Prerequisites

In order to be successful in AP Chemistry, students must have a firm understanding of introductory chemistry and of basic algebraic concepts. For this reason, students must have received a B or A in both Chemistry I and Algebra II in order to sign up for the course. Exceptions are made at the discretion of the instructor, with the final decision resting with the administration. Students who do not meet the prerequisite may be asked to take a Chemistry I midterm and final exam in order to assess their readiness for the course and discuss alternatives or remediation as necessary.

Student Goals, Enduring Understandings, and Science Practices

The curriculum for this course was constructed with three sets of principles in mind: student goals, enduring understandings of chemistry, and science practices.

Student Goals. Why take AP Chemistry? What can a student expect to gain from the course?

- Students will develop a qualitative and quantitative understanding of chemistry commensurate with that of a first year undergraduate course.
- Students will develop confidence, independence and proficiency at completing experiments, both when working alone or collaborating with others. Students will develop an ability to determine and communicate results and conclusions from those experiments.
- Students will develop an appreciation for how chemical principles determine the behavior and phenomena of our natural world.

Enduring Understandings or Big Ideas. The AP chemistry curriculum is centered on six enduring understandings. These are referenced in the course outline.

- 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 the 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 chemical reactions are determined by details of the molecular conditions.
- 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 Practices. Students will also developing scientific habits of mind and process skills. There are seven basic science practices, listed below and referenced in the course outline.

- 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 evaluation of evidence.
- Science Practice 6: The student can work with scientific explanation and theories.
- Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Course Structure

Classroom Instruction. This course meets for about 90 minutes each school day, for a total of 450 minutes a week. Students will find the in class time used in several ways.

- **Topic introduction, notes and problem solving.** The "lecturing" in this course usually consists of explanations and sample problems interspersed with problems and questions students try individually or in small groups. This helps students assess their own understanding and identify areas of confusion before they leave the classroom.
- **Laboratory work (see course outline for specific experiments).** Students should expect to spend at least 25% of instructional time doing laboratory work or associated activities.

- Students keep a composition style laboratory notebook in which all laboratory reports are done. This notebook should be brought to class every day. The specifics of the format are explained in the "Lab Notebook and Report Requirements" section below.
- The laboratory notebook and reports are considered an individual assignment, even when a student works with a partner during the laboratory period, and copying of a laboratory notebook will be regarded as plagiarism.
- Informal laboratory activities and demonstrations are also used throughout the year, often to introduce a topic or as a vehicle for review. These activities will not require a full report.
- Students will also have to submit formal lab reports for some labs during the year. General guidelines are in the "Lab Notebook and Report Requirements" section below and specific requirements will be discussed when the lab is done. At the end of the year depending on time considerations, students will do a laboratory-based project where they will create and submit a poster (similar to one used at a poster session or science fair) as the final product.
- Even when a student is successful on the AP exam, some institutions require the student to present evidence of actual laboratory work before granting laboratory credit.

- **Discussion of problem sets and AP practice.** Two or three problem sets are assigned per chapter. Also, AP practices consisting of adapted released AP free response questions are assigned and reviewed in class for each chapter starting with the third unit. Homework will be spot checked (where full credit is based on effort) on the day it is due, before solutions are discussed in class. Also, on the day of a test the assignments are due complete (since solutions have been discussed in class it is expected that all problems will be complete). Students may do the assignments on loose leaf paper or in a composition or spiral notebook.
- **Computer Simulations / group modeling activities.** Interactive computer exercises or modeling activities are done in class and assigned for homework as appropriate. These supplement lecture, laboratory work and problem sets, but do not replace them, except when it is impossible to provide a truly hands-on activity.
- **Tests and Checks.** There is usually one test for each chapter (see course outline for exceptions). Tests are free response with a few multiple choice questions on concepts and returned to the students. "Checks" can be prearranged or unannounced and consist of five multiple choice questions and are used to help students identify gaps in understanding. They are returned and discussed immediately. Grades on checks are recorded, but the corresponding test grade can replace any check grade.

