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Fourth Edition

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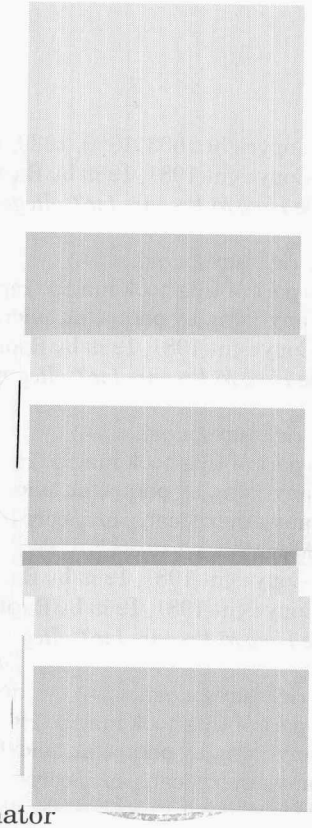

Joseph A. Mascetta
Former Principal
Chemistry Teacher and Coordinator
Science Department
Mount Lebanon High School
Pittsburgh, Pennsylvania

Science Educational Consultant

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All inquiries should be addressed to:
Barron's Educational Series, Inc.
250 Wireless Boulevard
Hauppauge, New York 11788
http://www.barronseduc.com

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PREFACE

This new edition has added four important elements to improve coverage of the material and to make it more useful for students in learning chemistry "the easy way."

1. THE MOST UP-TO-DATE TERMINOLOGY AND USAGE

All notations, word usage, units of measure, and terminology have been carefully checked to ensure that they reflect the most current practices employed in chemistry today. This new edition gives students an opportunity to learn chemistry using these latest innovations and to become confident that they are familiar with modern concepts and language should they decide to move on to more advanced material. The five practice tests also use the most current terminology and are formatted to resemble the current College Entrance Examination Board SAT II Chemistry Tests.

2. EXPANDED EXPLANATIONS, CHARTS, AND GRAPHS

Many of the explanations of major concepts and theories have been expanded to give students a more detailed, up-to-date understanding of the basic ideas of chemistry. These presentations are frequently reinforced with additional, concrete examples. Also included in this edition are more than 150 charts, diagrams, graphs, and illustrations designed to help students visualize and better understand the material.

3. MORE DETAILED SAMPLE PROBLEMS

The quantitative aspects of chemistry are explained in step-by-step fashion and then clarified with sample problems. The factor-label method of keeping track of units is used throughout this book. More sample problems have been added to this revision to aid in the development of problem-solving skills. "Problem Solving: A Thinking Skill" is a separate section in the **Introduction** intended to provide students with a methodology for attacking chemistry problems efficiently.

4. FIVE UP-TO-DATE PRACTICE TESTS WITH ANSWERS

This revised edition has five up-to-date tests covering the whole range of topics included in a high school chemistry course. These tests are modeled after the College Entrance Examination Board SAT II Chemistry Test, and each is accompanied by a detailed answer section. Also included is a self-evaluation section that enables students to identify their strengths and weaknesses. Finally, there is a study guide, referenced to individual sections of the text, that makes it easier to review the material.

INTRODUCTION

How to Use This Book

The purpose of this book is to introduce the student to the basic essentials of a good high school chemistry course. These are developed in a simplified manner with the visual reinforcement of charts, graphs, lists, and simplified drawings.

It is important that the student read and comprehend each section. To check this comprehension, each chapter has a review at the end of the text. This includes a variety of questions and usually a list of terms the student should know. The answers are given along with the chapter review, but all problems are explained in a separate section at the end of the book. A concise glossary of important chemical terms is also provided at the end of the book. The complete index assists the student in finding specific topics or information.

Since chemistry is a quantitative science, the mathematical solution of typical problems has been included. This process includes an introduction of the type of problem and a careful development of the solution.

