SCIENCE DEPARTMENT

The Department's Educational Philosophy

Students will engage in the process of science through scientific inquiry and application of the underlying scientific concepts. Students will use qualitative as well as computational thinking to analyze and interpret data. Students will develop the necessary skills to generate, interpret qualitative and quantitative data, evaluate scientific claims and provide evidence for scientific conclusions. .

Guiding Principles

- Students will engage with the process of science by participating in hands on activities and labs that help students to gain a better understanding of underlying concepts, elucidate concepts and relationships or develop inquiry based experiments
- Students will apply their computational skills to interpret and represent data
- Students will be able to evaluate the merits of conceptual models and apply the appropriate models and relationships
- Students will be able to support scientific claims, provide evidence for those claims and make conclusions based on qualitative and quantitative data
- Students will work collaboratively

CHEMISTRY (CP): Course # 433

Course Frequency: Full year course
Credits Offered: Five
Prerequisites: By teacher recommendation

Background to the Curriculum

This course is aligned with the MA Frameworks. This course is long-established and has developed over time to align with the Guiding Principles and Educational Philosophy of the ABRHS Science Department.

Core Topics/Questions/Concepts/Skills

- Atomic structure and theory
- Periodic table
- Bonding
- Naming and formula writing
- Chemical reactions
- The mole and stoichiometry
- Kinetics
- Gases
- Thermochemistry
- Solution chemistry
- Equilibrium
- Acids and bases
- Electrochemistry

Course-End Learning Objectives

Unit 1

Students should be able to:

- Define chemistry.
- Identify the different safety features of the classroom and the purpose of each feature.
- Distinguish between intramolecular forces and intermolecular forces and give an example of each.
- Distinguish between a physical and chemical change.
- List the indicators of a chemical change.
- Perform a series of experiments and use experimental observations to determine if the reaction is a chemical or physical change.
- Predict if a change is physical or chemical from a description.
- List the three states of matter and their characteristics.
- Construct a chart showing the organization of matter and their characteristics.
- Distinguish between homogeneous and heterogeneous mixtures.
- Identify the processes to separate: a) homogeneous mixture and b) heterogeneous mixture.
- Distinguish between an element and compound.
- Distinguish between an atom and molecule.
- State the Law of Conservation of Matter and explain.
- Use the Metric System for mass, volume, length and temperature.
- Convert quantities within the metric system.
- Convert very large or very small numbers into scientific notation and convert from scientific notation to standard numbers.
- Define density and determine the density of several objects using laboratory techniques.
- Calculate the volume or mass of a given substance.
- Calculate the density of a given substance.
- Compare two substances' properties using their density.

Laboratory Skills

- Consistently follow safety rules.
- Measure the volume or mass of a given substance using the correct measuring device and units.

Unit 2

Students should be able to:

- Explain the Law of Conservation of Matter and the Law of Definite Composition.
- Calculate the amount of product formed or reactant used during an experiment due to the Conservation of Mass.
- Express the amount of each element in a compound as a percent composition.
- Use percent composition to determine the amount of each element in a compound.
- Identify the sub-atomic parts of the atom and their charge.
- Distinguish between atomic number and atomic mass.
- Using the periodic table, identify all the information contained therein for each element.
- Identify common elements by their chemical symbol and identify the symbol of an element from its name.
- Define the term isotope and explain how isotopes of the same element are different.
- Define the term ion and explain how an ion differs from an atom. Distinguish between a cation and anion.
- Given the number of protons or the Atomic Number, identify the element.
- Identify trends on the periodic table in terms of what ion an element will form.
- Explain what a weighted atomic mass represents and be able to fill in a weighted average isotope worksheet.
- Define Molecular Mass, Formula Mass, Molar Mass and Avagadro's Number.
- Convert between or among (1) Mass and Moles; (2) Moles and Particles (Atoms/Molecules); and (3) Mass, Moles and Particles.
- Experimentally determine the average atomic mass of a hypothetical element
- Calculate the composition of an egg using experimental data.

