NGSS OVERVIEW

CHEMICAL REACTIONS

Performance Expectation MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Performance Expectation MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Performance Expectation MS-PS1-6*: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Performance Expectation MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Performance Expectation MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

* *Performance expectations marked with an asterisk integrate traditional science content with engineering through a Science and Engineering Practice or Disciplinary Core Idea.*

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **Investigation: Producing Circuit Boards** Students analyze and interpret data to compare the initial and final substances when a copper-coated circuit board is etched. This begins a series of activities that reveal patterns of changes indicating that chemical reactions have taken place.	MS-PS1.A MS-PS1.B	Analyzing and Interpreting Data Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Patterns	ELA/Literacy: RST.6-8.1 RST.6-8.9
2. **Laboratory: Evidence of Chemical Change** Students carry out an investigation and analyze the results to identify evidence that may indicate that a chemical change has taken place. In later activities, the patterns they observe at the macroscopic level will be explained in terms of changes at the atomic/molecular level.	MS-PS1.A MS-PS1.B	Planning and Carrying Out Investigations Analyzing and Interpreting Data Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Patterns	ELA/Literacy: RST.6-8.3 Mathematics: MP.2
3. **Reading: Physical Changes and Chemical Reactions** Students read about observable (macroscopic) and atomic/molecular-level patterns of changes in physical and chemical properties and how they can be signs of chemical reactions. They also read about how to use logical reasoning to avoid mistaking physical changes for chemical changes. They integrate ideas in the reading with their observations of chemical changes in the previous investigation, and analyze and interpret several examples to determine whether a change is physical or chemical.	MS-PS1.A MS-PS1.B	Analyzing and Interpreting Data Obtaining, Evaluating, and Communicating Information Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Patterns	ELA/Literacy: RST.6-8.1 RST.6-8.4 RST.6-8.7 WH.6-8.9

CHEMICAL REACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
4. **Modeling: Chemical Reactions at the Molecular Scale** Students use molecular models to explore the kinds and numbers of each kind of atom, as well as the arrangements of atoms, in the reactants and products of several chemical reactions. The patterns they observe demonstrate the concept of conservation of atoms in chemical reactions, as well as the relationship between changes at the atomic/molecular scale and changes in the observable properties of substances.	MS-PS1.B	Developing and Using Models Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	Energy and Matter Scale, Proportion, and Quantity Structure and Function	ELA/Literacy: RST.6-8.3 Mathematics: MP.2 MP.4
5. **Talking It Over: Physical or Chemical Change?** Students analyze and interpret information on the observable properties of substances before and after a change to determine whether the change is a physical change or a chemical reaction. This activity provides an assessment opportunity for Performance Expectation MS-PS1-2.	MS-PS1.A MS-PS1.B	Analyzing and Interpreting Data Systems and System Models Engaging in Argument from Evidence Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Patterns	ELA/Literacy: RST.6-8.1 SL.8.1
6. **Laboratory: Comparing the Masses of Reactants and Products** Students investigate conservation of mass on a macroscopic scale. Students analyze and interpret data from two reactions to determine how the total mass of the products of a chemical reaction compares to the total mass of the reactants.	MS-PS1.B	Analyzing and Interpreting Data Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	Energy and Matter Systems and System Models Scale, Proportion, and Quantity	ELA/Literacy: RST.6-8.3 Mathematics: MP.2 6.SP.B.5
7. **Modeling: Explaining Conservation of Mass** Students use a combination of molecular modeling and mathematical computation to describe the atomic/molecular basis for mass conservation in chemical reactions. They are introduced to the law of conservation of mass and the relevance of this law to various natural phenomena. This activity provides an assessment opportunity for Performance Expectation MS-PS1-5.	MS-PS1.B	Developing and Using Models Systems and System Models Connections to the Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	Energy and Matter Systems and System Models Scale, Proportion, and Quantity	Mathematics: MP.2 MP.4

