PAG 4 Rates of Enzyme-Controlled Reactions: OCR A Level Biology Exa

16 questions · 33 marks · about 40 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2016 · Q4(b)(i) · 1 mark

(b) Lipase is an enzyme that catalyses the breakdown of lipids.

An investigation was carried out to see the effect of temperature on the activity of a lipase.

- 5 cm^3 of an alkaline solution of lipid was poured into a test tube.
- The test tube was placed into a water bath maintained at 20 °C and left to equilibrate.
- A few drops of an indicator were added to the wells of a white spotting tile. The indicator is pink above pH values of 8.3 and turns colourless at pH values below 8.3.
- Once the lipid solution had equilibrated, 1 cm^3 of 0.5% lipase solution at the same temperature was then added to the test tube.
- For five minutes, at 30 second intervals, the solution was stirred and a few drops were removed from the test tube and placed in a well on the white spotting tile.
- The time was recorded when the solution and indicator did not remain pink.
- The procedure was repeated four more times at 20 °C and then again at a further six temperatures.

The results are shown in Table 4.1 below.

Temperature (°C)	Time when solution did not remain pink				
	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Replicate 5
20	210	270	240	300	270
25	90	120	210	180	120
30	60	60	90	90	60
35	60	60	60	90	60
40	210	120	210	180	210
45	240	300	300	–	270
50	–	–	–	–	–

Table 4.1

(i) Why is pH **not** a controlled variable in this investigation?

.....

.....

..... **[1]**

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(d) Catalase is an enzyme found in a wide range of tissues. It catalyses the breakdown of hydrogen peroxide into water and oxygen. A group of students used liver tissue to investigate the effect of temperature on the rate of reaction of catalase.

A diagram of the apparatus is shown in **Fig. 3.2**.

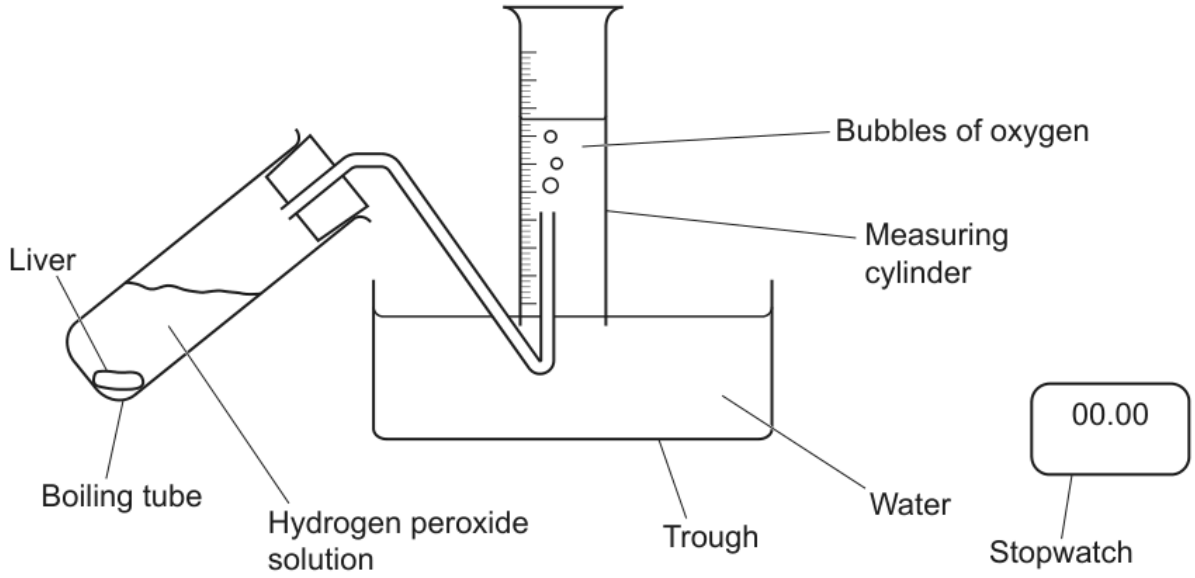


Fig. 3.2

Table 3 shows the results from the experiment carried out at 20 °C.

