College Chemistry

Belleville School District
Science
Grades 11 - 12, Duration 1 Year, 2 Credits
Elective Course

Course Description

This year long opportunity of Advanced Placement Chemistry is designed to be the equivalent of the general chemistry course that is usually taught during the first year of college. Students will be prepared to seek credit and/or appropriate placement in a college chemistry course. Students will experience laboratory experiments equivalent to that of a college course. The course will be designed around six big ideas outlined below.

Students will have the opportunity to complete the first semester for 1 credit of chemistry or both semesters for 2 credits of chemistry. A 75% or higher or instructor consent is required in the first semester to move into the second semester course. Students will only receive an AP designation on their transcript after successfully completing both semesters.

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. AP Learning Objectives 1.1-1.20

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. AP Learning Objectives 2.1-2.32

Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons. AP Learning Objectives 3.1-3.13

Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions. AP Learning Objectives 4.1-4.9

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter. AP Learning Objectives 5.1-5.18

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. AP Learning Objectives 6.1-6.25

Learning Targets
The learning objectives referenced are provided by the College Board.

Science Practices
These are provided by the College Board. They are listed within their respective units and their respective labs.

Connections to the Real World
One part of each require lab is that students connect what they learned in the unit lab to their everyday lives. An example is that while learning about flame tests students make connections between the colors they see and fireworks. Another example is that when students are learning about volatility they can explain in detail why mercury can be so dangerous.

Laboratory Experiments
Students will complete a number of labs. They will be expected to keep a lab notebook according to the guidelines provided. Lab reports are expected to include a heading, purpose/hypothesis, procedure/materials data/observations/graphs, calculations, analysis, error, and connections to the real world. I have included the guidelines for the conclusion below.

- *Conclusion is logical, it used data and prior knowledge to explain results, and it is easy to follow. The purpose and outcome of the lab is summarized and any questions that were asked were answered correctly and thoroughly.*
- *Mathematical relationships are addressed. The meanings of graphs, slopes, and equations are all discussed (if applicable).*
- *Sources of error are discussed. The error's impact on results, possible solutions for the future, and ways error was avoided are explained.*
- *Connections to the real world are discussed.*
- *If you liked the lab, why are why not, and suggestions for improvement.*

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In order to complete the 16 required labs students can expect to spend at least 25% of their class time in the lab. Labs are listed within their respective units and are marked as guided inquiry if they are an inquiry based lab.

Activities
Throughout the units demonstrations, short activities, and computer simulations will be utilized to enhance student learning. These occur outside of the traditional lab setting and students will be expected to keep record of these in their class notes. Activities are listed within their respective units.

**Timelines of topics within units are approximate. Two to four days have been added to each unit to provide time for assessments and unexpected delays.*

Scope and Sequence

Timeframe	Unit	Instructional Topics
8 Day(s)	Unit 1: Chemical Foundations	1. Introduction to Chemistry 2. Units of Measurement 3. Reliability of Measurements 4. Classification of Matter and its Changes
6 Day(s)	Unit 2: The Atom	1. The Atom 2. The Mole
11 Day(s)	Unit 3: The Periodic Table	1. Light and Waves 2. Quantum Mechanical Atom 3. Electron Configurations and Orbitals 4. Periodic Trends
7 Day(s)	Unit 4: Chemical Formulas	1. Chemical Bonds 2. Chemical Nomenclature 3. Chemical Compounds and Equations
13 Day(s)	Unit 5: Bonding	1. Lewis Dot Symbols and Structures 2. Bond Polarity 3. VSEPR Theory 4. Intermolecular Forces
13 Day(s)	Unit 6: Solids, Liquids, Gases	1. Phase Changes 2. Crystals 3. Basic Gas Laws 4. Kinetic Molecular Theory and Movement of Gases 5. Ideal and Real Gases 6. Moles of Gases
12 Day(s)	Unit 7: Chemical Quantities, Solutions, and Reactions	1. Stoichiometry 2. Solution Concentrations 3. Precipitation and Aqueous Reactions 4. Solutions, Solubility, and Colloids 5. Oxidation and Reduction Reactions
9 Day(s)	Unit 8: Thermochemistry	1. First Law of Thermodynamics 2. The Heat of Chemical Reactions 3. Reaction Enthalpies and Energy
10 Day(s)	Unit 9: Kinetics	1. The Rate Law 2. Integrated Rate Law 3. Reaction Rates and Mechanisms

		4. Catalysis
8 Day(s)	Unit 10: Equilibrium	1. Equilibria 2. Calculating Equilibrium Constant 3. Reaction Quotient 4. Finding Equilibrium Constants 5. Le Chatelier's Principle
9 Day(s)	Unit 11: Acids and Bases	1. Acids and Bases 2. Finding pH and pOH 3. Properties of Acids and Bases 4. Acidic Strength and Molecular Structure
9 Day(s)	Unit 12: Aqueous Ionic Equilibrium	1. Buffers 2. Titrations and pH Curves 3. Solubility and Precipitation 4. Qualitative Analysis
9 Day(s)	Unit 13: Thermodynamics	1. Spontaneous vs. Nonspontaneous 2. 2nd Law of Thermodynamics 3. Energy and its Changes 4. Free Energy Changes
8 Day(s)	Unit 14: Electrochemistry	1. Redox Revisited 2. Chemical Reactions and Electricity 3. Cell Potentials 4. Electroloysis
Ongoing	Unit 15: Final Unit	

Materials and Resources

Textbook:
Chemistry: A Molecular Approach (3rd Edition) by Nivaldo J. Tro (Jan 18, 2013)

Supply list:
Laboratory notebook, scientific calculator, notebook or looseleaf paper, folder or binder, and writing utensils (pencils, pens, and a 4 color pen is recommended).

