# VDOE Chemistry Instruction and Assessment Support Document

August 16, 2022

The 2018 *Science Standards of Learning* and the 2018 *Science Curriculum Framework* were adopted by the Virginia Board of Education (BOE) in October, 2018. These documents identify the academic content and essential components of the science curriculum at different grade levels for Virginia’s schools. The full implementation of the 2018 *Science Standards of Learning* is required in all classrooms starting fall, 2022. At this time, all public school divisions in Virginia are expected to teach and assess the 2018 *Science Standards of Learning*. In addition, the federally mandated state assessments in science will reflect the 2018 *Science Standards of Learning* starting spring, 2023.

Currently, the federal government requires one state mandated assessment in science in elementary, middle, and high school (grades 9-12). Biology has been identified by the BOE as the *Standards of Learnin*g assessment for high school students. Although Biology is the mandated state assessment, both the Earth Science and Chemistry *Standards of Learning* assessments are available for students in order to earn a verified credit in science needed for graduation in Virginia public schools. Although instruction of the 2018 *Science Standards of Learning* is required of all schools in Virginia, the content of both the Earth Science and Chemistry assessment will reflect the 2010 *Science Standards of Learning*.

The VDOE recognizes that a gap exists between expectations of the content and practices to be taught and those that are assessed in Chemistry. The purpose of this document is to provide support to teachers to address these gaps when preparing students to take the Chemistry assessment.

Points to consider when reviewing this document or adapting instruction to address gaps in content and expectations between the 2010 and 2018 *Science Standards of Learnin*g:

1. How many students currently enrolled in Chemistry do not have a verified credit in science through passing the state mandated Biology assessment?
2. Of these students, did all take the Biology *Standards of Learning* assessment as required by federal legislation?
3. Does your division provide additional curriculum to address gaps in content and/or expectations between the 2010 and 2018 standards?

**General changes evidenced in the Virginia 2018 *Science Standards of Learning*:**

* The 2018 Science *Standards of Learning* have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
* The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards. **Please refer to the leaves in the Essential Knowledge and Practices portion of the 2018 *Chemistry Curriculum Framework* for more information on the integration of the Scientific and Engineering Practices.**
* Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

**Summary of changes specific to Chemistry:**

* Redundant content from physical science standards was removed. An example is that the parts of the atom have been removed from the Chemistry standards and curriculum framework. The expectation is that students are taught this content in Physical Science. Pre-assessments should be used to determine any needed remediation/re-teaching that is needed to support instruction and build on foundational understandings of a concept.
* Content was reorganized to form standards on solutions (CH.5) and thermochemistry (CH.7).
* Organic chemistry from the previous CH.6 was integrated into existing standards.
* Equilibrium was removed from chemistry standards. *Additional instruction must be provided to students required to take the Chemistry Standards of Learning test in order to bridge the gap in content between the 2010 and 2018 science standards*.

