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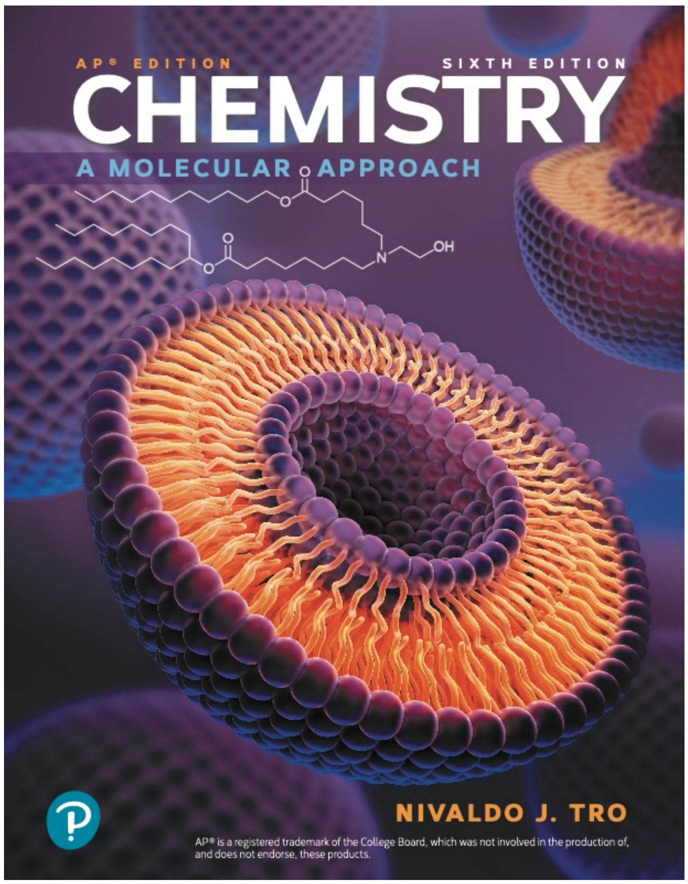

To the
College Board's AP® Chemistry Course and Exam Description Dated Fall 2020

Tips for AP Chemistry Exam Success

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Marian taught AP Chemistry at Centennial High School in Boise, Idaho. She earned the Presidential Award for Excellence in Science Teaching in 2009. Marian has been involved with the AP exam as a question writer, reader, table leader, and question leader.

Thomas served on the Advanced Placement Chemistry College Board Test Development Committee and has been involved with the reading of the exam. He has served as a reader, table leader, and question leader.

The tips below are based on the College Board's Curriculum Framework for AP Chemistry. This framework can be found at https://apcentral.collegeboard.org/pdf/ap-chemistry-course-and-exam-description.pdf?course=ap-chemistry. The AP Chemistry exam is offered each May. The exact date varies per year, but it is during the first of the month. These tips are based on the current Framework at the time of publication. Additional tips can be found at www.PearsonSchool. com/advanced.

The AP Exam

The Advanced Placement Chemistry Exam is comprehensive and includes most topics of a first-year general chemistry college course. The exam has two parts; multiple choice and free response. Each section is worth 50% of the total score.

The Multiple-Choice: For this section of the exam, you will get a periodic table and equation sheet. There are sixty (60) multiple-choice questions to do in ninety (90) minutes, and each has four choices. No points are deducted for a wrong answer, so guessing is OK. Approximately half of the questions will be "grouped" style. This means there will be one set of data or diagrams, and there will be several questions from the data. All the questions are tied to a learning objective and science practice as defined by the College Board. The learning objectives each have specific material they encompass, the science practices represent skills expected to be able to be demonstrated in answers.

Strategy: Answer every multiple-choice question!

Strategy: Practice with the periodic table and equation sheet from the sample exam during the school year so you are familiar with it. It will be very helpful to know commonly used masses and where to find equations and constants while taking the exam.

The Free Response: In this section of the exam, you will not only use the same periodic table and equation pages but also a calculator. There are seven (7) free response questions. Of the seven questions, the first three are long questions are worth ten (10) points each and have many subparts. The last four questions worth four (4) points each are short questions with generally two or three parts. Total time allowed for this section of the exam is 105 minutes. Each question in its subparts will cover a variety of topics. Most questions will involve more than one concept in chemistry. In all questions, you will be asked to explain concepts, show you understand lab design, show you know how to apply mathematics, and apply all the science practices.

In the test prep book, sample questions of both types of questions are provided in each section as well as a full-length practice exam at the end.

*Be cautious when using older exams or guidebooks or following guidance from those who have taken the exam before 2019.

Strategy: Practice explaining concepts and providing the evidence supporting the answer in three sentences or less.

Strategy: Any vocabulary in the learning objectives you do not know, make into flashcards and learn them. The vocabulary in the learning objectives is often used on the exam.

