Oxford Area School District Science Scope and Sequence – Quarter 1:

AP Chemistry

AP Chem Big Idea #2	• Converting between units • Using significant figures in calculations and measurement • Dimensional Analysis to solve problems
AP Chem Big Idea #1	• Composition of an atom • Development of atomic theory? • Describe radioactivity • Distinguish between empirical and molecular formulas • Written and name formulas for variety of compounds
AP Chem Big Idea #3	• Balance Eqns • Predict the product of a rxn • Calculate atomic weight from % abundances • Mole conversions, Calculate empirical formulas from % and given amounts • Mass-mass problems, Limiting Reactant problems
AP Chem Big Idea #3	• Ionic Equations, Reactions of acids and metals salts with metals • Acids/bases/salts • Solution Composition • Solution Stoichiometry
AP Chem Big Idea #3	• Oxidation Reduction Reactions

AP Chem Big Idea #3

- Balancing Redox Equations, Voltaic Cells
- Cell EMF, Spontaneity of Redox Eqns
- Effect of Concentration on EMF (Nernst Eqn)
- Batteries
- Corrosion
- Electrolysis

AP Chem Big Idea #5

- The Nature of Energy, First Law of Thermodynamics
- Enthalpy
- Enthalpies of Reaction
- Calorimetry, Hess's Law
- Enthalpies of Formation

AP Chem Big Idea #1

- Wave nature of light
- Quantized Energy and Photons
- Line Spectra and the Bohr Model
- The Wave Behavior of matter

Oxford Area School Science Scope and Sequence – Quarter 2:

AP Chemistry

AP Chem Big Idea #1

- Quantum Mechanics and Atomic Orbitals, Representations of Orbitals
- Many Electron Atoms, Electron Configurations and Periodic Table
- Development of Periodic Table, Effective Nuclear Charge, Ionization energy
- Sizes of Atoms and Ions, Electron Affinities, Metals, nonmetals, metalloids
- Trends for Active Metals and Selected Nonmetals

AP Chem Big Idea #2

- Bonds, Lewis Structures, Octet Rule
- Ionic Bonds, Covalent Bonds, Polarity, Electronegativity
- Drawing Lewis structures & resonance structures, Exceptions to Octet Rule
- Strengths of Covalent Bonds
- Molecular Shapes & VSEPR Model, Molecular Shape and Polarity
- Covalent Bonds, Orbital Overlap, Hybrid orbitals, Multiple Bonds
- Molecular Orbitals & Second Row Diatomics

AP Chem Big Idea #2

- Gas Laws, Ideal Gas Law, Applications of Ideal Gas Law
- Gas Mixtures and Partial Pressure, KMT & Effusion and Diffusion
- Real Gases, Deviations from Ideal
- Comparison of Liquids and solids, Intermolecular Forces
- Properties of Liquids
- Phase Changes, Vapor Pressure
- Phase Diagram
- Structure of Solids
- Bonding in Solids

AP Chem Big Idea #2,5

- The Solution Process, Saturated Solutions & Factors Affecting Solubility
- Expressing Concentrations
- Colligative properties, Colloids

Oxford Area School District Science Scope and Sequence – Quarter 3:

AP Chemistry

AP Chem Big Idea #4

- Factors Affecting Reaction Rates
- Concentration and Rate
- Change in Concentration with Time
- Temperature and Rate
- Reaction Mechanisms
- Catalysts
- Concept of Equilibrium and The Equilibrium Constant

AP Chem Big Idea #6

- Heterogeneous Equilibria
- Calculating Equilibrium Constants
- Applications of Equilibrium Constants
- LeChatelier's Principle

Oxford Area School District Science Scope and Sequence – Quarter 4:

AP Chemistry

AP Chem Big Idea #6

- Overview of Acid and Bases/Bronsted-Lowry Acid/bases
- Autoionization of Water
- PH scale
- Strong Acids and Bases, Weak Acids, Weak Bases
- Ka and Kb and properties of salts
- Acid-Base behavior and chemical structure
- Lewis acids and bases

