**STRUCTURE OF THE COURSE:**

AP Chemistry is designed to be equivalent to a two semester general chemistry college course. It is a full year course with classes meeting each day for 84 minutes. The course aims to provide students with a greater understanding of the principles and concepts of chemistry through a variety of problem solving experiences and an extensive laboratory program comprising a minimum of 25% of the class time. Chemistry concepts will be presented in the context of environmental, biological, and societal issues. Emphasis will be placed on inquiry-based learning. As part of this course, students will be conducting independent research on a topic of their choice and will exhibit the results of their research.

AP Chemistry is built around the six big ideas and the seven science practices listed below.

**BIG IDEA 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.

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

**BIG IDEA 3:** Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.

**BIG IDEA 4:** Rates of reactions are determined by details of molecular collisions.

**BIG IDEA 5:** The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

**BIG IDEA 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 PRACTICE 1:** The student can use representations and models to communicate scientific phenomena and solve scientific problems.

**SCIENCE PRACTICE 2:** The student can use mathematics appropriately.

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

**SCIENCE PRACTICE 4:** The student can plan and implement data collection strategies in relation to a particular scientific question.

**SCIENCE PRACTICE 5:** The student can perform data analysis and the evaluation of evidence.

**SCIENCE PRACTICE 6:** The student can work with scientific explanations and theories.

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

**TEXTBOOK and LAB BOOKS:**

Zumdahl, Steven and Zumdahl, Susan. *Chemistry*, 7th Edition. Boston: Houghton Mifflin Company, 2007

*AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*. New York, NY: The College Board, 2013

Randall, Jack. *Advanced Chemistry with Vernier*, 1st Edition. Beaverton, Oregon: Vernier Software & Technology, 2004

Holmquist, Randall, and Volz. *Chemistry with Vernier*, 1st Edition. Beaverton, Oregon: Vernier Software & Technology, 2007

**UNIT OVERVIEW**

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| Unit 1:  Summer/September | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch1: Chemical Foundations | * Units * Metric Prefixes * Significant Figures * Dimensional Analysis * Classification of Matter * Chemical and Physical Changes * Laboratory Safety | 1 | 1.A  1.D | * M&M Problem Solving Activity   *Students work in small groups to determine the depth of M&M candies if 1 mole of candies were covering the 48 contiguous United States* | 1.4 |
| Ch2: Atoms, Molecules, and Ions | * Law of Conservation of Mass * Law of Definite Proportions * Law of Multiple Proportions * Dalton’s Atomic Theory * Thompson’s Cathode Ray Experiment * Millikan’s Oil Drop Experiment * Rutherford’s Gold Foil Experiment * Protons, neutrons, electrons * Atomic Number * Mass Number * Ion charges * Polyatomic ions * Ionic vs Covalent Bonds * Nomenclature (simple inorganic) | 1  2 | 1.A  1.B  1.D  2.C | * Ionic compound bonding review   *To review formula writing and nomenclature of simple ionic compounds, students each choose a card containing an anion or cation. They then rotate around the room forming compounds by “bonding” with their classmates. They write the formulas for and name each compound.* | 2.23 |
| Ch3: Stoichiometry | * Weighted Mass Average (average atomic mass) * Molar mass * Mass spectrometry * Percent composition * Empirical formulas * Molecular formulas * Balancing chemical equations * Stoichiometry * Limiting reactant * Percent yield | 1  3 | 1.A  1.E  3.A  3.B | * Ch 3 Lab Skills Practice AP Problems   *Students work in small groups to complete the laboratory skills open response questions from the 1990 and 1997 AP exams. A class discussion results from their suggestions.* | 1.2  1.4  3.4 |
| Ch4: Types of Chemical Reactions and Solution Stoichiometry | * Solubility rules * Electrolytes * Strong vs weak acids and bases * Molarity * Precipitation reactions * Net ionic equations * Neutralization reactions * Redox reactions   Oxidation numbers  Oxidation half reactions  Reduction half reactions  Balancing redox reactions | 3 | 3.A  3.B | * Strong/weak acid Demonstration   *The pH of four solutions of acids (0.10 M HCl, 0.0010 M HCl, 0.10 M CH3COOH, and 0.00010 M CH3COOH) are measured. Students are required to draw particle diagrams representing each sample and explain the observed pH measurements.* | 2.9  6.11  6.12 |

