Roanoke Valley Governor's School for Science and Technology
RVGS Chemistry
Competency List, 2018-2019

(Last updated: August 18, 2018)

RVGS Chemistry explores the fundamental laws, theories, and mathematical concepts of chemistry. The major themes include the study of matter, its composition, structure, and properties, the changes they undergo, and the flow of energy that accompanies those changes. There is an emphasis on the use of technology for data collection and analysis. Virginia chemistry standards of learning are covered during the course.

This course is taught using best practices in gifted education. Each competency is aligned with Hockett's five principles of gifted education:

Gifted Education Principles:
(Hockett, J.A. (2009) "Curriculum for Highly Able Learners That Conforms to General Education and Gifted Education Quality Indicators." *Journal of Education for the Gifted***.** Vol. 32, No. 3, p. 394-440)

1. High-quality curriculum for gifted learners uses a conceptual approach to organize or explore content that is discipline based and integrative.
2. High-quality curriculum for gifted learners pursues advanced levels of understanding beyond the general education curriculum through abstraction, depth, breadth, and complexity.
3. High-quality curriculum for gifted learners asks students to use processes and materials that approximate those of an expert, disciplinarian, or practicing professional.
4. High-quality curriculum for gifted learners emphasizes problems, products, and performances that are true to life, and outcomes that are transformational.
5. High-quality curriculum for gifted learners is flexible enough to accommodate self-directed learning fueled by student interests, adjustments for pacing, and variety.

COMPETENCY I (VA SOL CH.1)
Demonstrate awareness and proper use of laboratory safety techniques.
Enabling Objectives:
1. Differentiate between safe and unsafe procedures, applications, and methods of disposal of chemicals.
2. Choose the appropriate safety equipment for specific laboratory situations.
3. Decide which safety and emergency procedures to follow in case of particular accidents including fires and hazardous material spills.
4. Demonstrate proper methods for carrying and moving chemicals and equipment.
5. Demonstrate the ability to understand and follow the safety codes on chemical containers.

COMPENTENCY II (VA SOL CH.1)

Apply System Internationale (SI) units as used in chemistry

Enabling Objectives:

1. Identify the base units of the SI system and describe the standards for each.
2. Describe the concept of a derived quantity and its units, and identify the dimension (combination of base units) for any derived quantity, initially including area, volume and density.
3. Using dimensional analysis, determine whether an equation is dimensionally valid, and establish the dimensions of a quantity.
4. Explain and give examples of the system of subdivision used in the SI system, including the use of prefixes to represent powers of ten.
5. Use conversion factors to convert quantities from one metric unit to another, and also between metric and English units.

COMPENTENCY III (VA SOL CH.1)

Integrate computer use into the laboratory environment.

Enabling Objectives:

1. Acquire and record experimental data from computer interfaced hardware and software.
2. Conduct statistical analysis of data using relevant spreadsheet and graphing programs.
3. Use statistical analysis programs to analyze experimental data, using standard deviation and statistical tests to evaluate significance.
4. Insert graphs, spreadsheets, photos, and other images into the document.
5. Insert a table to organize information in a document.
6. Add labels and arrows to an image.
7. Create graphs that have a title, units, and legend where needed.
8. Use a spreadsheet program and appropriate data to create a scatter plot with a linear curve fit.

COMPENTENCY IV (VA SOL CH.1)

Apply appropriate experimental and measurement skills and techniques to laboratory experiences, and organize laboratory data using proper report and notebook format.

Enabling Objectives:

1. Select appropriate systems of measurement, using proper units, metric prefixes and number of significant digits.
2. Report the degree of uncertainty of a measurement, and carry out mathematical operations with measurements containing stated uncertainties.
3. Determine the significant digits in a recorded measurement, and carry out mathematical operations using these measurements with answers rounded off to the correct number of significant digits.
4. Determine the limit (decimal place) to which a measurement can be made for any measuring instrument.
5. Differentiate between precision and accuracy and calculate each.
6. Make linear and volume measurements and determine masses of materials using various pieces of equipment.
7. Maintain a current, organized, and accurate laboratory notebook.
8. Write a laboratory report that includes title, introduction, procedure, data/observations, results, and conclusion.