The AP Curriculum

The AP curriculum has been separated into nine units. These are as follows:

1. *Atomic Structure and Properties*
2. *Molecular and Ionic Compound Structure and Properties*
3. *Intermolecular Forces and Properties*
4. *Chemical Reactions*
5. *Kinetics*
6. *Thermodynamics*
7. *Equilibrium*
8. *Acids and Bases*
9. *Applications of Thermodynamics*

Going across all these units are four Big Ideas: 1. Scale, Proportion, and Quantity (SPQ), 2. Structure and Properties (SAP), 3. Transformations (TRA), and 4. Energy (ENE).

Each Unit is broken into enduring understandings and learning objectives. Under these, the essential knowledge identify what students should know and be able to do. These learning objectives are important as all the AP test questions come from the learning objectives and can be combined with ANY science practice. This book has excellent explanations and diagrams that will help the student understand the concepts. It is good practice is to be able to explain any of the learning objectives in clear concise language and use a diagram in the explanation.

Strategy: Have each learning objective on an Index card and on the back make all your notes on the topic. Review your index cards each week.

Strategy: Also practice writing out explanations each week. The learning objectives in each chapter are identified in the overview of each chapter in the next section.

AP Science Practices

These practices can be combined with any learning objective in a test question. SP 3 will be a question in the free response since it requires representing a concept (drawing).

1. **Models and Representations**

    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. **Question and Method**

    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 representa-tions 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. **Representing Data and Phenomena**

    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).

4. **Model Analysis**

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

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

    4.C: Explain the connections between particulate-level and macroscopic-level 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.

5. **Mathematical Routines**

    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).

6. **Argumentation**

    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.

The processes students must be able to do on the test include the following commonly used task verbs:

1. Calculate: perform mathematical steps showing work and with correct labeling of units and significant figures.
2. Describe: Provide the relevant characteristics of a specified topic.
3. Determine: Arrive at a conclusion after reasoning, observation, or applying mathematical routines.
4. Estimate: Roughly calculate numerical quantities, values, or signs of quantities based on experimental evidence or on provided data.
5. Explain: Provide information about how a relationship, process, pattern, position, situation, or outcome occurs using evidence and/or reasoning to support or qualify a claim. May be stated explain how, explain why, or give a reason.
6. Identify/Indicate/circle: Indicate or provide information about a specific topic, Also phrased “Which” or “What is.”
7. Justify: Provide evidence to support, qualify, or defend a claim and/or provide reasoning to explain how the evidence qualifies the claim.
8. Make a claim: Make an assertion that is based on evidence or knowledge.
9. Predict/Make a prediction: Predict the cause or effects of a change in, or disruption to, one or more components in a relationship, pattern, process, or system.
10. Represent/Draw/Write and Equation/Complete a diagram: Use appropriate graphs. symbols, words, and/or models to describe phenomena, characteristics, and/or relationships.

AP Correlation Guide

This chart correlates the College Board's Advanced Placement Units and Unit Topics, which are aligned to the Enduring Understandings and Learning Objectives in the curriculum, to the corresponding chapters and sections in Chemistry: A Molecular Approach 5th Edition, AP® Edition.

Unit 1: Atomic Structure and Properties (8 topics) 7–9%

Big Ideas in this Unit are: Scale, Proportion, and Quantity (SPQ) and Structure and Properties (SAP)

SPQ-1: The mole allows different units to be compared.

SPQ-2. Chemical formulas identify substances by their unique combination of atoms.

SAP-1. Atoms and molecules can be identified by their electron distribution and energy.

SAP-2. The periodic table shows patterns in electronic structure and trends in atomic properties.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
1.1	Moles and Molar Mass	SPQ-1	SPQ-1.A Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.	2.9, 3.8, 3.9
1.2	Mass Spectroscopy of Elements	SPQ-1	SPQ-1.B Explain the qualitative relationship between the mass spectrum of an element and the masses of the element's isotopes.	2.6, 2.8
1.3	Elemental Composition of Pure Substances	SPQ-2	SPQ-2.A Explain the quantitative relationship between the elemental composition by mass and empirical formula of a pure substance.	1.3, 2.3, 3.3, 3.4, 3.9
1.4	Composition of Mixtures	SPQ-2	SPQ-2.B Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.	1.3, 3.9, 3.10
1.5	Atomic Structure and Electron Configuration	SAP-1	SAP-1.A Represent the electron configuration of an element or ions of an element using the Aufbau principle.	2.5, 2.6 9.2–9.7
1.6	Photoelectron Spectroscopy	SAP-1	SAP-1.B Explain the relationship between the photoelectron spectrum of an atom or ion and • the electron configuration of the species. • the interactions between the electrons and the nucleus.	refer to the AP Test Prep book to accompany Tro
1.7	Periodic Trends	SAP-2	SAP-2.A Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.	9.4–9.9, 10.6
1.8	Valence Electrons and Ionic Compounds	SAP-2	SAP-2.B Explain the relationship between trends in the reactivity of elements and periodicity.	4.5, 9.4, 9.5, 10.2–10.4

Unit 2: Molecular and Ionic Compound Structure and Properties (7 topics) 7–9%

Big Idea in this Unit is: Structure and Properties (SAP)

SAP-3. Atoms or ions bond due to interactions between them, forming molecules.

