16.1 Enzyme rate and controlled measurements

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS enzyme • denaturation

Objective

Enzyme rate and controlled measurements. Original classroom practice for IB SL; not an official IB paper.

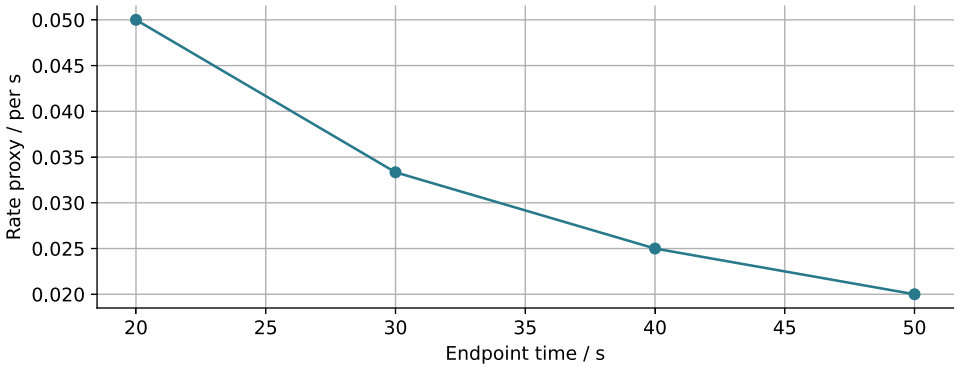
1 Key knowledge and worked examples

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.

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/time is a rate proxy if the same amount of product or substrate change defines the endpoint each time.

In the lab: 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

- Known: the endpoint is reached in 40 s.
- Use rate proxy = 1/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.

Your turn: A fixed endpoint takes 50 s. Calculate the rate proxy 1/time.

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.

Not true: A low temperature always permanently denatures an enzyme. Low temperature usually only slows an enzyme because molecules collide less often; the active site is unchanged and warming restores activity. Denaturation is a structural change from excessive heat or extreme pH, not a guaranteed result of cooling.

Key:

- An enzyme is a biological catalyst.
- Measure rate using product formed per unit time or a fixed endpoint.
- Watch for: an optimum is specific to the enzyme and conditions.

Write from a rate proxy of 0.025 per second

- A fixed endpoint takes 40 s.
- The rate proxy is 1 divided by time. A low temperature usually slows an enzyme. It does not permanently denature it.

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/time. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Low temperature usually only slows an enzyme because molecules collide less often; the active site is unchanged and warming restores activity. [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/time? Explain using product/time. [4]

Solutions

2.1 B Testing pH means changing only pH. Buffers of different pH at one fixed temperature isolate pH as the variable; changing temperature or enzyme concentration at the same time would mix two variables and the result could not be attributed to pH.

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

2.3 True. True. Low temperature usually only slows an enzyme because molecules collide less often; the active site is unchanged and warming restores activity. Denaturation is a structural change from excessive heat or extreme pH, not a guaranteed result of cooling.

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.