Mode of Action of Enzymes (3.1): Cambridge (CIE) A Level Biology 9700 Exam Questions by Topic

22 questions · 44 marks · about 53 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 2 · February/March 2019 (22) · Q2(a) · 4 marks

2 In mammalian red blood cells, carbonic anhydrase has an important role in the transport of carbon dioxide.

Carbonic anhydrase is an enzyme.

(a) Outline the features of an enzyme.

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Question 2 · Paper 2 · May/June 2023 (22) · Q2(c) · 1 mark

(c) Enzymes present in mucilage catalyse the breakdown of organic compounds in the soil. This increases the presence of mineral ions in the soil.

State the term used to describe enzymes that act **outside** the cells that synthesise them.

Question 3 · Paper 2 · October/November 2017 (22) · Q3(a) · 1 mark

3 Hydrolytic enzymes can function within the cell or can be secreted by the cell, where they are able to catalyse reactions.

(a) State the term used to describe an enzyme that functions within the cell.

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Question 4 · Paper 4 (A level) · February/March 2022 (42) · Q6(b)(i) · 1 mark

(b) Pitcher plants are carnivorous plants that trap and digest insects in a large modified leaf called a pitcher.

Fig. 6.3 shows a pale pitcher plant, *Sarracenia alata*.

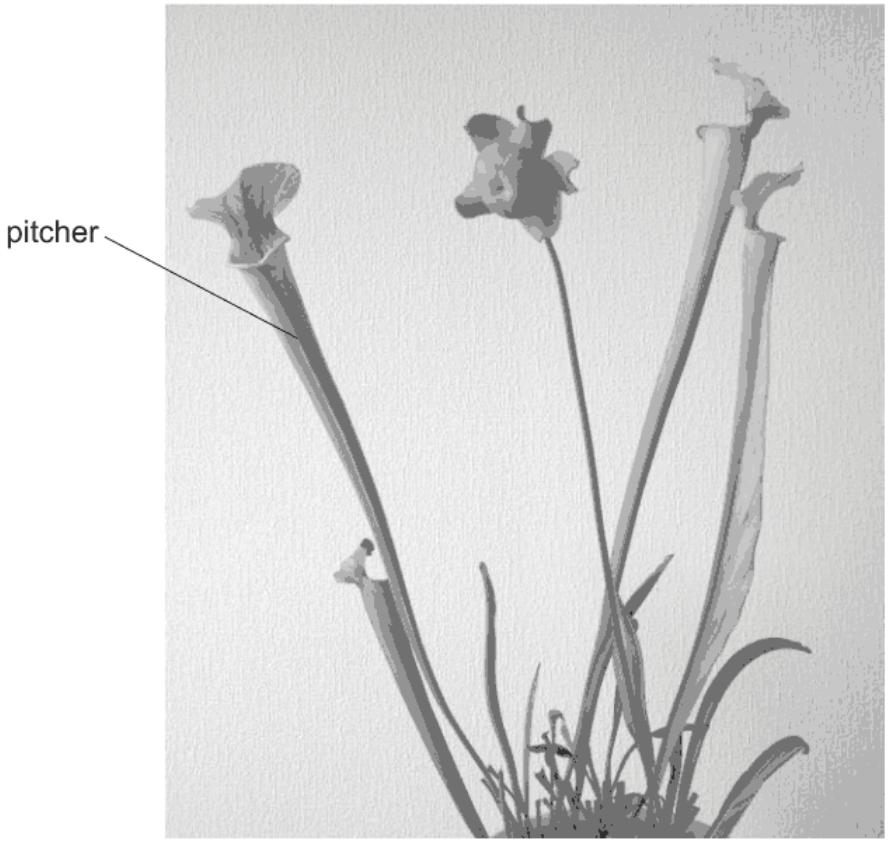


Fig. 6.3

(i) Unlike the Venus fly trap, pitcher plants have no moving parts to trap insects. Insects are attracted to scent produced at the top of the pitcher. Once inside the pitcher, the insect slides down to the bottom and into a liquid containing digestive enzymes.

Suggest a type of enzyme found in the pitcher plant that is used to digest insects.

Question 5 · information from earlier in the question

6 Telomerase is an enzyme that is important in maintaining the telomeres that are located at the ends of chromosomes.

Question 5 · Paper 2 · October/November 2019 (22) · Q6(c) · 1 mark

(c) Studies suggest that telomerase is a flexible molecule when binding its substrate. The active site changes its shape slightly to allow the formation of the enzyme-substrate complex.

Name the theory that describes this mode of enzyme action.

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Question 6 · Paper 2 · May/June 2024 (22) · Q3(a) · 3 marks

3 Lysozyme is an antibacterial enzyme that was discovered in 1921 by Alexander Fleming, the scientist who discovered penicillin.

Lysozyme catalyses the hydrolysis of glycosidic bonds present in peptidoglycan molecules to form smaller products, NAG (N-acetylglucosamine) and NAM (N-acetylmuramic acid).

(a) Before the induced fit hypothesis was proposed in 1958, scientists believed that the lock and key hypothesis explained how lysozyme catalyses the hydrolysis of peptidoglycan to its products.

Draw labelled **and** annotated diagrams in the space provided to show how the **lock and key hypothesis** was used to explain the mechanism of action of lysozyme on peptidoglycan.

Question 7 · Paper 2 · October/November 2025 (21) · Q3(a) · 2 marks

3 **(a)** The lock-and-key hypothesis and the induced-fit hypothesis are used to describe the interaction of enzymes and their substrates.

