



Science Department Curriculum Guide

Chemistry – AP

Course Description	
The AP Chemistry course provides students with a college-level foundation to support future advanced coursework in chemistry and is aligned with the College Board AP Chemistry curriculum. Students cultivate their understanding of chemistry through inquiry-based investigations, as they explore topics such as: atomic structure, intermolecular forces and bonding, chemical reactions, kinetics, thermodynamics, and equilibrium. The global impact of chemistry upon our society and the world economy and other associated issues will be discussed to complement the curriculum. The prerequisites for this course according to the College Board guidelines are: “Students should have successfully completed a general high school chemistry course and Algebra 2.” Students who do not meet these prerequisites may request permission to enroll in the course.	
Course Content	Science Practices
The AP Chemistry course is organized into eight units arranged in a logical sequence. Students will spend about 25% of instructional time engaged in hands-on, inquiry-based investigations. ■ Unit 1: Atomic Structure and Properties ■ Unit 2: Molecular and Ionic Compound Structure and Properties ■ Unit 3: Intermolecular Forces and Properties ■ Unit 4: Chemical Reactions ■ Unit 5: Kinetics ■ Unit 6: Thermodynamics ■ Unit 7: Equilibrium ■ Unit 8: Acids and Bases ■ Unit 9: Applications of Thermodynamics	The science practices describe what a student should be able to do while exploring course concepts. ■ Models and Representations: Describe models and representations, including across scales. ■ Question and Method: Determine scientific questions and methods. ■ Representing Data and Phenomena: Create representations or models of chemical phenomena. ■ Model Analysis: Analyze and interpret models and representations on a single scale or across multiple scales. ■ Mathematical Routines: Solve problems using mathematical relationships. ■ Argumentation: Develop an explanation or scientific argument.
Textbook	
▪ Chemistry: AP Edition, by Steven S. Zumdahl and Susan A. Zumdahl; published by Houghton Mifflin, 2005	

**AP Chemistry Big Ideas - AP CollegeBoard**

The big ideas serve as the foundation of the course and allow students to create meaningful connections among concepts. They are often abstract concepts or themes that become threads that run throughout the course. Revisiting the big ideas and applying them in a variety of contexts allows students to develop deeper conceptual understanding. Below are the big ideas of the course and a brief description of each.

Unit 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.

- 1.A.1: Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions.
- 1.B.1: The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's law is qualitatively useful for understanding the structure of the atom.
- 1.B.2: The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb's law.
- 1.C.1: Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure.
- 1.C.2: The currently accepted best model of the atom is based on the quantum mechanical model.
- 1.D.1: As is the case with all scientific models, any model of the atom is subject to refinement and change in response to new experimental results. In that sense, an atomic model is not regarded as an exact description of the atom, but rather a theoretical construct that fits a set of experimental data.
- 1.D.2: An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model.
- 1.D.3: The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration.
- 1.E.1: Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types.
- 1.E.2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

Unit 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.

- 2.A.1: The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures.



- 2.A.2: The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently.
- 2.A.3: Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.
- 2.B.1: London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules.
- 2.B.2: Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved.
- 2.B.3: Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions.
- 2.C.1: In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond.
- 2.C.2: Ionic bonding results from the net attraction between oppositely charged ions, closely packed together in a crystal lattice.
- 2.C.3: Metallic bonding describes an array of positively charged metal cores surrounded by a sea of mobile valence electrons.
- 2.C.4: The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model.
- 2.D.1: Ionic solids have high melting points, are brittle, and conduct electricity only when molten or in solution.
- 2.D.2: Metallic solids are good conductors of heat and electricity, have a wide range of melting points, and are shiny, malleable, ductile, and readily alloyed.
- 2.D.3: Covalent network solids have properties that reflect their underlying 2-D or 3-D networks of covalent bonds. Covalent network solids generally have extremely high melting points and are hard.
- 2.D.4: Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.

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

- 3.A.1: A chemical change may be represented by a molecular, ionic, or net ionic equation.
- 3.A.2: Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.
- 3.B.1: Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat.
- 3.B.2: In a neutralization reaction, protons are transferred from an acid to a base.



- 3.B.3: In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.
- 3.C.1: Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred.
- 3.C.2: Net changes in energy for a chemical reaction can be endothermic or exothermic.
- 3.C.3: Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells.

