Solutions Manual for Introductory Chemistry-A Foundation 10th Edition by Zumdahl, DeCoste

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Solution and Answer Guide

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CHAPTER 1: CHEMISTRY: AN INTRODUCTION

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1.1 CHEMISTRY: AN INTRODUCTION

2. The first paragraphs in this chapter ask you if you have ever wondered how and why various things in our everyday lives happen the way they do. For your next class meeting, make a list of five similar chemistry-related things for discussion with your instructor and the other students in your class.

   Answer:

   The answer will depend on student examples.

4. The "Chemistry in Focus" segment titled *Dr. Ruth—Cotton Hero* discusses the enormous contribution of Dr. Ruth Rogan Benerito to the survival of the cotton fabric industry in the United States. In the discussion, it was mentioned that Dr. Benerito became a chemist when women were not expected to be interested in, or good at, scientific subjects. Has this attitude changed? Among your own friends, approximately how many of your female friends are studying a science? How many plan to pursue a career in science? Discuss.

   Answer:
   Answer depends on student responses/examples.

1.2 WHAT IS CHEMISTRY?

6. We use chemical reactions in our everyday lives, too, not just in the science laboratory. Give at least five examples of chemical transformations that you use in your daily activities. Indicate what the "chemical" is in each of your examples and how you recognize that a chemical change has taken place.

   Answer:

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).

1.3 Solving Problems Using a Scientific Approach

8. Being a scientist is very much like being a detective. Detectives such as Sherlock Holmes and Miss Marple perform a very systematic analysis of a crime to solve it, much like a scientist does when addressing a scientific investigation. What are the steps that scientists (or detectives) use to solve problems?

   Answer:
   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.

1.4 The Scientific Method

10. Observations may be either qualitative or quantitative. A measurement is a quantitative observation involving both a number and a unit. What is a qualitative observation? List five examples of *qualitative observations* you might make around your home or school. List five examples of *measurements* you might make in everyday life.

    Answer:
    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.

12. True or false? If a theory is disproven, then all of the observations that support that theory are also disproven. Explain.

    Answer:
    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).

14. Discuss several political, social, or personal considerations that might affect a scientist’s evaluation of a theory. Give examples of how such external forces have influenced scientists in the past. Discuss methods by which such bias might be excluded from future scientific investigations.

Answer:
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."

16. Is the scientific method suitable for solving problems only in the sciences? Explain.

Answer:
No, it is useful whenever a systematic approach of observation and hypothesis testing can be used. Scientific thinking can help you in all parts of your life. It's worthwhile to learn how to think scientifically—whether you want to be a scientist, an auto mechanic, a doctor, a politician, or a poet!

1.5 Learning Chemistry

18. Why is the ability to solve problems important in the study of chemistry? Why is it that the *method* used to attack a problem is as important as the answer to the problem itself?

Answer:
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.

20. The "Chemistry in Focus" segment *Chemistry: An Important Component of Your Education* discusses how studying chemistry can be beneficial not only in your chemistry courses but also in your studies in general. What are some characteristics of a good student, and how does studying chemistry help achieve these characteristics?

Answer:
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.

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2. Early on in this text, some aspects of the best way to go about learning chemistry were presented. In *beginning* your study of chemistry, you may initially have approached studying chemistry as you would any of your other academic subjects (taking notes in class, reading the text, memorizing facts, and so on). Discuss why the ability to sort through and analyze facts and the ability to propose and solve problems are so much more important in learning chemistry.

   Answer:

   By now, after having covered three chapters in this book, it is hoped that you have adopted an “active” approach to your study of chemistry. You may have discovered (perhaps through a disappointing grade on a quiz (though we hope not), that you really have to get involved with chemistry. You can’t just sit and take notes, or just look over the solved examples in the textbook. You have to learn to solve problems. You have to learn how to interpret problems, and how to reduce them to the simple mathematical relationships you have studied. Whereas in some courses you might get by on just giving back on exams the facts or ideas presented in class, in chemistry you have to be able to extend and synthesize what has been discussed and to apply the material to new situations. Don’t get discouraged if this is difficult at first: it’s difficult for everyone at first.

4. Many college students would not choose to take a chemistry course if it were not required for their major. Do you have a better appreciation of *why* chemistry is a required course for your own particular major or career choice? Discuss.

