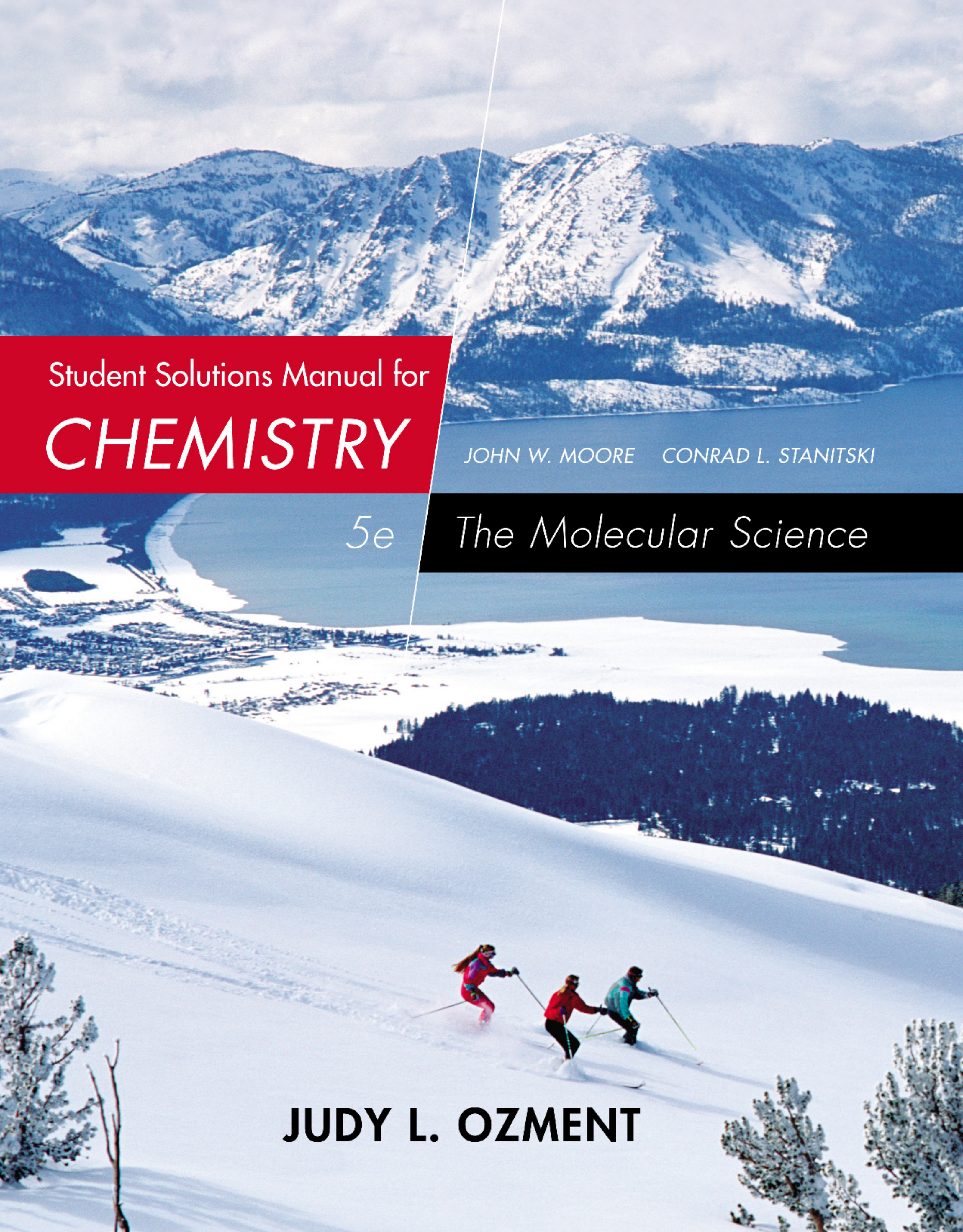

Student Solutions Manual for

CHEMISTRY

JOHN W. MOORE CONRAD L. STANITSKI

5e

The Molecular Science

JUDY L. OZMENT

Student Solutions Manual

Chemistry:
The Molecular Science

FIFTH EDITION

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Solutions for Red-Numbered Questions for Review and Thought

Introduction

This solutions manual was written specifically to accompany the fifth edition of the textbook *Chemistry The Molecular Science*, by Moore and Stanitski. It presents detailed solutions for the some of the Questions for Review and Thought at the end of each chapter. If a question's number is bold and blue, then its solution will be in this book.

Using this Book

Many of these solutions are presented using the same format described in Chapter 1 and Appendix A. They use a four-stage process: *analyze* the problem, *plan* a solution, and *execute* the plan, then do a *reasonable result check* to show how is reasonable. Following these stages should help to make methods more readily applicable to similar problems, or the same kind problem in a different context. Some of the solutions are patterned after the methods shown in Problem-Solving Examples throughout the text.

It is important to try to answer a question for yourself, before looking at the solutions book. When you find it necessary to use this book, try first to use it to get hints or directions by reading the first part of the *Analyze* section to see if that information clarifies the problem. If you find that your interpretation or evaluation of the problem is routinely incorrect or incomplete, then you might seek help from your instructor, a teaching assistant, a learning center staff person, or a tutor in reading word problems for comprehension. Sometimes, the best help for some problems can be gained from math tutors, since they often have experience helping students specifically with reading word problems.

If you find that you usually analyze the problem in a similar fashion as described here, but still need help understanding how to plan a solution, then read how the *plan* is developed. This will give general step-by-step instructions for how the problem is solved. For numerical answers, it is at this point where you should try to estimate what answer you anticipate. Do you expect it to be a large or small number? What units and sign do you expect it to have? What significant figures will it have? The more you are able to frame an expectation for the answer, the less likely you are to make mistakes along the way.

Step-by-step solutions are shown in the *Execute* section. If you can *analyze* the questions, *plan* solutions, and *execute* the plans before actually looking here, you will start gaining confidence in your ability to learn how to answer the questions on your own.

Once you have the result for a question, take a moment to think about whether it makes sense. Often, reflection will help you confirm the correctness of an answer, or expose its flaws. For example, if you just determined that an atom of gold weighs four times more than the mass of the entire earth, the *Reasonable Result Check* stage of the problem-solving method might help you see that you made a mistake. It is wise to go back to the question and read it again, then ask yourself: Does this result answer this question? Is the result the right size and sign? Is it what you expected? It is important to check the units and the significant figures at this point, also.

A true sign that you are learning how to do chemistry problems is if you find yourself relying on this solutions book less and less. Set goals for yourself whenever you use this book to limit how often you consult it and how extensively. It is easy to such books as a crutch, and crutches keep you from walking on your own.

