SYLLABUS DEVELOPMENT GUIDE

AP® Chemistry

The guide contains the following information:

Curricular Requirements

The curricular requirements are the core elements of the course. A syllabus must provide explicit evidence of each requirement based on the required evidence statement(s).

The Unit Guides and the "Instructional Approaches" section of the *AP® Chemistry Course and Exam Description* (CED) may be useful in providing evidence for satisfying these curricular requirements.

Required Evidence

These statements describe the type of evidence and level of detail required in the syllabus to demonstrate how the curricular requirement is met in the course.

Note: Curricular requirements may have more than one required evidence statement. Each statement must be addressed to fulfill the requirement.

Samples of Evidence

For each curricular requirement, three separate samples of evidence are provided. These samples provide either verbatim evidence or clear descriptions of what acceptable evidence could look like in a syllabus.

Curricular Requirements

CR1	The students and teacher have access to college-level resources including a recently published (within the last 10 years) college-level textbook and reference materials in print or electronic format.	*See page:* 3
CR2	The course is structured to incorporate the required content outlined in each of the units described in the AP Course and Exam Description (CED).	*See page:* 4
CR3	The course provides opportunities for students to develop the skills related to Science Practice 1: Models and Representations.	*See page:* 6
CR4	The course provides opportunities for students to develop the skills related to Science Practice 2: Question and Method.	*See page:* 7
CR5	The course provides opportunities for students to develop the skills related to Science Practice 3: Representing Data and Phenomena.	*See page:* 8
CR6	The course provides opportunities for students to develop the skills related to Science Practice 4: Model Analysis.	*See page:* 9
CR7	The course provides opportunities for students to develop the skills related to Science Practice 5: Mathematical Routines.	*See page:* 10
CR8	The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation.	*See page:* 11
CR9	The course provides students with opportunities to apply their knowledge of AP Chemistry concepts to real-world questions or scenarios to help them become scientifically literate citizens.	*See page:* 12
CR10	Students spend a minimum of 25% of instructional time engaged in a wide range of hands-on, laboratory investigations to support the learning of required content and development of science practice skills throughout the course. At minimum, 16 labs are performed including at least 6 labs conducted in a guided inquiry format.	*See page:* 13
CR11	The course provides opportunities for students to record evidence of their scientific investigations. Evidence can be recorded in lab reports or another appropriate formal manner for inclusion in lab notebooks/portfolios (print or digital format).	*See page:* 14

Curricular Requirement 1

The students and teacher have access to college-level resources including a recently published (within the last 10 years) college-level textbook and reference materials in print or electronic format.

Required Evidence

- ☐ The syllabus must cite the title, author, and publication date of a college-level textbook. The primary course textbook must be published within the last 10 years.

Samples of Evidence

1. The syllabus cites the title, author, and publication date (within the last 10 years) of a college-level chemistry textbook in print or electronic format.

   For example: OpenStax College. (2019). *Chemistry 2e.* Houston, TX: OpenStax CNX. Retrieved from **openstax.org/details/books/chemistry-2e**

2. The syllabus cites a textbook from the AP Example Textbook List for AP Chemistry.

   For example: Zumdahl Steven S., Susan A. Zumdahl and Donald J. DeCoste. *Chemistry (AP Edition),* 10th edition. National Geographic Learning/Cengage Learning. 2018.

3. The syllabus includes a resource section where a list of resources for AP Chemistry instruction is provided. The resource section includes the title and author of a recently published college-level chemistry textbook for science majors.

   For example: Theodore E. Brown, et al., *Chemistry: The Central Science*, 14th edition (2018).

Curricular Requirement 2

The course is structured to incorporate the required content outlined in each of the units described in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include an outline of course content by unit title or topic using any organizational approach to demonstrate the inclusion of required course content. All nine units must be included.

Note: If the syllabus demonstrates a different approach than the units outlined in the *AP Chemistry Course and Exam Description* (CED), the teacher must indicate where the content of each unit in the CED will be taught.

