Scope and Sequence: A Pathway to Learning for

High School Chemistry

Introduction

This scope and sequence is a product of collaborative efforts from secondary department heads and their respective departments and the Office of Learning and Instruction at the Amphitheater district offices. This document aims to provide a framework for each secondary science course that does the following:

- Prioritizes standards that have a high impact on student learning
- Identifies supporting standards for those priorities
- Creates equity of learning between sites
- Provides an easy-to-follow framework for personalized learning

The team started by establishing a set of topics and the order in which they are taught in each course. The team divided and embedded the Earth and Space standards within the core Biology, Chemistry and Physics courses so that students have access to all Science standards that appear on the state test within three courses instead of four. Within each topic, there are one or more phenomena, essential questions and/or tasks, some key vocabulary and concepts, and priority and support standards. This information serves as a bare minimum for concepts to cover within each topic. As the content experts, teachers then have the freedom to add to and plan inquiry-based units around the framework provided by this document.

Arc of Inquiry

The Science standards are designed to work within the arc of inquiry, as outlined within the state documentation. When creating this scope and sequence, the arc of inquiry was a driving factor in how essential questions/tasks were designed and how phenomena were chosen. In order to have students critically engage with Science content, it is vital to have open-ended, inquiry-based questions and tasks that challenge student thinking and ask them to apply and interact with the concepts they have learned. For more information about the arc of inquiry, refer to the 2018 Arizona Science Standards.

Framework for Success

One of the major goals of this scope and sequence is to provide a definitive framework for teachers to design their units. By emphasizing priority standards, homogenizing *some* key concepts and vocabulary, and providing a topic-wide emphasis (essential questions and phenomena), teachers can then focus on creating rigorous, engaging, and creative units while ensuring what one student is learning at one school will be similar to another student at a different school. This framework does not prescribe activities for each topic or have scripted lessons. Instead, it frees up teachers to focus more on the "how" of teaching instead of the "what." Each classroom has learners with different needs, so it is of the utmost importance that teachers focus on meeting those learners where they are but still maintain some equity across sites.

Flexible Document

As teachers work with the document throughout the school year, there will inevitably be feedback for improvements, additions, and/or refinement, and that feedback will be crucial for all parties to continue to make decisions focused on student learning. This is a version of a scope and sequence, and may change or evolve to meet the needs of teachers and the district. However, this scope and sequence represents a starting point for future editions and provides a foundation going forward.

The Office of Learning and Instruction extends special gratitude to the Amphitheater educators who were contributing members of this curricular resource development team.

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Standards that should be embedded within topics:

HS.P1U1.1:Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

HS.E1.U3.14:Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.

HS.P1U3.4:Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.

HS.P4U1.8:Engage in argument from evidence that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.

HS. E1.U3.14:Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how

HS. E2.U1.15:Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.

HS.P1U1.2:Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.

HS.P1U1.3:Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.

HS.P1U1.3:Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.

Supporting Standards that should be embedded within topics:

HS+C.P1U1.1: Develop and use models to demonstrate how changes in the number of subatomic particles (protons, neutrons,electrons) affect the identity, stability, and properties of the element.

HS+C.P1U1.2:Obtain, evaluate, and communicate the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.

HS+C.P1U3.8:Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.

HS+C.P1U1.4:Develop and use models to predict and explain forces within and between molecules.

HS+C.P1U1.5: Plan and carry out investigations to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.

HS+C.P1U1.7:Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions.

HS+C.P1U1.3:Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.

HS+C.P1U1.6: Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production

HS+C.P1U1.7:Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions.

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HS+C.P1U1.6: Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.

Topic/Unit Matter	Suggested Time Frame:	
Overarching topic: The Universe is made up of matter.	**Semester 1**	
Priority Clusters and Standards:	**Supporting Standards:**	
HS.P1U1.1 **Develop and use models** to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence. **HS. E1.U3.14** **Engage in argument from evidence** about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other. **HS.P1U3.4** **Obtain, evaluate, and communicate information** about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications. **HS.P4U1.8** **Engage in argument** from evidence that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings. **HS. E1.U3.14** **Engage in argument from evidence** about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how **HS. E2.U1.15** **Construct an explanation based on evidence** to illustrate the role of nuclear fusion in the life cycle of a star.	**HS+C.P1U1.1** **Develop and use models to demonstrate** how changes in the number of subatomic particles (protons, neutrons,electrons) affect the identity, stability, and properties of the element. **HS+C.P1U1.2** **Obtain, evaluate, and communicate** the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation. **HS+C.P1U3.8** **Engage in argument from evidence** regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.	