There are many ways to solve problems. Often times, the right answer can be derived in several ways that are equally valid. Your instructors may have different ways of describing how to work some of the problems solved here. All good methods have three things in common: (1) They always give the right answer. (2) They demonstrate how the answer was achieved. (3) And, they make sense. If any one of these three is missing, the method is flawed.

Cautions

RYou must resist the temptation to just read the solutions in this book without doing any work on your own. There are two very obvious reasons for this: (1) Recognition is easier than recall. It is far easier to look over a solution done correctly and believe that you understand it, than it is to look at the same question followed by a blank space (as would happen on a test, for example) and recall how to do it. (2) Most teachers will not let you use this book when they are testing you; hence, these solutions will not be there when you need to know how to do things.

All teachers using the textbook *Chemistry – The Molecular Science* also have a copy of the solutions in this book, so you must resist the temptation to copy work from this book into your assignments and call it your work. Besides being unethical, doing this defeats the purpose of an assignment designed to have you practice problem-solving. The instructor is asking you to do your own work, and to show what you have learned about the subject.

Learn How to Learn

Finally, keep in mind that you are learning basic chemistry and introductory physical science as a building block for other things. Those things are much more complicated. Always try to learn a subject with maximum flexibility. Whenever possible, look for how a solution can be generalized. Relying on rote memorization and narrowly-defined systems used to solve very specific types of problems may work to get you through this course, but it can be detrimental to your learning science or learning how to apply science to more complicated things, including life, the universe and everything. Sometimes, you will have to give up on preconceived notions to be able to learn more.

> "The man who grasps principles can successfully select his own methods.
> The man who tries methods, ignoring principles, is sure to have trouble."
>
> – Ralph Waldo Emerson

> "Imagination is more important than knowledge."
>
> – Albert Einstein

> "I know I have not found the answers to all of my questions. The answers I have found only serve to raise a whole set of new questions. In some ways I am as confused as ever, but I believe that I am confused on a higher level and about more important things."
>
> – unknown

Acknowledgements

I want to especially thank Karen Pesis, from the American River College in California, and Mr. Arya Kermansha, from Penn State University, for their patient and expert help in checking the accuracy of these solutions. I greatly appreciate the assistance and support of both of the book authors, Dr. Conrad Stantiski, and especially Dr. John Moore. I also want to express my thanks again to Leslie Kinsland, since much of what she helped me learn on the first edition of this book is still a part of these newer ventures.

Lastly, I gratefully acknowledge the fantastic support of my family, especially Karen and Emma Pesis, Lynda Webb, Susan Thompson, and Loretta Ozment, and good friends, especially Debra Lavagnino, Sara Shriner, Paul Bomboy, and Ann Schmiedekamp.

Chapter 1: The Nature of Chemistry

Solutions for Red-Numbered Questions for Review and Thought

Topical Questions

How Science is Done (Section 1-3)

9. *Result:* **(a) Qualitative (b) Quantitative and qualitative (c) Quantitative and qualitative (d) Qualitative**

Explanation:

(a) The details of the appearance of a substance (silvery-white) and information about the specific element it contains (sodium) are both **qualitative**.

(b) The temperature at which a solid melts (660 °C) is **quantitative** information. Information about what element it is (aluminum) is **qualitative**.

(c) The mass percentage of an element in the human body (about 23%) is **quantitative** information. Information about what element it is (carbon) is **qualitative**.

(d) The allotropic forms of an element (graphite, diamond, and fullerenes) and information about what element it is (carbon) are both **qualitative**.

Identifying Matter: Physical Properties (Section 1-4)

11. *Result/Explanation:* Bromine is a reddish-brown liquid. Sulfur is a chalky yellowish solid. They appear to have no property in common. The physical phase, shape, color, and appearance are different.

13. *Result:* **The solid will melt because your body temperature of 37°C is above the melting point of 29.76°C.**

Analyze and Plan: Many Americans only remember the human body temperature in the Fahrenheit scale. That is 98.6 °F. If that is the case, we can quickly apply the °F to °C conversion equation, so we can compare it to the melting point.

Execute:

$$^{\circ}\mathrm{C} = \frac{5}{9} \times \left(^{\circ}\mathrm{F} - 32 \right) = \frac{5}{9} \times \left(98.6 - 32 \right) = 37.0^{\circ}\mathrm{C}$$

If the sample melts at a temperature of 29.76 °C and your hand is 37 °C, the liquid will boil when exposed to the heat energy emitted by your hand when you hold the sample.

Measurements, Units, and Calculations (Section 1-5)

15. *Result:* **0.00283 kg, Ca and F**

Analyze and Plan: Given the mass of the crystal as 2.83 grams, find the mass in kilograms. Using the conversion factor between grams and kilograms, determine the mass in kilograms.

Execute:

$$2.83 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.00283 \text{ kg}$$

The symbols for the elements in this crystal are Ca (calcium) and F (fluorine).

☑ *Reasonable Result Check:* Kilograms are larger units than grams, so the number of kilograms should be smaller than the number of grams.

17. *Result:* **No, 23.4 mi/hr < 25 mi/hr**

Analyze: Given the length of the track and the time to run its length, determine the miles per hour and compare to 25 mi/hr.

Plan: Divide the meters by the seconds, then use conversion factors between meters and centimeters, centimeters and inches, inches and feet, and feet and miles to determine the distance in miles. And use the conversion factor between second and hours to determine the time in hours.

Execute:

$$\frac{100\ \text{m}}{9.58\ \text{s}} \times \left(\frac{100\ \text{cm}}{1\ \text{m}}\right) \times \left(\frac{1\ \text{in}}{2.54\ \text{cm}}\right) \times \left(\frac{1\ \text{ft}}{12\ \text{in}}\right) \times \left(\frac{1\ \text{mi}}{5280\ \text{ft}}\right) \times \left(\frac{3600\ \text{s}}{1\ \text{hr}}\right) = 23.4\frac{\text{mi}}{\text{hr}}$$

No, this runner could not be arrested for exceeding the 25 mi/hr speed limit, since 23.4 mi/hr < 25 mi/hr.

☑ *Reasonable Result Check:* No one on foot could chase and catch up with a car going 25 mph.

19. *Result:* **(a) Four (b) Three (c) Four (d) Four (e) Three (f) Four**

Analyze: Given several measured quantities, determine the number of significant figures.

