# AP® Chemistry
## Syllabus 3
## Overview of AP® Chemistry

AP Chemistry meets daily for one 45-minute period. Labs are conducted after school and/or during a three-and-a-half-hour session on the weekend. Approximately seven weekend **[C7]** lab sessions are held each quarter, and about 21 are held each year. At the beginning of the course, I send a handout home for students' parents describing the expectations and demands of the course. Although there has been some resistance to the idea of a weekend lab, the students do come, and their parents are very supportive.

**C7**—The course includes a laboratory component comparable to college-level chemistry laboratories. A minimum of one double-period per week or its equivalent is spent engaged in laboratory work. A hands-on laboratory component is required. Each student should complete a lab notebook or portfolio of lab reports. Note: Online course providers utilizing virtual labs (simulations rather than hands-on) should submit their laboratory materials for the audit. If these lab materials are determined to develop the skills and learning objectives of hands-on labs, then courses that use these labs may receive authorization to use the "AP" designation. Online science courses authorized to use the "AP" designation will be posted on the AP Central® Web site. (For information on the requirements for an AP Chemistry laboratory program, the Guide for the Recommended Laboratory Program is included in the Course Description.)*

## Course Design:

This course is designed to provide a solid first-year college chemistry experience, both conceptually and in the laboratory. The labs serve to supplement the learning in the lecture section of the course. Problem-solving skills, both on paper and in the lab, are emphasized. There are weekly labs during the first three quarters; during the last quarter, students take a total of five graded practice AP Exams. The exams are reviewed in class to increase students' awareness of test-taking strategies.

As this is a second-year course, students have previous knowledge of:

- molar relationships
- electronic structure **[C1]**
- periodicity **[C4]**
- history of atomic theory
- intramolecular and intermolecular bonding **[C1]**
- molecular geometry **[C1]**
- gas laws **[C2]**
- solutions and colligative properties **[C2]**
- nuclear chemistry

**C1—**Structure of Matter (Atomic Theory and Atomic Structure, Chemical Bonding)

**C4**—Descriptive Chemistry (Relationships in the Periodic Table)

**C2—**States of Matter (Gases, Liquids, and Solids, Solutions)

The course takes full advantage of students' first-year chemistry course because, although these topics are covered in detail in this course, we go over them quickly. Thus the chapters that are covered quickly include:

Chapter 1: Introduction: Matter and Measurement

Chapter 2: Atoms, Molecules, and Ions—atomic structure, masses, and nomenclature

Chapter 3: Stoichiometry: Calculations with Chemical Formulas and Equations—formula masses, mole to mole relationships

Chapter 4: Aqueous Reactions and Solution Stoichiometry—predicting which reactions will occur

Chapter 6: Electronic Structure of Atoms—quantum mechanics, quantum numbers

Chapter 7: Periodic Properties of the Elements

Chapter 8: Basic Concepts of Chemical Bonding—ionic and covalent bonding

Chapter 9: Molecular Geometry and Bonding Theories—molecular shapes

Chapter 10: Gases—including gas laws and kinetic molecular theory

Chapter 11: Intermolecular Forces, Liquids, and Solids

Chapter 13: Properties of Solutions—colligative properties

Chapter 21: Nuclear Chemistry

The following concepts' increased complexity or unfamiliar nature makes it necessary for me to allow more time when I cover them:

- chemical kinetics
- equilibrium **[C3]**
- thermodynamics
- redox reactions
- materials science
- buffer systems **[C3]**
- coordination complexes **[C1]**
- organic chemistry

**C3**— Reactions (Reaction Types, Stoichiometry, Equilibrium, Kinetics, Thermodynamics)

**C1—**Structure of Matter (Atomic Theory and Atomic Structure, Chemical Bonding)

The chapters within the text covered in greater detail include:

Chapter 5: Thermochemistry—First Law, Hess's Law

Chapter 14: Chemical Kinetics

Chapter 15: Chemical Equilibrium

Chapter 16: Acid-Base Equilibrium

Chapter 17: Additional Aspects of Aqueous Equilibria

Chapter 19: Chemical Thermodynamics—Second Law and Gibbs Energy

Chapter 20: Electrochemistry

Chapter 12: Modern Materials

Chapter 24: Chemistry of Coordination Compounds

Chapter 25: The Chemistry of Life: Organic and Biological Chemistry

# Teaching Ideas

To encourage my students to keep mentally alert, agile, and able, I use four main ideas throughout the year.

### Idea I: Practice, practice, practice!

Significant time should be taken to place students in a situation as close as possible to the conditions of an AP Exam. Exposure to the kinds of questions and problems with the same depth and breadth as those on the AP Exam itself enhances and cements student learning. Students need plenty of opportunities to learn how to approach multiple-choice questions. Teach them that quantitative multiple-choice questions fall into one of these categories:

1. All answers are significantly different.
2. All answers are given as different mathematical manipulations of the given.
3. Some answers are close and actual calculation is necessary. **[C6]**
4. Some answers are close but rounded values are easily manipulated to yield an answer—and reviewing all the answers before actual calculation is an effective way to select the best one. Completing multiple-choice questions without a calculator is an arduous task for students and must be practiced.

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

Prepared materials, such as Demmin's review text or AP Released Exams, are helpful in the preparation of chapter tests, review sheets, and other assessment tools. AP Released Exams are an invaluable source for free-response questions. Use them freely in quizzes, as homework problems, on chapter exams, or for final reviews. Give timed practice AP Exams and review them as a class.

### Idea 2: Write to learn and learn to write.

Writing is a skill that needs to be practiced constantly in order to be optimally effective. Precise and accurate language from each student can be expected when you require continual practice, correction, and revision. For example, after delivering a lecture on intermolecular forces, ask a direct question but require written answers. Have students exchange papers and verbally critique one other. The ensuing discussion will be informative for everyone. Collect and read the responses for your own edification, if desired.

### Idea 3: The more the information is shared, the more the information is stored.

Even commonplace communications, such as leaving a note to a lab partner to tell him or her how many titrations were completed today, requires a student to gather his or her thoughts and communicate them to another person. The act of communication requires a person to expend an effort to be understood.

In addition to the information sharing that occurs in class, I provide three other venues where such exchanges are made.

- **Monthly Bulletin Board Presentations**
  Students are responsible for designing and posting visually exciting and relevant information about a specific topic, which I assign.

- **Calculator-Based Lab (CBL) Presentations**
  Students demonstrate and discuss the possible uses of a particular CBL probe (for temperature, light, conductivity, voltage, or pH) and a Texas Instruments TI-82 calculator for the sixth-grade students, who are preparing for the local science fair.

- **Lab Presentations on the Internet**
  Working in pairs, students build a Web page that presents a lab complete with data, analysis, conclusion, and error analysis. This open record allows current students as well as those from subsequent years to add to the lab (using access buttons to their own websites) with new methodologies to reduce error or arrive at different conclusions.

### Idea 4: Doing chemistry is doing lab: There is no difference.

Labs support, convey, and cement the chemical principles presented in lectures and demonstrations. They also provide students with an opportunity to learn new physical skills (such as titration, quantitative transfer, or the use of volumetric equipment), foster good collaborative relationships, and improve problem-solving techniques, while they learn [C7] more about how chemistry really works. Different labs are performed for different reasons, all of which are stated on a lab assignment sheet.

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The labs come from a variety of resources that I have gathered over the years, including the Woodrow Wilson TORCH Chemistry Workshops and the National Science Foundation–sponsored workshops for AP Chemistry teachers. The sources for the labs on the lab schedule that follows are listed with the abbreviations used in the schedule.

Determination of Molecular Weight by the Dumas Method, in Modular Laboratory Program in Chemistry Series. (Flinn)

National Science Foundation–sponsored workshops held for many years at Northern Arizona University. (NAU)

Russo, Thomas, and Mark Meszaros. *Vial Organic*. (Russo)

Silberman, Robert G. *ACS Small-Scale Laboratory Assessment Activities*. (Silberman)

Slowinski, Emil J., et al. *Chemical Principles in the Laboratory*. 5th ed. (Slowinski)

Woodrow Wilson TORCH Institutes. (WWChem)

## Small-Scale Inquiry Labs

Four small-scale inquiry labs, which come from the Silberman text, have been added to the lab section. Students have 45 minutes to devise a lab using only the given materials to complete a task. These labs are conducted individually with no contact among the students. I always include several misleading items in their baskets of allowed materials. Students have no prior knowledge of the problem and must complete the lab in the time allotted. They also do not know when the labs will occur. I treat them as pop quizzes, indicating on the lab schedule which week will have a small-scale inquiry lab, but wait until the day of the lab to tell the students they will be doing one that day. To help them get used to this type of activity, I give a surprise inquiry lab at some point during week four and provide a little information, or "hint," about the problem they are to solve. This is the only time I give them help during an inquiry lab.

Additional labs can be obtained from the International Chemistry Olympiad Regional Exam, sponsored by the American Chemical Society.

## Course Requirements and Grading

I cover the Brown text at a rate of approximately one chapter every five to seven school days, with 15 to 20 problems assigned and reviewed per chapter. The assignments are on a chapter or weekly basis. Chapter exams consist of 20 multiple-choice questions and up to 4 free-response questions. These final four questions come from retired AP Released Exams whenever possible. During the final quarter, I substitute the lab percentage by the grades students earned on the five practice AP Exams. In addition to chapter problems, I base part of their homework grade on their group bulletin board presentations. A student's grade is a weighted average of the following:

| | |
|---|---|
| Tests | 50% |
| Quizzes | 15% |
| Labs | 25% |
| Homework | 10% |

### Required Texts

Brown, Theodore L., et al. *Chemistry: The Central Science*. 10th ed.

Slowinski, Emit J., et al. *Chemical Principles in the Laboratory*. 5th ed.

### Supplemental Texts

Demmin, Peter E. *Multiple-Choice Questions in Preparation for the AP Chemistry Examination*. 3rd ed.

Ehrenkranz, David, and John J. Mauch. *Chemistry in Microscale*.

Ellis, Arthur B., et al. *Teaching General Chemistry: A Materials Science Companion*.

Reger, Daniel L., et al. *Chemistry, Principles & Practice*.

# Lab Schedule

Each week's entry states the objectives, purpose, and requirements for the lab write-up. Entries also indicate which labs students are to do collaboratively in groups of two or more and which they are to do individually. Students are required to keep a lab notebook of all their reports. **[C5, C7]**

## Week 1

August 26–September 1

### Lab Orientation

- Check out the lab facilities.
- Know where the equipment is and what types are available.

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

**C7**—The course includes a laboratory component comparable to college-level chemistry laboratories. A minimum of one double-period per week or its equivalent is spent engaged in laboratory work. A hands-on laboratory component is required. Each student should complete a lab notebook or portfolio of lab reports. Note: Online course providers utilizing virtual labs (simulations rather than hands-on) should submit their laboratory materials for the audit. If these lab materials are determined to develop the skills and learning objectives of hands-on labs, then courses that use these labs may receive authorization to use the "AP" designation. Online science courses authorized to use the "AP" designation will be posted on the AP Central® Web site. (For information on the requirements for an AP Chemistry laboratory program, the Guide for the Recommended Laboratory Program is included in the Course Description.)*

### Mass Percentage of Carbon Dioxide in Alka-Seltzer (WWChem)

Determine by two separate methods and calculate the mass percentage of $CO_2$ found in a tablet of Alka-Seltzer.

- Group inquiry lab (lab is done by the class as a whole).
- Class lab report (a single report to which the class as a whole contributes) due September 2.

Lab write-up to include: **[C5]**

1. Succinct procedures for both methods
2. Complete calculations of the mass percentage of $CO_2$ **[C6]**
3. Thorough discussion of the possible sources of errors in each of the methods
4. An opinion regarding which of the two methods is probably the more accurate and an appropriate discussion with explanation

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 2

September 2–8

### Chromatography and Skittles Candy (WWChem)

Determine which FD & C and FD & C Lake dyes are in a given flavor of Skittles candy and an unknown dye.

- Group-directed lab.
- Prelab the Skittles lab from the handout.
- Directed lab write-up due September 9.

Lab write-up to include: **[C5]**

1. All chromatograms generated from both the standards and the candy, with each color identified and labeled
2. Rf values for each of the FD & C dyes in both the standards and the candy **[C6]**
3. A statement regarding which FD & C dyes can be found in any given color of Skittles candy. This should include an explanation and/or discussion of possible sources of error.

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

# Week 3

September 9–15

This lab has two parts:

**Experiment 11: Heat Effects and Calorimetry (Slowinski)** and

**Experiment 13: Water of Hydration (Slowinski)**

Determine the $C_p$ of an unknown substance and calculate its molar mass by using the Law of Dulong and Petit. **[C6]**

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

AND

Visually experience the solubilities of hydrates, the reversibility of hydration, and the properties of deliquescence and efflorescence. Determine the empirical formula of a hydrate.

- Parts A, B, and C of Lab 13 are to be completed by the entire class as one group.
- Students are to work in pairs on the rest of the labs.
- Directed lab reports are to be done by pairs and are due on September 16.
- Accuracy is a factor.

Lab write-up to include: **[C5]**

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

1. Write-up sheet from Lab 11, page 85
2. Write-up sheet from Lab 13, page 102, and the associated calculations

# Week 4

September 16–22.

### Inquiry Lab—Calculation of Standard Heat of Formation of MgO (NAU)

Magnesium and MgO both react exothermically with HCl. Assuming that the specific heat of a low enough concentration of HCl is close to that of water, determine the heat of formation of MgO by manipulating the heat of the given reactions in an application of Hess's Law.

- Students are to work individually with CBLs.
- Inquiry lab is to be done individually and is due immediately following the lab.

Lab write-up to include: **[C5]**

1. Complete calculations. Accuracy is important. **[C6]**

## Week 5

September 23–29

### Determination of a Solubility Product: $K_{sp}$ of $MgC_2O_4$ (NAU)

Standardization of a permanganate solution. Preparation of saturated magnesium oxalate solutions of known initial conditions.

- The permanganate standardization should be completed as a class lab with representative trials from each group.
- This is a two-week lab. Students are to work in pairs and need only complete Week 1 of the given procedures.
- Student-directed lab reports are to be done individually and are due on October 7.

Lab write-up is due upon completion of the lab next week.

## Week 6

September 30–October 6

### Determination of a Solubility Product: $K_{sp}$ of $MgC_2O_4$ (NAU)

Determine oxalate concentration by titration with permanganate and calculate the solubility product of the salt.

- Students are to work in pairs and need to complete the lab.
- Directed lab reports are to be done individually and are due on October 7.

Lab write-up to include: **[C5]**

1. Data table
2. Clear, complete work for all calculations and the calculated $K_{sp}$ of $MgC_2O_4$
3. Error percentage and error discussion **[C6]**

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 7

October 7–13

### $K_f$ of a Complex Ion (NAU)

Determination of an equilibrium constant for the formation of a complex ion with spectrophotometric readings on the absorbency of solutions.

- Prelab handout for procedure.
- Prepare solutions needed for lab.
- Students are to work in pairs.
- Individual directed lab reports are due on October 14.

Lab write-up to include: **[C5]**

1. Data table
2. Report form from the lab
3. Complete calculations **[C6]**
4. A computer-generated graph using the graphical analysis program in the computer lab. Also, use the interpolation feature on the program for determination of ion concentrations.

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 8

October 14–20

**Small-Scale Inquiry Lab for Quarter 1** (International Chemistry Olympiad Exam) Calculate the thickness of the layer of zinc on a washer.

- Lab write-up is due individually and immediately following the lab.

Lab write-up to include: **[C5]**

1. Complete procedures, data, and completion of the given task

## Week 9

October 21–27

### Molar Mass Determination by Freezing Point Depression (Slowinski)

Determine the molar mass of an unknown using the colligative properties of solutions.

- Prelab Lab 17.
- Students are to work in pairs.
- Directed lab reports are due by pairs on October 28.

Lab write-up to include: **[C5]**

1. Complete report form from the text and separate sheet with all related calculations

## Week 10

October 28–November 3

### Vapor Pressure of Water (WWChem)

Determine the relationship between the vapor pressure of water and the temperature in Kelvins and graphically represent the Clausius–Clapeyron equation.

- Prelab vapor pressure of water lab from handout. Students are to work in pairs.

- Directed lab reports are to be done individually and are due on November 4.

Lab write-up to include: **[C5]**

1. Data table
2. Large graph (the size of a whole page) generated by graphical analysis on the computer
3. Answers to all given questions

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

## Weeks 11–12

November 4–November 15

No lab during these weeks.

## Week 13

November 16–24

### The Structure of Crystals (Slowinski)

Visually experience and manipulate the various types of unit cells as well as 2-D diffraction patterns as an analogy for X-ray diffraction of crystals.

- Prelab handout on optical diffraction experiments. Students are to work in pairs.

- Directed lab reports are to be done by pairs and are due on November 25.

Lab write-up to include: **[C5]**

1. Write-up sheet from Lab 15 and the optical diffraction experiment and associated calculations **[C6]**
2. Application of 2-D diffraction patterns to ascertain geological sand sieve size

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 14

November 25–December 1

No lab during this week.

## Week 15

December 2–8

### Molar Mass of a Volatile Liquid (Flinn)

Determination of the molar mass of a volatile liquid using iodine as a coloring agent. Calculation using the Dumas method of determination of molar mass of gases.

- Prelab handout.
- Class-directed lab.
- Directed lab write-up due on December 9.

Lab write-up to include: **[C5]**

1. Data table
2. Write-up sheet from the lab and the associated calculations

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

## Week 16

December 9–16

### Small-Scale Inquiry Lab for Quarter 2 (Silberman)

Determine the volume (in milliliters) of acid needed to titrate 1.0 ml of Milk of Magnesia

- Lab write-up is due individually and immediately following the lab.

Lab write-up to include: **[C5]**

1. Complete procedures, data, and completion of the given task

## Weeks 17–18

December 17–January 3

No lab during these weeks.

## Week 19

January 4–12

### Microscale Acid-Base Titration Curve (NAU)

Experience a semiquantitative titration. Continue exposure to the concept of equivalence points on titration graphs.

- Students are to work in pairs.
- Directed lab reports are to be done individually and are due on January 13.

Lab write-up to include: **[C5]**

1. Write-up sheet from the lab
2. Four hand-drawn graphs, each with the equivalence point of the titration clearly indicated

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

## Week 20

January 13–17

No lab during this week.

## Week 21

January 18–26

### Ascorbic Acid in Vitamin C Tablets (NAU)

Standardize a base solution for subsequent quantitative determination of the milligrams of vitamin C in a commercially available tablet.

- Students are to work in pairs.
- Nondirected lab reports are to be done by pairs and are due on January 27.

Lab write-up to include: **[C5]**

1. Data table
2. Determination of the milligrams of vitamin C in the tablet and all associated calculations **[C6]**

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 22

January 27–February 2

### Identification of Ions in Salts (NAU)

## Week 23

February 3–9

### Iodination of Acetone, Including All Optional Sections (Slowinski)

Determine the order of a reaction with respect to a given reactant and graphically represent the relationship between temperature, rate constant, and the activation energy.

