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Chemistry Essentials

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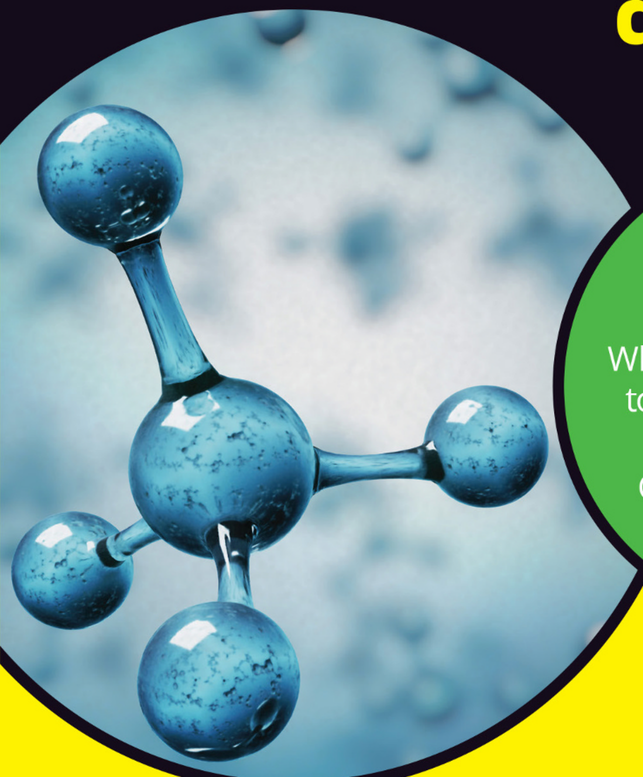

All of the critical calculations

What you need to know to conquer chemistry

Concise coverage of key topics

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Contents at a Glance

Table of Contents

Introduction

Congratulations on making a step toward discovering more about what I consider a fascinating subject: chemistry. For more than 40 years, I've been a student of chemistry. This includes the time I've been teaching chemistry, but I still consider myself a student because I'm constantly finding out new facts and concepts about this important and far-reaching subject.

Hardly any human endeavor doesn't involve chemistry in some fashion. People use chemical products in their homes — cleaners, medicines, cosmetics, and so on. And they use chemistry in school, from the little girl mixing vinegar and baking soda in her volcano to the Ivy League grad student working on chemical research.

Chemistry has brought people new products and processes. Many times this has been for the good of humankind, but sometimes it's been for the detriment. Even in those cases, people used chemistry to correct the situations. Chemistry is, as has been said many times, the central science.

About This Book

My goal with this book is to give you the really essential information and concepts that you would face in a first semester chemistry class in high school or college. I've omitted a lot of topics found in a typical chemistry textbook. This book is designed to give you the bare essentials.

Remember, this is a light treatment. If you want more, many other books are available. My favorite, naturally, is *Chemistry For Dummies.* I understand the author is really a great guy.

Conventions Used in This Book

Here are a couple of conventions you find in *For Dummies* books:

- I use *italics* to emphasize new words and technical terms, which I follow with easy-to-understand definitions.
- **Bold** text marks keywords in bulleted lists and highlights the general steps to follow in a numbered list.

In addition, I've tried to organize this book in approximately the same order of topics found in a one-semester general chemistry course. I've included some figures for you to look at; refer to them as you read along. Also, pay particular attention to the reactions that I use. I've attempted to use reactions that you may be familiar with or ones that are extremely important industrially.

Foolish Assumptions

I don't know your exact reasons for picking up this guide, but I assume you want to know something about chemistry. Here are some reasons for reading:

- You may be taking (or retaking) a chemistry class. This book offers a nice, quick review for your final exam. It can also give you a refresher before you plunge into a new course, such as biochemistry or organic chemistry.
- You may be preparing for some type of professional exam in which a little chemistry appears. This book gives you the essentials, not the fluff.
- You may be a parent trying to help a student with his or her homework or assignment. Pay attention to what your child is currently studying and try to stay a little ahead.
- Finally, you may be what people call a "nontraditional student." You knew most of this material once upon a time, but now you need a quick review.

Whatever the reason, I hope that I'm able to give you what you need in order to succeed. Good luck!

Icons Used in This Book

If you've read any other *For Dummies* books (such as the great *Chemistry For Dummies*), you'll recognize the two icons used in this book. Here are their meanings:

REMEMBER

This icon alerts you to those really important things you shouldn't forget. These are ideas that you most probably need to memorize for an exam.

TIP

This icon points out the easiest or quickest way to understand a particular concept. These are the tricks of the trade that I've picked up in my 40+ years learning chemistry.

Where to Go from Here

Where you go next really depends on you and your reason for using this book. If you're having difficulty with a particular topic, go right to that chapter and section. If you're a real novice, start at Chapter 1 and go from there. If you're using the book for review, skim quickly starting at the beginning and read in more depth those topics that seem a little fuzzy to you. You can even use this book as a fat bookmark in your regular chemistry textbook.

Whatever way you use this book, I hope that it helps and you grow to appreciate the wonderful world of chemistry.

IN THIS CHAPTER

- » **Understanding the states of matter**
- » **Differentiating between pure substances and mixtures**
- » **Measuring matter with the metric system**
- » **Examining the properties of chemical substances**
- » **Discovering the different types of energy**

Chapter 1 Matter and Energy: Exploring the Stuff of Chemistry

Simply put, chemistry is a whole branch of science about matter, which is anything that has mass and occupies space. Chemistry is the study of the composition and properties of matter and the changes it undergoes.