Course Details

UNIT: Unit 1: Chemical Foundations -- 8 Day(s)

Unit Description
Big Idea 3. The information in this unit is material needed in answer questions about chemistry concepts. How to use significant figures, the metric system, and how to do basic conversions are covered. It is important to master these skills to help with success in chemistry. Practice with identifying matter and its changes along with safe and basic lab practices will be covered. *Textbook chapters and sections:1.1-1.8*
Lab: Quick Ache Relief Components (Guided Inquiry #9).
Most over-the-counter drugs consist of mixtures, or physical blends, of active drug ingredient(s) and binders. The main characteristic of a mixture is that it has a variable composition—the components of the mixture may be present or mixed in varying proportions. The substances in a mixture retain their distinctive chemical identities, as well as some of their unique physical properties. The purpose of this investigation is to study the physical properties of ingredients in a synthetic pain relief mixture and determine its percent composition.The lab begins with an introductory activity to test the solubility of each possible component in an organic solvent, ethyl acetate, and in a basic aqueous solution of sodium bicarbonate. The results provide a model for the guided-inquiry design of a flow chart that will map the procedure used to separate components in a mixture and determine percent composition. Optional extension activities include varying the amounts of individual components in the synthetic mixtures and analyzing consumer samples. Students may also measure the melting points of the isolated components, acetylsalicylic acid and

acetaminophen, to confirm their identity. This advanced inquiry lab enforces understanding of solubility and chemical reactions as students carry out their own step-by-step experiments and work collaboratively with their peers. **Science Practices: 4, 5**

Activity: Physical and Chemical Changes
Through demonstrations of various chemical and physical changes students will be asked to decide if a change was chemical or physical and explain why.

TOPIC: Introduction to Chemistry -- 1 Day(s)

Topic Description
Topics covered:syllabus, safety, lab equipment, and scientific knowledge.
Textbook chapters and sections: 1.1-1.2

Learning Targets

TOPIC: Units of Measurement -- 1 Day(s)

Topic Description
Topics covered: scientific notation, metric system, base and derived units of measurement, and dimensional analysis.
Textbook chapters and sections: 1.6,1.8

Learning Targets

SP 2 The student can use mathematics appropriately.

TOPIC: Reliability of Measurements -- 1 Day(s)

Topic Description
Topics covered: accuracy and precision, significant figures, error and uncertainty.
Textbook chapters and sections:1.7

Learning Targets

SP 2 The student can use mathematics appropriately.

TOPIC: Classification of Matter and its Changes -- 2 Day(s)

Topic Description
Topics covered: physical and chemical properties, physical and chemical changes, and properties of matter.
Textbook chapters and sections:1.3-1.5

Learning Targets

LO 3.10 The student is able to evaluate the classification of a process as
a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.

UNIT: Unit 2: The Atom -- 6 Day(s)

Unit Description
Big Idea 2. This unit will cover various chemical laws, historical development of the atom, subatomic particles, moles, and molar conversions. *Textbook chapters and sections: 2.1-2.6, 2.8-2.9, 3.8*

Activity: Understanding the Mole
Students will be introduced to the idea of relative mass and Avogadro's number. The students will be given different types of beans and asked to calculate the relative masses of their beans. Students will determine the number of beans in each relative mass and should discover the number of beans is the same. From here students will learn about Avogadro's number and how to perform molar conversions. **Science Practices: 2, 4, 5**

TOPIC: The Atom -- 2 Day(s)

Topic Description
Topics covered: imaging, various atomic models, subatomic particles, isotopes, and ions.
Textbook chapters and sections: 2.1-2.6

Learning Targets

LO 1.1 The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

LO 1.12 The student is able to explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model.

LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.

SP 6 The student can work with scientific explanations and theories.

TOPIC: The Mole -- 2 Day(s)

Topic Description
Topics covered: mole, atomic mass, molar mass, and molar conversions.
Textbook chapters and sections: 2.8-2.9, 3.8

Learning Targets

LO 1.1 The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

LO 1.14 The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element.

LO 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes.

LO 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

UNIT: Unit 3: The Periodic Table -- 11 Day(s)

Unit Description
Big Idea 1. This unit will focus on the quantum mechanical model of the atom, orbitals, electron configurations, valence electrons, and periodic trends. This unit lays the groundwork for a deeper understanding of bonding and properties. Textbook chapters and sections: 7.1-7.6, 2.7, 8.1-8.9
Labs: Periodic Trends and Flame Tests
Periodic Trends. Students will complete a series of steps and through observations and qualitative data they will draw conclusions about periodicity involving ionization energy. **Science Practices: 2, 5**
Flame Tests. Students will identify unknown salts by using the light emitted to calculate the associated energy. **Science Practice: 2**

TOPIC: Light and Waves -- 2 Day(s)

Topic Description
Topics covered: nature of light, nature of waves, atomic spectroscopy, Bohr Model, and the Photoelectric Effect.
Textbook chapters and sections: 7.1-7.4

Learning Targets

LO 1.15 The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules.

