Kinetics: Why Are Some Reactions Fast While Others Are Slow?

Kinetics is a part of chemistry that helps you understand the factors that speed up or slow down a reaction. Most people encounter kinetics every day, whether they realize it or not. Take for example, when you open your refrigerator. Refrigerators cool your food to slow down the processes by which food and milk spoil. In this experience, you are going to observe factors other than temperature that affect reaction speed and come up with an explanation as to how they do so. You will then try to offer examples of kinetics at work in the world.

Watch Video 1

Observe

Summarize what you observed about the relationship between concentration and reaction speed.

As the concentration of hydrogen peroxide increases the rate of the reaction increases.

Identify an Experimental Design Flaw

Describe the problem with conducting a similar experiment to determine how changes to the hydrogen peroxide concentration affect reaction rate, in which the concentrations of hydrogen peroxide and sodium iodide are both varied across three trials.

If I repeat the experiment but vary the concentration of sodium iodide while also varying the concentration of hydrogen peroxide across the three trials, I would not be able to determine which one of the changes led to changes in the reaction rate. In other words, I would have too many independent variables and not enough control variables.

Refine/Expand the Experiment

Describe an experiment you could conduct to investigate the relationship between temperature and reaction rate for the hydrogen peroxide/sodium iodide/soap system.

I could set up an experiment in which temperature is the independent variable, hydrogen peroxide and sodium iodide concentrations are control variables, and reaction rate is the dependent variable. In other words, I could hold constant the reactant concentrations and vary the temperature of the reaction system, perhaps by conducting in a water bath, and observe the impact on the reaction rate, the dependent variable.

Practice Scientific Reasoning

Chemical reactions occur when particles (atoms, molecules, compounds) interact to form new kinds of particles. An idea called “collision theory” tells us that as the number of interactions between particles increases so too does the rate of a reaction.

Why do you think the reaction that used 30% hydrogen peroxide went faster than the reaction that used 10% hydrogen peroxide?

If particles must collide to react, and the number of collisions increases the rate of a reaction, it makes sense that as reactant concentrations, which describe the number of particles in solution, increase that reaction rates should also increase. Thus, it makes sense based on collision theory that 30% hydrogen peroxide decomposed faster than 10% hydrogen peroxide.

Connect to Your World

The conversion of iron to iron oxide is a process commonly called rusting. It results from the chemical reaction of Fe metal with atmospheric oxygen to form Fe_2O_3:

$$Fe(s) + O_2 \rightarrow Fe_2O_3$$

If you take a walk through a large parking lot populated with many cars you may notice that the older ones are more likely to show signs of rust (a reddish brown solid) than the newer cars because rusting is a process that takes time. What things do car manufacturers do to cars to slow or avoid their rusting?

Car manufacturers take steps to prevent collisions between Fe atoms and O_2 molecules from occurring. These steps include painting cars with materials that resist reaction with atmospheric oxygen and using materials that are not composed of iron.

Learn More by Exploring These Links

https://phet.colorado.edu/en/simulation/legacy/reactions-and-rates

At-Home Extension

If you would like to experience kinetics first-hand, in your home, all you need is baking soda, vinegar, tap water, and two glasses. Fill one glass a quarter full with water and then fill to the halfway point with vinegar. Fill the other glass to the halfway point with vinegar alone. You now have vinegar, or acetic acid, in variable concentrations. Add the same, controlled amount of baking soda to each glass and observe which reaction proceeds faster. For a demonstration of this idea, **Watch Video 2.**

Watch Video 2

In School

For an engaging introduction to kinetics, we recommend the following laboratory kit:
https://www.flinnsci.com/360-science-kinetics-of-crystal-violet-fading/