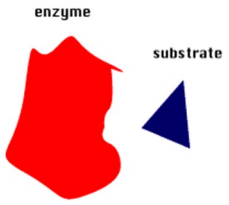
Name _____



Toothpick-ase: Introduction to Enzymes

Enzymes are proteins that are used as **catalysts** in biochemical reactions. A catalyst is a factor that controls the rate of a reaction without itself being used up. In biological systems, enzymes are used in all metabolic reactions to speed up the rate of a reaction and decrease the amount of energy necessary for the reaction to take place **(activation energy)**. Enzymes are **specific** for each reaction and are **reusable**. Each enzyme has an area called the **active site** to which a specific **substrate** will bond temporarily while the reaction is taking place. There are a number of factors that can affect the rate of an **enzyme-facilitated reaction**, such as the presence of the enzyme itself, **substrate concentration** and **temperature.**

Purpose: To simulate how substrate concentration and temperature affect enzyme function.

Part A- Rate of Product Formation in an Enzyme-Facilitated Reaction

Materials:

100 toothpicks per team	Bowl	Ice
Timer	Pencil	Paperclips

Procedures:

Part A: Rate of Product Formation in an Enzyme-Facilitated Reaction

In this activity, "Toothpickase" is a fictitious DIGESTIVE ENZYME which breaks down toothpicks into two units. The toothpicks represent the substrate and your thumbs and index fingers represent the enzyme, Toothpickase. When you break a toothpick, the place where the toothpick fits between your fingers represents the active site of the enzyme.

1. Count out 100 unbroken toothpicks into a bowl on your desk.
2. Assign team roles: one teammate is the time keeper, one is the recorder, & one will be the enzyme Toothpickase. (Be sure to switch roles for each activity so everyone gets a job.)
3. The Toothpickase person (the enzyme) will break toothpicks without looking at the bowl and all of its products (broken toothpicks). All broken toothpicks must remain in the bowl along with the unbroken toothpicks because the products and reactants mix together in metabolic reactions. You cannot re-break a broken toothpick- it has already been acted upon!
4. WITHOUT LOOKING AT THE BOWL, break as many toothpicks as you can in 10 seconds and record this on Data table 1.

   Remember: DO NOT BREAK TOOTHPICKS ALREADY BROKEN! When counting, two halves equal a whole broken toothpick. After counting, leave the broken toothpicks in the bowl.

5. Do another 10 seconds of breaking (20 seconds total now), then count and record the number of toothpicks broken.
6. Do another 10 seconds of breaking (30 seconds total now), then count and record the number of toothpicks broken.

7. Continue breaking toothpicks for these total time intervals (60, 120, and 180 seconds). **REMEMBER TO ALWAYS THROW BROKEN TOOTHPICKS BACK IN THE PILE** (because products & reactants stay mixed in reactions), **BUT DON'T RE-BREAK THEM** (the enzyme has already acted on the substrate).
8. Graph the number of toothpicks broken as a function of time (10, 20, 30, 60, 120, & 180 seconds.) Be sure to title your graph and to label the x and y-axis.

Part B: Effect of Substrate Concentration on Reaction Rate

9. Remove the broken toothpicks from the bowl. Place 100 paperclips in the empty bowl. The paper clips represent a "solvent" in which the toothpicks are "dissolved." Different concentrations are simulated by mixing different numbers of toothpicks with the paper clips.
10. For the first trial, place 10 toothpicks in the bowl with the paper clips and mix them up. The enzyme has 20 seconds to react (break as many toothpicks as possible). Remember, the enzyme breaks the toothpicks without looking at the bowl and all of the products (broken toothpicks) must remain in the bowl. The toothpicks can only be digested once- do not break toothpicks already broken! Record the number broken at a concentration of 10.
11. Remove the broken toothpicks and repeat with concentrations of 20, 30, 40, 50, 60, 70, 80, 90, and 100 toothpicks, each time mixing them with the 100 paper clips.
12. Graph the results.

Part C: Effect on Temperature Substrate Concentration on Reaction Rate

13. Select 10 toothpicks. Time how long it takes to break the 10 toothpicks as fast as you can. Record on data table.
14. Place your hands in the pail of iced water for 1 minute. Select 10 new toothpicks. Time how long it takes to break the 10 toothpicks as fast as you can. Record on data table.
15. Calculate the rate of enzyme action for each trial in toothpicks per second.

