

Applied Practice  
in  
*Chemical Bonding*

AP\* Chemistry Series  
**RESOURCE GUIDE**

\*AP is a registered trademark of the College Entrance Examination Board, which was not involved in the production of, and does not endorse, this product. Pre-AP is a trademark owned by the College Entrance Examination Board.

**APPLIED PRACTICE**  
**Resource Guide**  
*Chemical Bonding*

**Teacher Notes and Strategies**

A Note for Teachers .....	5
Teaching Strategies .....	8
Glossary of Terms .....	15

**Student Practices**

Multiple-Choice Questions .....	21
Types of Bonding.....	22
Electron Structure of Compounds .....	26
Modeling Molecules .....	30
Advanced Bonding Issues.....	34
Properties of Compounds .....	38
Free-Response Questions.....	43

**Answer Key and Explanations**

Multiple-Choice Answer Key .....	53
Multiple-Choice Answer Explanations.....	57
Free-Response Answers and Scoring Guides .....	69

\*AP is a registered trademark of the College Entrance Examination Board, which was not involved in the production of, and does not endorse, this product.

## 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.

### **COPYRIGHT NOTICE**

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material. Reproduction of individual worksheets from this booklet, excluding content intended solely for teacher use, is permissible by an individual teacher for use by his or her students in his or her own classroom. Content intended solely for teacher use may not be reproduced, stored in a retrieval system, or transmitted in any way or by any means (electronic, mechanical, photocopying, or otherwise) without prior written permission from Applied Practice. Reproduction of any portion of this booklet for use by more than one teacher or for an entire grade level, school, or school system, is strictly prohibited. By using this booklet, you hereby agree to be bound by these copyright restrictions and acknowledge that by violating these restrictions, you may be liable for copyright infringement and/or subject to criminal prosecution.

## GLOSSARY OF TERMS

**covalent bond**—attachment of atoms (nonmetals) held together by sharing a pair of valence electrons; overlap of valence orbitals between two atoms

**dipole**—a bond or molecule with oppositely charged ends (+/-)

**dipole moment**—the particular area of positive or negative charge in a molecule, measured in debyes

**double covalent bond**—two atoms attached in a molecule, held together by sharing two pairs of electrons; a sigma and a pi bond between two atoms

**ductile**—the ability to be drawn out into a wire; easily stretched without breaking

**electronegative**—tendency to gain electrons when forming bonds

**electrostatic attraction**—the natural attraction between opposite electric charges (+/-)

**expanded octet**—(hypervalent) more than eight electrons in the valence shell of a central atom in a molecule; ten or twelve electrons (five or six pairs)

**formal charge**—a method of determining the location of charge in a molecule and for comparing the validity of different Lewis structures:  $FC = \# \text{valence electrons} - (\# \text{nonbonding electrons} - \frac{1}{2} \text{bonding electrons})$

**hybridization**—(hybridisation) the mixing of atomic orbitals (*s*, *p* and sometimes *d*) when forming bonds in molecules; part of the valence bond theory; helps explain why bonds in a molecule are equivalent

**ionization energy**—energy required to remove an electron from an atom

**ionic character**—the property of a covalent bond relating to its tendency to have oppositely charged ends; the degree of polarity due to differences in electronegativity

**Lewis structure**—(Lewis dot diagram) the representation of the structure of a molecule, showing a covalent bond as either a pair of electrons (dots) or a line between atoms and unshared pairs of electrons as pairs of dots around the atoms. Molecular geometry can be determined from the Lewis structure

**lone pair**—(nonbonding pair) a pair of electrons in a valence orbital of an atom that is not shared between two atoms; not part of a covalent bond

**malleable**—the property of matter in which it can be hammered, stamped, or rolled without cracking or breaking

## Types of Bonding

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)  $\text{VCl}_3$
- (B)  $\text{CO}_2$
- (C)  $\text{NH}_3$
- (D)  $\text{CCl}_4$
- (E)  $\text{I}_2$

1. Which substance contains double polar covalent bonds, but is nonpolar overall?
2. Which substance is ionic?
3. Which substance contains single polar covalent bonds and is polar overall?
4. Which of the following lists contains ONLY ionic compounds?

- I.  $\text{NaCl}$ ,  $\text{MgCl}_2$ ,  $\text{H}_2\text{O}$
- II.  $\text{NaCl}$ ,  $\text{MgO}$ ,  $\text{NiCl}_2$
- III.  $\text{NiCl}_2$ ,  $\text{Li}_3\text{N}$ ,  $\text{CuSO}_4$

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

5. Correct statements about the molecule  $\text{SF}_6$  include

- I. It has nonpolar covalent bonds.
- II. It is a polar molecule.
- III. It contains polar covalent bonds but is a nonpolar molecule.

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

6. Which of the following molecules contains polar covalent bonds?
- I.  $\text{Cl}_2$
  - II.  $\text{CO}_2$
  - III.  $\text{MgCl}_2$
- (A) I only
  - (B) II only
  - (C) III only
  - (D) II and III only
  - (E) I, II, and III
7. Which of the following could be used to describe a molecule represented by the formula  $\text{XY}_5$  (X and Y are not chemical symbols), where Y is a more electronegative atom than X, and where there are no lone pairs of electrons around the central atom?
- I. The molecule has polar bonds.
  - II. The molecule is nonpolar overall.
  - III. Each individual X-Y covalent bond will have its own dipole.
- (A) I only
  - (B) II only
  - (C) III only
  - (D) I and II only
  - (E) I, II, and III
8. Which of the following molecules is the most polar?
- (A)  $\text{F}_2$
  - (B)  $\text{H}_2$
  - (C)  $\text{O}_2$
  - (D)  $\text{HCl}$
  - (E)  $\text{HF}$
9. Which of the following compounds is most likely to form covalent molecules?
- (A)  $\text{Rb}_2\text{O}$
  - (B)  $\text{CaCl}_2$
  - (C)  $\text{CS}_2$
  - (D)  $\text{MgO}$
  - (E)  $\text{BaF}_2$

2. Use your knowledge of bonding to explain each of the following observations.
- (a) Solid copper (II) sulfate will not conduct electricity but solid copper will.
  - (b) The carbon to carbon bond length is different in the molecules  $C_2H_4$  and  $C_2H_6$ .
  - (c) The sulfur to oxygen bond lengths are all identical in the  $SO_3$  molecule and they have a length that is longer than that of a sulfur-oxygen double bond, but shorter than that of a sulfur-oxygen single bond.
  - (d)  $SCl_6$  is a nonpolar molecule whereas  $SCl_4$  is a polar molecule.