   Answer:

   It is difficult sometimes for students (especially beginning students) to understand why certain subjects are required for a given college major. The faculty of your major department, however, have collectively many years of experience in the subject in which you have chosen to specialize. They really do know what courses will be helpful to you in the future. They may have had trouble with the same courses that now give you trouble, but they realize that all the work will be worth it in the end. Some courses you take, particularly in your major field itself, have obvious and immediate utility. Other courses, often times chemistry included, are provided to give you a general background knowledge, which may prove useful in understanding your own major or other subjects related to your major. In perhaps a burst of bravado, chemistry has been called "the central science" by one team of textbook authors. This moniker is very true however: in order to understand biology, physics, nutrition, farming, home economics, or whatever (it helps to have a general background in chemistry).

6. Most people think of science as being a specific, exact discipline, with a "correct" answer for every problem. Yet you were introduced to the concept of *uncertainty* in scientific measurements. What is meant by "uncertainty"? How does uncertainty creep into measurements? How is uncertainty *indicated* in scientific measurements? Can uncertainty ever be completely eliminated in experiments? Explain.

Answer:

Whenever a scientific measurement is made, we always employ the instrument or measuring device we are using to the limits of its precision. On a practical basis, this usually means that we *estimate* our reading of the last significant figure of the measurement. An example of the uncertainty in the last significant figure is given for measuring the length of a pin in the text in Figure 2.5. Scientists appreciate the limits of experimental techniques and instruments, and always assume that the last digit in a number representing a measurement has been estimated. Because the last significant figure in every measurement is assumed to be estimated, it is never possible to exclude uncertainty from measurements. The best we can do is to try to improve our techniques and instruments so that we get more significant figures for our measurements.

8. This chemistry course may have been the first time you have encountered the method of *dimensional analysis* in problem solving. Explain the terms *conversion factor* and *equivalence statement.* Give an everyday example of how you might use dimensional analysis to solve a simple problem.

Answer:

Dimensional analysis is a method of problem solving that pays particular attention to the units of measurements and uses these units as if they were algebraic symbols that multiply, divide, and cancel. Consider the following example. A dozen eggs costs $1.25. Suppose we want to know how much one egg costs, and also how much three dozens of eggs will cost. To solve these problems, we need to make use of two equivalence statements:

1 dozen eggs = 12 eggs

1 dozen eggs = $1.25

The first of these equivalence statements is obvious: everyone knows that 12 eggs is "equivalent" to one dozen. The second statement also expresses an equivalence: if you give the grocer $1.25, he or she will give you a dozen eggs. From these equivalence statements, we can construct the conversion factors we need to answer the two questions. For the first question (what does one egg cost) we can set up the calculation as follows

$$\frac{\$1.25}{12\text{ eggs}} = \$0.104 = \$0.10$$

as the cost of one egg. Similarly, for the second question (the cost of 3 dozens eggs), we can set up the conversion as follows

$$3 \text{ dozens} \times \frac{\$1.25}{1 \text{ dozen}} = \$3.75$$

as the cost of three dozens eggs. See Section 2.6 of the text for how we construct conversion factors from equivalence statements.

10. What is *matter?* What is matter composed of? What are some of the different types of matter? How do these types of matter differ, and how are they the same?

Answer:

Defining what scientists mean by "matter" often seems circular to students. Scientists say that matter is something that "has mass and occupies space", without ever really explaining what it means to "have mass" or to "occupy space"! The concept of matter is so basic and fundamental, that it becomes difficult to give a good textbook definition other than to say that matter is the "stuff" of which everything is made. Matter can be classified and subdivided in many ways, depending on what we are trying to demonstrate.

On the most fundamental basis, all matter is composed of tiny particles (such as protons, electrons, neutrons, and the other subatomic particles). On one higher level, these tiny particles are combined in a systematic manner into units called atoms. Atoms, in turn, may be combined to constitute molecules. And finally, large groups of molecules may be placed together to form a bulk sample of substance that we can see.

Matter can also be classified as to the physical state a particular substance happens to take. Some substances are solids, some are liquids, and some are gases. Matter can also be classified as to whether it is a pure substance (one type of molecule) or a mixture (more than one type of molecule), and furthermore whether a mixture is homogeneous or heterogeneous.

12. What is an *element,* and what is a *compound?* Give examples of each. What does it mean to say that a compound has a *constant composition?* Would samples of a particular compound here and in another part of the world have the same composition and properties?

