

Name:

Date:



Enzymes: Graphing, Critical Thinking, and Calculating Reaction Rates

Introduction: Enzymes are proteins that are highly specialized to speed up a particular reaction within cells. Without enzymes, the reactions of a cell would proceed too slowly, and the cell would die. Enzymes have a unique three-dimensional shape. Each enzyme has a pocket or groove into which substrate molecules must fit. Substrates are reactant molecules that are being converted to new and different products. Because enzymes lower the activation energy of a reaction, the reaction takes place faster and at a lower temperature.

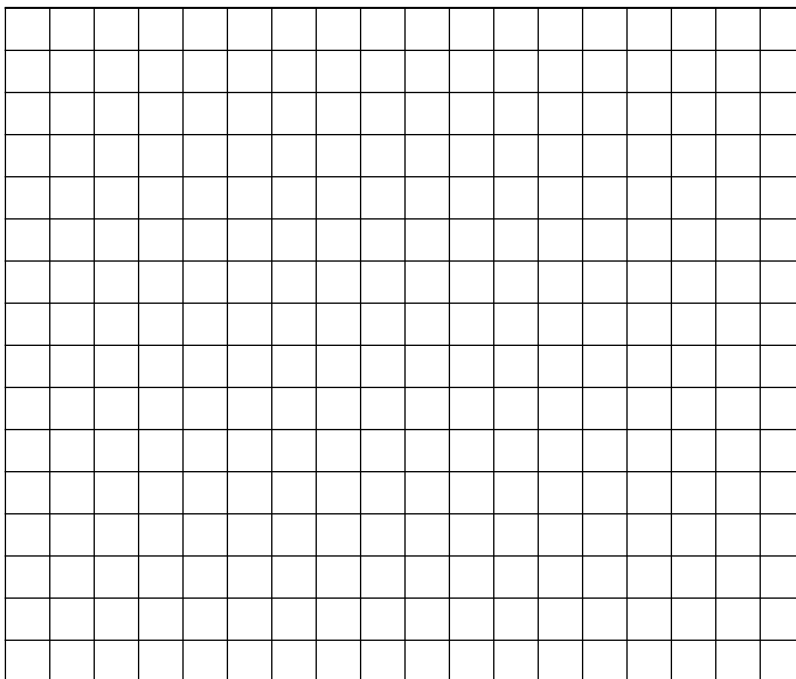
1. What do enzymes do? _____
2. What kind of compound are enzymes? _____
3. What is activation energy? _____

4. What is a substrate? _____
5. What is an active site? _____

Exercise 1: Graphing and Analyzing an Enzymatic Reaction

During the course of an enzymatic reaction, the substrate (reactant) is converted to new and different products. The following data shows the amount of product that is produced over time. Graph the data in the space provided below.

Time (minutes)	Amount of product formed (μmoles)
0 min	0
1 min	10
2 min	20
3 min	30
4 min	35
5 min	39
6 min	42
7 min	42



6. Notice on the graph that the time period between 0 and 3 minutes forms a straight line on the graph. What does this indicate about the rate of the reaction?

Calculating the Rate of Reaction.

Use the equation: $\frac{\Delta_y}{\Delta_x}$ or $\frac{y_2 - y_1}{x_2 - x_1}$

The rate of an enzyme-catalyzed reaction can be measured to determine how fast the enzyme is converting substrate into product. A “rate” is the speed at which something occurs during a certain time period. To determine the rate of reaction, pick any two points on the curve. Divide the difference in the amount of product formed between these two points by the difference in time between them.

7. Calculate the initial rate of the reaction. The initial rate is the time between 0 and 1 minute.
8. Calculate the rate of reaction between 2 and 3 minutes.

9. How does the reaction rate between 0 and 1 minute compare to the reaction rate between 2 and 3 minutes?

10. Does your answer in question 9 agree with your answer in question 6?

11. In a graph of an enzymatic reaction, explain why the line begins as a straight line.

12. As seen on the graph, what happens to product formation between 3 and 6 minutes? Explain what is happening in the reaction at this point.

