AP® Chemistry Syllabus 2013

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.	11
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.	11
CR3c The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 3: Chemical reactions.	11
CR3d The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 4: Rates of chemical reactions.	11
CR3e The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 5: Thermodynamics.	11
CR3f The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 6: Equilibrium.	11
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.	12
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.	3
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.	12-13
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.	12-13
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.	3-6, 11-13

Course Description

This AP Chemistry course is designed to be the equivalent of the general chemistry course usually taken during the first year of college. For most students, the course enables them to undertake, as a freshman, second year work in the chemistry sequence at their institution or to register in courses in other fields where general chemistry is a prerequisite. This course is structured around the six big ideas articulated in the AP Chemistry curriculum framework provided by the College Boa rd. **[CR2]** A special emphasis will be 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. AP Chemistry is open to all students that have completed a year of chemistry who wish to take part in a rigorous and academically challenging course.

Big Idea 1: Structure of matter
Big Idea 2: Properties of matter-characteristics, states, and forces of attraction
Big Idea 3: Chemical reactions
Big Idea 4: Rates of chemical reactions
Big Idea 5: Thermodynamics
Big Idea 6: Equilibrium

Textbooks, Lab Books, Notes and Videos

The College Board. AP Chemistry Guided Inquiry Experiments: Applying the Science Practices, 2013.

Thomas R. Gilbert, Rein V. Kirss, Natalie Foster, and Geoffrey Davies, Chemistry, Third Edition. Online version, W.W. Norton & Company, 2011. **[CR1]**

Zumdahl, Steven S. and Susan A. Zumdahl. Chemistry, Sixth Edition. Houghton Mifflin Company, New York, 2003.

Vonderbrink, Sally. Laboratory Experiments for AP Chemistry. Batavia: Flinn Scientific, 2001.

Randall, Jack. Advanced Chemistry with Vernier. Oregon: Vernier Software and Technology, 2004.

National Math + Science Initiative (NMSI) AP Chemistry Class lecture Notes and Instructional Videos, accessed August 2013:
http://apchemistrynmsi.wikispaces.com/AP+Chemistry+Class+Lecture+Notes+AND+instructional+videos

Required Materials

Graphing or scientific calculator, bound laboratory notebook.

Laboratory Work

The labs completed require following or developing processes and procedures, taking observations, and data analysis. See lab list provided for lab details. Students communicate and collaborate in lab groups. Each student maintains a lab journal in a bound composition book (see below for details) and writes a laboratory report in electronic format and submits it to a drop box (see below for details). **[CR7]** A minimum of 25% of student contact time will be spent doing hands-on laboratory activities. **[CR5a]**

Lab Journal Guidelines (provided to students)

One of the major goals of science is to be able to clearly and accurately describe results of experimentation and research. In order to achieve this goal, a **separate, bound notebook** (such as a composition book) will be used to keep an accurate, chronological journal of all lab work, following a scientific format. Pre-lab and post-lab discussions will emphasize safety precautions, help draw conclusions, and relate the labs to topics that are presently being discussed in class. Open-notebook, lab quizzes will be given periodically to evaluate student comprehension of the calculations and concepts used in the labs.

The first two pages of the journal should be used for a **table of content**, so that specific entries can be easily found. The journal is like a diary of work that is completed. It is not meant to be a formal lab report, but a concise summary of experimentation performed.

Every experiment should be documented with the following information:

Descriptive Title and date of completion

Specific Problem Statement - What problem are you trying to solve by conducting the experiment? List the objectives you hope to accomplish.

Basic Procedure - What are the essential steps that are completed as part of the experiment? Provide specific quantities of materials used only when it is critical to the outcome. Draw and label a two-dimensional representation of any <u>unusual</u> apparatus needed to complete the experiment.

Results - Results are recorded as one of three categories: **observations, data,** and **calculations**

Observations: General descriptions of visible appearances or changes that occur during the experiment, such as table salt looks like a white, cube-shaped crystal which dissolves in water.

Data: Neatly arranged measured values listed in tabular form, often with class spreadsheet tables having your values highlighted. The **units** of measurement ***must be included*** with the numerical values. The accuracy of the measurement can also be included as a range (+/-). Calculated answers that are derived by performing a mathematical operation with the data can also be included in the Data Table.