LO 1.6 The student is able to analyze data relating to electron energies for patterns and relationships.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Quantum Mechanical Atom -- 2 Day(s)

Topic Description
Topics covered: quantum mechanics and orbital shape.
Textbook chapters and sections: 7.5-7.6

Learning Targets

LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.

LO 1.15 The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules.

LO 1.6 The student is able to analyze data relating to electron energies for patterns and relationships.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Electron Configurations and Orbitals -- 2 Day(s)

Topic Description

Topics covered: development of The Periodic Table, electron configurations, orbital diagrams, , unshared electrons, and valence electrons.
Textbook chapters and sections: 2.7, 8.1-8.5

Learning Targets

LO 1.12 The student is able to explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model.

LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.

SP 6 The student can work with scientific explanations and theories.

LO 1.5 The student is able to explain the distribution of electrons in an atom or ion based upon data.

TOPIC: Periodic Trends -- 3 Day(s)

Topic Description
Topics covered: atomic radius, ionization energy, electron affinity, PES, and chemical behavior determination using trends. Textbook chapters and sections: 8.6-8.9

Learning Targets

LO 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.

LO 1.11 The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied.

LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.

LO 1.7 The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's law to construct explanations of how the energies of electrons within shells in atoms vary.

LO 1.8 The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

LO 1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model.

SP 3 The student can engage in scientific questions to extend thinking or to guide investigations within the context of the AP course.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

UNIT: Unit 4: Chemical Formulas -- 7 Day(s)

Unit Description
Big Ideas: 1, 2, and 3. This unit will cover bond types, chemical nomenclature, and balancing chemical equations. *Textbook Chapters and Sections: 3.1-3.7, 3.9-3.11*
Lab: Determination of an Empirical Formula
A weighed sample of copper oxide will be reacted with acid and an excess of zinc will be added to form copper. Students will filter the copper, determine its, mass, and determine its empirical formula. **Science Practices: 2, 5**

TOPIC: Chemical Bonds -- 1 Day(s)

Topic Description
Topics covered: bonds, molecules, and representing bonds.
Textbook chapters and sections: 3.1-3.4

Learning Targets

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

TOPIC: Chemical Nomenclature -- 2 Day(s)

Topic Description
Topics covered: chemical naming
Textbook chapters and sections: 3.5-3.7

Learning Targets

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

TOPIC: Chemical Compounds and Equations -- 2 Day(s)

Topic Description
Topics covered: mass percent, empirical and molecular formulas, balancing and writing basic chemical reactions.
Textbook chapters and sections: 3.9-3.11

Learning Targets

LO 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.

LO 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.

LO 3.6 The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

LO 1.3 The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.

UNIT: Unit 5: Bonding -- 13 Day(s)

Unit Description
Big Ideas 2 and 5. This unit covers models for the different types of bonds, bond polarity, bond energy, VSEPR theory, and intermolecular forces. *Textbook chapters and sections: 9.1-9.11, 10.1-10.8, 11.1-11.4*
Labs: Sticky Question (Guided Inquiry #5) and Intermolecular Forces
Sticky Question. Students will need to separate chemicals from a residue in order to identify the chemicals. The students will develop a process using their knowledge of bonding to separate the various chemicals from the residue. **Science Practices: 4, 5, 6**
Intermolecular Forces. The purpose of this experiment is to study the effects of intermolecular forces on the properties of water

and ethyl alcohol, and to determine the relative strength of these
forces in each compound. Various tests are used to compare the relative properties these two substances. **Science Practices: 1, 3, 6**

Activities: Molecular Polarity Simulation using PHET.

The students will be asked to build different molecules, observe, and explain why some molecules bend some don't, some are polar, some are not, and they will be expected to understand why some molecules are more polar than others (ranking polarity). This activity will aid students in their understanding of bond properties and intermolecular forces. **Science Practices: 1, 3**

TOPIC: Lewis Dot Symbols and Structures -- 3 Day(s)

Topic Description
Topics covered: Lewis Structures, resonance, formal charge, and exceptions.
Textbook chapters and sections: 9.1-9.5, 9.7-9.11

Learning Targets

LO 2.19 The student can create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity).

LO 2.23 The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.24 The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.

LO 2.25 The student is able to compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning.

LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.

LO 2.27 The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.28 The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level.

LO 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

LO 2.20 The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom.

TOPIC: Bond Polarity -- 2 Day(s)

Topic Description
Topics covered: Bond polarity
Textbook chapters and sections: 9.6

Learning Targets

LO 2.17 The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements.

LO 2.18 The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.

LO 5.1 The student is able to create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

LO 2.10 The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components.

TOPIC: VSEPR Theory -- 3 Day(s)

Topic Description
Topics covered: VSEPR Theory
Textbook chapters and sections: 10.1-10.8

Learning Targets

LO 2.21 The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

TOPIC: Intermolecular Forces -- 3 Day(s)

Topic Description
Topics covered: intermolecular forces
Textbook chapters and sections: 11.1-11.4

Learning Targets

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

LO 2.11 The student is able to explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces.

LO 2.12 The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions.

LO 2.13 The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.

LO 2.14 The student is able to apply Coulomb's law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds.

LO 2.15 The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.

LO 2.16 The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces.

LO 2.18 The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.

LO 2.19 The student can create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity).

LO 2.23 The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.24 The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.

LO 2.25 The student is able to compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning.

LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.

LO 2.27 The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.28 The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level.

LO 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.3 The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials.

LO 2.30 The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level.

LO 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance.

LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

LO 5.11 The student is able to identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions.

LO 2.22 The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.

LO 2.7 The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions.

UNIT: Unit 6: Solids, Liquids, Gases -- 13 Day(s)

Unit Description
Big Ideas 2 and 5. The understanding of IM forces will aide in the understanding of how and why matter often behaves the way it does. This will be done by studying solids, liquids, gases, the gas laws, and phase changes. *Textbook chapters and sections: 11.5 -11.13, 5.1-5.10*

Activities: Gas Law Activities
Through a series of demonstrations students will determine the relationships for the various gas laws. They will use their observations to predict various changes and problem solve for other situations. They will be asked to write and draw what is happening at the particle level. **Science Practices: 1, 3, 7**

TOPIC: Phase Changes -- 3 Day(s)

Topic Description
Topics covered: phase changes and water
Textbook chapters and sections: 11.5-11.9

Learning Targets

LO 2.15 The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.

LO 2.16 The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces.

LO 2.3 The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials.

LO 5.10 The student can support the claim about whether a process is a chemical or physical change (or may be classified as both) based on whether the process involves changes in intramolecular versus intermolecular interactions.

LO 5.9 The student is able to make claims and/or predictions regarding relative magnitudes of the forces acting within collections of interacting molecules based on the distribution of electrons within the molecules and the types of intermolecular forces through which the molecules interact.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

LO 5.11 The student is able to identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions.

TOPIC: Crystals -- 2 Day(s)

Topic Description
Topics covered: crystalline solids
Textbook chapters and sections: 11.10-11.14

Learning Targets

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

TOPIC: Basic Gas Laws -- 2 Day(s)

Topic Description
Topics covered: Simple Gas Laws
Textbook chapters and sections: 5.1-5.3

Learning Targets

LO 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample.

LO 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases.

LO 3.1 Students can translate among macroscopic observations of change, chemical equations, and particle views.
SP 2 The student can use mathematics appropriately.

TOPIC: Kinetic Molecular Theory and Movement of Gases -- 1 Day(s)

Topic Description
Topics covered: Kinetic Molecular Theory and the movement of gases
Textbook chapters and sections: 5.8-5.9

Learning Targets

LO 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors.
LO 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample.

TOPIC: Ideal and Real Gases -- 2 Day(s)

Topic Description
Topics covered: Ideal vs. Real Gases
Textbook chapters and sections: 5.4-5.5. 5.10

Learning Targets

LO 2.15 The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects.

LO 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors.

LO 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample.

LO 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Moles of Gases -- 1 Day(s)

Topic Description
Topics covered: partial pressures and molar volumes
Textbook chapters and sections: 5.6-5.7

Learning Targets

LO 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors.

LO 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample.

LO 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.

LO 3.4 The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

UNIT: Unit 7: Chemical Quantities, Solutions, and Reactions -- 12 Day(s)

Unit Description
Big Ideas 1,2,3, and 6. This unit will focus on various types of chemical reactions including the basic types, redox reactions, precipitation reactions, aqueous reactions, and the mathematical side of reactions. Students will also learn more about solutions.
Textbook chapters and sections: 4.1-4.7, 4.9, 12.1-12.4, 12.8
Labs: Determining the Stoichiometry of Chemical Reactions (AP Chemistry Laboratory #9) and/or What Makes Water Hard (Guided Inquiry #3)
Determining the Stoichiometry of Chemical Reactions. Double replacement reactions are generally considered to be irreversible. the formation of insoluble precipitate provides a driving force that makes the reaction proceed in one direction only. The purpose of this laboratory is to find the optimum mole ration for the formation of a precipitate in a double replacement reaction and use this information to predict the chemical formula of the precipitate. **Science Practices: 2, 3, 5**
What Makes Water Hard. The purpose of this advanced inquiry lab is to investigate the suitability of gravimetric analysis for determining the amount of water hardness in the form of calcium carbonate, $CaCO_3$, in various water samples. Six samples, representing a wide range of potential water hardness, from 50 ppm to 500 ppm, will be analyzed by various student groups as part of a cooperative class investigation to determine the accuracy and sensitivity of gravimetric analysis for water hardness testing.The lab begins with an introductory activity to develop skill in the calculations and techniques of gravimetric analysis, in particular, quantitative transfer and vacuum or gravity filtration. The procedure provides a model for guided-inquiry design of the cooperative class investigation described above. Antacid tablets are also provided as an opportunity for further inquiry for the use of gravimetric analysis to determine the amount of calcium in an over-the-counter medication. **Science Practices: 1, 2, 4, 5, 6, 7**

TOPIC: Stoichiometry -- 2 Day(s)

Topic Description
Topics covered: stoichiometry and limiting reactants
Textbook chapters and sections: 4.1-4.3

Learning Targets

LO 1.17 The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings.

LO 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.

LO 3.4 The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

SP 2 The student can use mathematics appropriately.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

LO 3.5 The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

TOPIC: Solution Concentrations -- 2 Day(s)

Topic Description
Topics covered: solution concentration and solution stoichiometry
Textbook chapters and sections: 4.4, 12.5

Learning Targets

LO 2.9 The student is able to create or interpret representations that link the concept of molarity with particle views of solutions.

SP 2 The student can use mathematics appropriately.

TOPIC: Precipitation and Aqueous Reactions -- 3 Day(s)

Topic Description
Topics covered: aqueous solutions, solubility, precipitation reactions
Textbook chapters and sections: 4.5-4.7

Learning Targets

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

LO 3.2 The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances.

LO 1.19 The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution.

TOPIC: Solutions, Solubility, and Colloids -- 2 Day(s)

Topic Description
Topics covered: solution formation and solubility
Textbook chapters and sections: 12.1-12.4, 12.8

Learning Targets

LO 2.8 The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.

LO 6.24 The student can analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations.

TOPIC: Oxidation and Reduction Reactions -- 1 Day(s)

Topic Description
Topics covered: Redox Reactions
Textbook chapter and section: 4.9

Learning Targets

LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.

UNIT: Unit 8: Thermochemistry -- 9 Day(s)

Unit Description
Big Idea 5. This unit deals with the concepts of heat, enthalpy, and energy. *Textbook Chapters and Sections: 6.1-6.10*
Lab: Designing a Handwarmer (Guided Inquiry #12)

In this advanced inquiry lab, students investigate the energy changes accompanying the formations of solutions for common laboratory salts, and then apply the results to design a hand warmer that is reliable, safe, nontoxic, and inexpensive. The students begin by familiarizing themselves with the principles of calorimetry and heat ofsolution calculations. The results provide a model for the guided-inquiry challenge. Students are given a series of solids, along with their costs and individual Material Safety Data Sheets (MSDS). The challenge is to determine the heat of solution for each solid and analyze the cost and safety information to propose a design for the best, all-around hand warmer. **Science Practices: 2, 4, 5, 6**

TOPIC: First Law of Thermodynamics -- 1 Day(s)

Topic Description

Topics covered: thermochemistry, thermal equilibrium, and heat capacity.
Textbook chapters and sections: 6.1-6.4

Learning Targets

LO 5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.

LO 5.5 The student is able to use conservation of energy to relate the magnitudes of the energy changes when two nonreacting substances are mixed or brought into contact with one another.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 2 The student can use mathematics appropriately.

LO 5.2 The student is able to relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell- Boltzmann distribution.

LO 3.11 The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes.

TOPIC: The Heat of Chemical Reactions -- 3 Day(s)

Topic Description
Topics covered: calorimetry and enthalpy
Textbook chapters and sections: 6.5-6.7

Learning Targets

LO 5.4 The student is able to use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow.

LO 5.6 The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $P\Delta V$ work.

LO 5.7 The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure.

LO 5.8 The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 2 The student can use mathematics appropriately.

SP 4 The student can plan and implement data collection strategies in relation to a particular scientific question.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

TOPIC: Reaction Enthalpies and Energy -- 3 Day(s)

Topic Description
Topics covered: enthalpy and Hess's Law
Textbook chapters and sections: 6.8-6.10

Learning Targets

LO 5.6 The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/ vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $P\Delta V$ work.

LO 5.8 The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds.

SP 2 The student can use mathematics appropriately.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

UNIT: Unit 9: Kinetics -- 10 Day(s)

Unit Description
Big Idea 4. This unit is about reaction rates and how they are altered. *Textbook Chapters and Sections:13.1-13.7*
Labs: Kinetics of a Reaction (AP Laboratory #12) and Kinetics of Crystal Violet Fading (Guided Inquiry #11)
Kinetics of a Reaction. If a reaction is too slow it may not be practical, if it is too fast it can be dangerous. The purpose of this experiment is to investigate how the rate of a reaction can be measured and how reaction conditions affect reaction rates. **Science Practices: 1, 2, 5, 6**Crystal Violet Fading. Crystal violet is a common, beautiful purple dye. In strongly basic solutions, the bright color of the dye slowly fades and the solution becomes colorless. The kinetics of this “fading” reaction can be analyzed by measuring the color intensity or absorbance of the solution versus time to determine the rate law. In this advanced inquiry lab, students use spectroscopy and graphical analysis to determine the rate law for the color-fading reaction of crystal violet with sodium hydroxide. Students begin by constructing a calibration curve of absorbance versus concentration for crystal violet. A series of known or standard solutions is prepared from a stock solution of crystal violet and the absorbance of each solution is measured at an optimum wavelength.A Beer'slaw plot of absorbance as a function of concentration may be used to calculate the concentration of an
“unknown” solution of the dye in a rate law experiment. This procedure provides a model for the guided-inquiry portion of the lab, during which students design experiments to determine the order of reaction with respect to both crystal violet and sodium hydroxide. **Science Practices: 4, 5, 6**
Activity: Reaction and Rate Activity
Using a computer simulation students will be asked to adjust variables such as temperature and concentration to guide them in drawing conclusions about reaction rates. **Science Practices: 1, 6, 7**

TOPIC: The Rate Law -- 2 Day(s)

Topic Description
Topics covered: chemical reaction rates, rate law
Textbook chapters and sections: 13.1-13.3

Learning Targets

LO 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.

