Amherst County Public Schools
AP Chemistry Curriculum Pacing Guide
College Board AP Chemistry Site

REV: 8/12

1st 9 weeks	AP Topic Pacing	Vocabulary
Unit 1: Basic Chemistry 1 Review **Quantitative Skills** Matter, Measurement, Significant Figures, Scientific Notation and Dimensional Analysis **Atoms, Molecules, and Ions** Atomic theory and structure, Moles, Ions, Formulas and Naming Compounds **Stoichiometry** Atomic masses, Calculations with moles, Molar mass, Percent Composition, Empirical and Molecular formulas, Chemical equations, Balancing equations, Mass relationships, Limiting reactants, and Theoretical and Percent Yield **15 Days**		Material data safety sheet Accuracy Precision Experimental error Systematic error Procedural error Percent error SI measurement Isotopes Atomic spectra Quantum numbers Electron affinities Oxidation number Avogadro's number
Unit 2: States of Matter & Material Science **-Gases** Ideal Gas law, Molar mass and Density, Partial pressures and Mole fractions, Kinetic Molecular Theory, Effusion and Diffusion(Graham's Law), & Ideal versus Real Gases **8 Days** **-Liquids and solids** Intermolecular forces, Liquid state, Solid structures, Structure and Bonding in Metals, Network Atomic Solids, Molecular and Ionic solids, Vapor pressure and Changes of state, & Phase diagrams **10 Days** **-Properties of Solutions** Solution Composition, Energy of solution formation, Solubility, Vapor pressures of solutions, Boiling-point elevation, Freezing-point depression, Osmotic pressure, Colligative properties, & Colloids **10 Days**		Avodgadro's hypothesis Real gas deviation Triple point Critical point Lattice energies Heating curves Raoult's Law Osmosis
9-weeks assessment test **2 days**		

2nd 9 Weeks	AP Topic Pacing	Vocabulary
Unit 3: Reaction Prediction **Types of Chemical Reactions and Solution Stoichiometry** Electrolytes, Molarity, Precipitation reactions, Solubility rules, Net Ionic equations, Acid-Base (strong/weak) reactions (Arrhenius, Bronstead-Lowry, Lewis), Titrations, and Oxidation-Reduction (Redox) reactions	**14 days**	Solubility rules Molality Mole Fraction Precipitation reactions Endpoint Coordination complexes Amphoterism Dilution Neutralization Half-reaction method Standard solution Spectator ions Oxidizing agent Reducing agent Volumetric analysis
<u>Unit 4: Equilibrium;</u> **Chemical Equilibrium** Equilibrium condition, Equilibrium constant, Equilibrium expressions with pressures, Heterogeneous equilibria, Applications of the Equibrium constant, Solving equilibrium problems, Le Châtelier's Principle **Acids and Bases** Acid strength, pH scale, pH, Calculating pH, Polyprotic acids, acid-base properties of salts, Structure effects on acids/bases, Acid-base properties of oxides, Lewis Acid-base model, Solving Acid-base problems **Applications of Aqueous Equilibria** Acid/Base solutions with a common ion, Buffers, Buffer capacity, Titrations and pH curves, Acid-base equilibria, Solubility equilibria, Solubility product, Precipitation and Qualitative analysis, and Equilibria with complex	29 days	Dynamic equilibrium Common ion effect Reaction quotient K values Law of mass action Equilibrium position conjugate acid/base Oxyacids Percent dissociation Millimole Equivalence point Buffered solution\\ Indicators Salt Dissociation reactions Complex ion Phenolphthalein
9- week assessment test	**2 Days**	