Time (s)	Volume of oxygen collected (cm^3)
30	6.0
60	12.0
90	15.0
120	18.0
150	21.0
180	22.0
210	23.5
240	24.0
270	24.5
300	25.0

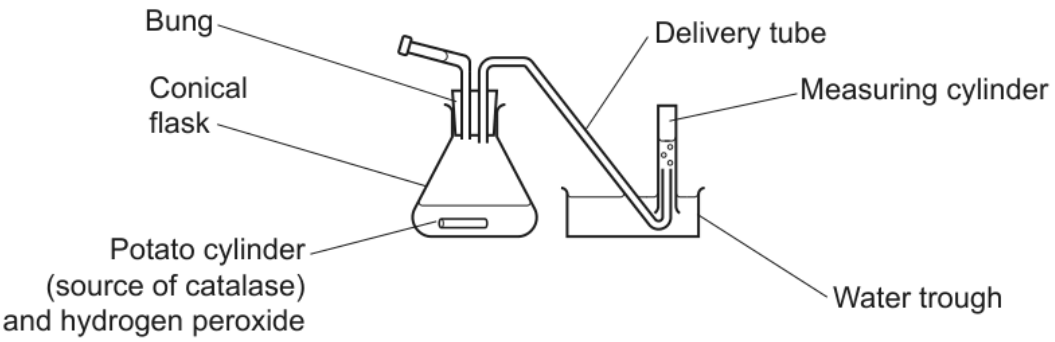
Table 3

Question 3 · A level Paper 2 · June 2023 · Q17(a)(i) · 1 mark

17 Catalase is found in many tissues. It is an enzyme that breaks down hydrogen peroxide into oxygen and water.

Some students do an experiment to investigate the effect of hydrogen peroxide concentration on the rate of this reaction using the apparatus shown in **Fig. 17.1**.

Fig. 17.1



This is the method the students use.

1. Use a stock solution of 250 cm^3 of 20 a.u. hydrogen peroxide, to make solutions of 8 a.u. and 2 a.u.
2. Cut 15 cylinders of potato of equal diameter, using a cork borer, and use a ruler to ensure that each one is 5 cm long.
3. Set up the apparatus as shown in **Fig. 17.1**.
4. Record the starting position of the water in the measuring cylinder.
5. Place one cylinder of potato into the conical flask.
6. Pour 50 cm^3 of 2 a.u. hydrogen peroxide into the flask, immediately secure the bung and start the stopwatch.
7. Record the volume of gas given off every 30 s for 3 min.
8. Repeat steps 3 to 7 twice.
9. Repeat steps 3 to 8 using 8 a.u. and 20 a.u. hydrogen peroxide.

(a) (i) State the independent variable in this investigation.

..... **[1]**

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Question 4 · A level Paper 2 · June 2023 · Q17(a)(iv) · 1 mark

(iv) The potato cylinders were cut to equal lengths.

Suggest a further precaution the students should have taken when preparing them, to ensure the investigation was valid.

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..... **[1]**

Turn over

Question 5 · A level Paper 2 · June 2023 · Q17(a)(iii) · 2 marks

(iii) Liver tissue contains a higher concentration of catalase than potato.

Suggest **two** reasons why the students chose potato rather than liver as a source of catalase.

1 .....

.....

2 .....

.....

[2]

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Question 6 · AS Paper 2 · November 2021 · Q3(a)(i) · 2 marks

3 Students carried out a practical investigation into the effect of enzyme concentration on the rate of reaction.

They were provided with:

- a 1% solution of the enzyme trypsin
- a supply of distilled water
- test tubes labelled 1–4
- 10 cm^3 syringes.

(a) (i) Describe how they would create **four** different enzyme concentrations using **tenfold serial dilutions**. They started by using a syringe to transfer 1 cm^3 of the 1% trypsin solution into tube 1. With a clean syringe, they then added 9 cm^3 of distilled water to tube 1.

.....

.....