COMPENTENCY V (VA SOL CH.1)
Categorize matter and its properties.
Enabling Objectives:

1. Describe the general properties of matter.
2. Identify common elements by chemical symbols.
3. Classify matter according to whether it is an element, a compound, or a mixture.
4. Experimentally determine density for a variety of substances.
5. Distinguish between physical and chemical properties of matter.
6. Carry out physical and chemical changes to determine chemical and physical properties of substances
7. Use physical methods to separate the components of a mixture.
8. Describe the events leading to the modern day arrangement of the periodic table.
9. Observe periodic trends of the general characteristics of metals, nonmetals, and metalloids.

COMPENTENCY VI (VA SOL CH.2)
Investigate the development of modern atomic theory.
Enabling Objectives:

1. Describe the postulates of the modern atomic theory.
2. Relate the Laws of Conservation of Mass, Definite Composition, and Multiple Proportions to atomic theory.
3. Locate and describe the main components of the atom as used in chemistry.
4. Define isotope, and relate atomic number, mass number, and the number of subatomic particles to each other, and interpret and write isotope symbols.
5. Calculate average atomic mass from isotope abundances.
6. Define Avogadro's number and its relationship to atomic mass.

COMPENTENCY VII (VA SOL CH.2)
Characterize the electronic structure of the atom.
Enabling Objectives:

1. State and interpret the postulates of quantum theory.
2. Relate energy differences, wavelength, and frequencies of EMR.
3. Describe the atomic spectrum of hydrogen in terms of the Bohr model.
4. Identify the four quantum numbers and relate each in terms of energy differences and mathematical interpretation.
5. Write electron configurations for elements.
6. Use Hund's rule to draw orbital diagrams for electrons in an atom.
7. Experimentally determine the wavelengths and frequencies in the line spectra of selected elements using a spectroscope.

COMPENTENCY VIII (VA SOL CH.2, CH.3, CH.6)

Relate ionic and covalent bonding to the electronic structure of atoms and the ionic and/or molecular compounds they form.

Enabling Objectives:

1. Identify basic differences between atoms, molecules, and ions and classify compounds as being ionic or molecular.
2. Describe the formation of cations and anions, and relate it to electronegativity and position on the periodic table.
3. Write Lewis structures to show the covalent bonding in molecules and polyatomic ions.
4. Determine the polarity of covalent bonds from electronegativities.
5. Explain the theory of atomic bonding in solids including covalent, Van der Waals, and metallic bonding.
6. Distinguish between electrolytes and nonelectrolytes using experimental observations.
7. Relate the vapor pressures and phases of two or more substances at a given temperature to the intermolecular attractions present in the substances.
8. Use VSEPR model to predict the geometric shape of simple molecules and polyatomic ions.
9. Construct models of molecules and polyatomic ions to illustrate their predicted geometric shapes.
10. Predict the polarity of molecules by using the VSEPR model for molecules containing polar covalent bonds.
11. Identify the unique properties of carbon that allow multi-carbon compounds.

COMPENTENCY IX (VA SOL CH.3)

Apply rules of chemical nomenclature to writing formulas and naming compounds.

Enabling Objectives:

1. Write names of ionic and binary covalent compounds from their formulas using the older system of prefixes and suffixes and the newer IUPAC system.
2. Use the ion-charge method to write formulas for ionic compounds.
3. Write formulas for binary covalent compounds.
4. Write formulas for common acids.

COMPENTENCY X (VA SOL CH.4)

Apply the mole concept to calculations involving masses and/or numbers of atoms, molecules, or formula units.

Enabling Objectives:

1. State the masses of atoms or molecules in terms of molar masses.
2. Convert numbers of atoms and molecules to masses and vice versa by using the mole concept.
3. Calculate and prepare solutions of known molarity.
4. Distinguish between empirical and molecular formulas.
5. Experimentally determine the anhydrous molar mass of a hydrated compound.
6. Calculate the percent composition of a compound from its formula, and from experimental data.
7. Calculate empirical and molecular formulas from experimental data.

COMPENTENCY XI (VA SOL CH.3)

Categorize and write balanced equations for chemical reactions.