Describe **one** similarity and **one** difference between the lock-and-key hypothesis and the induced-fit hypothesis.

similarity .....

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difference .....

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[2]

Question 8 · information from earlier in the question

4 Lignin and suberin are polymers that are present in plant tissues.

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(b) The enzyme laccase catalyses the formation of lignin in plants.

Fig. 4.1 is a diagram of the mode of action of laccase.

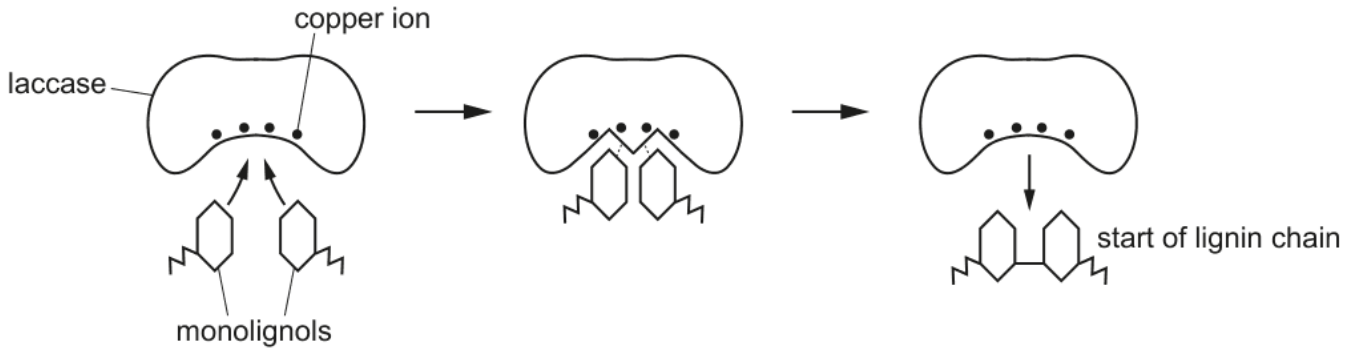


Fig. 4.1

Describe **and** explain the mode of action of laccase when catalysing the formation of lignin.

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Question 9 · information from earlier in the question

5 Sucrose phosphorylase is an enzyme found in some species of bacteria. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

Fig. 5.1 shows the reversible reaction that takes place within the bacterial cell.

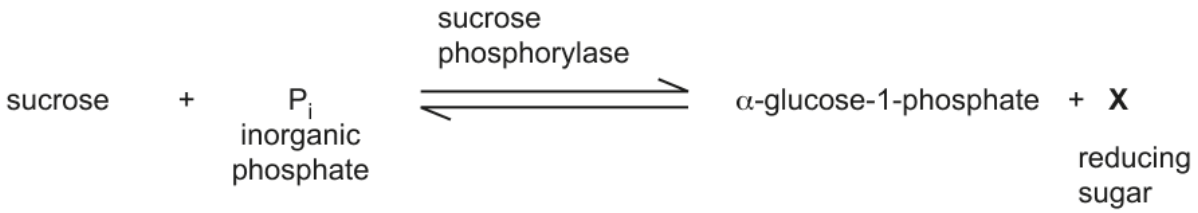


Fig. 5.1

Question 9 · Paper 2 · October/November 2020 (22) · Q5(b) · 2 marks

(b) In the absence of sucrose phosphorylase as a catalyst, the reaction shown in Fig. 5.1 would take too long to occur to allow the bacterial cell to function efficiently.

Explain why the reaction shown in Fig. 5.1 proceeds at a much faster rate in the presence of the enzyme.

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3 A tyrosine kinase receptor (TKR) is a protein complex found in the cell surface membrane of mammalian cells.

TKR has two components involved in the process of cell signalling:

- a receptor for the signalling molecule (ligand)
- an enzyme that catalyses the transfer of a phosphate group from ATP to an intracellular protein.

Fig. 3.1 is a diagram to show how TKR is involved in cell signalling.

