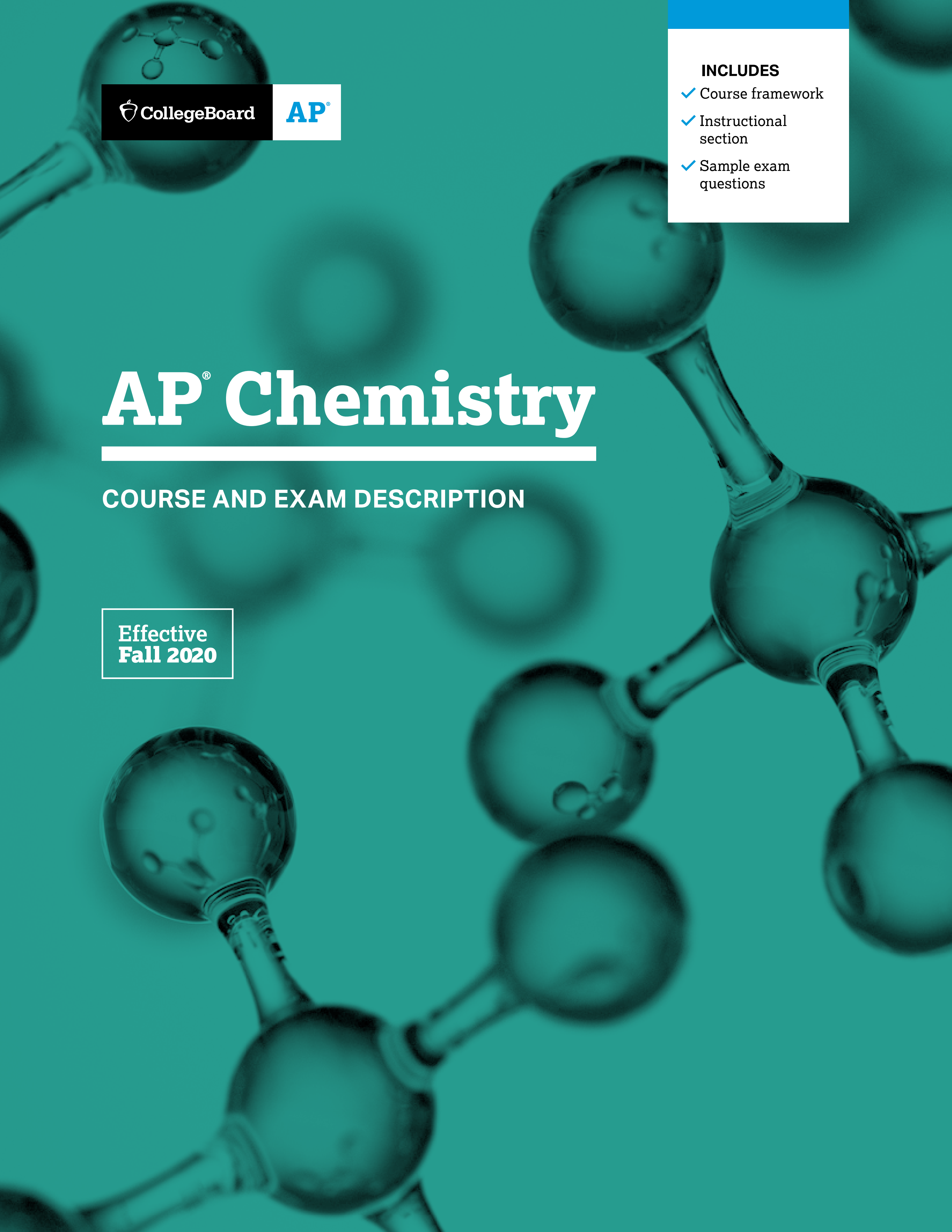

CollegeBoard AP®

INCLUDES

- ✓ Course framework
- ✓ Instructional section
- ✓ Sample exam questions

AP® Chemistry

COURSE AND EXAM DESCRIPTION

Effective
Fall 2020

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AP COURSE AND EXAM DESCRIPTIONS ARE UPDATED PERIODICALLY

Please visit AP Central (apcentral.collegeboard.org) to determine whether a more recent course and exam description is available.

Introduction

Given the speed with which scientific discoveries and research continuously expand scientific knowledge, many educators are faced with the challenge of balancing breadth of content coverage with depth of understanding. The AP Chemistry course addresses this challenge by focusing on a model of instruction which promotes enduring conceptual understandings and the content that supports them. This approach enables students to spend less time on factual recall and more time on inquiry-based learning of essential concepts, and it helps them develop the reasoning skills necessary to engage in the science practices used throughout their study of AP Chemistry.

To foster this deeper level of learning, the AP Chemistry content is defined in a way that distinguishes content essential to support the enduring understandings from the many examples or applications that can overburden the course. Content that is outside the scope of the course and exam is also identified.

This framework encourages student development of inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, creating models and representations, applying mathematical routines, developing a scientific argument, and connecting concepts in and across domains.

Students who receive a qualifying score on the AP Chemistry Exam may be able to take second-year chemistry coursework in their first year at their undergraduate institution. Or, their score may fulfill their institution's lab science requirements thereby freeing time for other courses.

Course Framework Components

Overview

This course framework provides a clear and detailed description of the course requirements necessary for student success. The framework specifies what students must know, be able to do, and understand to qualify for college credit or placement.

The course framework includes two essential components:

1 SCIENCE PRACTICES

The science practices are central to the study and practice of chemistry. Students should develop and apply the described practices on a regular basis over the span of the course.

2 COURSE CONTENT

The course content is organized into commonly taught units of study that provide a suggested sequence for the course. These units comprise the content and conceptual understandings that colleges and universities typically expect students to master to qualify for college credit and/or placement. This content is grounded in big ideas, which are cross-cutting concepts that build conceptual understanding and spiral throughout the course.

AP CHEMISTRY

Science Practices

Practice 1	Practice 2	Practice 3
Models and Representations 1 Describe models and representations, including across scales.	***Question and Method*** 2 Determine scientific questions and methods.	***Representing Data and Phenomena*** 3 Create representations or models of chemical phenomena.

SKILLS

1.A Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only. **1.B** Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic-level properties.	**2.A** Identify a testable scientific question based on an observation, data, or a model. **2.B** Formulate a hypothesis or predict the results of an experiment. **2.C** Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup). **2.D** Make observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate. **2.E** Identify or describe potential sources of experimental error. **2.F** Explain how modifications to an experimental procedure will alter results.	**3.A** Represent chemical phenomena using appropriate graphing techniques, including correct scale and units. **3.B** Represent chemical substances or phenomena with appropriate diagrams or models (e.g., electron configuration). **3.C** Represent visually the relationship between the structures and interactions across multiple levels or scales (e.g., particulate to macroscopic).

Science Practices *(cont'd)*

Practice 4

Model Analysis 4

Analyze and interpret models and representations on a single scale or across multiple scales.

4.A Explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations.

4.B Explain whether a model is consistent with chemical theories.

4.C Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.

4.D Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.

Practice 5

Mathematical Routines 5

Solve problems using mathematical relationships.

5.A Identify quantities needed to solve a problem from given information (e.g., text, mathematical expressions, graphs, or tables).

5.B Identify an appropriate theory, definition, or mathematical relationship to solve a problem.

5.C Explain the relationship between variables within an equation when one variable changes.

5.D Identify information presented graphically to solve a problem.

5.E Determine a balanced chemical equation for a given chemical phenomenon.

5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g., performing dimensional analysis and attending to significant figures).

Practice 6

Argumentation 6

Develop an explanation or scientific argument.

6.A Make a scientific claim.

6.B Support a claim with evidence from experimental data.

6.C Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.

6.E Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.

6.F Explain the connection between experimental results and chemical concepts, processes, or theories.

6.G Explain how potential sources of experimental error may affect the experimental results.

2

AP CHEMISTRY

Course Content

Based on the Understanding by Design® (Wiggins and McTighe) model, this course framework provides a clear and detailed description of the course requirements necessary for student success. The framework specifies what students must know, be able to do, and understand, with a focus on big ideas that encompass core principles and theories of the discipline. The framework also encourages instruction that prepares students for advanced chemistry coursework.

Big Ideas

The big ideas serve as the foundation of the course and allow students to create meaningful connections among concepts. They are often abstract concepts or themes that become threads that run throughout the course. Revisiting the big ideas and applying them in a variety of contexts allows students to develop deeper conceptual understanding. Below are the big ideas of the course and a brief description of each.

BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY (SPQ)
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.

BIG IDEA 2: STRUCTURE AND PROPERTIES (SAP)
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.

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BIG IDEA 3: TRANSFORMATIONS (TRA)

At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.

BIG IDEA 4: ENERGY (ENE)

Energy has two important roles in characterizing and controlling chemical systems. The first is accounting for the distribution of energy among the components of a system and the ways that heat exchanges, chemical reactions, and phase transitions redistribute this energy. The second is in considering the enthalpic and entropic driving forces for a chemical process. These are closely related to the dynamic equilibrium present in many chemical systems and the ways in which changes in experimental conditions alter the positions of these equilibria.

UNITS

The course content is organized into commonly taught units. The units have been arranged in a logical sequence frequently found in many college courses and textbooks.

