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|  | AP Chemistry Curriculum Guide  SCI 505/506 & SCI 523/524  2022-2023 |

<http://grading.dmschools.org>

<http://science.dmschools.org>

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| **Evidence shows the student ...** | **Topic Score** |
| Demonstrates proficiency (AT) in all learning targets and success at Level 4 | 4.0 |
| Demonstrates proficiency (AT) in all learning targets with partial success at Level 4 | 3.5 |
| Demonstrates proficiency (AT) in **all** learning targets | 3.0 |
| Demonstrates proficiency (AT) in **at least half** of the learning targets | 2.5 |
| Demonstrates some success criteria (PT) toward **all** learning targets | 2.0 |
| Demonstrates some success criteria (PT) towards **some** of the learning targets | 1.5 |
| Does not yet meet minimum criteria for the targets. | 1.0 |
| Produces no evidence appropriate to the learning targets at any level | 0 |

**Standards-Referenced Grading Basics**

**Our purpose in collecting a body of evidence is to:**

* Allow teachers to determine a defensible and credible topic score based on a representation of student learning over time.

**Start at Level 3 when determining a topic → score.**

* Clearly communicate where a student’s learning is based on a topic scale to inform instructional decisions and push student growth.
* Show student learning of targets through multiple and varying points of data
* Provide opportunities for feedback between student and teacher.

**Scoring**

A collaborative scoring process is encouraged to align expectations of the scale to artifacts collected. Routine use of a collaborative planning and scoring protocol results in calibration and a collective understanding of evidence of mastery. Enough evidence should be collected to accurately represent a progression of student learning as measured by the topic scale. Teachers look at all available evidence to determine a topic score. All topic scores should be defensible and credible through a body of evidence.

**Guiding Practices of Standards-Referenced Grading**

1. A consistent 4-point grading scale will be used.
2. Student achievement and behavior will be reported separately.
3. Scores will be based on a body of evidence.
4. Achievement will be organized by learning topic and converted to a grade at semester’s end.
5. Students will have multiple opportunities to demonstrate proficiency.
6. Accommodations and modifications will be provided for exceptional learners.

**\*\*\*Only scores of 4, 3.5, 3, 2.5, 2, 1.5, 1, and 0 can be entered as Topic Scores**.

**Multiple Opportunities**

Philosophically, there are two forms of multiple opportunities, both of which require backwards design and intentional planning. One form is opportunities planned by the teacher throughout the unit of study and/or throughout the semester. The other form is reassessment of learning which happens after completing assessment of learning at the end of a unit or chunk of learning.

Students will be allowed multiple opportunities to demonstrate proficiency. Teachers need reliable pieces of evidence to be confident students have a good grasp of the learning topics before deciding a final topic score. To make standards-referenced grading work, the idea of “multiple opportunities” is emphasized. If after these opportunities students still have not mastered Level 3, they may then be afforded the chance to reassess.

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| **AP Chemistry** |
| The AP Chemistry course provides students with a college-level foundation to support future advanced course work in chemistry. Students cultivate their understanding of chemistry through inquiry-based investigations, as they explore topics such as: atomic structure, intermolecular forces and bonding, chemical reactions, kinetics, thermodynamics, and equilibrium. This course requires that 25 percent of the instructional time provides students with opportunities to engage in laboratory investigations. This includes a minimum of 16 hands-on labs, at least six of which are inquiry based.  **AP Chemistry** **– Course Content:**  **Big Idea 1**: The chemical elements are fundamental building material of matter, and all matter can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions.  **Big Idea 2**: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.  **Big Idea 3**: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.  **Big Idea 4**: Rates of chemical reactions are determined by details of the molecular collisions.  **Big Idea 5**: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.  **Big Idea 6**: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.  **AP Chemistry – Scientific Practices:**  • Use representations and models to communicate scientific phenomena and solve scientific problems • Use mathematics appropriately  • Engage in scientific questioning to extend thinking or to guide investigations • Work with scientific explanations and theories  • Plan and implement data collection strategies in relation to a particular scientific question • Perform data analysis and evaluation of evidence  • Connect and relate knowledge across various scales, concepts, and representations in and across domains.  **AP Chemistry** **Exam: Format of Assessment – 3 Hours 15 Minutes**  **Section I: Multiple Choice | 60 Questions | 90 Minutes | 50% of Exam Score**  • Discrete Items and Items in Sets  **Section II: Free Response | 7 Questions | 105 Minutes | 50% of Exam Score**  • Three long- and four short-answer questions. The seven questions ensure the assessment of the following skills: experimental design, quantitative/qualitative translation, analysis of authentic lab data and observations to identify patterns or explain phenomena, creating or analyzing atomic and molecular views to explain observations, and following a logical/analytical pathway to solve a problem.  **Link to DMPS Grading Resources:** <http://grading.dmschools.org>  **Link to Course Resources**: <http://science.dmschools.org>  **Link to Course Information @ AP Central:** <http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/2119.html> |