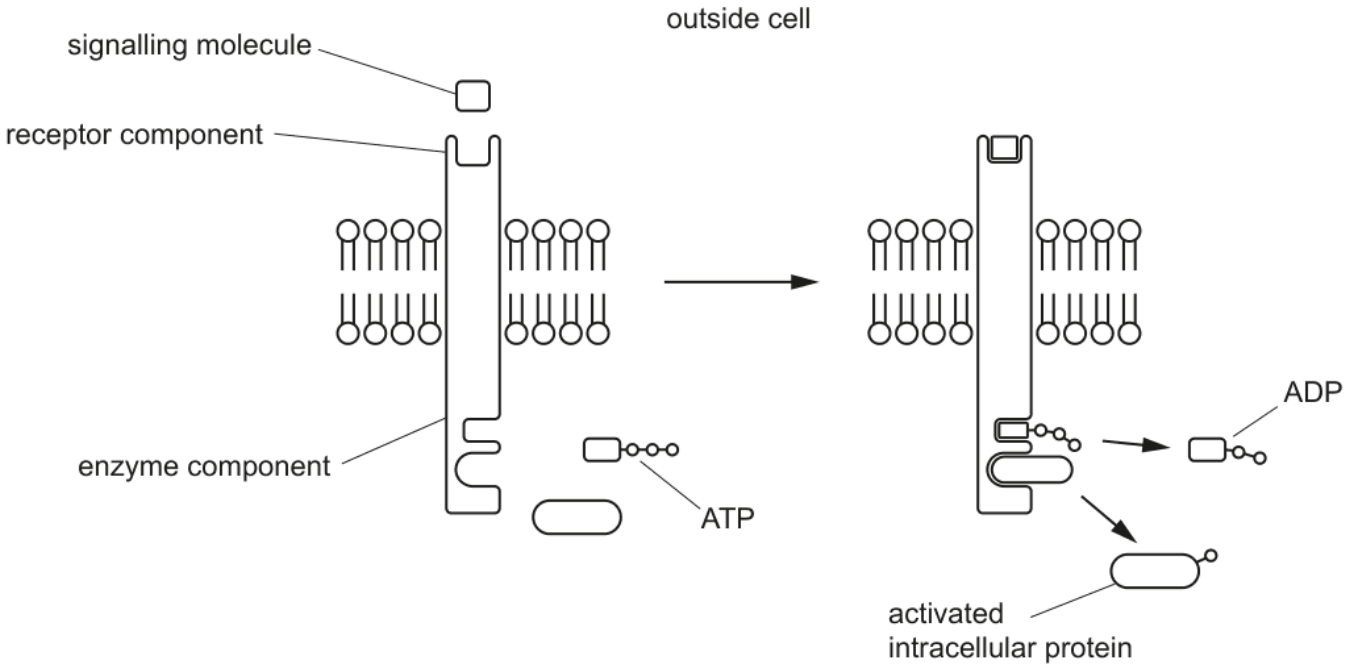


Fig. 3.1

(a) Most enzymes are specific to one reaction.

With reference to Fig. 3.1, explain how the structure of an enzyme provides its specificity.

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Question 11 · Paper 2 · October/November 2023 (22) · Q2(b) · 1 mark

(b) Protease enzymes hydrolyse proteins. Many proteases are able to hydrolyse more than one type of protein.

Suggest why it is possible for a protease to act on different types of protein.

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Question 12 · information from earlier in the question

4 The enzyme carbonic anhydrase has been found in a wide range of organisms and acts as a catalyst in many tissues.

Studies have shown that there are differences in the protein structure of the enzyme and differences in the number and organisation of introns and exons of the gene coding for the enzyme.

All carbonic anhydrase enzymes catalyse the same reversible reaction, shown in Fig. 4.1.

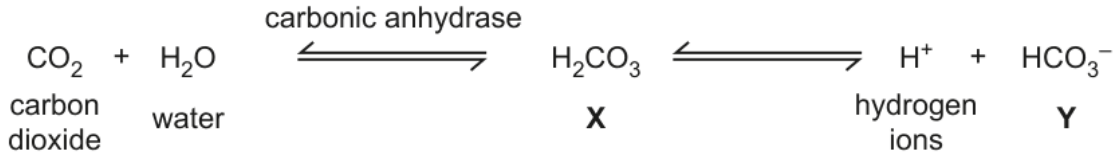


Fig. 4.1

Question 12 · Paper 2 · May/June 2022 (22) · Q4(b) · 1 mark

(b) Carbonic anhydrase enzymes can have different primary structures.

Suggest how all carbonic anhydrase enzymes can catalyse the same reaction, even though they have different primary structures.

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Question 13 · Paper 2 · October/November 2022 (21) · Q4(c) · 2 marks

(c) Different strains of the influenza virus have formed as a result of mutations. Each strain of the virus contains the enzyme neuraminidase. Neuraminidase helps the virus to leave host cells after the virus has replicated. In each strain of the influenza virus, the primary structure of the active site of the neuraminidase enzyme remains unchanged.

Suggest why the primary structure of the active site of neuraminidase remains unchanged in each strain of the influenza virus.

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Question 14 · information from earlier in the question

(c) Scientists have studied the process of cell death that occurs during the development of the cells that become mature xylem vessel elements.

During this development, the tonoplast ruptures (bursts) and releases hydrolytic enzymes contained in the vacuole into the cytoplasm.

Question 14 · Paper 2 · October/November 2022 (21) · Q5(c)(iii) · 2 marks

(iii) During development of the xylem vessel elements the pH of the cytoplasm decreases. This change in pH activates enzymes in the cytoplasm that cause organelles to swell.

Suggest how a change in pH of the cytoplasm can activate enzymes.

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Question 15 · information from earlier in the question

8 (a) In plants such as rice, *Oryza sativa*, rubisco has a low rate of activity, which in turn affects the rate of photosynthesis. The cereal crop sorghum, *Sorghum bicolor*, has a high rate of activity of rubisco.

A genetically modified (GM) variety of rice was produced. Parts of the quaternary structure of rubisco in rice were altered to be the same as the rubisco in sorghum.

The rate of activity of rubisco in non-GM rice and GM rice was measured at different concentrations of atmospheric carbon dioxide (CO_2).

The results are shown in Fig. 8.1.