SAP-4. Molecular compounds are arranged based on Lewis diagrams and Valence Shell Electron Pair Repulsion (VSEPR) theory.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
2.1	Types of Chemical Bonds	SAP-3	SAP-3.A Explain the relationship between the type of bonding and the properties of the elements participating in the bond.	10.2–10.6, 10.11, 11.5
2.2	Intramolecular Force and Potential Energy	SAP-3	SAP-3.B Represent the relationship between potential energy and the distance between atoms, based on factors that influence the interaction strength.	10.2, 10.4, 10.5, 11.6

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
2.3	Structure of Ionic Solids	SAP-3	SAP-3.C Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constit-uent ions.	10.2, 10.4, 13.4, 13.5
2.4	Structure of Metals and Alloys	SAP-3	SAP-3.D Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance.	10.2,10.11, 13.4, 25.4
2.5	Lewis Diagrams	SAP-4	SAP-4.A Represent a molecule with a Lewis diagram.	10.1–10.3, 10.5, 10.7, 11.2–11.5
2.6	Resonance and Formal Charge	SAP-4	SAP-4.B Represent a molecule with a Lewis dia-gram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures.	10.8, 10.9
2.7	VSEPR and Bond Hybridization	SAP-4	SAP-4.C Based on the relationship between Lewis dia-grams, VSEPR theory, bond orders, and bond polarities— • Explain structural properties of molecules. • Explain electron properties of molecules.	11.2–11.7

Unit 3: Intermolecular Forces and Properties (13 topics) 18–22%

Big Ideas in this Unit are: Scale, Proportion, and Quantity (SPQ) and Structure and Properties (SAP)

SAP-5 Intermolecular Forces can explain the physical properties of a material.

SAP-6 Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and mo-tion of molecules.

SAP-7 Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, and gas constant—and the molecularly by the motion of the gas.

SPQ-3 Interactions between intermolecular forces influence the solubility and separation of mixtures. SAP-8 Spectros-copy can determine the structure and concentration in a mixture of a chemical species.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
3.1	Intermolecular Forces	SAP-5	SAP-5.A Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when— • The molecules are of the same chemical species. • The molecules are of two different chemical species.	12.3, 23.5
3.2	Properties of Solids	SAP-5	SAP-5.B Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.	10.2, 10.11, 12.2–12.5, 13.4, 13.5, 13.6, 13.9, 25.4
3.3	Solids, Liquids, and Gases	SAP-6	SAP-6.A Represent the differences between solid, liquid, and gas phases using a particulate-level model.	6.2, 6.3,12.2, 13.4, 13.5
3.4	Ideal Gas Law	SAP-7	SAP-7.A Explain the relationship between the macroscopic properties of a sample of a gas or mixture of gases using the ideal gas law.	6.3–6.6

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
3.5	Kinetic Molecular Theory	SAP-7	SAP-7.B Explain the relationship between the motion of particles and the macroscopic proper-ties of gases with— • The kinetic molecular theory (KMT) • A particulate model • A graphical representation.	6.8
3.6	Deviations from Ideal Gas Law	SAP-7	SAP-7.C Explain the relationship among nonideal behaviors of gases, interparticle forces, and/or volumes.	6.10
3.7	Solutions and Mixtures	SPQ-3	SPQ-3.A Calculate the number of solute particles, volume, or molarity of solutions.	5.2, 14.2, 14.5
3.8	Representations of Solutions	SPQ-3	SPQ-3.B Using particulate models for mixtures— • Represent interactions between components. • Represent concentrations of components.	14.2, 14.3
3.9	Separation of Solutions and Mixtures Chromatography	SPQ-3	SPQ-3.C Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interac-tions between particles.	1.3, 14.2, 14.3, 14.4, refer to the AP Test Prep book to accompany Tro
3.10	Solubility	SPQ-3	SPQ-3.C2 Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interac-tions between particles.	12.3, 14.2, 14.3, 14.4
3.11	Spectroscopy and the Elec-tromagnetic Spectrum	SAP-8	SAP-8.A Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions asso-ciated with that region.	8.2, refer to the AP Test Prep book to accom-pany Tro
3.12	Photoelectric Effect	SAP-8	SAP-8.B Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or a molecule.	8.2, 8.3
3.13	Beer–Lambert Law	SAP-8	SAP-8.C Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity.	refer to the AP Test Prep book to accompany Tro

Unit 4: Chemical Reactions (9 topics) 7–9%

Big Ideas in this Unit are: Scale, Proportion, and Quantity (SPQ) and Transformations (TRA).