Essential Questions/Phenomenon:

- What is the structure of the atom?
- How do the subatomic particles affect the atom's identity, stability, and properties?
- What is the relationship of the structure of atoms to patterns and properties observed within the Periodic Table?
- How have the models of the atom been revised with new evidence?
- How do the repeating patterns of the periodic table reflect patterns of outer electron states?
- How does qualitative evidence support claims about how atoms absorb and emit energy in the form of electromagnetic radiation?
- How does the structure and interactions of matter at the bulk scale determine the forces within and between atoms?
- How can you predict interactions between a positively-charged nucleus composed of both protons and neutrons and the surrounding negatively-charged electrons, including how they affect atomic radius, electronegativity, stability and reactivity?
- What properties of subatomic particles, including physical location within an atom and their relative size, determine atomic structure, including their identity and charge?
- How can you identify and predict patterns in properties that determine how the periodic table is organized based on subatomic particles and element properties (i.e., the arrangement of the main groups of the periodic table reflects the patterns of outermost electrons (i.e. valence electrons)?
- How to predict the effects of changing the number of protons, neutrons, and electrons on atomic charges and isotopes of any given element.
- How can the properties of light be used to determine electron arrangement?
- How do atoms absorb and emit energy in the form of electromagnetic radiation?
- How is electromagnetic radiation either absorbed or emitted by different elements?
- How is scientific data regarding emission and absorption of energy use to identify elements?
- What is a nuclear transition and how does it produce gamma rays?
- What is the life cycle of a star and how does it relate to nuclear chemistry?
- What types of energy (i.e., chemical, thermal [endothermic vs. exothermic]) are entering and leaving a system?
- How is an element identified by the number of protons and the number of protons and neutrons in the nucleus before and after the decay.
- How do you know the identity of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma)?
- How do you engage in argument from evidence to: 1. critique and evaluate competing arguments about the benefits and liabilities of fission, fusion, and radioactive decay. 2. make and defend a claim about the benefits and liabilities of fission, fusion, and radioactive decay
- How is energy transferred and stored, and the validity of the law of conservation of energy?

Key Concepts:	Key Vocabulary:

Atomic Structure
    Proton, Electron, Neutrons
    Isotopes
    Allotropes
    Light Properties
    Using Light to Identify Presence of Elements
    Electron Arrangement/Configuration
Periodicity - Periodic Trends
    Periodic Table Structure (Groups/Periods)
    Property of Metals/Non-Metals and Metalloids
	Atom, nucleus, protons, neutrons, electrons, periodic table, chemical properties, electron states, stability
	
	Nuclear process, nuclear fusion

Chemical Properties - Groups Patterns of Valence Electrons Coulombic Attraction Atomic Radius Ionization Energy Electron Affinity Electronegativity Nuclear Reactions	

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<table>
<tr><th>Topic/Unit Chemical Bonds and Chemical Reactions</th><th colspan="2">Suggested Time Frame:</th></tr>
<tr><td>Overarching topic: Interactions of ions, molecules and compounds</td><td>Semester 1</td><td></td></tr>
<tr><th>Priority Clusters and Standards:</th><th colspan="2">Supporting Standards:</th></tr>
<tr><td>HS.P1U1.2

Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.</td><td colspan="2">HS+C.P1U1.4

Develop and use models to predict and explain forces within and between molecules.

HS+C.P1U1.5

Plan and carry out investigations to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.</td></tr>
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Essential Questions/Phenomenon:

- How does an atom transfer or share electrons to form ions, molecules, and compounds in both natural and synthetic system processes.
- How can VSEPR Theory be used as a model to explain attractions between molecules?
- How do forces within and between particles such as intermolecular forces and collision models be used to predict physical properties?
- How do patterns of behavior based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons determine the typical reactivity of an atom?
- How can the number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements be predicted and explained?
- How are ions, compounds, and molecules named and classified?

- How are valence electrons determined?
- How can the products formed as a result of combining two or more substances or inputting energy into a single pure substance.
- What are the types of chemical reactions, including how and why certain atoms rearrange in certain patterns (i.e., single replacement, double replacement, synthesis/combination, decomposition, combustion)?
- What variables affect reaction rates such as change in energy, change in entropy, and change in enthalpy?
- What are the properties of solids?

