Past-paper walk-through

Enzymes ▪ 3.1

eXercise

Questions in this set

- 2025 Q5
- 2022 Q3
- 2019 Q6

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 5

2025 ▪ Q5

Figure 1 shows the reactions of the metabolic pathway used to synthesize amino acid B from amino acid A in cells.

Figure 1. Synthesis of amino acid B from amino acid A

[Diagram of a linear metabolic pathway with feedback inhibition. Left to right: a triangle labeled "Amino Acid A" is converted by "Enzyme 1" (shown as a shape resembling a Pac-Man/wedge with a notch) into an intermediate; an arrow leads to a shape converted by "Enzyme 2" (a chevron/arrow shape, drawn shaded/filled darker to indicate it is the enzyme being asked about) producing "Intermediate X" (small triangle shape); an arrow leads to a shape converted further to produce "Intermediate Y" (a half-circle/D shape); an arrow leads through "Enzyme 3" (a half-circle notch shape) producing the final product, a rectangle labeled "Amino Acid B". Below the pathway, a curved arrow leads from "Amino Acid B" back down and around to

Question 5

"Enzyme 1", terminating in a flat bar (inhibition symbol, T-bar) pointing into the Enzyme 1 / Amino Acid A binding site, indicating that Amino Acid B feedback-inhibits Enzyme 1's binding of Amino Acid A.]

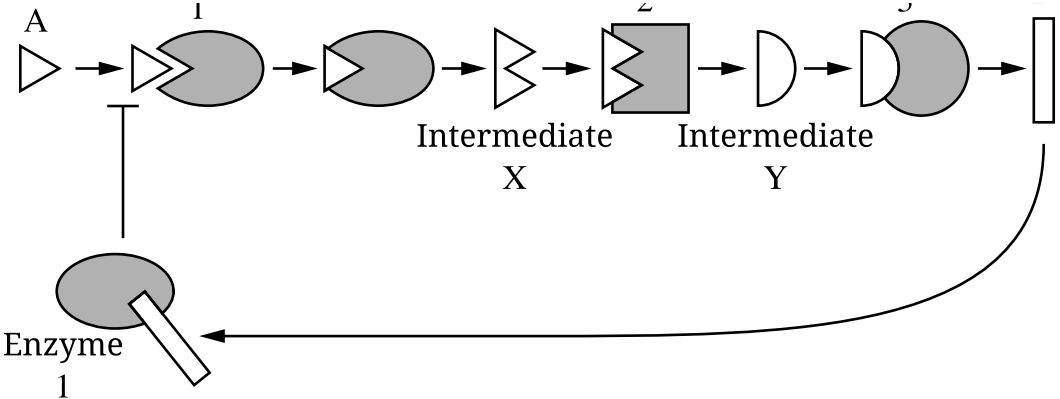
(a) Describe a characteristic of an enzyme's active site that allows it to catalyze a specific chemical reaction.

(b) Based on Figure 1, explain how the binding of amino acid A to enzyme 1 is regulated by amino acid B.

(c) Using the information in Figure 1, identify the product of the reaction catalyzed by enzyme 2: intermediate X, intermediate Y, or amino acid B.

(d) Based on Figure 1, explain how a change in pH could affect enzyme 3 in such a way that amino acid B cannot be produced.

Question 5



Solution 5

(a)

Mark scheme

- The active site's shape/charge is complementary/compatible with a specific substrate/amino acid, letting the enzyme bind only that substrate; the active site also positions the substrate in a way that makes the reaction more likely (induced fit stresses bonds, increasing the reaction's likelihood).

Solution 5

(b)

Mark scheme

- Amino acid B (the pathway's end product) inhibits the binding of amino acid A to enzyme 1 — it binds to an allosteric site on enzyme 1, causing the enzyme to change shape and preventing amino acid A from binding at the active site. This is feedback inhibition, shown in Figure 1 by the arrow from amino acid B back to enzyme 1.

Solution 5

(c)

Mark scheme

- Intermediate Y is the product of the reaction catalyzed by enzyme 2 (enzyme 2 converts intermediate X into intermediate Y in the pathway shown in Figure 1).