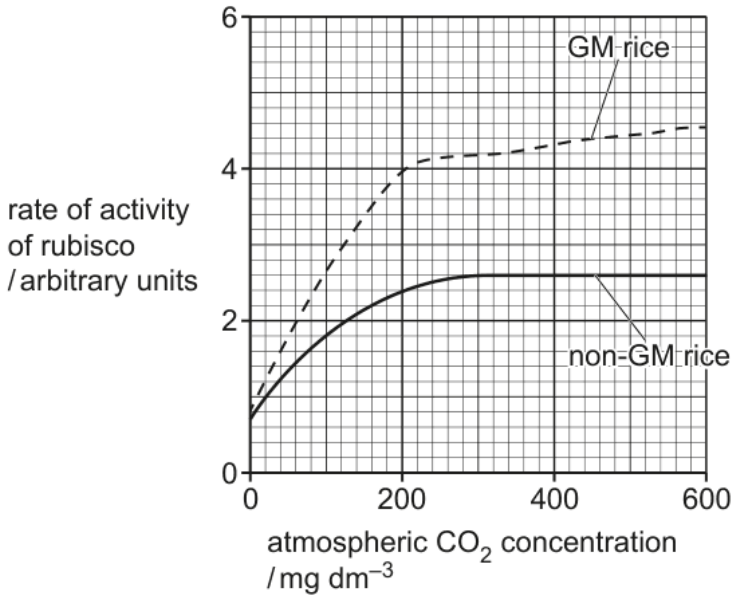


Fig. 8.1

Question 15 · Paper 4 (A level) · May/June 2023 (42) · Q8(a)(ii) · 1 mark

(ii) Suggest which part of the rubisco molecule was altered to produce the GM variety of rice.

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6 Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, which is a waste product of cell metabolism.

The reaction catalysed by catalase is shown in Fig. 6.1.

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Fig. 6.1

(a) A student carried out two experiments to investigate the progress of the reaction shown in Fig. 6.1. Potato tissue was used as the source of the enzyme.

Six pieces of potato were cut, each measuring 20 mm × 10 mm × 10 mm.

In the first experiment, hydrogen peroxide solution was added to three of the pieces of potato tissue and the progress of the reaction was measured.

Fig. 6.2 shows how the first experiment was set up.

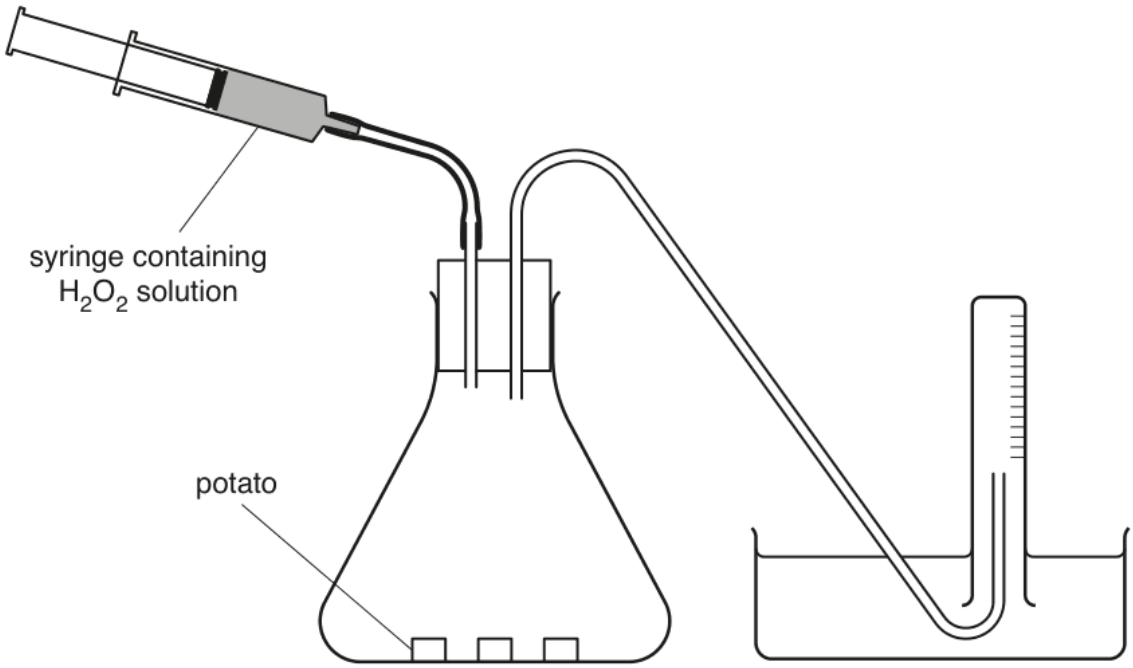


Fig. 6.2

(i) Suggest how the progress of the reaction could be measured.

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Question 17 · Paper 2 · February/March 2018 (22) · Q3(c) · 3 marks

(c) For a commercial application using an enzyme, the progress of the enzyme-catalysed reaction needs to be studied.

Outline how the progress of an enzyme-catalysed reaction can be investigated experimentally.

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3 (a) Scientists investigated the progress of reactions catalysed by two enzymes: dopa oxidase and neutrase. The reactions catalysed by these enzymes result in changes to the appearance of the reaction mixtures.

The reactions are shown in Fig. 3.1.