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| Semester 1 Topics | College Board Curriculum Framework Alignment |
| General Chemistry and Types of Reactions | Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.  EUs: 1.A, 1.E  Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.  EUs: 3.A, 3.B, 3.C |
| Stoichiometry, Gas Laws & Enthalpy | Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules, and the forces between them.  EUs: 2.A, 2.B  Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.  EUs: 3.C  Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.  EUs: 5.A, 5.B |
| Atomic Structure & Periodicity | Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.  EUs: 1.B, 1.C, 1.D |
| Bonding | Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules, and the forces between them.  EUs: 2.A, 2.C, 2.D  Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.  EUs: 5.C |
| IMFs & Solutions | Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules, and the forces between them.  EUs: 2.A, 2.B  Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.  EUs: 5.D |

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| Semester 2 Topics | College Board Curriculum Framework Alignment |
| Kinetics | Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.  EUs: 4.A, 4.B, 4.C, 4.D |
| Equilibrium | Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.  EUs: 6.A, 6.B |
| Acid/Base/Buffers | Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.  EUs: 3.B  Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.  EUs: 6.C |
| Thermo & Electrochemistry | Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.  EUs: 3.C  Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.  EUs: 5.E  Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.  EUs: 6.C, 6.D |

**Standards-Referenced Grading Basics**

The teacher designs instructional activities and assessments that grow and measure a student’s skills in the elements identified on our topic scales. Each scale features many such skills and knowledges, also called learning targets. These are noted on the scale below with letters (A, B, C) and occur at Levels 2 and 3 of the scale. In the grade book, a specific learning activity could be marked as being 3A, meaning that the task measured the A item at Level 3.

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| **The Body of Evidence in a Process-Based Course** |
| **Process-Based SRG** *is defined as an SRG course design where the same scale recurs throughout the course, but the level of complexity of text and intricacy of task increase over time.*  AP Chemistry cycles students through some topics repeatedly as they progress through the course, with changing content and an increasing complexity of scientific problem-solving, analysis, and expectations throughout.  To account for this, process-based courses like this have their evidence considered in a “Sliding Window” approach. When determining the topic score for any given grading topic, *the most recent evidence* determines the topic score. Teacher discretion remains a vital part of this determination, but it is hard to overlook evidence from the most recent (and therefore rigorous) assessments. |





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| General Chemistry and Types of Reactions |

| **Topic** | **4** | **3** | **2** |
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| **General Chemistry and Type of Reactions** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 1. **Analyze and explain the relationships between mass spectrum, mass, molar mass and empirical formula.** 2. **Model changes in matter utilizing chemical equations.** 3. **Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.** | A1. Calculate quantities of a substance of its relative number of particles using dimensional analysis and the mole concept. (1.1)  A2. Explain the quantitative relationship between the mass spectrum of an element and the masses of the element’s isotopes. (1.2)  A3. Explain the qualitative relationship between the elemental composition by mass and the empirical formula of a pure substance. (1.3)  A4. Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture. (1.4)  B1. Identify evidence of chemical and physical changes in matter (4.1)  B2. Represent changes in matter with a balanced chemical or net ionic equation: (4.2)   1. For physical changes. 2. For given information about the identity of the reactants and/or product. 3. For ions in a given chemical reaction.   B3. Represent a given chemical reaction or physical process with a consistent particulate model. (4.3)  B4. Identify a reaction as acid-base, oxidation-reduction, or precipitation. (4.7)  B5. Represent a balanced redox reaction equation using half-reactions. (4.9)  C1. Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process. (4.5)  C2. Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion. (4.6) |

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| Stoichiometry, Gas Laws & Enthalpy |