Enabling Objectives:

1. Write and balance chemical equations when given reactants and products.
2. Classify those equations that come under the heading of synthesis, decomposition, single and double replacement, and combustion reactions.
3. Predict the products of chemical reactions when given the reactants.
4. Define oxidation and reduction, and identify any species undergoing oxidation or reduction, and identify the oxidizing and reducing agents.
5. Use a solubility table to predict the formation of insoluble products, and the activity series to predict the occurrence of single replacement reactions.
6. Carry out examples of each kind of reaction, and write balanced equations for each.

COMPENTENCY XII (VA SOL CH.4)

Apply stoichiometry experimentally and in calculations.

Enabling Objectives:

1. Calculate mass relationships based on balanced chemical equations.
2. Determine the limiting reactant, and the theoretical yield for chemical reactions.
3. Experimentally determine the mole ratio for a chemical reaction, and use it to determine the equation for the reaction.
4. Carry out calculations involving solution concentrations expressed in molarity.

COMPENTENCY XIII (VA SOL CH.3)

Relate the concepts of energy, enthalpy, and entropy to chemical reactions.

Enabling Objectives:

1. Classify the various forms of energy.
2. Summarize the changes in energy that take place during a chemical reaction.
3. Experimentally determine the specific heat capacity for several substances, and relate these quantities to the structures of the substances.
4. Distinguish between exothermic and endothermic reactions.
5. Distinguish between heat and temperature.
6. Calculate ΔH° for a reaction using specific heats and heats of formation.
7. Experimentally measure heat flow using a calorimeter, and use the measurements to write a thermochemical equation for the reaction.
8. Define and calculate ΔH° and ΔS° for a reaction, and relate the signs to characteristics of the reaction.
9. Qualitatively relate a reaction's ΔH° and ΔS° values to the reaction's free energy (ΔG°), and how the value of ΔG° can be used to determine whether or not the reaction is thermodynamically favored.

COMPENTENCY XIV (VA SOL CH.4)

Relate the concept of equilibrium to chemical reactions, especially with reference to acids and bases.

Enabling Objectives:

Write the expression for K_c from the balanced chemical equation.

1. Calculate K_c from equilibrium concentrations of all species, or from original concentrations of all species and the equilibrium concentration of one species.
2. Using LeChâtelier's Principle, predict the effect of a change in the number of moles, volume, or temperature upon the position of a system at equilibrium.
3. Relate the acidic and basic properties of aqueous solutions to the dissociation of water.
4. Carry out calculations involving pH and pOH.
5. Compare strong and weak acids and bases.
6. Write equations for reactions between acids and bases.
7. Carry out acid-base titrations and write equations for the reactions.
8. Compare the Arrhenius and Bronsted-Lowry theories of acids.

COMPENTENCY XV (VA SOL CH.5)

Describe gases in terms of the kinetic theory of gases and apply the gas laws and the Ideal Gas Equation to problems.

Enabling Objectives:

1. Define pressure and relate to kinetic-molecular theory.
2. Describe the effect of temperature on pressure and volume of gases.
3. Apply the mole-volume relationship of gases to gas-phase reactions.
4. Describe the relationship between pressure and volume of gases.
5. Combine Boyle's, Charles, and Gay-Lussac's laws into the ideal gas law.
6. Describe mixtures of gases in terms of Dalton's Law of Partial Pressures.
7. Relate density of gases to molar volume and molar mass.
8. Carry out experiments dealing with Boyle’s Law, the Ideal Gas Law, and Dalton’s Law of Partial Pressures.
9. Describe the operation of mercury barometers.

COMPENTENCY XVI (VA SOL CH.6)

Carbon atoms can create unique, long-chain compounds.

Enabling Objectives:

1. Describe how saturation affects the shape and reactivity of carbon compounds.
2. Draw Lewis dot structures, identify geometries, and describe polarities of specific organic molecules.
3. Recognize that proteins and nucleic acids are important natural organic polymers.
4. Recognize that plastics formed from petrochemicals are synthetic organic polymers.
5. Identify the uses of organic compounds in pharmaceuticals and genetics, plastics, and food.