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# 2009 Ap Chemistry Free Response Solutions

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## The 2009 AP Chemistry Free Response: A Comprehensive Guide to Mastering the Exam

The Advanced Placement (AP) Chemistry exam has long been a benchmark for high school students seeking college-level chemistry credit. Among the many iterations of this challenging test, the **2009 AP Chemistry Free Response**section holds a special place in the memories of both students and educators. This particular exam represents a critical moment in AP Chemistry history, as it was one of the last exams before the major curriculum changes implemented in 2013. Understanding the 2009 free response questions offers not only a glimpse into the rigor of the past but also provides timeless insights into the core principles of chemistry that remain relevant today.

For anyone preparing for a modern AP Chemistry exam, studying the 2009 free response can be an invaluable exercise. While the format and emphasis have shifted over the years, the underlying chemical concepts tested in 2009 are fundamental to the discipline. This article will provide a thorough walkthrough of the 2009 AP Chemistry Free Response section, breaking down each question, discussing common pitfalls, and offering strategies that will serve you well on any AP Chemistry exam.

## Overview of the 2009 AP Chemistry Free Response Format

The 2009 AP Chemistry Free Response section consisted of two parts, just as it had for many preceding years. Students were given a total of 90 minutes to complete the entire free response portion of the exam. The section was divided into two distinct parts:

- Part A: Two required problems, each worth approximately 10 percent of the overall exam score. These problems typically focused on equilibrium, kinetics, thermodynamics, or electrochemistry.
- Part B: Six additional questions, of which students were required to answer four. These questions covered a broader range of topics, including descriptive chemistry, laboratory techniques, and reaction prediction.

This format placed a premium on time management and strategic question selection. Students had to quickly assess which Part B questions they could answer most confidently, allocating their time accordingly. The weighting of the questions meant that strong performance on the free response section could significantly boost a student's overall exam score.

## Analysis of Key Questions from the 2009 Free Response

### Equilibrium and Le Chatelier's Principle

One of the hallmark questions from the 2009 AP Chemistry Free Response dealt with chemical equilibrium, a

cornerstone topic in any AP Chemistry curriculum. The question typically presented a reversible reaction and asked students to calculate the equilibrium constant, Kc or Kp, based on initial concentrations and the concentration of one species at equilibrium.

The 2009 equilibrium question was notable for its emphasis on **Le Chatelier's Principle**. Students were asked to predict the direction of the shift in equilibrium when certain stresses were applied—such as changes in temperature, pressure, or concentration. This type of question tests not only computational ability but also conceptual understanding. To answer correctly, students had to distinguish between changes that affect the value of K (temperature) and those that do not (concentration or pressure).

This question also required students to write a balanced chemical equation for the equilibrium system, a skill that continues to be tested on modern exams. The ability to correctly identify the phases of reactants and products is critical, as it influences whether Kc or Kp is the appropriate equilibrium expression.

### Thermodynamics and Thermochemistry

Another major question in the 2009 free response section focused on thermodynamics. Students were asked to calculate enthalpy changes using Hess's Law, determine standard heats of formation, and interpret potential energy diagrams. The question often required students to relate the sign of the enthalpy change to the relative bond strengths of reactants and products.

The structure of this question was particularly instructive. Students were given a series of chemical reactions and asked to combine them to find the enthalpy change for a target reaction. This application of Hess's Law remains a staple of AP Chemistry exams to this day. The 2009 version, however, placed a greater emphasis on the theoretical justification behind the calculations. Students were asked to explain why the enthalpy change was exothermic or endothermic based on molecular-level reasoning.

Understanding the **2009 AP Chemistry Free Response**thermodynamics question helps modern students appreciate the importance of connecting mathematical calculations to conceptual explanations. The exam designers were not merely testing computational skill—they were assessing whether students truly understood the energy changes occurring during chemical reactions.

### Kinetics and Reaction Mechanisms

The kinetics question on the 2009 exam was considered by many to be one of the most challenging. Students were presented with experimental data showing initial rates of reaction at varying concentrations of reactants. From this data, they had to determine the rate law, calculate the rate constant with appropriate units, and propose a plausible reaction mechanism consistent with the rate law.

What made this question particularly demanding was the requirement to justify the proposed mechanism. Students had to demonstrate that the sum of the elementary steps yielded the overall reaction and that the rate-determining step was consistent with the experimentally determined rate law. This level of analysis requires a deep understanding of how reaction mechanisms are derived from kinetic data.

The 2009 question also tested students' ability to interpret graphical data. One part of the question asked students to sketch a reaction coordinate diagram showing the activation energy for the rate-determining step and the overall enthalpy change for the reaction. This integration of kinetics and thermodynamics is a hallmark of well-designed AP Chemistry questions.

## Common Student Mistakes on the 2009 Free Response

Reviewing student responses from the 2009 AP Chemistry Free Response reveals several recurring errors that are worth noting. Recognizing these mistakes can help current students avoid them on their own exams.

### Sign Errors in Thermodynamics Calculations

One of the most common errors was sign confusion in enthalpy calculations. When using Hess's Law, students would often forget to reverse the sign of the enthalpy change when a reaction was written in the opposite direction. This seemingly small error could cascade through an entire problem, leading to an incorrect final answer. The 2009 exam required careful attention to the direction of each reaction step, and many students lost points simply due to sign mismanagement.