Plan: Use rules given in Section 1-5, summarized here: All non-zeros are significant. Zeros that precede (sit to the left of) non-zeros are never significant (e.g., 0.003). Zeros trapped between non-zeros are always significant (e.g., 3.003). Zeros that follow (sit to the right of non-zeros are (a) significant, if a decimal point is explicitly given (e.g., 3300.) OR (b) not significant, if a decimal point is not specified (e.g., 3300).

Execute:

(a) 1374 kg has **four** significant figures. The 1, 3, 7, and 4 digits are each significant.

(b) 0.00348 s has **three** significant figures. The 3, 4, and 8 digits are each significant. The zeros are all before the first non-zero-digit 3 and therefore they are not significant.

(c) 5.619 mm has **four** significant figures. The 5, 6, 1, and 9 digits are each significant.

(d) 2.475×10^{-3} cm has **four** significant figures. The 2, 4, 7, and 5 digits are each significant.

(e) 33.1 mL has **three** significant figures. The 3, 3, and 1 digits are each significant.

(f) 2300. m has **four** significant figures. The 2, 3, 0, and 0 digits are each significant.

☑ *Reasonable Result Check:* Only 2 answers have zeros in them. Those in (b) are to the left of the first non-zero digit, so none of the zeros there were significant. Those in (f) are in a number with a decimal point, so all of them were significant.

21. *Result:* **(a) 1.9 g/mL (b) 291.2 cm³ (c) 0.0217 (d) 5.21×10^{-5}**

Analyze: Given numbers combined in calculations, determine the result with proper significant figures.

Plan: Perform the mathematical steps according to order of operations, applying the proper significant figures (addition and subtraction retains the least number of decimal places in the result; multiplication and division retain the least number of significant figures in the result). *Notice: if operations are combined that use different rules, we must stop and determine the intermediate result any time the rule switches.*

Execute:

(a)
$$\frac{4.850\ \text{g} - 2.34\ \text{g}}{1.3\ \text{mL}}$$

The numerator uses the subtraction rule. The first number has three decimal places (the 8, 5, and 0 are all decimal places -- digit that follow the decimal point to the right) and the second number has two decimal places (the 3 and the 4 are both decimal places), so the result of the subtraction has two decimal places.

$$\frac{2.51\ \text{g}}{1.3\ \text{mL}}$$

The ratio uses the division rule. The numerator has three significant figures and the denominator has two significant figures, so the answer will have two significant figures. Therefore, the answer is **1.9 g/mL**.

(b) $V = {}^4/_3\ \pi r^3 = {}^4/_3 \times (3.1415926) \times (4.112\text{ cm})^3$

This whole calculation uses the multiplication rule, with four significant figures, limited by the measurement of r. The numerals 4 and 3 are exact, in this context. The value of π must be carried to *more than four* significant figures, such as 3.1415926… The answer comes out **291.2 cm^3**.

(c) $(4.66 \times 10^{-3}) \times 4.666$

This calculation uses the multiplication rule. The first number, 4.66×10^{-3}, has three significant figures and the second number, 4.666, has four significant figures, so the answer has three significant figures **0.0217**.

(d) $\dfrac{0.003400}{65.2}$

This calculation uses the division rule. The numerator has four significant figures and the denominator has three significant figures, so the answer has three significant figures 0.0000521 or **5.21×10^{-5}**.

☑ *Reasonable Result Check:* The significant figures, size, and units of the answers are appropriate.

23. *Result:* **Copper**

Analyze and Plan: We have the mass of the metal and some volume information. We need to determine the density. Use the initial and final volumes to find the volume of the metal piece, then use the mass and the volume to get the density. The metal piece displaces the water when it sinks, making the volume level in the graduated cylinder rise.

Execute: The metal piece volume is the difference between the starting volume and the final volume:

$$V_{metal} = V_{final} - V_{initial} = (37.2\text{ mL}) - (25.4\text{ mL}) = 11.8\text{ mL}$$

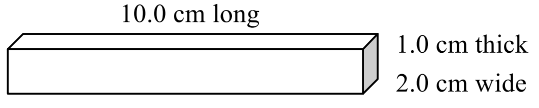
$$d = \frac{m}{V} = \frac{105.5\text{ g}}{11.8\text{ mL}} = 8.94\ \frac{\text{g}}{\text{mL}}$$

According to Table 1.1, this is very close to the density of copper (d = 8.93 g/mL).

☑ *Reasonable Result Check:* The metal piece sinks, so the density of the metal piece must be higher than water. (Table 1.1 gives water density as 0.998 g/mL.)

25. *Result:* **Aluminum**

Analyze: We have the three linear dimensions of a regularly shaped piece of metal.



We also have its mass. We have a table of densities (Table 1.1). We need to determine the identity of the metal.

Plan: Use the three linear dimensions to find the volume of the metal piece. Use the volume and the mass to find the density. Use the table of densities to find the identity of the metal.

Execute: V = (thickness) × (width) × (length) = (1.0 cm) × (2.0 cm) × (10.0 cm) = 20. cm^3

Using conversion factors, find the volume in mL: $20.\text{ cm}^3 \times \dfrac{1\text{ mL}}{1\text{ cm}^3} = 20.\text{ mL}$

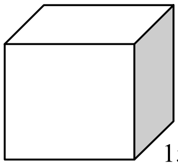
Find the density: $$d = \frac{m}{V} = \frac{54.0\text{ g}}{20.\text{ mL}} = 2.7\ \frac{\text{g}}{\text{mL}}$$

According to Table 1.1, the density that most closely matches this one is **aluminum** (d = 2.70 g/mL).

☑ *Reasonable Result Check:* The mass is larger than the volume. so d is larger than 1.

27. *Result:* **3.9 × 10^3 g**

Analyze: We have the three linear dimensions of a regularly shaped sodium chloride crystal:



We have a table of densities (Table 1.1). We need to determine the mass of the crystal.

Plan and Execute: Use the three linear dimensions to find the volume of the crystal. Use the volume and density (Table 1.1) to find the mass.

$$V = (\text{thickness}) \times (\text{width}) \times (\text{length}) = (10.\ \text{cm}) \times (15\ \text{cm}) \times (12\ \text{cm}) = 1800\ \text{cm}^3 = 1.8\times10^3\ \text{cm}^3$$

Using conversion factors, find the volume in mL:

$$1.8\times10^3\ \text{cm}^3 \times \frac{1\ \text{mL}}{1\ \text{cm}^3} = 1.8\times10^3\ \text{mL}$$

Find the mass using the density: $$1.8\times10^3\ \text{mL} \times \frac{2.16\ \text{g}}{1\ \text{mL}} = 3.9\times10^3\ \text{g}$$

Notice: We're carrying two significant figures since the length data was only that precise.

