CHAPTER 1

Chemistry: An Introduction

1. The specific answer will depend on student experiences. In general, students are intimidated by chemistry because they perceive it to be highly mathematical, requiring a great deal of memorization, and having a difficult technical vocabulary. Many students taking chemistry as a foundation science cannot see its relevance to their major.

2. The answer will depend on student examples.

3. There are obviously many such examples. Many new drugs and treatments have recently become available thanks to research in biochemistry and cell biology. New long-wearing, more comfortable contact lenses have been produced by research in polymer and plastics chemistry. Special plastics and metals were prepared for the production of compact discs to replace vinyl phonograph records. As for the "dark side," chemistry contributes increased global pollution if not conducted carefully.

4. Answer depends on student responses/examples.

5. This answer depends on your own experience.

6. This answer depends on your own experience, but consider the following examples: oven cleaner (the label says it contains sodium hydroxide; it converts the burned-on grease in the oven to a soapy material that washes away); drain cleaner (the label says it contains sodium hydroxide; it dissolves the clog of hair in the drain); stomach antacid (the label says it contains calcium carbonate; it makes me belch and makes my stomach feel better); hydrogen peroxide (the label says it is a 3% solution of hydrogen peroxide; when applied to a wound, it bubbles); depilatory cream (the label says it contains sodium hydroxide; it removes unwanted hair from skin).

7. David and Susan first recognized the problem (unexplained medical problems). A possible explanation was then proposed (the glaze on their china might be causing lead poisoning). The explanation was tested by experiment (it was determined that the china did contain lead). A full discussion of this scenario is given in the text.

8. The scientist must recognize the problem and state it clearly, propose possible solutions or explanations, and then decide through experimentation which solution or explanation is best.

9. A law tells what happens; a theory is our attempt to explain why it happens. Examples of laws include the law of conservation of mass and the ideal gas law (for gases). A theory includes Einstein's theory of general relativity.

10. Answer depends on student response. A quantitative observation must include a number. For example "There are two windows in this room" represents a quantitative observation, but "The walls of this room are yellow" is a qualitative observation.

11. Flow charts will vary. Figure 1.1 in the textbook shows a nice example with various parts of the scientific method. The first step in the scientific method is to state the problem and collect data (make observations). Observations may be qualitative or quantitative. The next step is to formulate hypotheses. A hypothesis is a possible explanation for the observation. The final step is to perform experiments. An experiment is something we do to test the hypothesis. We gather new information that allows us to decide whether the hypothesis is supported by the new information we have learned from the experiment. Experiments always produce new observations, and this brings us back to the beginning of the process again. To explain the behavior of a given part of nature, we repeat these steps many times. Laws and theories come out of applying the scientific method.

12. False. Theories can be refined and changed because they are interpretations. They represent possible explanations of why nature behaves in a particular way. Theories are refined by performing experiments and making new observations, not by proving the existing observations as false (which is something that can be witnessed and recorded).

13. Answer depends on student responses/examples.

14. Scientists are human, too. When a scientist formulates a hypothesis, he or she wants it to be proven correct. In academic research, for example, scientists want to be able to publish papers on their work to gain renown and acceptance from their colleagues. In industrial situations, the financial success of the individual and of the company as a whole may be at stake. Politically, scientists may be under pressure from the government to "beat the other guy."

15. Chemistry is not just a set of facts that have to be memorized. To be successful in chemistry, you have to be able to apply what you have learned to new situations, new phenomena, and new experiments. Rather than just learning a list of facts or studying someone else’s solution to a problem, your instructor hopes you will learn *how* to solve problems *yourself,* so that you will be able to apply what you have learned in future circumstances.

16. Chemistry is not merely a list of observations, definitions, and properties. Chemistry is the study of very real interactions among different samples of matter, whether within a living cell, or in a chemical factory. When we study chemistry, at least in the beginning, we try to be as general and as nonspecific as possible, so that the *basic principles* learned can be applied to many situations. In a beginning chemistry course, we learn to interpret and solve a basic set of very simple problems in the hope that the method of solving these simple problems can be extended to more complex real life situations later on. The actual solution to a problem, at this point, is not as important as learning how to recognize and interpret the problem, and how to propose reasonable, experimentally testable hypotheses.

17. In real life situations, the problems and applications likely to be encountered are not simple textbook examples. One must be able to observe an event, hypothesize a cause, and then test this hypothesis. One must be able to carry what has been learned in class forward to new, different situations.

18. A good student will: learn the background and fundamentals of the subject from their classes and textbook; will develop the ability to recognize and solve problems and to extend what was learned in the classroom to “real” situations; will learn to make careful observations; and will be able to communicate effectively. While some academic subjects may emphasize use of one or more of these skills, Chemistry makes extensive use of all of them.

CHAPTER 2

Measurements and Calculations

1. measurement

2. "Scientific notation" means we have to put the decimal point after the first significant figure, and then express the order of magnitude of the number as a power of ten. So we want to put the decimal point after the first 2:

   $2{,}421 \rightarrow 2.421 \times 10^{\text{to some power}}$

   To be able to move the decimal point three places to the left in going from 2,421 to 2.421, means I will need a power of 10^3 after the number, where the exponent 3 shows that I moved the decimal point 3 places to the left.

   $2{,}421 \rightarrow 2.421 \times 10^{\text{to some power}} = 2.421 \times 10^3$

3. a. 9.651
   b. 3.521
   c. 9.3241
   d. 1.002

4. a. 10^7
   b. 10^{-1}
   c. 10^{-5}
   d. 10^{12}

5. a. positive
   b. positive
   c. negative
   d. negative

6. a. negative
   b. zero
   c. negative
   d. positive

7. a. The decimal point must be moved one space to the right, so the exponent is negative; $0.5012 = 5.012 \times 10^{-1}$.
   b. The decimal point must be moved six spaces to the left, so the exponent is positive; $5{,}012{,}000 = 5.012 \times 10^6$.

c. The decimal point must be moved six spaces to the right, so the exponent is negative; $0.000005012 = 5.012 \times 10^{-6}$.

d. The decimal point does not have to be moved, so the exponent is zero; $5.012 = 5.012 \times 10^{0}$.

e. The decimal point must be moved three spaces to the left, so the exponent is positive; $5012 = 5.012 \times 10^{3}$.

f. The decimal point must be moved three spaces to the right, so the exponent is negative; $0.005012 = 5.012 \times 10^{-3}$.

8.
a. The decimal point must be moved three spaces to the right: 2,789
b. The decimal point must be moved three spaces to the left: 0.002789
c. The decimal point must be moved seven spaces to the right: 93,000,000
d. The decimal point must be moved one space to the right: 42.89
e. The decimal point must be moved 4 spaces to the right: 99,990
f. The decimal point must be moved 5 spaces to the left: 0.00009999

9.
a. six spaces to the right
b. five spaces to the left
c. one space to the right
d. The decimal point does not have to be moved.
e. 18 spaces to the right
f. 16 spaces to the left

10.
a. three spaces to the left
b. one space to the left
c. five spaces to the right
d. one space to the left
e. two spaces to the right
f. two spaces to the left

11. To say that scientific notation is in *standard* form means that you have a number between 1 and 10, followed by an exponential term.

a. The decimal point must be moved 4 spaces to the left, so the exponent will be 4: 9.782×10^{4}

b. 42.14 must first be converted to 4.214×10^{1} and then the exponents combined: 4.214×10^{4}

c. 0.08214 must first be converted to 8.214×10^{-2} and then the exponents combined: 8.214×10^{-5}

d. The decimal point must be moved four spaces to the right, so the exponent will be –4: 3.914×10^{-4}