Unit 6: Design and Manipulate Chemical Reactions: Rates and Equilibrium

Parent Guide

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SC4. Obtain, evaluate, and communicate information about how to refine the design of a chemical system by applying engineering principles to manipulate the factors that affect a chemical reaction.

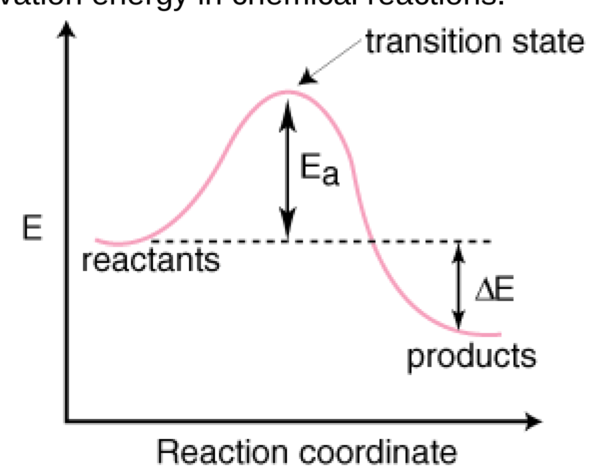
SC4. a. Plan and carry out an investigation to provide evidence of the effects of changing concentration, temperature, and pressure on chemical reactions. (Pressure should not be tested experimentally.)

For this standard, the students will learn how chemists control the rate of chemical reactions by selecting concentrations of reactants, temperatures, and pressures of gaseous reactants. Chemical reactions produce products when the reactant particles collide with enough kinetic energy at the appropriate orientation. Both variables must be correct: energy AND orientation. Chemists can increase the likelihood of productive collisions by increasing the concentrations or temperature of the reactants. Pressure changes affect gaseous reactants. When pressure is increased, less empty space exists between gas particles. More collisions are likely to occur, which statistically increases the possibility for productive collisions. Students can carry out a chemical reaction at various temperatures to discover the effects of increasing and decreasing temperature on rates of reactions. Students can also change the concentrations of reactants to discover the effects of reactant concentrations on rate. These experiences should prepare students to plan and carry out another experiment to provide their own evidence to support their conceptual understandings.

SC4. b. Construct an argument using collision theory and transition state theory to explain the role of activation energy in chemical reactions. (Reaction coordinate diagrams could be used to visualize graphically changes in energy (direction and flow and quantity) during the progress of a chemical reaction.)

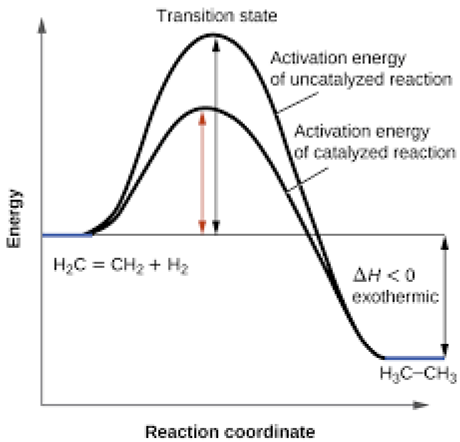
For this standard, the students will understand the role of activation energy in chemical reactions.

According to collision theory, chemical reactions only produce products when the reactant particles collide with enough kinetic energy at the appropriate orientation. Both variables must be correct: energy AND orientation. The kinetic energy is significantly related to the activation energy, or energy required for a reaction to proceed. When activation energy is achieved, the reactants will collide with enough energy, but the orientation of the particles collisions is not for certain. If the orientation is correct, then a transition state complex will occur.



Transition state theory follows collision theory. According to transition state theory, the formation of the transition state complex does not ensure products will be formed. The mechanism by which the complex breaks up can cause it to revert back to reactants or form products. In other words, the formation of reaction products occurs only after many variables from kinetic energy to collision orientation to transition state decomposition have aligned favorably.

SC4. c. Construct an explanation of the effects of a catalyst on chemical reactions and apply it to everyday examples.

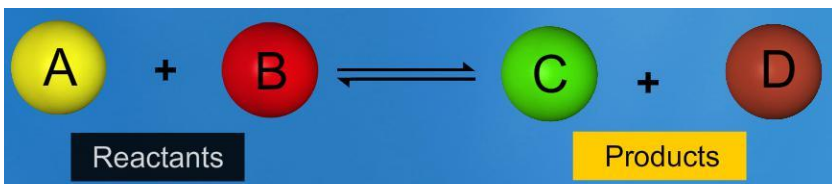


Chemists add catalysts to chemical reactions to lower the activation energy. With a lower activation energy, particles require less energy to reach the transition state. Catalysts do not alter the energy of the reactants or products, and they are not changed during the reaction. Therefore, catalysts are not considered reactants or products. Catalysts are extremely common in nature. Everyday life is impacted greatly by their ability to speed up necessary reactions.

http://www.scienceclarified.com/everyday/Real-Life-Chemistry-Vol-2/Catalysts-Real-life-applications.html

SC4. d. Refine the design of a chemical system by altering the conditions that would change forward and reverse rates and the amount of products at equilibrium. (Emphasis is on the application of LeChatelier's principle.)

For this standard, students will learn chemical reactions are often reversible, and reversible reactions reach a state of equilibrium where the forward and reverse reactions occur at the same rate. Chemists need to disrupt the equilibrium to push the production of specific compounds.



Equilibrium is reached by the following process:

- The reaction converting reactants to products is called the forward reaction. The forward reaction begins and products are quickly produced. As the concentrations of the reactants decrease, the rate of the forward reaction slows.
- As product molecules build up, they begin to collide. The reverse reaction begins slowly. As the concentrations of the products increase, the reverse reaction speeds up.
- Eventually, the forward and reverse reactions will reach equal rates. This state is called equilibrium. Reversible reactions will remain at equilibrium unless disturbed by an outside source.
- Equilibrium can present a challenge to a chemist who is trying to produce a certain product because the product is constantly being converted back to reactants.

Le Chatelier's principle explains that a chemical reaction will strive to maintain equilibrium and respond when stresses are introduced to disturb the equilibrium. Put simply, a reaction will attempt to undo what chemists do. Students must first learn to predict how an equilibrium system will respond to specific disturbances, and then students can begin designing their own plans to control the direction of a reaction.