away from the optimum pH will cause the enzyme to **denature** and activity will stop



Effect of pH on enzyme activity



Graph showing the effect of pH on rate of activity for an enzyme from the duodenum



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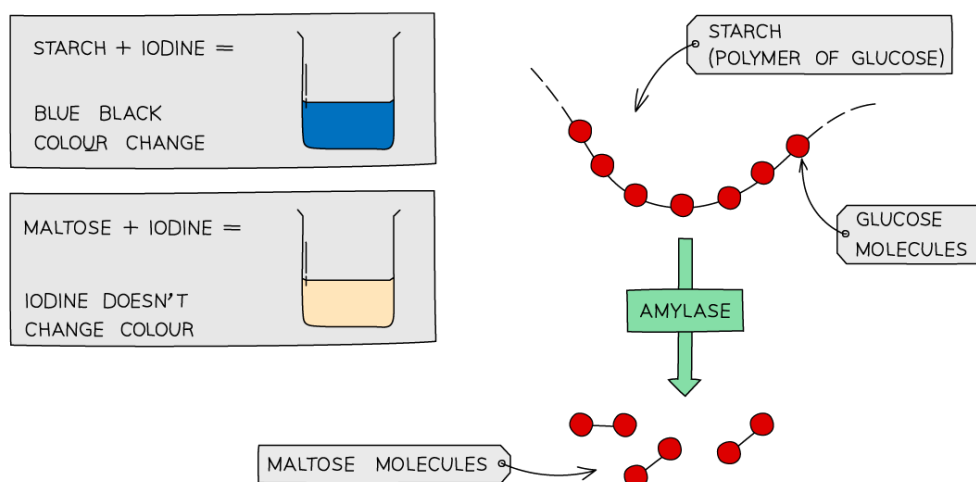
5.2 ENZYME INVESTIGATIONS

YOUR NOTES



Enzyme Investigations

- Amylase is an enzyme that digests **starch** (a polysaccharide of glucose) **into maltose** (a disaccharide of glucose)
- Starch can be tested for easily using **iodine solution**



Using iodine to test for starch

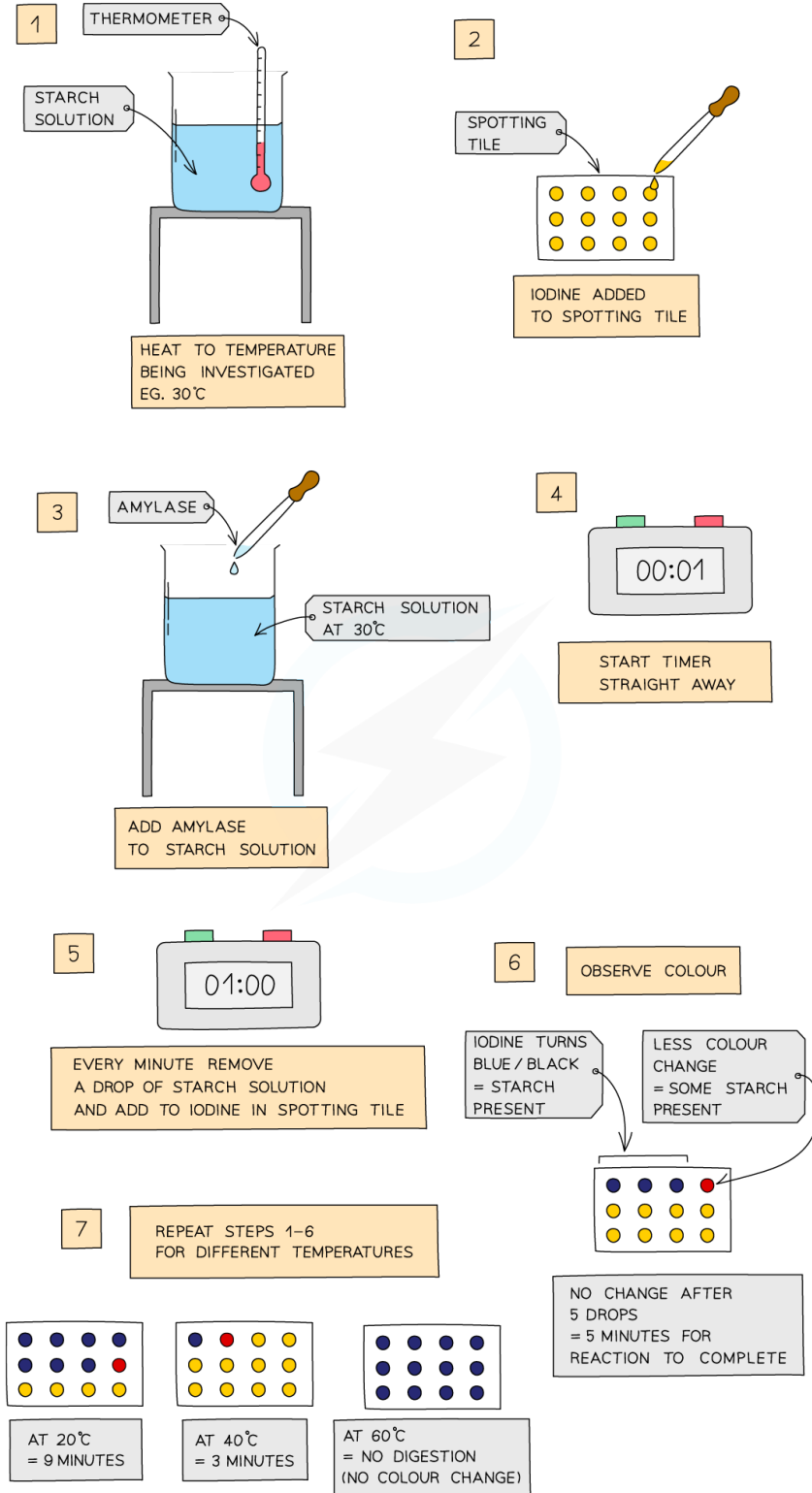
Investigating the Effect of Temperature on Amylase