3rd Nine weeks	AP Topic Pacing	Vocabulary
Unit 5: Thermochemistry **The Nature of Energy** First Law of Thermodynamics, Enthalpy, Calorimetry, Hess's Law, Spontaneity, Entropy, and Free Energy Spontaneous Processes and Entropy, Second Law of Thermodynamics, Free energy, Pressure Dependence of Free energy, Effects of Temperature, Pressure and Concentration on Spontaneity, Free energy and Equilibrium, and Free energy and Work 15 Days		Enthalpy of formation, Enthalpy of combustion Pathway Potential energy diagram State function System Internal energy Standard state Syngas Greenhouse effect Calorimeter Heat capacity Specific heat
Unit 6: Thermodyamics & the Atom **Atomic Structure and Periodicity** Electromagnetic radiation, Atomic spectrum, Bohr Model, Quantum numbers, Orbital Shapes and Energies. Electron spin, Wave and Energy level transitions, Periodic table functions, Properties of the elements, and Periodic Trends **Bonding: General Concepts** Chemical bond types, Electronegativity, Polarity and dipole moments, Electron configurations, Ionic character, Covalent bonding, Bond energies and Chemical reactions, Lewis structures, Octet Rule (exceptions), Molecular structure, & VSEPR Covalent bonding: Orbitals 20 Days		Quantum model Ground state Standing wave Wave function Quantum mechanical model Angular momentum Magnetic quantum SNodal surface/nodes Degenerate orbital Polyelectronic atoms Hybridization Electron Model Localized Electron Model Molecular Orbital Model, Homonuclear diatomic Heteronuclear diatomic
Unit 7: Organic Chemistry Organic Chemistry Nomenclature, Functional Groups, Reactivity, Lewis structures, and Isomers 8 Days		Biomolecule Hydrocarbon Branched molecules Aromatics Polymers Halogenatinon
9 -weeks assessment test	**2 Days**	

4th Nine Weeks	AP Topic Pacing	Vocabulary
Unit 8: Kinetics Chemical Kinetics Reaction rates, Rate laws, Determining rate law form and Integrated rate law. Reaction mechanisms, and Catalysis	**15 days**	Rate constant First -order reaction Second-order reaction Zero-order reaction Psudeo rate laws Elementary step Rate-determining step Collision model Activated complex Tranisiton state Steric factor Molecular orientation
Unit 9: Electrochemistry Galvanic cells, Standard reduction potentials, Cell potential and Electrical work. Free energy and Cell potential dependence on concentration. Batteries, Corrosion, and Electrolysis	**15 days**	Oxidation/reduction Redox Salt bridge Porous disk Anode Cathode Electromotive force Voltmeter Potentiometer Ion-selective electrode Concentraction cell Chlor-alkali process Cathodic protection Ampere
AP® CHEMISTRY EXAM – Early May		**1 Day**
After AP test: Independent Science Project (approved by teacher).	Approximately 15 Days	Dependent on project

The Course

The AP Chemistry course is designed to be the equivalent of the general chemistry course usually taken during the first college year. For some students, this course enables them to undertake, in their first year, second-year work in the chemistry sequence at their institution or to register in courses in other fields where general chemistry is a prerequisite. For other students, the AP Chemistry course fulfills the laboratory science requirement and frees time for other courses. AP Chemistry should meet the objectives of a good college general chemistry course. Students in such a course should attain a depth of understanding of fundamentals and a reasonable competence in dealing with chemical problems. The course should contribute to the development of the students' abilities to think clearly and to express their ideas, orally and in writing, with clarity and logic. The college course in general chemistry differs qualitatively from the usual first secondary school course in chemistry with respect to the kind of textbook used, the topics covered, the emphasis on chemical calculations and the mathematical formulation of principles, and the kind of laboratory work done by students. Quantitative differences appear in the number of topics treated, the time spent on the course by students, and the nature and the variety of experiments done in the laboratory. *Secondary schools that wish to offer an AP Chemistry course must be prepared to provide a laboratory experience equivalent to that of a typical college course.*

Prerequisites

The AP Chemistry course is designed to be taken only after the successful completion of a first course in high school chemistry. Surveys of students who take the AP Chemistry Exam indicate that the probability of achieving a score of 3 or higher is significantly greater for students who successfully complete a first course in high school chemistry prior to undertaking the AP course. *Thus it is strongly recommended that credit in a first-year high school chemistry course be a prerequisite for enrollment in an AP Chemistry class. In addition, the recommended mathematics prerequisite for an AP Chemistry class is the successful completion of a second-year algebra course.*

The advanced work in chemistry should not displace any other part of the student's science curriculum. It is highly desirable that a student have a course in secondary school physics and a four-year college-preparatory program in mathematics.

Time Allocations

Developing the requisite intellectual and laboratory skills required of an AP Chemistry student demands that adequate classroom and laboratory time be scheduled. Surveys of students taking the AP Chemistry Exam indicate that performance improved as both total instructional time and time devoted to laboratory work increased.