☑ *Reasonable Result Check:* This crystal is pretty large. So, while the mass calculated is a large number, the volume is still about half the mass, consistent with a density around two.

Chemical Change and Chemical Properties (Section 1-6)

29. *Result:* **(a) Physical (b) Chemical (c) Chemical (d) Physical**

Explanation:

(a) The normal color of bromine is a **physical** property. Determining the color of a substance does not change its chemical form.

(b) The fact that iron can be transformed into rust is a **chemical** property. Iron undergoes a transformation, from its elemental metallic state to become a part of the compound identified as rust.

(c) The fact that dynamite can explode is a **chemical** property. The dynamite is chemically changed when it is observed to explode.

(d) Observing the shininess of aluminum does not change it, so this is a **physical** property. Melting aluminum does not change it to a different substance, though it does change its physical state. It is still aluminum, so melting at 660 °C is a **physical** property of aluminum.

31. *Result:* **(a) Chemical (b) Chemical (c) Physical**

Explanation:

(a) Bleaching clothes from purple to pink is a **chemical** change. The purple substance in the clothing reacts with the bleach to make a pink substance. The purple color cannot be brought back nor can the bleach.

(b) The burning of fuel in the space shuttle (hydrogen and oxygen) to form water and energy is a **chemical** change. The two elements react to form a compound.

(c) The ice cube melting in the lemonade is a **physical** change. The H_2O molecules do not change to a different form in the physical state change.

33. *Result:* **(a) Forcing a chemical reaction to occur (b) Causing work to be done (c) Causing work to be done (d) Forcing a chemical reaction to occur**

Explanation:

(a) The conversion of excess food into fat molecules is the body's way of storing energy for doing work later. So, this represents an outside source of energy (from the food we eat) **forcing a chemical reaction to occur** (the production of fat).

(b) Sodium reacts with water rather violently. It produces a lot of heat energy and **causes work to be done**.

(c) Sodium azide in an automobile's airbag decomposes causing the bag to inflate. This uses a chemical reaction to release energy and **cause work to be done** (inflation of the air bag).

(d) The process of hard-boiling an egg on your stove uses energy from the stove to **cause a chemical reaction to occur** (the coagulation of the white and yolk of the egg).

Classifying Matter: Substances and Mixtures (Section 1-7)

35. *Result/Explanation:* It is clear by visual inspection that the mixture is non-uniform (**heterogeneous**) at the macroscopic level. Iron could be separated from sand **using a magnet**, since iron is attracted to magnets and the sand is not.

37. *Result/Explanation:* Sometimes, it is necessary to try some tests to see if different parts of the mixture respond differently to physical separation techniques. It may require some experimentation, such as testing whether samples of the pure substances dissolve in water or are attracted to a magnet. Such information may also be available on the internet.

(a) Table salt dissolved in water can be separated by **evaporating the water**, which would leave the dry salt.

(b) Testing shows that iron filings are attracted to a magnet, but magnesium pieces are not. **Using a magnet**, the iron filings can be lifted out of the mixture, leaving behind the magnesium pieces.

(c) This mixture will have shiny silver metal pieces in a white crystalline powder, so the first thing we could try is use tweezers or forceps to pick out the shiny metal zinc pieces from the white sugar crystals. Solubility testing shows that sucrose dissolves in water, but zinc does not. Therefore, put the mixture in water, **dissolve the sucrose, separate the solution from the solid zinc** using a filter or a sieve, then **evaporate the water**.

Classifying Matter: Elements and Compounds (Section 1-8)

39. *Result/Explanation:*

(a) A blue powder turns white and loses mass. The loss of mass is most likely due to the creation of a gaseous product. That suggests that the original material was a **compound that decomposed** into the white substance (a compound or an element) and a gas (a compound or an element).

(b) If three different gases were formed, that suggests that the original material was a **compound that decomposed** into three compounds or elements.

41. *Result:* **(a) Heterogeneous mixture (b) Pure compound (c) Element (d) Homogeneous mixture**

Explanation:

(a) Chunky peanut butter is definitely a **heterogeneous mixture**. The uncrushed peanut chunks do not have the same properties as the smooth, sweetened part of the mixture.

(b) Distilled water is a **pure compound**. The distillation process removes other minerals and substances from water, leaving it just water.

(c) Platinum is an **element** with the symbol "Pt".

(d) Air is usually considered to be a **homogeneous mixture**. Now, sometimes air has enough variable properties to qualify as heterogeneous, such as near the tailpipe of a diesel truck; however, most of the time, the gases in a sample of air are sufficiently well mixed such that there is no visible difference in the properties of various regions of that air sample.

43. *Result:* **(a) No (b) Maybe**

Explanation:

(a) The black substance was both the source of the element that contributes to the red-orange substance and the source of the oxygen in the water.

(b) The red-orange substance may be a combination of two or more elements including possibly hydrogen or oxygen, or it maybe an elemental substance, since the water produced could account for the hydrogen and the oxygen in the products.

Nanoscale Theories and Models (Section 1-9)

45. *Result/Explanation:* Using Figure 1.16 to help define scales. The scale bar defines the image scale to be in nanometers. The images of electrons from the scanning tunneling microscope are at the **nanoscale**.

47. *Result/Explanation:* When we open a can of a carbonated beverage, the carbon dioxide gas expands rapidly as it rushes out of the can.

At the nanoscale, this can be explained as large number of **carbon dioxide molecules crowded into the unopened can**. When the can is opened, the molecules that were about to hit the can surface where the hole was made continue forward through the hole. A large number of the carbon dioxide particles that were contained within the can **escape** very quickly **through the** same **hole**.

49. *Result/Explanation:* The atoms in the solid sucrose molecules start off at a relatively low energy and compose a rather complex molecule. A significant amount of heat energy must be added to increase the motion of these atoms so that they are able to break free of the bonds that hold them together in the sugar molecule and to interact with each other to make the "caramelized" products.

The Atomic Theory (Section 1-10)

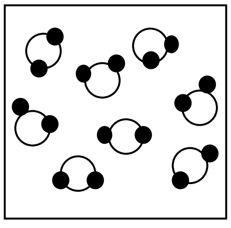
51. *Result/Explanation:* Conservation of mass is easy to see from the point of view of the atomic theory. A chemical change is described as the rearrangement of atoms. Because the atoms in the starting materials must all be accounted for in the substances produced, and because the mass of each atom does not change, there would be no change in the overall mass.

53. *Result/Explanation:* The law of multiple proportions says that if two compounds contain the same elements and samples of those two compounds both contain the same number of atoms of one element, then the ratio of the atoms of the other elements will be a small whole number.