The nine units in AP Chemistry, and their weighting on the multiple-choice section of the AP Exam, are listed below.

Pacing recommendations at the unit level and on the Course at a Glance provide suggestions for how to teach the required course content and administer the Personal Progress Checks. The suggested class periods are based on a schedule in which the class meets five days a week for 45 minutes each day.

While these recommendations have been made to aid planning, teachers should of course adjust the pacing based on the needs of their students, alternate schedules (e.g., block scheduling), or their school's academic calendar.

TOPICS

Each unit is broken down into teachable segments called topics. The topic pages (starting on p. 36) contain the required content for each topic. Although most topics can be taught in one or two class periods, teachers should pace the course to suit the needs of their students and school.

Units	Exam Weighting
Unit 1: Atomic Structure and Properties	**7–9%**
Unit 2: Molecular and Ionic Compound Structure and Properties	**7–9%**
Unit 3: Intermolecular Forces and Properties	**18–22%**
Unit 4: Chemical Reactions	**7–9%**
Unit 5: Kinetics	**7–9%**
Unit 6: Thermodynamics	**7–9%**
Unit 7: Equilibrium	**7–9%**
Unit 8: Acids and Bases	**11–15%**
Unit 9: Applications of Thermodynamics	**7–9%**

Spiraling the Big Ideas

The following table shows how the big ideas spiral across units.

Big Ideas	Unit 1 Atomic Structure 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
Scale, Proportion, and Quantity SPQ	✓		✓	✓					✓
Structure and Properties SAP	✓	✓	✓					✓	✓
Transformations TRA				✓	✓		✓		
Energy ENE					✓	✓			✓

Course at a Glance

Plan

The Course at a Glance provides a useful visual organization of the AP Chemistry curricular components, including:

- Sequence of units, along with approximate weighting and suggested pacing. Please note, pacing is based on 45-minute class periods, meeting five days each week for a full academic year.
- Progression of topics within each unit.
- Spiraling of the big ideas and science practices across units.

Teach

SCIENCE PRACTICES
Science practices spiral throughout the course.

- 1 Models and Representations
- 2 Question and Method
- 3 Representing Data and Phenomena
- 4 Model Analysis
- 5 Mathematical Routines
- 6 Argumentation

BIG IDEAS
Big ideas spiral across topics and units.

- SPQ Scale, Proportion, and Quantity
- SAP Structure and Properties
- TRA Transformations
- ENE Energy

Assess

Assign the Personal Progress Checks—either as homework or in class—for each unit. Each Personal Progress Check contains formative multiple-choice and free-response questions. The feedback from the Personal Progress Checks shows students the areas where they need to focus.

UNIT 1 Atomic Structure and Properties

~9–10 Class Periods | 7–9% AP Exam Weighting

Big Idea	Science Practice	Topic
SPQ	5	1.1 Moles and Molar Mass
SPQ	5	1.2 Mass Spectroscopy of Elements
SPQ	2	1.3 Elemental Composition of Pure Substances
SPQ	5	1.4 Composition of Mixtures
SAP	1	1.5 Atomic Structure and Electron Configuration
SAP	4	1.6 Photoelectron Spectroscopy
SAP	4	1.7 Periodic Trends
SAP	4	1.8 Valence Electrons and Ionic Compounds

Personal Progress Check 1

Multiple-choice: ~20 questions
Free-response: 2 questions

- Short-answer
- Short-answer

UNIT 2 Molecular and Ionic Compound Structure and Properties

~12–13 Class Periods | 7–9% AP Exam Weighting

Big Idea	Science Practice	Topic
SAP	6	2.1 Types of Chemical Bonds
SAP	3	2.2 Intramolecular Force and Potential Energy
SAP	4	2.3 Structure of Ionic Solids
SAP	4	2.4 Structure of Metals and Alloys
SAP	3	2.5 Lewis Diagrams
SAP	6	2.6 Resonance and Formal Charge
SAP	6	2.7 VSEPR and Bond Hybridization

Personal Progress Check 2

Multiple-choice: ~15 questions
Free-response: 1 question

- Long-answer

continued on next page

UNIT 3 Intermolecular Forces and Properties

~14–15 Class Periods | 18–22% AP Exam Weighting

SAP 4	3.1	Intermolecular Forces
SAP 4	3.2	Properties of Solids
SAP 3	3.3	Solids, Liquids, and Gases
SAP 5	3.4	Ideal Gas Law
SAP 4	3.5	Kinetic Molecular Theory
SAP 6	3.6	Deviation from Ideal Gas Law
SPQ 5	3.7	Solutions and Mixtures
SPQ 3	3.8	Representations of Solutions
SPQ 2	3.9	Separation of Solutions and Mixtures Chromatography
SPQ 4	3.10	Solubility
SAP 4	3.11	Spectroscopy and the Electromagnetic Spectrum
SAP 5	3.12	Photoelectric Effect
SAP 2	3.13	Beer-Lambert Law

