AP Chemistry Syllabus

Curricular Requirements	Page(s)
CR1 Students and teachers use a recently published (within the last 10 years) college-level chemistry textbook.	2
CR2 The course is structured around the enduring understandings within the big ideas as described in the AP Chemistry Curriculum Framework.	2
CR3a The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 1: Structure of matter.	2 - 7
CR3b The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 2: Properties of matter-characteristics, states, and forces of attraction.	5, 6
CR3c The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 3: Chemical reactions.	2 - 7
CR3d The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 4: Rates of chemical reactions.	5, 7
CR3e The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 5: Thermodynamics.	6, 7
CR3f The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 6: Equilibrium.	6
CR4 The course provides students with the opportunity to connect their knowledge of chemistry and science to major societal or technological components (e.g., concerns, technological advances, innovations) to help them become scientifically literate citizens.	5
CR5a Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time.	2
CR5b Students are provided the opportunity to engage in a minimum of 16 hands-on laboratory experiments integrated throughout the course while using basic laboratory equipment to support the learning objectives listed within the AP Chemistry Curriculum Framework.	2 - 7
CR6 The laboratory investigations used throughout the course allow students to apply the seven science practices defined in the AP Chemistry Curriculum Framework. At minimum, six of the required 16 labs are conducted in a guided-inquiry format.	2 - 7
CR7 The course provides opportunities for students to develop, record, and maintain evidence of their verbal, written, and graphic communication skills through laboratory reports, summaries of literature or scientific investigations, and oral, written, and graphic presentations.	2

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 dynamic competition, sensitive to initial conditions and external perturbations.

Text and supplementary reading materials:

Chemistry by Martin S. Silberberg, 7th edition, 2015, ISBN-13 9780073511177
Student Solutions Manual, ISBN 0-07-241052-3
Student Study Guide, ISBN-0-07-241051-5
AP Chemistry Guided- Inquiry Experiments: Applying the Science Practices
Laboratory Experiments, Nelson and Kemp, 6th edition, ISBN 0-13-338708-9
Chemistry Laboratory Manual, Tom Russo, ISBN 0-02-827459-8

Overview

The High School offers two to three sections of AP chemistry each year. AP chemistry is taught as a second year chemistry course. The prerequisite is an honors level chemistry course taken in the sophomore year. Each section of AP chemistry has 7 45-minute periods distributed as three single periods and two double periods per week. This course is structured around the six big ideas above. Emphasis is placed on the seven science practices which capture important aspects of the work that scientists engage in, with learning objectives that combine content with inquiry and reasoning skills. Teaching methods include demonstrations, direct instruction, problem solving, and a significant laboratory component. The instructor sings several songs about science at appropriate times during the year.

Laboratory

Students are engaged in hands-on laboratory work integrated throughout the course, which accounts for 25 percent of the course.

Students are required to keep a lab notebook with bound pages (composition book). All lab data and observations must be recorded in pen in this lab notebook. Each lab experiment must include title of the experiment, date, procedure, data, observations and calculations. At least 6 laboratory experiments employ a guided-inquiry format. The students use previous knowledge and gain new understanding of scientific inquiry as they

figure out how to achieve the goals of these labs. The students are required to generate hypotheses, design equipment and procedures.

All laboratory experiments listed below are "wet" labs in which students have hands-on experience with basic lab equipment, volumetric glassware, analytical balances, spectrometers, lab burners, etc. Laboratory experiments from Nelson and Kemp, AP Chemistry Guided-Inquiry Experiments and Tom Russo are named and cited. Experiments developed by the teacher are briefly described. A graphing calculator like the TI-83 is required. In addition to traditional lab experiments, the students choose and prepare demonstrations that they perform after the AP exam.

Students apply the following science practices in every laboratory experiment.

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

Science Practice 2
The student can use mathematics appropriately.

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

Science Practice 4
The student can plan and implement data collection strategies in relation to a particular scientific question. (Note: Data can be collected from many different sources, e.g., investigations, scientific observations, the findings of others, historic reconstruction and/or archived data.)

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

Science Practice 6
The student can work with scientific explanations and theories.

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

Each double-period lab experiment must be written up as a typed lab report including title, lab partners, date, introduction, summarized procedure, results, conclusions, error analysis and graphs (when appropriate).