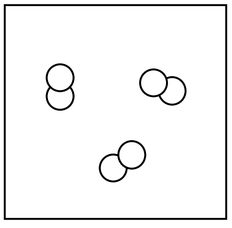
Communicating Chemistry: Symbolism (Section 1-11)

55. *Result/Explanation:* Formula for each substance and nanoscale picture:

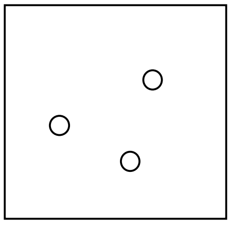
(a) Water H_2O



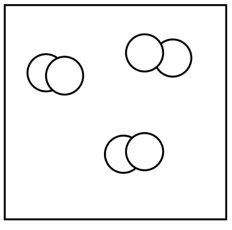
(b) Nitrogen N_2



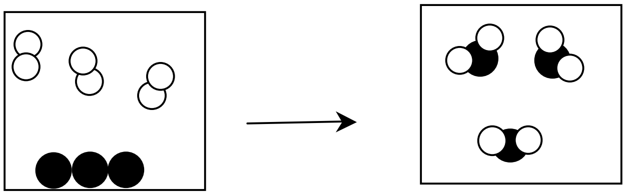
(c) Neon Ne



(d) Chlorine Cl_2



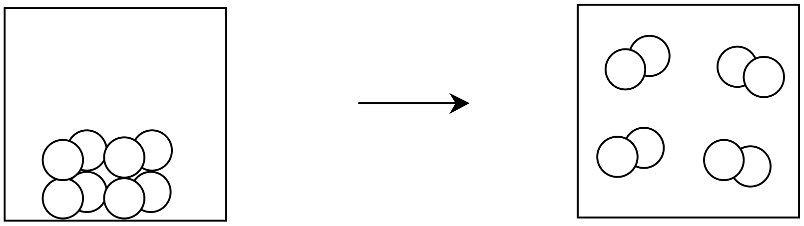
57. *Result/Explanation:* $S (s) + O_2 (g) \longrightarrow SO_2 (g)$



Sulfur solid and oxygen gas

Sulfur dioxide gas

59. *Result/Explanation:* $I_2 (s) \longrightarrow I_2 (g)$



solid iodine

iodine gas

The Chemical Elements (Section 1-12)

61. *Result/Explanation:* Many pairs of responses are equally valid. Below are a few common examples. These lists are not comprehensive; many other answers are also right. The periodic table on the inside cover of the textbook is color coded to indicate metals, non-metals and metalloids.

(a) Common metallic elements: iron, Fe; gold, Au; lead, Pb; copper, Cu; aluminum, Al

(b) Common non-metallic elements: carbon, C; hydrogen, H; oxygen, O; nitrogen, N

(c) Metalloids: boron, B; silicon, Si; germanium, Ge; arsenic, As; antimony, Sb; tellurium, Te

(d) Elements that are diatomic molecules: nitrogen, N_2; oxygen, O_2; hydrogen, H_2; fluorine, F_2; chlorine, Cl_2; bromine, Br_2; iodine, I_2

The Periodic Table (Section 1-13)

65. *Result/Explanation:* There are currently six elements in Group 4A of the periodic table. They are non-metal: carbon (C), metalloids: silicon (Si) and germanium (Ge), and metals: tin (Sn), lead (Pb) and flerovium (Fl).

67. *Result:* **(a) I (b) In (c) Ir (d) Fe**

Analyze: Look up the four elements on Figure 1.26 in Section 1-13.

(a) I, iodine, is the halogen (because it is in Group 7A)

(b) In, indium, is a main group metal (because it is a metal found in an A group—Group 3A)

(c) Ir, iridium, is a transition metal (colored blue on Figure 1.26) in period 6. The period number 6 is given to the far left of the row in the periodic table next to the element Cs.

(d) Fe, iron, is a transition metal (colored blue on Figure 1.26) in period 4. The period number 4 is given to the far left of the row in the periodic table next to the element K.

69. *Result:* **(a) Mg (b) Na (c) C (d) S (e) I (f) Mg (g) Kr (h) O (i) Ge** *Notice: There are multiple Results to (a), (b) and (i) in this Question. The ones given here are only examples.*

Analyze: Use the periodic table and information given in Section 1-13.

(a) An element in Group 2A is magnesium (Mg).

(b) An element in the third period is sodium (Na).

(c) The element in the second period of Group 4A is carbon (C).

(d) The element in the third period in Group 6A is sulfur (S).

(e) The halogen in the fifth period is iodine (I).

(f) The alkaline earth element in the third period is magnesium (Mg).

(g) The noble gas element in the fourth period is krypton (Kr).

(h) The non-metal in Group 6A and the second period is oxygen (O).

(i) A metalloid in the fourth period is germanium (Ge).

General Questions

75. *Result/Explanation:*

(a) The mass of the compound (1.456 grams) is **quantitative** and relates to a physical property. The color (white), the fact that it reacts with a dye, and the color change in the dye (red to colorless) are all **qualitative**. The *colors* are related to **physical properties**. The *reaction with the dye* is related to a **chemical property**.

(b) The *mass* of the metal (0.6 grams) is **quantitative** and relates to a **physical** property. The *identity* of the metal (lithium) and the *identities* of the chemicals it reacts with and produces (water, lithium hydroxide, and hydrogen) are all **qualitative** information. The fact that a chemical *reaction occurs* when the metal is added to water is **qualitative** information and related to a **chemical** property.

77. *Result:* **Garden requires 3.0 ft^3, which is more than 1.45 ft^3 bag.**

Analyze and Plan: Given the linear dimensions of the plot and the depth expected, calculate the volume needed, then compare to the volume in the bag.

Execute:

$$6\ \text{ft} \times 6\ \text{ft} \times 1\ \text{in} \times \frac{1\ \text{ft}}{12\ \text{in}} = 3.0\ \text{ft}^3$$

Garden requires 3.0 ft^3, which is more than 1.45 ft^3 bag.

☑ *Reasonable Result Check:* Perhaps the company meant to indicate ½" depth.

79. *Result:* **0.197 nm, 197 pm**

Analyze: A distance is given in angstroms (Å), which are defined. Determine the distance in nanometers and picometers.

Plan: Use the given relationship between angstroms and meters as a conversion factor to get from angstroms to meters. Then use the metric relationships between meters and the other two units to find the distance in nanometers and picometers.

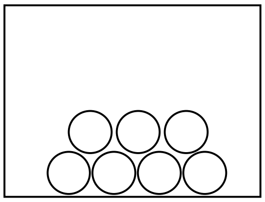
Execute:

$$1.97\ \text{Å} \times \frac{1\times 10^{-10}\ \text{m}}{1\ \text{Å}} \times \frac{1\ \text{nm}}{1\times 10^{-9}\ \text{m}} = 0.197\ \text{nm}$$

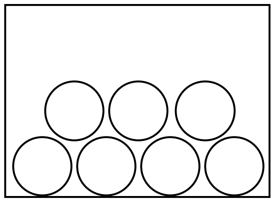
$$1.97\ \text{Å} \times \frac{1\times 10^{-10}\ \text{m}}{1\ \text{Å}} \times \frac{1\ \text{pm}}{1\times 10^{-12}\ \text{m}} = 197\ \text{pm}$$

☑ *Reasonable Result Check:* The unit nanometer is larger than an angstrom, so the distance in nm should be smaller. The unit picometer is smaller than an angstrom, so the distance in pm should be larger.

81. *Result/Explanation:* If the density of solid calcium is almost twice that of solid potassium, but their masses are approximately the same size, then the volume must account for the difference. This suggests that the atoms of calcium are smaller than the atoms of potassium:



solid calcium
smaller atoms
closer packed
smaller volume



solid potassium
larger atoms
less closely packed
larger volume

83. *Result:* **508 m**

Analyze: We have the mass of a spool of aluminum wire with known diameter. Assuming the wire is a cylinder, find the length (ℓ) of wire in meters. Use the density to find the volume from the mass, then use the given volume equation and the known diameter to find the length.

$$10.0\text{ lb} \times \frac{453.59\text{ g}}{1\text{ lb}} \times \frac{1\text{ mL}}{2.70\text{ g}} \times \frac{1\text{ cm}^3}{1\text{ mL}} = 1680\text{ cm}^3$$

The radius is half the diameter. Determine the radius in centimeters:

$$\text{R} = \frac{1}{2} \times \left(0.0808\text{ in}\right) \times \frac{2.54\text{ cm}}{1\text{ in}} = 0.103\text{ cm}$$

Rearrange $V = \pi r^2 \ell$ to solve for ℓ, plug in the known values and convert to meters:

$$\ell = \frac{V}{\pi r^2} = \frac{1680\text{ cm}^3}{(3.14159) \times \left(0.103\text{ cm}\right)^2} \times \frac{1\text{ m}}{100\text{ cm}} = 508\text{ m}$$

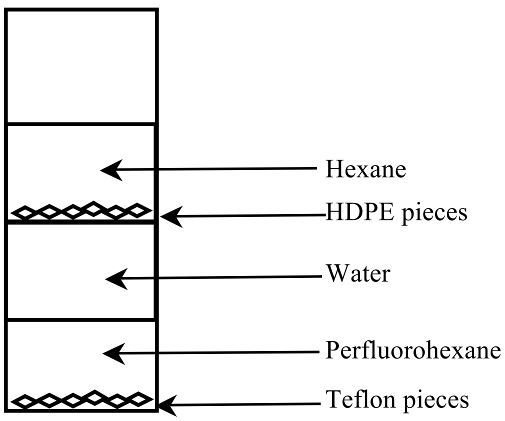
☑ *Reasonable Result Check:* It makes sense that a quantity of wire that weighs 10 pound would be several hundred feet long.

85. *Result/Explanation:* The highest density materials will sink to the bottom, with increasingly less dense materials floating on top.

The solid material with the highest density is the Teflon plastic pieces ($d = 2.3\text{ g/cm}^3$), so those pieces will be found at the bottom of the graduated cylinder sitting in the liquid perfluorohexane, which has the highest density of the liquids ($d = 1.669\text{ g/cm}^3$).

Floating on the surface of the perfluorohexane will be the liquid water ($d = 1.00\text{ g/cm}^3$).

Floating on the water will be the pieces of HDPE plastic ($d = 0.97\text{ g/cm}^3$) and the liquid hexane ($d = 0.766\text{ g/cm}^3$).



88. *Result:* **(a) K (b) Ar (c) Cu (d) Ge (e) H (f) Ca (g) Br (h) P**

Explanation: Use the periodic table and information given in Section 1-13.

(a) K is an alkali metal. (Group 1A)

(b) Ar is a noble gas. (Group 8A)

(c) Cu is a transition metal. (Group 1B)

(d) Ge is a metalloid. (Group 4A)

(e) H is a group 1 nonmetal.

(f) Ca is an alkaline earth metal. (Group 2A)

(g) Br is a halogen. (Group 7A)

(h) P is a nonmetal that is a solid. (Group 5A)

89. *Result/Explanation:* Look at the periodic table, given.

(a) A colorless gas is a non-metal. Those gases are found in the **lavender area**.

(b) A solid that is ductile and malleable are metals. Metals are found in the **gray and blue areas**.

(c) Non-metals and metalloids are poor electrical conductors. Solids with this characteristic are found in the **orange and lavender areas**.

91. *Result/Explanation:* Se and S have the greatest similarities in physical and chemical properties because they are both in the same periodic group (Group 6A).

93. *Result/Explanation:* A substance that can be broken down is not an element. A series of tests will result in a confirmation with one positive test. To prove that something is an element requires a battery of tests that all have negative results. A hypothesis that the substance is an element and cannot be broken down is more difficult to prove. (Section 1-3)

95. *Result:* **(a) Nickel, lead and magnesium (b) Titanium**

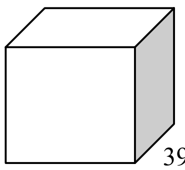
Explanation:

(a) According to the table of densities, a metal will float if the density is lower. That means that nickel, lead and magnesium will float on liquid mercury.

(b) The more different the densities, the smaller the fraction of the floating element will be below the surface. That means that titanium will float highest on mercury.

96. *Result:* $\mathbf{6.02 \times 10^{-29}\ m^3}$

Analyze and Plan: We have the length of the edge of a cube. Find the volume of the cube in m^3.



Use the linear dimensions to find the volume, then convert the volume to m^3 using metric conversions.

Execute:

$$V = (\text{thickness}) \times (\text{width}) \times (\text{length}) = (392\ \text{pm}) \times (392\ \text{pm}) \times (392\ \text{pm}) = 6.02 \times 10^7\ \text{pm}^3$$

Using conversion factors, find the volume in m^3:

$$6.02 \times 10^7\ \text{pm}^3 \times \left(\frac{10^{-12}\ \text{m}}{1\ \text{pm}}\right)^3 = 6.02 \times 10^{-29}\ \text{m}^3$$

☑ *Reasonable Result Check:* The cube is from the nanoscale, so it makes sense that it would be a very small volume using a macroscale unit of measure.

Applying Concepts

100. *Result:* **(a) Bromobenzene sample (b) Gold sample (c) Lead sample**

Explanation:

(a) (Table 1.1) density of butane = 0.579 g/mL; density of bromobenzene = 1.49 g/mL 1 mL butane weighs less than 1 mL of bromobenzene so, 20 mL butane weighs less than 20 mL of bromobenzene. The bromobenzene sample has a larger mass.

(b) (Table 1.1) density of benzene = 0.880 g/mL; density of gold = 19.32 g/mL There are 0.880 grams of benzene in 1 mL of benzene, so there are 8.80 grams of benzene in 10 mL of benzene. Since 1.0 mL of gold has a mass of 19.32 grams that means the gold sample has a larger mass.

(c) (Table 1.1) density of copper = 8.93 g/mL; density of lead = 11.34 g/mL Any volume of lead has a larger mass than the same volume of copper. That means the lead sample has a larger mass.

102. (a) *Result:* **2.7×10^2 mL ice (b) Deformed, overflowing, or broken**

Analyze: Use the volume of the bottle and the densities of water and ice to determine the volume of ice formed from a fixed amount of water.

Plan: Use the volume of the bottle and the density of water to determine the mass of water frozen, then calculate the volume of the ice.

Execute: At 25 °C, density of water is 0.997 g/mL.

At 0 °C, density of ice = 0.917 g/mL

$$250\ \text{mL water} \times \frac{0.997\ \text{g}\ H_2O(\ell)}{1\ \text{mL water}} \times \frac{1\ \text{g}\ H_2O(s)}{1\ \text{g}\ H_2O(\ell)} \times \frac{1\ \text{mL ice}}{0.917\ \text{g}\ H_2O(s)} = 2.7 \times 10^2\ \text{mL ice}$$

☑ *Reasonable Result Check:* The density of water is larger than the density of ice. It makes sense that the volume of the ice produced is larger than the volume of water.

(b) *Result/Explanation:* If the bottle is made of flexible plastic, it might be deformed and bulging if not cracked or broken. If the bottle is made of glass and the top came off, there would be ice (approximately 20 mL of it) oozing out of the top. Worst case scenario: if the bottle was glass and the top did not come off, it would be broken.

104. *Result/Explanation:*

(a) (Table 1.1) density of water = 0.998 g/mL, density of bromobenzene = 1.49 g/mL. Since water does not dissolve in bromobenzene, the lower density water will be the top layer of the immiscible layers.

(b) If poured slowly and carefully, the ethanol will float on top of the water and slowly dissolve in the water. Both ethanol and water will float on the bromobenzene.

(c) Stirring will speed up the ethanol dissolving with the water to make one phase. Assuming the new mixture has the average density of the original liquids, the water/ethanol layer (average density is 0.894 g/mL) will sit on top of the bromobenzene layer. (density is 1.49 g/mL)

106. *Result:* **Drawing (b)**

Explanation: The 90 °C mercury atoms will be a little bit further apart and moving somewhat more than the 10 °C mercury, though they still would be the same size atoms. The individual atoms in (c) are bigger – that doesn't happen. The individual atoms in (d) are smaller – that doesn't happen, either.

111. *Result:* **0.7527 g Ag, 0.2473 g Cl, 0.8854 g I**

Analyze and Plan: Write equations relating the mass of each atom to the sample masses, then use the relationship between the mass of an iodine atom to the mass of a chlorine atom to help calculate the mass of each element in the samples.

Execute:

$$1.0000 \text{ g AgCl} = m_{Ag} + m_{Cl}$$

$$1.6381 \text{ g AgI} = m_{Ag} + m_{I}$$

$$m_I = 3.580\ m_{Cl}$$

Subtract the first two equations to eliminate m_{Ag}:

$$1.6381 \text{ g} - 1.0000 \text{ g} = m_{Ag} + m_I - (m_{Ag} + m_{Cl}) = m_I - m_{Cl}$$

Substitute the third equation to eliminate m_I and solve for m_{Cl}:

$$0.6381 \text{ g} = 3.580\ m_{Cl} - m_{Cl} = 2.580\ m_{Cl}$$

$$m_{Cl} = 0.2473 \text{ g Cl}$$

Use the first equation to solve for m_{Ag}:

$$m_{Ag} = 1.0000 \text{ g AgCl} - m_{Cl} = 1.0000 \text{ g AgCl} - 0.2473 \text{ g} = 0.7527 \text{ g Ag}$$

Use the second equation to solve for m_I:

$$m_I = 1.6381 \text{ g AgI} - m_{Ag} = 1.6381 \text{ g AgI} - 0.7527 \text{ g Ag} = 0.8854 \text{ g I}$$

☑ *Reasonable Result Check:* The ratio of the calculated mass of I to the calculated mass of Cl (0.8854 g/0.2473 g) is 3.580, as indicated in the problem.

113. *Result:* **(a) 3 × 10^{22} molecules (b) Fraction = 3 × 10^{-20} (c) 300 molecules**

Analyze and Plan: (a) Use the time elapsed, breathing rate, one breath's volume, and molecules/mL to determine the number of molecules. (b) To determine the fraction, divide the molecules in speech by the molecules in the air (c) calculate the molecules in a single breath and multiply by the fraction.

Execute:

(a) $$10 \text{ min} \times \left(\frac{20 \text{ breaths}}{1 \text{ min}}\right) \times \left(\frac{500 \text{ mL}}{1 \text{ breath}}\right) \times \left(\frac{2.5 \times 10^{19} \text{ molecules}}{1 \text{ mL}}\right) = 2.5 \times 10^{24} \text{ molecules}$$

$$\simeq 3 \times 10^{22} \text{ molecules (1 sig fig)}$$

(b) $$\text{fraction} = \frac{2.5 \times 10^{24} \text{ molecules}}{1.1 \times 10^{44} \text{ molecules}} = 2.3 \times 10^{-20} \simeq 3 \times 10^{-20} \text{ (1 sig fig)}$$

(c) $$\frac{500 \text{ mL}}{1 \text{ breath}} \times \frac{2.5 \times 10^{19} \text{ molecules}}{1 \text{ mL}} = 1.25 \times 10^{19} \frac{\text{molecules}}{\text{breath}} \text{ (1 sig fig)}$$

$$\left(1.25 \times 10^{22} \frac{\text{molecules}}{\text{breath}}\right) \times \left(2.3 \times 10^{-20}\right) = 280 \text{ molecules} \simeq 300 \text{ molecules (1 sig fig)}$$

☑ *Reasonable Result Check:* Considering the large number of molecules in the speech, it makes sense that there may be a small number of recycled molecules in a later breath, even though the speech molecules represent a very tiny fraction of all the air molecules.

