Chapter 1

Problems & Exercises

Insight into Aluminum

1.2 What properties of aluminum might cause you concern if you had to use the aluminum tableware that Napoleon employed to impress his guests?

ANS Al tableware would be very susceptible to rapid oxidation and would have to be polished frequently.

1.4 Use the web to determine the amount of aluminum used in the US in a single year. What is the primary use for this material?

ANS The are radical changes in the amount of aluminum produced in the US as more production is shifted out of the US. Utilize a world wide web search engine to acquire the reference. Primary use for the material is transportation.

1.6 Use the web to determine the difference in how much aluminum is recycled in states where there are deposits on aluminum cans versus states where recycling is voluntary? What is the most reliable way to estimate this value? What uncertainty is there in the estimate?

ANS Recycling rates have steadily declined in recent years; utilize a world wide web search engine to acquire the most current reference.

The Study of Chemistry

1.8 Which of the following items are matter and which are not? (a) a flashlight (b) sunlight (c) an echo (d) air at sea level (e) air at the top of Mount Everest

ANS a) matter, b) not matter, c) not matter, d) matter, e) matter

1.10 How can a liquid be distinguished from a fine powder? What type of experiment or observation might be undertaken?

ANS Experiments related to the physical properties of the liquid and fine powder would prove useful. These could include properties such as surface tension, flow, and behavior in a high static electricity environment.

1.12 Do the terms element and atom mean the same thing? If not how do they differ?

ANS No, an element is a pure substance, but the natural occurring form of the element may contain two atoms. An example of this is elemental nitrogen (N_2). In this case the element has two atoms.

1.14 Why do physical properties play a role in chemistry if they do not involve any chemical changes?

ANS Physical properties can be used to identify substances in qualitative and quantitative analysis and can provide a wide range of useful information.

1.16 Identify the physical and chemical properties noted in the following statement: When a piece of iron is exposed to air it corrodes, forming a layer of red-brown powder that flakes off and is denser than the original material.

ANS Physical properties include the flaking of the powder and density comparison. The chemical properties here is the reaction to form the iron oxide(s).

1.18 All molecules attract each other to some extent, and the attraction decreases as the distance between particles increases. Based on this idea, which state of matter would you expect has the strongest interactions between particles, solids, liquids or gases?

ANS Intermolecular forces of attraction are greatest in solids as we will learn in further detail in Chapter 8.

Observations and Models

1.20 Complete the following statement: Data that have a large random error may be (accurate, precise, or neither).

ANS These data could be accurate but not precise.

1.22 Two golfers are practicing shots around a putting green. Each golfer takes 20 shots. Golfer 1 has 7 shots within 1 meter of the hole, and the other 13 shots are scattered around the green. Golfer 2 has 17 shots go into a small sand trap near the green and three just on the green near the trap. Which golfer is more precise?

Which is more accurate?

ANS Golfer 2 is more precise because his efforts are grouped more tightly about a central point (mean) even if it's not the intended spot. Golfer 1 is more accurate as there are more shots very close to the accepted "value" (the hole).

1.24 Suppose you are waiting at a corner for a bus. Three different routes pass this particular corner. You see a bus pass by from the two routes you are not interested in taking. When you say to yourself, "My bus must be next," what type of reasoning (deductive or inductive) are you using? Explain your answer.

ANS Deductive reasoning is being applied in this case. The first two buses represent pieces of information that are processed and lead to the conclusion that the "desired" bus must be next.

1.26 What is the difference between a hypothesis and a question?

ANS A hypothesis is a statement related to observation(s). The hypothesis is either accepted or rejected based upon experimentation. A question is simply posed.

1.28 What is a law of nature? Are all scientific laws examples of a law of nature?

ANS A law of nature is an irrefutable, self-evident fact. Not all scientific laws are examples of laws of nature.

Numbers and Measurements

1.30 What is the difference between a qualitative and a quantitative measurement?

ANS A quantitative measurement provides information as to *how much* analyte is present. A qualitative measurement answers the question, 'is the analyte present?'

1.32 What is a "derived" unit?

ANS A derived unit is a unit that is made up of two or more units itself.

1.34 The largest computers now include disk storage space measured in terabytes. How many bytes are in a terabyte? (Recall that in computer terminology, the prefix is only "close" to the value it designates in the metric system.)

ANS 1 terabyte = 1,000,000,000,000 bytes

1.36 Use the web to determine how the btu unit was initially established. For the engineering applications where this unit is still used today, why is it a sensible unit?

ANS The amount of energy required to raise one pound of liquid water 1 degree Fahrenheit at its maximum density (occurs at 39.1 F).

1.38 Convert the value 0.120 ppb into ppm.

ANS 1.20×10^{-4} ppm

1.40 Oxygen boils at –186°C. What is this temperature in Kelvin?

ANS 87 K

1.42 Express each of the following temperatures in °C. (a) 177 K (b) 298 K (c) 4 K (d) 1500 K

ANS a) -96°C, b) 25°C, c) -269°C, d) 1227°C

1.44 How many significant figures are present in each of the following experimental measurements? (a) 0.003 m (b) 6030 kg (c) 400.3 s (d) 0.000701 L (e) 31.624 km

ANS a) one, b) three c) four, d) three, e) five

1.46 Assuming the numbers given are measurements, carry out the indicated arithmetic operations and give the answer with the correct number of significant figures. (a) 7.132 / 6 (b) $3.65 \times 10^{2} + 8.1 \times 10^{3}$ (c) 18.13 - 1.3
(d) $9 \times 10^{-6} \times 1.33 \times 10^{-3}$

ANS a) 1.189, b) 8.5×10^{3}, c) 16.8, d) 1×10^{-8}

1.48 In an attempt to determine the velocity of a person on a bicycle, an observer uses a stopwatch and times the length of time it takes to cover 25 “squares” on a sidewalk. A measurement of one of the squares shows it to be 1.13 m long. The bicycle takes 4.82 seconds to travel this far. What velocity, in m/sec, should the observer report?

