

20.1 Enzyme rate and controlled measurements

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS enzyme • denaturation

Objective

Enzyme rate and controlled measurements. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

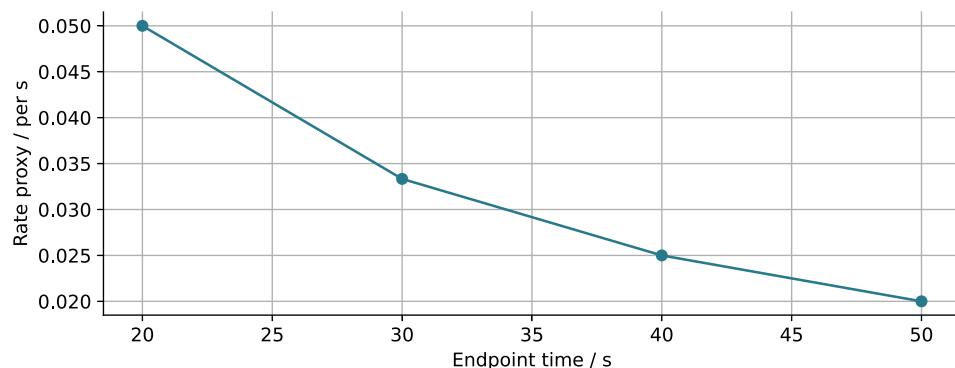
1 Key knowledge and worked examples

■ What would explain this observation?

- An **enzyme** works quickly at one temperature and slowly at another. Heating can increase successful collisions, but excessive heat can change the active site.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- An enzyme is a biological catalyst. The substrate binds at an active site whose shape and chemical properties support the reaction. A catalyst increases rate without being used up overall.
- enzyme: A biological catalyst; **denaturation** : A structural change that disrupts function.



■ Choose evidence that can test it

- Measure rate using product formed per unit time or a fixed endpoint. For an endpoint test, $1/\text{time}$ is a rate proxy if the same amount of product or substrate change defines the endpoint each time.
- For starch digestion, equilibrate enzyme and starch in a water bath, control pH with buffer, mix measured volumes, and test samples with iodine at fixed intervals. Use a clean spot for each test. Do not put iodine into the reaction mixture.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: the endpoint is reached in 40 s. Use rate proxy = $1/\text{time}$. Rate proxy = $1/40 = 0.025$ per second. At 20 s the proxy is 0.050 per second, twice as large. This comparison is valid only if the same endpoint and starting concentrations are used.

Example:

A fixed endpoint takes 50 s. Calculate the rate proxy $1/\text{time}$. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- An optimum is specific to the enzyme and conditions. Low temperature usually slows the reaction; it does not necessarily denature the enzyme. Endpoint intervals limit precision.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A low temperature always permanently denatures an enzyme. This claim is false: An optimum is specific to the enzyme and conditions. Low temperature usually slows the reaction; it does not necessarily denature the enzyme. Endpoint intervals limit precision.

Key:

Enzyme rate and controlled measurements: Measure rate using product formed per unit time or a fixed endpoint. For an endpoint test, $1/\text{time}$ is a rate proxy if the same amount of product or substrate change defines the endpoint each time.

2 Practice

2.1 Which change best tests the effect of pH? Choose one answer.

- **A** Change pH and temperature together
 - **B** Use buffers of different pH at one temperature
 - **C** Change enzyme concentration at each pH
- [1]

2.2 A fixed endpoint takes 50 s. Calculate the rate proxy $1/\text{time}$. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: A low temperature always permanently denatures an enzyme.

[2]

2.4 A biological catalyst: write the technical term.

[1]

3 Exam-style questions

3.1 One trial reaches a fixed endpoint in 20 s; another reaches twice as much product in 30 s. Can their rates be ranked by $1/\text{time}$? Explain using product/time.

[4]

Solutions

2.1 B Measure rate using product formed per unit time or a fixed endpoint. For an endpoint test, $1/\text{time}$ is a rate proxy if the same amount of product or substrate change defines the endpoint each time.

2.2 rate proxy = $1/t = 1/50 = 0.020 \text{ s}^{-1}$.

2.3 False. An optimum is specific to the enzyme and conditions. Low temperature usually slows the reaction; it does not necessarily denature the enzyme. Endpoint intervals limit precision.

2.4 enzyme. enzyme means A biological catalyst.

3.1 No: endpoints differ. Relative product/time values are $1/20$ and $2/30$; the second average is $4/3$ of the first under comparable conditions. Reciprocal-time comparison requires the same endpoint.