Knowing laboratory setups and the procedures for conducting particular tests is another important aspect of chemistry. The last chapter of this book summarizes typical laboratory techniques and the basic procedures for specific laboratory tests. A reference section also gives the student access to the most important tables and charts of chemical properties.

The last portion of the book is devoted to five practice tests. These should be of use to the student in preparing for any chemistry achievement test—be it the Regents test, College Entrance Examination Board test, or one of the privately produced standardized tests. The general advice is the same.

To prepare for a test, the student should allow sufficient time so that last minute cramming will be unnecessary. Start early! Review each of the chapters in this book and then attempt to answer the questions in the review section at the end of the chapter. When you experience difficulty on a particular topic, go back over the information here or in any good high school text until you feel you have mastered that concept. When you have finished this, go on to the general tests in the last section of this book. Attempt to answer the questions as quickly and accurately as possible so that you get some practice in pacing yourself. Omit difficult questions you are not sure of and then go back to them after you have answered the easier ones. Do not attempt questions for which you do not have the background to make a judgment since, on an actual test, a percentage of wrong answers may be automatically subtracted from the number of right answers. When you have finished each test, check your answers to see how well you have done and review material you have missed or omitted.

Diagnosing Your Needs

You can use the practice tests as a means of assessing your achievement in each of the major areas tested and as a guide for studying particular topics. To do this, you should take the practice test simulating the conditions, particularly the length of time allowed, of the actual test. You should give yourself 1 hour to answer the questions in Practice Test 1. Check your answers against the correct answers given immediately after the test. In the section following the answers to this test, directions are given to arrive at subscores for

each of the identified areas you need to emphasize by comparing your subscores. Plan to spend more time reviewing the areas in which your subscores were the lowest. However, do not omit any area in your review.

Taking a Test

Below are some suggestions for taking actual tests:

1. Get a good night's sleep. If you should become ill while taking the test, report this to the proctor so that he or she may record this information.
2. Read the instructions carefully and be sure you understand them.
3. Skip questions that seem too difficult for you. Go on to the other questions and come back to the omitted ones if time permits. An easy question counts as much as a hard question.
4. Avoid haphazard guessing since this probably will lower your score. If you can eliminate some of the choices to a question, however, it will be to your advantage to answer the question even if you must guess which of the remaining answers is correct. All questions that are answered correctly count the same toward your score.
5. It is important to pace yourself throughout the hour to answer as many questions as possible. Make the best use of your time! Don't be too upset then if you don't finish the test. At least you have done the best you could in the 1-hour time.

Problem Solving: A Thinking Skill*

Chemistry is a subject that deals with many problem situations that you, the student, must be able to solve. Solving problems may seem to be a natural process when the degree of difficulty is not very great. In these cases, you may not need to have a structured method to attack the problem. However, for complex problems you will need an orderly process to solve the problem. The following is such a problem-solving process. Each step is vital to the next step and to the final solution of the problem.

Step 1. Clarify the problem: to separate the problem into the facts, the conditions, and the questions that need to be answered, and to establish the goal.
Step 2. Explore: to examine the sufficiency of the data, to organize the data, and to apply previously acquired knowledge, skills, and understanding.
Step 3. Select a strategy: to choose an appropriate method to solve the problem.
Step 4. Solve: to apply the skills needed to carry out the strategy chosen.
Step 5. Review: to examine the reasonableness of the solution and to evaluate the effectiveness of the process.

The steps of the problem-solving process listed above should be followed in sequence. The subskills listed below for each step, however, are not in sequence. The order in which subskill patterns are used will differ with the nature of the problem and/or with the ways in

*Adapted with permission from *Thinking Skills Resource Guide*, a noncopyrighted publication of Mount Lebanon School District, Pittsburgh, Pa.

which the individual problem solver thinks. Also, not every subskill need be employed in solving every problem.

Clarify the Problem

Identify the facts. What is known about the problem?

Identify the conditions. What is the current situation?