Personal Progress Check 3

Multiple-choice: ~30 questions
Free-response: 2 questions
- Short-answer
- Short-answer

UNIT 4 Chemical Reactions

~14–15 Class Periods | 7–9% AP Exam Weighting

TRA 2	4.1	Introduction for Reactions
TRA 5	4.2	Net Ionic Equations
TRA 3	4.3	Representations of Reactions
TRA 6	4.4	Physical and Chemical Changes
SPQ 5	4.5	Stoichiometry
SPQ 3	4.6	Introduction to Titration
TRA 1	4.7	Types of Chemical Reactions
TRA 1	4.8	Introduction to Acid-Base Reactions
TRA 5	4.9	Oxidation-Reduction (Redox) Reactions

Personal Progress Check 4

Multiple-choice: ~20 questions
Free-response: 1 question
- Long-answer

UNIT 5 Kinetics

~13–14 Class Periods | 7–9% AP Exam Weighting

TRA 6	5.1	Reaction Rates
TRA 5	5.2	Introduction to Rate Law
TRA 5	5.3	Concentration Changes Over Time
TRA 5	5.4	Elementary Reactions
TRA 6	5.5	Collision Model
TRA 3	5.6	Reaction Energy Profile
TRA 1	5.7	Introduction to Reaction Mechanisms
TRA 5	5.8	Reaction Mechanism and Rate Law
TRA 5	5.9	Steady-State Approximation
TRA 3	5.10	Multistep Reaction Energy Profile
ENE 6	5.11	Catalysis

Personal Progress Check 5

Multiple-choice: ~25 questions
Free-response: 2 questions
- Short-answer
- Long-answer

continued on next page

UNIT 6 Thermodynamics

~10–11 Class Periods | 7–9% AP Exam Weighting

ENE 6	6.1	Endothermic and Exothermic Processes
ENE 3	6.2	Energy Diagrams
ENE 6	6.3	Heat Transfer and Thermal Equilibrium
ENE 2	6.4	Heat Capacity and Calorimetry
ENE 1	6.5	Energy of Phase Changes
ENE 4	6.6	Introduction to Enthalpy of Reaction
ENE 5	6.7	Bond Enthalpies
ENE 5	6.8	Enthalpy of Formation
ENE 5	6.9	Hess's Law

Personal Progress Check 6

Multiple-choice: ~20 questions
Free-response: 2 questions
- Short-answer
- Short-answer

UNIT 7 Equilibrium

~14–16 Class Periods | 7–9% AP Exam Weighting

TRA 6	7.1	Introduction to Equilibrium
TRA 4	7.2	Direction of Reversible Reactions
TRA 3	7.3	Reaction Quotient and Equilibrium Constant
TRA 5	7.4	Calculating the Equilibrium Constant
TRA 6	7.5	Magnitude of the Equilibrium Constant
TRA 5	7.6	Properties of the Equilibrium Constant
TRA 3	7.7	Calculating Equilibrium Concentrations
TRA 3	7.8	Representations of Equilibrium
TRA 6	7.9	Introduction to Le Châtelier's Principle
TRA 5	7.10	Reaction Quotient and Le Châtelier's Principle
SPQ 5	7.11	Introduction to Solubility Equilibria
SPQ 2	7.12	Common-Ion Effect
SPQ 2	7.13	pH and Solubility
SPQ 4	7.14	Free Energy of Dissolution

Personal Progress Check 7

Multiple-choice: ~30 questions
Free-response: 2 questions
- Short-answer
- Long-answer

UNIT 8 Acids and Bases

~14–15 Class Periods | 11–15% AP Exam Weighting

SAP 5	8.1	Introduction to Acids and Bases
SAP 5	8.2	pH and pOH of Strong Acids and Bases
SAP 5	8.3	Weak Acid and Base Equilibria
SAP 5	8.4	Acid-Base Reactions and Buffers
SAP 5	8.5	Acid-Base Titrations
SAP 6	8.6	Molecular Structure of Acids and Bases
SAP 2	8.7	pH and pK_a
SAP 6	8.8	Properties of Buffers
SAP 5	8.9	Henderson-Hasselbalch Equation
SAP 6	8.10	Buffer Capacity

Personal Progress Check 8

Multiple-choice: ~30 questions
Free-response: 1 question
- Long-answer

continued on next page

UNIT 9 Applications of Thermodynamics

~10–13 Class Periods | **7–9%** AP Exam Weighting

Personal Progress Check 9

Multiple-choice: ~30 questions
Free-response: 2 questions

- Short-answer
- Long-answer