HIGH SCHOOL CHEMISTRY: CHEMICAL REACTIONS

Standards Bundle:

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

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.(SEP:6;DCI: PS1.A, PS1.B; CCC: Patterns) [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] *[Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (SEP:5; DCI: PS1.B; CCC: Energy/Matter, Nature of Science/Consistency) [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] *[Assessment Boundary: Assessment does not include complex chemical reactions.]*

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

The outcome of a simple chemical reaction can be predicted. Chemical reactions under the umbrella of synthesis, decomposition, combustion, single replacement, and double replacement using main group elements can be predicted using only the reactants. Knowledge of valence electrons, trends in the periodic table, and patterns in chemical properties can be used to predict various reactions.

Chemical reactions always start and end with the same amount of atoms, though they will be arranged differently. The number of atoms before the reaction and after the reaction must be equal. In addition, the masses of the reactants must be the same as the masses of the products. The relationship between the masses of atoms in the reactants and to masses of products can be calculated and compared. In addition, moles of reactants and moles of products can be calculated and compared.

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.

- Magnesium is used as a "sacrificial anode" on the hulls of ships.
- A small square battery will produce bubbles in a glass of water.

- When experiencing heartburn or sour stomach, you are advised to take an antacid.
- The mass of a nail changes after it rusts.
- Silver changes color over time.
- Two notched pennies, one post-1982 and one pre-1982, are placed in a beaker of 6M HCl. After soaking for 24 hours, the pennies are removed. The post-1982 penny is hollow and contains only a copper wrapper.

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
Constructing Explanations and Designing Solutions ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Using Mathematical and Computational Thinking** ● Use mathematical representations of phenomena to support claims.	**PS1.A: Structure and Properties of Matter** ● The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** ● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. **Connections to the Nature of Science** ● 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.

Using the periodic table as a model, patterns of electrons in the outermost energy level of atoms can be used to predict chemical and physical properties. Models of atomic structure can be used to discover patterns in the periodic table such as horizontal arrangement based on a number of protons and vertical arrangement based on outer electrons. These patterns within the periodic table can be used to explain and predict an element's reactivity with another element.

Knowing the atomic structure, periodic trends, and patterns within the periodic table can help explain and predict the outcome of a chemical reaction. In addition, electrostatic forces between atoms can be mathematically predicted and used as evidence to explain an element's reactivity and type of bond formed. Furthermore, in a chemical reaction, the law of conservation of mass must be observed. This law can be used to explain how matter is conserved as atoms interact during a chemical reaction. The atomic composition of an element can be used to explain how elements interact and patterns within the periodic table.

Interactions of matter that form new substances are called chemical reactions. Explanations for these chemical reactions can be constructed using patterns found within the periodic table. These claims can be based on the chemical properties of the elements. Through investigations, data may be gathered to show that atoms are conserved during a chemical reaction. Mathematical and computational thinking may be used to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Mathematical and computational thinking are used to calculate the masses of unknown components of a chemical reaction. In a closed system, overall energy and matter are conserved when a chemical reaction occurs, showing consistency in natural systems.

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 Constructing Explanations and Designing Solutions.

- Explain the outcome of the given synthesis reaction based on knowledge of atomic structure, periodic trends, and knowledge of patterns of chemical properties.
- Explain the outcome of given simple chemical reactions based on atomic structure, periodic trends, bond types, and number of valence electrons present in each atom or group of atoms.

SEP Using Mathematical and Computational Thinking

- Use an algebraic expression from data collected in an experiment to prove that in a chemical reaction mass is conserved.

CCC Patterns

- Use the pattern found in combustion reactions to predict their outcome.
- Use the pattern found in synthesis reactions to predict their outcome.
- Use the pattern found in decomposition reactions to predict their outcome.
- Use the pattern found in single replacement reactions to predict their outcome.
- Use the pattern found in double replacement reactions to predict their outcome.

CCC Energy and Matter

- Prove, using two different mathematical representations, that mass is conserved in a balanced chemical reaction.
- Using a given chemical equation, calculate the moles of reactant when given the amounts in mass.

- Using a given chemical equation, calculate the amount of product made using a given number of reactants.

CCC Connections to the Nature of Science

- Using a chemical equation, show that the law of conservation of mass is observed in a chemical reaction.

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.

- **Explain how the** outermost (valence) electrons, which can be predicted by an element's position and *patterns from the periodic table*, can be used to predict the products of a reaction.
- **Discuss how the** *patterns of attraction between elements* allow the prediction of the different types of reactions that may occur.
- **Predict outcomes** of chemical reactions based upon the *patterns of reactivity within the periodic table*.
- **Identify and describe, in mathematical representative terms**, *the relationship between the* atoms, moles, and mass in a chemical reaction.
- **Explain and provide mathematical evidence** that atoms and mass are *conserved during a chemical reaction.*
- **Use stoichiometric calculations** to determine the quantities of reactants and products of a chemical reaction in a *closed system*.
- **Predict** the products for the basic types of chemical reactions on a molecular scale.
- **Describe** the relative mathematical relationship, in moles, between the reactants and products *of a balanced chemical equation*.