AP Chemistry

Curricular Requirements

CR1 - Students and teachers use a recently published (within the last 10 years) college-level chemistry textbook.

CR2 - The course is structured around the enduring understandings within the big ideas as described in the AP Chemistry Curriculum Framework.

CR3a – The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 1: Structure of matter.

CR3b – The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 2: Properties of matter - characteristics, states, and forces of attraction.

CR3c – The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 3: Chemical reactions.

CR3d – The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 4: Rates of chemical reactions.

CR3e - The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 5: Thermodynamics.

CR3f - The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 6: Equilibrium.

CR4 - The course provides students with the opportunity to connect their knowledge of chemistry and science to major societal or technological components (e.g. concerns, technological advances, innovations) to help them become scientifically literate citizens.

CR5a – Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time.

CR5b – Students are provided the opportunity to engage in a minimum of 16 hands-on laboratory experiments integrated throughout the course while using basic laboratory equipment to support the learning objectives listed within the AP Chemistry Curriculum Framework.

CR6 – The laboratory investigations used throughout the course allow students to apply the seven science practices defined in the AP Chemistry Curriculum Framework. At minimum, six of the required 16 labs are conducted in a guided inquiry format.

CR7 – The course provides opportunities for students to develop, record, and maintain evidence of their verbal, written, and graphic communication skills through laboratory reports, summaries of literature or scientific investigations, and oral, written, and graphic presentations.

Course Design

This course is designed to provide a solid, first-year college chemistry experience, both conceptually and in the laboratory. We cover a lot of material very quickly. A solid math background and a sound work ethic are essential to success in AP Chemistry. Students in AP Chemistry should be self-starters – there is simply not enough time to cover every conceptual detail in class. Students should come to class with questions. Attendance is extremely important. The teacher is also available from 3:00 to 4:00 after school each day if you need additional help.

Students are expected to come into the course with a sound previous knowledge of:
While these topics are covered in this course, we go over them quickly.

Due to their increased complexity or unfamiliar nature, more time is allotted to teaching the following concepts:
- chemical kinetics
- equilibrium
- thermodynamics
- redox reactions
- buffer systems
- coordination complexes
- nuclear chemistry
- organic chemistry

The AP chemistry course is built around the following six big ideas and their associated enduring understandings (see the college board website for the enduring understandings) and seven science practices.

**Big Ideas: (CR2)**

**BI 1** – The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.

**BI 2** – Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

**BI 3** - Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.

**BI 4** – Rates of chemical reactions are determined by details of the molecular collisions.

**BI 5** – The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

**BI 6** – Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

**Science Practices: (CR6)**

**SP 1** – The student can use representations and models to communicate scientific phenomena and solve scientific problems

**SP 2** – The student can use mathematics appropriately

**SP 3** – The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

**SP 4** – The student can plan and implement data collection strategies in relation to a particular
scientific question.

**SP 5** – The student can perform data analysis and evaluation of evidence.

**SP 6** – The student can work with scientific explanations and theories.

**SP 7** – The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

**Teaching Strategies**
The following strategies are used when teaching the AP Chemistry course:
1. From the very beginning, emphasize to students and parents that AP Chemistry will be extremely challenging.
2. Stress that attendance and punctuality are essential.
3. Emphasize to the students that self-motivation is very important. There is simply not enough time to cover all AP Chemistry concepts in depth in class. The ability to “teach oneself” becomes extremely important.
4. Encourage students to work together in order to learn.
5. Use Released AP Exam questions. Free-response questions from released exams are used in homework assignments and chapter review sheets.
6. Give tests as infrequently as possible so that testing does not take up too much time during the course. As often as possible, tests are constructed to mimic the AP Chemistry exam questions.
7. Practice, practice, practice. Significant time should be taken to place students in as close to an AP Exam situation as possible. Exposure to the kinds of questions with the same depth and breadth as those on the AP Exam itself enhances and cements student learning.

**Laboratory (CR5a, CR5b, CR6, CR7)**
Labs support, convey, and cement the chemical principles presented in lectures and demonstrations. They also provide students with an opportunity to learn new physical skills with laboratory equipment (such as titration with a buret, quantitative transfer using a digital balance, or the use of volumetric equipment to measure liquids), to foster good collaborative relationships, and improve problem-solving techniques, while they learn more about how chemistry really works. Different labs are performed for different reasons, all of which are stated on a lab assignment sheet.

Students are expected to keep a lab notebook (provided). All lab reports are contained in the lab notebook. Labs reports for each lab activity include a section for the purpose, procedure, data and calculations, conclusions, and will include sources of error. Students spend 25% of their class time doing lab investigations and will complete 17 hands-on laboratory investigations during the year. 6 of the laboratory investigations are guided inquiry labs.