Data:

Table 1:

Total Time (seconds)	Number of toothpicks broken
10	
20 (additional 10 seconds)	
30 (additional 10 seconds)	
60 (additional 30 seconds)	
120 (additional 60 seconds)	
180 (additional 60 seconds)	

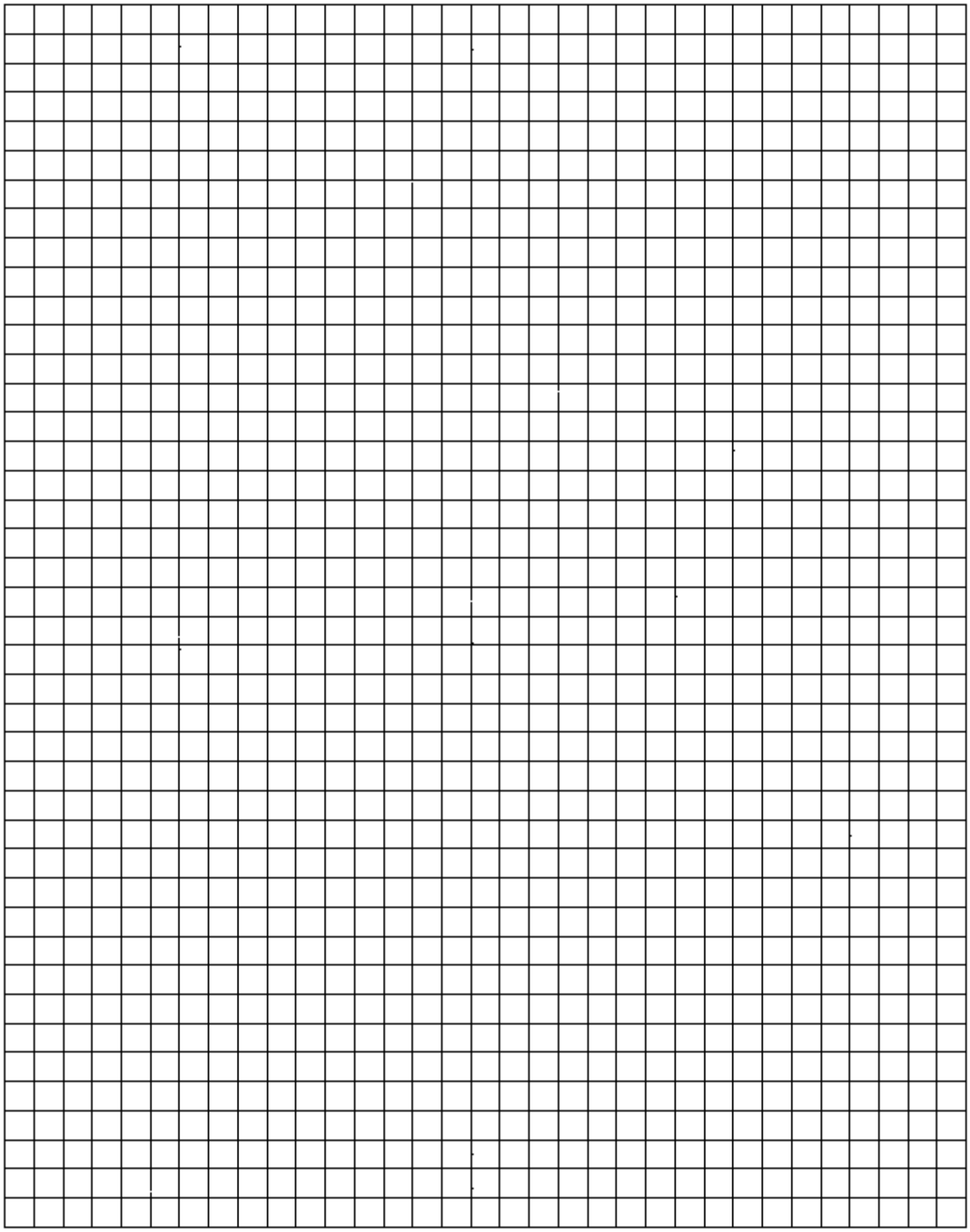
Table 2:

Time (seconds)	Substrate Concentration (Toothpicks)	Number of toothpicks broken
20	10	
20	20	
20	30	
20	40	
20	50	
20	60	
20	70	
20	80	
20	90	
20	100	