I. Structure of Matter (20%)

A. Atomic theory and atomic structure
   1. Evidence for the atomic theory
   2. Atomic masses; determination by chemical and physical means
   3. Atomic number and mass number; isotopes
   4. Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
   5. Periodic relationships including, for example, atomic radii, ionization energies, electron affinities, oxidation states

B. Chemical bonding
   1. Binding forces
      a. Types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion forces)
      b. Relationships to states, structure, and properties of matter
      c. Polarity of bonds, electronegativities
   2. Molecular models
      a. Lewis structures
      b. Valence bond: hybridization of orbitals, resonance, sigma and pi bonds
      c. VSEPR
   3. Geometry of molecules and ions, structural isomerism of simple organic molecules and coordination complexes; dipole moments of molecules; relation of properties to structure

C. Nuclear chemistry: nuclear equations, half-lives, and radioactivity; chemical applications

II. States of Matter (20%)

A. Gases
   1. Laws of ideal gases
      a. Equation of state for an ideal gas
      b. Partial pressures
   2. Kinetic molecular theory
      a. Interpretation of ideal gas laws on the basis of this theory
      b. Avogadro's hypothesis and the mole concept
      c. Dependence of kinetic energy of molecules on temperature
      d. Deviations from ideal gas laws

B. Liquids and solids
   1. Liquids and solids from the kinetic-molecular viewpoint
   2. Phase diagrams of one-component systems
   3. Changes of state, including critical points and triple points
   4. Structure of solids; lattice energies

C. Solutions
   1. Types of solutions and factors affecting solubility

2. Methods of expressing concentration (use of normalities is not tested)
3. Raoult's law and colligative properties (nonvolatile solutes); osmosis
4. Nonideal behavior (qualitative aspects)

III. Reactions (35–40%)

A. Reaction types
   1. Acid-base reactions; concepts of Arrhenius, Brønsted-Lowry and Lewis; coordination complexes; amphoterism
   2. Precipitation reactions
   3. Oxidation-reduction reactions
      a. Oxidation number
      b. The role of the electron in oxidation-reduction
      c. Electrochemistry: electrolytic and galvanic cells; Faraday's laws; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions

B. Stoichiometry
   1. Ionic and molecular species present in chemical systems: net ionic equations
   2. Balancing of equations, including those for redox reactions
   3. Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants

C. Equilibrium
   1. Concept of dynamic equilibrium, physical and chemical; Le Chatelier's principle; equilibrium constants
   2. Quantitative treatment
      a. Equilibrium constants for gaseous reactions: Kp, Kc
      b. Equilibrium constants for reactions in solution
         (1) Constants for acids and bases; pK; pH
         (2) Solubility product constants and their application to precipitation and the dissolution of slightly soluble compounds
         (3) Common ion effect; buffers; hydrolysis

D. Kinetics
   1. Concept of rate of reaction
   2. Use of experimental data and graphical analysis to determine reactant order, rate constants and reaction rate laws
   3. Effect of temperature change on rates
   4. Energy of activation; the role of catalysts
   5. The relationship between the rate-determining step and a mechanism

E. Thermodynamics
   1. State functions
   2. First law: change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry
   3. Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes

4. Relationship of change in free energy to equilibrium constants and electrode potentials

IV. Descriptive Chemistry (10–15%)

Knowledge of specific facts of chemistry is essential for an understanding of principles and concepts. These descriptive facts, including the chemistry involved in environmental and societal issues, should not be isolated from the principles being studied but should be taught throughout the course to illustrate and illuminate the principles. The following areas should be covered:

1. Chemical reactivity and products of chemical reactions
2. Relationships in the periodic table: horizontal, vertical and diagonal with examples from alkali metals, alkaline earth metals, halogens, and the first series of transition elements
3. Introduction to organic chemistry: hydrocarbons and functional groups (structure, nomenclature, chemical properties)

V. Laboratory (5–10%)

The differences between college chemistry and the usual secondary school chemistry course are especially evident in the laboratory work. The AP Chemistry Exam includes some questions based on experiences and skills students acquire in the laboratory:

- making observations of chemical reactions and substances
- recording data
- calculating and interpreting results based on the quantitative data obtained
- communicating effectively the results of experimental work

For information on the requirements for an AP Chemistry laboratory program, the *Guide for the Recommended Laboratory Program* is included on pages 29–39 of this book. The guide describes the general requirements for an AP Chemistry laboratory program and contains a list of recommended experiments. Also included in the guide are resources that AP Chemistry teachers should find helpful in developing a successful laboratory program. Colleges have reported that some AP students, while doing well on the exam, have been at a serious disadvantage because of inadequate laboratory experience. Meaningful laboratory work is important in fulfilling the requirements of a college level course of a laboratory science and in preparing a student for sophomore-level chemistry courses in college.

