Chapter 1
Introduction

This introductory chapter tells students the importance and relevance of studying chemistry. Upon completion of this chapter, the students should be able to:

1. Give examples of how chemistry is used in everyday life.
2. Explain the scientific method and how it is used.
3. Classify materials in terms of homogeneous and heterogeneous mixtures.
4. Distinguish between compounds and elements.
5. Explain physical versus chemical properties.
6. Name the commonly used SI unit prefixes.
7. Solve problems involving density, volume, and mass.
8. Convert between degrees for the Kelvin, Celsius, and Fahrenheit temperature scales.
9. Apply scientific notation and use proper number of significant figures in problem solving.
10. Discuss the difference between accuracy and precision.
11. Utilize the factor-label method of problem solving.
12. Name the common conversion factors for the metric system to English system. Examples of such conversion factors include grams to pounds, centimeters to inches, and liters to gallons.

Section 1.1: The Study of Chemistry

Students often wonder why they are required to take chemistry. Show them how chemistry, the Central Science, applies to their career choices. Assign them to find an article in a trade magazine of their field or in the popular press that involves chemistry. As your author has pointed out, everything from modern medicine to energy sources to “molecular computing” involve chemistry.
It is important to emphasize that chemists – in fact, all scientists – make observations. Students have made observations through their own experiences (macroscopic world). Building on students’ observations makes the information from relevant, thus making it easier for them to comprehend. The microscopic world is more difficult for students since they have not experienced it. It is important that students “see” what is happening on the microscopic level in order to understand their experience at the “macroscopic level”.

Section 1.2: The Scientific Method

Most students are introduced to the scientific method early in their education. The scientific method includes: a) defining the problem; b) making qualitative and quantitative observations; c) recording the data; d) interpreting the data into a hypothesis; e) testing the hypothesis with more observations until a theory is developed; and f) examining the theory over time until a law is accepted

Section 1.3: Classification of Matter

A mixture is a combination of two or more substances in which the substances retain their distinct identities. Different mixtures can have different compositions just like two solutions of sugar water can have different composition. However, if a mixture has constant composition throughout, then it is classified as homogeneous. If it has a variable composition depending on where it is sampled, then it is a heterogeneous mixture. Mixtures, both homogeneous and heterogeneous, can be separated into their original substances. Compounds, however, can be separated into their original elements only by chemical processes.

Students are familiar with the three states of matter: solid, liquid, and gas. In a demonstration using toy "slime," ask students which state of matter the toy "slime" represents.

Section 1.4: Physical and Chemical Properties of Matter

Physical changes do not change the composition of the material, while chemical changes do. Liquid water and steam seem to be considerably different; however, they are interchangeable simply by changing temperature. The burning of a sample of gasoline, at first glance, could be considered to be a physical change because the liquid is becoming a gas. It is not possible, however, to change those vapors back into gasoline.
The way to assist your students in distinguishing between extensive and intensive properties is to explain to them that **in**tensive properties are **in**dependent of the quantity of material that you have (density, temperature, etc.), while extensive properties depend upon how much you have (mass, volume, etc.).

Section 1.5: Measurement

"Mass" and "weight" are not the same. Our students understand that astronauts are "weightless" when working in a space station but are not "massless." Often mass and weight is interchanged; however, they are distinctly different and should be used properly. We define a gram as 1×10^{-3} kilogram. Many students have a difficult time comprehending numbers less than one. It is easier for many to understand that 1000 grams is equal to one kilogram rather than one gram is equal to 1×10^{-3} kilogram. For example, the conversion of 352 grams to kilograms can be shown two ways:

$$(352 \text{ grams})\left(\frac{1 \text{ kg}}{1000 \text{ grams}}\right) = 0.352 \text{ kg}$$

OR

$$(352 \text{ grams})\left(\frac{1 \times 10^{-3} \text{ kg}}{1 \text{g}}\right) = 0.352 \text{ kg}$$

While both methods are correct, if one uses the concept that it takes a great number (1000 to be exact) of grams to equal one kilogram, then the first method seems easier for students to understand. Since students should have memorized that kilo means 1×10^3, they will likely use the conversion $\frac{1\times10^3 \text{kg}}{1 \text{g}}$, which is totally incorrect. If the students are asked to review their conversion, such a mistake can be avoided.

The author points out that there are three temperature scales, the ones described in the text are Fahrenheit, Celsius, and Kelvin. There is yet another scale known as the Rankin scale that engineering students will encounter later in their academic career. It should be noted that the Kelvin scale omits the degree sign.

Equations 1.2 and 1.3 in Section 1.5 show the conversion of Fahrenheit to Celsius and Celsius to Fahrenheit, respectively. These equations can be explained using the following logic:

450º is what temperature on the Celsius scale?

