Virginia Science Grades 9-12
Curriculum Standards

CHEMISTRY	Boardworks High School Chemistry Presentation
Standard 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 of:	
a) Average atomic mass, mass number, and atomic number;	
i) Using a periodic chart, determine the atomic number, atomic mass, the number of protons, the number of electrons, and the number of neutrons of any neutral atom of a particular element.	Atomic Number and Mass Number Electron Configuration Electron Structure and the Periodic Table
b) Isotopes, half lives, and radioactive decay;	
i) An isotope is an atom that has the same number of protons as another atom of the same element but has a different number of neutrons. Some isotopes are radioactive; many are not.	Isotopes
ii) Half-life is the length of time required for half of a given sample of a radioactive isotope to decay	Half-life
iii)Determine the half-life of a radioactive substance.	Half-life
iv) Describe alpha, beta, and gamma radiation with respect to penetrating power, shielding, and composition.	Radioactivity Types of Radiation
c) Mass and charge characteristics of subatomic particles	
i) Electrons have little mass and a negative (-) charge. Theyare located in electron clouds or probability clouds outside the nucleus.	Atomic Structure
ii) Protons have a positive (+) charge. Neutrons have no charge. Protons and neutrons are located in the nucleus of the atom and comprise most its mass.	Atomic Structure
d) Families or groups;	
i) The names of groups and periods on the periodic chart are alkali metals, alkaline earth metals, transition metals, halogens, noble gases, and metalloids.	The Periodic Table
ii) Periods and groups are named by numbering columns and rows.	The Periodic Table
e) Series and periods;	
i) The names of groups and periods on the periodic chart are alkali metals, alkaline earth metals, transition metals, halogens, noble gases, and metalloids.	The Periodic Table
ii)Periods and groups are named by numbering columns and rows.	The Periodic Table
f) Trends including atomic radii, electronegativity, shielding effect, and ionization energy.	
i) The Periodic Law states that when elements are arranged in order of increasing atomic numbers, their physical and chemical properties show a periodic pattern.	Patterns of Behavior

ii) Some elements, such as oxygen, hydrogen, fluorine, chlorine, bromine, and nitrogen, naturally occur as diatomic molecules.	Introducing Atoms
iii) Electronegativity increases from left to right within a period and decreases from top to bottom within a group.	Electronegativity Patterns of Behavior
iv) Shielding effect is constant within a given period and increases within given groups from top to bottom.	Electronegativity
v) Atomic radius decreases from left to right and increases from top to bottom within given groups.	Electronegativity
vi) Ionization energies generally increase from left to right and decrease from top to bottom of a given group.	Ionization Energy Patterns of Behavior
g) Electron configurations, valence electrons, and oxidation numbers.	
i) Electrons are added one at a time to the lowest energy levels first (Aufbau Principle).	Energy Sublevels
ii) An orbital can hold a maximum of two electrons (Pauli Exclusion Principle).	Orbitals
iii)Electrons occupy equal-energy orbitals so that a maximum number of unpaired electrons results (Hund's Rule).	Orbitals
iv) Energy levels are designated 1-7. Orbitals are designated s, p, d, and f according to their shapes	Energy Sublevels Orbitals
v) s, p, d, f orbitals relate to the regions of the Periodic Table.	Energy Sublevels
vi) Loss of electrons from neutral atoms results in the formation of an ion with a positive charge (cation).	Formation of Ions
vii)Gain of electrons by a neutral atom results in the formation of an ion with a negative charge (anion).	Formation of Ions
viii) Transition metals can have multiple oxidation states.	Oxidation Numbers
ix) Use an element's electron configuration to determine the number of valence electrons and possible oxidation numbers.	Electron Structure and the Periodic Table Oxidation Numbers
h) Chemical and physical properties.	
i) Matter occurs as elements (pure), compounds (pure), and mixtures, which may be homogeneous (solutions) or heterogeneous.	Introducing Atoms Solutions
ii) Important physical properties are density, conductivity, melting point, boiling point, malleability, and ductility.	Comparing Bonding
iii)Reactivity is the tendency of an element to enter into a chemical reaction.	Why do Atoms Form Bonds?
i) Historical and quantum models.	