| **2010** | **2018** |
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| CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include1. designated laboratory techniques;
2. safe use of chemicals and equipment;
3. proper response to emergency situations;
4. manipulation of multiple variables, using repeated trials;
5. accurate recording, organization, and analysis of data through repeated trials;
6. mathematical and procedural error analysis;
7. mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis;
8. use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts;
9. construction and defense of a scientific viewpoint; and
10. the use of current applications to reinforce chemistry concepts.
 | CH.1 The student will demonstrate an understanding of scientific and engineering practices by 1. asking questions and defining problems
* ask questions that arise from careful observation of phenomena, examination of a model or theory, unexpected results, and/or to seek additional information
* determine which questions can be investigated within the scope of the school laboratory
* make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
* generate hypotheses based on research and scientific principles
* define design problems that involve the development of a process or system with interacting components, criteria and constraints
1. planning and carrying out investigations
	* individually and collaboratively plan and conduct observational and experimental investigations
* plan and conduct investigations or test design solutions in a safe manner, including planning for response to emergency situations
* select and use appropriate tools and technology to collect, record, analyze, and evaluate data
1. interpreting, analyzing and evaluating data
* record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms
* use data in building and revising models, supporting explanations for phenomena, or testing solutions to problems
* solve problems using mathematical manipulations including the International System of Units (SI), scientific notation, derived units, significant digits, and dimensional analysis
* analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution
* analyze data graphically and use graphs to make predictions
* differentiate between accuracy and precision of measurements
* consider limitations of data analysis when analyzing and interpreting data
* analyze data to optimize a design
1. constructing and critiquing conclusions and explanations
* construct and revise explanations based on valid and reliable evidence obtained from a variety of sources
* apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions
* compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence
* construct arguments or counterarguments based on data and evidence
* differentiate between scientific hypothesis, theory, and law
1. developing and using models
* evaluate the merits and limitations of models
* develop, revise, and/or use models based on evidence to illustrate or predict relationships
* use models and simulations to visualize and explain the movement of particles, to represent chemical reactions, to formulate mathematical equations, and to interpret data sets
1. obtaining, evaluating, and communicating information
* compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem
* gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source
* communicate scientific and/or technical information about phenomena and/or a design process in multiple formats
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| CH.2 The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of1. average atomic mass, mass number, and atomic number;
2. isotopes, half lives, and radioactive decay;
3. mass and charge characteristics of subatomic particles;
4. families or groups;
5. periods;
6. trends including atomic radii, electronegativity, shielding effect, and ionization energy;
7. electron configurations, valence electrons, and oxidation numbers;
8. chemical and physical properties; and
9. historical and quantum models.
 | CH.2 The student will investigate and understand that elements have properties based on their atomic structure. The periodic table is an organizational tool for elements based on these properties. Key information pertaining to the periodic table includes 1. average atomic mass, isotopes, mass number, and atomic number;
2. nuclear decay;
3. trends within groups and periods including atomic radii, electronegativity, shielding effect, and ionization energy;
4. electron configurations, valence electrons, excited electrons, and ions; and
5. historical and quantum models.
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| CH.3 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include1. nomenclature;
2. balancing chemical equations;
3. writing chemical formulas;
4. bonding types;
5. reaction types; and
6. reaction rates, kinetics, and equilibrium.
 | CH.3 The student will investigate and understand that atoms are conserved in chemical reactions. Knowledge of chemical properties of the elements can be used to describe and predict chemical interactions. Key ideas include1. chemical formulas are models used to represent the number of each type of atom in a substance;
2. substances are named based on the number of atoms and the type of interactions between atoms;
3. balanced chemical equations model rearrangement of atoms in chemical reactions;
4. atoms bond based on electron interactions;
5. molecular geometry is predictive of physical and chemical properties; and
6. reaction types can be predicted and classified.
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| CH.4 The student will investigate and understand that chemical quantities are based on molar relationships. Key concepts include1. Avogadro’s principle and molar volume;
2. stoichiometric relationships;
3. solution concentrations; and
4. acid/base theory; strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process.
 | CH.4 The student will investigate and understand that molar relationships compare and predict chemical quantities. Key ideas include1. Avogadro’s principle is the basis for molar relationships; and
2. stoichiometry mathematically describes quantities in chemical composition and in chemical reactions.
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|  | CH.5 The student will investigate and understand that solutions behave in predictable and quantifiable ways. Key ideas include1. molar relationships determine solution concentration;
2. changes in temperature can affect solubility;
3. extent of dissociation defines types of electrolytes;
4. pH and pOH quantify acid and base dissociation; and
5. colligative properties depend on the extent of dissociation.
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| CH.5 The student will investigate and understand that the phases of matter are explained by kinetic theory and forces of attraction between particles. Key concepts include1. pressure, temperature, and volume;
2. partial pressure and gas laws;
3. vapor pressure;
4. phase changes;
5. molar heats of fusion and vaporization;
6. specific heat capacity; and
7. colligative properties.
 | CH.6 The student will investigate and understand that the phases of matter are explained by the kinetic molecular theory. Key ideas include1. pressure and temperature define the phase of a substance;
2. properties of ideal gases are described by gas laws; and
3. intermolecular forces affect physical properties.
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|  | CH.7 The student will investigate and understand that thermodynamics explains the relationship between matter and energy. Key ideas include1. heat energy affects matter and interactions of matter;
2. heating curves provide information about a substance;
3. reactions are endothermic or exothermic;
4. energy changes in reactions occur as bonds are broken and formed;
5. collision theory predicts the rate of reactions;
6. rates of reactions depend on catalysts and activation energy; and
7. enthalpy and entropy determine the extent of a reaction.
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| CH.6 The student will investigate and understand how basic chemical properties relate to organic chemistry and biochemistry. Key concepts include1. unique properties of carbon that allow multi-carbon compounds; and
2. uses in pharmaceuticals and genetics, petrochemicals, plastics, and food.
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