- **Starch solution** is heated to a set temperature
- **Iodine** is added to wells of a spotting tile
- **Amylase** is added to the starch solution and mixed well
- Every minute, droplets of solution are added to a new well of iodine solution
- This is continued until the iodine **stops turning blue-black** (this means there is **no more starch** left in the solution as the amylase has broken it all down)
- Time taken for the reaction to be completed is recorded
- Experiment is repeated at different temperatures
- The quicker the reaction is completed, the faster the enzyme is working

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5.2 ENZYME INVESTIGATIONS cont...

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Investigating the effect of temperature on enzyme activity



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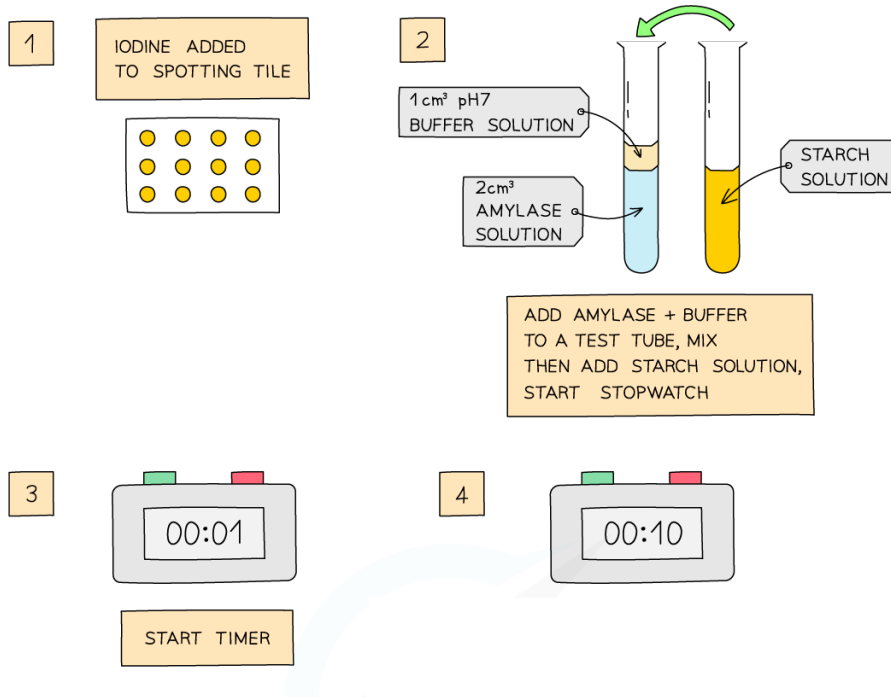
5.2 ENZYME INVESTIGATIONS cont...

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Investigating the Effect of pH on the Working of the Enzyme Amylase

- Place single drops of **iodine** solution in rows on the tile
- Label a test tube with the pH to be tested
- Use the syringe to place 2cm^3 of **amylase** in the test tube
- Add 1cm^3 of **buffer solution** to the test tube using a syringe
- Use another test tube to add 2cm^3 of **starch solution** to the amylase and buffer solution, start the stopwatch whilst mixing using a pipette
- After 10 seconds, use a pipette to place one drop of mixture on the first drop of iodine, which should turn blue black
- Wait another 10 seconds and place another drop of mixture on the second drop of iodine
- Repeat every 10 seconds **until iodine solution remains orange brown**
- Repeat experiment at different pH values – the less time the iodine solution takes to remain orange brown, the quicker all the starch has been digested and so the better the enzyme works at that pH