Calculations: Show only one sample calculation for each different type performed. Neatly demonstrate the math set-ups, including units and labels. Show sample error calculations, where appropriate.

Conclusion: Write a summary of your work on the topic under study. It should provide your interpretations of the results in order to answer the specific problem statement. Include a discussion of the accuracy and precision of results, comparing your answers to class averages and values. Suggest possible reasons for all errors and how to improve the accuracy and the precision of the experimental procedures.

Each student is required to record the results of the experimentation in their own lab journals, as the work is completed. At the conclusion of each lab period, it is the student's responsibility to show the journal entry to their instructor for verification of the data and information recorded.

Sample AP Lab Report (provided to students)

TITLE PAGE:

Use the following headings for the report:

ABSTRACT: A short paragraph summarizing what was performed, including the concluding results.

APPARATUS: Draw (provide image) and label two-dimensionally only <u>unusual</u> apparatus.

THEORY: Briefly develop underlying principles or theory.(1-4 paragraphs

PROCEDURE: Briefly describe how the experiment was performed.

DATA: Neatly arranged in tabular form, often class spreadsheet tables with your values highlighted.

CALCULATIONS: Show only different calculations. Use only the data of the best trial. Neatly demonstrate the math set-ups. Show sample error calculations.

CONCLUSION: A great deal of attention is focused on your ability to write a sophisticated analysis of the lab. It should be a unified summary of your work on the topic under study. It should not be brief, fragmentary, expansive, or excessively critical of apparatus or equipment. Write the conclusion soon after completing it, and edit it a day or two later.

Under this heading, include:

1) accuracy and precision of results. Compare your answers to class averages and values.

2) how to improve the accuracy and the precision (assume that you have as much time (and possibly money!) as you need to accomplish this.

3) reasons for all errors.

4) the degree of significance or influence of particular errors upon the final result.

AP Chemistry Course Overview

For each Major Topic:

- one exam is given
- homework problems are assigned at the beginning of the topic in two modes:
  - on-line problems using the Indiana University CALM system – auto-graded
  - problems from text, with solutions provided, as practice
- each student is assigned 1-3 problems from prior exams, student presents solutions **[CR 7]**

Chemistry Foundations

Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation:
1. Scientific Method	1..D.1:a
2. Classification of Matter	
a. pure substances vs mixtures	1.A.1:b
b. law of definite proportions	1.A.1:c
c. law of multiple proportions	1.A.1:d
d. chemical and physical changes	3.C.1:b, 3.C.1:c, 5.D:2
3. Binary compound nomenclature, formulas	1.E.2:b
4. Polyatomic ions and other compounds	1.E.2:b

Stoichiometry

Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation:
1. Determination of atomic masses	1.A.1:a
2. Mole concept	1.A.3:b, 1.A.3:c, 1.A.3:d, 1.E.2:b
3. Percent composition	1.A.2:a
4. Empirical and molecular formula	1.A.2:b
5. Writing chemical equations, representations	1.E.1:a, 1.E.1:c, 3.C.1:a
6. Balancing chemical equations	1.A.3:a, 1.E.2:c, 1.E.2:d, 3.A.1:a
7. Applying mole concept to chemical equations	1.A.3:a, 1.E.1:b
8. Determine limiting reagent, theoretical and %yield	3.A.2:a

Chemical Reactions

Class Periods (42 minutes): 14

Topics Covered:	Curriculum Framework Articulation:
1. Electrolytes and properties of water	2.A.3:h
2. Molarity and preparation of solutions	1.D.3:c, 2.A.3:i, 2.A.3:j
3. Redox and single replacement reactions	3.A.1, 3.B.3:e, 3.C.1:d
4. Double replacement reactions	3.A.1, 3.C.1:d
5. Combustion reactions	3.A.1, 3.B.3:e
6. Addition reactions	3.A.1, 3.B.1:a
7. Decomposition reactions	3.A.1, 3.B.1:a, 3.C.1:d
8. Precipitation reactions and solubility rules	6.C.3:d
9. Acid Base reactions and formation of a salt by titration	1.E.2:f, 3.A.2:c
10. Balancing redox	3.B.3:a, 3.B.3:b, 3.B.3:c, 3.B.3:d
11. Simple redox titrations	1.E.2:f
12. Gravimetric calculations	1.E.2:e

