

Kinetics of a Reaction

Inquiry Guidance and AP* Chemistry Curriculum Alignment



Introduction

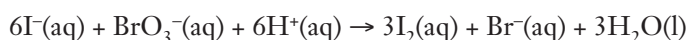
How fast will a chemical reaction occur? If a reaction is too slow, it may not be practical. If the reaction is too fast, it may explode. Measuring and controlling reaction rates makes it possible for chemists and engineers to make a variety of products, everything from antibiotics to fertilizers, in a safe and economical manner. The purpose of this experiment is to investigate how the rate of a reaction can be measured and how reaction conditions affect reaction rates.

Opportunities for Inquiry

Determining the total rate law for an oxidation–reduction reaction is an experiment that combines concepts from several chemistry big ideas and learning objectives such as reactions, rate laws, and catalysts. Kinetics and rate determinations require students to develop science practice skills involving mathematical reasoning and data analysis.

The classic AP chemistry experiment can be transitioned to a guided-inquiry experiment using some or all of the following approaches. These strategies will encourage students to be better prepared, more engaged, and more confident in the lab.

- Take away data tables, post-lab questions and worksheet calculations. Introduce the experiment with a detailed overview that describes the general objective and calculations: “The purpose of this experiment is to utilize a microscale technique to determine the total rate law for the oxidation of iodide ions by bromate ions in the presence of acid.”



- Divide the overall lab, which has several parts, into a cooperative class project. First, the order for each of the reactants may be found by varying the concentration of each reactant individually. The rate constant is then calculated. Secondly, the activation energy is found by repeating the experiment at several different temperatures, measuring the rate, and calculating the rate constants at the different temperatures. A graph of the reciprocal of absolute temperature versus the natural logarithm of the rate constant allows the calculation of the activation energy. Lastly, a catalyst is added and the change in reaction rate is observed.
- Have students convert the lab to a macroscale challenge lab! Instead of drops of reagents, have students convert volumes to milliliters. Instead of reaction strips, use test tubes. Students record reaction times for three concentrations of potassium iodide, and then analyze and graph the results to predict the concentration of KI needed to make the color appear at exactly 35 seconds. Students should conduct several trial runs to refine their graphs and test their predictions. Once satisfied, they are ready for their final test, against the clock!

Alignment with AP Chemistry Curriculum Framework—Big Ideas 1 and 4

Enduring Understandings and Essential Knowledge

All matter is made of atoms. There are a limited number of types of atoms; these are the elements.

(Enduring Understanding 1A)

1A3: The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.

Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. (Enduring Understanding 4A)

4A1: The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent.

4A2: The rate law shows how the rate depends on reactant concentrations.

4A3: The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant.

Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products. (Enduring Understanding 4B)

4B3: A successful collision can be viewed as following a reaction path with an associated energy profile.

Reaction rates may be increased by the presence of a catalyst. (Enduring Understanding 4D)

4D1: Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism.

Learning Objectives

- 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.
- 4.1 The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.
- 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.
- 4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction.
- 4.6 The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate.
- 4.8 The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst.

Science Practices

- 1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.
- 2.2 The student can apply mathematical routines to quantities that describe natural phenomena.
- 4.2 The student can design a plan for collecting data to answer a particular scientific question.
- 5.1 The student can analyze data to identify patterns or relationships.
- 6.1 The student can justify claims with evidence.
- 6.2 The student can construct explanations of phenomena based on evidence produced through scientific practices.
- 6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.

The *Kinetics of a Reaction*—AP Chemistry Classic Laboratory Kit is available from Flinn Scientific, Inc.

| Catalog No. | Description |
|-------------|--|
| AP5913 | Kinetics of a Reaction—AP Chemistry Classic Laboratory Kit |

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