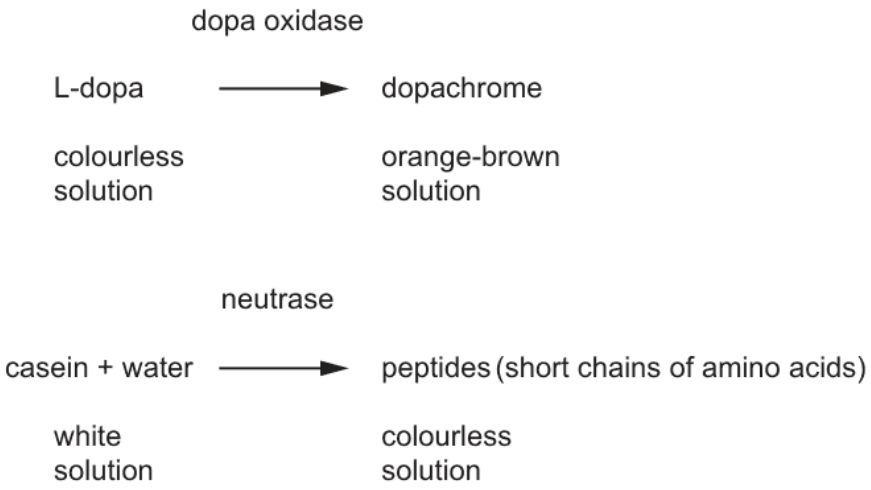
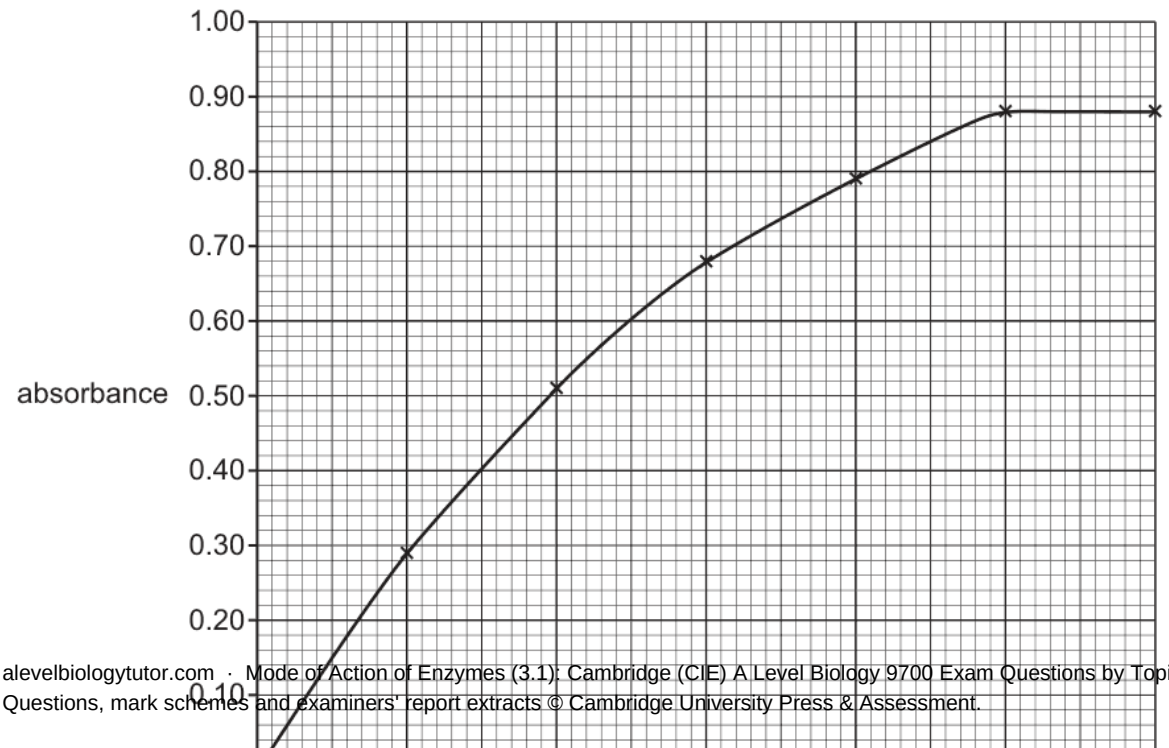


Fig. 3.1

The changes in appearance of the reaction mixtures make it possible to follow the reactions using a colorimeter.

Fig. 3.2 shows the progress of the reaction catalysed by dopa oxidase as recorded from a colorimeter.

Fig. 3.3 shows the progress of the reaction catalysed by neutrase as recorded from a colorimeter.



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Question 19 · Paper 2 · May/June 2025 (21) · Q3(a)(ii) · 2 marks

(ii) Suggest **two** advantages of using a colorimeter to investigate the progress of reactions such as those shown in Fig. 3.1.

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Question 20 · information from earlier in the question

(b) Studies of nitrate uptake and nitrate metabolism help to provide information to scientists who are investigating ways to increase the yield of crop plants.

The first step of nitrate metabolism in leaf cells is the reduction of nitrate to nitrite, catalysed by the enzyme nitrate reductase. The activity of the enzyme can be studied by detecting the presence of nitrite formed.

Question 20 · Paper 2 · May/June 2024 (22) · Q4(b)(ii) · 2 marks

(ii) One method used to detect the presence of nitrite formed from the reduction of nitrate in leaf tissue involves:

- using an inhibitor to prevent nitrite from taking part in further reactions in the leaf tissue
- immersing the leaf tissue in a solution containing a colourless test reagent.

The nitrite from the leaf tissue enters the surrounding solution, changing the colour of the solution to magenta (red-purple).

Suggest why using a colorimeter can improve this method to detect the presence of nitrite.

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Question 21 · Paper 2 · October/November 2025 (22) · Q3(e)(i) · 2 marks

(e) Some people with lactase non-persistence may be lactose intolerant. They may have symptoms, such as abdominal pain, if their diet contains lactose.

(i) Lactase supplements (tablets) can be taken before milk or milk-based products are consumed to avoid symptoms of lactose intolerance.

A student compared the activity of two different concentrations of a lactase supplement using an artificial substrate, ONPG, instead of lactose.

