Chemistry

Special Note for the 2014-15 School Year: In 2013, the Maryland State Board of Education adopted the *Next Generation Science Standards* (NGSS) that set forth a vision for science education where the Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs) of science, and Crosscutting Concepts (CCCs) of science are blended seamlessly into a three dimensional learning environment for all students. The transition to NGSS across Maryland and in HCPSS will be deliberate, and full implementation of NGSS in Maryland is planned for the 2017-18 school year. The shifts required in NGSS implementation are great, and revision of curriculum requires careful consideration of these changes as well as time to develop, pilot, and implement. During this transitional period, resources in support of NGSS are being developed and posted for teachers' use within Alfresco. Additionally, beginning in 2014-15, select schools will pilot project based learning experiences developed by HCPSS curriculum writers. All students in HCPSS high school science courses regardless of the whether the student attends a school that is an early implementer of NGSS or not, will have exposure to the skills and processes and the content included in the Essential Curriculum documents. The order in which students encounter these concepts, however, may differ slightly among schools due to this transition.

G/T Differentiation
Conceptually challenging, in-depth, distinctive, and complex learning experiences should be the hallmark of the G/T Chemistry Course. Students are expected to engage in longer-term investigations where they research complex topics or issues that lead them to create new knowledge or to design original solutions much like professionals within the discipline. Teachers are expected to use a wide array of instructional strategies that encourage creative problem solving appropriate for highly able/high achieving students.

UNIT I: Introduction to Chemistry

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will be able to describe what chemistry is and its scope.

Objectives - The student will be able to:
a. Define chemistry.
b. Explain that chemistry overlaps many other areas of science.

Goal 2. The student will be able to identify and apply the scientific process.

Objectives - The student will be able to:
a. List and describe the steps of the scientific process.
b. Apply the steps to a real world example.

Goal 3. The student will be able to identify and apply basic safety procedures and identify basic equipment.

Objectives - The student will be able to:

a. Identify appropriate safety procedures.
b. Apply safety procedures to a given situation.
c. Identify basic lab equipment (i.e., beaker, graduated cylinder, balance, Bunsen burner, and thermometer.)

Goal 4. The student will be able to identify and use appropriate units of measurement and the sources and implications of uncertainty in measurements.

Objectives - The student will be able to:

a. Explain what SI Units are and why scientists use them.
b. Measure quantities using appropriate units for measurement (i.e., grams, meters, liter, second, etc.)
c. Utilize scientific notation to express numerical measurements.
d. Explain that all measurements have some amount of error or uncertainty and to compensate for this scientists use significant figures.
e. Distinguish between accurate and precise measurements.
f. Identify the number of significant figures in a measurement and express the measurement properly in scientific notation. **[GT]**
g. Round numbers to the correct number of decimal places or significant figures. **[GT]**
h. When calculating a sum or difference, determine the correct number of decimal places in the answer. **[GT]**
i. When calculating a product or quotient, determine the correct number of significant figures in the answer. **[GT]**

Goal 5. The student will be able to convert among units.

Objectives - The student will be able to:

a. Define a conversion factor.
b. Convert from one unit to another given a conversion factor using dimensional analysis or factor-label method.

UNIT II: Properties of Matter

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to classify the different kinds of matter.

Objectives - The student will be able to:

a. Differentiate among element, compound, homogenous mixture, or heterogeneous mixture.
b. Identify the smallest part of each pure substance.
c. Determine the number of each kind of atom in a compound, given the chemical formula.
d. Differentiate between physically blended and chemically bonded.

Goal 2. The student will demonstrate the ability to explain how matter may be identified, classified, and changed.

Objectives - The student will be able to:

a. Describe the arrangement and distances among particles in the solid, liquid, and gas state.
b. Relate the physical state of the substance to the temperature at which the substance exists.
c. Distinguish between physical and chemical properties.
d. Contrast physical and chemical changes.
e. Calculate the density of a substance from experimental data.
f. Contrast the properties of inorganic and organic compounds.

Goal 3. The student will demonstrate the ability to summarize and apply the Law of Conservation of Matter and Energy.

Objectives - The student will be able to:

a. Distinguish between reactants and products of a chemical reaction.
b. Use the Law of Conservation of Mass and Energy to prove that the mass remains constant during both physical and chemical changes.

