Temperature and the rate of decay

Answers, marking points and revision notes | AQA GCSE Biology 8461 only (not Combined Science)

GCSE science required practicals

This practical online

Answers

1 Name the independent variable and the dependent variable in Mohammed and Grace's investigation. (2 marks)

The independent variable is the temperature. The dependent variable is the time taken for the pink colour to disappear (which shows the rate of decay).

Marking points

- Independent: temperature
- Dependent: time for the colour to disappear (or rate of decay)

2 Give one control variable and explain why it must be kept the same. (2 marks)

The volume of lipase solution. More enzyme would break down the fat faster, so the time would change even at the same temperature.

Marking points

- A sensible control, such as volume or concentration of lipase, volume or type of milk, or volume of sodium carbonate
- A matching reason, such as it would change the rate of reaction for another reason

3 Explain why the milk mixture and the lipase are put in the water bath separately for 5 minutes before they are mixed. (2 marks)

So both reach the temperature of the water bath before the reaction starts. If they were mixed straight away, the reaction would begin at room temperature and the time would not match the temperature being tested.

Marking points

- So both are at the bath temperature before mixing
- So the reaction happens at the stated temperature from the start (otherwise the time is wrong)

4 Describe one hazard in this practical and how to reduce the risk. (2 marks)

Phenolphthalein is dissolved in ethanol, which is flammable and can irritate the eyes. Wear safety glasses and keep it away from any Bunsen burner flames.

Marking points

- A hazard, such as phenolphthalein or ethanol, lipase allergy or hot water
- A matching precaution, such as eye protection, no flames, avoid skin contact or use a tube holder

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5 Explain why the pink colour disappears during the reaction. (2 marks)

Lipase breaks down the fat in milk into fatty acids and glycerol. The fatty acids lower the pH, so the mixture is no longer alkaline and the phenolphthalein turns colourless.

Marking points

- Lipase breaks fat (lipid) into fatty acids (and glycerol)
- Fatty acids lower the pH, so the indicator goes colourless

6 Identify the anomalous result. Explain how you know. (2 marks)

Time 2 at 45 °C, 168 s, is anomalous. The other two times at 45 °C were 102 s and 98 s, so 168 s is much longer and does not fit.

Marking points

- 168 s at 45 °C
- It is far from the other repeats at that temperature (102 s and 98 s)

7 Calculate the mean time at 45 °C. Do not include the anomalous result. (2 marks)

(102 + 98) / 2 = 100 s

Leave out 168

102 + 98 = 200

200 / 2 = 100

Mean time = 100 s

Marking points

- Adds 102 and 98 and divides by 2
- 100 s

8 Calculate the rate of reaction at 35 °C and at 45 °C using rate = 1000 / mean time.
Give your answers to 2 significant figures. Show your working. (3 marks)

35 °C: 1000 / 131 = 7.6 s^{-1}

45 °C: 1000 / 100 = 10 s^{-1}

Rate = 1000 / mean time

35 °C: rate = 1000 / 131 = 7.633...

Rate at 35 °C = 7.6 s^{-1}

45 °C: rate = 1000 / 100 = 10

Rate at 45 °C = 10 s^{-1}

Marking points

- Uses rate = 1000 / mean time
- 35 °C: 7.6 s^{-1}
- 45 °C: 10 s^{-1} (using the mean from the previous question)

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9 Describe how the rate of decay changes with temperature from 15 °C to 55 °C. (2 marks)

The rate increases as the temperature rises from 15 °C to 45 °C, as the time drops from 405 s to 100 s. The rate then falls between 45 °C and 55 °C, where the time goes up to 298 s.

Marking points

- Rate increases from 15 °C up to about 45 °C (times get shorter)
- Rate decreases above 45 °C (time increases to 298 s at 55 °C)

10 Explain why the rate at 55 °C is lower than at 45 °C. (3 marks)

At 55 °C the high temperature breaks some of the bonds holding the lipase molecule in shape, so the enzyme denatures. The shape of its active site changes and fat molecules no longer fit into it. Fewer enzyme-substrate complexes form, so fat is broken down more slowly.

Marking points

- Enzyme (lipase) is denatured at high temperature
- The active site changes shape
- So the substrate (fat) no longer fits and fewer enzyme-substrate complexes form

11 **Higher tier**

How many times faster is the reaction at 35 °C than at 15 °C? Give your answer to 2 significant figures. (2 marks)

Rate is inversely proportional to time, so 405 / 131 = 3.1 times faster.

Rate at 35 °C / rate at 15 °C = time at 15 °C / time at 35 °C

= 405 / 131

= 3.09...

= 3.1 times faster

Marking points

- Divides the time at 15 °C by the time at 35 °C (or compares the two rates)
- 3.1 times faster

12 Grace repeated the test at 35 °C using a pH probe instead of the indicator. The pH fell from 9.5 to 7.7 in 3 minutes.

Calculate the rate of pH change in pH units per minute. (2 marks)

Change in pH = 9.5 - 7.7 = 1.8. Rate = 1.8 / 3 = 0.6 pH units per minute

Change in pH = 9.5 - 7.7 = 1.8

Rate = change in pH / time

= 1.8 / 3

= 0.6 pH units per minute

Marking points

- Change in pH = 1.8
- 0.6 pH units per minute

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13 Mohammed and Grace found it hard to decide exactly when the pink colour had gone.

a. Is this a source of random error or systematic error? Explain your answer.

b. Suggest an improvement and explain why it helps.