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| **Topic** | **4** | **3** | **2** |
| **Stoichiometry, Gas Laws & Enthalpy** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 1. **Develop a model to make predictions about how pressure, volume, number of particles, and temperature change in a closed system. Explain how changes in one variable affect the other variables.** 2. **Describe the exchange of energy required for changes in a substance’s properties or changes into different substances.** 3. **Develop and utilize a model to describe the energy exchanged in a chemical transformation.** | A1. Explain the relationship between the macroscopic properties of a sample of as or mixture of gases using the ideal gas law. (3.4)  A2. Explain the relationship between the motion of particles and the macroscopic properties of gases with:   * 1. The kinetic molecular theory (KMT).   2. particulate model.   3. A graphical representation. (3.5)   A3. Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. (3.6)  B1. Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. (6.1)  B2. Represent a chemical or physical transformation with an energy diagram. (6.2)  B3. Explain the relationship between the transfer of thermal energy and molecular collisions. (6.3)  B4. 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. (6.4)  C1. Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation. (6.8)  C2. Represent a chemical or physical process as a sequence of steps. (6.9)  C3. Explain the relationship between the enthalpy of a chemical or physical process and the sum of enthalpies of the individual steps. (6.9) |

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| Atomic Structure & Periodicity |

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| **Topic** | **4** | **3** | **2** |
| **Atomic Structure & Periodicity** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 1. **Analyze the relationship between absorbed and emitted photons and electron transitions in an atom.** 2. **Represent the arrangement of electrons within an atom and explain the relationship of the interactions between the electrons and the nucleus.** 3. **Explain the relationship between trends in atomic properties and reactivity of elements and periodicity.** | A1. Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region. (3.11)  A2. Explain the properties of an absorbed or emitted photon in relationship to an electron transition in atom or molecule. (3.12)  B1. Represent the electron configuration of an element or ions of an element using the Aufbau principle. (1.5)  B2. Explain the relationship between the photoelectron spectrum of an atom or ion and:   1. The electron configuration of the species, 2. The interactions between the electrons and nucleus. (1.6)   C1. Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity. (1.7)  C2. Explain the relationship between trends in the reactivity of elements and periodicity. (1.8) |

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| Bonding |

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| **Topic** | **4** | **3** | **2** |
| **Bonding** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 1. **Explain and represent the type of bonding present in chemical substances due to the properties of the substances.** 2. **Represent the energy exchanged during a chemical transformation that is required to break and form bonds.** 3. **Represent molecular compounds using Lewis diagrams to model molecular geometry based on VSEPR theory.** | A1. Explain the relationship between the type of bonding and the properties of the elements participating in the bond. (2.1)  A2. Represent an ionic solid with a particulate model that is consistent with Coulomb’s law and the properties of the constituent ions. (2.3)  A3. Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance. (2.4)  B1. Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. (2.2)  B2. Calculate the heat *q* absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction. (6.6)  B3. Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. (6.7)  C1. Represent a molecule with a Lewis diagram. (2.5)  C2. Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures of that uses formal charge to select between non-equivalent structures. (2.6)  C3. Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:   1. Explain structural properties of molecules. 2. Explain electron properties of molecules. (2.7) |

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| IMFs & Solutions |

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| **Topic** | **4** | **3** | **2** | |
| **IMFs and Solutions** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 1. **Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the relative strength of the intermolecular forces between particles.** 2. **Calculate and explain how to prepare a solution and determine the concentration of the solution.** 3. **Represent the interactions and solubility of different substances at the particulate level for mixtures.** | A1. Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:   1. The molecules are of the same chemical species. 2. The molecules are of two different chemical species. (3.1)   A2. Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles. (3.2)  A3. Represent the differences between solid, liquid, and gas phases using a particulate-level model. (3.3)  A4. Explain the relationship between macroscopic characteristics and bond interactions for both chemical and physical processes. (4.4)  B1. Calculate the number of solute particles, volume, or molarity of solutions. (3.7)  B2. Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. (3.11)  C1. Using a particulate model for mixtures:   1. Represent interactions between components. 2. Represent concentration of components. (3.8)   C2. Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles. (3.9/3.10) | |
| Laboratory Techniques (Semester 1) | | | |

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| **Topic** | **4** | **3** | **2** |
| **Laboratory Technique** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 3A: Always follows appropriate safety protocols in the laboratory  3B: Design and/or interpret the results of an experiment regarding the factors (temperature, concentration, surface area) that may influence the rate of a chemical reaction.  3C: Analyze concentration vs. time data to determine the rate law for a zeroth, first-, or second-order reaction.  3D: Design and/or interpret the results of an experiment to determine the equilibrium constant of a reaction.  3E: Interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values. 6.22  3F: Interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. (6.23)  3G: Design and/or interpret data from a reaction between an acid (strong or weak) and a base (strong or weak) to determine quantity of interest (concentration, molar mass, pKa, titration curve)  3H: Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. (6.18)  3I: Build a galvanic cell with a desired voltage.  3J: Use qualitative analysis to determine the identities of substances in a mixture. | 2A: Knows the location, and use, of safety equipment in the laboratory.  2B: Produce data to investigate how factors affect the rate of a chemical data.  2C: Graph data to determine how concentration changes over time.  2D: Produce data to determine the equilibrium constant of a chemical reaction.  2E: Produce data to determine the solubility of a salt.  2F: Describe how factors, such as common ion or pH, can impact the solubility of salts.  2G.1: Determine the equivalence point of an acid/base reaction  2G.2: Produce data and graph a titration curve.  2H: Use a pH product to determine pH of a solution at various points in a titration.  2I: Use a multi-meter to measure voltage in an electrochemical cell.  2J: Describe how qualitative analysis can be used to determine the identity of substances in a mixture. |

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| Kinetics |

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| **Topic** | **4** | **3** | **2** |
| **Kinetics** | *In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal.* | 1. **Express and analyze experimental data with a consistent rate law expression.** 2. **Analyze the data to identify the rate law expression of a chemical reaction using data that shows how the concentration of reaction species change over time.** 3. **Identify the rate law for a reaction from a multistep reaction mechanism and analyze changes to elementary reactions on the overall reaction.** | A1. Explain the relationship between the rate of a chemical reaction and experimental parameters. (5.1)  A2. Represent experimental data with a consistent rate law expression. (5.2)  A3. Represent an elementary reaction as a rate law expression using stoichiometry. (5.4)  B1. Identify the rate law expression of a chemical reaction using data that show how the concentration of reaction species change over time. (5.3)  C1. Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. (5.5)  C2. Represent the activation energy and overall change in an elementary reaction using a reaction energy profile. (5.6)  C3. Identify the components of a reaction mechanism. (5.7)  C4. Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. (5.8)  C5. Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. (5.9)  C6. Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile. (5.10)  C7. Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. (5.11) |

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| Equilibrium |

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| **Topic** | **4** | **3** | **2** |
| **Equilibrium** | *In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal.*  4: Use the quadratic equation to solve ICE-box/charts. | 1. **Explain the relationship between the rates of the forward and reverse reactions and the system at equilibrium.** 2. **Analyze the data to identify the equilibrium expression and calculate the equilibrium constant and explain the relationship of the constant to the relative concentrations of the chemical species at equilibrium.** 3. **Identify the concentrations or partial pressures of chemical species at equilibrium based on initial conditions and evaluate the role of the reaction quotient in determining the direction the reaction will proceed to reach equilibrium.** 4. **Determine the degree and effect of the dissolution of a salt that can be influenced by environmental factors such as pH or other dissolved ions.** | A1. Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations. (7.1)  A2. Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions. (7.2)  A3. Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction. (7.6)  A4. Represent a system undergoing a reversible reaction with a particulate model. (7.8)  A5. Identify the response of a system at equilibrium to an external stress, using Le Chatelier’s principle. (7.9)  B1. Represent the reaction quotient *Q*c or *Q*p, for a reversible reaction, and the corresponding equilibrium expressions Kc=Qc or Kp=Qp. (7.3)  B2. Calculate the Kc or Kp based on experimental observations of concentrations or pressures at equilibrium. (7.4)  B3. Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium. (7.5)  C1. Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant. (7.7)  C2. Explain the relationships between Q, K and the direction in which a reversible reaction will proceed to reach equilibrium. (7.10)  D1. Calculate the solubility of a salt based on the value of Ksp for the salt. (7.11)  D2. Identify the solubility of a salt, and/or the value of Ksp for the salt, based on the concentration of a common ion already present in solution. (7.12)  D3. Identify the qualitative effect of changes in pH on the solubility of a salt. (7.13) |