Unit 4 Rates of chemical reactions are determined by details of the molecular collisions.

- 4.A.1: The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent.
- 4.A.2: The rate law shows how the rate depends on reactant concentrations.
- 4.A.3: The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant.
- 4.B.1: Elementary reactions can be unimolecular or involve collisions between two or more molecules.
- 4.B.2: Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds.
- 4.B.3: A successful collision can be viewed as following a reaction path with an associated energy profile.
- 4.C.1: The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction.
- 4.C.2: In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step.
- 4.C.3: Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions.
- 4.D.1: Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism.
- 4.D.2: Important classes in catalysis include acidbase catalysis, surface catalysis, and enzyme catalysis.

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

- 5.A.1: Temperature is a measure of the average kinetic energy of atoms and molecules.
- 5.A.2: The process of kinetic energy transfer at the particulate scale is referred to in this course as heat transfer, and the spontaneous direction of the transfer is always from a hot to a cold body
- 5.B.1: Energy is transferred between systems either through heat transfer or through one system doing work on the other system.
- 5.B.2: When two systems are in contact with each other and are otherwise isolated, the energy that comes out of one system is equal to the energy that goes into the other system. The combined energy of the two systems remains fixed. Energy transfer can occur through either heat exchange or work.



- 5.B.3: Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions.
- 5.B.4: Calorimetry is an experimental technique that is used to determine the heat exchanged/transferred in a chemical system.
- 5.C.1: Potential energy is associated with a particular geometric arrangement of atoms or ions and the electrostatic interactions between them.
- 5.C.2: The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released.
- 5.D.1: Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force.
- 5.D.2: At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions.
- 5.D.3: Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.
- 5.E.1: Entropy is a measure of the dispersal of matter and energy.
- 5.E.2: Some physical or chemical processes involve both a decrease in the internal energy of the components ($\Delta H^\circ < 0$) under consideration and an increase in the entropy of those components ($\Delta S^\circ > 0$). These processes are necessarily "thermodynamically favored" ($\Delta G^\circ < 0$).
- 5.E.3: If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.
- 5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.
- 5.E.5: A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control).

Unit 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.

- 6.A.1: In many classes of reactions, it is important to consider both the forward and reverse reaction.
- 6.A.2: The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient, Q .
- 6.A.3: When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. Equilibrium results from an equality between the rates of the forward and reverse reactions, at which point $Q = K$.
- 6.A.4: The magnitude of the equilibrium constant, K , can be used to determine whether the equilibrium lies toward the reactant side or product side.
- 6.B.1: Systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (Le Chatelier's principle).



- 6.B.2: A disturbance to a system at equilibrium causes Q to differ from K , thereby taking the system out of the original equilibrium state. The system responds by bringing Q back into agreement with K , thereby establishing a new equilibrium state.
- 6.C.1: Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry.
- 6.C.2: The pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing pH to pK_a allows one to determine the protonation state of a molecule with a labile proton.
- 6.C.3: The solubility of a substance can be understood in terms of chemical equilibrium.
- 6.D.1: When the difference in Gibbs free energy between reactants and products (ΔG°) is much larger than the thermal energy (RT), the equilibrium constant is either very small (for $\Delta G^\circ > 0$) or very large (for $\Delta G^\circ < 0$). When ΔG° is comparable to the thermal energy (RT), the equilibrium constant is near 1.

Subject: Chemistry – AP

Units	Standards	Key Activities
Scientific Method Classification of Matter Term 1 Summer Work Plus 3 weeks in school	Scientific Method - BI 1.D.1:a Classification of Matter - Pure substances vs. mixtures - Law of definite proportions - Law of multiple proportions - Chemical and physical changes 1.A.1:b 1.A.1.c 3.C.1:b, 3.C.1:c, 5.D:2 Nomenclature and formula of binary compounds 1.E.2:b Polyatomic ions and other compounds 1.E.2:b Determination of atomic masses 1.A.1:a Mole Concept 1.A.3:b, 1.A. Percent Composition 1.A.2:a	Lab: Separating ink using chromatography



