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.

ADVANCED CHEMISTRY (H/AP): COURSE #439

Course Frequency: Full year course

Credits Offered: Five

Prerequisites: Chemistry and by Teacher Recommendation (Minimum grade of B in Chemistry H strongly preferred)
Students must be enrolled in Advanced Chemistry Lab 438 (H/AP) concurrently

Background to the Curriculum

This course is aligned with the College Board AP Chemistry Curriculum. The course curriculum was developed over the past 20+ years to incorporate the most up to date AP Chemistry Curriculum Learning Objectives.

Core Topics/Questions/Concepts/Skills

The AP Chemistry curriculum is centered around the four big ideas below.

1. **Scale, Proportion and Quantity (SPQ)**

   Quantities in chemistry are expressed at both the macroscopic and atomic scale.

   Explanations, predictions and other forms of argumentation in chemistry require understanding the meaning of these quantities and the relationship between quantities at the same scale and across scales.

2. **Structure and Properties (SAP)**

   Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.

3. **Transformations (TRA)**

   At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of transformation is also of interest, as particles must move and collide to initiate reaction events.

4. **Energy (ENE)**

Energy has two important roles in characterizing and controlling chemical systems. The first is accounting for the distribution of energy among the components of a system and the ways that heat exchanges, chemical reactions, and phase transitions redistribute this energy. The second is considering the enthalpic and entropic driving forces for a chemical process. These are closely related to the dynamic equilibrium present in many chemical systems and the ways in which changes in experimental conditions alter the positions of these equilibria.

Course-End Learning Objectives

SPQ-1.A Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

SPQ-1.B Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.

SPQ-2.A Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.

SPQ-2.B Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.

SPQ-3.A Calculate the number of solute particles, volume, or molarity of solutions.

SPQ-3.B Using particulate models for mixtures:

A. Represent interactions between components.

B. Represent concentrations of components.

SPQ-3.C Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles.

SPQ-4.A Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.

SPQ-4.B Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.

SPQ-5.A Calculate the solubility of a salt based on the value of K_{sp} for the salt.

SPQ-5.B Identify the solubility of a salt, and/or the value of K_{sp} for the salt, based on the concentration of a common ion already present in a solution..

SPQ-5.C Identify the qualitative effect of changes in pH on the solubility of a salt.

SPQ-5.D Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process.

SAP-1.A Represent the electron configuration of an element or ions of an element using the Aufbau Principle.

SAP-1.B Explain the relationship between the photoelectron spectrum of an atom or ion and:

SAP-2.A Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.

SAP-2.B Explain the relationship between trends in the reactivity of elements and periodicity.

SAP-3.A Explain the relationship between the type of bonding and the properties of the elements participating in the bond.

SAP-3.B Represent the relationship between potential energy and distance between atoms, based factors that influence the interaction strength.

SAP-3.C Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions.

SAP-3.D Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance.

SAP-4.A Represent a molecule with a Lewis diagram.

SAP-4.B Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures that uses formal charge to select between nonequivalent structures.

SAP-4.C Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:

A. Explain structural properties of molecules.

B. Explain electron properties of molecules.

SAP-5.A Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:

A. The molecules are of the same chemical species.

B. The molecules are of two different chemical species.

SAP-5.B Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.

SAP-6.A Represent the differences between solid, liquid, and gas phases using a particulate-level model.

SAP-7.A Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.

SAP-7.B Explain the relationship between the motion of particles and the macroscopic properties of gases with:

A. The kinetic molecular theory (KMT)

B. A particulate model

C. A graphical representation

SAP-7.C Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes.

SAP-8.A Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region.

SAP-8.B Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule.

SAP-8.C Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity.

SAP-9.A Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water.

SAP-9.B Calculate the pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base.

SAP-9.C Explain the relationship among pH, pOH, and concentrations of all species in a solution of monoprotic weak acid or weak base.

SAP-9.D Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases.

SAP-9.E Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.

SAP-9.F Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.

SAP-10.A Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pK_b of the conjugate base.

SAP-10.B Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution.

SAP-10.C Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer.

SAP-10.D Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and the conjugate base components of the solution.

TRA-1.A Identify evidence of chemical and physical changes in matter.

TRA-1.B Represent changes in matter with a balanced chemical or net ionic equation:

A. For physical changes

B. For given information about the identity of the reactants and/or product.

C. For ions in a given chemical reaction.

TRA-1.C Represent a given chemical reaction or physical process with a consistent particulate model.

TRA-1.D Explain the relationship between macroscopic characteristics and bond interactions for:

A. Chemical processes.

B. Physical processes.

TRA-2.A Identify a reaction as acid-base, oxidation-reduction, or precipitation.

TRA-2.B Identify species and Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, based on proton transfer involving those species.

TRA-2.C Represent a balanced redox reaction equation using half-reactions.

TRA-3.A Explain the relationship between the rate of a chemical reaction and experimental parameters.

TRA-3.B Represent experimental data with a consistent rate law expression.

TRA-3.C Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.

TRA-4.A Represent an elementary reaction as a rate law expression using Stoichiometry.

TRA-4.B Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions.

TRA-4.C Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.

TRA-5.A Identify the components of a reaction mechanism.

TRA-5.B Identify the rate law for a reaction from a mechanism in which the first step is rate limiting.

TRA-5.C Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting.

TRA-5.D Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile.

TRA-6.A Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations.

TRA-6.B Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.

TRA-7.A Represent the reaction quotient, Q_c or Q_p, for a reversible reaction, and the corresponding equilibrium expressions $K_c = Q_c$ or $K_p = Q_p$.

TRA-7.B Calculate K_c or K_p based on experimental observations of concentrations or partial pressures at equilibrium.

TRA-7.C Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium.

TRA-7.D Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction.

TRA-7.E Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.

TRA-7.F Represent a system undergoing a reversible reaction with a particulate model.

TRA-8.A Identify the response of a system at equilibrium to an external stress, using LeChatelier's principle.

TRA-8.B Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium.

ENE-1.A Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism.

ENE-2.A Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.

ENE-2.B Represent a chemical or physical transformation with an energy diagram.

ENE-2.C Explain the relationship between the transfer of thermal energy and molecular collisions.

ENE-2.D Calculate the heat *q* absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature.

ENE-2.E Explain changes in the heat *q* absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition.

ENE-2.F Calculate the heat *q* absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction.

ENE-3.A Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction.

ENE-3.B Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation.

ENE-3.C Represent a chemical or physical process as a sequence of steps.

ENE-3.D Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps.

ENE-4.A Identify the sign and relative magnitude of the entropy change associated with chemical or physical properties.

ENE-4.B Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.

ENE-4.C Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG°.

ENE-4.D Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.

ENE-5.A Explain whether a process is thermodynamically favored using the relationships between K, ΔG°, and T.

ENE-5.B Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.

ENE-6.A Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell.

ENE-6.B Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell.

ENE-6.C Explain the relationship between deviations from standard cell conditions and changes in the cell potential.

ENE-6.D Calculate the amount of charge flow based on the changes in the amounts of reactants and products in an electrochemical cell.

Assessment

Student learning will be measured through tests, quizzes and lab work including lab practicals.

Materials and Resources

Zumdahl, Steven S., and Susan A. Zumdahl. *Chemistry*. Belmont, CA: Brooks/Cole, Cengage Learning, 2014. Print.