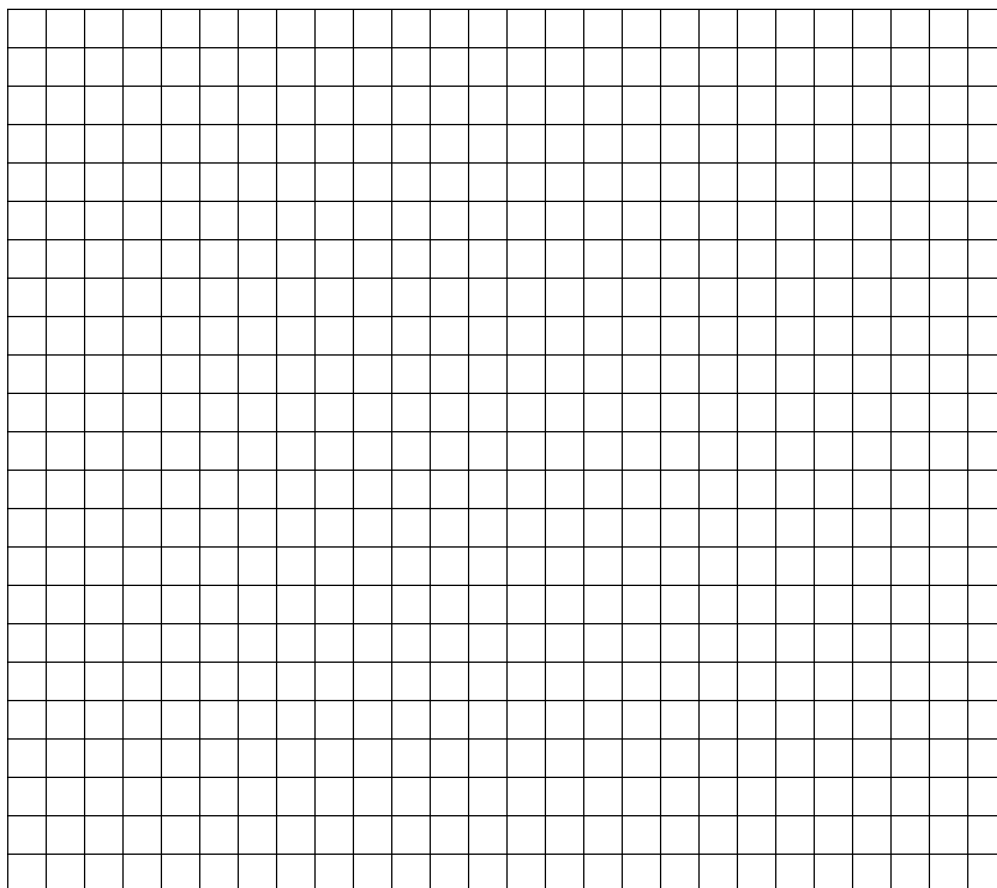
13. What is the rate of reaction after 6 minutes? Show the calculation for this.

14. As seen on the graph and by your calculation above, what happens to the reaction rate after 6 minutes? Explain what is happening in the reaction at this point.

Exercise 2: The Effect of Temperature on Enzyme Functioning

Every enzyme has an optimum temperature at which it functions the best. Below is the data showing the effect of temperature on two different enzymes. Graph the data in the space provided, and answer the questions below.