Samples of Evidence

1. The syllabus outline of course content cites specific chapter titles of the required text that correspond to the unit outline in the AP Course and Exam Description.

Chapter #	Chapter Title	AP Unit #
1	Introduction: Matter, Energy, and Measurement	1
2	Atoms, Molecules, and Ions	1
3	Chemical Reactions and Reaction Stoichiometry	4
4	Reactions in Aqueous Solution	4
5	Thermochemistry	6
6	Electronic Structure of Atoms	1
7	Periodic Properties of the Elements	1
8	Basic Concepts of Chemical Bonding	2
9	Molecular Geometry and Bonding Theories	2
10	Gases	3
11	Liquids and Intermolecular Forces	3
13	Properties of Solutions	3
14	Chemical Kinetics	5
15	Chemical Equilibrium	7
16	Acid-Base Equilibria	8
17	Additional Aspects of Aqueous Equilibria	8
19	Chemical Thermodynamics	9
20	Electrochemistry	9

2. The course includes the required content organized into the following units based on the AP Course and Exam Description:

   Unit 1: Atomic Structures and Properties

   Unit 2: Molecular and Ionic Compound Structure and Properties

   Unit 3: Intermolecular Forces and Properties

   Unit 4: Chemical Reactions

   Unit 5: Kinetics

   Unit 6: Thermodynamics

   Unit 7: Equilibrium

   Unit 8: Acids and Bases

   Unit 9: Applications of Thermodynamics

3. The syllabus organizes the required content using a different approach or sequence than that described in the AP Course and Exam Description and specifies where the content from each AP unit is taught in the course.

Unit	Content	AP Unit
1	Review of Stoichiometry and Nomenclature	1, 4
2	Gas Laws	3
3	Kinetics	5
4	Equilibrium	7, 8
5	Thermodynamics and Electrochemistry	6, 9
6	Atomic Structure and the Periodic Table	1
7	Bonding	2
8	Solutions and Intermolecular Forces	3

Curricular Requirement 3

The course provides opportunities for students to develop the skills related to Science Practice 1: Models and Representations, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students describe models and representations, including across scales.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. **Science Practice 1:** Students work in pairs and complete an activity introducing them to particulate level representations. The goal of the activity is to teach the students how to interpret and draw particulate representations. Throughout the year, students translate between particulate, macroscopic, and symbolic representations.

2. **SP1:** Students complete the shells and subshells activity in a POGIL format during units 1.5 and 1.6 on atomic structure and photoelectron spectroscopy.

3. Students are given Lewis dot structures on a sheet of paper and asked to describe the evaporation rate of each molecule in comparison with each other. The teacher swipes the substances on the lab table to help students observe which evaporates faster and then describes why in terms of molecular structure. **(Science Practice 1)**

Curricular Requirement 4

The course provides opportunities for students to develop the skills related to Science Practice 2: Question and Method, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students determine scientific questions and methods.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. **Science Practice 2:** Students observe a demonstration in which substances generate different colored flames. They then develop a question that could generate data to explain this phenomenon.

2. After viewing a video about processes at a water treatment facility, students are asked to identify and describe the experimental procedure of filtration to separate a hazardous precipitate from a solution. **(SP 2)**

3. Students are given data where a catalyst has been added to a chemical system, and the students are asked to analyze the effect of the catalyst on the reaction. In small groups, students develop an experimental procedure that could be used to study the effects of this or analogous catalysts on the rate of the chemical reaction, including what measurements could be made, what equipment is needed, and how the data will be processed. **(Science Practice 2)**

Curricular Requirement 5

The course provides opportunities for students to develop the skills related to Science Practice 3: Representing Data and Phenomena, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students create representations or models of chemical phenomena.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. **Science Practice 3:** When reaction writing, students draw particulate representations of the chemical equations. This is repeated throughout the year.