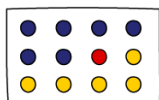
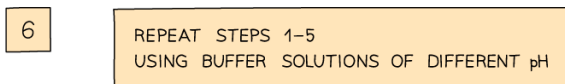
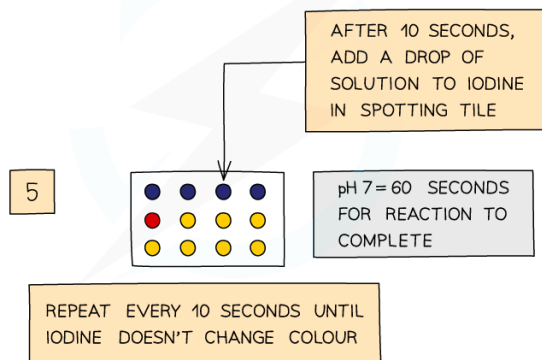




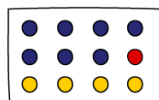
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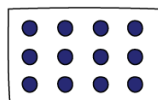
YOUR NOTES



pH 5
= 80 SECONDS



pH 9
= 90 SECONDS



pH 14
= NO REACTION

Investigating the effect of pH on enzyme activity



EXAM TIP

Describing and explaining experimental results for enzyme experiments is a common type of exam question.

So understand what is happening and, for a 7, 8 or 9, be able to:

- relate this to changes in the active site of the enzyme when it has denatured
- or, if it is a low temperature, relate it to the amount of kinetic energy the molecules have.

> NOW TRY SOME EXAM QUESTIONS



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EXAM QUESTIONS

YOUR NOTES

**? QUESTION 1**

Which of the following best describes what an enzyme is?

- A A catalyst that speeds up reactions in cells, being used up in the process
- B A protein that speeds up reactions in cells, being used up in the process
- C A carbohydrate that functions as a biological catalyst
- D A protein that functions as a biological catalyst

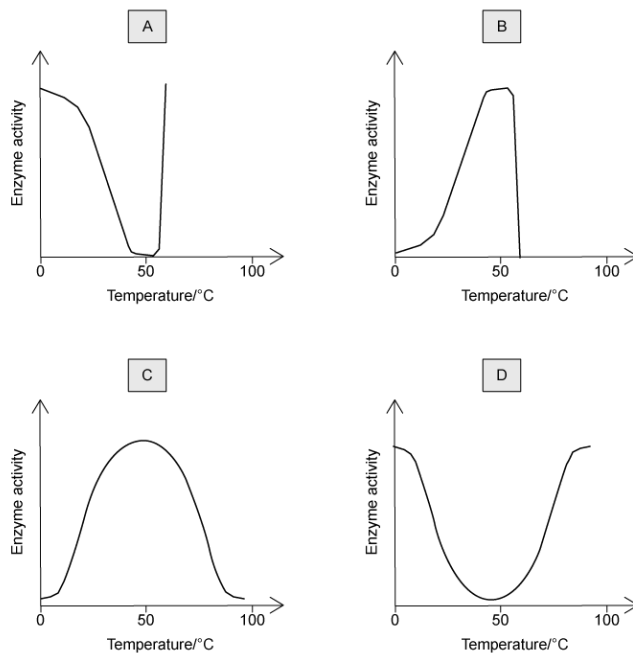
? QUESTION 2

What is a feature of all catalysts?

- A They are made from protein
- B They are not changed by the reaction
- C They are broken down in the reaction
- D They are altered by the rate of the reaction

? QUESTION 3

Which graph in the image below shows the correct effect of temperature on the activity of an enzyme?



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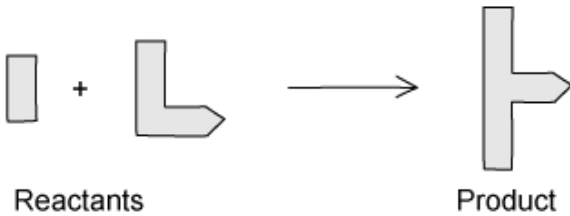
EXAM QUESTIONS cont...

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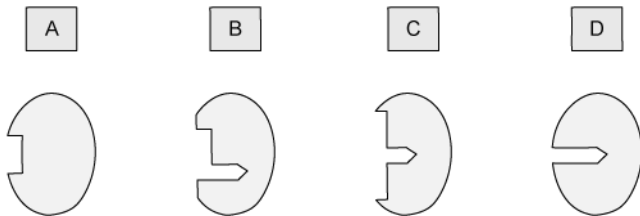


? QUESTION 4

The image below represents a chemical reaction.



Which of the following best represents the enzyme responsible for catalysing this reaction?



? QUESTION 5

What can be said to be true of all enzymes?

	Their optimum pH is 7	They are made from amino acids	They move about randomly in a fluid
A	x	x	x
B	x	✓	✓
C	✓	x	✓
D	✓	✓	x

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