Applied Practice in

REDOX and Electrochemistry

AP* Chemistry Series

RESOURCE GUIDE

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APPLIED PRACTICE
Resource Guide
REDOX and Electrochemistry

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.

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GLOSSARY OF TERMS

ampere—(*amp* or A) a unit of electric current equivalent to one coulomb per second

anode—the electrode where current flows from; where oxidation occurs

cathode—the electrode where current flows to; where reduction occurs

coefficient—number written before a formula in a balanced equation to show the relative number of moles of that substance in the reaction

coulomb—(C) a unit of electric charge

current—rate of flow of electric charge; measured in amperes or amps

disproportionation—a REDOX reaction in which the same element is both oxidized and reduced

double displacement—a reaction in which parts of two species have been exchanged; of the form: AB + CD → AD + CB

electrochemical cell—(galvanic cell) a system that has interfaces between metallic terminals(electrodes) and electrolytic solutions, typically in which a current is generated.

electrode—an electrical conductor through which electricity flows, making contact with a nonmettalic part of an electrochemical or electrolytic cell

electrolysis—a reaction in system using a nonspontaneous REDOX reaction; requires an outside power source

Faraday—(F) a unit of charge equivalent to one mole of electrons or 96,500 coulombs

galvanic cell—see *electrolytic cell*

half-cell—a portion of an electrochemical cell in which half of the overall REDOX reaction takes place, either the reduction or the oxidation half

half-reaction—one of two parts of a REDOX reaction; either the reduction half, where electrons are gained, or oxidation half where electrons are lost

halogen displacement reaction—a single replacement reaction in which a more active halogen replaces a less active halogen in a salt

molten—having been melted; the liquid state of a substance that is normally a solid

Oxidation and Reduction

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) 0
(B) +2
(C) +5
(D) +6
(E) +7

1. The number of electrons in the half-reaction that shows permanganate ions being reduced to Mn^{2+} ions in acid solution

2. The oxidation state of Cr in the dichromate ion

3. The number of electrons transferred in the halogen displacement reaction between chlorine gas and bromide ions when the equation is balanced with the lowest possible integers

4. Consider the REDOX reaction shown below. Which of the following statements is true?

$$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

I. Copper is the reducing agent.
II. Six electrons are transferred in the process.
III. The change in oxidation state of N is from +5 to +2.

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

5. When the following half-reactions are correctly combined into a complete REDOX equation, which of the following statements is true?

$$Zn \rightarrow Zn^{2+} + 2e^-$$
$$Cu^{2+} + 2e^- \rightarrow Cu$$

I. A total of four electrons are transferred in the reaction.
II. Copper metal is the oxidizing agent.
III. Zinc metal is the reducing agent.

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

6. The oxidation state of vanadium in VO^{2+} is

(A) -4
(B) 0
(C) +1
(D) +2
(E) +4

7. Which of the following is NOT a REDOX reaction?

(A) $Zn + Cu^{2+} \rightarrow Cu + Zn^{2+}$
(B) $C + O_2 \rightarrow CO_2$
(C) $2CO + O_2 \rightarrow 2CO_2$
(D) $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
(E) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

8. In the ion $HAsO_4^{2-}$, what are the oxidation numbers of hydrogen, arsenic, and oxygen, respectively?

(A) +1, +3, -4
(B) +1, +5, -4
(C) +1, +5, -2
(D) +1, +7, -2
(E) -1, +5, -2

2. In order to find the standard voltage generated by a standard Daniel Cell (copper and zinc electrochemical cell), a student is provided with the following equipment:

   Two beakers
   Sodium nitrate solution
   Filter paper
   A high-resistance voltmeter
   Electrical wire
   A strip of copper metal
   A strip of zinc metal
   Solutions of 1.0 M copper(II) sulfate and 1.0 M zinc sulfate

   (a) Explain why the filter paper is an integral part of the cell.

   (b) Write the cell notation for the reaction.

   (c) In which direction do electrons flow in the external circuit?

   (d) Identify the cathode and write the chemical equation for the reaction occurring there.

   (e) Write a chemical equation that summarizes the full REDOX reaction.

   (f) Without performing a calculation, predict what would happen to the observed voltage if the initial concentration of the $ZnSO_4$ was incorrectly made up to be 0.1 M but all of the other conditions were the same? Explain your prediction.