CHEMICAL REACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
8. **Investigation: Chemical Batteries** Students investigate how chemical energy can be transformed via a chemical process into electrical energy. After building a prototype wet cell, students brainstorm improvements and build, test, and evaluate new prototypes to meet a set of predetermined criteria within specified constraints.	MS-PS1.B MS-ETS1.B MS-ETS1.C	Constructing Explanations and Designing Solutions	Energy and Matter	ELA/Literacy: RST.6-8.3 Mathematics: MP.2 6.SP.B.5
9. **Laboratory: Thermal Energy and Reactions** Students explore chemical reactions that absorb or release thermal energy. Through classroom discussion, students are introduced to the crosscutting concept that energy and matter are conserved but can transfer within a system between reactants, products, and the environment. They are also introduced to the idea that the absorption or release of energy is caused by the rearrangement of atoms during a reaction. Some rearrangements require energy; others release it.	MS-PS1.B MS-PS3.A	Analyzing and Interpreting Data	Energy and Matter	ELA/Literacy: RST.6-8.3 Mathematics: MP.2 6.SP.B.5
10. **Design: Developing a Prototype** Students undertake a design challenge to construct and test a hand warmer device that uses the thermal energy released from an iron exothermic reaction. When testing their designs, students analyze their results and brainstorm ideas for further modification.	MS-PS1.B MS-ETS1.B MS-ETS1.C MS-PS3.A	Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Developing and Using Models	Energy and Matter	Mathematics: MP.2 6.SP.B.5
11. **Design: Refining the Design** Students use the thermal energy release from combining iron, calcium chloride, and water to design a hand warmer. Students redesign, construct, test, and evaluate their hand warmer designs from the "Developing a Prototype" activity. A new criterion is introduced— students must consider how to control the start of the chemical reaction in their design modifications. This activity provides an assessment opportunity for Performance Expectation MS-PS1-6.	MS-PS1.B MS-ETS1.B MS-ETS1.C MS-PS3.A	Analyzing and Interpreting Data Constructing Explanations and Designing Solutions	Energy and Matter	Mathematics: MP.2 6.SP.B.5

CHEMICAL REACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
12. **Laboratory: Recovering Copper** Students investigate the use of reactions with three metals for reducing copper waste and reclaiming copper from the used copper-etching solution produced in the first activity of the unit. Students use data from their investigation and text sources to develop an evidence- based argument for which metal is the best choice for recovering copper from the waste solution.	MS-PS1.A MS-PS1.B	Analyzing and Interpreting Data Planning and Carrying Out Investigations Engaging in Argument from Evidence	Patterns Energy and Matter	ELA/Literacy: WHST.6-8.1 Mathematics: MP.2
13. **Laboratory: Another Approach to Recovering Copper** Students close the unit by applying what they have learned in previous activities to conduct a final investigation to figure out which precipitation reaction works best to remove copper from wastewater. Students analyze and interpret their data from this activity and previous activities to develop their evidence-based argument for the best choice of reactions.	MS-PS1.A MS-PS1.B	Analyzing and Interpreting Data Planning and Carrying Out Investigations Engaging in Argument from Evidence	Patterns Energy and Matter	ELA/Literacy: WHST.6-8.1 Mathematics: MP.2 6.SP.B.5

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

CHEMICAL REACTIONS

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Unit Issue: The use of chemical reactions to solve problems.

Anchoring Phenomenon: Chemical reactions can be used to solve problems but can also create problems. Examples explored include combining certain substances releases a gas, combining certain substances releases energy (such thermal energy, light, electricity), and combining certain liquids results in a color change or formation of a solid. Students generate and answer questions such as: What happens when new materials are formed? How do particles combine into new substances? How can chemical reactions solve and create problems?

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Sometimes when we make a product, we get side products that we don't want.	What are the wastes from producing circuit boards, and is there anything we can do about them?	What happens when chemical processes are used to produce electronic devices? (Activity 1)	1 (12, 13)	MS-PS1-2 MS-PS1-5	Chemical reactions are used to produce desirable products (circuit boards), but they also lead to production of wastes (by-products) from chemical processes. (Substances can be identified by their properties and can't be made to just "go away.")
When you mix some substances, they do things like fizz, change color, disappear or change temperature.	What is happening when substances appear to change?	How can you tell if a chemical change has occurred? (Activity 2)	2, 3, 5	MS-PS1-2 MS-PS1-5 MS-PS1-6	Four common signs may frequently indicate that chemical reactions have taken place.
		What is the difference between a physical and a chemical change? (Activity 3)			Careful observation of properties is needed to distinguish physical and chemical changes. These macroscopic changes can be explained by what is happening at the level of atoms and molecules.
		Is the phenomenon observed a physical change or a chemical change (reaction)? (Activity 5)			In this activity, students apply what they have learned about physical and chemical changes to several scenarios.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