### Unit Mismanagement in Kinetics

The kinetics question exposed a persistent weakness in many students' understanding: unit analysis. When calculating the rate constant k from the rate law, students frequently wrote incorrect units. For a second-order reaction, for example, the rate constant should have units of M" 1s" 1, but many students wrote M/s or s" 1. This error indicated a surface-level understanding of the rate law equation.

### Le Chatelier's Principle Misapplications

Another frequent error involved misapplying Le Chatelier's Principle. Students often assumed that a change in pressure would always shift the equilibrium toward the side with fewer moles of gas. However, this is only true if the volume of the container is changed. Adding an inert gas at constant volume, for example, does not shift the equilibrium, a nuance that many students overlooked on the 2009 exam.

## How to Use the 2009 AP Chemistry Free Response for Modern Exam Preparation

While the AP Chemistry exam has undergone significant changes since 2009—including the adoption of a more conceptual, less computational focus—the 2009 free response questions remain an excellent preparation tool. Here is how to use them effectively.

### Focus on Conceptual Understanding

The 2009 exam required students to explain their reasoning in clear, written sentences. This emphasis on conceptual explanation is even stronger on the modern exam. When working through the 2009 questions, do not just calculate the answer—practice writing out the reasoning behind each step. Explain why you are using a particular equation, why the sign is positive or negative, and what the answer means in chemical terms.

### Practice Time Management

The 90-minute time limit for the free response section has remained consistent. Use the 2009 questions to practice pacing yourself. Give yourself 15 minutes for each major question and 10 minutes for each shorter question. Do not spend more than 20 minutes on any single question, as the modern exam also requires balanced time allocation across all questions.

### Identify Core Principles

The specific chemical systems described in the 2009 questions may differ from those on a modern exam, but the core principles are identical. When you study the 2009 free response, ask yourself: What fundamental concept is being tested here? Is it conservation of energy, the relationship between concentration and rate, or the conditions for equilibrium? By abstracting the underlying principle, you prepare yourself to recognize similar concepts in unfamiliar contexts.

## Comparing the 2009 and Modern AP Chemistry Exams

The 2009 AP Chemistry Free Response section was more computationally heavy than the current exam. The modern exam relies more heavily on quantitative reasoning rather than algorithmic calculation. For example, while the 2009 exam might have required students to perform a multi-step calculation of the pH of a buffer solution, the modern exam is more likely to ask students to predict the relative change in pH when a specific amount of acid or base is added.

Another key difference is the emphasis on laboratory techniques. The 2009 exam included questions about specific experimental procedures, such as titration and gravimetric analysis. The modern exam continues this tradition but also includes questions about error analysis and experimental design. Students are now expected to evaluate the validity of experimental results and propose modifications to improve accuracy.

Despite these changes, the 2009 AP Chemistry Free Response remains remarkably relevant. The types of equations students must write, the periodic trends they must understand, and the stoichiometric relationships they must manipulate have not changed. Chemistry is a cumulative discipline, and the knowledge tested in 2009 is largely the knowledge tested today.

## Detailed Walkthrough of a Representative 2009 Question

To illustrate the depth of thinking required on the 2009 exam, let us examine a representative equilibrium question step by step. This question involved the decomposition of phosphorus pentachloride gas into phosphorus trichloride gas and chlorine gas.

**Step 1: Write the balanced chemical equation.**
PCl5(g) !Ì PCl3(g) + Cl2(g)

**Step 2: Set up an ICE table.**
Students were given the initial concentration of PCl5 and the equilibrium concentration of Cl2. From this information, they could deduce the changes in concentration for all three species.

**Step 3: Calculate Kc.**
Using the equilibrium concentrations from the ICE table, students substituted into the equilibrium expression and calculated the numerical value of Kc. The 2009 exam required explicit attention to significant figures, and points were deducted for rounding errors.

**Step 4: Predict the effect of a temperature increase.**
Students were told that the decomposition reaction is endothermic. They had to predict whether the value of Kc would increase or decrease with increasing temperature, and they had to explain their reasoning using Le Chatelier's Principle. A complete answer acknowledged that increasing temperature favors the endothermic direction, causing the equilibrium to shift right and increasing Kc.

This four-step approach demonstrates the integration of calculation, conceptual understanding, and written explanation that characterizes the AP Chemistry exam at its best.

## Conclusion

The **2009 AP Chemistry Free Response**section stands as a testament to the depth and rigor of the AP Chemistry program. While the modern exam has evolved in format and emphasis, the fundamental chemical principles tested in 2009 remain at the heart of the discipline. By studying these questions, today's students can strengthen their understanding of equilibrium, thermodynamics, kinetics, and stoichiometry in ways that directly apply to the current exam.

Beyond exam preparation, working through the 2009 free response questions builds genuine chemical intuition. The ability to analyze a system, identify relevant principles, and communicate reasoning clearly is valuable far beyond any single test. Whether you are a student preparing for the AP Chemistry exam or an educator seeking high-quality practice materials, the 2009 free response questions offer enduring insights into the beautiful complexity of chemistry. Approach them with curiosity, persistence, and a willingness to think deeply, and you will emerge with a stronger command of chemistry that will serve you well in any scientific endeavor.

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