Outside the classroom. Students who are successful report spending up to 4 to 5 hours per week outside the classroom in some aspect of AP Chemistry study. This time is divided among the following.

- **Reading the chapter and working out example problems.**

- **Doing assigned problem sets and AP practices.**
- **Studying by trying extra practice and study guide problems as needed.**
- **Completing laboratory reports.**

Grading.

- **Six weeks.** Each six weeks grade is calculated with the quiz average 70% of each nine weeks, "checks" on understanding and homework 10% of each nine weeks and laboratory work 20% of each nine weeks.
- **Semester average.** The semester grade is calculated with each nine weeks comprising 40% of the grade, and the semester exam comprising 20% of the grade.

Supplies (provided by the student). Please bring these to school every day.

- **Composition style laboratory notebook.**
- **Scientific calculator** (a graphing calculator is helpful for some sections, but not required – I do have enough graphing calculators to have one available for each student during a test.)
- **Three ring binder with extra paper.**
- **Pen for laboratory work and pen or pencil for notes, problems, etc.**

Lab Notebook and Report Requirements

- **Lab notebook grading.** Students keep a composition style laboratory notebook in which they record all their laboratory investigations. Laboratory notebooks are usually collected on every other Friday and returned the next Monday or as announced by the instructor. Grades for laboratory work are recorded in the notebook. In the case that a student did not finish essential elements of a lab (for example, the calculations or discussions are missing) a notation may be made that the student can complete the work and turn it in for reduced credit by a certain date. Students are urged to check their laboratory grades when they receive the notebook back so that they can take advantage of any opportunities to complete the laboratory work properly and receive credit for it.

- **Structure of the laboratory notebook.**
    - For scientists working in research and industry, the laboratory notebook can be used as evidence in legal proceedings, patent disputes, etc. For this reason, ALL writing in your laboratory notebook should be in ink. If you make a mistake, just cross through it.

- Students should use the first few pages of the notebook for a table of contents, where the title, date and page number of each investigation is listed. This should be updated throughout the year.
- Before the lab, students should prepare for the lab by reading and making sure they understand the procedure. In addition, the following sections should be completed in the notebook before the lab starts. This may be spot checked by the instructor.
    - lab title and date you are doing the lab
    - purpose(s) and/or goal(s) of the lab
    - chemicals used – list the proper names, formulas, Kekule structures (for organic compounds) and special hazards. Other information may be requested in this section by the instructor.
    - prelab questions if appropriate. The question should be understood from the answer written in the book.
    - a summary of the lab procedure including a diagram if appropriate (sometimes, you may be asked to develop a procedure beforehand or with your lab partner).
    - a data table if appropriate
- During the lab, students should record data DIRECTLY in the lab notebook as they do the lab. It is important to take the time to do this as the lab proceeds, and not to write it on a scratch piece of paper to transfer later, or play on copying the data from a lab partner. By recording data and observations as the lab is done, the integrity of the laboratory notebook as a "legal document" or true account of what happened is preserved.
- After the lab, students complete the following.
    - Calculations section (as appropriate). Calculations should always have the setup shown with units (if there are multiple calculations with the same setup, a sample calculation can be shown for the first one.) Attention should be paid to significant figures.
    - Sometimes, especially when probeware is utilized, a computer-generated graph is taped into the lab notebook. Other times, students may make a graph or sketch by hand. Graphs should be of appropriate scale and have titles and labeled axes with units. (This may mean that a computer generated graph is annotated.)
    - Discussion/Conclusion section. In each lab, students should answer any specific postlab questions as assigned. In addition, a short paragraph should be written stating what the student learned or observed in the lab and how it relates to appropriate topics in the coursework. In addition, the student should reflect on whether the goal was met and if he has any suggestions for improvement on the experiment.
- If a reference other than the lab procedure is used to answer questions (for example, a chemical handbook), bibliographic information on the reference should be footnoted.
- The student should sign and date the lab, and indicate any lab partners for the activity when appropriate.