AP Chem Big Idea #6

- Common-Ion Effect
- Buffered Solutions
- Acid-Base titrations
- Solubility equilibria and factors affecting solubility
- Precipitation and qualitative analysis

AP Chem Big Idea #3

- Spontaneous Processes
- Entropy and Second Law of Thermo Dynamics
- Molecular Interpretation of entropy and enthalpy in reactions
- Molecular Interpretation of entropy and enthalpy in reactions
- Free energy, temperature, and equilibrium constant

Big Idea: 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

Essential Questions: 1.A.What makes up matter?
1.B. How does the interaction of electrons with the nucleus effect atomic structure?
1.C. What is periodicity?
1.D. How are models used to explain data?
1.E. Are atoms conserved in physical and chemical processes?

Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
1A.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.A.2 Chemical analysis can be used to determine the number of atoms, purity, or identity of a substance. 1.A.3. The mole is the fundamental unit for counting particles. 1.B.1 The atom is composed of negatively charged electrons and a positively charged nucleus made of protons and neutrons. The attraction of the electrons for the nucleus is the basis for atomic structure. 1.B.2 The electronic structure of the atom can be described using an electron configuration. 1.C.1. Atoms exhibit periodic trends that are reflective of the periodicity of electronic structure. 1.C.2. The accepted model of the atom is based on the quantum mechanical model. 1.D.1 An atomic model is not	CC.3.5.11-12.C-Key Ideas and Details ~ Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CC.3.5.11-12.G-Integration of Knowledge and Ideas ~ Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CC.3.5.11-12.H-Integration of Knowledge and Ideas ~ Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. CC.3.5.11-12.I-Integration of Knowledge and Ideas ~ Synthesize information from a range of sources (e.g., texts,	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch. 2 and Experiment #9 – Physical and Chemical Changes Ch.3 Ch. 6 and Experiment #1 Spectroscopy Ch. 7	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

regarded as an exact description of the atom, but rather a theoretical construct that fits 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.	experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. CC.3.6.11-12.A.4-Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CC.3.6.11-12.A.5-Provide a concluding statement or section that follows from or supports the argument presented. CC.3.6.11-12.B-Text Types and Purposes ~ Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. CC.3.6.11-12.B.1-Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CC.3.6.11-12.B.5-Provide a concluding statement or section that follows from and supports the information or explanation		

	provided (e.g., articulating implications or the significance of the topic). CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2 CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.2.HS.D.8 Apply inverse operations to solve equations or formulas for a given variable. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.9 Use reasoning to solve equations and justify the solution method. A1.1.1.4.1, A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.10 Represent,		

	solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4 CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable. A1.2.2.1.2, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, CC.2.4.HS.B.2 Summarize, represent, and interpret data on two categorical and quantitative variables. A1.2.1.1.1, A1.2.1.1.2, A1.2.1.1.3, A1.2.1.2.1, A1.2.1.2.2, A1.2.2.2.1, A2.2.1.1.1, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.3 Analyze linear models to make interpretations based on the data. A1.2.2.2.1, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and observational studies. A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.2.1, A2.2.3.2.2, A2.2.3.2.3		
Vocabulary Law of conservation of mass, law of multiple proportions, cathode ray, electron, radioactivity, nucleus, atomic number, mass number isotope, amu, atomic weight, periods, groups, metals, nonmetals, metalloids, chemical formula, anion, cation, ionic compounds, decomposition reactions, combustion reactions, mole, Avogadros number, molar mass, limiting reactant, theoretical yield, percent yield, valence orbitals, effective nuclear charge, atomic radius, ionization energy, electron affinity, metallic character			

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.

Essential Questions:
2.A: Can matter be described by its physical properties? What do the physical properties of a substance generally depend on?
2.B: Why are forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature?
2.C: What are the strong electrostatic forces of attraction holding atoms together in a unit are called?
2.D: How can the type of bonding in the solid state can be deduced from the properties of the solid state?

Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
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 molecular 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	CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2 CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.2.HS.D.8 Apply inverse operations to solve equations or formulas for a given variable. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3,	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch 1 Ch 8 and Experiment #6 Bonding in Solids Ch 9 and Pigment Research Project Ch 10 and Experiment #3 Gravimetric Analysis Ch 11and Experiment #5 Chromatography Ch 13	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

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	A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.9 Use reasoning to solve equations and justify the solution method. A1.1.1.4.1, A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4 CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable. A1.2.2.1.2, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, CC.2.4.HS.B.2 Summarize, represent, and interpret data on two categorical and quantitative variables. A1.2.1.1.1, A1.2.1.1.2, A1.2.1.1.3, A1.2.1.2.1, A1.2.1.2.2, A1.2.2.2.1, A2.2.1.1.1, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.3 Analyze linear models to make interpretations based on the data. A1.2.2.2.1, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and		

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.	observational studies. A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.2.1, A2.2.3.2.2, A2.2.3.2.3		
Vocabulary Matter, elements, atoms, molecule, pure substance, compounds, mixtures, physical/chemical properties and changes, extensive and intensive properties, SI units, Kelvin, derived unit, significant figures, accuracy and precision, ionic, covalent, metallic bonds, octet, Lewis structures, lattice energy, polarity, nonpolar covalent, polar covalent, dipole, formal charge, resonance, bond enthalpy, VSEPR, electron domains, electron geometry, molecular geometry, hybrid orbitals, sigma bonds, pi bonds, MO theory, bond order, paramagnetism, diamagnetism, KMT, diffusion, effusion, STP, intermolecular forces, polarizability, viscosity, surface tension, critical temperature, critical pressure, supercritical fluid, vapor pressure, volatile, normal boiling point, phase diagram, normal melting point, hydration, saturated, unsaturated, supersaturated, miscible, immiscible, molality, colligative property, osmosis, osmotic pressure			

Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons

Essential Questions:
3.A: How are chemical changes represented? What does a balanced chemical equation show?
3.B: What are the classes of chemical Reactions?
3.C: How are chemical and physical transformations may be observed? What is typically involve in a chemical or physical change?

Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
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.	CC.3.5.11-12.C-Key Ideas and Details ~ Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CC.3.5.11-12.G-Integration of Knowledge and Ideas ~ Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CC.3.5.11-12.H-Integration of Knowledge and Ideas ~ Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch3 and Experiment #7 Stoichiometry Ch 4 Ch 20 and Experiment #8 Redox Titration	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

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.	or challenging conclusions with other sources of information. CC.3.5.11-12.I-Integration of Knowledge and Ideas ~ Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. CC.3.6.11-12.A.4-Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CC.3.6.11-12.A.5-Provide a concluding statement or section that follows from or supports the argument presented. CC.3.6.11-12.B-Text Types and Purposes ~ Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. CC.3.6.11-12.B.1-Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia		

	when useful to aiding comprehension. CC.3.6.11-12.B.5-Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2 CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.2.HS.D.8 Apply inverse operations to solve equations or formulas for a given variable. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.9 Use reasoning to solve equations and justify the		

	solution method. A1.1.1.4.1, A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4 CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable. A1.2.2.1.2, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, CC.2.4.HS.B.2 Summarize, represent, and interpret data on two categorical and quantitative variables. A1.2.1.1.1, A1.2.1.1.2, A1.2.1.1.3, A1.2.1.2.1, A1.2.1.2.2, A1.2.2.2.1, A2.2.1.1.1, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.3 Analyze linear models to make interpretations based on the data. A1.2.2.2.1, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and observational studies. A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.2.1, A2.2.3.2.2, A2.2.3.2.3		

Vocabulary
Electrochemistry, reducing agent, oxidizing agent, voltaic cell, anode, cathode, cell potential, electromotive force, reduction potential, SHE, battery, electrolysis, aqueous solutions, solvent, solute, electrolyte, precipitate, metathesis reactions, net ionic equation, acids, bases, strong/weak acids and bases, salt, oxidation, oxidation number, redox reactions, activity series, molarity, titration, equivalence point

Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.
Essential Questions: 4.A: Reaction rates that depend on what factors? 4.B: How are elementary reactions are mediated? What type of collisions lead to the formation of products? 4.C: How do most reactions proceed? 4.D: What is the effect of a catalyst on reaction rate?

Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
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	CC.3.5.11-12.C-Key Ideas and Details ~ Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CC.3.5.11-12.G-Integration of Knowledge and Ideas ~ Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CC.3.5.11-12.H-Integration of Knowledge and Ideas ~ Evaluate the hypotheses, data, analysis,	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch 14 and Experiment #10 Kinetics of Reactions. Experiment #11 Rate Laws Ch 15	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

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 acid-base catalysis, surface catalysis, and enzyme catalysis.	and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. CC.3.5.11-12.I-Integration of Knowledge and Ideas ~ Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. CC.3.6.11-12.A.4-Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CC.3.6.11-12.A.5-Provide a concluding statement or section that follows from or supports the argument presented. CC.3.6.11-12.B-Text Types and Purposes ~ Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. CC.3.6.11-12.B.1-Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a		

	unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CC.3.6.11-12.B.5-Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2 CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.2.HS.D.8 Apply inverse operations to solve equations or formulas for a given variable. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3,		

	A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.9 Use reasoning to solve equations and justify the solution method. A1.1.1.4.1, A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4 CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable. A1.2.2.1.2, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, CC.2.4.HS.B.2 Summarize, represent, and interpret data on two categorical and quantitative variables. A1.2.1.1.1, A1.2.1.1.2, A1.2.1.1.3, A1.2.1.2.1, A1.2.1.2.2, A1.2.2.2.1, A2.2.1.1.1, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.3 Analyze linear models to make interpretations based on the data. A1.2.2.2.1, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and observational studies. A1.2.3.2.1,		

	A1.2.3.2.2, A1.2.3.2.3, A2.2.3.2.1, A2.2.3.2.2, A2.2.3.2.3		
Vocabulary Kinetics, reaction rate, rate law, reaction order, half-life, collision model, activation energy, activated complex, reaction mechanisms, intermediate, rate determining step, catalyst, adsorption, equilibrium, Habor process, law of mass action, equilibrium constant expression, equilibrium constant, reaction quotient, Le Chateliers principle			

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
Essential Questions: 5.A: Two systems with different temperatures that are in thermal contact will exchange? The quantity of thermal energy transferred from one system to another is called? 5.B: Energy is neither created nor destroyed, but only? 5.C: Breaking bonds requires what? Making bonds releases what? 5.D: How are intermolecular forces formed? What is required to break intermolecular interactions? 5.E: What drives a chemical or physical processes?

Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
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.	CC.3.5.11-12.C-Key Ideas and Details ~ Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CC.3.5.11-12.G-Integration of	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch 5 and Experiment #12	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

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	Knowledge and Ideas ~ Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CC.3.5.11-12.H-Integration of Knowledge and Ideas ~ Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. CC.3.5.11-12.I-Integration of Knowledge and Ideas ~ Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. CC.3.6.11-12.A.4-Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CC.3.6.11-12.A.5-Provide a concluding statement or section that follows from or supports the argument presented. CC.3.6.11-12.B-Text Types and Purposes ~ Write	Calorimetry Ch 13 and Experiment #2 Spectroscopy Ch 19	

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 ($\Delta H^o < 0$) under consideration and an increase in the entropy of those components ($\Delta S^o > 0$). These processes are necessarily "thermodynamically favored" ($\Delta G^o < 0$). 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	informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. CC.3.6.11-12.B.1-Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CC.3.6.11-12.B.5-Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).		

energy change is positive 5.E.5: A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control).			
Vocabulary Spontaneous reactions, reversible reactions, entropy, second law of thermodynamics, third law of thermodynamics, free energy, thermodynamics, thermochemistry, kinetic and potential energy, system, surroundings, work, heat, energy, first law of thermodynamics, endothermic, exothermic, state function, enthalpy, calorimeter, heat capacity, Hess's law, enthalpy of formation, standard states			