Laboratory Skills

- Determine what measurements are needed to determine the mass of difference components of an egg.
- Accurately measure the mass of an object using the appropriate instrument.
- Record data from measurements.
- Measure the mass of an object.
- Determine the "abundance" of each "isotope".
- Calculate the percent abundance of each "isotope".
- Calculate the weighted average of their M&Mium sample.
- Compile class data for various M&Mium samples.
- Recognize the effect of an isotope's abundance on its element's atomic mass.

Unit 3

Students should be able to:

- List and discuss the scientists who contributed to the evolution of the model of the atom (Democritus, Dalton, Thomson, Rutherford, Chadwick and Bohr).
- List and discuss key experiments conducted during the evolution of the model of the atom (the Cathode Ray Experiment and the Gold Foil Experiment).
- Describe how light is a particle but behaves as a wave.
- Compare the wavelength and frequency of a particular color wave.
- Calculate the energy associated with a particular wavelength of light.
- Distinguish between the photoelectric effect and spectral line.
- Describe the electromagnetic spectrum.
- Compare wavelength, frequency and energy on electromagnetic spectrum.
- Compare and contrast continuous spectrum and line spectrum.
- Explain Schrodinger's Quantum Mechanical Model of the Atom using the following terms: orbital, electron density map, probability, sublevel and energy level.
- Distinguish between: (1) ground state and excited state; and (2) absorb and emit energy.
- Indicate where the electrons are likely to be found within the atom using the following rules: Aufbau Principle, Pauli Exclusion Principle and Hund's Rule.
- Determine the number of valence electrons each element has.
- Fill in an energy diagram.
- Write the electron configuration for elements (including the shorthand notation).
- Use the Periodic Table to describe the trend for the number of valence electrons within a group and within a series.

Laboratory Skills

- Understand the difference between a continuous and discontinuous spectrum.
- Understand how a spectroscope works.
- Use a spectroscope to view the line spectrum of an element.
- Use a line spectrum to match an unknown spectrum to its chemical element.
- Safely light a Bunsen burner.
- Determine the identity of 2 unknowns using collected data.
- Explain when each flame is a different colored light.
- Explain what is occurring on a molecular level to produce the colored light.

Unit 4

Students should be able to:

- List the properties of metals, nonmetals and metalloids.
- Locate and name most reactive metal and nonmetal on Periodic Table.
- Label the names of each of the main groups and list their properties AND number the groups and periods.
- Explain how Mendeleev created the first accepted Periodic Table arranged by atomic mass.
- Explain how Mendeleev accurately predicted an undiscovered element and its properties based on gaps in his table.
- Explain how the current Periodic Table is arranged by atomic number.
- Explain the Periodic Law.
- Identify an element based on its group number and period.
- Relate electron configuration to the layout of the Periodic Table.
- Describe and explain the trends for valence electrons.
- Describe and explain the atomic radius trend.
- Write the ion configuration for a specific element and predict the ion that a specific element will form.
- Describe and explain the ion radius trends.
- Describe and explain the ionization energy trend.
- Explain the trend for the 1st, 2nd, 3rd…ionization energy.
- Describe and explain the electronegativity trend.
- Compare elements to one another based on a specific trend; atomic radius, ion size, ionization energy (1st, 2nd, 3rd), electronegativity.
- Predict likely ion charge based on first, second, third, etc. ionization energies.

Unit 5

Students should be able to:

- Identify the number of valence electrons for any atom.
- Explain how an ionic bond forms between two elements.
- Draw Lewis dot structures for atoms and ions and show the transfer of electrons.
- Predict the chemical formula for ionic substances based on ion charges and electron transfer.
- Identify and describe some physical and chemical properties of ionic compounds.
- Explain how that covalent bonding involves the sharing of electrons.
- Predict the presence of double or triple bonds.
- Draw Lewis Dot structures for covalent molecules.