115. *Result:* **7.056 g/cm^3 ≠ 7.917 g/cm^3 Densities are not the same, so they are not the same metal.**

Analyze and Plan: Calculate the volume of each cube and divide it into the mass to get the density. If the densities are not the same, then the metals are not the same.

Execute: Density = mass/volume = mass/(side length)^3

$$\text{Your cube: } \frac{16.23 \text{ g}}{(1.32 \text{ cm})^3} = 7.056 \frac{\text{g}}{\text{cm}^3}$$

$$\text{Partner's cube: } \frac{24.64 \text{ g}}{(1.46 \text{ cm})^3} = 7.917 \frac{\text{g}}{\text{cm}^3}$$

Because the two cubes do not have the same density, they are not made from the same metal.

☑ *Reasonable Result Check:* It makes sense that the instructor would give different unknowns.

More Challenging Questions

119. *Result:* **(a) Copper (b) 120 mL**

Analyze: Given the mass of a flask filled with a fixed volume of water, the mass of a flask filled with a given number of shots and the rest water, and the mass of the container with the same number of shots, (a) determine what pure metal the shots are made of and (b) determine the volume occupied by 500 shots.

Plan: Using the density of water, determine the mass of the water in the flask. From the combined mass of the flask + water, determine the mass of the flask. Use the combined mass of the flask, shots, plus water; the mass of the shots; and the density of water to determine the volume of water displaced by the shots. Subtract this volume from 100.0 mL to determine the volume of the water displaced by the shots. (a) Take a ratio of the mass of the shots to their volume to determine the density, then use Table 1.1 to determine what the metal is. (b) Use the volume of 20 shots to determine the volume of 500 shots.

Execute:

(a)

$$100.0 \text{ mL water} \times \frac{0.998 \text{ g water}}{1 \text{ mL water}} = 99.8 \text{ g water}$$

$$122.3 \text{ g} - 99.8 \text{ g} = 22.5 \text{ g flask}$$

$$159.9 \text{ g} - 42.3 \text{ g} - 22.5 \text{ g} = 95.1 \text{ g water in the container with shots}$$

$$95.1 \text{ g water} \times \frac{1 \text{ mL water}}{0.998 \text{ g water}} = 95.3 \text{ mL water}$$

Volume of water displaced can be calculated by subtracting the volume of water with shots from the volume of water without shots:

$$\text{Volume of water displaced} = 100.0 \text{ mL} - 95.3 \text{ mL} = 4.7 \text{ mL}$$

$$d = \frac{m}{V} = \frac{42.3 \text{ g}}{4.7 \text{ mL}} = 9.0 \text{ g/mL}$$

The closest pure metal element listed in Table 1.1 to this value is **copper** (d = 8.93 g/mL)

(b)

$$500 \text{ shots} \times \frac{4.7 \text{ mL}}{20 \text{ shots}} = 120 \text{ mL}$$

☑ *Reasonable Result Check:* (a) The density of the metal is fairly close to copper. It would have been useful if the scientific observer would have reported the color of the metal to distinguish it from possibly being nickel (with d = 8.90 g/mL), instead. (b) When the number of shots increases, the volume increases.

122. *Result:* **(a) 32.1 g sulfur (b) 29.8 g zinc sulfide**

Analyze: Given the mass of one reactant and the mass of product of their combination, find the mass of the second reactant in the product, then determine the mass of product that could be formed from a different mass of reactant.

(a) *Plan:* The product is composed of two elements. The difference between the given masses must be the mass of the second element.

Execute: 97.5 g zinc sulfide – 65.4 g zinc = 32.1 g sulfur

(b) *Plan:* The elements combine in fixed ratios, so we can set up a zinc-to-product ratio to determine how the mass of product changes with a different mass of zinc.

Execute:

$$\frac{32.1\ \text{g zinc}}{65.4\ \text{g zinc sulfide}} = \frac{20.0\ \text{g zinc}}{x\ \text{g zinc sulfide}}$$

$$x = 29.8\ \text{g zinc sulfide}$$

☑ *Reasonable Result Check:* The sum of the reactant elements is the mass of the product, according to the conservation of mass. A smaller mass of one element will produce a smaller mass of product.

124. *Result:* **No, the samples contain variable percentages of iron**

Analyze: Given the mass of various portions of a sample known to contain only iron and sulfur and the mass of iron in each portion, determine if the sample is a compound of iron and sulfur, and explain the decision.

Plan and Execute:

If the sample is a compound, the elements will be combined in a fixed proportion, so we can calculate the percentage of iron in each portion and compare them.

$$\%\ \text{iron portion 1} = \frac{0.964\ \text{g iron}}{1.518\ \text{g portion}} \times 100\ \% = 63.5\ \%$$

$$\%\ \text{iron portion 2} = \frac{1.203\ \text{g iron}}{2.056\ \text{g portion}} \times 100\ \% = 58.51\ \%$$

$$\%\ \text{iron portion 3} = \frac{1.290\ \text{g iron}}{1.873\ \text{g portion}} \times 100\ \% = 69.87\ \%$$

The percentage of iron changes from portion to portion, so the sample is not composed of a single compound of iron and sulfur.

☑ *Reasonable Result Check:* The variable iron content proves that the sample cannot be a single compound.

126. *Result:* **3.1 L**

Analyze: Given the mass of one substance, the volume and density of a solution, and the mass of the solution after a reaction produces a gas with known density that escapes, determine the volume of the gas produced.

Plan and Execute: Calculate the total mass of the original mixture before the reaction occurs by adding the masses of the calcium carbonate and the hydrochloric acid solution:

$$\text{Total mass} = 12.6\ \text{g calcium carbonate} + 63.0\ \text{mL solution} \times \frac{1.096\ \text{g}}{1\ \text{mL}} = 81.6\ \text{g before reaction}$$

Use the conservation of mass to calculate the mass of escaped gas. Assuming that nothing else escaped the solution (such as water in the form of steam), the difference between the mass of the mixture before the reaction and the mass after must be the mass of the escaped gas:

Mass gas = 81.6 g before reaction – 76.1 g after reaction = 5.5 g gas

Use the density of the gas to determine the volume from this mass:

$$5.5\ \text{g} \times \frac{1\ \text{L}}{1.798\ \text{g}} = 3.1\ \text{L}$$

☑ *Reasonable Result Check:* It makes sense that the solution's mass is smaller than the original mixture's mass because a gas escaped. The low density of the gas produces a large volume of gas.