i) Major insights regarding the atomic model of the atom and principal scientists include: - particles - Democritus - first atomic theory of matter - John Dalton - discovery of the electron - J. J. Thompson - discovery of the nucleus - Ernest Rutherford - discovery of charge of electron - Robert Millikan - planetary model of atom - Niels Bohr - periodic table by atomic mass - Demitry Mendeleev - periodic table by atomic number - Henry Moseley - quantum nature of energy - Max Planck - uncertainty principle - Werner Heisenberg - wave theory - Louis de Broglie.	Introducing Atoms The Periodic Table
Standard CH.2 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include:	
a) Nomenclature;	
i) The IUPAC system is used for naming compounds.	Naming Compounds
ii) Write the chemical formulas for certain common substances, such as ammonia, water, carbon monoxide, carbon dioxide, sulfur dioxide, and carbon tetraflouride.	Naming Compounds
b) Balancing chemical equations;	
i) Determine formulas, write equations, and balance chemical equations.	Naming Compounds Reacting Masses Types of Formulae
c) Writing chemical formulas (molecular, structural, and empirical; and Lewis diagrams);	
i) When pairs of elements form two or more compounds, the masses of one element that combine with a fixed mass of the other element form simple, whole-number ratios (Law of Multiple Proportions).	Percentage Composition by Mass
ii) The empirical formula shows the simplest whole-number ratio in which the atoms of the elements are present in the compound.	Reacting Masses Types of Formulae
iii) The molecular formula shows the actual number of atoms of each element in one molecule of the substance.	Types of Formulae
iv) Structural formulas also show the arrangements of atoms and bonds.	–
v) Predict, draw, and name molecular shapes (bent, linear, trigonal planar, tetrahedral, and trigonal pyramidal).	Shapes of Molecules

vi) Recognize the formulas and names of certain polyatomic ions, such as carbonate, sulfate, nitrate, hydroxide, phosphate, and ammonium, and use these polyatomic ions for naming and writing the formulas of ionic compounds.	Naming Compounds
vii) Draw Lewis Dot Diagrams to show covalent bonding.	–
d) Bonding types (ionic and covalent).	
i) Covalent bonds involve the sharing of electrons.	Covalent Bonding
ii) Ionic bonds involve the transfer of electrons.	Formation of Ions Ionic Bonding
iii) Ionization energy is the energy required to remove the most loosely held electron from a neutral atom. Elements with low ionization energy form positive ions (cations) easily. Elements with high ionization energy form negative ions (anions) easily.	Formation of Ions Ionic Bonding Ionization Energy
iv) Electronegativity is the measure of the attraction of an atom for electrons in a covalent bond	Electronegativity
v) Polar molecules result when a molecule behaves as if one end were positive and the other end negative.	Electronegativity
vi) Name binary covalent compounds.	Covalent Bonding
vii) Name binary ionic compounds (using the Roman numeral system where appropriate).	Ionic Bonding
e) Reaction types (synthesis, decomposition, single and double replacement, oxidation-reduction, neutralization, exothermic, and endothermic);	
i) Major types of chemical reactions are: - synthesis (A+B → AB) - decomposition (BC → B+C) - single replacement (A+BC → B+AC) - double replacement (AC+BD → AD+BC).	Neutralization Thermal Decomposition
ii) Chemical reactions based on the net heat energy are exothermic reaction (heat producing) and endothermic reaction (heat absorbing).	Endothermic Reactions Exothermic Reactions
iii) Reactions can occur in two directions simultaneously.	Le Chatelier's Principle Reversible Reaction
iv) Skills - Recognize equations for redox reactions and neutralization reactions.	Redox Reactions
f) Reaction rates and kinetics (activation energy, catalysis, and degree of randomness).	
i) Le Chatelier's Principle indicates the qualitative prediction of direction of change with temperature, pressure, and concentration.	Concentration, Pressure and Reaction Rates Le Chatelier's Principle Temperature and Reaction Rates
ii) Catalysts decrease the amount of activation energy needed.	Surface Area, Catalysts and Reaction Rates
iii) Interpret reaction rate diagrams.	Rates of Reaction

