Syllabus

Advanced Chemistry - Semester A

Course Overview

The Advanced Chemistry course is designed around the AP Chemistry Curriculum Framework established by the College Board. The course is presented through the lens of scientific inquiry—the process of channeling human curiosity into purposeful exploration, discovery, and application of observable natural phenomena. In this course, students will grow to understand their physical world in a deep way. At the same time, an inquiry and STEM-oriented approach to chemistry offers students a shared method of asking questions about the world around them. Their experience and knowledge from this course—tied to a strong emphasis on qualitative and quantitative analysis and communication—is designed to enable them to understand important scientific and societal problems and to creatively grapple with such problems.
In this blended online course (employing both online and face-to-face learning), students will be taught and encouraged to continually pose questions about the subject matter. Through exploration and discovery of the phenomenon at the core of each lesson, students will be guided to answer their own questions and will be able to discuss the phenomenon in ways that reflect sound scientific practices.

In particular, students will explore the six content areas that have been identified as the focus of the AP Chemistry course:

- **Atoms and Elements**—composition of matter, conservation of matter, atomic structure, spectroscopy, periodicity, and Coulomb's Law
- **Properties of Matter**—states of matter, physical properties, gas behavior, kinetic molecular theory, solutions, intermolecular and intramolecular interactions, the Lewis structure model, and the VSEPR model
- **Chemical Reactions**—chemical equations, types of chemical reactions, endo- and exothermicity, and electrochemistry
- **Kinetics**—rate laws, reaction mechanisms, activation energy, and factors affecting reaction rates
- **Thermodynamics**—energy transfer, conservation of energy, enthalpy, calorimetry, potential energy and geometric arrangement of atoms, and entropy
- **Equilibrium**—reversible reactions, reaction quotients, Le Chatelier's principle, acid-base chemistry, solubility, and Gibbs free energy

Instructional Resources

Textbook:

Zumdahl, Steven S., and Susan A. Zumdahl. *Chemistry: APEdition*, 8th ed. Brooks/Cole: Belmont, CA, 2010.

Lab manuals:

AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices.

Teacher Edition. New York: The College Board, 2013.

Zumdahl, Steven S., and Susan A. Zumdahl. *AP Experimental Chemistry*, 8th ed. Brooks/Cole: Belmont, CA, 2010.

Online instruction:

Online lessons will provide instructional content that approximates the classroom experience for this content but will not be comprehensive on its own. In addition, in some instances, published articles available online may be referenced for instructional purposes.

Teaching Strategies

Structure

This blended online course is organized around the AP Chemistry Curriculum Framework's six Big Ideas, as well as the enduring understandings within the Big Ideas, and the essential knowledge within the enduring understandings. At least one Big Idea will unify each unit, and each lesson will incorporate multiple learning activities designed to develop, apply, and assess specific learning objectives. Application and inquiry requiring higher-level cognitive work will be an integrated part of the lessons. Students will submit written work online for review, comment, and grading.

Concept Development Activities

- **Lesson Tutorials –** Each instructional module or lesson includes an instructional tutorial with direct instruction and practice interactions. Instruction engages learners through the use of videos, animations, interactive timelines, and click-to-see graphics. Practice interactions include drag-and-drops, ordered problem solvers, multiple-choice questions, and fill-in-the-blank questions that all help students check their progress at mastering new concepts. Some tutorials also

include Web links to informational sites, games, and videos, which broaden students' access to information on the topic.

- **Lesson Activities –** An inquiry-oriented lesson activity is also included in almost all of the instructional modules or lessons. Lesson activities ask students to explore, develop, and analyze specific concepts and their applications. Typically, these activities are online laboratory investigations that serve to provide additional inquiry experience beyond the required hands-on laboratories in the course. Lesson activities make extensive use of online simulations, which student can manipulate, and then make observations, gather data, analyze results, and make generalizations. Other lesson activities employ additional online resources for investigation, such as online chemical databases and online repositories of 3D molecules.

- **Discussions –** Discussions encourage interaction with instructors and other students, which is a key 21st century skill and learning method. An online threaded discussion mirrors the educational experience of a classroom discussion. Instructors can initiate a discussion by asking a complex, open-ended question. Students can engage in the discussion by responding to the question and to the thoughts of others. Discussions encourage students to participate more actively in learning. Discussions prompt student research that promotes connection of students' knowledge of chemical and scientific concepts to societal issues, ethical concerns, and technological advances.