Units	Standards	Key Activities
Stoichiometry Term 1 4 weeks	Empirical and Molecular Formulas 1.a.2:b Writing Chemical Equations and drawn representations 1.E.1:a, 1.E.1:c, 3.C.1:a Balancing Chemical Equations 1.A.3:a, 1.E.2:c, 1.E.2:d, 3.A.1:a Applying mole concept to chemical equations (Stoich) 1.E.1:a, 1.E.1:b Determine limiting reagent, theoretical and % yield 3.A.2:a	Lab: Evidence of Chemical Reaction
Solution Chemistry Term 1 3 weeks	Electrolytes and properties of water 2.A.3:h Molarity and preparation of solutions 1.D.3:C, 2.A.3:i, 2.A.3:j Precipitation Reactions and solubility rules 6.C.3:d Acid Base reactions and formation of a salt by titration 1.E.2:f, 3.A.2:c Balancing Redox 3.B.3:b, 3.B.3:b, 3.B.3:c, 3.B.3:d Simple Redox Titrations 1.E.2:f Gravimetric calculations 1.E.2:e	Lab: Determining the concentration of household vinegar Lab: Make a solution and dilution Lab: Determining the formula of a hydrate Lab: Qualitative analysis of ions in solution Lab: Using spectrophotometer to find solution concentration (Beer's Law)
Gases Term 1 2 weeks	Measurement of gases General gas laws: Boyle, Charles, Combined and ideas 2.A.2:a, 2.A.2:c Dalton's Law of Partial Pressure 2.A.2:b Molar volume of gases and stoichiometry 3.A.2:b Graham's Law and Demo KMT 2.A.2:d, 5.A.1 Real Gases and deviation from ideal gas law 2.A.2:e, a..2:f, 2.A.2:g, 2.B.2:c, 2.B.2:d	Lab: Molar volume of hydrogen gas Lab: Molar mass of butane



Units	Standards	Key Activities
Thermochemistry Term 2 2 weeks	Law of conservation of energy, work and internal energy ▪ 5.B.1, 5.E.2:a Endothermic and Exothermic reactions ▪ 3.C.2, 5.B.3:e, 5.B.3:f Potential energy diagrams ▪ 3.C.2, 5.C.2:c, 5.C.2:d, 5.C.2:e Calorimetry, heat capacity and specific heat ▪ 5.A.2, 5.B.2, 5.B.3:a, 5.B.3:b, 5.B.4 Hess's Law ▪ 5.B.3:a Heat of formation/combustion ▪ 5.C.2:g Bond Energies ▪ 2.C.1:d, 5.C.1, 5.C.2:a, 5.C.2:b	▪ Lab: Determine the heat of reaction through calorimetry ▪ Lab: Which fuel is best, methanol or ethanol
Atomic Structure, Periodic Trends & Electromagnetic Radiation Term 2 1 weeks	Electron configuration and the Aufbau principle ▪ 1.B.2:a Valence electrons and Lewis dot diagrams ▪ 1.B.2:c Periodic trends ▪ 1.B.1:b, 1.B.1:c, 1.B.2:b, 1.B.2:d, 1.C.1:c, 1.D.1:b, 2.C.1:a, 2.C.1:b Table arrangements based on electronic properties ▪ 1.C.1:a, 1.C.1:b, 1.C.1:d Properties of light and study of waves ▪ 1.C.2:e, 1.D.3:a, 5.E.4:b Atomic spectra of hydrogen and energy levels ▪ 1.B.1:d, 1.B.1:e, 1.D.3:b Quantum mechanical model ▪ 1.C.2:d Quantum theory and electron orbitals ▪ 1.C.2:c	▪ Lab: Emission spectrum of hydrogen