Temperature (°C)	Rate of Reaction for Enzyme A (mmol/min)	Rate of Reaction for Enzyme B (mmol/min)
5 °C	4	2.2
10 °C	7.5	4.7
20 °C	13.5	9.5
28 °C	16.4	12.8
40 °C	17.4	17.8
50 °C	12.9	20.8
55 °C	7.5	22
60 °C	0	19.5



15. What is the optimum temperature for the functioning of enzyme A? _____
16. What is the optimum temperature for the functioning of enzyme B? _____
17. At what temperature do enzymes A and B have equal reaction rates? _____
18. What conclusion can you draw from the data on enzyme A? _____

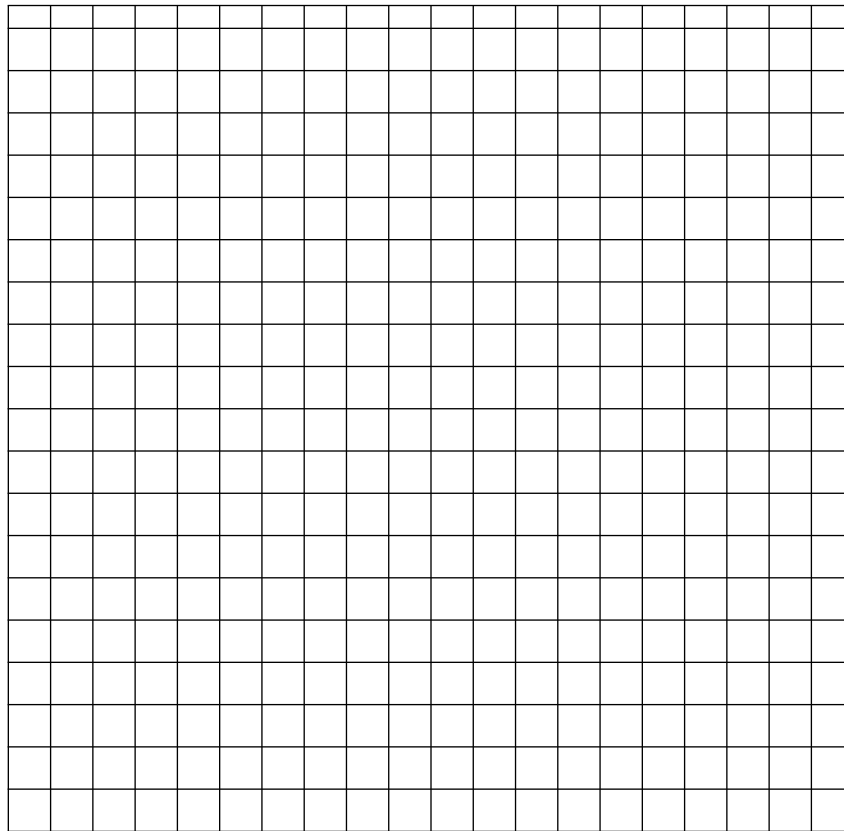
19. In both enzyme A and B the reaction rate increases to a point and then begins to decrease. Explain why the reaction rate begins to decrease.

20. What is the rate of reaction for enzyme A when the temperature is 15 °C? _____

Exercise 3: The Effect of pH on Enzyme Functioning

Every enzyme has an optimum pH at which it functions the best. Below is the data showing the effect of pH on two different digestive enzymes, amylase and pepsin. Graph the data in the space provided, and answers the questions below.

pH	Amylase Reaction Rates (mmol/min)	Pepsin Reaction Rates (mmol/min)
1	0	9.5
2	0	10.5
3	.5	9
4	1	7.5
5	3	2
6	7.5	.5
7	9.0	.2
8	8	0
9	5.5	0
10	2	0
11	.2	0
12	0	0
13	0	0



21. What is the optimum pH for the functioning of amylase? _____
22. What is the optimum pH for the functioning of pepsin? _____
23. Which enzyme works best in a highly acidic environment? _____
24. Both amylase and pepsin are enzymes found in the digestive system of mammals. However, these enzymes are found in different locations of the digestive system. Given the data in the data table, suggest a possible location as to where these enzymes might be found.
- _____
- _____
- _____
- _____
25. What happens to an enzyme that is placed in an environment drastically different from its optimum pH? _____
- _____