AP BIOLOGY · UNIT 3 · TOPIC 3.2

Environmental Impacts on Enzyme Function

Learning objective 3.2.A Explain how environmental factors (temperature, pH and concentration) affect the structure and function of an enzyme.

Name: Date: Period:

Use the tool **Push It Too Far**. Part 1 and Part 2 use the **Temperature and pH** tab, Part 3 uses **Concentration**, Parts 4 to 6 use **Two inhibitors**, and Part 7 uses **Check yourself**. Each question in this topic is about the shape of a graph, so sketch the graph before writing an answer.

switch tab *scroll down* *record from the tool*

sketch a graph *score yourself* *reset the tool*

The purple bar in the margin names the AP science practice a question uses.

Part 1 · Where each enzyme works fastest

Temperature and pH | Concentration | Two inhibitors | Check yourself

Use the **Temperature and pH** tab. It is the one showing when the tool opens.

Select each enzyme in turn. Before every reading, press **Fetch a fresh batch of enzyme**, so each reading starts with an intact enzyme at its own optimum. Then set only the condition named in the column head and record the rate.

Enzyme	Optimum temperature	Rate at 37 °C	Rate at pH 7	Rate at pH 2
A human enzyme				
Pepsin				
Hot-spring enzyme				

SP 4 · REPRESENTING AND DESCRIBING DATA

1. Describe the effect of temperature on the reaction rate, from well below the optimum temperature to well above it.

2. Pepsin and the human enzyme have the same optimum temperature but very different optimum pH values. Explain why no single pH is optimal for all enzymes.

Part 2 · What comes back and what does not

Stay on the **Temperature and pH** tab.

Select **A human enzyme** and press **Fetch a fresh batch of enzyme**. Carry out each row of the table in order, using a fresh batch at the start of every row.

Step	**Rate at the end**	**Site intact or denatured?** *circle one*
Set the temperature to 47 °C		intact / denatured
…then back to 37 °C		intact / denatured
Fresh batch, then 57 °C		intact / denatured
…then back to 37 °C		intact / denatured
Fresh batch, then pH 12		intact / denatured
…then back to pH 7		intact / denatured

SP 4 · REPRESENTING AND DESCRIBING DATA

3. In the Part 2 table, the enzyme recovered its rate after one of the three treatments but not after the other two. Describe how the treatment the enzyme recovered from differs from the two it did not recover from.

SP 1 · CONCEPT EXPLANATION

4. Explain, in terms of protein structure, why cooling a denatured enzyme back to its optimum temperature does not restore the reaction.

SP 6 · ARGUMENTATION

5. A student heats an enzyme to 60 °C, sees the reaction stop, cools it to 37 °C and predicts the reaction will restart. Evaluate the student's prediction.

Part 3 · Two things that raise the rate, and one ceiling

Temperature and pH | **Concentration** | Two inhibitors | Check yourself

Click the **Concentration** tab at the top of the tool.

Select 1× enzyme. Move the substrate slider to each value and record the rate and the gain the readout shows.

[S]	Rate	Gain from the last +25	Share of the maximum
25			
50			
100			
200			
400			

6. (a) Describe the effect of increasing the substrate concentration on the gain in rate from each added 25 units.

(b) Explain why the gain changes in this way.

7. With the substrate slider at 400, switch to 2× enzyme.
(a) Describe the effect of doubling the enzyme concentration on the rate at [S] = 400.

(b) Describe the effect of doubling the enzyme concentration on the maximum rate.

(c) Explain how the effect of doubling the enzyme concentration differs from the effect of adding more substrate in question 6.

SP 1 · CONCEPT EXPLANATION

8. The rate of a reaction stays constant even as more substrate is added.
(a) Identify the factor that limits the rate.

(b) Describe one change that would increase the rate.

Part 4 · Two inhibitors, one experiment

Temperature and pH | Concentration | **Two inhibitors** | Check yourself

Click the **Two inhibitors** tab at the top of the tool.

Press **Set [S] to 25** and record the top row, then press **Flood it with substrate** and record the bottom row.

Substrate	No inhibitor	Competitive	Non-competitive
[S] = 25			
[S] = 600			

SP 3 · QUESTIONS AND METHODS

9. Explain why a single rate measurement at [S] = 25 cannot identify which inhibitor is present.

10. (a) Propose an experiment that would distinguish a competitive inhibitor from a non-competitive inhibitor.

(b) Predict the result that would indicate each type of inhibitor.

Part 5 · Identify three flasks

Stay on the **Two inhibitors** tab and scroll down to the **Identify the inhibitor** panel.

Work three flasks. For each one, record the two rates given, the inhibitor you identify, and a short reason.

Flask	Rate at ordinary [S]	Rate when flooded	Inhibitor *circle one*	Reason
1			competitive / non-competitive	
2			competitive / non-competitive	
3			competitive / non-competitive	

11. (a) Identify the measurement that best distinguishes a competitive inhibitor from a non-competitive inhibitor.

(b) Explain why that measurement distinguishes them.

12. A reaction mixture contains a competitive inhibitor. Predict the effect of doubling the substrate concentration on the reaction rate. Justify your prediction.

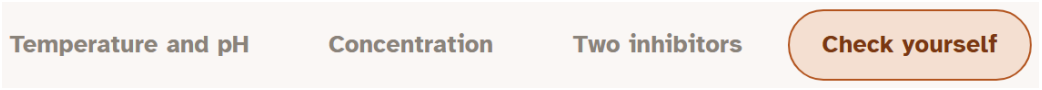
SP 6 · ARGUMENTATION

Part 6 · Draw the three curves

This graph is one of the most common ways this topic is tested. Construct it from memory first, then check it against the **Two inhibitors** tab and correct it in a different color.

13. Construct an appropriately labeled graph that represents the reaction rate as a function of substrate concentration for an uninhibited enzyme, the same enzyme with a competitive inhibitor, and the same enzyme with a non-competitive inhibitor. Mark the maximum rate each curve reaches.

Part 7 · Learning check self-report



Click the **Check yourself** tab at the top of the tool.

The **Learning check** is at the top of that tab. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

Question	Points possible	Points I earned	Missed opportunities (what the rubric wanted that I left out)
1	3		
2	2		
3	3		
4	2		
5	3		
Total	**13**		

What the model simplifies

The temperature and pH curves are drawn as symmetrical bell shapes with a hard cut-off at the denaturing point. Real curves are not symmetrical: the fall above the optimum is steeper than the rise below it, because two different things are happening. Denaturation also sets in over a range rather than at a single temperature.

Rate is on an arbitrary scale where 1.00 is the enzyme working at its optimum. The substrate curve uses the standard Michaelis–Menten form; Km here is 25 arbitrary units and is used only to give the curve a realistic shape.

Real competitive inhibition is a matter of proportion rather than an on/off switch: the inhibitor and the substrate are always in competition, and raising the substrate shifts the balance. The model captures the outcome (the maximum rate is reached eventually) without modeling the binding equilibrium.

The three enzymes are representative rather than measured. Pepsin's optimum pH of about 2 and its inactivation near neutral pH are real; the hot-spring enzyme stands in for the thermostable enzymes of thermophilic bacteria.