Solution 5

(d)

Mark scheme

- A change in pH could alter the structure/active site/shape of enzyme 3 (e.g., by disrupting the ionic and hydrogen bonds that maintain its 3D structure) so that intermediate Y/the substrate can no longer bind to it, or could denature enzyme 3 entirely so intermediate Y cannot bind and be converted into amino acid B.

Question 3

2022 ▪ Q3

Fireflies emit light when the enzyme luciferase catalyzes a reaction in which its substrate, D-luciferin, reacts to form oxyluciferin and other products (Figure 1). In order to determine the optimal temperature for this enzyme, scientists added ATP to a solution containing D-luciferin, luciferase, and other substances needed for the reaction. They then measured the amount of light emitted during the first three seconds of the reaction when it was carried out at different temperatures.

$$\text{D-Luciferin} + O_2 + \text{ATP} \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + CO_2 + \text{AMP} + PP_i + \text{Light}$$

Figure 1. Light is emitted as a result of the reaction catalyzed by luciferase.

(a) Describe a characteristic of the luciferase enzyme that allows it to catalyze the reaction.

Question 3

(b) Identify the dependent variable in the experiment.
(c) State the null hypothesis for the experiment.
(d) A student claims that, as temperature increases, there will be an increase in the amount of light given off by the reaction in the first three seconds. Support the student's claim.

Solution 3

(a)

Mark scheme

- The luciferase enzyme has an active site/shape that can bind the substrate(s) and bring the reactants together (or has a charge compatible with the substrate(s)), allowing it to catalyze the light-producing reaction.

Solution 3

(b)

Mark scheme

- The dependent variable is the amount of light emitted (measured during the first three seconds of the reaction).

Solution 3

(c)

Mark scheme

- Null hypothesis: temperature has no effect on the amount of light emitted by the luciferase reaction.

Solution 3

(d)

Mark scheme

- Support for the student's claim: higher temperature increases the frequency of collisions/interactions between molecules (substrate and enzyme), resulting in an increased reaction rate and thus more light emitted in the first three seconds; alternatively, the higher temperature causes a change to the active site that enhances substrate binding, also increasing the reaction rate.

Question 6

2019 ▪ Q6

TABLE 1 (data table referenced by the question, reproduced below as Table 1 with the growth results for the three haploid strains):

	MEDIUM	STRAINS — Wild Type	STRAINS — Mutant 1	STRAINS — Mutant 2
Treatment I	All amino acids present	+	+	+
Treatment II	No amino acids present	+	−	−
Treatment III	All amino acids present EXCEPT methionine	+	−	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	−

Question 6

Table 1. The data show the growth of haploid *Saccharomyces cerevisiae* yeast strains on media that differ in amino acid content. A plus sign (+) indicates that the yeast strains grow, and a minus sign (−) indicates that the strains do not grow.
The yeast *Saccharomyces cerevisiae* is a single-celled organism. Amino acid synthesis in yeast cells occurs through metabolic pathways, and enzymes in the synthesis pathways are encoded by different genes. The synthesis of a particular amino acid can be prevented by mutation of a gene encoding an enzyme in the required pathway.

Question 6

A researcher conducted an experiment to determine the ability of yeast to grow on media that differ in amino acid content. Yeast can grow as both haploid and diploid cells. The researcher tested two different haploid yeast strains (Mutant 1 and Mutant 2), each of which has a single recessive mutation, and a haploid wild-type strain. The resulting data are shown in Table 1.

(a) Identify the role of treatment I in the experiment.

Question 6

		STRAINS			
	MEDIUM	Wild Type (haploid)	Mutant 1 (haploid)	Mutant 2 (haploid)	Diploid Cells Produced by Mating Mutant 1 and Mutant 2
Treatment I	All amino acids present	+	+	+	
Treatment II	No amino acids present	+	–	–	
Treatment III	All amino acids present EXCEPT methionine	+	–	+	
Treatment IV	All amino acids present EXCEPT leucine	+	+	–	

Question 6

		STRAINS		
	MEDIUM	Wild Type	Mutant 1	Mutant 2
Treatment I	All amino acids present	+	+	+
Treatment II	No amino acids present	+	−	−
Treatment III	All amino acids present EXCEPT methionine	+	−	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	−