Electrochemistry

Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation:
1. Balancing redox equations	3.B.3:a, 3.B.3:b, 3.B.3:c, 3.B.3:d
2. Electrochemical cells and voltage	3.C.3:a, 3.C.3:b, 3.C.3:c, 5.E.4:a
3. The Nernst equation	3.C.3:d
4. Spontaneous and non-spontaneous equations	3.C.3:e
5. Chemical applications	3.C.3:f

Equilibrium

Class Periods (42 minutes): 14

Topics Covered:	Curriculum Framework Articulation:
1. Characteristics and conditions of chemical equilibrium	6.A.1, 6.A.3:a, 6.A.3:f
2. Equilibrium expression derived from rates	6.A.3:b
3. Factors that affect equilibrium	6.A.3:c
4. Le Chatlier's principle	6.A.3:b, 6.8.1, 6.8.2, 6.C.3:e, 6.C.3:f
5. The equilibrium constant	6.A.3:d, 6.A.3.e, 6.A.4
6. Solving equilibrium problems	6.A.2

Acid / Base Equilibrium
Class Periods (42 minutes): 17

Topics Covered:	Curriculum Framework Articulation:
1. Definition and nature of acids and bases	3.8.2, 6.C.1:c, 6.C.1:d, 6.C.1:e, 6.C.1:f
2. K_w and the pH scale	6.C.1:a, 6.C.1:b, 6.C.1:g
3. pH of strong and weak acids and bases	6.C.1:h
4. Polyprotic acids	6.C.1:n
5. pH of salts	
6. Structure of Acids and Bases	

Solution Equilibrium
Class Periods (42 minutes): 17

Topics Covered:	Curriculum Framework Articulation
1. Characteristics and capacity of buffers	6.C.2
2. Titrations and pH curves	6.C.1:i, 6.C.1:j, 6.C.1:k, 6.C.1:l, 6.C.1:m
3. Choosing Acid Base Indicators	
4. pH and solubility	
5. K_{sp} Calculations and Solubility Product	6.C.3:a, 6.C.3:b

Kinetics
Class Periods (42 minutes): 14

Topics Covered:	Curriculum Framework Articulation
1. Rates of reactions	4.A.1:a
2. Factors that effect rates of reactions/collision theory	4.A.1:b, 4.A.1:c, 4.D.1, 4.D.2
3. Reaction Pathways	4.B.3:a, 4.B.3:b
4. Rate equation determination	4.A.2:a
a. rate constants	4.A.3
b. mechanisms	4.B.1, 4.C.1, 4.C.2, 4.C.3
c. method of initial rates	4.A.2:c
d. integrated rate laws	4.A.2:b, 4.A.3:d
5. Activation energy and Boltzmann distribution	4.B.2, 4.B.3:c

Thermochemistry and Thermodynamics
Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation
1. Law of conservation of energy, work, and internal energy	5.B.1, 5.E.2:a
2. Endothermic and exothermic reactions	3.C.2, 5.B.3:e, 5.B.3:f
3. Potential energy diagrams	3.C.2, 5.C.2:c, 5.C.2:d, 5.C.2:e
4. Calorimetry, heat capacity, and specific heat	5.A.2, 5.B.2, 5.B.3:a, 5.B.3:b, 5.B.4
5. Hess's law	5.B.3:a
6. Heat of formation/combustion	5.C.2:g
7. Bond energies	2.C.1:d, 5.C.1, 5.C.2:a, 5.C.2:b
8. Laws of thermodynamics	
9. Spontaneous process and entropy	5.E.1
10. Spontaneity, enthalpy, and free energy	5.E.2:c, 5.E.3
11. Free energy	5.E.2:d, 5.E.2:e, 5.E.2:f, 6.C.3:c, 6.D.1:a
12. Free energy and equilibrium	5.E.2, 6.D.1:b, 6.D.1:c, 6.D.1:d
13. Rate and Spontaneity	5.E.2:e, 5.E.5

Atomic Structure and Periodicity
Class Periods (42 minutes): 14

Topics Covered:	Curriculum Framework Articulation
1. Electron configuration and the Aufbau principle	1.B.2:a
2. Valence electrons and Lewis dot structures	1.B.2:c
3. Periodic trends	1.B.1:b, 1.B.1:c, 1.B.2:b, 1.B.2:d, 1.C.1:c, 1.D.1:b, 2.C.1:a, 2.C.1:b
4. Table arrangement based on electronic properties	1.C.1:a, 1.C.1:b, 1.C.1:d
5. Properties of light and study of waves	1.C.2:e, 1.D.3:a, 5.E.4:b
6. Atomic spectra of hydrogen and energy levels	1.B.1:d, 1.B.1:e, 1.D.3:b
7. Quantum mechanical model	1.C.2:d
8. Quantum theory and electron orbitals	1.C.2:c
9. Orbital shape and energies	1.C.2:b
10. Spectroscopy	1.D.2:a, 1.D.2:b, 1.D.2:c, 1.D.3:b

Bonding
Class Periods (42 minutes): 14

Topics Covered:	Curriculum Framework Articulation
1. Lewis Dot structures	2.C.4:a
2. Resonance structures and formal charge	2.C.4:c, 2.C.4:d, 2.C.4:e
3. Bond polarity and dipole moments	2.C.1:c, 2.C.1:e, 2.C.1:f
4. VSEPR models and molecular shape	2.C.4:b, 2.C.4:e, 2.C.4:f
5. Polarity of molecules	2.C.1:e
6. Lattice energies	1.B.1:a, 1.C.2:a, 2.C.1:d (1-2), 2.C.2:a, 2.C.2:b, 2.D.1:b
7. Hybridization	2.C.4:g
8. Molecular orbitals and diagrams	2.C.4:h, 2.C.4:i

Gases
Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation
1. Measurement of gases	
2. General gas laws- Boyle, Charles, Combined, and Ideal	2.A.2:a, 2.A.2:c
3. Dalton's Law of partial pressure	2.A.2:b
4. Molar volume of gases and Stoichiometry	3.A.2:b
5. Graham's Law	
6. Kinetic Molecular Theory	2.A.2:d, 5.A.1
7. Real Gases and deviation from ideal gas law	2.A.2:e, 2.A.2:f, 2.A.2:g, 2.B.2:c, 2.B.2:d

Liquids, Solids, and Solutions
Class Periods (42 minutes): 10

Topics Covered:	Curriculum Framework Articulation
1. Structure and bonding	
a. metals, network, and molecular	2.A.1:a, 2.A.1:d, 2.C.3, 2.D.1:a, 2.D.2:a, 2.D.1:b, 2.D.3, 2.D.4
b. ionic, hydrogen, London, van der Waals	2.A.1:b, 2.B.1:a, 2.B.1:b, 2.B.1:c, 2.B.2:a, 2.B.2:b, 2.B.2:c, 2.B.2:d, 2.B.3:a, 5.D:1
2. Vapor pressure and changes in state	
3. Heating and cooling curves	2.A.1:e, 5.B.3:c, 5.B.3:d
4. Composition of solutions	2.A.1:c, 2.A.3:b, 2.A.3:c, 2.B.3:b
5. Colloids and suspensions	2.A.3:a, 2.A.3:b, 2.A.3:g
6. Separation techniques	2.A.3:e, 2.A.3:f
7. Effect on biological systems	2.B.3:e, 2.D.3, 5.E.4:c

Review
Class Periods (42 minutes): Approximately 20
Review all Topics **Curriculum Framework Articulation:** 1.A.2:c
4 AP Style Review Exams (2 multiple choice, 2 Free Response, each 90 minutes)

Guided-Inquiry Activities (outside of lab environment): [CR3a-f]

1. **Students enter data and construct graphs using MS Excel to predict demonstrate, and identify periodic trends. Students will use graphs and data to justify exceptions to identified trends and present information in a class discussion. [CR3a]**

2. **Valence Shell Electron Pair Repulsion (VSEPR) Model (Trout, AP Chemistry Guided Inquiry Activities for the Classroom, College Board, 2013) [CR3b]**

3. **Acid-Base Neutralization Reactions (Greenbowe and DeWane, AP Chemistry Guided Inquiry Activities for the Classroom, College Board, 2013) [CR3c]**

4. **Students orally present solutions to problems given a set of data of change in concentration versus time, indicating the order of the reaction and the value of the rate constant with appropriate units. [CR3d]**

5. **Students create energy diagrams to explain why catalysts and raising the temperature can increase the rate of a chemical reaction. [CR3e]**