- **Unit Activities –** Unit activities give students the opportunity to demonstrate higher-order thinking skills as the students apply and integrate Big Idea concepts across lessons within a course unit. Unit activities supply a document for offline use by students to record results.

Advanced Placement Chemistry Content

The Big Ideas

Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.

Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

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

Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.

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

Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Units of Instruction: Advanced Chemistry – Semester A

Unit 1 – Matter and Atomic Structure (2 Weeks, 4 Lessons)

Big Ideas: 1, 2, 3
Connected to these enduring understandings:

1.B: The atoms of each element have unique structures arising from interactions between electrons and nuclei.

1.C: Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.

1.D: Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.

2.A: Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.

3.A: Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.

3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 1, 2, 3, 10, 11

Unit 1 Instructional Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. Types of Matter (LO 2.3, 2.10; SP 1, 4, 5, 6, 7)
2. Physical Changes Versus Chemical Changes (LO 3.10; SP 7)
3. Models of the Atom (LO 1.6, 1.12, 1.13; SP 1, 6, 7)
4. Isotopes and Atomic Mass (SP 2, 5, 6)

Unit 1 Additional Online Activities:

1. Discussion – Matter and Atomic Structure
2. Unit Activity – Matter and Atomic Structure: Students review Earnest Rutherford's contribution to our understanding of atomic structure. Students also simulate Rutherford's experiments and observe the angles of deviation in the path of alpha particles in relation to their distance from an atomic nucleus. Connects EU 1.B to BI 1 (LO 1.13; SP 1.4)

Unit 1 Lab Investigations: Big Idea 3

1. Guided Inquiry – AP Chemistry Lab Investigation 9: Can the Individual Components of Quick Ache Relief Be Used to Resolve Consumer Complaints? (EU 3.C) (LO 3.10)(SP 1, 4, 6)

Unit 2 – The Periodic Table (3 Weeks, 5 Lessons)

Big Idea: 1
Connected to these enduring understandings:

1.B: The atoms of each element have unique structures arising from interactions between electrons and nuclei.

1.C: Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.

1.D: Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 2, 7

Unit 2 Instruction Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. The Periodic Table (LO 1.6, 1.9, 1.10; SP 1, 4, 5)
2. Electron Configurations (LO 1.5, 1.6, 1.9; SP 1, 5, 6, 7)
3. Periodic Trends (LO 1.9, 1.10; SP 5, 6, 7)
4. Electromagnetic Radiation (SP 1, 2, 5)
5. Spectral Lines (LO 1.6; SP 1, 2, 4, 6, 7)

Unit 2 Additional Online Activities:

1. Discussion – The Periodic Table (LO 1.9, LO 1.10; SP 3, 4)
2. Unit Activity – The Periodic Table: Students will research the history of the periodic table and practice using the properties of known and unknown elements to place the elements in the correct position in the periodic table. Students then write electron configurations of the elements and rank the elements according to electronegativity and ionization energy. Connects EU 1.C to BI 1. (LO 1.7, 1.9, 1.10; SP 1, 4, 5)

Unit 2 Lab Investigations: Big Idea 1

1. *Guided Inquiry* – AP Chemistry Lab Investigation 1: What is the Relationship Between the Concentration of a Solution and the Amount of Transmitted Light Through the Solution? (EU 1.D) (LO 1.15, 1.16) (SP 2, 4, 5, 6)
2. Zumdahl Experiment 10: Chemistry of the Halogens (EU 1.C) (LO 1.9, 1.10) (SP 4, 5, 6)

Unit 3 – Bonding (4 Weeks, 8 Lessons)

Big Ideas: 1, 2
Connected to these enduring understandings:

2.A: Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.

2.B: 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: The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.

2.D: The type of bonding in the solid state can be deduced from the properties of the solid state.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 2, 8, 10

Unit 3 Instruction Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. Ionic, Covalent, and Metallic Bonds (LO 2.19, 2.20, 2.24, 2.28; SP 1, 7)
2. Compound Names (SP 5)
3. Lewis Structures (LO 2.21; SP 1, 5, 6, 7)
4. Electronegativity (LO 2.17; SP 1, 4, 5, 6)
5. Three-Dimensional Molecules (LO 2.17; SP 1, 6)
6. Molecular Polarity (LO 2.21; SP 1, 5, 6)
7. Intermolecular Forces (LO 2.13; SP 1, 4, 5, 6, 7)

Unit 3 Additional Online Activities:

1. Discussion – Bonding (LO 2.8; SP 4, 6)
2. Unit Activity – Bonding: Students will research the concept of global warming, learn which chemical species are involved, and understand the phenomenon on a molecular level. Students will also observe and compare simulations of molecular vibrational modes and then formulate an explanation of why diatomic species in the air are not greenhouse gases, while molecules made up of three or more atoms are. Connects EU 1.D (EK 1.D.3) to BI 2. (LO 1.15; SP 1, 4, 5, 6, 7)

Unit 3 Lab Investigations: Big Idea 2

1. *Guided Inquiry* – AP Chemistry Lab Investigation 6: What's in That Bottle? (EU 2.D) (LO 2.22, 2.24, 2.28, 2.32) (SP 1, 4, 6, 7)
2. Zumdahl Experiment 13: Molecular Geometry and VSEPR (EU 2.C) (LO 2.21) (SP 1, 6, 7)
3. *Guided Inquiry* – AP Chemistry Lab Investigation 5: Sticky Question: How Do You Separate Molecules That Are Attracted to One Another? (EU 2A, 2B) (LO 2.10, 2.13) (SP 1, 4, 5, 6)

Unit 4 – The Mole Concept (3 Weeks, 4 Lessons)

Big Idea: 1
Connected to these enduring understandings:

1.A: All matter is made of atoms. There are a limited number of types of atoms; these are the elements.

1.D: Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapter 3

Unit 4 Instruction Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. Moles and Molar Mass (LO 1.4; SP 2)
2. Mole Calculations (LO 1.4; SP 2)
3. Percent Composition (LO 1.1, 1.2, 1.4; SP 2)
4. Empirical and Molecular Formulas (LO 1.2; SP 2)

Unit 4 Additional Online Activities:

1. Discussion – The Mole Concept (LO 1.4; SP 4, 6)
2. Unit Activity – The Mole Concept: Students will research the history of Avogadro's number and the mole and then use the mole concept to solve for the percent composition, empirical formula, and molecular formula of an unknown compound. Using this information and an online chemical database, students determine the name of the compound, its characteristics, and its common uses. Connects EU 1.A to BI 1. (LO 1.1, 1.2, 1.4; SP 2, 3, 4, 5, 6)

Unit 4 Lab Investigations: Big Ideas 1 and 3

1. *Guided Inquiry* – AP Chemistry Lab Investigation 2: How Can Color Be Used to Determine the Mass Percent of Copper in Brass? (EU 1.D, 3.A) (LO 1.16, 3.4) (SP 1, 2, 4, 6)
2. Zumdahl Experiment 29: Synthesis and Analysis of an Iron Compound (EU 1.A, 1.D) (LO 1.2, 1.16) (SP 2, 4, 5)

Unit 5 – Chemical Reactions (3 Weeks, 6 Lessons)

Big Ideas: 1, 3
Connected to these enduring understandings:

1.E: Atoms are conserved in physical and chemical processes.

3.A: Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.

3.B: Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 3, 4

Unit 5 Instruction Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. Balancing Chemical Equations (LO 3.2; SP 1, 5)
2. Types of Reactions (LO 3.8; SP 5, 7)
3. Predicting Chemical Products (LO 3.2; SP 1, 6)
4. Mole Ratios and Stoichiometry (LO 1.4, 3.2, 3.4, 3.6; SP 1, 2, 6, 7)
5. Mass and Volume Stoichiometry (LO 1.4, 3.3, 3.4; SP 2, 6)
6. Percent Yield (LO 3.3, 3.4; SP 2)

Unit 5 Additional Online Activities:

1. Discussion – Chemical Reactions (LO 1.4, 1.17, 2.14; SP 2, 4)
2. Unit Activity – Chemical Reactions: Students will investigate the chemistry of fireworks; they will identify different types of chemicals used in fireworks, the role each type of chemical plays, and the types of reactions that take place. Then students will perform limiting reagent and percent yield calculations for hypothetical chemical reactions in fireworks. Connects EU 3.A and 3.B to BI 3. (LO 1.4, 1.17, 3.3, 3.4; SP 1, 2, 4, 5, 7)

Unit 5 Lab Investigations: Big Idea 3

1. Zumdahl Experiment 3: Gravimetric Analysis of a Sulfate Mixture (EU 1.E, 3.A) (LO 1.19, 3.4) (SP 2, 4, 5, 6)
2. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 7: Using the Principle that Each Substance Has Unique Properties to Purify a Mixture: An Experiment Applying Green Chemistry to Purification (EU 3.A, 3.B) (LO 3.3, 3.5) (SP 2, 4, 5, 6)

Unit 6 – Kinetic Molecular Theory and Gas Laws (3 Weeks, 8 Lessons)

Big Ideas: 2, 5
Connected to these enduring understandings:

2.A: Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them.