A solution of ONPG is colourless, but the hydrolysis of ONPG by lactase releases a coloured product.

The student planned to follow the progress of the reaction for each concentration of lactase using a colorimeter.

Explain why the student chose to use a colorimeter to follow the progress of the reaction for each concentration of lactase.

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2 Glucose is used in the synthesis of amylose. Glucose is first converted to glucose 1-phosphate (G 1-P).

Starch phosphorylase is an intracellular enzyme that can catalyse the synthesis of amylose from G 1-P, which is the substrate for the reaction:

(glucose 1-phosphate)n ⟶ amylose + (phosphate ions)n

n = a large number

Students used a colorimeter to investigate the progress of the reaction.

The students made a reaction mixture containing 0.01 mol dm^{-3} G 1-P in a buffer solution at pH 6.0. A very small quantity of amylose was added to initiate the reaction.

A solution of starch phosphorylase was added to the reaction mixture and samples were taken at 1-minute intervals. Each sample was added to a dilute iodine solution, stirred and then poured into a cuvette. The absorbance of each solution was recorded.

The results of the investigation are shown in Fig. 2.1.

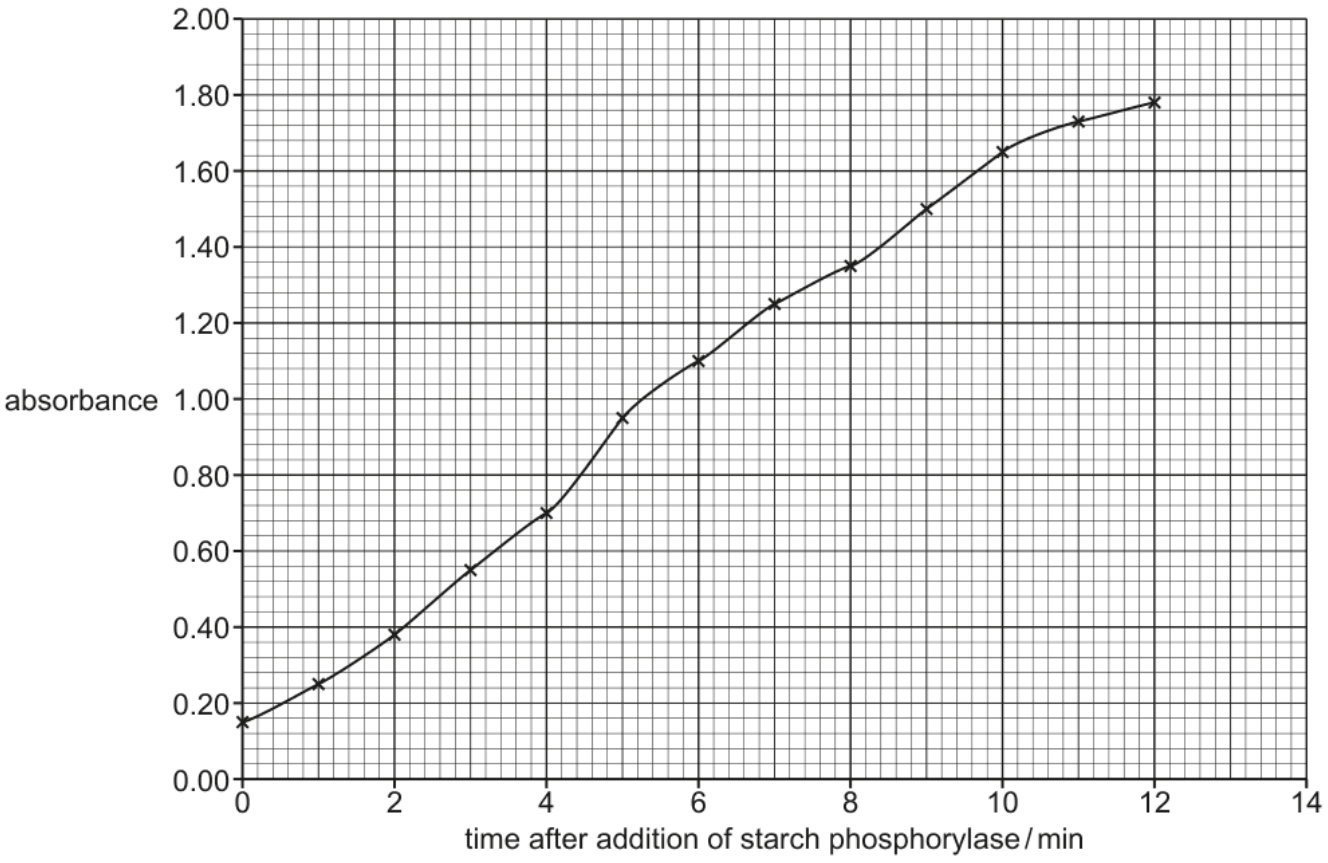


Fig. 2.1

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Question 22 · Paper 2 · October/November 2023 (23) · Q2(a)(iii) · 1 mark

(iii) State an advantage of using a colorimeter in determining the progress of the reaction.

