04 Applications of Chemical Reactions

Content Area: **Science**
Course(s): **Chemistry CP**
Time Period: **Semester 2**
Length: **10 weeks**
Status: **Published**

Standards

HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
	Constructing Explanations and Designing Solutions
	Patterns
HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
	Constructing Explanations and Designing Solutions
PS1.B	Chemical Reactions
	Stability and Change
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
	Constructing Explanations and Designing Solutions
ETS1.B	Developing Possible Solutions
	Stability and Change

Enduring Understandings

1. The macroscopic rate of chemical processes—whether in gaseous mixtures, aqueous solutions, or acid-base neutralizations—is governed by the frequency, orientation, and energy of molecular collisions. Altering external conditions, specifically increasing the temperature (which raises particle kinetic energy) or increasing the concentration/pressure of reacting particles, directly accelerates reaction rates by maximizing effective collisions.

2. Many chemical systems establish a dynamic, condition-dependent balance where forward and reverse reaction rates are equal, determining the final amounts of reactants and products present. This equilibrium state is highly sensitive to external stresses; scientists can intentionally manipulate and refine a chemical system by altering conditions like temperature, pressure, or concentration to shift the balance and optimize product yields.

3. Chemical and electrochemical transformations are driven by the rearrangement of conserved atoms and the flow of electrons, resulting in strict mass conservation and a precise balance between chemical binding energy and kinetic or electrical energy. These principles dictate how batteries store and release electrical energy, how solutions conduct currents via dissolved ions, and how energy flows through biological and geophysical systems.

4. The macroscopic behavior of gases—defined by predictable relationships between volume, temperature, pressure, and particle velocity—underlies major planetary systems and human industrial processes. The accumulation of specific gaseous combustion products in the atmosphere alters global thermal energy retention, necessitating the deep study of gas behavior to accurately model, analyze, and predict human-induced climate change.

5. Engineering sustainable solutions to reduce human impacts on climate change and optimize chemical systems requires balancing competing constraints, including cost, safety, reliability, and socio-environmental impacts. Because complex design problems cannot be solved with a single unyielding approach, engineers break criteria down systematically, utilize trade-off matrices, and employ computer simulations to iteratively test and refine technologies like carbon-capture systems, alternative batteries, and green chemical manufacturing.

Essential Questions

1. How do the invisible mechanics of molecular collisions, particle orientations, and kinetic energies dictate the predictable, macro-level speed of a chemical reaction?

2. In what ways can a scientist manipulate variables like temperature, concentration, or pressure to intentionally accelerate or slow down chemical processes in gaseous mixtures and aqueous solutions?

3. How does a chemical system establish a state of dynamic equilibrium, and how can Le Chatelier's principle be leveraged to force a system to yield maximum products?

4. How do the microscopic characteristics of acids, bases, and buffer solutions maintain a condition-dependent chemical balance within highly sensitive biological and environmental systems?

5. How does the strict conservation of mass and the flow of subatomic particles allow us to manipulate chemical binding energy to store and release electrical power in device batteries?

6. How do shifts between chemical binding energy and thermal kinetic energy explain the difference between a highly stable system and a spontaneous, destructive transformation like a grease fire or contact explosion?

7. How do the mathematical relationships governing gas particles (pressure, volume, temperature) allow us to model, predict, and analyze the thermal retention capacity of Earth’s atmosphere?

8. When designing a technological solution to mitigate human impacts on global climate change, how do engineers systematically evaluate trade-offs between competing criteria like cost, safety, reliability, and social impact?

9. How can iterative testing frameworks, physical prototypes, and computer simulations be used to refine and optimize green technologies, such as carbon-capture mechanisms or alternative fuel infrastructures?

Knowledge and Skills

Knowledge

1. Students will analyze the macroscopic behaviors of gases and reaction rates through a subatomic lens, explaining how altering external conditions—such as manipulating a syringe volume with marshmallows or plunging glowsticks into varying water temperatures—directly shifts particle kinetic energies, collision frequencies, and structural orientations to alter a system's rate of transformation. (DCI PS1.B. Chemical Reactions).

2. Students will evaluate how dynamic chemical equilibria, buffer systems, and phase changes establish condition-dependent balances, analyzing how systems naturally evolve toward minimized energy states or resist external stresses, such as blood pH regulation or shifting (N2O4/NO2) gas colors under varying temperature and pressure. (DCI PS1.B. Chemical Reactions).

3. Students will evaluate how complex chemical and climate-related engineering systems must be systematically optimized, evaluating how changing a single variable to maximize product yield or reduce emissions requires navigating real-world trade-offs between cost, structural safety, reliability, and social impacts. (DCI ETS1.B. Developing Possible Solutions)

Skills

1. Design and conduct an iterative investigation using indicators and various combinations of weak acids/bases (such as baking soda and grape juice invisible ink) to construct a chemical buffer system, justifying its capacity to resist pH degradation against a set of real-world biological or cosmetic manufacturing constraints.

2. Formulate a mathematical model or predictive explanation based on the kinetic molecular theory to calculate how variations in temperature, volume, or pressure alter the threshold frequency of effective collisions, using empirical evidence from balloon popping or the iodine clock reaction.

3. Refine the design of a reversible chemical system (such as an oscillating clock reaction or the N2O4 NO2 equilibrium system) by specifying precise external condition modifications that utilize Le Chatelier's principle to force an increased amount of product yield at equilibrium.

4. Evaluate the efficacy of competing technological climate solutions—such as alternative fuel combustion or atmospheric carbon-capture methods—by using an interactive computational model to systematically analyze and weigh maximum chemical efficiency against real-world constraints like implementation costs, public safety, structural reliability, and long-term socio-environmental impacts.

Resources

Core Resources:

CK-12 Chemistry Intermediate

Supplemental Resources:

- Chemistry in the Community 4th Edition
- Edpuzzles
- Pivot Interactives
- Antacid Reading
- Acid Sea Reading
- Phet pH Scale lab

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing