Syllabus Development Guide: AP® Chemistry

The guide contains the following sections and information:

Curricular Requirements	The curricular requirements are the core elements of the course. Your syllabus must provide clear evidence that each requirement is fully addressed in your course.
Scoring Components	Some curricular requirements consist of complex, multipart statements. These particular requirements are broken down into their component parts and restated as "scoring components." Reviewers will look for evidence that each scoring component is included in your course.
Evaluation Guideline(s)	These are the evaluation criteria that describe the level and type of evidence required to satisfy each scoring component.
Key Term(s)	These ensure that certain terms or expressions, within the curricular requirement or scoring component that may have multiple meanings, are clearly defined.
Samples of Evidence For each scoring component, three separate samples of evidence are provided. These statements provide clear descriptions of what acceptable evidence should look like.	

Curricular Requirement 1	Students and teachers use a recently published (within the last 10 years) college-level chemistry textbook.
Evaluation Guideline(s)	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.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus cites a primary textbook from the AP® Example Textbook List for chemistry. 2. The syllabus cites an electronic version of a recent college-level primary textbook from the AP Example Textbook List for chemistry. 3. The syllabus cites a college-level primary textbook in chemistry used for science majors.

Curricular Requirement 2	The course is structured around the enduring understandings within the big ideas as described in the AP Chemistry Curriculum Framework.
Evaluation Guideline(s)	The syllabus must demonstrate how the course plan is structured around the enduring understandings in each of the big ideas as described in the AP Chemistry Curriculum Framework. While all six big ideas need to be explicit, each of the enduring understandings does not need to be specifically listed.
Key Term(s)	**Big ideas:** encompass the core scientific principles, theories, and processes governing chemical systems. **Enduring understandings:** incorporate the core concepts that students should retain from the learning experience.
Samples of Evidence	1. The syllabus contains a statement that the course is organized around the six big ideas, and the enduring understandings listed in the syllabus are tied into an appropriate list of textbook chapters. For example, Big Ideas 2, 3, and 4 are covered in Chapter 12 Aqueous Solutions. 2. The six big ideas are explicitly stated in the introduction of the syllabus, and enduring understandings are used throughout the syllabus as a structure for the course. For example, Big Ideas 1 through 6 are connected to applicable enduring understandings, within each unit of study. 3. The syllabus provides a table correlating the big ideas to the chapters used in the units of study. For example:

Chapters	**Big Ideas**
1. Matter & Measurement	1 and 2
2. Atoms, Molecules & Ions	1 and 2
3. Mass Relations in Chemistry; Stoichiometry	1 and 3

Curricular Requirement 3	Students are provided with opportunities to meet the learning objectives within each of the big ideas as described in the AP Chemistry Curriculum Framework. These opportunities must occur in addition to those within laboratory investigations.
Scoring Component 3a	The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 1: Structure of matter.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 1.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 1.17*** *The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings.* Students are provided manipulatives (symbols and shapes of reactants and products) to express symbolically the law of conservation of mass. Based on the written and balanced reactions provided, students create associated particulate drawings. 2. ***Learning Objective 1.9*** *The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model.* Students construct a graph of ionization energy versus atomic number for the first 54 elements. Students then predict trends and justify exceptions in a class discussion. 3. ***Learning Objective 1.4*** *The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.* Students are given a problem set and asked to determine the limiting reagents for a chemical reaction (e.g., interconverts particles, moles, mass, and volume of given substances).

Curricular Requirement 3	Students are provided with opportunities to meet the learning objectives within each of the big ideas as described in the AP Chemistry Curriculum Framework. These opportunities must occur in addition to those within laboratory investigations.
Scoring Component 3b	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.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 2.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 2.1*** *The student can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.* Students work in groups to connect given substance properties to chemical formulae and express such a connection of a substance property to a chemical formula through a group-drawn particle view. Then students individually predict substance properties based on chemical formula. 2. ***Learning Objective 2.17*** *The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements.* Given combinations of atoms, students use the periodic table to predict the type of bonding present (i.e., ionic, covalent, metallic). 3. ***Learning Objective 2.16*** *The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces.* Students are presented with the structure of two similar compounds and then write an explanation as to why they differ in physical state under standard conditions (e.g., why is methane a gas and water a liquid?)