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| Unit 2  September/October | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch7: Atomic Structure and Periodicity | * Electromagnetic Radiation * Wavelength * Frequency * X-ray diffraction * Bohr model * Quantum mechanical model * Electron configurations * Photoelectron Spectroscopy * Periodic Trends   Atomic radius  Ionization Energy  Electron Affinity  Valence Electrons | 1 | 1.B  1.C  1.D | Periodic Trends graphing activity:  *Students graph the trends for atomic radii and first ionization energy using Microsoft Excel. They analyze the trends across periods and down groups and explain why the trends occur based on atomic structure and then propose explanations for any inconsistencies in the general trends.* | 1.7  1.9  1.10  1.12 |
| Ch8: Bonding: General Concepts | * Electronegativity * Bond Energy * Coulomb’s Law * Bond Length * Bond Polarity * Lattice Energy * Endo/exothermic processes * Lewis Structures * Resonance * Formal charge * VSEPR * Dipoles | 2  3  5 | 2.B  2.C  2.D  3.C  5.C  5.D | VSEPR Modeling Activity:  *Students use marshmallows and toothpicks to build models showing the optimal molecular shapes/bond angles for simple molecules with varying numbers of bonded and nonbonded pairs of electrons on the central atom.* | 2.21 |
| Ch9: Covalent Bonding: Orbitals | * Hybridization * Sigma and pi bonding * Para/diamagnetism | 2 | 2.C  2.D |  |  |

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| Unit 3  October/November | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch5: Gases | * Kinetic Molecular Theory * Pressure units/conversions * Gas Laws * Effusion and Diffusion * Real vs ideal gases | 2 | 2.A | Interactive Gases Animation:  *Students use the website* [*http://phet.colorado.edu/en/simulation/gas-properties*](http://phet.colorado.edu/en/simulation/gas-properties) *to explore the effect of changing conditions on both heavy and light gas particles.* | 2.4  2.12  2.16  5.2 |
| Ch6: Thermo-chemistry | * Forms of energy * Energy conservation * Heat and work * Enthalpy * Calorimetry * Hess’s Law * Enthalpy of Formation * Energy Sources   Renewable vs nonrenewable | 3  5 | 3.C  5.A  5.B  5.C | Ethanol vs Gasoline Worksheet:  *Students work in small groups to perform calculations that compare the amount of energy released by the burning of ethanol and gasoline (octane). They also compare the amount of CO2 formed per energy unit for each fuel. They then make a statement either for or against the use of ethanol as fuel based on environmental and economic impacts.* | 5.6  5.8 |

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| Unit 4  November/December | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch10: Liquids and Solids | * Types of Intermolecular Forces * Properties of Liquids * Types of Solids * Properties of Solids * Crystal Structures * Semiconductors * Coulomb’s Law | 2 | 2.A  2.B  2.C  2.D | Structure and Properties of Solids Worksheet:  *Students are given diagrams of various types of solids. They identify the type, list properties, explain why these properties exist and list examples of two solids that fall into each category.* | 2.24  2.28  2.30  2.32 |
| Ch11: Solutions | * Expressing concentration * Enthalpy of Solution * Factors affecting solubility * Rates of dissolving * Raoult’s Law * Ideal vs Nonideal solutions * Colligative Properties | 2  3 | 2.A  2.D  3.C | Like dissolves like Demonstration:  *A crystal of iodine is added to three solvents (water, hexane, and ethanol) and mixed. Students must explain their observations.* | 2.15 |