Identify the questions. What needs to be answered before the problem can be solved?

Visualize the problem.

- Make mental images of the problem.
- If desirable or necessary, draw a sketch or diagram, make an outline, or write down symbols or equations that correspond to the mental images.

Establish the goal. The goal defines the specific result to be accomplished through the problem-solving process. It defines the purpose or function the solution is expected to achieve and serves as the basis for evaluating the solution.

Explore

Review previously acquired knowledge, skills, and understanding. Determine whether the current problem is similar to a previously seen type of problem.

Estimate the sufficiency of the data. Does there seem to be enough information to solve the problem?

Organize the data. There are many ways in which data can be organized. Some examples are outline, written symbols and equations, chart, table, graph, map, diagram, and drawing. Determine whether the data organized in the way(s) you have chosen will enable you to partially or completely solve the problem. The organization of data may suggest what new data need to be collected.

Determine what new data, if any, need to be collected. What new information may be needed to solve the problem? Can the existing data be reorganized to generate new information? Do other resources need to be consulted? This step may suggest possible strategies to be used to solve the problem.

Select a Strategy

A strategy is a goal-directed sequence of mental operations. Selecting a strategy is the most important and also the most difficult step in the problem-solving process. Although there may be several strategies that will lead to the solution of a problem, the skilled problem solver uses the most efficient strategy. The choice of the most efficient strategy is based on

knowledge and experience as well as a careful application of the clarify-and-explore steps of the problem-solving method. Some problems may require the use of a combination of strategies.

The following search methods may help you to select a strategy. They do not represent all of the possible ways in which this can be done. Other methods of strategy selection are related to specific content areas.

Trial-and-error search. Such a search either doesn't have or doesn't use information that indicates that one path is more likely to lead to the goal than any other path.

Trial-and-error search comes in two forms, blind and systematic. In *blind search*, the searchers pick paths to explore blindly, without considering whether they have already explored these paths. A preferable method is *systematic search*, in which the searchers keep track of the paths they have already explored and do not duplicate them. Because this method avoids multiple searches, systematic search is usually twice as efficient as blind search.

Reduction method. This involves breaking the problem into a sequence of smaller parts by setting up subgoals. Subgoals make problem solving easier because they reduce the amount of search required to find the solution.

You can set up subgoals by working part way into a problem and then analyzing the partial goal to be achieved. In doing this, you can drop the problem restrictions that do not apply to the subgoal. By adding up all the subgoals, you can solve the "abstracted" problem.

Working backward. When you have trouble solving a problem head-on, it is often useful to try to work backward. Working backward involves a simple change in representation or point of view. Your new starting point is the original goal. Working backward can be helpful because problems are often easier to solve in one direction than in another.

Knowledge-based method. This strategy uses information stored in the problem solver's memory, or newly acquired information, to guide the search for the solution. The problem solver may have solved a similar problem and can use this knowledge in a new situation. In other cases, problem solvers may have to acquire needed knowledge. For example, they may solve an auxiliary problem to learn how to solve the one they are having difficulty with.

Searching for analogous (similar) problems is a very powerful problem-solving technique. When you are having difficulty with a problem, try to pose a related, easier one and hope to learn something that will help you solve the harder problem.

Solve

Use the strategy chosen to actually solve the problem. Executing the solution provides you with a very valuable check on the adequacy of your plan. Sometimes students will look at a problem and decide that, since they know how to solve it, they need not bother with the drudgery of actually executing the solution. Sometimes the students are right, but at other times they miss an excellent opportunity to discover that they were wrong.

Review

Evaluation. The critical question in evaluation is Does the answer I propose meet all of the goals and conditions set by the problem? Thus, after the effort of finding a solution, you must turn back to the problem statement and check carefully to be sure your solution satisfies it.

With easy problems there is a strong temptation to skip evaluation because the probability of error seems small. In some cases, however, this can be costly. Evaluation may prove that errors were present.

Verifying the reasonableness of the answer. It is easy to become so involved with the process and mathematics of a problem that an answer is recorded that is totally illogical. To avoid this mistake, you should simplify the numbers involved and solve for an answer. Having done this, compare your estimated result with your answer to ensure that your answer is feasible.

For example, a problem requires the following operations:

$$5.12 \times 10^5 \times 3.98 \times 10^6 \text{ divided by } 910$$

And doing all the math, you get an answer of

$$0.02239 \times 10^{11} \text{ or } 2.24 \times 10^9$$

To estimate the answer, first simplify the numbers to one significant figure (significant figures are discussed in Chapter 1). This gives

$$5 \times 10^5 \times 4 \times 10^6 \text{ divided by } 9 \times 10^2$$

which is

$$20 \times 10^{11} \text{ divided by } 9 \times 10^2 = 2.2 \times 10^9$$

This is the estimated answer, which validates the answer above.

When you are dealing with test items that provide multiple-choice answers, you can often use estimation to arrive at the answer without doing the more complicated mathematics.

Consolidation. Here the basic question to be answered is What can I learn from the experience of solving this problem? The following more specific questions may help you to answer this general one:

- Why was this problem difficult?
- Was it difficult to follow a plan?
- Was it difficult to decide on a plan? If so, why?
- Did I take the long way to the answer?
- Can I use this plan again in similar problems?

The important thing is to reflect on the process that you used in order to make future problem solving easier.

CONTENTS

PART I:
AN INTRODUCTION

Chapter 1

INTRODUCTION TO CHEMISTRY

Matter

Definition of Matter

Matter is defined as anything that occupies space and has mass. *Mass* is the quantity of matter that a substance possesses and, depending on the gravitational force acting on it, has a unit of *weight* assigned to it. Although the weight can then vary, the mass of the body is a constant and can be measured by its resistance to a change of position or motion. This property of mass to resist a change of position or motion is called *inertia*. Since matter does occupy space, we can compare the masses of various substances that occupy a particular unit volume. This relationship of mass to a unit volume is called the *density* of the substance. It can be shown in a mathematical formula as $D = m/V$. The basic unit of mass (m) in chemistry is the gram (g), and of volume (V) is the cubic centimeter (cm^3) or milliliter (mL).

An example of how density varies can be shown by the difference in the volume occupied by 1 g of a metal, such as gold, and 1 g of styrofoam. Both have the same mass, that is, 1 g, but the volume occupied by the styrofoam is much larger. Therefore the density of the metal will be much larger than that of the styrofoam. When dealing with gases in chemistry, the standard units for the density of gases are grams per liter at a standard temperature and pressure. This aspect of the density of gases is dealt with in Chapter 6. Basically then, density can be defined as the mass per unit volume.

States of Matter

Matter occurs in three states: solid, liquid, and gas. A *solid* has both a definite size and shape. A *liquid* has a definite volume but takes the shape of the container, and a *gas* has neither a definite shape nor a definite volume. These states of matter can often be changed by the addition of heat energy. An example of this is ice changing to liquid water and finally to steam.

Composition of Matter

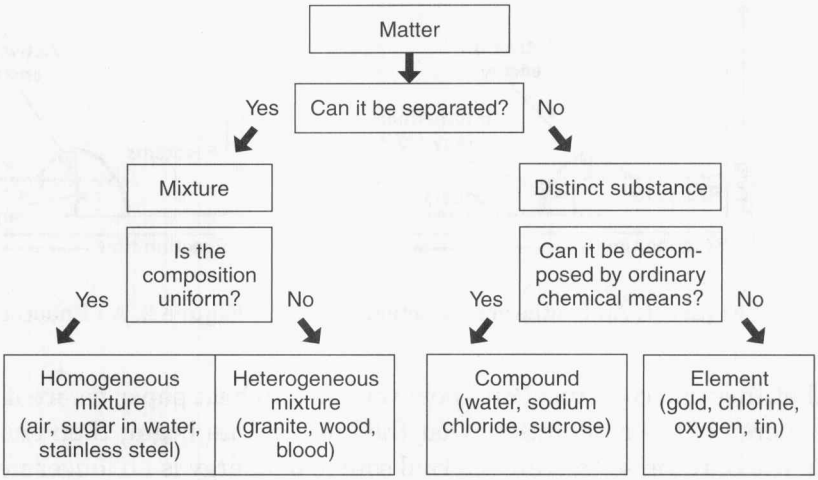
Matter can be subdivided into two general categories: distinct substances and mixtures. Distinct substances are substances that can be subdivided into the smallest particle that still has the properties of the substance. At that point, if the substance is made up of only one kind of atom, it is called an *element*. Atoms are considered to be the basic building blocks of matter that cannot be easily created or destroyed. The word *atom* comes from the Greek and means the smallest possible piece of something. Today there are approximately 109 different kinds of atoms, each with its own unique composition. These atoms then are the building blocks of elements when only one kind of atom makes up the substance. If, however, there are two or more kinds of atoms joined together in definite grouping, this distinct substance is called a *compound*. Compounds are made by combining elements in a definite proportion (or ratio) by mass and are made up of two or more kinds of atoms. This is called the *Law of Definite Composition (or Proportions)*. The smallest natural occurring unit of a compound is called a *molecule* of that compound. A molecule of a compound has a definite shape that is determined by how the atoms are bonded to or combine with each other. This bonding is described in Chapter 3. An example is the compound water: it always occurs in a two hydrogen atoms to one oxygen atom relationship. *Mixtures*, however, can vary in their composition.

In general, then:

Mixtures	Distinct Substances
1. Composition is indefinite (generally heterogeneous).* (Example: marble) 2. Properties of the constituents are retained. 3. Parts of the mixture react differently to changed conditions.	**Elements** 1. Composition is made up of one kind of atom. (Examples: nitrogen, gold, neon) 2. All parts are the same throughout (homogeneous). **Compounds** 1. Composition is definite (homogeneous). (Examples: water, carbon dioxide) 2. All parts react the same. 3. Properties of the compound are distinct and different from the properties of the individual elements that are combined in its makeup.

*Solutions are mixtures, such as sugar in water, but since the substance, like sugar, is distributed evenly throughout the water, it can be said to be a homogeneous mixture.

The following chart shows a classification scheme for matter.



Chemical and Physical Properties

Physical properties of matter are those properties that can usually be observed with our senses. They include everything about a substance that can be noted when no change is occurring in the type of structure that makes up its smallest component. Some common examples are physical state, color, odor, solubility in water, density, melting point, taste, boiling point, and hardness.

Chemical properties are those properties that can be observed in regard to whether or not a substance reacts with other substances. For example, iron rusts in moist air, nitrogen does not burn, gold does not rust, sodium reacts with water, silver does not react with water, and water can be decomposed by an electric current.

Chemical and Physical Changes

The changes matter undergoes are classified as either physical or chemical. In general, a *physical change* alters the physical properties of matter, but the composition remains constant. The most often altered properties are form and state. Some examples are breaking glass, cutting wood, melting ice, and magnetizing a piece of metal. In some cases, the process that caused the change can be easily reversed and the substance regains its original form.

Chemical changes are changes in the composition and structure of a substance. They are always accompanied by energy changes. If the energy released in the formation of a new structure exceeds the chemical energy in the original substances, energy will be given off, usually in the form of heat or light or both. This is called an *exothermic reaction*. If, however, the new structure needs to absorb more energy than is available from the reactants, the result is an *endothermic reaction*. This can be shown graphically.

Notice that in Figures 1 and 2 the term *activation energy* is used. The activation energy is the energy necessary to get the reaction going by increasing the energy of the reactants