Curricular Requirement 3	Students are provided with opportunities to meet the learning objectives within each of the big ideas as described in the AP Chemistry Curriculum Framework. These opportunities must occur in addition to those within laboratory investigations.
Scoring Component 3c	The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 3: Chemical reactions.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 3.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 3.2*** *The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances.* Students observe a demonstration of a series of chemical reactions and then write appropriately balanced chemical equations. 2. ***Learning Objective 3.8*** *The student is able to identify redox reactions and justify the identification in terms of electron transfer.* Students are given a set of reactions from which they will identify the oxidation and the reduction half reactions. 3. ***Learning Objective 3.11*** *The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes.* Students observe a demonstration and then draw an energy diagram to illustrate what is occurring on a particulate level (e.g., energy transformation of ammonium thiocyanate and barium hydroxide).

Curricular Requirement 3	Students are provided with opportunities to meet the learning objectives within each of the big ideas as described in the AP Chemistry Curriculum Framework. These opportunities must occur in addition to those within laboratory investigations.
Scoring Component 3d	The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 4: Rates of chemical reactions.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 4.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 4.6*** *The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate.* In collaborative groups, students compare and contrast different energy profiles evaluating both the reaction energetics and how a change in temperature alters the rate of the reaction and why. 2. ***Learning Objective 4.2*** *The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.* Students orally present the solution to a problem given a set of data of concentration against time to the class, indicating the order of the reaction and the rate constant with appropriate units. 3. ***Learning Objective 4.5*** *The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation.* Students view a computer animation and provide explanations for effective and ineffective collisions that lead to chemical reactions.

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Scoring Component 3e	The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 5: Thermodynamics.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 5.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 5.13*** *The student is able to predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed.* Students solve problems in which they qualitatively and quantitatively predict the signs and magnitude of $\Delta H°$, $\Delta S°$, and $\Delta G°$ from a set of thermochemical data. 2. ***Learning Objective 5.16*** *The student is able to use LeChatelier's principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product.* Students predict the effect of adding carbon dioxide to the hydrogen carbonate ion/carbonic acid system in blood. 3. ***Learning Objective 5.7*** *The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure.* As a pre-lab assignment, students calculate the efficiency (joules per gram) of a variety of fuels when given their heats of combustion and the formulae.

Curricular Requirement 3	Students are provided with opportunities to meet the learning objectives within each of the big ideas as described in the AP Chemistry Curriculum Framework. These opportunities must occur in addition to those within laboratory investigations.
Scoring Component 3f	The course provides students with opportunities outside the laboratory environment to meet the learning objectives within Big Idea 6: Equilibrium.
Evaluation Guideline(s)	The syllabus must briefly describe at least one assignment or activity outside the laboratory environment designed to meet one learning objective within Big Idea 6.
Key Term(s)	**Learning objectives:** provide clear and detailed articulation of what students should know and be able to do.
Samples of Evidence	1. ***Learning Objective 6.5*** *The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K.* Students use data to calculate the concentration of either reactant or products or use these quantities to calculate the equilibrium constant. 2. ***Learning Objective 6.3*** *The student can connect kinetics to equilibrium by using reasoning about equilibrium, such as LeChatelier's principle, to infer the relative rates of the forward and reverse reactions.* Students determine the concentration of species at equilibrium given the rate constant and the concentration of other species in the reaction at equilibrium. Students will apply LeChatelier's principle quantitatively to equilibrium systems that are altered. 3. ***Learning Objective 6.20*** *The student can identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base.* In a written assignment, students identify the components of a buffer solution, identify the species present, and qualitatively predict and explain the changes in concentration of those species on addition of acid or base.

Curricular Requirement 4	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.
Evaluation Guideline(s)	The syllabus must describe at least one assignment or activity requiring students to connect their knowledge of chemistry and science to issues that have a societal or technological component.
Key Term(s)	None at this time.
Samples of Evidence	1. ***Essential Knowledge 1.D.1.a:*** *Scientists use experimental results to test scientific models. When experimental results are not consistent with the predictions of a scientific model, the model must be revised or replaced with a new model that is able to predict/explain the new experimental results. A robust scientific model is one that can be used to explain/predict numerous results over a wide range of experimental circumstances.* Students use a temperature probe to monitor the temperature of the air in a sample being warmed by an incandescent lightbulb. In this supervised inquiry activity, students have access to cylinders of the laboratory gases nitrogen, carbon dioxide, oxygen, and a spray bottle for water vapor. The air in the bottle simulates Earth's atmosphere as students research and learn about global warming, and the greenhouse effect. 2. ***Essential Knowledge 1.C.1.d:*** *Periodicity is a useful tool when designing new molecules or materials, since replacing an element of one group with another of the same group may lead to a new substance with similar properties.* The syllabus states that students select a *Chemical & Engineering News* article to summarize on a poster or a class oral presentation. The articles cover a wide variety of everyday products that involve innovations based on chemistry, environmental concerns, and technological components. 3. ***Essential Knowledge 6.A.1.a:*** *Many readily observable processes are reversible.* Students write a report whereby they make claims as to the effects of increased carbon dioxide in the atmosphere on the carbon cycle and climate change, basing their claims on concepts from the chapter on Environmental Science.