- Use VSEPR (Valence Shell Electron Pair Repulsion) to predict shape and bond angles of covalent molecules.
- Explain bond polarity and determine bond polarity using electronegativity values.
- Predict polarity of molecules using bond polarity and molecular shape.
- Identify and describe some chemical and physical properties of covalent compounds.
- Identify and describe London Dispersion, dipole-dipole, and hydrogen bonding forces and their relative strength.
- Predict which intermolecular force exists between molecules.

Laboratory Skills

- Correctly identify the mass of the crucible, mass of crucible and reactant, and mass of crucible and product.
- Correctly calculate the mass of reactant, product and added element using the experimental data.
- Use the experimental data to determine the moles of each element in the compound.
- Use experimental data to determine the lowest whole number ratio and chemical formula for an unknown compound.
- Group compounds based on their common physical properties.
- Determine the chemical makeup of two groups of compounds using their chemical formulas.

Unit 6

Students should be able to:

- Write chemical formulas for ionic substances using valence electrons/ion charges.
- Name ionic substances including roman numerals for ion charge when necessary.
- Define and determine the empirical formula of a compound using given amounts of each element.
- Write chemical formulas for covalent substances based on the name.
- Name covalent substances based on the formula using correct prefixes when appropriate.
- Write chemical formulas for acids based on the name.
- Name acids based on the formula (using -ic and -ous correctly).
- Define and determine the molecular formula of a compound using given amounts of each element and the molar mass of the compound.

Laboratory Skills

- Use experimental data to determine the number of grams and moles of each element in the compound and determine the lowest whole number ratio.

Unit 7

Students should be able to:

- Name and write the chemical formula for the reactants and products in a chemical equation.
- Balance a chemical equation using coefficients.
- Apply the conservation of mass to determine the amount of products or reactants involved in general reaction.
- Identify the diatomic elements.
- Write the chemical formula equations from word equations.
- Write the word equation from the balanced chemical equations.
- Identify and define the five Reaction Types; synthesis, decomposition, combustion, single replacement, double replacement.
- Predict and write the chemical formulas of the products of from the reactants.
- Explain the meaning of the coefficients.
- Define and write mole ratios from a balanced chemical reaction.
- Perform stoichiometric calculations (Moles A ↔ Moles B; Grams A ↔ Grams B; Grams A ↔ Moles B; Moles A ↔ Grams B).
- Predict products and perform stoichiometric calculations.
- Define Actual Yield, Theoretical Yield, and Percent Yield.
- Calculate the percent yield, theoretical yield or actual yield from given data.
- Perform stoichiometric calculations with percent yield.
- Relate collision theory and activation energy to reaction rate.
- List and explain factors that affect the rate of a reaction.

Unit 8

Students should be able to:

- Relate collision theory and activation energy to reaction rate.
- List and explain factors that affect the rate of a reaction.
- Compare and contrast the properties of gases compared to the liquid and solid state.
- Explain the general characteristic of gases.
- Define the variables used to describe a gas: pressure, volume, temperature, amount of substance.
- Identify the units associated with each variable used to describe a gas and convert from one unit to another.
- Define Pressure and atmospheric pressure.
- Explain the relationship between atmospheric pressure and altitude.
- Explain the use of a barometer and generally how it works.

- Identify and explain the relationship between the gas law variables qualitatively using the basic Gas Laws: Boyle's Law, Charles' Law, Gay-Lussac's Law.
- Apply and solve gas law problems using the basic Gas Laws equations.
- Define absolute zero temperature and understand its significance.
- State and apply STP conditions to the gas laws.
- Explain the basic gas laws at a molecular level regarding gas particles and collisions.
- Identify and apply the General or Combined Gas Law to calculation problems.
- Understand Avogadro's Law and can complete calculations using this law.
- Identify and apply Ideal Gas Law to find an unknown variable (P, V, n or T).
- Define Molar Volume (1 mol of a gas = 22.4 L).
- Perform stoichiometric calculations with gases.
- Explain the behavior of gases using the kinetic molecular theory (KMT).
- Compare and contrast ideal gases versus real gases.
- Identify the conditions where real gases behave like ideal gases.