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| Unit 5  December/January | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch12: Chemical Kinetics | * Relative reaction rates * Differential rate laws * Integrated rate laws * Half-life (including radioactive decay) * Reaction mechanism * Collision Theory * Energy Diagrams * Arrhenius Equation * Catalysts | 3  4 | 3.C  4.A  4.B  4.C  4.D | Concentration vs Time Graphing Activity:  *Students are given concentration of a reactant vs time experimental data for three different reactions. Students use their graphing calculators to make plots of the data to determine the order of the reaction.* | 4.2 |
| Ch13: Chemical Equilibrium | * LeChatelier’s Principle * Equilibrium expressions * Equilibrium constants * Kp vs Kc * Reaction Quotient * Solving ICE problems | 6 | 6.A  6.B | ICE Problems Worksheet: *Students are given a series of equilibrium problems in which Q and K are calculated and compared to determine the direction and extent of shift in an equilibrium system.* | 6.4  6.5  6.6 |

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| Unit 6  January/February | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch14: Acids and Bases | * Arrhenius Theory * Neutralization Reactions * Bronsted Lowry Theory * Strong vs weak acids * Percent ionization * pH and pOH * Kw * Ka and Kb * Hydrolysis/pH of Salts | 3  6 | 3.B  6.C | Comparing Strong and Weak Acids:  *Small groups of students are given the identity of a specific strong acid, a specific weak acid, and a desired pH value. They must calculate the concentration of each acid to result in the desired pH.* | 6.12 |
| Ch15: Applications of Aqueous Equilibria | * Buffers * Titrations * pH Indicators * Ksp * Qualitative Analysis | 6 | 6.C | Designing a Buffer Activity: *Students work in small groups to describe how to prepare a buffer to maintain a particular pH and buffering capacity. They need to show relevant chemical equations to explain how the assigned buffer functions when acid or base is added.* | 6.18  6.20 |

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| Unit 7  March | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch17: Electro-chemistry | * Redox Reactions (review) * Oxidizing agents * Reducing Agents * Electrochemical Cells   Anode  Cathode  Salt Bridge  Cell Potential (Ecell)   * Thermodynamic Favorability of Electrochemical Cells (G) * Galvanic vs Electrolytic Cells * Effect of Concentration on Ecell * Electrolysis Calculations   Ampere  Faraday  Coulomb | 3  5 | 3.A  3.B  3.C  5.E | Voltaic Cells Simulation:  *Students will investigate the properties of electrochemical cells by completing two inquiry activities (Voltaic Cells and Concentration Cells) using the simulations created by John Gelder’s group at Oklahoma State University.*  [*http://genchem1.chem.okstate.edu/ccli/Startup.html*](http://genchem1.chem.okstate.edu/ccli/Startup.html) | 3.12  3.13 |
| Ch16: Spontaneity, Entropy, and Free Energy | * Entropy * Second Law of Thermodynamics * Free Energy * Free energy and Thermodynamic Favorability * Gibb’s Equation * Free energy and equilibrium | 5  6 | 5.E  6.D |  |  |

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| Unit 8  April/May | | | | | |
| Textbook Alignment | Topics Covered | BI | EU | Example Activity | LO |
| Ch21: Transition Metals and Coordination Chemistry | * Lewis Acid-Base Theory * Ligands * Nomenclature of Coordination Compounds * Isomers * Chirality * d-orbital splitting * strong and weak field ligands * high and low spin cases | 2 |  |  |  |
| Ch22: Organic and Biological Molecules | * Hydrocarbons * Hydrocarbon Nomenclature * Organic Functional groups * Isomers * Esterification * Polymerization * Amino Acids and Proteins * Protein Folding * Protein structure and function * Carbohydrates * Nucleic Acids and DNA * Lipids | 2  5 | 2.B  5.D | “Fold-It” Activity:  *Students will use this computer modeling game to investigate how attractive forces within the protein play an important part in the determination of tertiary protein structure.* | 5.11 |

**LABORATORY INVESTIGATIONS**

Students collect data from each laboratory investigation in a laboratory notebook. Laboratory reports including purpose, procedure, data, data analysis, error analysis and conclusion are completed for each lab. Students create a poster presentation for at least two lab investigations throughout the year.