Curricular Requirement 5	Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time, which must include a minimum of 16 hands-on laboratory experiments while using basic laboratory equipment to support the learning objectives listed within the AP Chemistry Curriculum Framework.
Scoring Component 5a	Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time.
Evaluation Guideline(s)	The syllabus must include an explicit statement that at least 25 percent of instructional time is spent in hands-on laboratory experiences integrated throughout the course. Virtual labs do not count towards the 25 percent of instructional time.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus includes the following statement: “Students are engaged in hands-on laboratory work, integrated throughout the course, which accounts for 25 percent of the course.” 2. The syllabus states that the total hands-on lab time will be a minimum of 25 percent of total instructional time, with investigations distributed throughout the course. 3. The syllabus includes a statement to indicate that 25 percent of this course is spent doing hands-on laboratory investigations.

Curricular Requirement 5	Students are provided the opportunity to engage in investigative laboratory work integrated throughout the course for a minimum of 25 percent of instructional time, which must include a minimum of 16 hands-on laboratory experiments while using basic laboratory equipment to support the learning objectives listed within the AP Chemistry Curriculum Framework.
Scoring Component 5b	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.
Evaluation Guideline(s)	The syllabus must include and describe a minimum of 16 hands-on laboratory investigations that use basic laboratory equipment. Molecular modeling may count for one of the 16 hands-on labs.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus lists and describes 16 hands-on experiments by title. 2. The syllabus cites all labs in the *AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices* (e.g., How Can Color Be Used to Determine the Mass Percent of Copper in Brass?) 3. The syllabus lists the title of 16 experiments from an established lab manual of college-level hands-on chemistry experiments.

Curricular Requirement 6	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.
Evaluation Guideline(s)	The syllabus must list all laboratory investigations and their associated science practices. A minimum of six investigations must be identified as guided inquiry.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus identifies six guided-inquiry investigations. The seven science practices are also identified. For example, the syllabus includes the following description: **Lab Title:** Chromatography of Popular Consumer Beverages (guided inquiry) **Science Practice(s): 4 and 5** ***Skills applied:*** Students design a plan for collecting data to answer a particular scientific question (the identities of FD&C dyes), and compare and analyze the collected data from several beverages to identify patterns or relationships. 2. The syllabus provides a title of six guided-inquiry labs from the AP Chemistry Lab Manual. All labs are associated with one science practice or more. **Lab Title:** What Makes Hard Water Hard? (guided inquiry) **SP: 4.2 and 5.1** 3. The seven science practices are illustrated in a matrix which describes how they are used by teachers and students for all laboratory investigations. For example:

Guided Inquiry Investigation	Science Practice(s)
Colorimetric Determination of the Mass Percent of Copper in a Penny.	4.2: The student can design a plan for collecting data to answer a particular scientific question; 5.1: The student can analyze data to identify patterns or relationships.

Curricular Requirement 7	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.
Evaluation Guideline(s)	The syllabus must include the components of the written lab reports required of students for all the laboratory investigations engaged in throughout the course. 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 of their lab reports.
Key Term(s)	**Lab report components:** examples could include purpose, procedure, data, data analysis, error analysis, statistics, and conclusion.
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. Students orally present lab findings based on their written lab reports. 2. The syllabus indicates that a laboratory report is required for all hands-on experiments and a section pertaining to the laboratory component of the syllabus delineates the essential elements of the laboratory report. All reports are kept in a lab notebook. 3. A set of laboratory reports, each consisting of the following: purpose, procedure, data, data analysis, error analysis, statistics, and conclusion, is collected in a laboratory notebook or electronic portfolio for the students to present to the college of their choice.

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