SPQ-4: When a substance changes into a new substance or when its properties change, no mass is lost or gained.

TRA-1: A substance that changes its properties, or that changes into different substances, can be represented by chemical equations and

TRA-2: A substance can change into another substance through different processes, and the change itself can be classified by the sort of processes that produced it.

Unit Section Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
4.1	Introduction to Reactions	TRA-1	TRA-1.A Identify evidence of chemical and phys-ical changes in matter.	1.4
4.2	Net Ionic Equations	TRA-1	TRA-1.B Represent changes in matter with a balanced chemical or net ionic equation— • For physical changes. • For given information about the identity of the reactants and/or product. • For ions in a given chemical reaction.	1.4, 4.2, 5.6

Unit Section Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
4.3	Representation of Reactions	TRA-1	TRA-1.C Represent a given chemical reaction or physical process with a consistent particulate model.	3.2–3.3, 4.2, 5.4–5.9
4.4	Physical and Chemical Changes	TRA-1	TRA-1.D Explain the relationship between macroscopic characteristics and bond interactions for— • Chemical processes. • Physical processes.	1.4, 1.5, 14.2, 14.3
4.5	Stoichiometry	SPQ-4	SPQ-4.A Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.	4.3, 4.4, 5.2, 5.3, 6.4
4.6	Introduction to Titration	SPQ-4	SPQ-4.B Identify the equivalence point in a titration based on the amounts of titrant and analyte, assuming the titration reaction goes to completion.	5.7, 18.4
4.7	Types of Chemical Reactions	TRA-2	TRA-2.A Identify a reaction as acid–base, oxidation–reduction, or precipitation.	5.4–5.9, 17.2, 17.3
4.8	Introduction to Acid–Base Reactions	TRA-2	TRA-2.B Identify species as Bronsted–Lowry acids, bases, and/or conjugate acid–base pairs, based on proton-transfer involving those species.	5.7, 17.2, 17.3
4.9	Oxidation–reduction (redox) reactions	TRA-2	TRA-2.C Represent a balanced redox reaction equation using half-reactions.	5.8, 5.9, 20.2, 20.3, 20.4, 20.5

Unit 5: Kinetics (11 Topics) 7–9%

Big Ideas in this Unit are: Transformations (TRA) and Energy (ENE)

TRA-3 Some reactions happen quickly, while others happen more slowly and depend on reactant concentrations and temperature.

TRA-4 There is a relationship between the speed of a reaction and the collision frequency of particle collisions.

TRA-5 Many chemical reactions occur through a series of elementary reactions when combined form a chemical equation. ENE-1 The speed at which a reaction occurs can be influenced by a catalyst.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
5.1	Reaction Rates	TRA-3	TRA-3.A Explain the relationship between the rate of a chemical reaction and experimental parameters.	15.2–15.3
5.2	Introduction to Rate Law	TRA-3	TRA-3.B Represent experimental data with a consistent rate law expression.	15.2, 15.3, 15.5
5.3	Concentration Changes Over Time	TRA-3	TRA-3.C Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.	15.3, 15.4, 21.6
5.4	Elementary Reactions	TRA-4	TRA-4.A Represent an elementary reaction as a rate law expression using stoichiometry.	15.5, 15.6
5.5	Collision Model	TRA-4	TRA-4.B Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions.	15.5, 21.6
5.6	Reaction Energy Profile	TRA-4	TRA-4.C Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.	15.5, 21.6

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
5.7	Introduction to Reaction Mechanisms	TRA-5	TRA-5.A Identify the components of a reaction mechanism.	15.6, 15.7
5.8	Reaction Mechanism and Rate Law	TRA-5	TRA-5.B Identify the rate law for a reaction from a mechanism in which the first step is rate limiting.	15.6
5.9	Steady-State Approximation	TRA-5	TRA-5.C Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting.	15.6
5.10	Multistep Reaction Energy Profile	TRA-5	TRA-5.D Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile.	15.6
5.11	Catalysts	ENE-1	ENE-1.A Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism.	15.7

Unit 6: Thermodynamics (9 Topics) 7–9%

Big Idea in this Unit is: Energy (ENE)

ENE-2 Changes in a substance's properties or change into a different substance requires an exchange of energy.

ENE-3 The Energy exchanged in a chemical transformation is required to break and form bonds.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
6.1	Endothermic and Exothermic Processes	ENE-2	ENE-2.A Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.	7.2–7.6, 14.3
6.2	Energy Diagrams	ENE-2	ENE-2.B Represent a chemical or physical transformation with an energy diagram.	7.3, 7.9, 14.3
6.3	Heat Transfer and Thermal Equilibrium	ENE-2	ENE-2.C Explain the relationship between the transfer of thermal energy and molecular collisions.	7.3–7.5
6.4	Heat Capacity and Calorimetry	ENE-2	ENE-2.D Calculate the heat q absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature.	7.3–7.7
6.5	Energy of Phase Changes	ENE-2	ENE-2.E Explain changes in the heat q absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition.	12.5–12.7
6.6	Introduction to Enthalpy of Reaction	ENE-2	ENE-2.F Calculate the heat q absorbed or released by a system undergoing a chemical reaction in relationship to the amount of reacting substance in moles and the molar enthalpy of reaction.	7.6–7.9
6.7	Bond Enthalpies	ENE-3	ENE-3.A Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction.	7.8, 7.9
6.8	Enthalpy of Formation	ENE-3	ENE-3.B Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation.	7.9
6.9	Hess's Law	ENE-3	ENE-3.C Represent a chemical or physical process as a sequence of steps.	7.8–7.9

Unit 7: Equilibrium (14 Topics) 7–9%

Big Ideas in this Unit are: Transformations (TRA) and Scale, Proportion, and Quantity (SPQ)

TRA-6 Some reactions can occur in both forward and reverse directions, sometimes proceeding in each direction simultaneously.

TRA-7 A system at equilibrium depends on the relationships between concentrations, partial pressures of chemical species, and the equilibrium constant *K*.

TRA-8 Systems at equilibrium respond to external stresses to offset the effect of the stress.

SPQ-5 The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
7.1	Introduction to Equilibrium	TRA-6	TRA-6.A Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations.	16.2, 16.3, 16.7
7.2	Direction of Reversible Reactions	TRA-6	TRA-6.B Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.	16.2, 16.3, 16.7
7.3	Reaction Quotient and Equilibrium Constant	TRA-7	TRA-7.A Represent the reaction quotient Q_c or Q_p, for a reversible reaction, and the corresponding equilibrium expressions $K_c = Q_c$ or $K_p = Q_p$.	16.3–16.7
7.4	Calculating the Equilibri-um Constant	TRA-7	TRA-7.B Calculate K_c or K_p based on experimental observa-tions of concentrations or pressures at equilibrium.	16.4, 16.5, 16.6
7.5	Magnitude of the Equilibrium Constant	TRA-7	TRA-7.C Explain the relationship between very large or very small values of *K* and the relative concentrations of chemical species at equilibrium.	16.3
7.6	Properties of the Equi-librium Constant	TRA-7	TRA-7.D Represent a multistep process with an overall equilibrium expression, using the constituent *K* expressions for each individual reaction.	16.3
7.7	Calculating Equilib-rium Concentrations	TRA-7	TRA-7.E Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.	16.4, 16.5, 16.6, 16.8
7.8	Representations of Equilibrium	TRA-7	TRA-7.F Represent a system undergoing a revers-ible reaction with a particle model.	16.2
7.9	Introduction to Le Châtelier's Principle	TRA-8	TRA-8.A Identify the response of a system at equi-librium to an external stress, using Le Châtelier's principle.	16.9
7.10	Reaction Quotient and Le Châtelier's Principle	TRA-8	TRA-8.B Explain the relationships between *Q*, *K*, and the direction in which a reversible reaction will proceed to reach equilibrium.	16.7, 16.9
7.11	Introduction to Solu-bility Equilibria	SPQ-5	SPQ-5.A Calculate the solubility of a salt based on the value of *K*sp for the salt.	5.4, 5.5, 18.5, 18.6
7.12	Common-Ion Effect	SPQ-5	SPQ-5.B Identify the solubility of a salt, and/or the value of *K*sp for the salt, based on the concentration of a common ion already present in solution.	18.5, 18.6

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
7.13	pH and Solubility	SPQ-5	SPQ-5.C Identify the qualitative effect of changes in pH on the solubility of a salt.	18.5
7.14	Free Energy of Dissolution	SPQ-5	SPQ-5.D Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process.	14.3, 14.4, 19.3, 19.5, 19.6, 19.7, 19.9, 19.10

Unit 8: Acids and Bases (7 Topics) 11–15%

Big Idea in this Unit is: Structure and Properties (SAP)

SAP-9 The chemistry of acids and bases involves reversible proton-transfer reactions, with equilibrium concentrations being related to the strength of the acids and bases involved.