- Once each grading period, the student will complete a more formal laboratory report. Specific requirements will be indicated but the general format is as follows.
    - Laboratory reports are to be typed, double spaced.
    - Laboratory reports have the same sections as the laboratory notebook with the following exceptions.
        - The front page of the laboratory report should have an abstract, in addition to the title of the lab, the date submitted, and the student's name. An abstract is a short (1/2 page or less) summary of the experiment and the results found.
        - While the lab notebook is informal record (that may contain spelling, grammar errors, etc.), a formal lab report should be written in standard English and be free of spelling errors.
        - Often, additional sections will be assigned in a laboratory report (for example, an analysis of cost feasability etc.)

- **Other formats of scientific communication.** At the end of the year, students will research and present in poster and oral formats in the Ethics Poster and Environmental Investigations (see end of topic outline below).

Primary Textbook: Masterton, Hurley and Neth. Chemistry, Principles and Reactions, 7th edition.

Unit: sections in textbook: instructional time in weeks	Major Concepts and Laboratory Activities	Big Ideas/ Scientific Practices	Examples of activities with corresponding learning objectives and success criteria
Atoms, Molecules, and Ions: Chapter 2: 1 week	Atomic theory, atomic number, mass number, relationship of atomic mass and isotopes, introduction to relationships in the periodic table, chemical and physical properties, naming compounds and writing formulas Laboratory Activities:	BI 1, 2 SP 3, 4	LO 1.14 As an in-class activity, students will be given mass spectrometry data and asked to identify the

	(Inquiry-based) Identification of unknown solutions: Students develop their own procedure for identification of unknown solutions. (STS Connection) Separation and identification of Plastics: Plastics are categorized according to the well-known recycling code system (1-6 or 1-7). Students determine the physical and chemical properties of different plastic samples and identify according to recycling code.	SP 2, 5, 6, 7	element and/or isotopes.
Matter and Measurements: Chapter 1: 1 week	Laboratory safety, scientific method, significant figures and Error analysis, dimensional analysis Laboratory Activities: Determination of density of unknown liquids and solids (STS Connection) Students determine the identity of an unknown medication by Thin Layer Chromatography	BI 1 SP 2, 5 SP 2, 5, 6	LO 1.3 Using the skills in measurement, units, and dimensional analysis, students will be asked to determine density of various objects on the earth and in the universe (i.e. density of a star).
Mass Relations in Chemistry; Stoichiometry : Chapter 3: 1.5 weeks	Introduction to writing and balancing equations, mass, mole and volume relationships, empirical and molecular formulas, limiting reactants Laboratory Activities: Determination of the Formula of a Compound Determination of Limiting Reactant	BI 1, 3 SP 2, 5	LO 3.6 Students obtain “data” from an interactive program online that simulates the combustion compound to find the empirical

		SP 2, 5	formula for the compound.
Reactions in aqueous solutions: Chapter 4: 2 weeks	Types of chemical reactions (acid/base, precipitation, redox) Molecular, complete ionic, net ionic equations Oxidation states; balancing redox reactions using the half-reaction method Methods of expressing concentration Laboratory Activities: Determination of Iron using a redox titration (Inquiry-Based): Exploration of redox reactions in acidic and basic solutions. Given solutions, students discover if and how pH affects efficacy of reaction and identity of products. (Inquiry-Based): Determination of solubility rules. Students observe the solubility of various ionic compounds, determine rules for solubility based on their observations, compare to accepted rules in literature, and discuss inconsistencies.	BI 3 SP 2, 5 SP 3, 4, 6 SP 6	LO 1.17 Students explore "the stoichiometry of s'mores" before completing a worksheet involving limiting reactant and percent yield.
Gases: Chapter 5: 2 weeks	Ideal gas law (Including Avogadro's, Boyle's, Charles' law), Dalton's law of partial pressures, KMT, Real gases Laboratory Activities: Determination of the molar mass of a volatile liquid Determination of molar mass using the rate of diffusion	BI 1, 2 SP 2, 5	LO 2.4 Students mimic the behavior of gas molecules in a "game", observing their collisions with others when they move faster,