Units	Standards	Key Activities
Bonding and Molecular Structure Term 2 2 weeks	Lewis dot diagram 2.C.4:a Resonance structure and formal charge 2.C.4:c, 2.C.4:d, 2.C.4:e Bond polarity and dipole moments 2.C.1:c, 2.C.1:e, 2.C.1:f VSEPR models and molecular shape 2.C.4:b, 2.C.4:e, 2.C.4:f Polarity of molecules 2.C.1:e Lattice energies 1.B.1:a, 1.C.2:a, 2.C.1:d(1-2), 2.C.2:a, 2.C.2:b, 2.D.1:b Hybridization 2.C.4:g Molecular orbitals and diagrams 2.C.4:h, 2.C.4:i	Lab: Packing atoms and ions in a crystal animation Lab: Build models of molecules and demonstrate effect of polarity
Intermolecular Forces, Liquids, Solids and Solutions Term 2 2 weeks	Structure and bonding a) Metals, network and molecular b) Ionic, hydrogen, London, van der Waals 2.A.1:a, 2.A.1:d, 2.C.3, 2.D.1:a, 2.D.2:a, 2.D.1:b, 2.D.3, 2.D.4 2.A.1:b, 2.B.1:a, 2.B.1:b, 2.B.1:c, 2.B.2:a, 2.B.2:b, 2.B.2:c, 2.B. 2:d, 2.B.3:a, 5.D:1 Vapor pressure and changes in state Heating and cooling curves 2.A.1:e, 5.B.3:c, 5.B.3:d Composition of solutions 2.A.1:c, 2.A.3:b, 2.A.3:c, 2.B.2:b Colloids and suspensions 2.A.3:a, 2.A.3:b, 2.A.3:g Separation techniques 2.A.3:e, 2.A.3:f Effect on biological system 2.B.3:e, 2.D.3, 5.E.4:c	



Units	Standards	Key Activities
Kinetics Term 3 2 weeks	Rates of Reactions 4.A.1:a Factors that affect rates of reactions/collision theory 4.A.1:b, 4.A.1:c, 4.D.1, 4.D.2 Reaction pathways 4.B.3:a, 4.B.3:b Rate equation determination - Rate constants - Mechanisms - Method of initial rates - Integrated rate laws 4.A.2:a 4.A.3 4.B.1, 4.C.1, 4.C.2, 4.C.3 4.A.2:c 4.A.2:b, 4.A.3:d Activation energy and Boltzmann distribution 4.B.2, 4.B.3:c	Lab: The effect of concentration and temperature on the rate of a reaction
Equilibrium Term 3 2 weeks	Characteristics and conditions of chemical equilibrium 6.A.1, 6.A.3:a, 6.A.3:f Equilibrium expression derived from rates 6.A.3:b Factors that affect equilibrium 6.A.3:c Le Chatalier's principle 6.A.3:b, 6.B.1, 6.B.2, 6.C.3:e, 6.C.3:f The equilibrium constant 6.A.3:d, 6.A.3:e, 6.A.4 Solving equilibrium problems 6.A.2	Lab: Testing and explaining LeChatelier's Principle
Acids and Bases Term 3 2 weeks	Definition and nature of acids and bases 3.B.2, 6.C.1:d, 6.C.1:e, 6.C.1:f Kw and pH scale 6.C.1:a, 6.C.1:b, 6.C.1:g pH of strong and weak acids and bases 6.C.1:h Polyprotic acids 6.C.1:h pH of salts Structure of acids and bases	Lab: Determining a pH of solutions with indicators



Units	Standards	Key Activities
Buffers Term 3 3 weeks	Characteristics and capacity of buffers 6.C.2 Titrations and pH curves 6.C.1:l, 6.C.1:j, 6.C.1:k, 6.C.1:l, 6.C.1:m Choosing acid base indicators pH and solubility Ksp calculations and solubility product 6.C.3:a, 6.C.3:b	Lab: Creating titration curve quantitatively and experimentally
Thermodynamics Term 4 2 weeks	Laws of thermodynamics 5.E.1 Spontaneous process and entropy 5.E.2:c, 5.E.2:d, 5.E.2:e, 5.E.2:f, 6.C.3:c, 6.D.1:a Spontaneity, enthalpy, and free energy 5.E.2:e, 5.E.5 Free energy 5.E.2:d, 5.E.2:e, 5.E.2:f, 6.C.3:c, 6.D.1:a Free energy and equilibrium 5.E.2:e, 6.D.1:b, 6.D.1:c, 6.D.1:d Rate and spontaneity 5.E.2:e, 5.E.5	Lab: Verify spontaneous reaction after quantitative calculation of Free Energy
Electrochemistry Terms 1&4 2 weeks	Balancing redox reactions 3.B.3:a, 3.B.3:b, 3.B.3:c, 3.B.3:d Electrochemical cells and voltage 3.C.3:a, 3.C.3:b, 3.C.3:c, 5.E.4:a The Nernst equation 3.C.3:d Spontaneous and non-spontaneous equations 3.C.3:e Chemical applications 3.C.3:f	Lab: Measuring Cell potential in galvanic cell Lab: Electrolysis of ionic solutions