LO 4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction.

LO 4.4 The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively.

SP 2 The student can use mathematics appropriately.

SP 5 The student can perform data analysis and evaluation of evidence.

TOPIC: Integrated Rate Law -- 2 Day(s)

Topic Description
Topics covered: integrated rate law
Textbook chapters and sections: 13.4

Learning Targets

LO 4.1 The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.

LO 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.

LO 4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction.

LO 4.4 The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively.

SP 2 The student can use mathematics appropriately.

SP 4 The student can plan and implement data collection strategies in relation to a particular scientific question.

SP 5 The student can perform data analysis and evaluation of evidence.

TOPIC: Reaction Rates and Mechanisms -- 3 Day(s)

Topic Description
Topics covered: reaction rates
Textbook chapters and sections: 13.5-13.6

Learning Targets

LO 4.1 The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.

LO 4.5 The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation.

LO 4.6 The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

LO 4.7 The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate.

TOPIC: Catalysis -- 1 Day(s)

Topic Description
Topics covered: catalysts
Textbook chapters and sections: 13.7

Learning Targets

LO 4.8 The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst.

LO 4.9 The student is able to explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

UNIT: Unit 10: Equilibrium -- 8 Day(s)

Unit Description
Big Ideas 5 and 6. This unit covers the ideas surrounding equilibrium and Le Chatelier's Principle. *Textbook Chapters and Sections: 14.1-14.9*
Lab: Applications of LeChatelier's Principle (Guided Inquiry #13)
In this advanced inquiry lab, students investigate six chemical equilibrium systems to analyze patterns and trends in the principles, concepts, and definitions of equilibrium. Students begin with an activity that introduces the properties of a system at equilibrium: the reversible complex-ion reaction between iron(III) nitrate and potassium thiocyanate. Deliberate “stresses,” such as temperature changes and changes in the amounts of reactants and products, are added to the system and students analyze the resulting color changes. This procedure provides a model for guided-inquiry analysis of five additional equilibrium systems. Inquiry activities include a reversible acid−base
indicator reaction, copper and cobalt complex ions, gas−liquid solubility of carbon dioxide, and the solubility of magnesium hydroxide. **Science Practice: 4**
Activity: Reaction Completion and Reversibility
With the use of a reversible reaction computer simulation on PHET students will be able to describe how the motion of reactant molecules (speed and direction) contributes to a reaction happening, predict how changes in temperature, or use of a catalyst will affect the rate of a reaction, use a potential energy graph to identify the activation energy for forward and reverse reactions.
Science Practices: 1, 2, 6

TOPIC: Equilibria -- 2 Day(s)

Topic Description
Topics covered: equilibrium and the equilibrium constant (K)
Textbook chapters and sections: 14.1-14.5

Learning Targets

LO 6.1 The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes.
SP 6 The student can work with scientific explanations and theories.

LO 6.2 The student can, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on *Q* or *K*.

LO 5.17 The student can make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction.

TOPIC: Calculating Equilibrium Constant -- 1 Day(s)

Topic Description
Topics covered: calculating equilibrium constants
Textbook chapters and sections: 14.6

Learning Targets

LO 6.5 The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, *K*.

SP 2 The student can use mathematics appropriately.

TOPIC: Reaction Quotient -- 1 Day(s)

Topic Description
Topics covered: reaction quotient (Q)
Textbook chapters and sections: 14.7

Learning Targets

LO 6.4 The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, *K*, use the tendency of *Q* to approach *K* to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached.

LO 6.6 The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, *K*, use stoichiometric relationships and the law of mass action (*Q* equals *K* at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction.

LO 6.7 The student is able, for a reversible reaction that has a large or small *K*, to determine which chemical species will have very large versus very small concentrations at equilibrium.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Finding Equilibrium Constants -- 1 Day(s)

Topic Description
Topics covered: equilibrium constants
Textbook chapters and sections: 14.8

Learning Targets

LO 6.5 The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, *K*.

LO 6.6 The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, *K*, use stoichiometric relationships and the law of mass action (*Q* equals *K* at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction.

LO 6.7 The student is able, for a reversible reaction that has a large or small *K*, to determine which chemical species will have very large versus very small concentrations at equilibrium.

TOPIC: Le Chatelier's Principle -- 1 Day(s)

Topic Description
Topics covered: Le Chatelier's Principle
Textbook chapters and sections: 14.9

Learning Targets

LO 6.10 The student is able to connect Le Chatelier's principle to the comparison of *Q* to *K* by explaining the effects of the stress on *Q* and *K*.

LO 6.3 The student can connect kinetics to equilibrium by using reasoning about equilibrium, such as Le Chatelier's principle, to infer the relative rates of the forward and reverse reactions.

LO 6.8 The student is able to use Le Chatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium.

