03 Conservation of Matter and Energy

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

Standards

HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
	Developing and Using Models
PS1.B	Chemical Reactions
	Energy and Matter
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
	Using Mathematics and Computational Thinking
PS1.B	Chemical Reactions
	Energy and Matter
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.
	Using Mathematics and Computational Thinking
PS3.B	Conservation of Energy and Energy Transfer
	Systems and System Models
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
	Planning and Carrying Out Investigations
PS3.D	Energy in Chemical Processes
	Systems and System Models

Enduring Understandings

1. Chemical reactions occur as molecules collide and atoms rearrange into new configurations, a process where total mass is conserved and energy changes are balanced between kinetic energy and bond energies.

2. Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in total binding energy (i.e., the sum of all bond energies in the set of molecules) that are matched by changes in kinetic energy.

3. Reaction rates, energy transfers, and the establishment of dynamic equilibria are dictated by changes in binding and kinetic energy, with uncontrolled systems naturally evolving toward more stable, uniform

energy distributions.

4. Resolving the environmental impacts of these processes and managing natural resources sustainably requires breaking complex problems down into simpler, testable components. To achieve this, engineers and scientists utilize physical prototypes and computer simulations to iteratively design solutions that balance cost, safety, and reliability against social, cultural, and environmental constraints.

Essential Questions

1. What is meant by conservation of energy and matter?
2. How is energy transferred between objects or systems?
3. How do the microscopic collisions of molecules and the rearrangement of atoms dictate the macroscopic changes we observe during a chemical reaction?
4. How can we quantify the amount of energy stored in a bond?
5. How can we quantify the energy released when a bond is broken?
6. How do shifts in binding and kinetic energy govern reaction rates and determine when a system establishes a dynamic, condition-dependent equilibrium?
7. Why do uncontrolled chemical and physical systems naturally progress toward more stable, uniform energy distributions?
8. How can scientists and engineers break down highly complex global environmental impacts into simpler, testable components to design sustainable resource management solutions?
9. How do engineers balance competing constraints—such as cost, safety, reliability, and cultural impacts—when using prototypes and computer simulations to iteratively refine a design?

Knowledge and Skills

Knowledge

1. Students will evaluate the law of conservation of mass during open and closed system reactions, identifying why certain phenomena—like burning steel wool—appear to gain mass due to atmospheric oxygen integration. (DCI PS1.B. Chemical Reactions)
2. Formulate and balance chemical equations representing synthesis, decomposition, combustion, and single/double replacement reactions (such as the calcium carbonate reaction in "bendy bones" or lead nitrate precipitates), proving that total atomic count is strictly conserved. (DCI PS1.B. Chemical Reactions)
3. Students will critique the underlying chemical mechanics of emergency mitigation protocols, justifying

why adding water, flour, or sugar to a grease fire accelerates thermodynamic instability rather than suffocating the reaction. (DCI PS3.D. Energy in Chemical Processes)

4. Students will analyze the quantitative, proportional relationships between reactants and products in a chemical reaction, establishing how balanced equations serve as exact mathematical recipes for matter transformation. (DCI PS1.B. Chemical Reactions)
5. Students will evaluate how a limiting reactant restricts the theoretical yield of a product, analyzing how excess reagents remain unreacted once the limiting component is entirely consumed. (DCI PS1.B. Chemical Reactions)
6. Students will analyze how energy is stored or released during a chemical change, contrasting exothermic reactions (like the intense light and thermal output of burning magnesium wire) with endothermic processes. (DCI PS3.B. Conservation of Energy and Energy Transfer)
7. Students will evaluate phase changes and thermal transitions by tracking kinetic and potential energy shifts along a heating curve, utilizing empirical data from substances like lauric acid. (DCI PS3.B. Conservation of Energy and Energy Transfer)
8. Students will critique how molecular geometry, atomic crowding, and weak chemical bonds create structural "molecular strain," making the sudden degradation of contact explosives highly thermodynamically favorable. (DCI PS3.D. Energy in Chemical Processes)

Skills

1. Formulate and balance complex chemical equations (including synthesis, decomposition, combustion, and single/double replacement reactions), using particle diagrams and mass bar charts.
2. Design and execute a guided investigation to classify unknown reactions based on thermodynamic and physical indicators, utilizing gas-evolution pairs (like barium hydroxide in water) to defend their classifications.
3. Construct a mathematical stoichiometry model using a limiting reactant framework—conceptually modeled first through structured s'mores or sandwich production constraints—to predict theoretical yields, identify excess materials, and calculate percent yield from actual lab data.
4. Design an optimization algorithm or chemical recipe scale-up procedure that adjusts reactant quantities to minimize waste and maximize product output, accounting for real-world material limitations and costs.
5. Construct a particulate-level energy profile diagram to calculate and track net changes in total molecular binding energy vs. kinetic energy, using a food calorimeter setup or the intense exothermic energy release of burning magnesium wire to prove the first and second laws of thermodynamics.
6. Design and test an insulated calorimeter system to quantitatively measure specific heat capacity or enthalpy of a reaction, iteratively modifying the design to minimize environmental heat loss and reduce calculated percent error.

Resources

Core Resources:

CK-12 Chemistry Intermediate

Supplemental Resources:

- Chemistry in the Community 4th Edition
- Edpuzzles
- Pivot Interactives
- Phet: Reactants, Products and Leftovers 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