2. Students draw Lewis structures in 2-D and construct models of the 3-D electronic and molecular geometry for each substance. **(SP 3)**

3. Using data provided from a weak acid/strong base titration, students create a titration curve (pH as a function of the volume of base added). They then identify critical points (e.g., equivalence point) on the graph in a group discussion. **(Science Practice 3)**

Curricular Requirement 6

The course provides opportunities for students to develop the skills related to Science Practice 4: Model Analysis, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students analyze and interpret models and representations on a single scale or across multiple scales.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. **Science Practice 4:** Students draw Lewis dot structures for three compounds: H_2O, CH_3OH, and CH_3CH_2OH. In a written response, students predict which will have the highest boiling point and explain why in terms of the intermolecular forces.

2. Students graph values for atomic radius, electronegativity, and ionization energy to predict trends and explain the organization of the periodic table in regard to Coulomb's law, nuclear charge, number of electrons, and shell number. **(SP 4)**

3. Students, working in pairs, are given data about an experimental rate law and asked to determine (through guided questions) which mechanism is consistent with that rate law. **(Science Practice 4)**

Curricular Requirement 7

The course provides opportunities for students to develop the skills related to Science Practice 5: Mathematical Routines, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students solve problems using mathematical relationships.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. **Science Practice 5:** Students are provided with the masses of two reactants (and the associated chemical equation for the subsequent reaction). Students use dimensional analysis and stoichiometry to calculate the maximum yield of the product.

2. **SP 5:** Students determine the order of the reaction based on the following data and present their solution to the class.

   The thermal decomposition of compound *A* produced the following data:

t / (10^3 s)	[A] / (mol L^{-1})
0	1.10
2.00	0.86
4.00	0.67
6.00	0.52
8.00	0.41
10.00	0.32
12.00	0.25
∞	0.00

3. After reviewing a series of precipitation reactions, students are asked to write the net ionic equation for each precipitation reaction. **(Science Practice 5)**

Curricular Requirement 8

The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation, as outlined in the AP Course and Exam Description (CED).

Required Evidence

- ☐ The syllabus must include a **brief description** of an activity or series of activities **(not including the labs listed in Curricular Requirement 10)** in which students develop an explanation or scientific argument.
- ☐ Activities must be labeled with the relevant science practice(s).

Samples of Evidence

1. Students are given data on ΔS° and ΔH° of a chemical reaction. Students must make a claim about the temperature conditions under which the reaction is thermodynamically favorable, supporting their claim with a calculation that is presented on a whiteboard. **(Science Practice 6: Argumentation)**

2. **Science Practice 6:** Using a magnetic model of a mass spectrometer, the teacher demonstrates that steel ball bearings of different masses will deflect different amounts as they roll past the magnet. Students are asked to make a prediction for how future masses (larger or smaller) will deflect relative to what they had observed previously. Afterward, students are asked which parameters of the setup could be modified to separate masses that are too large to be deflected or are so small that they stick to the magnet. Students must justify their suggestions with the results that they have observed for previous trials.

3. Students are given the percent ionization of *HF* at a particular concentration and volume. Students are then asked whether the percent ionization is altered when the volume is doubled by adding water. Students must justify their response qualitatively or quantitatively. **(Science Practice 6)**

Curricular Requirement 9

The course provides students with opportunities to apply their knowledge of AP Chemistry concepts to real-world questions or scenarios to help them become scientifically literate citizens.

Required Evidence

- ☐ The syllabus must label and provide a **brief description** of at least one assignment or activity requiring students to apply their knowledge of AP Chemistry concepts to understand real-world questions or scenarios.

Samples of Evidence

1. **Real World Investigation**

   After students complete the Kool Aid® chromatography lab, they write an analysis on the GRAS (generally regarded as safe) requirements, the use of, the chemical structure of, and problems associated with certain food dyes.

2. **Real World Application**

   Students solve a stoichiometry problem on the amount of carbon dioxide produced in the burning of a tankful of gasoline (assumed to be octane) with information on the size of the gas tank of the vehicle, the density of octane (0.7028 g mL^{-1}) and a variety of other conversion factors.