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Mark schemes

Question 1 · Paper 2 · February/March 2019 (22) · Q2(a) · 4 marks

2(a)	*any **four** from:* 1 globular protein ; **A** spherical / ball-shaped **I** circular 2 acts as a catalyst ; 3, 4 further detail ; ; e.g. increases the rate of a reaction (cf. to no enzyme) **A** speeds up a reaction / makes the reaction go faster does not get used up (in the reaction) **I** does not take part in the reaction **A** can be re-used **A** is not changed (by the reaction) does not alter the (chemical) equilibrium (between reactants and products) 5 lowers the, activation energy / energy needed for substrate to reach transition state ; 6 detail ; e.g. holds substrate to place strain on bond (for bond to break) holds substrates, in position / close, for bonds to form facilitates transfer of, electrons / protons 7 effective in tiny quantities / AW ; 8 shows specificity / active site shape complementary to substrate / forms enzyme–substrate complex / lock and key or induced fit mechanism of action ; 9 AVP ; e.g. may need, cofactor / coenzyme / prosthetic group, to function each has an optimum, temperature / pH	**4**

Question 2 · Paper 2 · May/June 2023 (22) · Q2(c) · 1 mark

2(c)	extracellular (enzymes) ;	**1**

Question 3 · Paper 2 · October/November 2017 (22) · Q3(a) · 1 mark

3(a)	intracellular (enzyme) ; **R** interacellular	**1**

Question 4 · Paper 4 (A level) · February/March 2022 (42) · Q6(b)(i) · 1 mark

6(b)(i)	hydrolytic / extracellular / protease / proteinase / peptidase / AW ;	**1**

Question 5 · Paper 2 · October/November 2019 (22) · Q6(c) · 1 mark

6(c)	induced fit ;	**1**

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Question 6 · Paper 2 · May/June 2024 (22) · Q3(a) · 3 marks

3(a)	*any **three** from:* active site with a specific shape as part of a lysozyme molecule drawn and active site labelled or included in an annotation ; complementary shaped peptidoglycan drawn and, peptidoglycan / **s**ubstrate, labelled or included in an annotation; enzyme-substrate complex drawn and labelled ; lysozyme with same shaped active site and, two products / NAM and NAG drawn (formed from hydrolysed peptidoglycan) ; AVP ; e.g. water shown enzyme active site labelled 'lock' and substrate labelled 'key' *max 2 if no ref. to specific example e.g. label for lysozyme **or** peptidoglycan **or** murein **or** the products NAG and NAM* *max 1 no labels but otherwise clearly lock and key* ***or** by gaining the enzyme-substrate complex mark if induced fit drawn*	**3**

Question 7 · Paper 2 · October/November 2025 (21) · Q3(a) · 2 marks

3(a)	**one** similarity ; e.g. substrate binds to active site enzyme-substrate complex forms product leaves active site interaction does not alter enzyme for re-use lower activation energy specific to one or very similar substrate(s) interaction can be affected by, action of inhibitors / pH / AW **one** difference ; e.g. induced-fit **ora** for lock-and-key active site not fully complementary to substrate change in, conformation / shape, of active site / AW *context of binding substrate or after product release* less specificity to substrate	**2**

Question 8 · Paper 2 · May/June 2024 (23) · Q4(b) · 5 marks

4(b)	*max 4 if no reference to laccase / monolignols* *allow substrate(s) for monolignols* *any **five** from*: **1** laccase uses induced fit ; **2** *idea that* active site shape not fully complementary to (shape of) monolignols ; **3** active site changes shape to, fit / bind to, monolignols ; AW **4** becomes fully complementary ; **5** forming enzyme-substrate complex ; **6** lowers, activation energy / energy of activation; **7** suggestion of how activation energy is lowered ; **8** laccase returns to original shape, after product leaves active site / for re-use / AW ; **9** AVP ; e.g. *suggestion that,* copper ions are, cofactors / necessary for enzyme action *suggestion that* monolignols are held in place by (temporary) H bonds	**5**

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Question 9 · Paper 2 · October/November 2020 (22) · Q5(b) · 2 marks

5(b)	*any **two** from:* formation of enzyme-substrate complex / substrate fits into active site ; **A** substrate binds to active site (so) reactants held close together (e.g. for bond formation) ; lowers, activation energy / energy of activation ; **A** Ea / Ae *can award annotated on a sketch* detail ; e.g. transfer of electrons strain on bonds alternative pathway holds substrate in a way that the bonds needed to be broken are exposed	**2**

Question 10 · Paper 2 · May/June 2022 (21) · Q3(a) · 2 marks

3(a)	**1** active site, shape / tertiary structure ; **2** complementary to, substrate(s) / (intracellular) protein / ATP ;	**2**

Question 11 · Paper 2 · October/November 2023 (22) · Q2(b) · 1 mark

2(b)	*any **one** from:* *idea that* area to be, hydrolysed / AW, could be between same amino acids ; **A** *ref. to* (always), hydrolyses / breaks down / acts on, peptide bonds suggestion that active site has (some) flexibility for, hydrolysing / binding to / AW, similar substrates ; (proteins / substrates) similar shape(s) so fit active site ; active site and, substrates / proteins, (still) have complementary shapes ; **R** 'complementary to the antigen or the shape' AVP ; e.g. (large enzyme / enzyme complex, with) more than one active site	**1**

Question 12 · Paper 2 · May/June 2022 (22) · Q4(b) · 1 mark

4(b)	*any **one** from:* similar / same, active site ; have the same catalytic amino acids ; similar / same, tertiary structure ; **A** same quaternary structure	**1**

Question 13 · Paper 2 · October/November 2022 (21) · Q4(c) · 2 marks

4(c)	*any **two** from:* no change in, shape / tertiary structure / conformation, of active site ; **ora** (same) substrate able to bind to active site ; **ora** consequence ; e.g. so viruses can leave host cell to infect other cells the mutation is not occurring in the, gene / section of gene coding for amino acids in active site for neuraminidase ; the gene for neuraminidase is essential for survival ; AVP ;	**2**