UNIT III: Atomic Structure

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to trace the history of the development of the modern atomic theory and model.

Objectives - The student will be able to:

a. Explain how science is a developing field where theories are constantly challenged.
b. Contrast the contributions of Dalton, Thomson, Rutherford, Bohr, and Schroedinger in the development of the modern understanding of atomic structure.
c. Contrast the modern understanding of atomic structure with historic understandings.

Goal 2. The student will demonstrate the ability to determine the composition of any atom, ion, or isotope.

Objectives - The student will be able to:

a. Use language appropriate to atomic structure including atom, ion, isotope, subatomic particle, atomic number, mass number, average atomic mass, and atomic mass unit.
b. Identify and calculate the number of protons, neutrons, and electrons in any atom, ion, or isotope given sufficient information.
c. Recognize the existence of smaller particles composing matter, i.e. gluons, quarks, and mesons. **[GT]**
d. Explain the quantum model and photoelectric effect. **[GT]**

Goal 3. The student will demonstrate the ability to analyze the fundamentals of radioactivity.

Objectives - The student will be able to:

a. Explain how some isotopes are made of unstable nuclei, which decay over time emitting particles and energy.
b. Contrast the three kinds of emissions (alpha, beta, and gamma), the composition of the emission, and the material required to shield them.
c. Differentiate between nuclear fission and fusion.
d. Identify the common uses of nuclear fission and fusion.
e. Balance a nuclear equation. **[GT]**
f. Explain how the process of decay can change the isotope's atomic and mass numbers. **[GT]**
g. Compare the relative amounts of energy released from chemical versus nuclear reactions. **[GT]**
h. Calculate average atomic mass from isotopic data. **[GT]**

UNIT IV: Electron Arrangement

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to explain how electrons are organized around the nucleus.

Objectives - The student will be able to:

a. Distinguish among energy levels, sublevels, and orbitals.
b. Use the Aufbau principle to fill an energy level diagram.
c. Determine both the full and shorthand electron configurations for an atom or ion.
d. Determine the orbital notation for the electron arrangement in an atom or ion using Hund's rule and Pauli's exclusion principle.
e. Determine the quantum numbers associated with an electron. **[GT]**

Goal 2. The student will demonstrate the ability to explain the source and common use of atomic spectra.

Objectives - The student will be able to:

a. Describe the process that creates atomic spectra.
b. Explain the uniqueness of atomic spectra.
c. Provide examples of the common applications of atomic spectra, i.e. analysis of a mixture using atomic spectra.
d. Describe the relative energies of ultraviolet, visible, infrared, microwave, X-ray, radio, and TV waves. **[GT]**
e. Distinguish between absorption (excitation) and emission of energy. **[GT]**
f. Describe the properties of light. (i.e. wavelength, frequency and energy)
g. Calculate the wavelength, frequency and energy for a given electron transition. **[GT]**

UNIT V: The Periodic Table

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to describe the origin and organization of the modern Periodic Table.

Objectives - The student will be able to:

a. Contrast Dimitri Mendeleev and Henry Mosely's contributions and method of organizing the Periodic Table.

b. Collect and use information on the Periodic Table, including atomic number, atomic mass, family designation, period number, classification of element (metal, nonmetal, semimetal, or metalloid), and the state of the element at room temperature.
c. Identify regions of the periodic table including alkali metals, alkaline earth metals, transition metals, halogens, noble gases, lanthanide, and actinide series.
d. Relate the family or group of elements to their corresponding number of valence electrons.
e. Relate a period of elements to the energy level of valence electrons.

Goal 2. The student will demonstrate the ability to explain periodicity.

Objectives - The student will be able to:

a. Compare ionization energy, electronegativity, and atomic radius; contrast the trends in these properties as one proceeds across a period and down a family of elements on the Periodic Table.
b. Identify an element as belonging to the *s*-, *p*-, *d*-, or *f*-block in the Periodic Table. **[GT]**
c. Explain trends and patterns in the ionic radius, electron affinity, and reactivity within families and periods of representative elements. **[GT]**

UNIT VI: Bonding

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.A—Structure and Properties of Matter

Essential Question:
How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to distinguish among ionic, polar, and nonpolar covalent bonds.