**Course Requirements and Grading**
A student’s grade is a weighted average of the following:

- Tests & Quizzes 50%
- Labs 25%
- Homework 25%

**Text (provided for each student) (CR1)**
Chapter 1: Chemistry – The Study of Change (BI 1, BI 2)

Classification of Matter; Three States of Matter; Physical and Chemical Properties of Matter; Measurement and Uncertainty; Dimensional Analysis; Significant Figures

Laboratory: “Composition of a Post-1982 Penny” (SP 1, 2, 4, 5)

Proper laboratory procedure, accurate measuring, dimensional analysis, and significant figures are all utilized in this beginning lab. Students will remove the zinc core of a post-1982 penny and measure the amounts of copper and zinc in the penny. They will then measure the amount of cooper in a pre-1982 penny. Using these measurements students will then:

- Calculate the cost of copper in a pre-1982 penny
- Calculate the cost of copper in a post-1982 penny
- Calculate the cost of zinc in a post-1982 penny
- Calculate the total cost of a post-1982 penny
- Calculate how much money is saved by using zinc instead of pure copper in pennies
- Calculate what percent mass of the new penny is copper
- Determine the number of moles of copper and zinc in a new penny

Activity/Homework: Chapter 1 Practice Problems - Students distinguish between physical and chemical properties and changes, classify types of matter, and use significant digits to solve problems with the correct units. (CR3b)

Chapter 2: Atoms, Molecules, and Ions (BI 1, BI 2)

Atomic Theory; Atomic Number, Mass Number, Isotopes; The Periodic Table; Molecules and Ions; Chemical Formulas; Naming Compounds

Laboratory: “Determination of the Formula of a Hydrate”-Inquiry style lab (SP 1, 2, 5, 6)

Students write their own procedure for this lab. Students are given a sample of an unknown hydrated metal salt and determine the number of water molecules bound per metal ion in the unknown hydrate.

Activity/Homework: Students determine the number of protons, neutrons, and electrons in various isotopes. Students write empirical formulas, molecular formulas, and names for compounds. (CR3a)
Chapter 3: Stoichiometry  (BI 1, BI 3)
Atomic Mass; Avogadro’s Number and the Molar Mass of an Element; Molecular Mass; Percent Composition; Empirical Formulas; Chemical Reactions and Chemical Equations; Amounts of Reactants and Products; Limiting Reagents; Percent Yield

Laboratory: “Stoichiometric Determinations” (SP 1, 2, 3, 4, 5)
Students prepare solutions of hydrochloric acid and sulfuric acid and determine the stoichiometric ratio in which these acids react with the base sodium hydroxide. Students perform several trials of these acid/base reactions in which the amount of each reagent used is systematically varied between the trials. By monitoring the temperature changes that take place as the reaction occurs, students have an index of the extent of reaction. The maximum extent of reaction will occur when the reactants have been mixed together in the correct stoichiometric ratio for reaction. Students prepare two graphs of the experimental data – one for the reaction of hydrochloric acid and sodium hydroxide and the second graph for the reaction of sulfuric acid and sodium hydroxide. (plot temperature change vs. number of moles sodium hydroxide used) The intersection of the ascending and descending points on each graph represents the maximum extent of the reaction for each particular experiment.

Activity/Homework: Students make conversions between mass, moles, atoms, molecules, and formula units. Students determine the empirical formulas when given relative amounts of elements in a compound, and will also determine the molecular formula when given the molar mass. Students write balanced chemical equations, then determine limiting reactants and solve stoichiometry problems involving mass. (CR3a)

Chapter 4: Reactions in Aqueous Solutions  (BI 1, BI 2, BI 3)
Precipitation Reactions; Acid-Base Reactions; Redox Reactions; Concentration of Solutions; Gravimetric Analysis; Acid-Base Titrations; Redox Titrations

Laboratory: “Make a Precipitate Lab” -Inquiry Style Lab (SP 1, 2, 3, 4, 5, 7) (CR7)
Students write their own procedure for this lab. They must determine how to make exactly one gram of a precipitate, then demonstrate and explain it to their classmates.

