MIDDLE SCHOOL PHYSICAL SCIENCE: CHEMICAL REACTIONS

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

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. (SEP: 8; DCI: PS1.A, PS1.B; CCC: Patterns) [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [*Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.*]

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. (SEP: 2 ; DCI: PS1.B; CCC: Energy/Matter) [Clarification Statement: Emphasis is on law of conservation of mass and on physical models or drawings, including digital forms, that represent atoms.] [*Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.*]

Content Overview

This section provides a generic overview of the expectations of the standards above.

During chemical reactions, the atoms of substances rearrange and regroup to produce new substances that have different properties than the original substances. Throughout the reaction and rearrangement, all the atoms are accounted for and none are lost or created. The atoms from the original substance are just in a new configuration and the total number and types of atoms present before the reaction are equal to the total number and types of atoms after the reaction.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- When baking soda (a solid) and vinegar (a liquid) are combined in a flask with a balloon over the opening, the balloon blows up.
- My 1980 Chevrolet pick-up was once painted white. Now it is areas that are brown and full of holes.
- A piece of bread browns in the toaster.
- Taste a pinch of this citric acid and baking soda mixture.
- Smell or taste melted chocolate vs. burned chocolate.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data ● Analyze and interpret data to determine similarities and differences in findings. **Developing and Using Models** ● Develop a model to describe unobservable mechanisms	**PS1.A: Structure and Properties of Matter** ● Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B: Chemical Reactions** ● 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. ● The total number of each type of atom is conserved, and thus the mass does not change.	**Patterns** ● Macroscopic patterns are related to the nature of microscopic and atomic level structure. **Energy and Matter** ● Matter is conserved because atoms are conserved in physical and chemical processes.

Once students have an understanding of atomic and molecular structure, MS-PS1-1, they can explore substance properties and how substances react with one another. The characteristic properties of a substance are determined by the molecular structure of the substance and include melting point, boiling point, density, solubility, flammability and odor. When a substance reacts with another substance, the products of the reaction have new properties unlike those of the original substances (reactants). A chemical reaction is the process by which the atoms of one substance interact with the atoms of another substance to form new substances with different atomic arrangements and characteristic properties. Chemical reactions can be introduced by describing the reaction of $Na_{(s)}$+ $Cl_{(g)}$ → $NaCl_{(s)}$. The explosive and toxic atoms of $Na_{(s)}$ and $Cl_{(g)}$ (reactants) will rearrange to create a new edible molecule of $NaCl_{(s)}$ (product) commonly known as table salt. When a chemical reaction occurs, atoms are rearranged to create a different substance. Even though reactions cannot be seen at an atomic level, observable evidence that a chemical reaction has occurred includes a color change, temperature change, formation of a gas, or formation of a precipitate (a solid formed from mixing of solutions). Students can analyze and interpret data from investigations, such as burning sugar or steel wool, reacting baking soda with vinegar, mixing zinc with hydrochloric acid (HCl), or mixing fat with sodium hydroxide (NaOH) to determine if a chemical reaction occurred. Data collected during investigations may include the properties (density, melting point, boiling point, solubility, etc) of the substances both before and after the chemical reaction to determine if a chemical reaction has occurred and new substances are formed.

In addition to recognizing chemical reactions, students can use these investigations to collect data that can be used to develop a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. The law of conservation of mass states the mass of the products in a

chemical reaction must equal the mass of the reactants. Students demonstrate this law using physical models or drawings, including digital forms that represent atoms in the product and the reactant. The balancing of equations is not a requirement of this bundle, however simple balanced equations (e.g. $2H_2 + O_2 = 2H_2O$; or $N_2 + 3H_2 = 2NH_3$; or $CH_4 + 2O_2 = CO_2 + 2H_2O$) can be utilized to model the law of conservation of mass. The concept that the number of atoms entering a reaction equals the number of atoms at the end of a reaction should be the focus, not the act of balancing equations.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

SEP Analyzing and Interpreting Data

- Describe or show a variety of physical and chemical change examples and have students collect observations for each. Ask students to identify and describe the patterns they see in the organized data.
- Students will differentiate between physical and chemical changes through analysis of data (given or student derived).

SEP Developing and Using Models

- Present students with the Law of Conservation of Mass, then ask students to draw a model that explains this theory using what they know about the atoms in a chemical reaction.

CCC Patterns

- What is one way you could classify substance changes to create groups of changes that are similar to each other? Describe the characteristics you are using to classify the property changes.
- What does the pattern of data you see allow you to conclude about the differences between chemical and physical changes?

CCC Energy and Matter

- What evidence is there that matter is conserved in these scenarios?
    - Baking soda and vinegar reacting to fill up a balloon.
    - Alka Seltzer and water reacting in a closed water bottle cause the lid to pop.

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Develop and use models** to demonstrate the *law of conservation of mass*, and how the atoms are regrouped and rearranged to form new substances with chemical properties that differ from the original substance.
- **Plan and carry out** investigations to determine *patterns* in chemical and physical changes of substances.
- **Analyze and interpret data** to determine *patterns* in how the properties of substances change when they chemically react.
- **Construct explanations** to describe the chemical properties *before and after a chemical reaction*.
- **Engage in argument** using evidence to *describe patterns in determining* when substances have undergone a chemical reaction according to their properties.
- **Make a claim and support it with evidence** that when a chemical reaction has occurred, new substances (products) are formed that have different properties than the original substances (reactants).
- **Analyze and interpret given data** about the characteristic physical and chemical properties of pure substances before and after they interact to *detect patterns among these changes*.