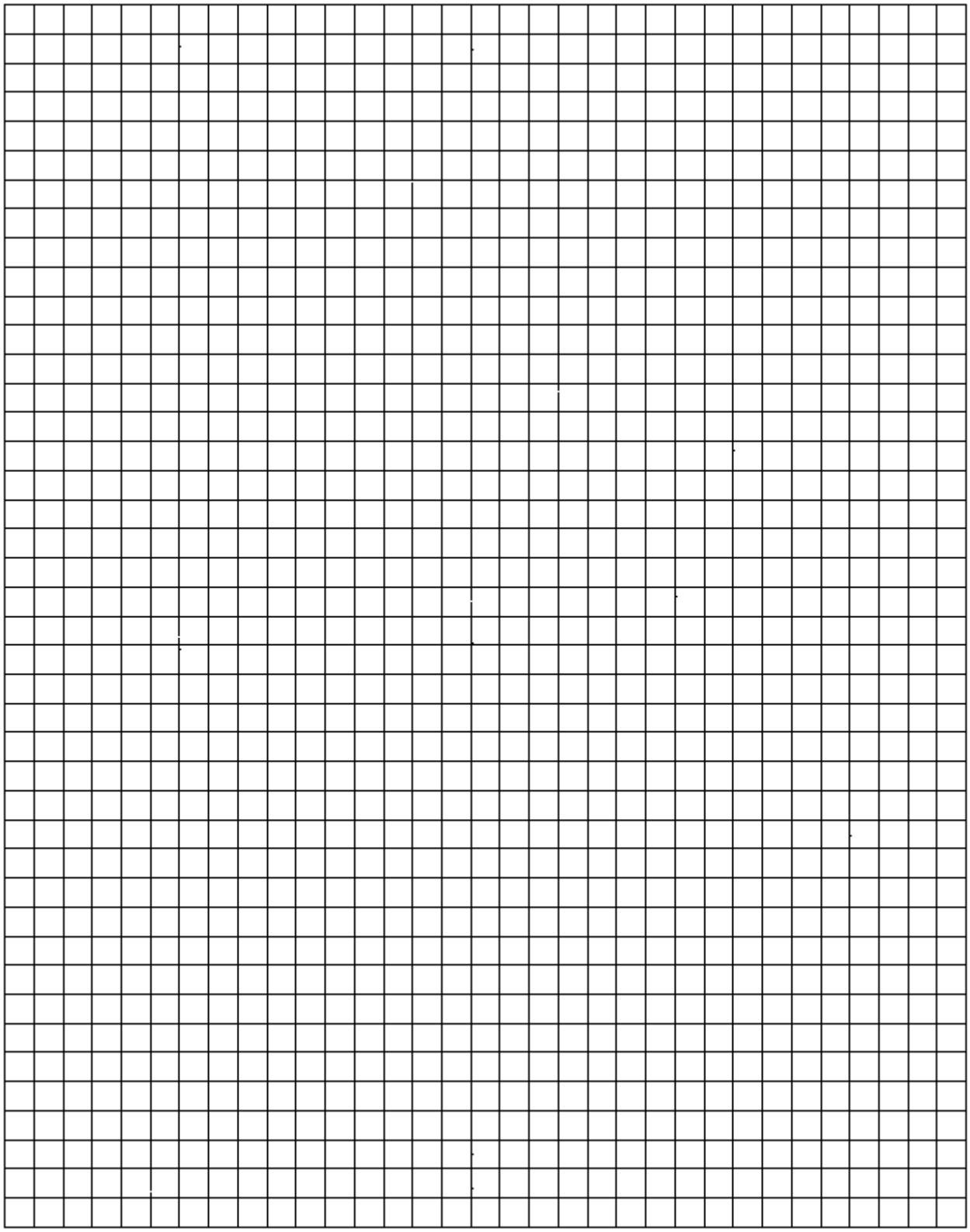
Table 3:

Condition	Number of Toothpicks	Time taken to break 10 toothpicks (sec.)	Rate of enzyme action (toothpicks/sec.)
Trial 1 Enzyme at room temperature	10		
Trial 2 Enzyme at 0º C (ice water)	10		

Graph 1:



Graph 2:



Analysis:

1. What happens to the reaction rate as the supply of toothpicks runs out?

2. What would happen to the reaction rate if the toothpicks were spread out so that the "breaker" has to reach for them?

3. What would happen to the reaction rate if more toothpicks (substrate) were added?

4. What would happen to the reaction rate if there were two "breakers" (more enzymes)?

5. What happens if the breaker wears bulky gloves (active site affected) when picking up toothpicks?

6. Explain what would happen to an enzyme-facilitated reaction if temperature were increased. Be sure to include the effect if temperature were increased to 100°C.

7. What is the optimal temperature (°C) for enzymes functioning in the human body?

Additional Discussion Topics:

1. Discuss your results and explain why the rates were different at different concentrations. Summarize the effect of substrate concentration on enzyme action
2. Compare the two rates.
3. Discuss your results and explain why the rates were different at different temperatures. Summarize the effect of temperature on enzyme action.