Course Description Summary

The course is divided into units of one to three chapters. Each unit begins with one or more demonstrations related to the unit, followed by lectures and problem sets based closely on the textbook. Problem sets are similar in structure, content and difficulty to questions on the AP Exam. Emphasis is also placed on drawing and analyzing graphs and

deriving equations. Sections for each chapter in Silberberg are listed. Sections not listed are either not covered or considered too basic for review. Students are instructed to read these sections, when appropriate. Demonstrations for each unit are listed. Not included are additional demonstrations resulting from student questions or current events.

The AP Chemistry Course

Summer Assignment

Chapters 1-3 in Silberberg are assigned for summer work. The students are instructed to read specific sections of these chapters and complete four homework assignments that are collected on the first day of school in September.

First Semester

Unit 1, Review concepts: Scientific Method, Scientific Notation, History of the Atom, Nomenclature, Stoichiometry (2 weeks)

Silberberg, Chapters 1-3
Sections 1.1 – 1.6, 2.2, 2.4, 2.5, 2.8, 3.1 – 3.5

Demonstrations:
- drinking bird
- JJ Thomson's cathode ray tube
- burning magnesium (limiting reagent)
- reaction of hydrochloric acid and calcium carbonate
- Song: Yes, I'm a Chemist

Lab experiments:
1. Oxidation of a nail in copper sulfate solution, observations and conclusions, scientific method, 1 hour. Guided inquiry. Science practices 1-7.
2. Basic Laboratory Equipment (Nelson and Kemp). Lab safety review, volumetric pipette technique, cutting and bending glass tubing. 2 hours. Science practices 1-7.
3. Bagging the Gas, limiting reagent lab in which students predict and confirm the production of a certain volume of gas. 1 hour. Guided inquiry. Science practices 1-7.
4. Percent water in a hydrate. Students heat a common hydrate to drive off water, determine percent water present. Science practices 1-7.

Unit 2, Classes of Chemical Reactions (2.5 weeks)

Silberberg, Chapter 4, sections 4.1 – 4.7, 21.1 (balancing oxidation-reduction reactions by half reaction method)

Demonstrations
- water deflection using Styrofoam to show effect of electric fields on charged particles
- conductivity of aqueous solutions using light bulb
- precipitation reactions, preparation of solutions using volumetric glassware

- acid-base titration
- sugar and chlorate reaction
- "wine" to "water" to "milk."

Lab Experiments:

1. Preparation of standard solutions. Students calculate molarities and prepare solutions of specific concentration using volumetric glassware. 1 period. Science practices 1-7.
2. Types of Chemical Reactions. Students perform several chemical reactions. Students must describe the types of reactions, write balanced equations, determine products. 1 hour. Science practices 1-7.
3. Redox titration of iron with permanganate solution. 2 periods. Science practices 1-7.

Unit 3, Gases (2 weeks)

Silberberg, Chapter 5, all sections

Demonstrations

- water barometer
- crushing can
- collecting butane over water (this can be done as a lab experiment if time allows)
- Boyle's law device (clear piston and pressure gauge, displayed using projector)
- diffusion of hydrogen chloride gas and ammonia gas

Lab experiments:

1. Determination of the Gas Constant R, Nelson and Kemp. Use of specialized glassware, application of gas laws, volume and temperature measurement. 2 hours. Guided inquiry. Science practices 1-7.
2. Determining the molar mass of butane by gas collection over water. Use of specialized glassware, application of gas laws, volume and temperature measurement. Guided inquiry. Science practices 1-7.

Unit 4, Thermochemistry (1.5 weeks)

Silberberg, Chapter 6, all sections

Demonstrations

- Happy and Sad balls
- methanol rocket
- bicycle pump
- lead sheet in boiling water (specific heat)
- Song: Machine Like You, about the main source of energy on Earth, the sun

Lab experiment: Measuring Heat of Reaction, Tom Russo. Application of thermodynamic principles, volume and temperature measurement. 1 hour. Science practices 1-7.