Standard CH.3 The student will investigate and understand that quantities in a chemical reaction are based on molar relationships. Key concepts include:	
a) Avogadro's principle and molar volume;	
i) Avogadro's number = 6.02 × 1023 particles per mole.	What are Moles?
ii) Molar volume = 22.4 dm3/mole and/or 22.4 L/mole for any gas at STP.	Gases and Moles
iii) Make calculations involving the following relationships: - mole-mole; - mass-mass; - mole-mass; - mass-volume; - mole-volume; and - volume-volume.	 Gases and Moles Molar Mass What are Moles?
b) Stoichiometric relationships.	
i) Molar mass of a substance is its average atomic mass in grams from the Periodic Table.	Molar Mass
ii)Total grams of reactant(s) = total grams of product(s).	Conservation of Mass
iii) Identify the limiting reactant (reagent) in a reaction.	–
iv) Calculate percent yield of a reaction.	Yield and Atom Economy
c) Partial pressure;	–
d) Gas laws;	
i) The pressure and volume of a sample of a gas at constant temperature are inversely proportional to each other (Boyle's Law).	–
ii) At constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature (Charles' Law).	–
iii) The sum of the partial pressures of all the components in a gas mixture is equal to the total pressure of a gas mixture (Dalton's law of partial pressures).	–
iv) The sum of the partial pressures of all the components in a gas mixture is equal to the total pressure of a gas mixture (Dalton's law of partial pressures).	–
v) Ideal Gas Law states that PV = nRT.	Ideal Gas Laws
vi) Molarity = moles/dm3 or moles/L of solution.	Gases and Moles
vii) Pressure Units include K Pa and mm of Hg.	–
viii) Solve problems and interpret graphs involving the gas laws.	Ideal Gas Laws
e) Solution concentrations;	Solubility Solutions

f) Chemical equilibrium.	Dynamic Equilibrium Equilibrium - Changing Conditions Le Chatelier's Principle Neutralization pH and Indicators
g) Acid/base theory: strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process.	
i) Arrhenius acids are characterized by their sour taste, low pH, and the fact that they turn litmus paper red. Arrhenius bases are characterized by their bitter taste, slippery feel, high pH, and the fact that they turn litmus paper blue.	Neutralization pH and Indicators Properties of Acids and Alkalis
ii) Bronsted-Lowry-acids are proton donors, whereas bases are proton acceptors.	Neutralization Properties of Acids and Alkalis
iii) The pH number denotes hydrogen (hydronium) ion concentration. The pOH number denotes hydroxide ion concentration.	–
iv) pH + pOH = 14	–
v) pH is a number scale ranging from 0 to 14 that represents the acidity of a solution.	pH and Indicators
vi) Strong acid-strong base titration is the process that measures [H+] and [OH-].	Neutralization Properties of Acids and Alkalis
vii) Indicators show color changes at certain pH levels.	pH and Indicators Properties of Acids and Alkalis
viii) Strong electrolytes dissociate completely. Weak electrolytes dissociate partially.	Properties of Acids and Alkalis
Standard CH.4 The student will investigate and understand that the phases of matter are explained by kinetic theory and forces of attraction between particles. Key concepts include:	
a) Pressure, temperature, and volume;	
i) Pressure, temperature, and volume changes can cause a change in physical state.	–
ii) Forces of attraction include hydrogen bonding, dipoledipole attraction, and London dispersion (van der Waals) forces.	Intermolecular Forces
b) Vapor pressure.	–
c) Phase changes;	
i) A liquid's boiling point and freezing point are affected by changes in atmospheric pressure.	–
ii) Graph and interpret a heating curve (temperature vs. time).	Changing State
iii) Interpret a phase diagram of water.	–
d) Molar heats of fusion and vaporization;	
i) Calculate energy changes, using molar heat of fusion and molar heat of vaporization.	–
e) Specific heat capacity;	

i) Graph and interpret a heating curve (temperature vs. time).	–
ii) Perform calorimetry calculations.	Calorimetry
f) Colligative properties.	
i) A liquid's boiling point and freezing point are affected by the presence of certain solutes.	–
ii) Recognize polar molecules and non-polar molecules.	Electronegativity