Objectives - The student will be able to:

a. Determine the number of valence electrons in an atom from its position in the Periodic Table.
b. Describe how atoms interact with one another by transferring and sharing valence electrons.
c. Use electronegativity values to determine whether a compound is ionic, polar or non-polar covalent.
d. Illustrate neutral atoms and ions using electron dot notation.
e. Illustrate ionic and covalent bonds utilizing electron dot notation.
f. Use appropriate materials to build adequate models of simple molecules and polyatomic ions representing the shapes of these species. **[GT]**
g. Describe van der Waals forces (London forces and dipole-dipole forces) and hydrogen bonds. **[GT]**

Goal 2. The student will demonstrate the ability to recognize various shapes that molecules can exhibit.

Objectives - The student will be able to:

a. Identify and differentiate among the linear, bent, and tetrahedral shapes. **[GT]**
b. Predict the shape of a molecule from its chemical formula. **[GT]**
c. Predict the polarity of a molecule given its shape and types of bonds. **[GT]**

Goal 3. The student will demonstrate the ability to differentiate properties of metallic, ionic, and covalent solids.

Objectives - The student will be able to:

a. Describe the properties of metallic, ionic, and covalent solids.
b. Classify a substance as metallic, ionic, or covalent based on data (solubility, melting point, boiling point, conductivity).

UNIT VII: Nomenclature

Goal 1. The student will demonstrate the ability to compose a proper formula for a compound.

Objectives - The student will be able to:

a. Determine the oxidation number of a metal, nonmetal, or polyatomic ion and relate it to the loss or gain of electrons.
b. Combine a cation and an anion such that the sum of the oxidation numbers will equal zero.
c. Use subscripts and parentheses, if needed, and determine the number of atoms represented by the formula.

Goal 2. The student will demonstrate the ability to describe and name ionic compounds (binary or ternary) and covalent compounds (binary).

Objectives - The student will be able to:

a. Differentiate between a binary and ternary compound.
b. Name a binary ionic compound using roman numerals, if needed.
c. Name a ternary ionic compound using roman numerals, if needed.
d. Name binary covalent compounds.
e. Name a binary or ternary ionic compound using the Stock (-ous/-ic) system of nomenclature. **[GT]**

UNIT VIII: Chemical Reactions

Associated Disciplinary Core Ideas (DCIs) from NGSS include:
PS1: Matter and Its Interactions
PS1.B—Chemical Reactions
PS1.C—Nuclear Processes

Essential Question:

How can one explain the structure, properties, and interactions of matter?

Goal 1. The student will demonstrate the ability to write and balance simple equations.

Objectives - The student will be able to:

a. Distinguish between reactants and products in a chemical reaction.
b. Write a word or symbolic equation to represent a chemical reaction.
c. Balance a simple equation.
d. Explain how a balanced chemical equation supports the Law of Conservation of Mass.
e. Compare the amount and kinds of atoms of reactants and products in a chemical reaction.

Goal 2. The student will demonstrate the ability to classify chemical reactions and predict the products.

Objectives - The student will be able to:

a. Categorize the types of chemical reactions based on the nature of observed changes.
b. Identify the type of chemical reactions based on the reactants given.
c. Predict the products of a synthesis, decomposition, single replacement, and double replacement or combustion reaction, for a given combination of reactants. **[GT]**
d. Write net ionic reactions for precipitation reactions. **[GT]**

UNIT IX: Moles and Stoichiometry

Goal 1. The student will demonstrate the ability to explain and do calculations with the mole.

Objectives - The student will be able to:

a. Explain how a balanced chemical equation relates to the law of conservation of mass.
b. Define the mole and describe its importance.
c. Describe how Avogadro's number is related to a mole of any substance.
d. Define and calculate the molar mass of a compound.
e. Convert among the number of particles, mass, moles, and volume of a substance.

Goal 2. The student will demonstrate the ability to determine the percent composition of a compound.

Objectives - The student will be able to:

a. Calculate the percent composition of a substance from its chemical formula.
b. Calculate the percent composition of a substance from experimental data.

Goal 3. The student will demonstrate the ability to determine the empirical and molecular formulas of a compound.

