

Applied Practice in

Acids, Bases, and other Equilibria

AP* Chemistry Series **RESOURCE GUIDE**

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APPLIED PRACTICE
Resource Guide
Acids, Bases, and other Equilibria

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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

acid ionization—(acid dissociation) a reaction in which an H^+ separates from the acid molecule.

Arrhenius—acid-base theory which describes acids as substances that increase the amount of H^+ (H_3O^+) in water and bases as a substances that increase the concentration of OH^- in water

base ionization—a reaction in which a weak base reacts with water to form a hydroxide ion and a conjugate acid

Beers-Lambert Law—states that the relationship of the absorption of light to the concentration of a solution as being linear

Brønsted-Lowry—acid-base theory which describes acids as reacting as proton(H^+) donors in reactions and bases as proton acceptors

buffer—an aqueous solution that has a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid; resists changes in pH when strong acids and bases are added

colorimetry—quantitative study of the absorption of specific colors(wavelengths) of light in a solution

conjugate—in the Brønsted-Lowry acid theory, either of a pair of acid and base on opposite sides of a reaction that differ only by one H^+ ion

dissociate—to come apart, as ions in an electrolyte when in a water solution: $Na_2SO_{4(s)} \rightarrow 2 Na^+_{(aq)} + SO_4^{2-}$

dissolution—the process of dissolving into a solution

electronegative—tendency to gain electrons when forming bonds

endothermic—a chemical reaction in which heat is absorbed

equilibrium constant—(K_a , K_b , K_w , etc.) the constant value that expresses the relationship between the concentration of products and reactants in a reversible chemical reaction at equilibrium

equilibrium constant expression—the ratio of the multiplicative product of the concentration of chemical products raised to the power of their coefficients divided by multiplicative product of the concentration of chemical reactants raised to the power of their coefficients

equimolar—two or more substances that exist in the same concentration in solutions or in equal amounts of moles

equivalence point—the point in an acid-base titration when the amount of acid added is equal to the amount of base you started with, or vice-versa

Henderson-Hasselbalch equation—used to determine the pH of a buffer system; $pH = pK_a + \log \frac{[base]}{[acid]}$

Acid-Base Theories

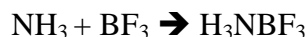
The following answer choices can be used in questions 1-3. Each answer may be used once, more than once, or not at all.

- (A) Arrhenius base
- (B) Brønsted-Lowry acid
- (C) Brønsted-Lowry base
- (D) Conjugate acid
- (E) Lewis acid

1. Describes the role of water in the reaction below



2. Describes the role of BF_3 in the reaction below



3. Is defined as the ability of a substance to produce $\text{OH}^-_{(\text{aq})}$ in solution

4. Which of the following statements is true in relation to the reversible reaction shown below?



- I. In the forward reaction, water is a base.
- II. $\text{H}_3\text{O}^+_{(\text{aq})}$ is the conjugate base of $\text{H}_2\text{O}_{(\text{l})}$.
- III. $\text{CH}_3\text{COOH}_{(\text{aq})}$ is a polyprotic acid.

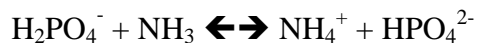
- (A) I only
- (B) II only
- (C) III only
- (D) I and II only
- (E) I, II, and III

5. In which of the following reactions is water acting as a base?

- I. $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
- II. $\text{HBr} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Br}^-$
- III. $\text{CN}^- + \text{H}_2\text{O} \rightarrow \text{HCN} + \text{OH}^-$

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

6. Which of the following shows the correct sequence of acids and bases in the reaction below?



- (A) ACID + BASE \rightleftharpoons ACID + BASE
- (B) ACID + ACID \rightleftharpoons BASE + BASE
- (C) BASE + ACID \rightleftharpoons ACID + BASE
- (D) BASE + ACID \rightleftharpoons BASE + ACID
- (E) ACID + BASE \rightleftharpoons BASE + ACID

7. What feature do all Lewis bases have in common?

- (A) They have protons to donate.
- (B) They accept hydrogen ions.
- (C) They donate electron pairs.
- (D) They accept electron pairs.
- (E) They form H_3O^+ in solution.

8. All of the following can act as Brønsted-Lowry bases EXCEPT

- (A) NH_3
- (B) OH^-
- (C) H_2O
- (D) Cl^-
- (E) NH_4^+

2. Consider the relatively insoluble salt Ag_3PO_4 , which has a $K_{\text{sp}} = 1.8 \times 10^{-18}$.
- (a) Write the K_{sp} expression for the dissolution of Ag_3PO_4 .
 - (b) Calculate the molar solubility of silver phosphate in pure water.
 - (c) Calculate the molar solubility of silver phosphate in a 0.05 M solution of AgNO_3 .
 - (d) Comment on the relative magnitude of your answers to parts (b) and (c) above.
 - (e) Silver also forms another relatively insoluble compound, AgCl with a $K_{\text{sp}} = 1.8 \times 10^{-10}$. A solution that contains phosphate ions at a concentration = 2.0×10^{-6} M and chloride ions at a concentration = 1.0×10^{-5} M has a solution containing silver ions slowly added to it. Which salt will precipitate out first, Ag_3PO_4 or AgCl ? Show calculations to support your answer (Assume negligible change in volume.)