Laboratory: “Acid/Base Titrations” -Inquiry style lab (SP 1, 2, 3, 4, 5, 7)
1. Students will prepare a standardized base solution by titrating sodium hydroxide with an oxalic acid solution. Students will then titrate an unknown acid with the standardized sodium hydroxide solution to determine the molecular mass of the acid.
2. Students will analyze an unknown weak acid by the process of titration, using a standard sodium hydroxide solution. The sodium hydroxide solution to be used for the analysis will be prepared approximately and will then be standardized against a weighed sample of a known acid salt.
3. Inquiry: Students must determine which indicator is best for a particular titration.
Laboratory: Oxidation-Reduction
Students observe the changes in colors as the result of transition metals changing their oxidation states in chemical reactions, then write balanced redox equations for the reactions.

Activity/Homework: Students distinguish between strong electrolytes, weak electrolytes, and nonelectrolytes. Students determine the solubility of ionic compounds and write net ionic equations for chemical reactions. Students describe the preparation of a solution of a certain molarity using either a solute and water or a stock solution of known concentration. Students identify the element oxidized and element reduced in a redox reaction in either acidic or basic solution. (CR3a)

Chapter 5: Gases  (BI 2, BI 6)
Gas Laws; Ideal Gas Equation; Gas Stoichiometry; Dalton’s Law; Kinetic-Molecular Theory of Gases; Deviation from Ideal Gas Behavior

Laboratory: “Molar Mass of a Volatile Liquid” -Inquiry Style Lab (SP 1, 2, 3, 4, 5, 7)  
Students will collaborate to decide what method will best to determine the volume of a large flask, then use that method in their lab. They will then calculate the molar mass of a volatile liquid by measuring what weight of vapor is needed to fill a flask of known volume at a particular temperature and pressure (vapor density method).

Activity/Homework: Students use Boyle’s Law, Charles’ Law, Dalton’s Law and Avogadro’s Law to predict pressure, volume, or temperature for gases. Students use the Ideal Gas equation to solve problems and to explain everyday phenomena. Students explain which conditions will lead to deviations from the behavior predicted by the ideal gas law. (CR3b)

Chapter 6: Thermochemistry  (BI 5, BI 6)
The Nature and Types of Energy; Energy Changes in Chemical Reactions; Introduction to Thermodynamics; Enthalpy; Calorimetry; Standard Enthalpy of Formation; Heat of Solution

Laboratory: “Calorimetry” (SP 1, 2, 4, 5, 6, 7) (CR7)  
Students will determine the calorimeter constant for a simple coffee-cup calorimeter and use the calorimeter to determine the specific heats of an unknown metal and of ordinary glass. Students will research and attempt to identify the type of glass.

Activity/Homework: Students solve problems involving heat and work done by or on a system. Students use balanced thermodynamic equations to show endothermic and exothermic reactions. Students use these equations to predict the heat absorbed or given off by a given amount of reactant. Students use the standard enthalpy of formation and/ or Hess’s Law to calculate heat changes in chemical reactions. (CR3e)

Chapter 7: Quantum Theory and the Electronic Structure of Atoms  (BI 3)
Bohr’s Theory; The Dual Nature of the Electron; Quantum Mechanics; Quantum Numbers; Atomic Orbitals; Electron Configuration; The Aufbau Principle

Laboratory: “Identifying Elements by Flame Tests” (SP 3, 6, 7)
Students observe the flame colors characteristic of two elements and will use the colors to trace the path of these elements in a chemical reaction.

Activity/Homework: Students calculate the wavelength, frequency, and energy for subatomic particles. Students describe the electrons in an atom using quantum numbers, electron configurations, and/or orbital-filling diagrams. (CR3c)

Chapter 8: Periodic Relationships Among the Elements (BI 2, BI 3)

Periodic Classification of the Elements; Periodic Variation in Physical Properties; Ionization Energy; Electron Affinity

Activity/Homework: Students use periodic trends to rank elements on the basis of their atomic radius, ionic radius, ionization energy, electron affinity, and electronegativity. (CR3b)

Chapter 9: Chemical Bonding I (BI 1, BI 2, BI 3)

Lewis Dot Diagrams; The Ionic Bond; Lattice Energy The Covalent Bond; Electronegativity; Formal Charge and Lewis Structure; Resonance; The Octet Rule and Exceptions; Bond Enthalpy

Laboratory: “Qualitative Analysis of the Group I Cations” (SP 1, 3, 4, 5, 7)
Students analyze a sample containing only the Group I cations for the presence of silver (I), mercury (I), and lead (II) ions.