6. **Students determine the concentration of species at equilibrium given the equilibrium constant and the concentration of other species in the reaction at equilibrium. Students will apply Le Châtelier's Principle quantitatively to equilibrium systems that are altered. [CR3f]**

Labs: [CR4], [CR5a], [CR5b], [CR6], [CR7]

1. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 2: "How Can Color Be Used to Determine the Mass Percent of Copper in Brass?" Big Idea 1; LO 1.16, 3.4; SP 5.1, 4.1, 6.4, 4.2, 2.2**

2. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 3: "What Makes water Hard?" Big Idea 1; LO 1.19, 2.10, 3.2, 3.3; SP 7.1, 1.5, 2.2, 5.1, 6.4, 5.3, 6.2, 7.2**

3. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 5: "Sticky Question: How Do You Separate Molecules That are Attracted to One Another?" Big Idea 2; LO 2.10, 2.13; SP 4.2, 4.3, 5.2, 6.4, 5.3, 5.1, 1.4**

4. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 8: "How Can We Determine the Actual Percentage of H_2O_2 in a Drugstore Bottle of Hydrogen Peroxide?" Big Idea 3; LO 3.9, 1.20, 3.3; SP 2.1, 2.2, 4.2, 6.1, 6.4**

5. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 10: "How Long will That Marble Statue Last?" Big Idea 4; LO 4.1, 4.2; SP 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 7.1, 7.2, 6.4**

6. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 11: "What is the Rate Law of the Fading of Crystal Violet Using Beer's Law?" Big Idea 4; LO 4.2, 4.1; SP 1.4, 2.1, 2.2, 4.2, 5.1**

7. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 12: "The Hand Warmer Design Challenge: Where Does the Heat Come From?" Big Idea 5; LO 5.7, 5.6; SP 1.4, 6.4, 7.2, 4.2, 5.3, 2.2, 2.3, 5.1**

8. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 13: "Can We Make the Colors of the Rainbow? An Application of Le Châtelier's Principle" Big Idea 6; LO 6.9; SP 4.1, 4.3, 4.2, 5.1, 6.2, 6.4**

9. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, 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?" Big Idea 6; LO 6.13, 1.18, 1.20, 6.11, 6.12; SP 1.1, 1.2, 2.1, 2.2, 4.3, 5.1, 5.3, 6.1**

10. **AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices, Investigation 16: "The Preparation and Testing of an Effective Buffer: How Do Components Influence a Buffer's pH and Capacity?" Big Idea 6; LO 6.20, 1.20, 6.18, 1.4; SP 1.4, 6.4, 7.1, 2.2, 2.3, 5.2, 5.3, 4.2, 4.3, 4.4**

Green Crystal Lab (sequence of labs to determine empirical formula of a complex hydrate salt obtained from APSI 2007, performed at the Institute) LO 1.2, 2.7, 2.10, 3.7, 3.8, 3.9, 5.11; SP 2, 5, 6

11. **Green Crystal Lab: "Synthesis and Analysis of a Complex Iron Salt"**

12. **Green Crystal Lab: "Determination of the Percent Water in an Iron Oxalato Complex Salt"**

13. **Green Crystal Lab: "Preparation of a Sodium Hydroxide Solution and Molar Mass Determination of a Weak, Diprotic Acid"**

14. **Green Crystal Lab: "Standardization of a Sodium Hydroxide Solution with Potassium Hydrogen Phosphate"**

15. **Green Crystal Lab: "Determination of the Percent Potassium and Percent Iron by Ion Exchange and a Double Equivalence Point Titration"**

16. **Green Crystal Lab: "Standardization of a Potassium Permanganate Solution"**

17. **Green Crystal Lab: "Determination of the Percent Oxalate by Redox Titration; Determination of the Empirical Formula of the Green Crystal"**

Determination of the Percent Composition of Rumford Baking Powder (teacher-developed): SP 2, 3, 4, 5, 6; post-AP exam, three-week final project where groups develop their own lab procedures and perform them to ascertain the percent composition of a baking powder containing cornstarch, sodium hydrogen carbonate, and calcium hydrogen phosphate. Specific approaches include

18. **Gravimetric analysis involving solubility, precipitation and filtration**

19. **Gas collection over water, gravimetric analysis**

20. **Acid-base titration, with back-titration**