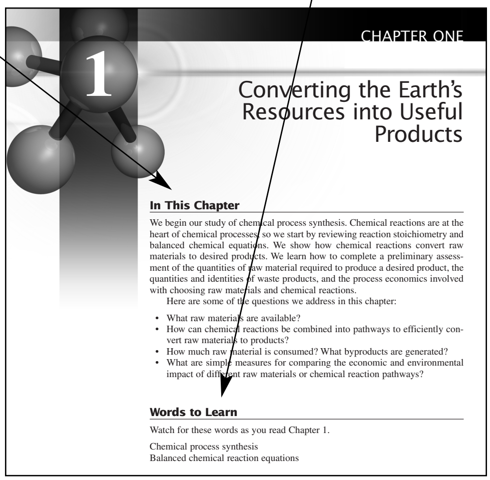
# Guided Tour

## Tools that Reinforce Concepts

### In this Chapter

### Words to Learn

An ***In this Chapter*** section provides a brief introduction of the subject matter and a bulleted list of questions that are addressed in each chapter. A list of ***Words to Learn*** is also outlined at the beginning of each chapter. These elements help the reader to focus on the fundamental points as they read each chapter.



CHAPTER ONE

1

Converting the Earth's Resources into Useful Products

**In This Chapter**

We begin our study of chemical process synthesis. Chemical reactions are at the heart of chemical processes, so we start by reviewing reaction stoichiometry and balanced chemical equations. We show how chemical reactions convert raw materials to desired products. We learn how to complete a preliminary assessment of the quantities of raw material required to produce a desired product, the quantities and identities of waste products, and the process economics involved with choosing raw materials and chemical reactions.

Here are some of the questions we address in this chapter:

- What raw materials are available?
- How can chemical reactions be combined into pathways to efficiently convert raw materials to products?
- How much raw material is consumed? What byproducts are generated?
- What are simple measures for comparing the economic and environmental impact of different raw materials or chemical reaction pathways?

**Words to Learn**

Watch for these words as you read Chapter 1.

Chemical process synthesis
Balanced chemical reaction equations

**Quick Quiz 5.8**

From the Antoine equation, what's the saturation pressure for $H_2O$ at 100°C?

### Quick Quizzes

The ***Quick Quizzes*** are sprinkled within the chapters and are intended to test student understanding of the topics covered in each chapter. Answers to the quizzes are provided at the end of each chapter.

### Helpful Hints

### Did you Know?

***Helpful Hints*** ! and ***Did You Know*** ? sections can be found in the margins sprinkled throughout the text. *Helpful Hints* are designed to help students with difficult points.

**! Helpful Hint**
The ideal gas law does not apply to liquids and solids!

**? Did You Know?**
Chemical engineers tend to prefer continuous processes. But it's not clear that consumers do. For example, the label on a bag of gourmet potato chips brags "made in small batches." "Batch" manufacturing is used to imply more lovingly made, higher-quality products; such products command a premium price at the grocery store.

**Example 3.10** **Integral Equation with Unsteady Flow and Chemical Reaction: Controlled Drug Release**

Patients with certain diseases are treated by injection of proteins or drugs into their bloodstream. Upon injection there is a sudden increase in the protein or drug concentration in the blood to very high levels, but then the concentration rapidly falls. A steadier blood concentration is often desirable, to reduce toxic side effects and increase therapeutic efficacy. Controlled-release technology reduces the variability in drug concentration in the blood. With controlled release, the protein or drug is encapsulated in a polymer and is released slowly into the bloodstream. This maintains the concentration of drug or protein in the bloodstream at a lower, more constant level.

### Examples

Over 100 worked examples indicate the conceptual idea the problem is designed to illustrate as well as the specific application chosen. Classical and modern topics are used in the example problems.

**CASE STUDY** Six-Carbon Chemistry

In this case study we illustrate how the concepts introduced in Chap. 1 are used to make decisions about raw materials, products, and reaction pathways, by looking in some depth at specific processes of importance in the organic chemicals business. These processes are linked by their connection to 6-carbon compounds. We'll look at two questions:

1. Benzene is a 6-carbon compound purified from petroleum. Suppose we have available 15,000 kg/day benzene. What are some useful 6-carbon products we might make from benzene?