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| Acid/Base |

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| **Topic** | **4** | **3** | **2** | |
| **Acid/Base** | *In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal.* | 1. **Explain, calculate, and predict the relationship among pH, pOH and concentrations of strong or weak acids and/or bases.** 2. **Understand and explain the effects of a buffer in an acidic or basic solution and identify the properties of buffers.** 3. **Interpret and explain the results from the titration of a mono- or polyprotic acid or base solution in relation to the properties of the solution and its components using lab data.** 4. **Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.** | A1. Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water. (8.1)  A2. Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. (8.2)  A3. Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. (8.3)  B1. Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. (8.4)  B2. 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. (8.8)  B3. Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer. (8.9)  B4. 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. (8.10)  C1. 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. (8.5)  C2. Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base. (8.7)  D1. Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. (8.6)  D2. Identify species as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. (4.8) | |
| Thermochemistry & Electrochemistry | | | |

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| **Topic** | **4** | **3** | **2** |
| **Thermo & Electro- Chemistry** | *In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal.* | 1. **Calculate and identify the sign and relative magnitude of enthalpy, entropy, and Gibb’s free energy and analyze whether the process can occur without intervention.** 2. **Explain how the relationship between ΔG°, K, and T can be used to determine the favorability of a chemical or physical transformation.** 3. **Differentiate between electrochemical cells that are thermodynamically favorable (Galvanic/voltaic/electrochemical) and those that are not (electrolytic) under standard and non-standard conditions.** | A1. Identify the sign and relative magnitude of the energy change associated with chemical or physical processes. (9.1)  A2. Calculate the energy change for a chemical or physical process based on the absolute entropies of the species involved in the process. (9.2)  A3. Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG°. (9.3)  A4. Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate. (9.4)  A5. Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process. (7.14)  B1. Explain whether a process is thermodynamically favored using the relationships between K, ΔG°, and T. (9.5)  B2. Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes. (9.6)  C1. Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. (9.7)  C2. Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. (9.8)  C3. Explain the relationship between deviations from standard cell conditions and changes in the cell potential. (9.9)  C4. Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell. (9.10) |

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| Laboratory Techniques (Semester 2) |

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| **Topic** | **4** | **3** | **2** |
| **Laboratory Technique** | In addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond the learning goal. | 3A: Always follows appropriate safety protocols in the laboratory  3B: Design and/or interpret the results of an experiment regarding the factors (temperature, concentration, surface area) that may influence the rate of a chemical reaction.  3C: Analyze concentration vs. time data to determine the rate law for a zeroth, first-, or second-order reaction.  3D: Design and/or interpret the results of an experiment to determine the equilibrium constant of a reaction.  3E: Interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values. 6.22  3F: Interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. (6.23)  3G: Design and/or interpret data from a reaction between an acid (strong or weak) and a base (strong or weak) to determine quantity of interest (concentration, molar mass, pKa, titration curve)  3H: Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. (6.18)  3I: Build a galvanic cell with a desired voltage.  3J: Use qualitative analysis to determine the identities of substances in a mixture. | 2A: Knows the location, and use, of safety equipment in the laboratory.  2B: Produce data to investigate how factors affect the rate of a chemical data.  2C: Graph data to determine how concentration changes over time.  2D: Produce data to determine the equilibrium constant of a chemical reaction.  2E: Produce data to determine the solubility of a salt.  2F: Describe how factors, such as common ion or pH, can impact the solubility of salts.  2G.1: Determine the equivalence point of an acid/base reaction  2G.2: Produce data and graph a titration curve.  2H: Use a pH product to determine pH of a solution at various points in a titration.  2I: Use a multi-meter to measure voltage in an electrochemical cell.  2J: Describe how qualitative analysis can be used to determine the identity of substances in a mixture. |

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| **SRG Scale Score** | **Topic:**  **AP-Style Assessments** | **AP Exam**  **Score Conversion** |
| **4** | In addition to meeting the learning goal, the student demonstrates in-depth inferences and applications that go beyond the goal. | **90-100%** |
| **3.5** | Student’s performance reflects exceptional facility with **some**, but not all Level 4 learning targets. | **80-89%** |
| **3**  **Learning Goal** | Student’s performance reflects success on **all Level 3** learning targets. | **70-79%** |
| **2.5** | Student’s performance reflects success on **some**, but not all, Level 3 learning targets | **60-69%** |
| **2** | Student’s performance reflects success on **all Level 2** learning targets. | **50-59%** |
| **1.5** | Student’s performance reflects success on **some** but not all Level 2 learning targets | **40-49%** |
| **1** | Student’s performance reflects insufficient progress towards foundational skills and knowledge. | **20-39%** |