Applied Practice
in

IMF, Liquids, and Solids

AP* Chemistry Series

RESOURCE GUIDE

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APPLIED PRACTICE
Resource Guide
IMF, Liquids, and Solids

Teacher Notes and Strategies

Student Practices

Answer Key and Explanations

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 though 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.

GLOSSARY OF TERMS

allotrope—distinct forms in which a chemical element occurs in the same physical state, each of which differs in its physical properties

Born-Haber cycle—a thermochemical cycle, based on Hess's Law, of chemical reactions used for calculating either the energy required to break down a crystalline solid into its constituent ions (lattice energy), assumes 100% ionic character in the substance

charge density—how concentrated an electric charge is on an ion or dipole moment, related to intensity of attraction/repulsion as determined by Coulomb's Law: $E=\frac{kQ_1Q_2}{r}$, where Q represents the electric charges of the ions and r is the span between them. Smaller ions with higher charges have greater charge density, thus attract and repel more strongly

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

critical point—the temperature above which no amount of pressure can liquefy a gas, associated with the pressure that would liquefy it at that temperature

dipole-dipole forces—an intermolecular force (IMF) in which the oppositely charged ends of two polar molecules attract

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

electron affinity—the energy change when an electron is added to a neutral atom in the gaseous state to form a negative ion

endothermic— a chemical reaction in which heat is absorbed

enthalpy of atomization—the energy required to convert an elemental substance into separate atoms

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

exothermic— a chemical reaction that produces heat

hydrogen bonding—an intermolecular force (IMF), not a true "bond", between a hydrogen atom in one molecule, and the oxygen, nitrogen, or fluorine atom (which must be covalently bonded to a hydrogen) in another molecule; the strongest of the IMFs

Intermolecular Forces

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) London dispersion forces
(B) Hydrogen bonding
(C) Dipole-dipole intermolecular forces
(D) Ionic bonding
(E) Covalent bonding

1. The interaction that occurs between molecules of water but NOT between molecules of chlorine

2. The interaction that occurs between molecules of hydrogen chloride but NOT between molecules of chlorine

3. The interaction that accounts for the increasing melting and boiling points of the halogens on descending group 17

4. When sodium chloride dissolves in water, which of the following statements is true?

I. As part of the process, the lattice energy of the sodium chloride must be overcome.
II. The attraction between the sodium and chloride ions and the water molecules can be described as an ion-dipole interaction.
III. The polarity of the water molecules is essential to the process.

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

5. Which of the following molecules will have London dispersion forces that form *some* part of the intermolecular attractions present?

   I. Fluorine, F_2
   II. Ammonia, NH_3
   III. Hydrogen fluoride, HF

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

6. Which of the following has the substances listed in order of increasing boiling point?

   I. Water < nitrogen < ammonia
   II. Nitrogen < water < chlorine
   III. Chlorine < bromine < iodine

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

7. Which of the following statements is true on descending group 17?

   I. The boiling points of the halogen molecules decrease.
   II. The molecules become more polarizable.
   III. The dipole-dipole intermolecular interactions increase.

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

3. A 5.00 g sample of H_2O is removed from a freezer and heated from an initial temperature of -5.00 ^oC through to a final temperature of 102.0 ^oC.

   (a) Given the following data, calculate the amount of energy that has to be absorbed by the H_2O during the whole process.

   Freezing point of H_2O = 0.00^oC; Boiling point of H_2O = 100.^oC
   ΔH_{fusion} of H_2O = 6.01 kJ mol^{-1}
   $\Delta H_{evaporation}$ of H_2O = 40.7 kJ mol^{-1}
   Specific heat capacity of ice = 2.05 J g^{-1} K^{-1};
   Specific heat capacity of water = 4.18 J g^{-1} K^{-1}
   Specific heat capacity of steam = 2.08 J g^{-1} K^{-1}

   (b) Calculate the percentage of the total energy required for the overall process in (a) that is used just in heating the liquid water.

   (c) Calculate the mass of ice at 0.00^oC, that can be melted in 30 minutes by a heater that produces 8000 kJ of energy per hour but in such a way that only 70% of the heat produced is absorbed by the ice.