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..... **[2]**

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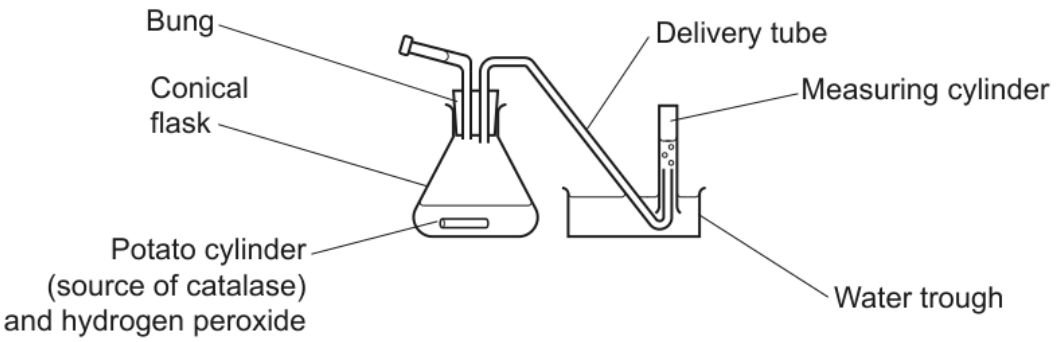
Question 7 · information from earlier in the question

17 Catalase is found in many tissues. It is an enzyme that breaks down hydrogen peroxide into oxygen and water.

Some students do an experiment to investigate the effect of hydrogen peroxide concentration on the rate of this reaction using the apparatus shown in **Fig. 17.1**.

Fig. 17.1



This is the method the students use.

1. Use a stock solution of 250 cm^3 of 20 a.u. hydrogen peroxide, to make solutions of 8 a.u. and 2 a.u.
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7. Record the volume of gas given off every 30 s for 3 min.
8. Repeat steps 3 to 7 twice.
9. Repeat steps 3 to 8 using 8 a.u. and 20 a.u. hydrogen peroxide.

(a) (i) State the independent variable in this investigation.

..... **[1]**

Question 7 · A level Paper 2 · June 2023 · Q17(a)(ii) · 2 marks

(ii) Describe how a student could produce an 8 a.u. solution from a 20 a.u. stock solution.

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..... **[2]**

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Question 8 · A level Paper 2 · June 2023 · Q17(b)(iv) · 2 marks

(iv) When analysing the results, the students assumed that the volume of oxygen collected was the same as the volume of oxygen produced from breakdown of hydrogen peroxide.

Suggest **two** reasons why the value the students recorded for volume of oxygen collected might not accurately reflect the volume of oxygen produced.

1 .....

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2 .....

.....

[2]

Turn over

Question 9 · AS Paper 2 · June 2025 · Q3(c) · 2 marks

(c) The student completes a different experiment to investigate the effect of pH on enzyme action.

Suggest how they would vary **and** detect the pH in their experiment.

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..... **[2]**

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Question 10 · AS Paper 2 · June 2025 · Q3(b)(i) · 3 marks

