HIGH SCHOOL CHEMISTRY: PERIODIC TABLE

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.

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. (SEP: 2; DCI: PS1.A, PS2.B; CCC: Patterns) [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] *[Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*

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 periodic trends could include atomic size, electronegativity strength, or reactivity of atoms forming compounds or and molecules.] *[Assessment Boundary: Assessment is limited to simple chemical reactions. Assessment does not include differentiating between different types of reactions.]*

Content Overview

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

The position of elements on the periodic table is based on patterns of properties of the elements including energy levels and outer electrons. An element's position on the periodic table can be used to predict an element's number of outer electrons.

Within the periodic table there are trends of atomic size, electronegativity, reactivity of metals, reactivity of nonmetals, electron affinity, and ionization energy. Trends occur in periods as well as families of the periodic table. Knowing and understanding the trends will allows students to later make predictions within chemical reactions.

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.

- Most elements cannot be found pure in nature.
- All elements, except astatine, in group VIIA exist as diatomic molecules in nature.
- Hydrogen gas cannot be used like helium in balloons.
- On a family vacation I noticed the Statue of Liberty was a blue-green color, but yet I read that it was constructed from copper.
- Before a special family dinner, I was looking in my grandmother's china hutch at her silver spoon, only to notice that many of them did not look like silver spoons anymore. My grandmother asked me to restore them to their original condition.
- While at a fireworks show, I noticed that the fireworks were not all the same color.
- While enjoying a campfire with family friends, I noticed that when a piece of copper tubing was placed into the fire, a green color appeared.
- We can look through a spectroscope at stars and learn that the universe is expanding.

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
Developing and Using Models • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/ or solve problems. **Constructing Explanations and Designing Solutions** • Apply scientific ideas, principles, and/ or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. 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. • 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. **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **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.

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 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. The trends in reactivity and electronegativity are a result of the combination of the size of the nuclear charge, the number of electrons in each energy level, and the distance from the nucleus. 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.

In chemical reactions, the law of conservation of matter 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.

Formative Assessment

Formative Question Prompts *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

- Construct an explanation based on evidence for the organization of the periodic table according to valence electrons.
- Construct an explanation of the pattern of formula for the alkaline earth family and its chlorides.
- Construct an explanation of the pattern of formula for the alkaline earth family and its oxides.
- Construct an explanation of the properties of a missing element based upon the chemical properties of the group it belongs to.

SEP Developing and Using Models

- Utilizing the arrangement of atoms on the periodic table, predict the properties of electronegativity, ionization energy, atomic size, and rate of reactivity of the elements based on the patterns.
- Utilizing the periodic table as a model, predict the types of bonds that form between atoms from different periodic groups based on valence electrons.
- Describe the valence electron arrangement between diatomic molecules using the periodic table.
- Using the periodic table as a model, predict the relative chemical properties of each family of the periodic table based on the patterns of electrons in the outermost energy level of atoms.

CCC Patterns

- What are the patterns of electronegativity, atomic size, and ionization energy that can be observed horizontally and vertically on the periodic table?
- How can the patterns of electronegativity, atomic size, and ionization energy be be explained through the an atom's number of valence electrons and number of energy levels?
- How can the pattern of the vertical group charge's be explained on the periodic table through an atom's number of valence electrons and the octet rules?
- How can the periodic pattern of valence electrons predict the bond type formed between atoms of different or similar elements?
- What patterns in the data of electronegativity, atomic size, and valence electrons do you observe in the main group elements?
- What types of bonds are formed involving the alkali metals and the halogens using the patterns of valence electrons?

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.

- **Use the periodic table as a model** to predict the physical and chemical properties of an element based upon its position *and patterns known.*
- **Construct an explanation** *of the patterns of* electronegativity, atomic number, atomic size, and valence electrons when moving left to right on the periodic table based on the strengths of attraction between the nucleus and electrons
- **Construct an explanation** *of the patterns of* electronegativity, atomic number, atomic size, and valence electrons when moving top to bottom on the periodic table based on the effect of distance/energy levels of the electrons and the attractive forces of the nucleus
- **Through multiple scientific ideas** such as periodic trends and valence electrons, **create models** that describe how the columns of the periodic table reflect the *patterns of electrons.*
- **Through multiple scientific ideas** such as periodic trends and valence electrons, **create models** that describe how the rows of the periodic table reflect the *patterns of electrons.*

- **Explain why** elements with similar chemical properties are placed in columns through an explanation that includes concepts of *patterns of valence electrons.*
- **Conduct investigations** to explore the properties of elements, compounds, and molecules and relate their properties to their location on the periodic table.
- **Plan and carry out an experiment** that demonstrates that matter is conserved even though it may *change* in its structure and phase.
- **Collect experimental data** that proves that the total number of atoms in reactants and products *remains the same* during a chemical reaction.