Objectives - The student will be able to:

a. Distinguish between empirical and molecular formulas.
b. Derive the empirical formula for a compound by using experimentally obtained masses of each element.

c. Derive the empirical formula for a compound by using percent composition data.
d. Derive the molecular formula for a compound by using the empirical formula and the molar mass of the compound.

Goal 4. The student will demonstrate the ability to explain the quantitative relationship that exists between reactants and products in a chemical reaction.

Objectives - The student will be able to:

a. Define stoichiometry and describe its importance.
b. Identify stoichiometric ratios from balanced chemical equations.
c. Calculate different types of stoichiometry problems. (i.e. mass-mass, mass-volume, volume-volume)

Goal 5. The student will demonstrate the ability to describe a limiting reactant.

Objectives - The student will be able to:

a. Define limiting reactant.
b. Explain how limiting reactants affect the amount of products formed.
c. Identify the limiting reactant in a reaction and calculate the theoretical yield of product(s) and the quantity of other reactant(s) consumed or un-reacted. **[GT]**

Goal 6. The student will demonstrate the ability to calculate percent yield.

Objectives - The student will be able to:

a. Differentiate between actual yield and expected yield. **[GT]**
b. Determine percent yield based on actual yield and expected yield. **[GT]**

UNIT X: Gases

Goal 1. The student will demonstrate the ability to describe the behavior of gases and relate the behavior to gas properties.

Objectives - The student will be able to:

a. Identify the properties of gases.
b. Differentiate among the behavior of particles in solids, liquids, and gases.
c. Explain the effects of temperature, pressure, and volume changes on the behavior of particles.
d. Define kinetic energy in terms of velocity (or speed) and mass of particles. **[GT]**
e. Relate molecular motion to temperature and molecular collisions to pressure. **[GT]**

Goal 2. The student will demonstrate the ability to identify the volume, temperature, pressure, and amount of a gas.

Objectives - The student will be able to:

a. Explain which equipment and units are used to measure gas quantities.
b. Define standard temperature and pressure.
c. Define kinetic molecular theory and use it to explain differences in real versus ideal gases. **[GT]**
d. Define molar volume. **[GT]**

Goal 3. The student will demonstrate the ability to describe the relationships among the four quantities of a gas and perform calculations based on those relationships.

Objectives - The student will be able to:

a. State the written and mathematical expression of five gas laws (Boyle's Law, Charles' Law, Gay-Lussac's Law, Combined Gas Law, Ideal Gas Law).
b. Apply the gas laws to problems involving the temperature, volume, pressure, and amount of a gaseous substance.
c. Explain how the total pressure in a mixture of gases is equal to the sum of the partial pressures of each gas present.
d. Compare the diffusion rates of two gases.
e. Compare velocities and masses of different gas molecules, measured at the same temperature. **[GT]**
f. Calculate the pressure of a dry gas when collected over water. **[GT]**

UNIT XI: Solutions

Goal 1. The student will demonstrate the ability to describe characteristics of solutions.

Objectives - The student will be able to:

a. Distinguish between homogeneous and heterogeneous mixtures. Explain how dissolving is different from melting.
b. Identify and compare the nine different solute-solvent combinations.
c. Compare solutions, suspensions, and colloids.

d. Define: dilute, concentrated, unsaturated, saturated, and supersaturated.

Goal 2. The student will demonstrate the ability to describe factors affecting solubility.

Objectives - The student will be able to:

a. Explain how stirring, surface area, temperature, and concentration influence the rate of solution formation.
b. Explain how distillation, crystallization, and chromatography are used to separate solutions into their components.
c. Apply "like dissolves like" to everyday events. (i.e. actions of detergents and soap)
d. Interpret a solubility curve.
e. Explain the relationship between equilibrium and solubility. **[GT]**
f. Explain why gases become less soluble at higher temperatures, whereas most solids become more soluble. **[GT]**
g. Explain why a precipitate forms when solutions of two ionic compounds are mixed. **[GT]**

Goal 3. The student will demonstrate the ability to determine molarity.

Objectives - The student will be able to:

a. Calculate the molarity of a solution given the amount of solute and the volume of solvent.
b. Calculate the amount of solute needed to prepare a specific volume of a given molarity.
c. Recognize the difference between concentration and amount, calculating the molarity and molality of a solution and calculations associated with dilutions. **[GT]**
d. Generate a standard curve of molarity versus absorbance using spectrophotometry and then use the curve. **[GT]**

Goal 4. The student will demonstrate the ability to describe colligative properties.