Because chemistry professors at some institutions ask to see a record of the laboratory work done by an AP student before making a decision about granting credit, placement or both, in the chemistry program, students should keep a laboratory notebook that includes reports of their laboratory work in such a fashion that the reports can be readily reviewed.

The Exam

The AP Chemistry Exam has two main parts, Section I and Section II, that contribute equally (50 percent each) toward the final score. Section I consists of 75 multiplechoice questions that cover a broad range of topics. Section II consists of six freeresponse questions: three multipart quantitative questions, one question on writing balanced chemical equations and answering a short question for three different sets of reactants, and two multipart questions that are essentially nonquantitative. Teachers should not try to prepare students to answer every question in Section I of the exam. To be broad enough in scope to give every student who has covered an adequate amount of material an opportunity to make a good showing, the exam must be so comprehensive that no student should be expected to make a perfect or nearperfect score. A period of 90 minutes is allotted for Section I of the exam. Section II is divided into two parts: for Part A (55 minutes), students are allowed the use of a calculator, but for Part B (40 minutes), no calculators are permitted. Every Section II of the exam will contain one quantitative question that is based on chemical equilibrium and one question that is based on laboratory. The laboratory question may appear in Part A and be quantitative, or it may appear in Part B and require little or no calculation. In past AP Chemistry Examinations, the practice for writing units associated with changes in thermodynamic quantities in given reactions has been to use kJ/mol and kJ/(mol •K) for energy and entropy changes, respectively. Starting in May 2012, the use of the term "molrxn" (read aloud as "mole reaction" or "mole of reaction") in thermodynamic units will be phased in as a move toward a standard practice in the AP Chemistry Examination. Specifically, the term molrxn will be used in the denominator when quantities such as changes in enthalpy, Gibbs free energy, and entropy are expressed in the context of given reactions. For example, consider the reaction represented below.

$$2\,Al(s) + 3\,Cl_2(g) \rightarrow 2\,AlCl_3(s)$$

For this reaction, $\Delta H^\circ = -1411$ kJ/molrxn, $\Delta G^\circ = -1260$ kJ/molrxn, and $\Delta S^\circ = -505$ J/(mol rxn•K). In each case, the values given are for the reaction that occurs as written, specifically with the coefficients referring to numbers of moles of substances (not individual atoms or molecules).

Calculators

The policy regarding the use of calculators on the AP Chemistry Exam was developed to address the rapid expansion of the capabilities of scientific calculators, which include not only programming and graphing functions but also the availability of stored equations and other data. For the section of the exam in which calculators are permitted, students should be allowed to use the calculators to which they are accustomed, except as noted below.* On the other hand, they should not have access to information in their calculators that is not available to other students, if that information is needed to answer the questions. Therefore, calculators are not permitted on the multiple-choice section of the AP Chemistry Exam. The purpose of the multiple-choice section is to assess the breadth of students' knowledge and understanding of the basic concepts of chemistry. The multiple-choice questions emphasize conceptual understanding as well as qualitative and simple quantitative applications of principles. Many chemical and physical principles and relationships are quantitative by nature and can be expressed as equations. Knowledge of the underlying basic definitions and principles, expressed as equations, is a part of the content of chemistry that should be learned by chemistry students and will continue to be assessed in the multiple-choice section. However, any numeric calculations that require use of these equations in the multiple-choice section will be limited to simple arithmetic so that they can be done quickly, either mentally or with paper and pencil. Also, in some questions the answer choices differ by several orders of magnitude so that the questions can be answered by estimation. Refer to sample questions on pages 15–17 (#6, 8, 11, 12, 16, and 17), which can be answered using simple arithmetic or by estimation. Students should be encouraged to develop their skills not only in estimating answers but also in recognizing answers that are physically unreasonable or unlikely. Calculators (with the exceptions previously noted) will be allowed only during the first 55 minutes (Part A) of the free-response section of the exam. During this time, students will work on three problems. Any programmable or graphing calculator may be used, and students will NOT be required to erase their calculator memories before or after the exam. Students will not be allowed to move on to the last portion of the free-response section until time is called and all calculators are put away. For the last 40 minutes (Part B) of the exam, students will work without calculators on the remaining portion of the free-response section.