SAP-10 A buffered solution resists changes to its pH when small amounts of acid or base are added.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
8.1	Introduction to Acids and Bases	SAP-9	SAP-9.A Calculate the values of pH and pOH, based on K_w and the concentration of all species present in a neutral solution of water.	5.7, 17.2–17.5, 17.7
8.2	pH and pOH of Strong Acids and Bases	SAP-9	SAP-9.B Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base.	17.4–17.7
8.3	Weak Acid and Base Equilibria	SAP-9	SAP-9.C Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base.	17.4–17.8
8.4	Acid–Base Reactions and Buffers	SAP-9	SAP-9.D Explain the relationship among concentrations of major species in a mixture of weak and strong acids and bases.	17.3–17.7, 18.2–18.4
8.5	Acid–Base Titrations	SAP-9	SAP-9.E Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.	5.7, 18.4
8.6	Molecular Structure of Acids and Bases	SAP-9	SAP-9.F Explain the relationship between the strength of an acid or a base and the structure of the molecule or ion.	17.3, 17.4, 17.8, 17.10
8.7	pH and p*Ka*	SAP-10	SAP-10.A Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and pK_a of the conjugate acid or the pK_b of the conjugate base.	17.5, 17.8, 18.4
8.8	Properties of Buffers	SAP-10	SAP-10.B Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution.	18.2
8.9	Henderson-Hasselbalch Equation	SAP-10	SAP-10.C Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid–base pair used to create the buffer.	18.2, 18.3
8.10	Buffer Capacity	SAP-10	SAP-10.D Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution.	18.3

Unit 9: Applications of Thermodynamics (Thermodynamics) (10 Topics) 7–9 %

Big Idea in this Unit is: Energy (ENE)

ENE-4 Some chemical or physical processes cannot occur without intervention.

ENE-5 The relationship between $\Delta G°$ and K can be used to determine favorability of a chemical or physical transformation. ENE-6 Electrical energy can be generated by chemical reactions.

Unit Topic Number	Unit Section Topic	Enduring Understanding	Learning Objective	Chapter and Section
9.1	Introduction to Entropy	ENE-4	ENE-4.A Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes.	19.3, 19.4, 19.7
9.2	Absolute Entropy and Entropy Change	ENE-4	ENE-4.B Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.	19.7
9.3	Gibbs Free Energy and Thermodynamic Favorability	ENE-4	ENE-4.C Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of $\Delta G°$.	19.6, 19.8, 19.9, 19.10
9.4	Thermodynamic and Kinetic Control	ENE-4	ENE-4.D Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.	19.2
9.5	Free Energy and Equilibrium	ENE-5	ENE-5.A Explain whether a process is thermodynamically favored using the relationships among K, $\Delta G°$, and T.	19.10
9.6	Coupled Reactions	ENE-5	ENE-5.B Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.	19.8, 20.8
9.7	Galvanic (Voltaic) and Electrolytic Cells	ENE-6	ENE-6.A Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell.	20.3
9.8	Cell Potential and Free Energy	ENE-6	ENE-6.B Explain whether an electrochemical cell is thermodynamically favored based on its standard cell potential and the constituent half-reactions within the cell.	20.3, 20.4, 20.5
9.9	Cell Potential Under Nonstandard Conditions	ENE-6	ENE-6.C Explain the relationship between deviations from standard cell conditions and changes in the cell potential.	20.5, 20.6
9.10	Electrolysis and Faraday's Law	ENE-6	ENE-6.D Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell.	20.5, 20.8

Upon publication, this text was correlated to the College Board's AP Chemistry Course and Exam Description Dated Fall 2020. We continually monitor the College Board's AP Course Description for updates to exam topics. For the most current AP correlation for this textbook, visit Savvas.com/AdvancedCorrelations.

Syllabus for the New AP Curriculum

Framework Overview Per Chapter

For every concept be able to draw macroscopic and particle representations.

