Standards

HS. CHEMICAL REACTIONS

HS. ENGINEERING DESIGN

Performance Expectation(s)
The materials/lessons/activities outlined in this article are just one step toward reaching the performance expectations listed below.

HS-PS1-6. Matter and its Interactions
Redefine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

HS-PS1-7. Matter and its Interactions
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

HS-ETS1-2. Engineering Design
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Dimension	Name and *NGSS* code/citation	Specific Connections to Classroom Activity
Science and Engineering Practices	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	Students develop a model to represent the process of an airbag deploying with specific emphasis on the chemical reaction occurring within the bag. This takes place over the course of the unit. Through engineering design, students design a model airbag system in a prototype car using a reaction of sodium bicarbonate and acetic acid that will protect a raw egg in a simulated crash test.
	Use Mathematics and Computational Thinking Use mathematical representations of phenomena to support claims.	Students use stoichiometry to support the design of their model airbag system, emphasizing that atoms, and therefore mass, are conserved in a chemical reaction.
	Constructions Explanations and Designing Solutions Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	Students engage in the engineering design process to refine a solution to how we design airbags to inflate with the right amount of gas to prevent harm. This involves designing, building, and refining their own airbag systems and developing an evidence-based explanation based on their efforts.
Disciplinary Core Ideas	**PS1.B: Chemical Reactions** The fact that atoms are conserved, together with the knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	Students develop a deep understanding of chemical reactions through model-based inquiry and engineering design.
	ETS1.C: Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	Students engage in optimizing the design solution through engineering design in which they design and refine their airbag models through a series of individually developed designs and methods of testing with aims of producing a successful airbag design.

Crosscutting Concept(s)	**Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions-including energy, matter, and information flows-within and between systems at different scales. **Energy and Matter** The total amount of energy and matter in closed systems is conserved. **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.	Students construct pictorial models to represent an airbag system and to simulate how the components are related. Additionally, students compare this model to the model constructed through engineering design to see the differences in similar systems. Students participate in a series of activities designed to help students recognize that energy and matter in closed systems is conserved. Students construct models and evidence-based explanations to describe how observable and unobservable mechanisms change within the system before, during and after an airbag is deployed.

Connections to Nature of Science (when appropriate):

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
Science assumes the universe is a vast single system in which basic laws are consistent.

Common Core State Standards Connections:

ELA/Literacy
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-6)

Mathematics
MP.2 Reason abstractly and quantitatively. (HS-PS1-7)
MP.4 Model with mathematics. (HS-ETS1-2)
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and origin in graphs and data displays. (HS-PS1-7)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-7)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-7)