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| Topic | Description | Science Practices Addressed | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Scientific Method  (INQUIRY) | Baggie Lab: Students design a procedure to investigate a reaction in a zip top bag and record detailed observations. Emphasis is placed on the difference between observations and conclusions and review of concepts covered in first year chemistry. |  |  | X | X | X | X |  |
| Percent Composition | Percent of Potassium Chlorate in a Mixture Lab: Students thermally decompose KClO3 to determine the % oxygen in the sample. They then use their results to determine the % KClO3 in a mixture of KClO3 and KCl. |  | X | X | X | X | X |  |
| % Yield | Copper Cycle Lab: Starting with a sample of elemental copper, students conduct a series of reactions which ultimately result in the formation of elemental copper. % yield is calculated. |  | X | X |  | X |  |  |
| Beer’s Law  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 2: How Can Color Be Used to Determine the Mass Percent of Copper in Brass? |  | X | X | X | X | X | X |
| Chromatography Lab  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 5: Sticky Question: How Do You Separate Molecules That Are Attracted to One Another | X | X | X | X | X | X | X |
| Gas Laws | *Advanced Chemistry with Vernier*: Experiment 5: The Molar Volume of a Gas |  | X |  | X | X | X | X |
| Gas Laws | *Advanced Chemistry with Vernier*: Experiment 3: Molar Mass of a Volatile Liquid |  | X | X | X | X | X | X |
| Intermolecular Forces | *Chemistry with Vernier*: Experiment 9: Evaporation and Intermolecular Attractions | X |  | X | X | X | X | X |
| Thermochemistry | *Chemistry with Vernier*: Experiment 18: Additivity of Heats of Reaction: Hess’s Law |  | X |  | X | X |  | X |
| Kinetics  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 10: How Long will that Marble Statue Last? |  | X | X | X | X | X | X |
| Kinetics  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 11: What is the Rate Law of the Fading of Crystal Violet Using Beer’s Law? |  | X | X | X | X | X | X |
| Equilibrium | *Advanced Chemistry with Vernier*: Experiment 10: The Determination of an Equilibrium Constant |  | X | X | X | X | X |  |
| Equilibrium  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 13: Can We Make the Colors of the Rainbow? An Application of LeChatelier’s Principle | X |  | X | X | X | X | X |
| Hydrolysis of Salts | Hydrolysis of Salts Lab: Students must predict the pH of a specific concentration of a salt and provide justification for their prediction. They then make the solution and check their prediction. | X | X | X |  | X | X | X |
| Buffers | *Advanced Chemistry with Vernier*: Experiment 24: Determining Ka by the Half-Titration of a Weak Acid |  | X | X | X | X | X |  |
| Titration | *Advanced Chemistry with Vernier*: Experiment 6: Standardization of a Solution of Sodium Hydroxide  AND  *Advanced Chemistry with Vernier*: Experiment 7: Acid-Base Titration |  | X |  | X | X | X |  |
| Gravimetric Analysis, Ksp  (INQUIRY) | *AP Chemistry Guided Inquiry Experiments: Applying the Science Practices*: Investigation 3: What Makes Water Hard? | X | X | X | X | X | X | X |
| Voltaic Cells | *Advanced Chemistry with Vernier*: Experiment 20: Electrochemistry Voltaic Cells | X |  | X | X | X | X |  |
| Avogadro’s Number Lab | *Advanced Chemistry with Vernier*: Experiment 31: Determining Avogadro’s Number | X | X |  | X | X | X | X |
| Coordination Complexes | Determining the Relative Stabilities of Coordination Compounds: Students make a series of copper coordination complexes to determine relative stabilities of various complexes. | X |  | X | X | X | X | X |
| Organic Chemistry  (INQUIRY) | Synthesis of Esters Lab: Given an assortment of organic acids and alcohols, students make a variety of esters and determine if there is a relationship between structure and odor. |  |  | X | X | X | X | X |