5.A: Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat.

5.B: Energy is neither created nor destroyed, but only transformed from one form to another.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 5, 10

Unit 6 Instruction Modules / Lessons (Tutorial, Lesson Activity, Mastery Test):

1. Energy and Chemical Reactions (LO 5.1; SP 1, 4, 5, 6, 7)
2. Endothermic and Exothermic Reactions (LO 3.11, 5.6; SP 5,7)
3. Kinetic Theory (LO 2.4, 5.2; SP 1, 6)
4. States of Matter (LO 2.3, 5.2; SP 1, 5)
5. Heating Curves and Phase Changes (LO 2.3, 5.2; SP 1, 5)
6. Gas Law Calculations (LO 2.4, 2.5, 2.6; SP 2, 3, 6, 7)
7. Ideal Gas Law (LO 2.4, 2.6; SP 1, 2, 5)
8. Dalton's Law and Graham's Law (LO 2.4, 2.6; SP 1, 2, 5)

Unit 6 Additional Online Activities:

1. Discussion – Kinetic Molecular Theory and Gas Laws (SP 1, 2, 6)
2. Unit Activity – Kinetic Molecular Theory and Gas Laws: Students will research the structure of Earth's atmosphere and relate the weather-causing changes in the troposphere to Kinetic Molecular Theory. Students simulate the greenhouse effect and observe the interaction between photons of infrared light and greenhouse materials. Connects EU 2.A and 5.A to BI 5. (LO 2.4, 2.5, 5.2; SP 1, 5)

Unit 6 Lab Investigations: Big Idea 2

1. Zumdahl Experiment 7: Molar Mass by Vapor Density (EU 2.A) (LO 1.4, 2.6) (SP 2, 7)

Lab Components

Purpose

The lab activities for science subjects provide learners with hands-on exposure to the scientific concepts they are studying and exploring. Science instruction is as much about learning how to do science as it is about developing a conceptual understanding. Labs bring those two elements together.

Labs and Inquiry in a Blended Learning Environment

This course employs a blended learning model, mixing online learning with face-to-face interaction, focusing especially on the laboratory experience. A great many inquiry-based lesson activities are provided in this course using online simulations, models, tools, and data sets. The recommended hands-on experiments for chemistry, however, act as the backbone for this advanced course in chemistry, designed to be conducted in person with the planning and guidance of the teacher.

Regular hands-on laboratory experience with professional direction and guidance is crucial for a rigorous college-level course. A minimum of 25 percent of instructional time will be devoted to completion of the specified laboratory activities.

Students will engage in 23 laboratory experiments that will allow them to demonstrate proficiency with the scientific practices and learning objectives laid out in the AP Chemistry Curriculum Framework. Fourteen of the labs will be guided-inquiry experiments.

Students are required to complete lab reports for all laboratory activities. These reports are teacher-graded, and students are required to maintain a portfolio of their graded lab reports. Each lab report should contain the following components: purpose, procedure, observations/data, calculations and analysis, and conclusion.

Student Evaluation

Multiple evaluation tools will be used to assess understanding at all appropriate cognitive levels:

- **Unit Discussions:** Each unit will have an online discussion topic that draws from the knowledge students have gained in the unit and challenges them to apply it in a novel situation and discuss it with their peers. Each discussion is teacher-graded based on a rubric.

- **Self-Assessment Lesson Activities:** Especially useful in constructivist/inquiry lessons, self-assessment activities will provide sample responses against which learners can assess their own learning.
- **Lesson-Level Mastery Tests:** Each lesson will be accompanied by a multiple-choice mastery test to assess mastery of the basic lesson concepts.
- **Laboratory Activities:** All hands-on laboratory activities and reports will be teacher-scored.
- **Unit-Level Posttests:** Each unit will have a multiple-choice assessment to confirm that all the material within the unit has been retained and can be applied in a larger context than a single-lesson format.
- **Unit-Level Activities:** Learners will have the chance to apply their knowledge of the concepts that cut across the lessons within a unit. All units will include this teacher-graded activity for evaluation of higher-order thinking skills.
- **End-of-Semester Tests:** At the end of each of the two semesters, learners will take a multiple-choice test to assess mastery of lesson concepts and to practice for a long-form exam.