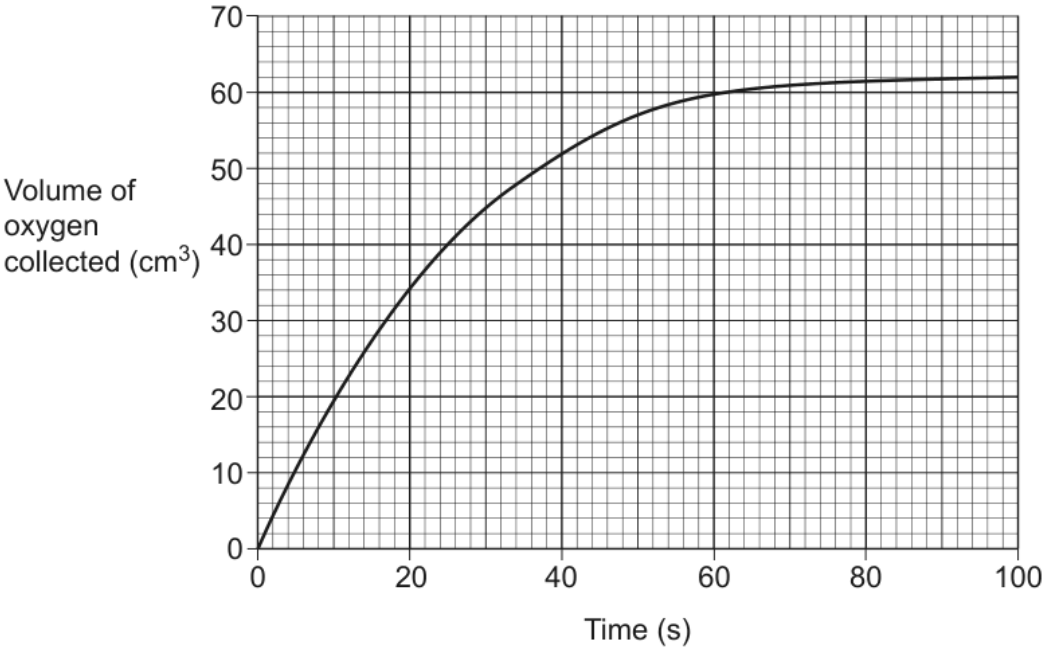
(b) Peas can be used in experiments as a source of catalase.

Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide to water and oxygen gas.

A student mashes some peas in distilled water to release the catalase.

They investigate the effect of temperature on the rate of the enzyme reaction.

The graph shows the results they obtain at 20 °C.



(i) Use the graph to calculate the initial rate of the reaction.

Give your answer to **2** significant figures.

Initial rate of the reaction = ... $cm^3 s^{-1}$ **[3]**

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Question 11 · information from earlier in the question

(c) A group of students investigated the effect of temperature on the activity of two forms of trypsin: human trypsin and icefish trypsin.

Part of their method is shown below:

- use 10 cm^3 of 5% trypsin solution for all trials
- measure enzyme activity at 10, 20, 30, 40 and 50 °C for both enzymes
- carry out each trial in the same pH buffer
- repeat the experiment 5 times at each temperature
- measure enzyme activity by recording the area of gelatine on a photographic film that is broken down over a set time period
- calculate the rate of enzyme activity at each temperature.

(i) Suggest **and** explain two improvements that would increase the validity of the students' investigation.

Improvement .....

Explanation .....

.....

Improvement .....

Explanation .....

.....

[4]

Question 11 · A level Paper 3 · June 2019 · Q3(c)(ii) · 1 mark

(ii) Suggest appropriate units to use to represent the rate of enzyme activity in this investigation.

..... **[1]**

Turn over

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(b) Lipase is an enzyme that catalyses the breakdown of lipids.

An investigation was carried out to see the effect of temperature on the activity of a lipase.

- $5\,cm^3$ of an alkaline solution of lipid was poured into a test tube.
- The test tube was placed into a water bath maintained at 20 °C and left to equilibrate.
- A few drops of an indicator were added to the wells of a white spotting tile. The indicator is pink above pH values of 8.3 and turns colourless at pH values below 8.3.
- Once the lipid solution had equilibrated, $1\,cm^3$ of 0.5% lipase solution at the same temperature was then added to the test tube.
- For five minutes, at 30 second intervals, the solution was stirred and a few drops were removed from the test tube and placed in a well on the white spotting tile.
- The time was recorded when the solution and indicator did not remain pink.
- The procedure was repeated four more times at 20 °C and then again at a further six temperatures.

The results are shown in Table 4.1 below.

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35	60	60	60	90	60
40	210	120	210	180	210
45	240	300	300	–	270
50	–	–	–	–	–

Table 4.1

(i) Why is pH **not** a controlled variable in this investigation?

.....

.....

..... **[1]**

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Question 12 · AS Paper 2 · June 2016 · Q4(b)(v) · 1 mark

(v) What can be concluded from the results in Table 4.1 about the optimum temperature for lipase activity?

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..... **[1]**

Question 13 · AS Paper 2 · June 2016 · Q4(b)(vi) · 4 marks

(vi) Describe **two different** ways in which the procedure could be modified to obtain a more accurate value for the optimum temperature for lipase activity.