It is understood the 100 units on the Celsius scale is equal to 180 units on the Fahrenheit scale. This is known from the fact that water freezes at 0ºC and boils at 100ºC (100 C units), while it freezes and boils at 32ºF and 212ºF (180 F units), respectively. Therefore, 450ºF is 450 − 32 or 418 F units above freezing.

$$(418 \text{ F units})\left(\frac{100 \text{ C Units}}{180 \text{ F Units}}\right) = 232 \text{ C units above freezing}$$

232 C units above freezing is 232ºC. If one examines equation 1.2, it is seen that the two-step logical process described above gives the same result.

85.0ºC is what temperature on the Fahrenheit scale?
85.0ºC is 85.0 C units above freezing

$$(85.0 \text{ C units})\left(\frac{180 \text{ F Units}}{100 \text{ C Units}}\right) = 153 \text{ F units above freezing}$$

This corresponds to 153 + 32 = 185ºF

Temperatures below freezing are handled in a similar fashion. For example, **10ºF is what temperature on the Celsius scale? 10ºF is 32 − 10 or 22 F units below freezing.**

$$(22 \text{ F units})\left(\frac{100 \text{ C Units}}{180 \text{ F Units}}\right) = 12 \text{ C units below freezing}$$

12 C units below freezing = −12^{o}C.

−40^{o}C is what temperature on the Fahrenheit scale?

−40^{o}C is 40 C units below freezing

$$(40 \text{ C units})\left(\frac{180 \text{ F Units}}{100 \text{ C Units}}\right) = 72 \text{ F units below freezing}$$

Since water freezes at +32^{o}F, 72 F units below freezing would be (72 − 32) or 40 F units below zero or –40^{o}F. **This is the only temperature where Fahrenheit and Celsius temperatures are equal.** The Kelvin scale has the same size degree as the Celsius scale. The Kelvin scale starts at absolute zero with 0 K and is 273.15 K at the freezing point of water; thus, the conversion is to add 273.15 to the Celsius temperature to get the temperature in Kelvins. The Rankin scale mentioned earlier is not covered in this textbook. It has the same size degree as the Fahrenheit scale with 0^{o}R being absolute zero. Zero degrees Rankin corresponds to –460^{o}F; thus, water freezes at 492^{o}R and boils at 672^{o}R. The Rankin scale is used in some engineering courses; however, it is probably not wise to confuse the students by introducing this fourth scale. It should be noted that many calculators have preprogrammed temperature conversion keys that make problems dealing with this issue obsolete.

Section 1.6: Handling Numbers

Students often feel that scientific notation and significant figures are not important in "real-world" practice. It may be of interest to point out the American Society of Testing & Materials (ASTM) has a standard method, E-380 "Excerpts from Standard Practice for use of the International System of Units (SI) (the Modernized Metric System)," which deals specifically with these topics. It should be understood that one needs to have all numbers to the same power of 10 if using scientific notation in order to correctly count the number of significant figures to the right of the decimal. For example,

$$\mathbf{8.323\times10^{3} + 1.35\times10^{2}}$$

is correctly expressed as

$$\mathbf{8.323\times10^{3} + 0.135\times10^{3} = 8.458\times10^{3}}$$

Note that the answer has three significant figures to the right of the decimal. One gets the same result if the numbers are expressed as

$$\mathbf{83.23\times10^{2} + 1.35\times10^{2} = 84.58\times10^{2} \text{ or } 8.458\times10^{3}}$$

or as

$$\mathbf{8323. + 135.458 = 8.458 \times 10^3}$$

Your author does not address problems that include a combination of addition/subtraction and multiplication/division. The rules apply as shown in the following example:

$$\frac{(15.49 + 9)(24)(3.9506)}{5.7623} = \frac{(24)(3.9506)}{5.7623}$$

$$= 16$$

Section 1.7: Dimensional Analysis in Solving Problems

The author uses the terms factor-label method or dimensional analysis. A third term to describe the same system of problem solving is unit analysis. In the example of converting 2.46 dollars to pennies, your author uses

$$(2.46\text{ dollars})\left(\frac{100\text{ pennies}}{1\text{ dollar}}\right) = 246\text{ pennies}$$

The author used the logic of finding a conversion factor that has dollar in the denominator. Some students find it more logical to start with the conversion factor first (the factor that has pennies in the numerator) and then multiply by terms to get rid of the denominator

$$\left(\frac{100\text{ pennies}}{1\text{ dollar}}\right)(2.46\text{ dollars}) = 246\text{ pennies}$$

Both methods are very similar in that it may be more logical for some students to start with the correct numerator first.

In example 1.8, it should be emphasized that the factor

$$\left(\frac{1\text{ m}}{100\text{ cm}}\right)^3 \text{ is } \frac{1\text{ m}^3}{1\times10^6\text{ cm}^3}$$

shows that both the numerator and the denominator have been cubed. Failure to cube both terms is a very common error for students just beginning to study chemistry.