Objectives - The student will be able to:

a. Explain why the boiling point increases and the freezing point decreases when solute particles are dissolved.
b. Give everyday examples of freezing point depression and boiling point elevations.

UNIT XII: Reactions Rates and Equilibrium

Goal 1. The student will demonstrate the ability to describe factors that affect the reaction rate.

Objectives - The student will be able to:

a. Predict the effects of adding a catalyst or changing the temperature, surface area, concentration, or pressure on the rate of a reaction.
b. Interpret a potential energy diagram including activation energy and enthalpy change.
c. Explain the role of activation energy in chemical reactions and its change with the addition of a catalyst.

Goal 2. The student will demonstrate the ability to describe the energy changes occurring during a chemical reaction or process.

Objectives - The student will be able to:

a. Compare endothermic and exothermic reactions using the terminology enthalpy and enthalpy change.
b. Differentiate between heat and temperature.
c. Calculate the change in heat energy in a system using calorimetry. **[GT]**

Goal 3. The student will demonstrate the ability to explain chemical equilibrium.

Objectives - The student will be able to:

a. Explain that some chemical reactions are reversible.
b. Discuss dynamic equilibrium.
c. Calculate the equilibrium constant and use its value to judge whether reactants or products are favored.
d. Use Le Chatelier's Principle to explain how equilibrium systems adjust to stresses such as temperature and concentration changes.
e. Explain the meaning of a reaction mechanism. Identify rate determining step, intermediate, and catalysts. **[GT]**
f. Distinguish a reaction mechanism from the overall equation describing a reaction. **[GT]**
g. Define entropy and free energy and discuss their relationships to chemical reactions. **[GT]**
h. Solve simple equilibrium problems. **[GT]**

UNIT XIII: Acids and Bases

Goal 1. The student will demonstrate the ability to describe and name acids and bases.

Objectives - The student will be able to:

a. Explain that many reactions involve the transfer of hydrogen ions.
b. Compare Arrhenius, Bronsted-Lowry, and Lewis theories of acids and bases.
c. Identify the properties of acids and bases.
d. Name a binary acid.
e. Name a ternary acid.

Goal 2. The student will demonstrate the ability to compare characteristics of strong and weak acids and bases.

Objectives - The student will be able to:

a. Discuss and compare ionization of strong and weak acids and bases.
b. Calculate the hydrogen ion concentration for a strong acid.
c. Use the ionization constant to calculate the hydrogen ion concentration for weak acids.

Goal 3. The student will demonstrate the ability to describe acid-base reactions.

Objectives - The student will be able to:

a. Write a neutralization reaction.
b. List the characteristics of a salt.
c. Discuss the self-ionization of water and utilize K_w to determine hydrogen ion concentrations.
d. Identify the salt product produced in an acid-base reaction. **[GT]**
e. Given a salt, specify the acid and base from which it could be produced. **[GT]**
f. Use the ionization constant to calculate the hydrogen ion concentration for weak acids. **[GT]**

Goal 4. The student will demonstrate the ability to describe and use the pH scale.

Objectives - The student will be able to:

a. Measure acidity levels of common substances using the pH scale.
b. Calculate pH given the hydrogen ion concentration.
c. Calculate pH given the hydroxide ion concentration.
d. Calculate pH for a weak and strong acid solution.

Goal 5. The student will demonstrate the ability to explain how the concept of neutralization applies to titrations.

Objectives - The student will be able to:

a. Perform a titration using an indicator to identify the endpoint.
b. Calculate the molarity of an unknown acid or base from titration data.

UNIT XIV: Organic Chemistry

Goal 1. The student will be able to explain why organic compounds are so numerous and diverse.

Objectives - The student will be able to:

a. Differentiate between properties of inorganic and organic compounds.
b. Differentiate between alkanes, alkenes, alkynes, and cyclic hydrocarbons.
c. Identify, name and draw structural formulas for the first ten alkanes.
d. Recognize that many organic compounds contain functional groups, which determine the properties and uses of that compound.