(3 marks)

a) Random error, because sometimes they would stop the clock a little early and sometimes a little late, so the times scatter around the true value.

b) Use a pH probe and data logger to record when the pH falls to the same value each time. This removes the need to judge the colour by eye, so the end point is measured the same way every time and the results are more accurate.

Marking points

- Random error
- Because the judgement varies from one test to the next (readings scatter either side)
- Improvement with reason, such as a pH probe or data logger (or a colour standard to compare with) so the end point is not judged by eye

14 Plan an investigation to find out how the concentration of lipase affects the rate of decay of the fat in milk.

(6 marks)

Make lipase solutions of 1%, 2%, 3%, 4% and 5% by diluting a stock solution with distilled water. Put 5 cm^3 of full-fat milk, 7 cm^3 of sodium carbonate solution and 5 drops of phenolphthalein into a test tube so it turns pink. Put 1 cm^3 of the 1% lipase in a separate tube. Stand both tubes in a water bath at 35 °C for 5 minutes, checking the temperature with a thermometer. Pour the lipase into the milk, stir and start a stopwatch. Stop the stopwatch when the pink colour disappears, looking against a white tile. Repeat three times for each concentration, using fresh milk each time and the same volumes, and calculate the mean time, leaving out any anomalous results. Calculate the rate as 1000 / mean time and plot a graph of rate against lipase concentration. Wear eye protection and avoid skin contact with the lipase.

Marking points (any 6, with the method in a logical order)

- Uses a range of at least five lipase concentrations
- Mixes milk, sodium carbonate and phenolphthalein so the mixture is pink
- Same volume of milk, sodium carbonate, indicator and lipase each time
- Temperature kept constant with a water bath
- Lets the solutions reach the bath temperature before mixing
- Times how long until the pink colour disappears
- Repeats for each concentration and calculates a mean
- Calculates rate as 1000 / time and plots against concentration
- Sensible safety, such as eye protection

How it is marked

- 5-6 marks: a clear, ordered plan that changes lipase concentration over a sensible range, keeps temperature and volumes constant, times the colour change, repeats, and turns times into rates.
- 3-4 marks: a workable plan with the main steps, but some controls, the end point or repeats are missing or unclear.
- 1-2 marks: a few relevant ideas, such as adding different amounts of lipase to milk and timing something, with little detail or control.

Revision notes: the method

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Aim: To find out how temperature affects the rate at which lipase breaks down the fat in milk, by timing a pH change.

Equipment

- Full-fat milk
- Lipase solution
- Sodium carbonate solution (makes the milk alkaline)
- Phenolphthalein indicator
- Test tubes and a rack
- Measuring cylinders or syringes
- Water baths set at different temperatures
- Thermometer
- Stopwatch
- Glass stirring rod
- White tile behind the tubes

Method

1. Measure 5 drops of phenolphthalein into a test tube.
2. Add 5 cm^3 of milk and 7 cm^3 of sodium carbonate solution; the mixture turns pink because it is alkaline.
3. Put 1 cm^3 of lipase solution into a separate test tube.
4. Stand both tubes in a water bath at 15 °C and leave them for 5 minutes so they reach the temperature; check with a thermometer.
5. Pour the lipase into the milk mixture, stir and start the stopwatch at once.
6. Stop the stopwatch when the pink colour disappears, viewing the tube against a white tile.
7. Repeat twice more at this temperature and calculate a mean time.
8. Repeat the whole method at 25 °C, 35 °C, 45 °C and 55 °C.
9. Calculate the rate for each temperature using rate = 1000 / mean time.

Variables

- **Independent:** Temperature of the water bath.
- **Dependent:** Rate of decay, found from the time taken for the pink colour to disappear (rate = 1000 / time).
- **Control:** Volume and type of milk (same fat content); Volume and concentration of lipase; Volume of sodium carbonate solution; Number of drops of phenolphthalein; Same end point judged against a white tile

Hazards

Hazard	What could happen	How to reduce the risk
Phenolphthalein (made up in ethanol)	Flammable and irritating to the eyes	Wear eye protection and keep it away from naked flames
Lipase enzyme	Can cause an allergic reaction if it touches the skin or is breathed in	Avoid skin contact, wash off any spills straight away, and wear eye protection
Hot water in the 55 °C bath	Scalds	Handle tubes with a test tube holder and do not overfill the bath

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Key points

- Lipase breaks fat down into fatty acids and glycerol; the fatty acids lower the pH, so the indicator changes colour.
- Phenolphthalein is pink in alkali and colourless when the pH falls below about 8.3.
- Rate = 1000 / time: the shorter the time, the faster the rate.
- Warm both the milk mixture and the lipase to the bath temperature before mixing.
- Above the optimum temperature the enzyme denatures: its active site changes shape, so the rate falls.
- The end point is a judgement, so a pH probe or data logger gives a more accurate result than watching the colour.

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