LO 6.9 The student is able to use Le Chatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

UNIT: Unit 11: Acids and Bases -- 9 Day(s)

Unit Description

Big Ideas 1,2 and 6. Acid-Base theories and definitions will be covered in this unit. The mathematics of acids and bases will be covered as well. Polyprotic acid calculations (15.9) will not be covered in this unit. *Textbook chapters and sections: 4.8, 15.1-15.10, 15.12*

Lab: Acid Base Titration (Guided Inquiry #14)

In this advanced inquiry lab, students conduct a series of acid–base titrations and determine the concentrations of two unknowns. The lab begins with an introductory activity in which students qualitatively analyze an acid and base using pH paper.This activity provides a model for a guided inquiry experiment, during which students collect quantitative titration data using a buret and pH meter. Each group uses two acids and two bases. One of the acids will have a known molarity and the other will have an unknown molarity. The same applies to the two bases. Students will graph titration curves from the collected data and determine the concentration of each unknown. A variety of acids and bases, strong and weak, are provided for the class to perform different combinations of titrations. **Science Practices: 4, 5, 6Activity: Acid-Base Particulate Computer Simulation on PHET.**

Students will compare macroscopic observations, particulate representations, symbolic representations, and quantitative measurements using PHET.

TOPIC: Acids and Bases -- 2 Day(s)

Topic Description

Topics covered: defining and naming acids and bases, acidic strength and acid dissociation constant
Textbook chapters and sections: 4.8, 15.1-15.4, and 15.7

Learning Targets

LO 6.11 The student can generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium.

LO 6.19 The student can relate the predominant form of a chemical species involving a labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a solution and the p*Ka* associated with the labile proton.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

SP 7 The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

LO 3.7 The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.

LO 1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.

TOPIC: Finding pH and pOH -- 2 Day(s)

Topic Description
Topics covered: pH and pOH calculations
Textbook chapters and sections: 15.5-15.6, and part of 15.7

Learning Targets

LO 6.14 The student can, based on the dependence of *K*w on temperature, reason that neutrality requires [H+] = [OH-] as opposed to requiring pH = 7, including especially the applications to biological systems.

SP 2 The student can use mathematics appropriately.

LO 6.15 The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution.

LO 6.16 The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/ or infer the relative strengths of the weak acids or bases from given equilibrium concentrations.

TOPIC: Properties of Acids and Bases -- 2 Day(s)

Topic Description
Topics covered: properties of acids and bases, pH/pOH calculations, and polyprotic acids
Textbook chapters and sections: 15.8-15.9

Learning Targets

LO 6.15 The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution.

LO 6.16 The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/ or infer the relative strengths of the weak acids or bases from given equilibrium concentrations.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Acidic Strength and Molecular Structure -- 1 Day(s)

Topic Description
Topics covered: bond polarity and acidic strength
Textbook chapters and sections: 15.10

Learning Targets

LO 6.17 The student can, given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with *K* >1) and what species will be present in large concentrations at equilibrium.

SP 6 The student can work with scientific explanations and theories.

LO 2.2 The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium.

UNIT: Unit 12: Aqueous Ionic Equilibrium -- 9 Day(s)

Unit Description
Big Idea 6. This unit covers buffers, titration curves, and solubility equilibria. *Textbook chapters and sections: 16.1-16.7*
Labs: Selecting Indicators for Acid-Base Titrations (AP Laboratory #11) and Buffering Activity of Household Products (Guided Inquiry #15)
Selecting Indicators for Acid-Base Titrations. The students will perform A-B titrations and will select appropriate indictors for the titrations. A weak acid titrated with a strong base and a weak base titrated with a strong acid will be the titrations performed. Students will create titration curves of pH vs. volume to verify their selections. **Science Practices: 2, 5**
Buffering Activity of Household Products. Many household products contain buffering chemicals such as citric acid, sodium carbonate, sodium benzoate, and phosphates or phosphoric acid. The lab begins with an introductory activity to identify the buffering regions in the neutralization of a
polyprotic weak acid. The results provide a model for guided-inquiry design of a procedure to determine the buffering agents in eight different household products, including foods and beverages and over-the-counter drugs. Procedures may include creating titration curves, calculating pKa
values, and analyzing the buffer capacity and composition. **Science Practices: 4, 5, 6**

TOPIC: Buffers -- 2 Day(s)

Topic Description
Topics covered: buffers and pH
Textbook chapters and sections: 16.1-16.3

Learning Targets

LO 6.15 The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution.

LO 6.18 The student can design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity.

LO 6.20 The student can identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Titrations and pH Curves -- 2 Day(s)

Topic Description
Topics covered: titrations and pH curves
Textbook chapter and section: 16.4

Learning Targets

LO 6.11 The student can generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium.

LO 6.12 The student can reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration.

LO 6.13 The student can interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the p*Ka* for a weak acid, or the p*Kb* for a weak base.

LO 6.15 The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution.

LO 6.20 The student can identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base.

SP 1 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP 5 The student can perform data analysis and evaluation of evidence.

LO 1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.

TOPIC: Solubility and Precipitation -- 2 Day(s)

Topic Description
Topics covered: solubility, ICE tables, precipitation
Textbook chapter and sections: 16.5-16.6

Learning Targets

LO 6.21 The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant *Ksp* values.

LO 6.22 The student can interpret data regarding solubility of salts to determine, or rank, the relevant *Ksp* values.