Answer:

Chemists tend to give a functional definition of what they mean by an "element": an element is a fundamental substance that cannot be broken down into any simpler substances by chemical methods. Compounds, on the other hand, can be broken down into simpler substances (the elements of which the compound is composed). For example, sulfur and oxygen are both elements (sulfur occurs as S_8 molecules and oxygen as O_2 molecules). When sulfur and oxygen are placed together and heated, the compound sulfur dioxide (SO_2) forms. When we analyze the sulfur dioxide produced, we notice that each and every molecule consists of one sulfur atom and two oxygen atoms, and on a mass basis, consists of 50% each of sulfur and oxygen. We describe this by saying that sulfur dioxide has a constant composition. The fact that a given compound has constant composition is usually expressed in terms of the mass percentages of the elements present in the compound. The reason the mass percentages are constant is because of a constant number of atoms of each type present in the compound's molecules. If a scientist anywhere in the universe analyzed sulfur dioxide, he or she would find the same composition: if a scientist finds something that does not have the same composition, then the substance cannot be sulfur dioxide.

Problems

14. For each of the following, make the indicated conversion.
    a. 4,861,903 to standard scientific notation
    b. 3.8136×10^2 to ordinary decimal notation
    c. 5.1×10^{-3} to ordinary decimal notation
    d. 0.000744 to standard scientific notation
    e. $8.621 \times 10^5 \times 5.353 \times 10^{-3}$ to standard scientific notation
    f. $\dfrac{6.283 \times 10^{-6}}{4.115 \times 10^{4}}$

    Answer:

    a. The decimal point must be moved six places to the left: 4.861903×10^6
    b. The decimal point must be moved two places to the right: 381.36
    c. The decimal point must be moved three places to the left: 0.0051
    d. The decimal point must be moved four places to the right: 7.44×10^{-4}
    e. The arithmetic must be performed and then the exponents combined: 4.615×10^3
    f. The arithmetic must be performed and then the exponents combined: 1.527×10^{-10}

16. Without performing the actual calculations, determine to how many significant figures the results of the following calculations should be reported.
    a. $\dfrac{(2.991)(4.3785)(1.97)}{(2.1)}$
    b. $\dfrac{(5.2)}{(1.9311 + 0.4297)}$
    c. $1.782 + 0.00035 + 2.11$
    d. $(6.521)(5.338 + 2.11)$
    e. $9 - 0.000017$
    f. $(4.2005 + 2.7)(7.99118)$
    g. $(5.12941 \times 10^4)(4.91 \times 10^{-3})(0.15)$
    h. $97.215 + 42.1 - 56.3498$

    Answer:

    a. two (based on the factor of 2.1 in the denominator)
    b. two (based on the factor of 5.2 in the numerator)
    c. three (one before the decimal point, and two after the decimal point)
    d. three (based on the sum of 5.338 and 2.11)
    e. one (based on 9 only having one significant figure)
    f. two (based on the sum of 4.2005 and 2.7)
    g. two (based on the factor of 0.15)
    h. three (two before the decimal point, and one after the decimal point)

18. a. Given that 100. mL of ethyl alcohol weighs 78.5 g, calculate the density of ethyl alcohol.
    b. What volume would 1.59 kg of ethyl alcohol occupy?
    c. What is the mass of 1.35 L of ethyl alcohol?
    d. Pure aluminum metal has a density of 2.70 g/cm^3. Calculate the volume of 25.2 g of pure aluminum.
    e. What will a rectangular block of pure aluminum having dimensions of 12.0 cm × 2.5 cm × 2.5 cm weigh?

Answer:

density = mass/volume   mass = volume × density   volume = mass/density

a. $\text{density} = \dfrac{78.5\text{ g}}{100.\text{ mL}} = 0.785\text{ g/mL}$

b. $\text{volume} = \text{mass/density} = \dfrac{1.590\text{ kg} \times \dfrac{1000\text{ g}}{1\text{ kg}}}{0.785\text{ g/mL}} = 2025\text{ mL} = 2.03\text{ L}$

c. $\text{mass} = \text{volume} \times \text{density} = 1.35\text{ L} \times \dfrac{1000\text{ mL}}{1\text{ L}} \times \dfrac{0.785\text{ g}}{1\text{ mL}} = 1060\text{ g} = 1.06\text{ kg}$

d. $\text{volume} = \text{mass/density} = \dfrac{25.2\text{ g}}{2.70\text{ g/cm}^3} = 9.33\text{ cm}^3$

e. volume = 12.0 cm × 2.5 cm × 2.5 cm = 75 cm^3
   mass = volume × density = 75 cm^3 × 2.70 g/cm^3 = 202.5 g = 2.0×10^2 g