Key Concepts:	Key Vocabulary:

Valence Electrons
Formation of Ions
Intramolecular Forces
  Formation of Ionic Bonds
      Ionic Nomenclature
      Ionic Crystal Lattice
  Formation of covalent bonds
      Covalent Nomenclature
      Lewis Structure
      Molecular Geometry
      Molecular Polarity
  Formation of Metallic Bonds
     Properties of Alloys
Intermolecular Forces
  London Dispersion, Dipole/Dipole and H Bonding
  Physical Properties due to IMF
Properties of Solids
Writing and Balancing Chemical Equations
Classification of Chemical Reactions
Nuclear Reactions
	Chemical process, rate, collisions, kinetic energy, reaction, conservation

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Topic/Unit: Quantitative Relationships within a Chemical Reaction	Suggested Time Frame:	
Overarching topic: Changes in Matter	**Semester 2**	
Priority Clusters and Standards:	**Supporting Standards:**	
HS.P1U1.3 Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.	**HS+C.P1U1.7** Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions. **HS+C.P1U1.3** Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws. **HS+C.P1U1.6** Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize Production	

Essential Questions/Phenomenon:

- How can characteristics of particles within solids, liquids and gasses such as volume, density, and relative energy be explained using models?
- How is energy transferred and stored, and the validity of the law of conservation of energy?
- How to measure and determine qualitative and quantitative relationships between characteristics of a system such as temperature, volume, pressure, and number of particles.
- What is the mole concept?
- How do you determine the empirical and molecular formula of a compound?
- How to balance chemical equation(s) and quantify the claim that atoms, and therefore mass, are conserved during a chemical reaction (i.e., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product?.
- How can molar relationships such as molar mass, molarity, volume of a gas at standard temperature and pressure, and number of particles in a mole be used stoichiometrically?
- How can molar relationships between reactants and products in a chemical reaction be determined through dimensional analysis?
- How can energy changes in a chemical or physical process be quantified?
- How is the concentration of a solution expressed and determined?
- What are the properties of solutions?

Key Concepts:	Key Vocabulary:
Mole Concept Empirical and Molecular Formulas Stoichiometric Relationships Energy changes within a process Properties of Solutions Solutions - Molarity	Chemical process, rate, collisions, reaction, conservation, potential energy, kinetic energy

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Topic/Unit: Gases and Solutions	Suggested Time Frame:
Overarching topic:	
Priority Clusters and Standards:	**Supporting Standards:**
HS.P1U1.3 Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.	**HS+C.P1U1.7** Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions. **HS+C.P1U1.3** Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws. **HS+C.P1U1.6** Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.

Essential Questions/Phenomenon:

- How is the evidence from Kinetic molecular theory in regard to gas particle behavior explain:
    - a. Gasses are made of molecules and atoms that move only in straight lines.
    - b. Because of how small they are, gasses have negligible volume. For this reason, we consider the volume of the container to be the volume of the gas.
    - c. Gas particles move so fast, that there are no attractive or repulsive forces between particles (no intermolecular forces).
    - d. Since there are no intermolecular forces, all collisions between particles are completely elastic (no net loss of energy).
    - e. Absolute temperature is the average kinetic energy.
- What are the observable properties of gasses?
- What is ideal gas behavior?
- How can you identify and describe potential changes in a component of the given chemical reaction system that will cause an increase in the amounts of a particular component at equilibrium?
- How to describe the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and explicitly using Le Chatelier's principle?
- What types of energy (i.e., chemical, thermal [endothermic vs. exothermic]) are entering and leaving a system?
- What are the properties of Acids and Bases?
- What are the definitions of acids and bases? (Arrhenius, and Brontsed-Lowry)
- What is the concept of pH?
- How can pH be determined?

Key Concepts:	Key Vocabulary:
Equilibrium Kinetic Molecular Theory Gas Laws - Properties of Gases Acids/Bases pH	kinetic energy, dilution, pH, molarity

Supporting standards that should be embedded within topics:

HS+C.P1U1.1: Develop and use models to demonstrate how changes in the number of subatomic particles (protons, neutrons,electrons) affect the identity, stability, and properties of the element.

HS+C.P1U1.2:Obtain, evaluate, and communicate the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.

HS+C.P1U3.8:Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.

HS+C.P1U1.4:Develop and use models to predict and explain forces within and between molecules.

HS+C.P1U1.5: Plan and carry out investigations to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.

HS+C.P1U1.7:Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions.

HS+C.P1U1.3:Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.

HS+C.P1U1.6: Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production

HS+C.P1U1.7:Use mathematics and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions.

HS+C.P1U1.3:Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.

HS+C.P1U1.6: Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production.