CHEMICAL REACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
In chemical reactions, the total amount of matter after the reaction is the same as the total amount of matter before the reaction.	How is mass conserved during a chemical reaction?	What happens to atoms and molecules during a chemical reaction? (Activity 4)	4, 6, 7	MS-PS1-2 MS-PS1-5	Atoms are reorganized and conserved in chemical reactions. Changes in the organization of particles at the atomic/ molecular scale helps to explain physical and chemical changes and to distinguish one from the other.
		What happens to the mass of the reactants during a chemical reaction? (Activity 6)			The total mass of the products of a reaction equals the total mass of the reactants.
		Why is mass always conserved in chemical reactions? (Activity 7)			The conservation of atoms during reactions explains the conservation of mass.
When you mix some chemicals, they get hot or cold or give off electricity or light.	How can chemical reactions be used to provide energy?	How can we improve the design of a chemical battery? (Activity 8)	8, 9, 10, 11	MS-PS1-2 MS-PS1-6 MS-ETS1-3 MS-ETS1-4	Changing certain variables can affect how much energy is produced from a reaction.
		What does thermal energy have to do with chemical reactions? (Activity 9)			Chemical reactions can be used to release or absorb thermal energy.
		How do engineers design and test a prototype hand warmer? (Activity 10)			Variables can be modified as a device, such as a cold pack, is designed and refined through testing.
		How can the hand warmer design prototypes be redesigned and improved? (Activity 11)			

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

CHEMICAL REACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Sometimes when we make a product, we get side products that we don't want— but we can do something about it.	What are the wastes from producing circuit boards, and is there anything we can do about them?	Which metal is best at reclaiming copper from the used copper chloride solution? (Activity 12)	12, 13	MS-PS1-2 MS-PS1-5	Several chemical reactions can be used to reclaim copper from circuit board production, and the best reaction to use can be evaluated based on several criteria.
		What is the best option for reclaiming copper metal from the used copper chloride solution? (Activity 13)			

NGSS CORRELATIONS

CHEMICAL REACTIONS

Crosscutting Concepts		Activity Number
Energy and Matter	Matter is conserved because atoms are conserved in physical and chemical processes.	4, 6, 7, 8, 12, 13
	The transfer of energy can be tracked as energy flows through a designed or natural system.	9, 10, 11
Patterns	Macroscopic patterns are related to the nature of microscopic and atomic-level structure	1, 2, 3, 5, 12, 13
Scale, Proportion, and Quantity	Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.	4, 6, 7
Structure and Function	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.	4
Systems and System Models	Systems may interact with other systems and be a part of larger complex systems.	6, 7
Science and Engineering Practices		**Activity Number**
Analyzing and Interpreting Data	Analyze and interpret data to determine similarities and differences in findings.	1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 13
Constructing Explanations and Designing Solutions	Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	8, 10, 11
Developing and Using Models	Develop a model to describe unobservable mechanisms.	4, 7
	Evaluate limitations of a model for a proposed object or tool.	10
Engaging in Argument from Evidence	Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	12, 13
	Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	5
	Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.	13

Science and Engineering Practices		Activity Number
Obtaining, Evaluating, and Communicating Information	Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	3
Planning and Carrying Out Investigations	Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	2, 12, 13
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	1, 2, 3, 5
	Laws are regularities or mathematical descriptions of natural phenomena.	4, 6, 7, 8
Disciplinary Core Ideas		**Activity Number**
Developing Possible Solutions (ETS1.B)	A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.	8, 10, 11
	There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	11
	Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.	8, 10, 11
Optimizing the Design Solution (ETS1.C)	Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.	8, 10, 11
	The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	10, 11
Structure and Properties of Matter (PS1.A)	Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.	1, 2, 3, 5, 12, 13
Chemical Reactions (PS1.B)	Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13
	The total number of each type of atom is conserved, and thus the mass does not change.	4, 6, 7, 12
	Some chemical reactions release energy, others store energy.	2, 3, 5, 8, 9 10, 11