1. *Matter, Measurement, and Problem Solving*
   The information in this chapter is primarily background material reviewing skills needed in answering questions about chemistry concepts. How to use significant figures and do basic conversions are covered. While not tested individually as math problems, these skills must be mastered to earn marks on numerical problems. Skills in the curriculum using introductory concepts include how to identify physical and chemical changes and how to use the lab practices of distillation and filtration to identify compounds and mixtures. Students must also be able to look at particulate representations, and explain the difference between sugar and table salt dissolving.
2. *Atoms and Elements*
   Most of this chapter should also be a review from a first year course or elementary or middle school science. The Law of Conservation, the Law of Definite Proportions, The Law of Multiple Proportions, and what evidence supports these laws should be reviewed. The history of what we know about the atom is discussed. For each experiment, know how the resulting evidence changed our view of the atom. In particular, know how the evidence from the gold foil experiment by Rutherford led to knowing there is a nucleus in an atom. Major concepts reviewed include isotopes and the evidence from a mass spectrum indicating their presence, the basics of the periodic table, atomic mass, molar mass, and moles.
3. *Molecules, Compounds, and Chemical Equations*
   The main focus of this chapter is a review of naming of ionic compounds, molecular compounds, acids, and the basics of organic naming. Balancing equations is an extremely important key concept to be mastered. The chart in Figure 3.11 is very useful reminder on the steps in naming. How to use experimental data to determine a chemical formula should also be mastered.
4. *Chemical Reactions and Chemical Quantities*
   This chapter extends the basic mathematics of chemistry started in the previous chapter: balancing equations, stoichiometry, limiting reagents, theoretical yield, percent yield, and reagents in excess. Three types of reactions are introduced combustion, reactions with alkali metals, and reactions with halogens. This chapter focuses on the mathematics that is foundational to understanding chemistry. The principles learned in this chapter will apply throughout the course.
5. *Introduction to Solutions and Aqueous Reactions*
   This chapter is an introduction to solutions and the basic concepts of oxidation–reduction (redox) that will be applied in later chapters. Solution vocabulary is important to understand, knowing how to calculate molarity, the concentration unit used in AP Chemistry, and knowing how to determine an oxidation number.
6. *Gases*
   Most of the material in this chapter should be a review. The focus in the review should be how to explain (in writing) all the gas laws using kinetic molecular theory (KMT) as well as performing calculations using standard equations. Gas reaction stoichiometry, partial pressures, and molar gas volume should be mastered in this chapter. Know how to explain how intermolecular forces affect the behavior of real gases. Understanding graphical representations of all gas laws and concepts should be emphasized.
7. *Thermochemistry*
   This chapter introduces the concepts of heat and enthalpy, and calculations involving these concepts. Mastering this material will be essential before the second chapter on Thermodynamics, Chapter 19. This material is all part of Unit Six “The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.” Energy diagrams for reactions and physical changes need to be understood and as well as to identify and explain all the features of such diagrams. Section 7.5 Constant Volume Calorimetry is not in the AP Curriculum.
8. *The Quantum-Mechanical Model of the atom*
   Through history, the model of the atom has changed. It is important to understand how the models have changed and be able to draw representations of each of the models and especially the difference between the Bohr model and quantum model. Additional material includes photon energy calculations, emission and absorption spectrums.
   Also be able to draw the basic shape differences between s and p orbitals. Even though quantum numbers are not strictly part of the curriculum, one needs to be able to identify and explain where the electrons are located.
9. *Periodic Properties of the Elements*
   Chapter 9 is a continuation of Chapter 8 and electron locations. Electron configurations, valence versus core electrons, periodic trends, Coulomb’s Law, effective nuclear charge, and shielding are concepts important to master. These need to be used to explain periodic table trends, such as ionization energy. Understanding these concepts is crucial to understanding Chapters 10 and 11 on bonding. It is important to practice writing explanations of differences between atoms of an element, its neighbors in the periodic table, and other members of its family (or group) in the periodic table.
10. *Chemical Bonding I: The Lewis Model*
    Chapter 10 addresses the basic differences and models of covalent, ionic, and metallic bonding. Types of chemical bonds, ionic lattice energies, bond polarity, Lewis structures, resonance, bond energies, bond length, and the “electron sea” in metallic bonds are covered. These topics

are important to understanding molecular shapes in Chapter 11 and properties of solids and solutions in Chapters 12 and 14. These concepts help to explain the properties substances exhibit. These relationships need to be explained and models should be able to be drawn to support each concept.

11. *Chemical Bonding II: Molecular Shapes, Valence Bond Theory, and Molecular Orbital Theory*
The concepts of VSEPR, predicting geometries, molecular orbital theory, shape and polarity, sp, sp^2, and sp^3 hybridizations (other hybridizations are not in the AP curriculum) are in this chapter.

12. *Liquids, Solids, and Intermolecular Forces*
Intermolecular forces in solids, liquids, and gases are the crux of this chapter's focus. Understanding and being able to draw particle (molecular) representations of the concepts of surface tension, viscosity, and capillary action are important in this chapter. Also covered are the importance of water and its properties, including the energies of phase changes and heating curves of water. Not included in the AP curriculum are phase diagrams although they need to be understood. Table 12.4 is important to understand along with Figures 12.36 and 12.40. Using drawings and evidence, explain how different intermolecular forces such as hydrogen bonding and dispersion forces affect physical properties of substances.

13. *Solids and Modern Materials*
This chapter explains the structure of ionic solids, net-work covalent solids, and many modern materials, such as polymers, semiconductors, and ceramics. Modern materials explain many cross domain uses of chemistry.

14. *Solutions*
Understanding and being able to explain all the types of solutions and the evidence of intermolecular forces through species interactions for each type of solution is required material. Solution equilibrium and factors affecting solution equilibrium should be understood. There are many types of concentration units but the one to know for the AP Chemistry Examination is the concentration in molarity (M). Not included in the AP curriculum from this chapter are colligative properties and the calculations of freezing point depressions and boiling point elevations.

15. *Chemical Kinetics*
What affects the rate of a reaction is an important branch of chemistry. Determining orders, writing rate laws, and solving for the rate constant are in the AP curriculum. In addition, the integrated rate law and half-life equations for zero-, first-, and second-order reactions should be understood. Another important skill in this chapter is explaining with the use of diagrams how collisions affect rates (collision theory). Energy profile diagrams with and without a catalyst, chemical mechanisms, identifying intermediates and catalysts, and how they affect rates are vital concepts in this chapter needing to be explained.
Different types of catalysts and examples of each including surface catalysts, acid–base catalysts, and enzyme catalysts should be able to be explained.

