

Applied Practice
in

Solutions and Equilibrium

AP* Chemistry Series
RESOURCE GUIDE

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APPLIED PRACTICE
Resource Guide
Solutions and Equilibrium

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A NOTE FOR TEACHERS

The *Applied Practice in AP Chemistry* series was designed for use by teachers as an instructional supplement to major units in the AP Chemistry curriculum. This series was also conceived as a resource for teachers in preparing students for the AP Chemistry Exam. As you teach each unit, your students will have the opportunity to practice and to develop those skills required on the exams.

Each book in the series includes:

- Teaching notes and strategies
- Glossary of terms
- 75 multiple-choice questions replicating Section I of the AP Chemistry Exam
- Multiple-choice answer keys and answer explanations
- 6 free-response questions replicating Section II of the AP Chemistry Exam
- Free-response answer keys and scoring guide

We offer a few suggestions and explanations to help you receive the maximum benefit from our materials:

1. Applied Practice booklets do not purport to duplicate exactly an Advanced Placement Examination. However, questions are modeled on those typically encountered on these exams. Thus, students using these materials will become familiar and comfortable with the format, question types, and terminology of Advanced Placement Examinations.
2. Each Applied Practice booklet focuses on one topic within the AP Chemistry curriculum. These booklets are excellent resources for teachers and their students. Their unique format includes questions designed for use during the initial teaching of the required topics. Other questions are exceptional for the review phase of the course, as students pull the entire year together leading up to the AP Chemistry Exam. The AP exam often will require knowledge in multiple content areas on the same question.
3. You have the option of using the Applied Practice booklets for your own lesson and test preparation or, if you so choose, students may work through an Applied Practice test booklet on their own as they progress through the course. The students can check their own answers with the answer key and read the answer explanations provided in the teacher edition, conferring with the teacher as needed.
4. The order of topics in the Applied Practice booklets has been organized to follow a logical progression that is similar to the sequence in many of the most widely selected AP chemistry textbooks. You will find that they can easily be adapted to whatever sequence you find most productive at your school.

5. The free response questions in each topic were created to provide practice questions similar to both those given in part A of the AP Chemistry Exam, which allows use of a calculator, and those given in part B, in which no calculator is allowed. In a few cases, the specific content is best assessed with a combination of both types.
6. Due to the emphasis on laboratory experience in the College Board's AP Chemistry program, the Applied Practice booklets in AP Chemistry frequently include laboratory-based questions appropriate to the subtopic addressed. A required laboratory-based question does appear on the AP Chemistry Exam. While most Applied Practice booklets in the AP Chemistry series do contain laboratory-based free-response questions, some topics do not lend themselves to the College Board-recommended laboratory experiments. However, each Applied Practice booklet does contain multiple-choice questions related to both laboratory and descriptive chemistry. Only one of the six free-response questions included on the AP Chemistry Exam is laboratory based.
7. Each booklet includes a glossary of terms that applies to the vocabulary of that particular topic.
8. If the teacher wishes to replicate the conditions under which students will take the actual AP Chemistry Exam, he or she should understand the following about multiple-choice versus free-response questions when using Applied Practice booklets: When answering multiple-choice questions (AP Exam, Section I) students are not allowed the use of a calculator, and the only reference information available to them is a periodic table (with only symbol, mass number, atomic number) and a small table of abbreviations/symbols used in the questions. When answering free-response questions (AP Exam, Section II), much more information is available to the student. In addition to the periodic table, a table of standard reduction potentials in aqueous solutions and a relatively complete list of equations, constants, and abbreviations/symbols are provided.