1 .....

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2 .....

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[4]

Turn over

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Question 14 · A level Paper 3 · June 2019 · Q3(c)(i) · 4 marks

(c) A group of students investigated the effect of temperature on the activity of two forms of trypsin: human trypsin and icefish trypsin.

Part of their method is shown below:

- use 10 cm^3 of 5% trypsin solution for all trials
- measure enzyme activity at 10, 20, 30, 40 and 50 °C for both enzymes
- carry out each trial in the same pH buffer
- repeat the experiment 5 times at each temperature
- measure enzyme activity by recording the area of gelatine on a photographic film that is broken down over a set time period
- calculate the rate of enzyme activity at each temperature.

(i) Suggest **and** explain two improvements that would increase the validity of the students' investigation.

Improvement .....

Explanation .....

.....

Improvement .....

Explanation .....

.....

[4]

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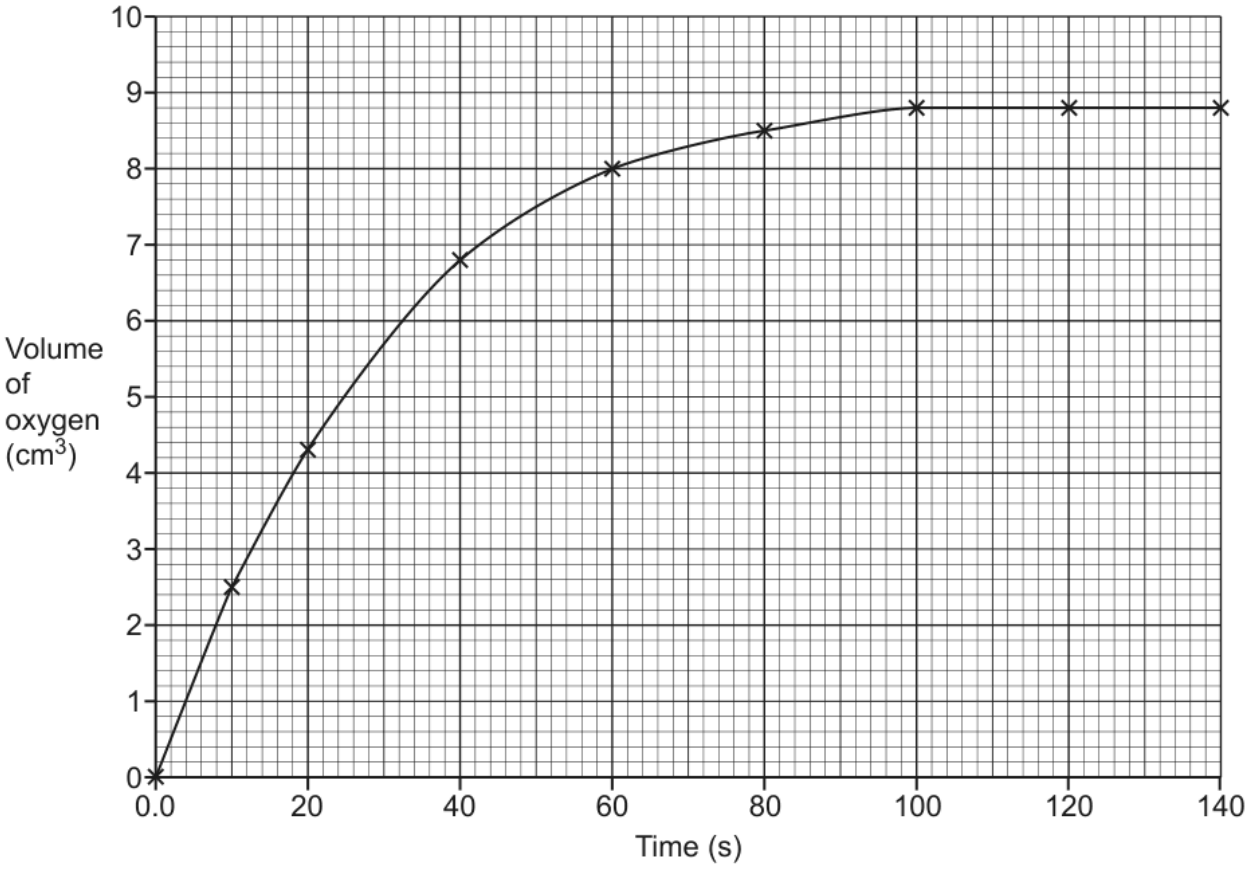
Question 15 · information from earlier in the question