16. *Chemical Equilibrium*
Reactions that do not go to completion, but reach an equilibrium condition, comprise a large component of the AP Chemistry Exam. Dynamic equilibrium; equilibrium constants; K_p, K_c, and Q, the reaction quotient; and what the numerical values of these indicates, need to be understood both qualitatively and quantitatively. In addition, Le Châtelier's principle and how equilibrium systems react to disturbances or stresses of temperature, pressure, and concentration are notable concepts to master.

17. *Acids and Bases*
The acid–base theories of Arrhenius and Brønsted–Lowry are in the AP curriculum. Acid ionization constant, K_a, base ionization constant, K_b, and the water ionization constant, K_w, are vital topics to master. The pH scale, pH acid–base properties of ions and salts, polyprotic acids, acid molecular structure complete the chapter. Everything in the chapter except Lewis Acids and Bases and calculations with polyprotic acids (which are excluded from the AP curriculum) is essential content.

18. *Aqueous Ionic Equilibrium*
This chapter addresses two major concepts: buffer solutions and solubility equilibria. Buffer solution concepts include identifying buffer solutions, buffer effectiveness, buffer range, and buffer capacity. Titrations and various pH curves and identifying areas of each curve are fully covered and need to be mastered. Choosing indicators is also an important skill to master. The second part of the chapter covers K_{sp}, solubility equilibria, qualitative analysis, and selective precipitation. Those topics not in the AP curriculum in this chapter are complex ion equilibria (K_f), and calculating pH after addition acid or base to a buffer.

19. *Free Energy and Thermodynamics*
Chapter 19 applies the concept of enthalpy introduced in Chapter 6, Thermochemistry. The Laws of Thermodynamics, the concepts of entropy and Gibb's free energy are at the crux of chemistry. Why reactions happen are rationalized using these concepts. Understanding the relationships between these concepts and energy diagrams,
equilibrium constants, and favorable and unfavorable processes is highly important. Particular figures and tables to explain are Figure 19.11, and Table 19.1 Note: The AP test will not use the terms spontaneous and nonspontaneous but instead uses "thermodynamically favored or thermodynamically unfavored." All parts of this chapter are included in the AP Chemistry curriculum.

20. *Electrochemistry*
Oxidation–reduction reactions were first introduced in Chapter 5. This chapter goes into more detail and introduces the ideas of electrochemistry that use these reactions. Balancing oxidation–reduction reactions, predicting

the direction of a cell, voltaic cells, electrode potentials, and cell potential are all principle skills needed. Explaining the components and the function of each component in Figure 20.2 is required material. Concepts and calculations in relation to Gibbs free energy and the equilibrium constant are essential topics. Electrolysis and electrolysis calculations are also included. Material not in the AP Chemistry curriculum includes all the types of batteries, and how they work.

21. *Radioactivity and Nuclear Chemistry*
Neither radioactivity nor nuclear chemistry is included in the AP Chemistry curriculum although nuclear reactions and half-lives are examples of first-order kinetics, which is covered in Chapter 15.

22. *Organic Chemistry*
This chapter introduces the basics of organic chemistry (chemistry of carbon compounds, mostly important to life). Remember that Chapter 3 taught about naming organic compounds. The Lewis structures, functional groups, and basic properties of these types of compounds needs to be learned. This chapter goes into considerably more detail than required by the AP curriculum by covering chirality, enantiomers, and organic reactions such as addition and condensation reactions.

23. *Biochemistry*
Although the majority of this chapter has a biology focus, the basic structures of lipids, carbohydrates, and proteins are in this chapter. It focuses on knowing how the nucleic acids are important to the building blocks of protein structures such as DNA shows an understanding of the chemistry structure affecting a biological system.

24. *Chemistry of the Nonmetals*
Specific properties and reactions of the nonmetals are in this chapter. Particular significant nonmetals, such as carbon, silicon, nitrogen, phosphorus, oxygen, sulfur, and the halogens fluorine and chlorine are discussed. Many cross domain applications and affects of reactions with these elements or their compounds are given. One example of a cross domain reference is how the oxides of nitrogen affect air pollution. This chapter also has background material on properties of materials, such as the differences between graphite and diamond.

25. *Metals and Metallurgy*
Metals are the majority of the elements in the periodic table. Some key metals such as copper and zinc, their compounds, and uses are covered in this chapter. This chapter is primarily background material for understanding the uses of chemistry across domains.

26. *Transition Metals and Coordination Compounds*
Similar to Chapters 24 and 25, the majority of this chapter is background material specific to transition metals and understanding coordination compounds and the uses of them.