Demonstrating Understanding on the AP Chemistry Exam

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One of the major changes in the redesigned AP Chemistry course is the requirement that students demonstrate their depth of understanding of chemistry content through the application of science practices. The *AP Chemistry Curriculum Framework* articulates specific learning objectives that merge content with science practice skills (e.g., analyzing data). These learning objectives should not be considered in isolation; they must be taught and learned within the broad context of the entire curriculum framework, which includes the big ideas, enduring understandings, essential knowledge statements, and science practices.

On the free-response section of the AP Chemistry Exam, students are expected to demonstrate their understanding of chemistry in the context of authentic problems and research. Whether asked to *justify*, *explain*, *predict*, or *describe*, students must clearly articulate their understanding of the key chemistry principle(s) or concept(s) underlying the phenomenon being investigated. **In short, to be successful on the AP Chemistry Exam, students must clearly connect a chemical concept to a larger big idea or enduring understanding** while using designated science practices and skills. On the exam, students must make claims and defend them — providing evidence as part of their reasoning. This should include making appropriate and insightful connections across big ideas and/or enduring understandings.

When developing their reasoning and selecting supporting evidence to demonstrate understanding, students might consider applying the following strategies:

- Relate a proposed cause to a particular observation (e.g., if asked, The concentration of $Ba^{2+}(aq)$ in the solution decreases as the volume of added 0.10 M H_2SO_4 increases from 30.0 mL to 31.0 mL. Explain.)
- Identify assumptions and limitations of a conclusion (e.g., if asked, Is there sufficient data obtained in the experiments to determine the value of the equilibrium constant, K_p, for the decomposition of $CaCO_3(s)$ at 1100 K? Justify your answer.)
- Connect technique/strategy with its stated purpose/function in an investigation (e.g., if asked, Explain the purpose of drying and weighing the filter paper with the precipitate three times.)
- Identify patterns or relationships (and anomalies) from observations or a data set (e.g., if asked, The temperature of the equilibrium mixture is increased to 425 K. Will the value of K_p increase, decrease, or remain the same? Justify your prediction.)
- Rationalize one choice over another, including selection and exclusion of data to substantiate a claim (e.g., if asked, A student claimed that the final pressure in the container in each experiment became constant because all of the $CaCO_3(s)$ had decomposed. Based on the data in the experiments, do you agree with this claim? Explain.)

In addition, within the AP Chemistry Exam, the terms **calculate**, **explain**, and **justify** have specific meanings. Students should pay careful attention to these words in order to obtain maximum credit for their responses. The word *calculate* is used when students must mathematically process information and quantitative data to arrive at a numerical answer. The word *explain* is used when students must provide chemical reasoning to account for a given phenomenon or observation. The word *justify* is typically used when students are asked to make a claim or a choice and then support their answer with evidence.

Calculate

Students will often be asked to calculate the numerical value for a quantity. For a calculation, students are expected to show the steps taken to arrive at their final answer, including algebraic expressions and properly substituted numbers. Attention should be paid to significant figures and units in each answer. It is important for students to realize that a correct numerical answer may not earn credit if the answer is not supported by them showing the steps used to arrive at it. It is to students' advantage to provide the steps as a record of their reasoning because points may be earned even if there is an error in an individual step.

Explain
Students will often be asked to explain a given phenomenon or observation. Sometimes they will be prompted to respond in terms of specific chemical principles or particle-level reasoning. Diagrams and equations can be included as part of an explanation. Answers should be written in prose that is concise and to the point. Providing long explanations that include extraneous information does not serve students; in fact, this practice may be detrimental because it can obscure or even contradict the part of the answer scorers are looking for in a student's response.

Justify
Students will often be asked to make a claim (such as a prediction or choice) and justify this claim. In order to earn credit, the justification must correctly couple evidence (which often includes data and observations) with the reasoning for how the evidence supports the claim. The justification will typically earn most (if not all) of the credit in a particular part of a question, especially in cases where students are asked to select from a limited number of choices.