   Following the solution of this problem, we will discuss what happens to this carbon dioxide. We will talk about the greenhouse effect, whether the burning of fossil fuels contributes to global climate change, and if something should be done about the burning of fossil fuels (especially given current estimates for the amount of fossil fuel remaining in the earth and the students' estimated lifetimes).

3. **Current Events in Chemistry**

   The syllabus states that students select a *Chemical & Engineering News* article to summarize on a poster or in an oral presentation. The articles explore a wide variety of everyday products that involve recent innovations based on chemistry, environmental concerns, and technological components.

Curricular Requirement 10

Students spend a minimum of 25% of instructional time engaged in a wide range of hands-on, laboratory investigations to support the learning of required content and development of science practice skills throughout the course. At minimum, 16 labs are performed including at least 6 labs conducted in a guided inquiry format.

Required Evidence

- ☐ The syllabus must include an explicit statement that at least 25% of instructional time is spent engaged in hands-on laboratory experiences. Virtual labs do not count towards the 25% of instructional time, nor one of the 16 lab investigations. However, molecular modeling may count for one of the 16 hands-on labs.

  AND

- ☐ A minimum of 16 lab investigations with descriptive titles must be listed.

  AND

- ☐ A minimum of six investigations must be identified as guided inquiry.

Samples of Evidence

1. The syllabus states, "During the year, 25% of my instructional time will be used for lab experiments. We will be completing 16 labs, and 6 of them will be guided inquiry."

   Descriptive lab titles are included for each lab. Guided inquiry labs are labeled as "GI." For example:

   - Gravimetric analysis of calcium and hard water
   - Redox titration of hydrogen peroxide
   - Hand warmer lab **(GI)**

2. The syllabus includes a statement to indicate that 25% of class time is spent conducting lab investigations and includes 16 lab experiments, at least 6 of which are guided inquiry.

   The list of labs includes descriptive titles along with at least six guided inquiry labs labeled accordingly. For example:

   Descriptive titles:

   - Standardization of NaOH
   - Titration of Vitamin C

   Guided inquiry labs:

   - Heat of Fusion of Ice

3. The syllabus includes a statement specifying that a minimum of 25% of instructional time is spent engaged in laboratory investigations and provides a table listing at least 16 lab experiments, 6 of which are conducted in a guided inquiry format. The table includes the following information for each lab:

	Laboratory Title	Guided Inquiry
1	Kool-Aid Chromatography and Spectrophotometric Analysis of Food Dye	
2	Hess's Law to Determine Enthalpy of Formation for MgO	
3	Kinetic Study of the Bleaching of Food Coloring	✓

Curricular Requirement 11

The course provides opportunities for students to record evidence of their scientific investigations. Evidence can be recorded in lab reports or another appropriate formal manner for inclusion in lab notebooks/ portfolios (print or digital format).

Required Evidence

- ☐ The syllabus must include the components of the written reports required of students for all laboratory investigations.

  AND

- ☐ The syllabus must include an explicit statement that students are required to maintain a lab notebook or portfolio (hard-copy or electronic) that includes all their lab reports.

Samples of Evidence

1. Students submit a complete report for each lab experiment, including a hypothesis, procedure, observations/data, calculations, and a conclusion. All reports are kept in a lab notebook.

2. Students will submit their lab reports electronically. All reports will include the following sections and will be compiled into an electronic portfolio:
   - Purpose
   - Safety Considerations
   - Procedure
   - Data
   - Calculations
   - Claim
   - Evidence
   - Reasoning
   - Conclusions
   - Error Analysis

3. The syllabus provides information on scoring student lab reports that includes the components/sections required in reports and states that students compile all lab reports in a notebook or portfolio.

Section of Report*	Points Earned
Beginning Question(s)	
Safety Considerations	
Procedure (Pre-Lab)	
Experiment and Tests	
Claim(s)	
Evidence and Analysis	
Reading, Reflection, and Post-Lab Questions	

*All lab reports are compiled in a laboratory notebook.