Activity: Students use Lewis structures to show bonding between atoms. Students will identify bonds as ionic, polar covalent, or nonpolar covalent. Students use resonance structures and formal charges to describe compounds. Students calculate the bond enthalpy for compounds. (CR3f)

Chapter 10: Chemical Bonding II (BI 1, BI 2, BI 3)

Molecular Geometry; VSEPR Model; Dipole Moments; Valence Bond Theory; Hybridization of Atomic Orbitals; Molecular Orbital Theory; Delocalized Molecular Orbitals

Laboratory: “Molecular Geometry” (SP 1, 3, 6, 7)
Students use large and small gumdrops, small marshmallows, and toothpicks to build molecular models of twelve molecules. The correct Lewis structure, parent geometry, and actual geometry are required for each molecule.

Activity/Homework: Students use VESPR theory to predict the shape and polarity of
molecules. Students arrange compounds in order of increasing dipole moment. (CR3c)

**Semester Two – 17 Weeks**

Chapter 11: Intermolecular Forces and Liquids and Solids (BI 6)
The Kinetic-Molecular Theory of Liquids and Solids; Intermolecular Forces; Properties of Liquids; Amorphous Solids; Phase Changes; Phase Diagrams

**Laboratory: “Sticky Question – How Do You Separate Molecules Attracted to One Another? – Inquiry Style Lab (SP 1, 3, 4, 5, 6, 7)**
Students will design and interpret the results of a separation experiment involving paper chromatography to determine the relative strength of interactions between the components.

**Activity/Homework:** Students predict relative boiling points, melting points, and viscosity by determining the intermolecular forces in compounds. (CR3f)

Chapter 12: Physical Properties of Solutions (BI 6)
Types of Solutions; Concentration Units; The Effect of Temperature and Pressure on Solubility; Colligative Properties

**Laboratory: “Colligative Properties of Solutions” (SP 2, 4, 5, 6, 7)**
Students determine the freezing points of a pure solvent (naphthalene), a solution of a known solute (1,4-dichlorobenzene) dissolved in naphthalene, and an unknown solution of sulfur in naphthalene. From the first two results students determine the molal freezing point depression constant \( K_f \) for naphthalene. Students then use freezing point of the pure solvent and the molal freezing point depression constant to calculate the molar mass of sulfur. They then determine the number of sulfur atoms that must be present in a molecule of elemental sulfur to give rise to this molar mass.

**Activity/Homework:** Students calculate solution concentration using molarity, molality, and percent by mass. Students describe the effect of solute on properties such as boiling point, melting point, and vapor pressure. (CR3b)

Chapter 13: Chemical Kinetics (BI 4)
Reaction Kinetics; Rate Law Expressions; Order of Reactions; Rate Constant; Half-Life; Activation Energy; Reaction Mechanisms; and Catalysis

**Laboratory: “Rates of Chemical Reactions” – Inquiry Style Lab (SP 2, 3, 4, 5, 7)**
In this experiment, students study a reaction known as the “iodine clock.” Potassium iodate and sodium hydrogen sulfite react with each other producing elemental iodine. A small amount of starch is added to heighten the color of the iodine. Students
perform several runs of the reaction using the same concentration of all other reagents but varying the concentration of potassium iodate in a systematic manner. By measuring the time required for each reaction to occur with different concentrations of potassium iodate, students determine the order of the reaction with respect to the concentration of potassium iodate. Students must decide how to best find the order of the reaction. (To determine this correctly, students must apply their knowledge of graphing and kinetics) (CR7)

**Activity/Homework:** Students determine the average rate of several chemical reactions. Students calculate the rate constant and half-life for zero, first, and second order reactions. Students write rate law expressions for chemical reactions. Students identify the rate determining step, catalysts, and intermediates within a reaction mechanism. Students describe the effect of a catalyst on the activation energy of a reaction. Students make and interpret graphs showing reaction kinetics. (CR3d)

**Chapter 14: Chemical Equilibrium** (BI 5, BI 6)
Laws of Mass Action; Equilibrium Expressions; Homogeneous and Heterogeneous Equilibria; and Le Chatelier's Principle

**Laboratory: “Determination of an Equilibrium Constant”** (SP 1, 2, 4, 5, 6, 7)
Students study the reaction between aqueous iron (III) nitrate, Fe(NO₃)₃, and potassium thiocyanate, KSCN to produce the blood-red complex [Fe(SCN)]²⁺. Students prepare a series of standard solutions that contain known concentrations of [Fe(SCN)]²⁺ and will determine their absorbances at 447 nanometers. The concentrations and absorbance values will be used to construct a calibration graph for [Fe(SCN)]²⁺. Various combinations of Fe(NO₃)₃ and KSCN will then be combined. The amount of product formed, [Fe(SCN)]²⁺, will be determined from the calibration graph. From the original amounts of reactants for each trial and the amount of product formed, the concentration of all species at equilibrium may be determined. When these concentrations are substituted into the equation for the equilibrium constant, values for the equilibrium constant are determined. An average value for the constant is then determined.