Matter and energy are the two basic components of the universe. Scientists used to believe that these two things were separate and distinct, but now they realize that matter and energy are linked. In an atomic bomb or nuclear reactor, for instance, matter is converted into energy. (Perhaps someday science fiction will become a reality and converting the human body into energy and back in a transporter will be commonplace.)

In this chapter, you examine the different states of matter and what happens when matter goes from one state to another. I show you how to use the SI (metric) system to make matter and energy measurements, and I describe types of energy and how energy is measured.

Knowing the States of Matter and Their Changes

Matter is anything that has mass and occupies space. It can exist in one of three classic states: solid, liquid, and gas. When a substance goes from one state of matter to another, the process is called a *change of state,* or *phase change.* Some rather interesting things occur during this process, which I explain in this section.

Solids, liquids, and gases

Particles of matter behave differently depending on whether they're part of a solid, liquid, or gas. As Figure 1-1 shows, the particles may be organized or clumped, close or spread out. In this section, you look at the solid, liquid, and gaseous states of matter.

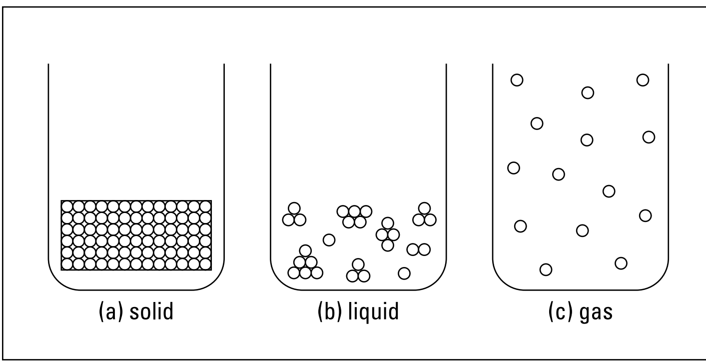

FIGURE 1-1: Solid, liquid, and gaseous states of matter.

Solids

At the *macroscopic level,* the level at which you directly observe with your senses, a solid has a definite shape and occupies a definite volume. Think of an ice cube in a glass — it's a solid. You can easily weigh the ice cube and measure its volume.

At the *microscopic level* (where items are so small that people can't directly observe them), the particles that make up the solid are very close together and aren't moving around very much (see Figure 1-1a). That's because in many solids, the particles are pulled into a rigid, organized structure of repeating patterns called a *crystal lattice.* The particles in the crystal lattice are still moving but barely — it's more of a slight vibration. Depending on the particles, this crystal lattice may be of different shapes.

Liquids

Unlike solids, liquids have no definite shape; however, they do have a definite volume, just like solids do. The particles in liquids are much farther apart than the particles in solids, and they're also moving around much more (see Figure 1-1b).

Even though the particles are farther apart, some particles in liquids may still be near each other, clumped together in small groups. The attractive forces among the particles aren't as strong as they are in solids, which is why liquids don't have a definite shape. However, these attractive forces are strong enough to keep the substance confined in one large mass — a liquid — instead of going all over the place.

Gases

A gas has no definite shape and no definite volume. In a gas, particles are much farther apart than they are in solids or liquids (see Figure 1-1c), and they're moving relatively independent of each other. Because of the distance between the particles and the independent motion of each of them, the gas expands to fill the area that contains it (and thus it has no definite shape).

Condensing and freezing

If you cool a gaseous or liquid substance, you can watch the changes of state, or *phase changes*, that occur. Here are the phase changes that happen as substances lose energy:

- **Condensation:** When a substance *condenses,* it goes from a gas to a liquid state. Gas particles have a high amount of energy, but as they're cooled, that energy decreases. The attractive forces now have a chance to draw the particles closer together, forming a liquid. The particles are now in clumps, as is characteristic of particles in a liquid state.
- **Freezing:** A substance *freezes* when it goes from a liquid to a solid. As energy is removed by cooling, the particles in a liquid start to align themselves, and a solid forms. The temperature at which this occurs is called the *freezing point (fp)* of the substance.

TIP

You can summarize the process of water changing from a gas to a solid in this way:

$$H_2O(g) \rightarrow H_2O(l) \rightarrow H_2O(s)$$

Here, the *(l)* stands for liquid, the *(g)* stands for gas, and *(s)* stands for solid.

Melting and boiling

As a substance heats, it can change from a solid to a liquid to a gas. For water, you represent the change like this:

$$H_2O(s) \rightarrow H_2O(l) \rightarrow H_2O(g)$$

This section explains melting and boiling, the changes of state that occur as a substance gains energy.

From solid to liquid

When a substance melts, it goes from a solid to a liquid state. Here's what happens: If you start with a solid, such as ice, and take temperature readings while heating it, you find that the temperature of the solid begins to rise as the heat causes the particles to vibrate faster and faster in the crystal lattice.

After a while, some of the particles move so fast that they break free of the lattice, and the crystal lattice (which keeps a solid *solid*) eventually breaks apart. The solid begins to go from a solid state to a liquid state — a process called *melting*. The temperature at which melting occurs is called the *melting point (mp)* of the substance. The melting point for ice is 32°F, or 0°C.

REMEMBER

During changes of state, such as melting, the temperature remains constant — even though a liquid contains more energy than a solid. So if you watch the temperature of ice as it melts, you see that the temperature remains steady at 0°C until all the ice has melted.

TIP

The melting point (solid to a liquid) is the same as the freezing point (liquid to a solid).

From liquid to gas

The process by which a substance moves from the liquid state to the gaseous state is called *boiling*.