25 A student investigates the rate of catalase activity as it breaks down hydrogen peroxide into oxygen and water.

The volume of oxygen released was recorded over a period of 140 seconds. The results are shown in the graph.



(a) Use the graph to calculate the rate of reaction at **50** seconds.

Give your answer to **2** significant figures.

Rate = ... $cm^3 s^{-1}$ **[2]**

Turn over

Questions, mark schemes and examiners' report extracts © OCR.

Question 15 · AS Paper 1 · June 2024 · Q25(b) · 2 marks

(b) Hydroxylamine inhibits catalase.

Describe how the student could show that hydroxylamine is a competitive inhibitor.

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..... **[2]**

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(ii) Catalase is found in all living things that are exposed to oxygen. It protects cells from oxidative damage by breaking down hydrogen peroxide to water and oxygen.

Catalase is a useful biomarker of oxidative stress in fish exposed to water contaminated with copper ions.

A group of students carried out an experiment to explore the effects of copper sulfate on the action of catalase. They measured the activity of catalase exposed to different concentrations of copper sulfate.

The results of their experiment are shown in Table 4.

Concentration of copper sulfate (moles dm^{-3})	Volume of oxygen gas produced (cm^3)
0.00	14.50
0.05	10.50
0.10	7.55
0.15	5.80
0.20	4.20

Table 4

17

In the space provided below, **sketch** a graph of the results in Table 4.

[2]

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Question 16 · AS Paper 2 · June 2018 · Q4(b)(iv) · 3 marks

(iv) Three rivers in the Himalayan foothills were polluted with copper, which affected the aquatic wildlife. Scientists were provided with one dead Indian Barb fish, *Esomus danricus*, from each of the rivers.

Scientists were unable to take a direct measurement of the copper ion concentration in the fish.

Using the information provided in 4(b)(ii), suggest how the scientists could use the fish tissue to compare the copper ion pollution in the three rivers.

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..... **[3]**

Turn over

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Mark schemes

Question 1 · AS Paper 2 · June 2016 · Q4(b)(i) · 1 mark

4	(b)	(i)	*one from* pH / it , is , the dependent variable / being measured ✓ (pH changes as) fatty acids are produced ✓

1	**ACCEPT** pH (change) indicates the rate of the reaction if pH were controlled there would be no , colour change / end point indicated because the pH (change) shows that the , reaction is happening / lipid is being broken down **IGNORE** we are investigating pH / pH is being investigated

Question 2 · AS Paper 2 · November 2021 · Q3(d)(i) · 2 marks

3	(d)	(i)	*any correct factor from list below and way of controlling this factor:* *Factor:* mass of liver OR surface area of liver OR volume of liver ✓ weigh with, balance / scales OR measure with, ruler / (laminated) graph paper OR measure water displaced / use Eureka can ✓ *Factor:* volume of, hydrogen peroxide / substrate ✓ use, measuring cylinder / syringe / pipette ✓
			Factor: concentration of, hydrogen peroxide / substrate ✓ use, known / set / labelled, concentration / dilution ✓ *Factor:* pH of solution ✓ use buffer ✓

2 max	AO3.3	1st mark for factor. 2nd mark for way of controlling factor. The way of controlling the factor **must** match the factor stated.

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Question 3 · A level Paper 2 · June 2023 · Q17(a)(i) · 1 mark

17	(a)	(i)	hydrogen peroxide concentration ✓	1	3.3	**IGNORE** conc.