ANS 5.87 m/s

1.50 Measurements indicate that 23.6% of the residents of a city with a population of 531,314 are college graduates. Considering significant figures, how many college graduates are estimated to reside in this city.

ANS 1.25×10^5

1.52 A rock is placed on a balance and it’s mass is determined to be 12.1 g. When the rock is then placed in a graduated cylinder that originally contains 11.3 mL of water the new volume is roughly 17 mL. What should the density of the rock be reported as?

ANS 2 g/mL

Problem Solving in Chemistry and Engineering

1.54 If a 1.00-kg bag containing 8 apples costs $1.48, how much does one apple cost? What mass of apples costs $1.00?

ANS a) $0.185 per apple

b) 0.676 kg

1.56 The distance between two atoms in a molecule is 148 pm. What is this distance in meters?

ANS 1.48×10^{-10} m

1.58 Carry out the following unit conversions. (a) 82 μg to mg (b) 6.73×10^{-4} mm to nm(c) 1.37×10^{6} nA to mA (d) 4.8×10^{18} mW to GW

ANS a) 8.2×10^{-2} mg

b) 6.73×10^{2} nm

c) 1.37 mA

d) 4.8×10^{6} GW

1.60 If a vehicle is traveling 92 m/s what is its velocity in miles per hour? 0.60 miles = 1.00 km.

ANS 200 mph

1.62 A tube of toothpaste occupies a volume of 75 mL and contains toothpaste with a mass of 230 g. What is the density of the toothpaste?

ANS 3.1 g/mL

1.64 Mercury has a density of 13.6 g/mL. What is the mass of 4.72 L of mercury?

ANS 6.42×10^4 g

1.66 Draw a molecular scale picture to show how a crystal differs from a liquid.

ANS The drawing should represent the increase in intermolecular forces in the solid that give rise to the crystal. This means a sketch that shows each atom interacting with its neighbors. This interaction would not be all encompassing in a liquid leaving the structure free to assume the volume of a container for example.

1.68 In the description of the refining of aluminum the molecular scale depiction of precipitation was not included. Use the web to determine what chemicals are involved in the precipitation process and draw a molecular scale drawing of this reaction.

ANS Utilize a world wide web search engine to acquire the reference.

Insight into Materials Selection and Bicycle Frames

1.70 Rank aluminum, steel and titanium in order of increasing stiffness.

ANS Al < titanium << steel (see Table 1.3 Chapter 1)

1.72 Aluminum is not as strong as steel. What other factor should be considered when comparing the desirability of aluminum versus steel if strength is an important consideration for a design?

ANS Density (and hence mass) of material.

1.74 Use the web to research the elastic modulus and yield strength of carbon fiber composites. How do these materials compare to aluminum, steel and titanium?

ANS Elastic modulus of the carbon fiber is about 150 GPa. That of the aluminum is 69 GPa, steel ranges from 190-210 GPa, and titanium ranges from 105-120 GPa.

Focus on Problem Solving Exercises

1.76 A student was given two metal cubes that looked similar. One was 1.05 cm on an edge and had a mass of 14.32 grams; the other was 2.66 cm on a side and had a mass of 215.3 grams. How can the student determine if these two cubes of metal are the same material using only the data given?

ANS Determine the density of each cube. If the densities vary significantly, the cubes are not the same material. If the densities are similar, the student can suggest that

the materials "appear" to be similar but can not say that they are the same without doubt. In this particular case, the first cube has a density of 12.4 g/cm^3 and the second has a density of 11.4 g/cm^3. This difference suggests that the two materials are not the same.

1.78 Battery acid has a density of 1.285 g/mL and contains 38.0% sulfuric acid by mass. Describe how you would determine the mass of pure sulfuric acid in a car battery, noting what item(s) you would have to measure or look up.

ANS Measuring the volume of battery acid and using the density value provided would give you a mass of battery acid. From there, the % sulfuric acid would provide a reliable measure of the mass of pure sulfuric acid

1.80 A solution of ethanol in water has a volume of 54.2 mL and a mass of 49.6 g. What information would you need to look up and how would you determine the percentage of ethanol in this solution?

ANS To determine the % of ethanol one would have to know the density of ethyl alcohol. Make the assumption that the primary components are water and ethanol. Set "x" equal to the percentage of ethanol in the sample, and "1-x" is the percentage of water. Multiple "x" by the density of ethanol and to this quantity add "1-x" multiplied by the density of water. The sum of these two components should equal the overall density found by mass/volume.

1.82 Mercury is traded by the "flask," a unit that has a mass of 34.5 kg. How would you determine the volume of one of these flasks? What would you have to look up to solve the problem?

ANS One would need to know the density of Hg. By multiplying the mass of a flask (34.5 kg) by this density, the volume of the flask may be calculated.

1.84 Imagine you place a cork measuring 1.30 cm x 4.50 cm x 3.00 cm in a pan of water. On top of this cork you place a small cube of lead measuring 1.15 cm on a side. Describe how you would determine if the combination of the cork and lead cube will still float in the water. Note any information you would need to look up to answer the question.

ANS Find the mass of the cork and that of the lead. The sum of masses can be divided by the sum of volumes (19.1 cm^3) to find an average density for the pair. If this

is less than 1 g/cm^3, the pair is expected to float.