Syllabus

Advanced Chemistry - Semester B

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 B

Unit 1 – Solutions (2 Weeks, 6 Lessons)

Big Idea: 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.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 4, 11

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

1. The Dissolving Process (LO 2.8, 2.13, 2.15; SP 6, 7)
2. Rate of Dissolution (SP 1, 6, 7)
3. Degrees of Saturation (LO 2.14; SP 1, 5, 6, 7)
4. Expressing Concentration (SP 2)
5. Dilution and Stoichiometry Calculations (LO 3.4; SP 2)

6. Colligative Properties of a Solution (SP 4)

Unit 1 Additional Online Activities:

1. Discussion – Solutions
2. Unit Activity – Solutions: Students will use the concepts of solubility and factors affecting solubility to design a manufacturing process for making tomato soup. Students write chemical reactions to describe and compare the processes that take place during the dissolution of an ionic compound and a covalent compound. Students also perform concentration calculations and predict how different concentrations of a solute compare in terms of protecting the soup from freezing. Connects EU 2.A and EK 2.A.3 to BI 2. (LO 2.14, 3.4; SP 2, 3, 4, 5, 6)

Unit 1 Lab Investigations: Big Ideas 1, 2, and 3

1. *Guided Inquiry* - College Board AP Chemistry Lab Investigation 3: What Makes Hard Water Hard? (EU 2.A, 3.A)(LO 1.9, 2.10, 2.14, 2.15, 3.2, 3.3) (SP 1, 2, 4, 5, 6, 7)
2. Zumdahl Experiment 4: The Concentration of Acetic Acid in Vinegar (EU 3.A) (LO 1.4, 1.17, 1.20, 3.4) (SP 4, 5, 6)

Unit 2 – Reaction Rates (3.5 Weeks, 6 Lessons)

Big Idea: 4
Connected to these enduring understandings:

4.A: Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time.

4.B: Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products.

4.C: Many reactions proceed via a series of elementary reactions.

4.D: Reaction rates may be increased by the presence of a catalyst.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapter 12

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

1. Reaction Rates (LO 4.1; SP 2, 3, 4, 5)

2. Activation Energy (LO 4.5, 4.6, 4.8; SP 1, 5, 7)

3. Rate Law for a Reaction (LO 4.1, 4.2, 4.3; SP 2, 5, 6)

4. Integrated Rate Equations (LO 4.2, 4.3; SP 2, 5, 6, 7)
5. Reaction Mechanisms and Rate Law (SP 6)
6. Factors Affecting Rate Constants (LO 4.1, 4.4; SP 2, 5)

Unit 2 Additional Online Activities

1. Discussion – Reaction Rates (LO 4.9; SP 7)
2. Unit Activity – Reaction Rates: Students will research the chemistry of the ozone layer, comparing characteristics of ozone to those of diatomic oxygen. Students write the rate law equation for the formation of ozone in the atmosphere and perform calculations using the equation. Students identify the rate-determining step and the overall mechanism for the formation of nitrogen oxide and for the reaction between chlorine atoms and ozone molecules. Connects EUs 4.B, 4.C, and 4.D to BI 4. (LO 4.1, 4.7; SP 2, 3, 5, 6, 7)

Unit 2 Lab Investigations: Big Idea 4

1. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 10: How Long Will That Marble Statue Last? (EU 4.A) (LO 4.1, 4.2) (SP 3, 4, 5, 6, 7)
2. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 11: What is the Rate Law of the Fading of Crystal Violet Using Beer's Law? (EU 4.A) (LO 1.16, 4.1, 4.2) (SP 1, 2, 4, 5, 6)

Unit 3 – Chemical Equilibrium (3 Weeks, 5 Lessons)

Big Idea: 6
Connected to these enduring understandings:

6.A: Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.

6.B: Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system.

6.C: Chemical equilibrium plays an important role in acid-base chemistry and in solubility.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 13, 16

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

1. Chemical Equilibrium (LO 6.1; SP 1, 3, 4, 5, 6)
2. Equilibrium Constants (LO 6.5. 6.6; SP 2, 5)

3. Reaction Quotient (LO 6.4, 6.6; SP 2, 5)
4. Le Chatelier's Principle (LO 6.8; SP 4, 5, 6)
5. Solubility Equilibrium (LO 6.22; SP 2)

Unit 3 Additional Online Activities:

1. Discussion – Chemical Equilibrium
2. Unit Activity – Chemical Equilibrium: Students will perform virtual solubility experiments using the compound silver bromide. Students write a solubility expression and perform solubility calculations for the substance. They form hypotheses about how the concentration of silver ions compares in two saturated solutions with different concentrations of silver bromide. Students then test the hypotheses through additional simulations. Connects EUs 6.A and 6.B to BI 6. (LO 6.1, 6.3, 6.7, 6.8; SP 1, 2, 3, 4, 5, 6)

Unit 3 Lab Investigations: Big Idea 6

1. Zumdahl Experiment 25: Determination of an Equilibrium Constant (EU 6.A) (LO 6.3, 6.5) (SP 2, 4, 5)
2. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 13: Can We Make the Colors of the Rainbow? An Application of Le Chatelier's Principle (EU 6.A, 6.B) (LO 6.9) (SP 4, 5, 6)

Unit 4 – Acids and Bases (4 Weeks, 9 Lessons)

Big Idea: 6
Connected to these enduring understandings:

6:A: Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.

6.B: Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system.