## Case Studies

***Case Studies*** are provided at the end of each chapter. These in-depth examples illustrate the application of key concepts from that chapter to modern problems. Case studies integrate analysis and synthesis, and boost student confidence in their ability to tackle complex problems and issues.

## End-of-Chapter Summaries

The ***Summary*** sections appear at the end of each chapter and provide an overview of the key definitions and equations from that chapter.

**Summary**

- Chemical processes convert raw materials into useful products. In the initial stages of **chemical process synthesis,** we choose raw materials to make a specific product, or products to make from a specific raw material. We choose a chemical reaction pathway for converting the chosen raw materials into desired products. These choices all have profound consequences on the technical and economic feasibility of the process.

**ChemiStory: Changing Salt into Soap**

Soap is made by combining fats or oils from animals or plants with an alkaline material. Today caustic soda (sodium hydroxide, NaOH) is the alkali used for making soap, but in the past sodium carbonate ($Na_2CO_3$), potassium hydroxide (KOH), and potassium carbonate ($K_2CO_3$) were common choices.

In the 1700s in Europe, soap was a luxury reserved for the wealthy. But technology to make cheaper cotton clothing was rapidly developing. Cotton

## ChemiStories

***ChemiStories*** describe historical events in the lives of the people who contributed to the chemical industry and its products. The stories bring to life the chemical products we take for granted, illustrate the humanity of the heroes of chemical technology, demonstrate that social and political forces drive scientific and engineering progress, and caution readers that technological breakthroughs sometimes have unwanted adverse effects.

**Chapter 2 Problems**

Warm-Ups

**P2.1** (a) 1 g hydrogen ($H_2$) is mixed with 1 g benzene ($C_6H_6$) and 1 g cyclohexane ($C_6H_{12}$). The mixture is all gas. What is the mass fraction and mole fraction of hydrogen, benzene, and cyclohexane in the mixture?
(b) 1 gmol hydrogen ($H_2$) is mixed with 1 gmol benzene ($C_6H_6$) and 1 gmol cyclohexane ($C_6H_{12}$). The mixture is all gas. What is the mole fraction and mass fraction of hydrogen, benzene, and cyclohexane in the mixture?

**P2.2** You go into the lab and put a 100-mL volumetric flask on a balance. You tare the balance so that it reads 0 g. Then you measure out anhydrous fructose ($C_6H_{12}O_6$—the major sugar in fruit) into the flask until the balance reads 15.90 g. Then you fill the flask up to the 100-mL line with water. The balance now reads 105.97 g. Calculate the wt% fructose and mol% fructose of the solution. The molar mass of fructose is 180 g/gmol and that of water is 18 g/gmol.

Drills and Skills

**P2.21** Turn on a faucet in your bathroom or kitchen full blast. Then measure the water flow rate, using a bucket and watch. Report your measurement in the following units: gallons per minute, grams per second, pound-moles per hour, and tons per year. At this flow rate, would your faucet have a capacity similar to a typical commodity, specialty, or pharmaceutical plant? (Refer to Table 1.4.)

**P2.22** Oxygen flows into a reactor at 115 lb/min. Plot the volumetric flow rate ($ft^3$/min) at a range of temperatures from 0°C to 150°C at 1 atm pressure, and at a range of pressures from 1 psia to 100 psia at 25°C. Use the ideal gas law to model the specific volume of oxygen as a function of pressure and temperature.

## Homework Problems

***Homework Problems*** are broken into four categories:

**-Warm-Ups:** Short-answer questions that cover basic definitions and straightforward calculations. Minimal proficiency.

**-Drills and Skills:** Drills and Skills problems cover the fundamental skills and concepts learned in that chapter. Average proficiency.

**-Scrimmage:** Scrimmage problems require application of more than one skill or concept and may involve material from multiple (previous) chapters. Creativity is needed and some problems require library research.

**-Game Day:** Game Day problems are best suited for use in the classroom or as term projects and can be used to promote teamwork and improve communication skills.