LO 6.23 The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility.

SP 2 The student can use mathematics appropriately.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Qualitative Analysis -- 1 Day(s)

Topic Description
Topics covered: qualitative analysis and defining complex ions
Textbook chapter and sections: 16.7-16.8

Learning Targets

LO 6.21 The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant *Ksp* values.

LO 6.22 The student can interpret data regarding solubility of salts to determine, or rank, the relevant *Ksp* values.

LO 6.23 The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

UNIT: Unit 13: Thermodynamics -- 9 Day(s)

Unit Description
Big Ideas: 5 and 6. This unit continues with the thermodynamics laws, free energy, and energy diagrams. *Textbook Chapters and Sections: 17.1-17.9*
Lab: Enthalpy and Hess's Law
In this experiment, students verify Hess's Law. Three acid-base reactions, chosen so that the third reaction equation equals the first reaction minus the second, are measured for temperature change by calorimetry. The values of heat change and enthalpy of reaction are calculated for each of the three reactions. The reaction results are then compared to verify Hess's Law. Students gain

valuable experience with the process of calorimetric determinations. **Science Practices: 2, 3, 5, 7**

TOPIC: Spontaneous vs. Nonspontaneous -- 1 Day(s)

Topic Description
Topics covered: review 1st law of thermodyanmics and intro to 2nd law of thermodynamics
Textbook chapters and sections: 17.1-17.2

Learning Targets

LO 5.18 The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions.

TOPIC: 2nd Law of Thermodynamics -- 2 Day(s)

Topic Description
Topics covered: entropy and 2nd law of thermodynamics
Textbook chapters and sections: 17.3-17.4

Learning Targets

LO 5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes.

LO 5.13 The student is able to predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed.

TOPIC: Energy and its Changes -- 2 Day(s)

Topic Description
Topics covered: Gibbs free energy and entropy changes
Textbook chapters and sections: 17.5-17.6

Learning Targets

LO 5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes.

LO 5.14 The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy.

LO 5.18 The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions.

TOPIC: Free Energy Changes -- 2 Day(s)

Topic Description
Topics covered: free energy changes for various states.
Textbook chapters and sections: 17.7-17.9

Learning Targets

LO 5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes.

LO 5.16 The student can use Le Chatelier's principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product.

LO 5.18 The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions.
SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

LO 6.25 The student is able to express the equilibrium constant in terms of $\Delta G°$ and RT and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process.

UNIT: Unit 14: Electrochemistry -- 8 Day(s)

Unit Description
Big Ideas 3 and 5. This unit will cover in greater detail some of the ideas learned with regards to oxidation and reduction, Gibbs free energy and equilibrium will resurface during this unit. *Textbook chapters and sections: 18.1-18.6, 18.8-18.9*
Lab: Measurements Using Electrochemical Cells and Eelctroplating (AP Laboratory # 20)
Students study a series of metals and nonmetals to determine their relative reactivity, then rank them according to their reactivity in an activity series. First, the reactivity of the metals are determined by reacting a series of metals with metal salt solutions. Second, the reactivity of the halogens are determined by reacting each of the halogens with a halide solution. Based on the observed reactivity in each case, students develop a separate activity series for the metals and the halogens. Students understand why some metals can "replace" other metals, and why some redox reactions are spontaneous while others require a battery. Students also learn that the reactivity for the halogens is opposite that for the other families in the periodic table. **Science Practices: 1, 2, 3, 5, 6**

TOPIC: Redox Revisited -- 1 Day(s)

Topic Description
Topics covered: balancing using the half-reaction method, corrosion
Textbook chapters and sections: 18.1-18.2, 18.9

Learning Targets

LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.
SP 6 The student can work with scientific explanations and theories.

LO 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration.

TOPIC: Chemical Reactions and Electricity -- 2 Day(s)

Topic Description
Topics covered: voltaic and galvanic cells, half-cell reactions, salt bridges, cell notation, and electrochemical cells.
Textbook chapters and sections: 18.3

Learning Targets

LO 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/ or Faraday's laws.

LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.
SP 2 The student can use mathematics appropriately.
SP 6 The student can work with scientific explanations and theories.

TOPIC: Cell Potentials -- 2 Day(s)

Topic Description
Topics covered: electrode potentials and cell potentials
Textbook chapters and sections: 18.4-18.6

Learning Targets

LO 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/ or Faraday's laws.

LO 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.

SP 2 The student can use mathematics appropriately.

SP 5 The student can perform data analysis and evaluation of evidence.

SP 6 The student can work with scientific explanations and theories.

TOPIC: Electroloysis -- 1 Day(s)

Topic Description
Topics covered: electrolysis and rust
Textbook chapters and sections: 18.8, 18.9

Learning Targets

LO 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/ or Faraday's laws.

LO 5.15 The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable.

SP 2 The student can use mathematics appropriately.

SP 6 The student can work with scientific explanations and theories.

UNIT: Unit 15: Final Unit -- Ongoing

Unit Description
This unit will include the time needed for review before the AP test.
After the AP test topics will be covered that were not a part of the AP curriculum. The amount of time available will determine how many topics are covered. Possible topics include nuclear chemistry, organic chemistry, and biochemistry.