Kinetics and Equilibrium – Bernard Beckerman

Purpose

This lesson will be taught during a unit on kinetics and equilibrium and will help students build a mechanistic understanding of reaction kinetics and equilibrium behavior. Additionally it will teach them how computers can be used to uncover patterns in a seemingly random environment, and how to critique and possibly edit models when their abstract nature falls short of reality.

Overview

Students will model chemical reactions via a computer simulation where collisions of sufficient energy (the activation energy) result in a change of particle species from Blue to Red or vice versa.

Student Outcomes

SWBAT define the reaction constant k and determine the reaction rate r using k and the particle concentrations; conversely SWBAT calculate k given the particle concentrations as a function of time; SWBAT relate the activation energy to the reaction rate constant k; SWBAT define and calculate the equilibrium constant K and use it to calculate equilibrium concentrations; SWBAT relate forward and reverse reaction rates to equilibrium, and see equilibrium as a dynamic state; SWBAT critique the model used and suggest possible improvements and [reach] to edit the model to include these.

Standards Addressed

HS-PS1-5, HS-PS1-6, HS-ETS1-4

Time

Two 40-minute periods. Additionally the model is extensible to be completed alongside a unit on kinetics and equilibrium.

Level

AP chemistry.

Materials and Tools

- Laptops with NetLogo 5.1.0 or later installed.
- Model, worksheet, and Powerpoint slides found here.
  https://northwestern.box.com/s/i3j0rh1tigv44wvcpxl0gnjp0aruy81y

Preparation

Pre-install NetLogo and distribute the model (kinetics-and-equilibrium.nlogo) to your students. Print the attached worksheet (kinetics-and-eq-wksht.docx) for your students and access a computer with projector for the attached slides (kinetics-and-eq-slides.pptx).

Prerequisites

A regular- or honors-level chemistry course should provide sufficient prior knowledge. Specifically, students should be able to define and compute concentrations of molecules, understand the concept of a rate, understand linear functions, slope, and intercept, and be familiar with chemical equations.

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Background
See the attached PPT.

Teaching Notes
On the slide with the skateboarder analogy is a link to the PhET website for a skate park model. It may be useful for students to see the model in action, but if the teacher sees this as a diversion, feel free to skip.

Certain slides of the PPT may be better presented on the chalkboard so the students can see the math in action, particularly the slide titled "Equilibrium Constant *K*". The slide titled "Adjusting the activation energies" should be presented when the students are beginning to change the activation energies during equilibrium, also perhaps on the chalkboard and modified to student questions. This slide may be useful to connect to the skateboarder analogy and should help students understand how changing the activation energies affects the kinetics and equilibrium behavior of the simulation.

Assessment
Assessment is performed via clicker questions, via the attached worksheet, and informally during the lesson and with an exit ticket.
simulation.

Additional Notes
This activity is highly extensible. Students can use it to explore many advanced concepts such as the Arrhenius relationship between the reaction rate coefficient and temperature, or they can modify it so it covers different reactions, for instance by adjoining the two particles via a harmonic spring if a reaction occurs, by requiring three particles to be present for a reaction to study third-order kinetics, or by introducing one or more new species for the existing species to react with.