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Question 14 · Paper 2 · October/November 2022 (21) · Q5(c)(iii) · 2 marks

5(c)(iii)	*allow two suggestions or a suggestion with further detail, for two marks* active site becomes complementary to substrate ; (because) bonds altered between R groups of amino acids ; **A** hydrogen / ionic, bonds removal of a portion that blocks the active site ; AW substrate can enter active site ; *idea of* cofactor / AW, associates with the enzyme ; enzymes becomes functional ; sets off an enzyme cascade / ref. cell signalling ; AVP ;	**2**

Question 15 · Paper 4 (A level) · May/June 2023 (42) · Q8(a)(ii) · 1 mark

8(a)(ii)	active site ; **A** allosteric site	**1**

Question 16 · Paper 2 · May/June 2019 (22) · Q6(a)(i) · 2 marks

6(a)(i)	*any two from:* correct ref. to time ; correct ref. to volume of oxygen ; **A** gas for oxygen **A** volume of water displaced by oxygen **A** measuring height of water level (decreasing) **A** cm^3 instead of volume AVP ; subtract volume of gas displaced by H_2O_2 addition	**2**

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Question 17 · Paper 2 · February/March 2018 (22) · Q3(c) · 3 marks

3(c)	*any **three** from:* 1 ref. to controlled variables ; e.g. constant, pH / temperature 2 take samples at timed intervals ; **A** regular intervals 3 determine, substrate concentration / product concentration ; 4 plot graph of, dependent variable (*y*-axis) against time (*x*-axis) ; 5 ref. to rate of disappearance of substrate **or** ref. to rate of appearance of product ; 6 determine initial rate ;	**3**

Question 18 · Paper 2 · May/June 2025 (21) · Q3(a)(i) · 3 marks

3(a)(i)	**1** change in, absorbance / rate of reaction, and (then), reaches a time when there is no further change / reaches a plateau / reaction stops / absorbance becomes constant ; **A** *for change* absorbance increases, in Fig. 3.2 / for dopa oxidase, and decreases, in Fig. 3.3 / for neutrase **A** decrease in rate of reaction **R** if rate of reaction increases **2** due to change in (intensity / shade, of) colour (of reaction mixture) ; **3** due to, collisions between substrate and enzyme / enzyme-substrate complexes form(ing) / product being made ; **4** *idea that, no / little, change in absorbance* because, all / most, of the substrate is used up / AW ; **A** substrate is limiting factor **I** reactants are used up	**3**

Question 19 · Paper 2 · May/June 2025 (21) · Q3(a)(ii) · 2 marks

3(a)(ii)	*any **two** from:* **1** can take, quantitative / numerical, readings / results ; **2** *idea that* can use values from the colorimeter to plot graph(s) ; **3** can take readings continuously/do not have to take samples ; **I** continuous data **4** results are not subjective/no judgements made by eye/no bias in the results/AW ; **A** results are objective/more accurate **I** precise **5** can determine / AW, rates of reactions ; **6** AVP ; e.g. *ref. to* use of, standards / calibration curve, to obtain actual concentrations e.g. can detect, small differences in, colour / cloudiness / AW	**2**

Question 20 · Paper 2 · May/June 2024 (22) · Q4(b)(ii) · 2 marks

4(b)(ii)	*any **two** from:* improves accuracy of results / results not by eye / results not subjective ; **A** detects smallest change in, (intensity of) colour / concentration / quantity provides quantitative results / obtain numerical values ; **A** described e.g. absorbance values / can measure absorbance/ gives percentage transmission / absorbance readings *idea that* different, intensities / shades of, colour / magenta / red-purple, relate to different, quantities / concentrations, of nitrites ; **A** relate to (rates of) nitrate uptake can produce calibration curve (for quantitative results) ; AVP ; e.g. can detect, (very) low concentrations / faintly coloured samples	**2**

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Question 21 · Paper 2 · October/November 2025 (22) · Q3(e)(i) · 2 marks

3(e)(i)	*any **two** from:* *idea of* can, detect increase in / distinguish between, the intensity of colour (as products form) ; can obtain quantitative results (for coloured product of ONPG) ; **A** can provide numerical, values / readings / results / measurements **R** if stated that the results are wavelengths *ref. to* not subjective / AW ; *idea of* not by-eye judgments / difficulty in describing different colour shades can obtain accurate, results / readings / values ; **A** *idea of* greater accuracy in obtaining results *vague references to accuracy should be considered for ideas linked to 'not subjective'* can construct numerical graphs of results to compare curves of each (lactase) concentration ; AW AVP ; e.g. more sensitive to small colour changes at the beginning of the experiment not able to see initial reaction proceeding by eye *ref. to* use of a (prepared) calibration, curve / graph (to compare rates / product concentrations)	**2**

Question 22 · Paper 2 · October/November 2023 (23) · Q2(a)(iii) · 1 mark

2(a)(iii)	*any **one** from:* colorimeter gives, quantitative / numerical, results / readings ; *idea that* can use values from the colorimeter to plot graph(s) ; results are not subjective / no judgements made by eye / AW ; *idea that* can use calibration curve to determine concentrations (of starch) ; can take continuous readings / do not have to take samples ; **I** *'more accurate', 'actual results', 'reliable', 'exact', 'precise', etc.*	**1**

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