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.			
Essential Questions: 6.A: What is a dynamic, reversible state in which rates of opposing processes are equal? 6.B: Are systems at equilibrium responsive to external perturbations? Does a response leading to a change in the composition of the system occur as a result of these perturbations? 6.C: Does a chemical equilibrium play an important role in acid-base chemistry and in solubility? 6.D: How is the equilibrium constant related to temperature and the difference in Gibbs free energy between reactants and products?			
Eligible Content/Concepts	PA Core/ Competencies	Resources	Assessments
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,	CC.3.5.11-12.C-Key Ideas and Details ~ Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. CC.3.5.11-12.G-Integration of Knowledge and Ideas ~ Integrate and evaluate multiple sources of	Brown, Lemay, Bursten, Murphy, Woodward, Stotzfus. *Chemisty the Central Science 13th ed.* Pearson Prentice Hall, 2015 The College Board. *AP Chemistry Guided-Inquiry Experiments.* The College Board, 2013 Ch 15 and Experiment #13 Equilibrium	Chapter Homework Problems Written Chapter Tests Formal Laboratory Reports Multi-Chapter Free Response Tests

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 disturbancs 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 withK, 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 pKa allows one to determine the protonation state of a molecule with a labile proton. 6.C.3: The solubility of a	information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. CC.3.5.11-12.H-Integration of Knowledge and Ideas ~ Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. CC.3.5.11-12.I-Integration of Knowledge and Ideas ~ Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. CC.3.6.11-12.A.4-Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. CC.3.6.11-12.A.5-Provide a concluding statement or section that follows from or supports the argument presented. CC.3.6.11-12.B-Text Types and Purposes ~ Write informative/explanatory texts, including the narration of historical	Ch 16 and Experiment #14 Acid-base Titration. Experiment #4 Titrations Ch 17 and Experiment #15 Buffering Activity. Experiment #16 Buffering Design.	

substance can be understood in terms of chemical equilibrium. 6.D.1: When the difference in Gibbs free energy between reactants and products (ΔG^o) is much larger than the thermal energy (RT), the equilibrium constant is either very small (for $\Delta G^o>0$) or very large (for $\Delta G^o<0$). When ΔG^o is comparable to the thermal energy (RT), the equilibrium constant is near 1.	events, scientific procedures/ experiments, or technical processes. CC.3.6.11-12.B.1-Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. CC.3.6.11-12.B.5-Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic). CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.2.1.2.1, A1.2.1.2.2, A2.2.2.1.1, A2.2.2.1.2 CC.2.1.HS.F.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2,		

	A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.2.3.1.1, A2.2.3.1.2 CC.2.2.HS.D.8 Apply inverse operations to solve equations or formulas for a given variable. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.9 Use reasoning to solve equations and justify the solution method. A1.1.1.4.1, A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4, A2.1.3.2.1, A2.1.3.2.2 CC.2.2.HS.D.10 Represent, solve, and interpret equations/inequalities and systems of equations/inequalities algebraically and graphically. A1.1.2.1.1, A1.1.2.1.2, A1.1.2.1.3, A1.1.2.2.1, A1.1.2.2.2, A1.1.3.1.1, A1.1.3.1.2, A1.1.3.1.3, A1.1.3.2.1, A1.1.3.2.2, A2.1.3.1.1, A2.1.3.1.2, A2.1.3.1.3, A2.1.3.1.4 CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable. A1.2.2.1.2, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, CC.2.4.HS.B.2 Summarize, represent, and interpret data on two categorical and quantitative variables. A1.2.1.1.1, A1.2.1.1.2, A1.2.1.1.3, A1.2.1.2.1, A1.2.1.2.2, A1.2.2.2.1, A2.2.1.1.1, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.3 Analyze linear		

	models to make interpretations based on the data. A1.2.2.2.1, A1.2.3.1.1, A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.1.1, A2.2.3.1.2 CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and observational studies. A1.2.3.2.1, A1.2.3.2.2, A1.2.3.2.3, A2.2.3.2.1, A2.2.3.2.2, A2.2.3.2.3		
Vocabulary Hydronium ion, Bronsted-Lowry acid/base, amphiprotic, conjugate acid/base, ion-product, pH, ka, polyprotic acids, kb, Lewis acids, common ion, buffer, buffer capacity, titration curve, Ksp, complex ions			