**Activity/Homework:** Students write equilibrium expressions for concentration and pressure for a system. Students use LeChatelier’s Principle to determine the effect of concentration, temperature, and pressure on a system. Students calculate the equilibrium constant for reactions and will use them to find the equilibrium concentration of all species in a system. (CR3f)

**Chapter 15: Acids and Bases** (BI 1, BI 2, BI 6)
Arrhenius, Brønsted, and Lewis Acid Theories; pH, K_a and K_b Expressions; Degree of Ionization; K_w Expressions; Salt Hydrolysis

**Activity/Homework:** Students identify acids and bases using Arrhenius, Bronsted-Lowry, and Lewis theory. Students write equilibrium expressions for acids and bases. Students calculate the equilibrium constant for acids and bases and use them to
determine relative strengths and degree of ionization. (CR3f)

**Science & Society Activity:** Students conduct an investigation into acid rain, and write the reactions that occur between the pollutant and naturally occurring compounds such as water, oxygen, and carbon dioxide. (CR4)

Chapter 16: Acid-Base Equilibria and Solubility Equilibria **(BI 1, BI 2, BI 6)**
Buffers; pH Titrations; Solubility Equilibria, Complex Ion Equilibria

**Laboratory:** “Preparing Buffers and Buffer Capacity” **(SP 1, 2, 4, 5, 6, 7)**
Students use the Henderson-Hasselbach equation to determine the amount of acetic acid and sodium acetate required to prepare a series of buffer solutions. Once the buffer solutions have been prepared, their buffer capacity is be determined.

**Activity/Homework:** Students determine the pH of strong and weak acids and bases. Students determine the pH after titration of a strong acid with a weak base or a strong base with a weak acid. Students use the Henderson-Hasselbach equation to determine pH for buffered systems. (CR3f)

Chapter 18: Entropy, Free Energy, and Equilibrium **(BI 5, BI 6)**
Thermodynamic Laws; Spontaneous Processes; Entropy; Gibbs Free Energy; Free Energy and Chemical Equilibrium

**Activity/Homework:** Students calculate entropy, enthalpy, and free energy and use these values to determine the spontaneity of reactions. Students explain the effect of temperature on spontaneity in various situations. (CR3f)

Chapter 19: Electrochemistry **(BI 3, BI 6)**
Redox Reactions; Galvanic Cells; Standard Reduction Potentials; Spontaneity of Redox Reactions; Batteries; Electrolysis

**Laboratory:** “Voltaic Cells” **(SP 1, 3, 4, 5, 6, 7)**
Standard Voltaic Cells: Six standard voltaic cells will be set up and the potential generated by each is measured. (Copper, lead, zinc, and silver solutions will be used.) The half-cells are set up on a piece of filter paper with sodium nitrate solution on the center of the paper to serve as a salt bridge. Potentials for each cell will be measured and compared to literature values.
Non-standard voltaic cells: Nonstandard voltaic cells are analyzed and their potential values calculated using the Nernst equation.

**Activity/Homework:** Students write net ionic equations for the reactions that occur in galvanic cells, and explain the function of a salt bridge. Students use standard reduction potentials to determine the voltage of a galvanic cell. Students write equations and determine energy changes for batteries and for electrolysis reactions. (CR3c)
Chapter 23: Nuclear Chemistry  (BI 2, BI 3)

Radioactivity; Nuclear Transmutation; Fission; Fusion; Isotopes

**Activity/Homework:** Students write balanced equations for alpha, beta, and gamma decay reactions. Students write balanced nuclear transmutation reactions. Students differentiate between nuclear fission and fusion reactions in terms of the amount of energy released and the types of reactants and products. (CR3c)

Chapter 24: Organic Chemistry  (BI 1, BI 2, BI 3)

Classes of Organic Compounds; Aliphatic Hydrocarbons; Aromatic Hydrocarbons; Chemistry of the Functional Groups

**Laboratory:** “The Preparation and Properties of Esters” (SP 2, 4, 5, 7)

Students use salicylic acid and acetic anhydride to prepare acetylsalicylic acid (aspirin) in the laboratory. After the aspirin samples have thoroughly dried, the melting point is determined by the capillary method. Students compare the observed melting points of their laboratory-produced aspirin with literature values.

**Activity/Homework:** Students name and identify saturated and unsaturated hydrocarbons. Students identify functional groups and then name organic compounds such as alcohols, carboxylic acids, esters, ethers, and ketones. Students follow the reactions of these functional groups in simple organic reactions. (CR3a, CR3b)