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GLOSSARY OF TERMS

aqueous—dissolved in water; in a water solution

boiling point—the temperature at which the substance changes from liquid to vapor; the temperature at which the vapor pressure of the liquid equals the atmospheric pressure

catalyst—a substance that increases the rate of a chemical reaction without being consumed in the reaction

colligative property—a property of a solution that is related to the number of solute particles but not the type of particles

concentrated—a solution that has a relatively high amount of solute

concentration—a general term concerning the relative quantity of material (solute) dissolved into a solution

covalent character—having properties of covalent bonding; relatively equally effective nuclei so that electrons in a bond are equally shared

dilute—(n) a solution that has a relatively low amount of solute; (v) to lower the concentration of a solution by adding more solvent (typically water)

diprotic acid—an acid with two ionizable hydrogens, for example: sulfurous acid, H_2SO_3

dissociate—to come apart, as ions in an electrolyte when in a water solution: $\text{Na}_2\text{SO}_{4(s)} \rightarrow 2 \text{Na}^+_{(aq)} + \text{SO}_4^{2-}_{(aq)}$

electrolyte—a substance that forms free moving ions in solution; soluble salts, strong acids and strong bases

endothermic—a chemical reaction in which heat is absorbed

equilibrium—a system where opposite reactions (such as phase changes: melting, freezing) occur at equal rates

equilibrium constant—(K_{eq} , K_c , K_p , etc.) the constant value that expresses the relationship between the concentration of products and reactants in a reversible chemical reaction at equilibrium

freezing point—the temperature at which a liquid will turn into a solid

The Solution Process

The following answer choices can be used in questions 1-3. Each answer may be used once, more than once, or not at all.

- (A) Concentrated
- (B) Dilute
- (C) Supersaturated
- (D) Saturated
- (E) Solution

1. This term describes a solution into which no more solute can be dissolved under normal conditions.
2. This term describes a solution in which additional solute can be added to the saturated solution because of some change in conditions
3. The general term that describes the result when any amount of solute is dissolved in any amount of solvent.

4. Which of the following would increase the solubility of a gas in water?

- I. Raising the temperature
- II. Increasing the pressure above the solution
- III. Agitating the solution

- (A) I only
- (B) II only
- (C) III only
- (D) I and II only
- (E) I, II, and III

5. Which of the following is a possible unit for the concentration of a solution?

- I. mol L^{-1}
- II. g mL^{-1}
- III. g mol

- (A) I only
- (B) III only
- (C) I and II only
- (D) II and III only
- (E) I, II, and III

6. A solution has a density of 3.00 g/mL and is made by dissolving 150 g of solute in every 1.00 L of solution. What is the % by mass of solute in the solution?
- (A) 1
(B) 3
(C) 5
(D) 10
(E) 15
7. What is the final concentration of $\text{Cl}^-_{(\text{aq})}$ when 9.53 g of magnesium chloride is dissolved in 500. mL of solution?
- (A) 0.002 M
(B) 0.005 M
(C) 0.100 M
(D) 0.200 M
(E) 0.400 M
8. Molar solubility has units of
- (A) mol g^{-1}
(B) mol L^{-1}
(C) g L^{-1}
(D) g
(E) mol
9. All of the following will increase the solubility of a solute in water EXCEPT
- (A) greater ionic character of the solute as opposed to greater covalent character
(B) increased temperature
(C) greater attraction between the solute and solvent particles
(D) lower lattice enthalpies of the solute as opposed to higher lattice enthalpies
(E) lower hydration enthalpies of the ions as opposed to higher hydration enthalpies
10. Which of the following aqueous solutions would exhibit the lowest electrical conductivity?
- (A) 0.5 M NaCl
(B) 0.5 M MgCl_2
(C) 0.4 M $\text{Al}(\text{NO}_3)_3$
(D) 0.5 M $\text{C}_2\text{H}_5\text{OH}$
(E) 0.5 M CH_3COOH

2. The Haber process utilizes the equilibrium shown below.



- (a) Write the expression for K_c .
- (b) Write the expression for K_p .
- (c) 1.2×10^{-3} moles of $\text{N}_{2(\text{g})}$ are brought together with 4.0×10^{-3} moles of $\text{H}_{2(\text{g})}$ in an evacuated 1.25 L container and equilibrium is established at a temperature of 500 K. The reaction mixture is found to contain 4.0×10^{-4} moles of $\text{NH}_{3(\text{g})}$.
 - (i) Calculate the equilibrium concentrations of each component of the mixture
 - (ii) Calculate a value for K_c at this temperature
 - (iii) Why should a temperature value be quoted with any discussion of equilibria and equilibrium constants?
- (d) Calculate the value of K_p .
- (e) Predict how the value of K for the reaction might change as the temperature is changed to 900 K. Explain.