Disciplinary Core Ideas		Activity Number
Definitions of Energy (PS3.A)	The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.	9, 1, 11
Performance Expectations		**Activity Number**
Matter and Its Interactions (PS1)	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (MS-PS1-2)	5
	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (MS-PS1-5)	7
	Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* (MS-PS1-6)	11

COMMON CORE STATE STANDARDS: CONNECTIONS AND CORRELATIONS

CHEMICAL REACTIONS

Making Connections in ELA

As with all SEPUP instructional materials, this unit introduces multiple opportunities for students to engage in a range of ELA practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. Specifically, in the first third of the unit, students build their familiarity with basic chemical reactions and understanding of physical and chemical changes through specific textual evidence which they cite to support their data analysis (RST.6-8.1). Activity 1 in particular has students compare and contrast information from the experiment with textual information (RST.6-8.9). A more complex reading in Activity 3 provides them with additional opportunities to explore domain-specific words and phrases in context (RS.6-8.4), integrate textual and visual information (RST.6-8-7), and to draw evidence from the informational text to support their analysis of chemical and physical changes (WHST.6-8.9). Students engage in collaborative discussions throughout the unit, and in Activity 5 they are provided with a structured activity to build these skills as they analyze and interpret data about physical changes and chemical reactions, building on each other's ideas to help them clearly express their own understanding (SL.8.1). Students investigate concepts at multiple points in the unit (Activities 2, 4, 6, 8, and 9) through experiments requiring multi-step procedures to make observations, collect and analyze data, and develop a deeper understanding of chemical reactions (RST.6-8.3). The unit culminates with Activities 12 and 13 in which students synthesize this understanding in conjunction with two further experiments that provide data which they use as evidence in developing arguments for which materials and methods are the best choices for recovering copper from waste solution (WHST.6-8.1). Specific literacy strategies are embedded throughout the unit to support student development of particular ELA skills and practices. In addition, appendix E in the Student Book contains optional resources to support reading, writing and oral communication.

Common Core State Standards – English Language Arts		Activity Number
Reading in Science and Technical Subjects (RST)	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (RST.6-8.1)	1, 3, 4, 5
	Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. (RST.6-8.3)	2, 4, 6, 8, 9
	Determine the meaning of symbols, Key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. (RST.6-8.4)	3
	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (RST.6-8.7)	3
	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (RST. 6-8.9)	1

Common Core State Standards – English Language Arts		Activity Number
Speaking and Listening (SL)	Engage effectively in a range of collaborative discussions (e.g., one-on-one, in groups, teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (SL.8.1)	5
Writing in History/ Social Studies, Science, and Technological Subjects (WHST)	Write arguments focused on discipline-specific content. (WHST.6-8.1)	12, 13
	Draw evidence from informational texts to support analysis, reflection, and research. (WHST.6-8.9)	3

Making Connections in Mathematics

Throughout this unit, students have numerous opportunities to summarize numerical data sets in the context of the experiments and investigations (6.SP.B.5). In Activity 8, students carry out an investigation to determine the optimal design of a battery. To evaluate their designs, they gather and analyze data on the output of each design. In Activities 10 and 11, students gather and analyze the results of their prototypes and redesigns of a hand warmer. In Activities 12 and 13, students conduct investigations to determine the most effective method for reclaiming copper from waste solution. In the process, they gather and analyze quantitative data. This unit also provides multiple opportunities for students to engage in the important mathematical practice of reasoning abstractly and quantitatively (MP.2). For example, in Activity 2, students reason quantitatively about the substances present before and after a chemical reaction. In Activities 4 and 7, students reason quantitatively about the number and types of atoms in the reactants and products of a chemical reaction. In these same activities, students model chemical reactions with mathematics (MP.4).

Common Core State Standards – Mathematics		Activity number
Mathematical Practice (MP)	Reason abstractly and quantitatively. (MP.2)	2, 4, 6, 7, 8, 9, 10, 11, 12, 13
	Model with mathematics. (MP.4)	4, 7
Statistics and Probability (SP)	Summarize numerical data sets in relation to their context. (5.SP.B.5)	6, 8, 9, 10, 11, 13