Unit 9

Students should be able to:

- Define temperature versus heat.
- Define boiling and explain the process of boiling.
- Identify exothermic versus endothermic reactions AND draw the energy diagrams for both types of reactions.
- Explain the flow of energy in a system and the change in temperature in an exothermic reaction or endothermic reaction.
- Explain the relationship between the conservation of energy and an energy diagram; and I can write an equation to represent this relationship.
- Define enthalpy (H).
- Define specific heat.
- Calculate specific heat or unknown variable using the formula for specific heat.
- Compare and contrast substances based on specific heat values, change in temperature, mass or amount of energy applied.
- Define heat of formation and calculate for the standard heat of formation for a reaction.
- Solve calorimetry problems using given data.
- Use stoichiometry to calculate for the heat absorbed or released in a reaction.

Unit 10

Students should be able to:

- Define and apply solution vocabulary.
- Explain the process of solvation and dissociation.
- Define solubility and express solubility of a solute using solubility graph.
- Explain ways of increasing the rate of dissolving and why.
- Explain factors that affect solubility of a solute (solid or gas) in a solvent.
- Interpret a Solubility graph.
- Define and explain if a solution saturated, unsaturated and supersaturated from descriptors or graph.
- Explain the molarity of a solution and how to prepare a solution.
- Use the molarity equation to solve for an unknown variable.
- Find an unknown value for a chemical reaction using stoichiometry and/or percent yield.
- Use the molality equation to solve for an unknown variable.
- Explain how a solvent's vapor pressure, boiling point and freezing point is affected by adding a solute to the solvent.
- Use the boiling point elevation or freezing point depression equation to solve for an unknown variable.

Unit 11

Students should be able to:

- Explain what it means for a chemical reaction to be at equilibrium.
- Explain the conditions necessary for a reaction to be at equilibrium.
- Write the equilibrium expression for a reversible reaction.
- Calculate the equilibrium constant using concentrations at equilibrium or calculate the concentration of a reactant or product at equilibrium using equilibrium constant.
- Explain what the value of the equilibrium constant means in terms of on concentration of reactants versus products.
- Determine the direction in which the reaction will proceed to reach equilibrium if the conditions are not at equilibrium (Q value) and explain why this direction causes reaction to reach equilibrium.
- Use LeChatelier's Principle to determine the direction in which a reaction will proceed to reach equilibrium when a stress (change in concentration, temperature or pressure) is put on a reaction at equilibrium.

Unit 12

Students should be able to:

- Distinguish between an acid, base and salt using their experimental properties and chemical formulas.
- Name acids, bases and salts.
- Understand and identify acids and bases using the Arrhenius and the Bronsted-Lowry definitions.
- Explain why Bronsted-Lowry definition is more encompassing than the Arrhenius definition.
- Define Bronsted-Lowry conjugate-acids, conjugate-bases and conjugate acid base pairs.
- Label Bronsted-Lowry acid, base, conjugate-acid, conjugate-base and determine conjugate acid base pairs.
- Define amphoteric and autoionization (Kw).
- Calculate $[H_3O^{+1}]$ or $[OH^{-1}]$ using Kw expression and determine if solution is acidic, basic or neutral.
- Calculate $[H_3O^{+1}]$, $[OH^{-1}]$, pH and/or pOH from given information or molarity of an acid or base and determine if solution is acidic, basic or neutral.
- Explain what it means for a solution to be acidic, basic or neutral.
- Write and balance the neutralization reaction that occurs between a specific acid and base reaction.
- Use stoichiometry to calculate the unknown concentration or volume of a reactant using given information.
- Explain how a titration works using appropriate terminology.
- Perform a titration to determine the unknown concentration of a reactant.

Assessment

Student learning will be measured through a variety of assessments including, but not limited to, tests, quizzes, and lab work, including lab practicals.

Materials and Resources

LeMay, H. (2000). *Prentice Hall Chemistry*. Upper Saddle River, N.J.: Prentice Hall.