		SP 2, 5	move to a larger space, etc.
Thermochemistry: Chapter 8: 2 weeks	State functions, Energy, enthalpy, change in energy and enthalpy, Hess's law, Heats of reaction, formation, vaporization, fusion, Calorimetry Laboratory Activities: (Inquiry-based and STS Connection) What makes the best hand warmer? Determination of specific heat and heat of reaction.	BI 3, 5 SP 2, 3, 4, 5 SP 2, 5, 6, 7	LO 5.6 and 5.7. In preparation for and as post-lab discussion, students determine how calculations/estimations can be used to determine enthalpy of reaction (fusion/vaporization etc. as well as chemical reactions) and specific heat. Discussion is on both qualitative and quantitative aspects and includes examples not included in the lab experience.
Spontaneity of Reaction: Chapter 16: 1 week	Three laws of thermodynamics, Entropy, Gibbs free energy (formation, reaction), Spontaneity Laboratory Activities: Observation of thermodynamics of various reactions	BI 5, 6 SP 6, 7	LO 5.12 In a class discussion, the reasons for higher or lower absolute entropy of various substances are discussed (i.e.,

			solid vs. liquid vs. gas, diatomic vs. atomic) and then students predict the change in entropy of various reactions and do calculations with standard values to confirm, connecting qualitative observations with quantitative calculations.
Gaseous Chemical Equilibrium: Chapter 12: 2 weeks	Le Chatelier's principle, Dynamic equilibrium Equilibrium constants (Kp and Kc) and related calculations, Heterogeneous equilibria Laboratory Activities Determination of an equilibrium constant How do systems respond to stress? (Several experiments exploring Le Chatelier's Principle)	BI 6 SP 2, 5 SP 1, 6, 7	LO 6.1-6.4. After students complete laboratory activities, they use an interactive computer resource (WWW) to assess their skills in predicting responses to various stresses on systems at equilibrium, using Le Chatelier's principle and Q/K comparisons.

Acids and Bases, and Equilibria in Acid-Base Solutions: Chapters 13 and 14: 3 weeks	Definitions of acids and bases Amphoteric behavior Acid-base reactions Ka, pKa, pH, pOH calculations for strong and weak acids and bases, polyprotic acids Titration calculations (pKa, pH, pOH etc.) Buffers and common ion effect Laboratory activities: (Inquiry-based) Exploration of titration curves – students do a strong and weak acid titration and investigate the differences/similarities between them. Using titration to determine a) Molar mass of an unknown compound b) Concentration of a solution c) Mass percent of a solution d) Number of acidic hydrogens and Ka values [Lab groups are assigned one type of investigation and develop a procedure/method of analysis to determine their unknown.]	BI 6 SP 2, 5, 6 SP 2, 5, 6	LO 6.11-6.13. Lab groups present their method and conclusions to the class, then design and administer a short assessment that all students complete. For example, the group doing "number of acidic hydrogens and Ka values" would explain how they found these, then ask the class to see if they can find these results in a problem they give the students.

Complex Ion and Precipitation Equilibria: Chapter 15: 1.5 weeks	Ksp calculations including the common ion effect Basic complex ion equilibria and nomenclature Laboratory activities Qualitative observations of the common ion effect The silver one-pot reaction	BI 6 SP 1, 5, 7 SP 1, 5, 7	LO 6.21-6.24. Students work in small groups to solve problems involving solubility, common ion effect, and Ksp.
Rate of Reaction: Chapter 11: 2 weeks	Rates of reaction 0^{th}, 1^{st}, and 2^{nd} order rate laws, using experimental data and graphical methods Effect of temperature changes and catalysts on rates Mechanisms and rate determining steps Laboratory Activities (Inquiry-Based) What will affect reaction rates? Students design a series of experiments to determine the effect of different variables on reaction rate Determination of the order of a reaction	BI 4 SP 3, 4, 6, 7 SP 2, 5	LO 4.2, 4.3. Students utilize calculator technology to determine rate laws from research data available online
Equilibrium and nonstandard conditions: Chapter 16 part 2: 0.5 weeks	Nonstandard conditions Relationship of free energy to equilibrium constant	BI 5, 6	LO 6.25. Students make a concept map of big ideas and equations in kinetics, equilibrium and thermodynamics