Unit 5, Atomic Structure (3 weeks)

Silberberg, Chapters 7 and 8, sections 7.1 – 7.4, 8.2 – 8.5

Demonstrations
- ripple tank
- laser diffraction through grating and on CD surface
- heat dime or quarter to red heat (blackbody radiation)
- orbital models
- gas tubes containing various elements viewed with spectrometers
- Song: Pi Song on the guitar, to demonstrate relationship between wavelength and frequency, compare string vibration to three dimensional wave

Lab experiments:
1. Flame Tests. Students observe flame colors from wooden splints soaked in various metal chloride solutions, determine the identity of two unknown solutions. 1 period. Guided inquiry. Science practices 1-7.
2. Trends in Reactivity within Groups, Tom Russo. Use of glassware, lab balance, observations. 1 hour. Science practices 1-7.
3. Determination of Cobalt Concentration Using a Spectrometer. Students prepare standard solutions and measure cobalt concentration using a Spec 20. Use of volumetric glassware. 2 hours. Science practices 1-7.

Unit 6, Chemical Bonds (2 weeks)

Silberberg, Chapters 9, 10, and 11, all appropriate sections

Demonstrations
- use liquid nitrogen to condense liquid oxygen from the air (oxygen is attracted to a magnet showing that oxygen is paramagnetic)
- show space-filled models of all atomic orbital hybridizations
  Activity: students use model kits to build VSEPR models.

Lab experiment. Sticky Question: How Do You Separate Molecules That Are Attracted to One Another? 2 periods. Guided inquiry. Science practices 1-7.

Unit 7, Intermolecular Forces, Solids, Liquids and Mixtures (2 weeks)

Silberberg, Chapters 12 and 13, sections 12.2 – 12.6, 13.1 – 13.5

Demonstrations
- burn paper with water by heating steam in a coiled copper pipe
- show glass capillary apparatus
- show viscosity of sugar syrup
- use models to show simple, body-centered and face-centered cubic crystals
- show types and uses of semiconductors (computer motherboard, homemade guitar amplifier)
- show crystallization of a supersaturated solution
- show examples of solutions, colloids

- show supercooling of water.

Lab experiments:

1. Determination of polarity based polar and non-polar solvent interactions. 1 period. Science practices 1-7.
2. Surface tension activity. Students float a paperclip on water, count drops of several liquids (water, soapy water, alcohol) on a penny to compare surface tension. 1 period. Science practices 1-7.

Unit 8, Organic Chemistry (1.5 weeks)

Silberberg, Chapter 15, sections 15.1-15.4

Demonstrations

- show hydrocarbons in all phases, methane through candle wax
- ignite methane bubbles
- show optical activity of sugar solution by passing polarized light through the solution
- show models of isomers
- show pi bond models of double and triple bonded molecules

Lab experiments:

1. Students model functional groups using ball-and-stick model kits. 1 period. Science practices 1-7.
2. Preparation of Aspirin and Oil of Wintergreen, Nelson and Kemp. Use of glassware, measurement. 2 hours. Science practices 1-7.

Second Semester

Unit 9, Kinetics (two weeks)

Silberberg, chapters 16 and 24, sections 16.1 – 16.8, 24.1 – 24.3

Demonstrations

- decomposition of hydrogen peroxide with manganese (IV) oxide (genie in a bottle)
- burning of steel wool in oxygen
- Iodine clock reaction
- song: Global Warming which includes a solution to ozone pollution (nitrogen monoxide catalyzes ozone production)
- use a Geiger counter to show radioactivity of uranium ore, smoke detector, potassium chloride

Lab experiment: What is the Rate Law of the Fading of Crystal Violet? Guided inquiry format. 2 hours. Science practices 1-7.

Unit 10, Equilibrium, Acid-Base Equilibrium (2.5 weeks)

Silberberg, chapters 17 and 18, all sections.

Demonstrations

- show temperature effect on equilibrium by showing cold and warm nitrogen dioxide tubes
- show acid/base equilibria using mixtures of strong and weak acids and bases in the presence of universal indicator
- show properties of acids, bases
- use a pH meter and pH indicators to demonstrate strong vs. weak acids

Lab experiments:

1. Spectrophotometric Determination of an Equilibrium Constant. Students make standard solutions, measure $Fe(SCN)^{2+}$ concentrations to determine equilibrium constant. Use of volumetric glasssware, visible spectrometer. 2 periods. Science practices 1-7.
2. Can We Make the Colors of the Rainbow? An Application of Le Châtelier's Principle. 2 periods. Guided inquiry. Science practices 1-7.
3. Household Acids and Bases. Students boil cabbage juice to make an acid-base indicator. They use this indicator to determine the relative strength of household solutions, from lemon juice to drain cleaner. 1 period. Science practices 1-7.