Question 4 · A level Paper 2 · June 2023 · Q17(a)(iv) · 1 mark

(iv)	ensure there is no skin on / consistent potato variety ✓	1	3.4

ALLOW use potatoes that are the same age
IGNORE drying / use same (part of) potato / measure mass

Question 5 · A level Paper 2 · June 2023 · Q17(a)(iii) · 2 marks

(iii)	easier to control surface area ✓ less chance of ethical objection (to use of animal material) ✓ AVP ✓	**2 max**

3.4	**ALLOW** lower risk of infection **ALLOW** more acceptable to vegetarians **ALLOW** e.g., less chance of violent frothing reaching delivery tube / slower reaction so easier to record accurately **IGNORE** cheaper

Question 6 · AS Paper 2 · November 2021 · Q3(a)(i) · 2 marks

3	(a)	(i)	*any two from:* shake tube / mix contents ✓ remove 1cm^3 from tube 1 and add 9cm^3 of distilled water to tube 2 ✓ repeat process for tubes 3 and 4 ✓	**2 max**

AO2.8	**ALLOW** for any correct pair of tubes.

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Question 7 · A level Paper 2 · June 2023 · Q17(a)(ii) · 2 marks

(ii)	(mix with) distilled water ✓ ratio of 3 (water) : 2 (stock solution) ✓	**2**	3.3

ALLOW deionized water

ALLOW any suggested volumes if proportion (3:2) is correct
IGNORE units
IGNORE any procedure with more than one step

Question 8 · A level Paper 2 · June 2023 · Q17(b)(iv) · 2 marks

(iv)	**1**	bung not airtight / some (gas) escaped ✓
	2	some , oxygen / gas , dissolved (in solution) ✓
	3	difficult to judge (volume at a set time) / AW , if rate of gas production is high / AW ✓
	4	gas other than oxygen collected ✓

2 max	3.3	**1 IGNORE** gas entering **2 ALLOW** some oxygen used in respiration **3 ALLOW** e.g., measuring cylinder fills too quickly to measure accurately at 20 (a.u.) **4 IGNORE** non-standard atmospheric gases

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Question 9 · AS Paper 2 · June 2025 · Q3(c) · 2 marks

(c)	*vary by:* adding, acid(s) / alkali(s) (solutions) **OR** using buffer solutions (to regulate the pH) ✓ *detect by:* using, universal indicator paper / universal indicator solution / pH paper / pH probe / pH meter ✓	**2**	**3.4**

ALLOW correct description of use of acid **and** alkali (solutions)
IGNORE addition of H^+/OH^- unqualified
IGNORE add "different solutions of different pH" or "use different pH solutions" unqualified

IGNORE litmus paper (as does not determine actual pH value)
IGNORE indicator paper unqualified
ALLOW pH test strips
ALLOW 'universal indicator'

Question 10 · AS Paper 2 · June 2025 · Q3(b)(i) · 3 marks

(b)	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.0 cm^3 s^{-1} award 3 marks** Initial rate = 16/8 = 2.0 cm^3 s^{-1} appropriately drawn tangent between 0 to 8s **OR** single data point used between 0 to 8s ✓ correct working: difference in *y* axis readings divided by difference in *x* axis ✓ correct answer to two significant figures ✓	**3**	**2.4**

ALLOW a range of 2.0 to 2.2 with supporting tangent line drawn

ALLOW ECF for tangent drawn at incorrect position

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Question 11 · A level Paper 3 · June 2019 · Q3(c)(ii) · 1 mark

ii	mm^2 / cm^2 **and** s^{-1} / min^{-1} ✓	1	**ALLOW** /s /min **DO NOT ALLOW** 'per' or 'sec' or 'minute'

Question 12 · AS Paper 2 · June 2016 · Q4(b)(v) · 1 mark

4	(b)	(v)	(the optimum temperature) is between 30°C and 35°C ✓	1

Must give a range
°C must be stated once

IGNORE 35°C alone / 'around 35°C'

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Question 13 · AS Paper 2 · June 2016 · Q4(b)(vi) · 4 marks