6.C: Chemical equilibrium plays an important role in acid-base chemistry and in solubility.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 4, 14, 15

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

1. Properties of Acid and Bases (SP 3, 4, 6)
2. Types of Acids and Bases (LO 3.7; SP 1, 6)

3. The pH Scale (LO 6.11, 6.12; SP 1, 2, 4, 5, 6)
4. Strong and Weak Acids and Bases (LO 6.11, 6.12, 6.16; SP 1, 2, 5)
5. Equilibrium for Weak Acids and Bases (LO 6.14, 6.19; SP 2)
6. Buffer Solutions and the Common Ion Effect (LO 6.20; SP 1, 5, 6)
7. Hydrolysis Equilibriums (LO 6.17; SP 1, 3)
8. Neutralization Reactions (SP 5, 6)
9. Titration Calculations (LO 6.13; SP 1, 2, 4)

Unit 4 Additional Online Activities:

1. Discussion – Acids and Bases
2. Unit Activity – Acids and Bases: Students research acid-base chemistry of real-world applications and give chemical equations for specific examples, such as acid rain formation, soil alkalization, soil acidification, moss removal, and neutralization of acids or bases with sodium bicarbonate. Connects EUs 6.A, 6.B, and 6.C to BI 3 and 6. (SP 4, 7)

Unit 4 Lab Investigations: Big Ideas 1, 3, and 6

1. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 14: How Do the Structure and the Initial Concentration of an Acid and a Base Influence the pH of the Resultant Solution During a Titration? (EU 1.E, 3.A) (LO 1.18, 1.20, 6.11, 6.12, 6.13) (SP 1, 2, 3, 4, 5, 6, 7)
2. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 16: The Preparation and Testing of an Effective Buffer: How Do Components Influence a Buffer's pH and Capacity? (EU 1.A, 6.B, 6.C) (LO 1.4, 6.18) (SP 1, 2, 4, 5, 6, 7)

Unit 5 – Energy (2.5 Weeks, 5 Lessons)

Big Ideas: 4, 5
Connected to these enduring understandings:

4.B: Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products.

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

5.C: Breaking bonds requires energy, and making bonds releases energy.

5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.

Chapters: Zumdahl, *Chemistry*, 8th ed. Chapters 6, 17

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

1. Entropy (LO 5.12; SP 1, 2)
2. Thermochemical Calculations (LO 5.6, 5.7; SP 2)
3. Energy Diagrams for Reactions (LO 4.5, 4.6, 4.8; SP 1, 6)
4. Hess's Law (LO 5.6, 5.8; SP 2)
5. The Gibbs Free Energy Equation (LO 5.14; SP 2)

Unit 5 Additional Online Activities:

1. Discussion – Energy (SP 7)
2. Unit Activity – Energy: Students will explore allotropes of carbon and calculate the entropy and enthalpy of formation of graphite and diamond. They will draw an energy diagram for the conversion of graphite to diamond and show whether the reaction is endothermic or exothermic. Students will calculate the Gibbs free energy of the reaction and thereby show whether or not the reaction is thermodynamically favored. Connects EUs 4.B and 5.E to BI 5. (LO 4.5, 4.6, 5.8, 5.12, 5.13, 5.14; SP 2, 5, 7)

Unit 5 Lab Investigations: Big Idea 5

1. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 12: The Hand Warmer Design Challenge: Where Does the Heat Come From? (EU 5.B, 5.C, 5.E) (LO 5.6, 5.7) (SP 1, 2, 4, 5, 6, 7)
2. Zumdahl Experiment 8: Heats of Reaction and Hess's Law (EU 5.C) (LO 5.7, 5.8) (SP 2, 5, 6)

Unit 6 – Oxidation-Reduction Reactions (3 Weeks, 6 Lessons)

Big Idea: 3
Connected to enduring understandings:

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.

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 4, 18

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

1. Oxidation and Reduction (LO 3.8; SP 5, 6, 7)
2. Redox Reactions (LO 3.8; SP 2)
3. Standard Reduction Potentials (LO 3.12, 3.13; SP 1, 2, 6)
4. Voltaic and Electrochemical Cells (LO 3.12, 3.13; SP 1, 6, 7)
5. Standard Cell Potentials (LO 3.12; SP 2)
6. Nonstandard Cells (LO 3.12; SP 1, 2, 5)

Unit 6 Additional Online Activities:

1. Discussion – Oxidation Reduction Reactions (LO 3.8; SP 7)
2. Unit Activity – Oxidation-Reduction Reactions: Students will research current progress related to development of more efficient batteries and fuel cells. Students will then perform calculations for systems relevant to these technologies. Specifically, students will calculate the standard reduction potential, the overall cell potential, the Gibbs free energy change, and K for both a lithium ion battery and a hydrogen fuel cell. Students then analyze their calculations and use their results to compose a summary that describes the advantages and disadvantages of the two energy technologies. Connects EUs 3.B and 3.C to BI 3. (LO 3.12, 3.13; SP 2, 5, 6, 7)

Unit 6 Lab Investigations: Big Idea 3

1. *Guided Inquiry* – College Board AP Chemistry Lab Investigation 8: How Can We Determine the Actual Percentage of H_2O_2 in a Drugstore Bottle of Hydrogen Peroxide? (EU 3.B) (LO 1.20, 3.3, 3.9) (SP 2, 4, 6)
2. Zumdahl Experiment 27: Electrochemical Cells (EU 3.C) (LO 3.12, 3.13) (SP 2, 5, 6)

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.