Unit 11, Ionic Equilibria in Aqueous Systems (2 weeks)

Silberberg, chapter 19, all sections.

Demonstrations

- show pH stability in a sodium acetate/acetic acid solution compared to a strong acid solution by adding aliquots of strong base to each and observing pH change using universal indicator
- show precipitation of sodium chloride from water by adding common ion, Cl- from concentrated hydrochloric acid

Lab experiment:

- Acid/Base Titration, modified to include a pH meter so that students can determine the acid dissociation constant of a weak acid, Tom Russo. Volumetric analysis, measurement techniques, use of a buret. 3 periods. Science practices 1-7.
- The Preparation and Testing of an Effective Buffer: How Do Components Influence a Buffer's pH and Capacity? Two periods. Science practices 1-7.

Unit 12, Entropy, Free Energy, Spontaneity (1 week)

Silberberg, chapter 20, all sections.

Demonstrations

- demonstrate the spontaneity of an endothermic reaction by mixing barium hydroxide and ammonium nitrate, freezing the beaker to a piece of wood
- revisit spontaneous crystallization of super-saturated sodium acetate, explain in terms of entropy and enthalpy change
- show that copper does not react in cold hydrochloric acid, but does react in hot acid
- students experiment with rubber bands, explain changes in temperature when the rubber band stretches and contracts

Lab experiment: The Hand Warmer Design Challenge: Where Does the Heat Come From? 2 periods.

Unit 13, Electrochemistry (1.5 weeks)

Silberberg, chapter 21, all sections.

Demonstrations

- show various types of electrolytic cells, Cu/Zn battery, HCl/Cu/Mg battery
- show cell potential using a volt meter
- show concentration cell using different concentrations of $CuSO_4$ in two beakers
- show the cross-section of a standard dry cell by cutting it in half with a hacksaw, check the voltage before and after to show that it doesn't change

Lab experiments:

1. The 6-cent battery, Tom Russo. Measurement using a volt/ohm meter. 1 period. Science practices 1-7.
2. Copper Plated Key. Students use a power supply to electroplate a key with copper. Designing and setting up an electric circuit with ammeter, electrodes, connecting wire. 2 periods. Science practices 1-7.

Unit 14, Descriptive Chemistry (1 week)

This topic is presented before Spring Break as a review of chemical reactions, solubility rules, oxidation-reduction reactions. A handout is distributed with practice problems. The students are required to work through the practice problems. They are evaluated after Spring Break.
After the completion of these units, the students are given two full-length practice exams. These are reviewed and discussed. Test taking strategies are discussed.

After the AP Exam

Demonstration Program

This activity provides students with the opportunity outside the laboratory environment to meet the learning objectives within the six Big Ideas. The students are separated into groups of three or four students each. Each group chooses a set of chemistry demonstrations. They must be able to safely prepare and present the demonstrations and they must be able to explain their demonstrations at a level appropriate for AP Chemistry students. This program takes about a week to prepare and present. Typical demonstrations chosen by the students:

CR3c, CR3d. Genie in a bottle - catalytic decomposition of hydrogen peroxide
CR3c and CR3e. Screaming gummi bear - sugar oxidation with hot potassium chlorate
CR3c.Oxidation of luminol
CR3a and CR3b. Silver mirror – oxidation of glucose by silver ion
CR3a, CR3c, CR3e. Thermite reaction
CR3c. Burning money – dollar bill soaked in 50/50 isopropyl alcohol/water
CR3b, CR3c, CR3e. Methane bubbles

CR3d, CR3f. Various indicator color changing reactions demonstrating chemical equilibrium and reaction kinetics.
CR3c, CR3e. Methanol rocket – combustion of methanol in a gallon milk jug
CR3c, CR3d. Elephant toothpaste, catalytic decomposition of hydrogen peroxide.

Supplemental Lab Activities

At the end of the year, several lab experiments are performed, as time allows. These reinforce concepts learned throughout the year.

1. 14 unknown solutions. Students use 14 unknown solutions to determine the identities of each. 2 hours. Science practices 1-7.
2. Alien Periodic Table, Tom Russo. Science practices 1-7.
3. Determining Absolute Zero, Tom Russo. Science practices 1-7.
4. Copper to Gold, the Alchemist's Dream, Tom Russo. Science practices 1-7.