- Prepare solutions.
- Students are to work in pairs.
- Directed lab reports are to be done individually and are due on February 10.

Lab write-up to include: **[C5]**

1. Report form from Lab 29 with all associated calculations

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

## Week 24

February 10–16

### Using pH Titrations to Identify Weak Acids (NAU)

Obtain a titration curve for a weak, unknown acid and use it to determine its Ka. Identify the weak acid from a list of known Ka values.

- Students are to work in pairs.
- Directed lab reports are to be done by pairs and are due on February 17.

Lab write-up to include: **[C5]**

1. The calculations that lead to the K of the unknown acid
2. Identification of the unknown acid
3. A computer-generated graph using graphical analysis of the titration curve for the unknown acid, with appropriate calculations **[C6]**

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 25

February 17–23

### Formation of an Ester (Russo)

The formation of a useful ester: aspirin.

- Grading is dependent on percentage yield and purity.
- Lab write-up, sample, and calculations due February 24.

Lab write-up to include: **[C5]**

1. Completion of the lab handout
2. Small Ziploc bag containing sample prepared in class

## Week 26

February 24–March 2

### Electrochemical Cells (NAU)

Determine an activity series using electrochemical potentials. Observe the effect of variable concentration on the potential of a cell.

- Students are to work in pairs.
- Directed lab reports are to be done by pairs and are due on March 3.

Lab write-up to include: **[C5]**

1. Data table
2. An activity series of the given metals
3. All calculations involved in determining the $E_o$ and n value for the Zn/Cu cell **[C6]**
4. A computer-generated graph illustrating the Nernst equation

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)

**C6**—The course emphasizes chemical calculations and the mathematical formulation of principles.

## Week 27

March 3–9

### Small-Scale Inquiry Lab for Quarter 3 (Silberman)

When solutions A and B are mixed, a white precipitate slowly forms. Determine the order of the reaction with respect to A.

The lab write-up is due individually and immediately following the lab.

Lab write-up to include: **[C5]**

1. Complete procedures, data, and completion of the given task

## Week 28

March 10–16

### Small-Scale Inquiry Lab for Quarter 4 (Silberman)

Identify the five white powders, which may be ground-up chalk, Alka-Seltzer, washing soda, baking soda, or vitamin C. The labeled pipettes contain water, vinegar, or phenolphthalein solution.

Lab write-up is due individually and immediately following the lab.

Lab write-up to include: **[C5]**

1. Complete procedures, data, and completion of the given task

## Weeks 29–33

March 17–April 20

### Inquiry Lab: Preparing Buffers and Making a Botanically Based Universal Indicator (teacher-generated)

Prepare buffer solutions of known pH values. Prepare a botanically based, universal indicator with a range of at least 10 pH units. Determine the pH of an unknown solution using the prepared universal indicator:

- The class is to work together to prepare buffers from pH 1–14 and use these buffers to test the indicator ability of various botanical extracts.
- Prepare a mixture of natural, botanically based indicators showing distinctly different colors over a range of at least 10 pH units. Make a standard of these colors in two eight-well strips sealed with a cover strip.
- Use the student-made universal indicator to determine the pH of three given, unknown solutions.
- Class nondirected lab write-up is due on April 21.

Lab write-up to include: **[C5]**

1. Two separate eight-well strips clearly showing the range of colors of the student-prepared universal indicator
2. Determination of the pH of the three unknown solutions
3. A "recipe" of the relative amounts, plant names, and parts of the plants used for all the components of the universal indicator
4. Clear photos of the plants used
5. A clearly stated procedure for the preparation of all the buffers used in the lab as well as the mathematical proof/calculation for each buffer

**C5**—Laboratory (Physical manipulations; Processes and procedures; Observations and data manipulation; Communication, group collaboration, and the laboratory report)