4	(b)	(vi)		4

1A use more intermediate temperature values ✓

1B in the 30°C - 35°C range ✓

2A take samples at more frequent intervals (than 30 seconds) ✓

2B e.g. every 15 seconds ✓

3A use of colorimeter ✓

3B colour change would be less , subjective / biased ✓

4A use of pH , meter / probe / sensor ✓

4B obtain a numerical value ✓

Mark the first 2 suggestions seen.
B mark must relate to the appropriate A mark point

1A e.g. test , every 2 °C / at 1 °C intervals
use temperatures less than 5°C apart

1B **CREDIT** a range of 25°C - 40°C
Units must be given once

Note:

'test a range of temperatures between 30°C and 35°C'

'carry out more experiments between 30°C and 35°C'
= 2 marks (mps 1 & 2)

2A **ACCEPT** sample more regularly

2B time interval must be experimentally workable, so should be from 10 and less than 30 seconds.

Note:

'take samples every 15 seconds' = 2 marks (mps 3&4)

'take samples every 5 seconds' = 1 mark (mp 3 only)

3B obtain a numerical value

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Question 14 · A level Paper 3 · June 2019 · Q3(c)(i) · 4 marks

c	**i**	*I*: another named control variable (not mentioned in text) ✓ *E*: *idea of* prevent other factors (other than temperature) affecting results ✓ *I*: *idea of* standardised method ✓ *E*: minimises experimental error ✓ *I*: temperature intervals closer together ✓ *E*: (gives a more) accurate estimate of optimum temperature ✓ *I*: control group / tube with no trypsin / tube with boiled trypsin ✓ *E*: to see if gelatine breaks down without trypsin (at different temperatures) / to allow comparison (with experimental data) ✓

4 max	*Read as prose as improvement mark could be found in explanation e.g. 'I; substrate concentration E; should be kept constant ' gets I mp* *Marks for explanation can be awarded if the linked improvement mark is attempted but not given* e.g. area of film / volume of pH buffer / source of trypsin thickness / volume / concentration, of, gelatine / substrate **IGNORE** amount e.g. thickness may affect rate of breakdown of gelatine e.g. film is placed in the solution in the same way each time / measure time for set volume of gelatine to be broken down / use a thermostatically controlled water bath **ALLOW** improves, accuracy / reproducibility/ repeatability / precision **IGNORE** improves reliability **ALLOW** extend temperature range below 10°C **ALLOW** shows the optimum / best temperature (for trypsin) **ALLOW** improves precision

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Question 15 · AS Paper 1 · June 2024 · Q25(b) · 2 marks

(b)	carry out the experiment at different <u>concentrations</u> of , hydrogen peroxide / substrate ✓ without inhibitor **AND** with inhibitor ✓ rate (of reaction) with inhibitor (also) increases as the concentration of substrate increases **OR** (with inhibitor has) greater inhibition at lower concentrations of substrate / less inhibition at higher concentrations of substrate ✓	

2 max	**ACCEPT** hydroxylamine for inhibitor

Question 16 · AS Paper 2 · June 2018 · Q4(b)(iv) · 3 marks

4(b)(iv)	**1** compare / measure / test, catalase activity / oxygen produced ✓ **2** experimental detail ✓ **3** further experimental detail ✓ **4** less, oxygen / catalase (activity), means more, copper / pollution ✓ **5** use, Table 4 / graph, to estimate copper (ion) concentration ✓	3 max	**IGNORE** how much oxygen is in each fish **IGNORE** how much catalase is in each fish *experimental detail points:* **ALLOW** AW throughout **IGNORE** amount throughout **i** prepare a , catalase / fish / tissue, extract / sample (e.g. ref. pestle and mortar / chopping / liquidiser) **ii** equal / known / controlled, volume / sized samples (of fish / tissue / extract) **iii** equal / known / controlled, concentration / volume, of hydrogen peroxide **iv** measure, volume of, oxygen / gas, in a given time **v** use gas syringe / collect gas under water **ALLOW** correct statement of relationship between copper or pollution **and** oxygen **or** amount of catalase present **or** catalase activity **even if wrong experiment is done** (e.g. adding catalase or copper sulphate to fish) or measuring 'how much oxygen is in fish'
Question	**Answer**	**Mark**	**Guidance**

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