			that shows the interconnections between the topics.
Electrochemistry: Chapter 17: 2 weeks	Electrolytic and galvanic cells Faraday’s law Standard half-cell potentials Nernst equation Spontaneous/nonspontaneous electrochemical reactions Relationship to equilibrium constant Laboratory Activities (STS Connection) Making batteries: students explore the different components in a battery (for example, a car battery with the acid removed) and then make their own battery and test it. Students also combine their batteries with other groups to observe series/parallel circuits. Using electrolysis to electroplate a penny (copper zinc bronze alloy) Determination of an electrochemical series (Students develop procedure with guidance – guided-inquiry)	BI 1, 3, 5, 6 SP 1, 3, 6 SP 1, 7 SP 3, 4, 6	LO 3.12-LO 3.13 Students add electrochemistry topics to their concept maps.
Electronic Structure and the Periodic	Modern atomic theory Atomic spectra, quantum numbers, atomic orbitals	BI 1	LO 1.10. Students use the properties

Table: Chapter 6: 1.5 weeks	Periodic trends (atomic radii, etc.) Relationships in the periodic table Spectroscopy as a method for determining and confirming atomic structure, including PES Chemical reactivity Laboratory Activities (Guided-inquiry) Students try to determine what is inside a "black box" by shooting marbles through openings in the box and observing the projectile of the marbles as they leave. Flame tests and observations of atomic spectra, including hydrogen Observations of periodic trends	SP 3, 4, 5, 6, 7 SP 1, 2, 6, 7 SP 3, 6, 7	of supplied "unknown" elements to predict placement in the periodic table and reactivity.
Covalent Bonding: Chapter 7: 2.5 weeks	Types of bonding (ionic, covalent, polar metallic, van der Walls, hydrogen) Relationships of bonding to properties and structure Lewis structures Use of spectroscopy, including PES, to determine and confirm molecular structure VSEPR Theory, geometry of molecules and ions Hybridization of orbitals Structural isomerism Dipole moments	BI 1, 2, 6	LO 2.19 After exploring the properties of different types of compounds, students draw pictures of the microscopic arrangements in compounds (i.e., ions or atoms) and

	Molecular orbital theory Sigma and pi bonds Laboratory activities Comparison of different types of substances (inquiry based) Building of molecular models "Like dissolves like": an exploration of the effects of polarity	BI 1, 2, 6 SP 1, 4, 6, 7 SP 1, 7 SP 1, 3, 4, 7	write a discussion for each type of compound explaining why the observed properties are a result of microscopic structure.
Liquids and Solids: Chapter 9: 1.5 weeks	Phase diagrams Changes of state Structure of solids Laboratory Investigations What is the relationship between intermolecular forces and heat of vaporization? Observation of the triple point of carbon dioxide	BI 1, 2, 5 SP 1, 5, 6, 7	LO 5.4, 5.5 and 5.8. Students determine the enthalpy change of various physical and chemical reactions (heat of vaporization, heat of solution etc.) using tabulated data, then relate to microscopic interactions between particles.
Solutions: Chapter 10: 1.5 weeks	Factors affecting solubility Raoult's law Colligative properties		LO 5.9. Students predict the solubility and

	Osmosis Nonideal behavior: Laboratory Investigations: (STS Connection) Determination of the molar mass of ethylene glycol	SP 2, 5	energetics of solubility based on polarity.
AP Exam Review 3 weeks			